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Bibliometric Analysis of Climate Change Impacts on Global Water Issues (2014-2024)

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Abstract: This study presents a comprehensive analysis of critical bibliometric methods, including trend analysis, correlation analysis, rainfall-runoff modeling, multivariate statistical approaches, and flood frequency analysis, to assess the impact of climate change on hydrology and flood risks. Climate change significantly threatens global water security by altering the hydrological cycle and increasing the frequency and intensity of extreme weather events. The review underscores the necessity for multidisciplinary, context-specific approaches that integrate knowledge from fields such as policy studies, ecology, hydrology, climatology, and social sciences. These collaborative efforts are essential for enhancing the understanding of dynamic sectoral vulnerabilities, adaptation strategies, cascade effects, and ecological responses to water-related challenges induced by climate change. A significant obstacle identified is the integration of multidisciplinary impact assessments with climate models, crucial for comprehending the complex interactions between water scarcity and climate change. This review also highlights the importance of sustained research projects and financial support from various institutions, including government agencies, international organizations, and national science foundations. To promote sustainable water management practices and enhance resilience, it is imperative that researchers, policymakers, and stakeholders collaborate to develop viable solutions. This can be achieved by recognizing the limitations of current approaches and adopting innovative strategies. The value of continued financial and institutional support is emphasized to ensure ongoing progress in addressing these critical issues.

Keywords: VOSviewer analysis; Bibliometric method; Climate change; Extreme weather; Water issues

1. Introduction

Global water supplies are impacted by the Earth's water cycle, which is significantly affected by climate change (Hao et al., 2023). By speeding up evaporation and changing the distribution of precipitation, rising temperatures make droughts more frequent and severe in certain areas while raising the danger of flooding in others. Climate change makes urban floods more severe, particularly in developing countries. This study states that urgent action is required to protect vulnerable communities as climate change is predicted to increase rainfall unpredictability. This increased variability in precipitation patterns seriously threatens urban areas that need proper stormwater management systems. Extreme weather events impact water quality and are exacerbated by climate change. Enough rain can overwhelm water treatment plants and increase the outflow of pollutants. Warmer seas also tend to have higher rates of toxic algal blooms, degrading water quality. This study emphasizes how climate change worsens flood control and water management issues in rapidly urbanizing areas. Global water management systems are being strained by these changes, which also escalate competition for scarce water supplies and possible geopolitical tensions worldwide. Developing nations are more susceptible to these abrupt transitions, frequently requiring more significant infrastructure and resources. According to this study, addressing these problems through Sustainable Urban Drainage Systems (SUDS) may be a viable solution that complies with integrated flood risk management and green infrastructure objectives. Suction-controlled drainage systems and enhanced flood mitigation capabilities are highlighted as possible ways to improve climate resilience with SUDS (Deng et al.,

2024). Quantitative bibliometric techniques that detect, measure, and statistically analyze hydroclimatic changes are essential to understanding climate change impacts on water resources and flooding (Ngong Deng & Ikhsan, 2024). This study reviews the literature on critical bibliometric methods to assess climate change effects on hydrology and flood hazards, including trend analysis, correlation analysis, rainfall-runoff modeling, flood frequency analysis, and multivariate statistical approaches. The strengths and limitations of these techniques are discussed, along with essential findings, uncertainties, and future research needs. Successful bibliometric analysis is crucial for elucidating climate change and hydrology linkages to support adaptation efforts in water resource management and flood risk reduction (Deng et al., 2023). The articles analyze the projected impacts of climate change on drought frequency and intensity across the globe using VOSviewer techniques.

In climate change and global water research, trend analysis starts with careful data from trustworthy sources, including long-term hydrological and climate records (Zeleke et al., 2022). Then researchers carefully examine the data quality, using the proper statistical methods to deal with anomalies and gaps. Using the correct parameters in trend analysis is essential to obtaining insightful findings. To account for natural climate variability, researchers usually select a time series that spans at least three decades. Spatial scales can be used to examine the effects of climate change in various geographic contexts, from local to global. Important climate variables usually include temperature, precipitation, and evapotranspiration; important hydrological variables include streamflow, soil moisture, and groundwater levels (Rossi & Peres, 2023). Trend analysis has numerous benefits that give policymakers quantifiable proof of long-term variations in water supplies, empowering them to make well-informed decisions. Trend analysis identifies regions most susceptible to the effects of climate change, supporting focused adaptation strategies. Correlation analysis starts with careful variable selection in climate change and water research, emphasizing pertinent hydrological and climate characteristics. To provide reliable results, data pre-treatment is crucial and should include multicollinearity tests and normalization. Depending on the data type, researchers can then calculate correlation coefficients like Pearson's r or Spearman's rho. Observed correlations are subjected to rigorous significance testing to ascertain their statistical validity. The last stage entails carefully interpreting the data and assessing the direction and strength of links between variables to decipher the intricate connections between climate and water (Wang et al., 2023a).

The data distribution and the study's goals determine which parametric and non-parametric correlation techniques are best. The usual significance thresholds are $\alpha = 0.05$ or 0.01 to balance the dangers of Types I and II errors (Alaoui et al., 2024). Researchers must also ensure that the spatial and temporal scales of climate and water variables are well matched and consider possible lag times in hydrological responses to climate forcings. Using correlation analysis in water and climate change studies has various benefits. It reveals complex connections between water and climatic variables, assisting in identifying essential factors influencing hydrological changes. Additionally, by facilitating the creation of prediction models, this approach improves the comprehension of the dynamics of water resources in the future. Furthermore, this approach needs to be modified to simplify complicated, non-linear connections in hydrological systems because it is susceptible to outliers and problems with data quality. Modeling rainfall runoff is a sophisticated way to comprehend how climate change affects water supplies. The first step in the process is the careful selection of the model. Depending on the research goals and the availability of data, one might choose between conceptual, physical, or data-driven techniques. The next step is data preparation, which entails gathering and pre-processing important input variables like temperature and rainfall. Parameter estimation is a crucial step in guaranteeing that model parameters accurately depict hydrological processes, and it involves calibrating model parameters using historical data. Thorough model validation with separate datasets is necessary to evaluate its predicted ability. Lastly, to assess potential effects on water supplies in the future, researchers run calibrated models using predicted climate data as part of climate change scenario analyses (Kone et al., 2024).

In rainfall-runoff modeling, choosing parameters necessitates striking a careful balance between computational efficiency and model complexity. The study objectives and available data must be carefully considered while selecting the spatial and temporal resolutions. To capture representative hydrological conditions, it is essential to choose the appropriate calibration periods. To evaluate the model's correctness, researchers must additionally use pertinent performance metrics, such as Kling-Gupta Efficiency (KGE) or Nash-Sutcliffe Efficiency (NSE). Using rainfall-runoff modeling in water and climate change studies has various advantages (Huntjens et al., 2012). Quantitative forecasts of future water resources under different climate scenarios make robust impact assessments possible. Scenario analysis is made possible by this method, which aids in assessing various management techniques considering climatic unpredictability. Furthermore, complex models can include the effects of land use and climate change, providing a more complete picture of future hydrological circumstances. However, these models have certain drawbacks, such as the quality of the input data and parameter estimation, which can affect the results and lead to uncertainty propagation in climate projections through hydrological simulations. In addition, significant computational resources might be needed for complicated, distributed models, making their general deployment difficult. Utilizing bibliometric techniques in climate change and water research provides an effective way to discover patterns in research and areas of incomplete information. This method starts with carefully selecting databases, concentrating on extensive scientific repositories like the Scopus database. Subsequently,

scholars develop intricate search tactics, creating exhaustive query phrases that encompass the entire range of pertinent material. Then data extraction gathers comprehensive bibliographic data, such as authors, titles, abstracts, and citation information. Subsequently, sophisticated bibliometric methods like co-citation analysis and keyword co-occurrence are employed to reveal trends and connections in the literature. Developing powerful visuals like network maps and time series plots is the last phase in effectively communicating research patterns and multidisciplinary relationships (Brandt et al., 2013).

In bibliometric analysis, choosing a parameter needs considerable thought. Researchers must establish appropriate periods to document changing research trends. Choosing which document categories (articles, reviews, and conference papers) to include can significantly influence the outcome. Identifying pertinent subject areas ensures a targeted examination of water and climate change. To balance comprehensiveness with the requirement to emphasize crucial contributions, citation thresholds may be set to identify highly significant works. Using bibliometric analysis in water and climate change studies has many benefits. It offers a thorough summary of research trends and aids in identifying new areas of study and knowledge gaps. This approach directs scholars toward important contributions by highlighting significant writers, organizations, publications, and leading countries on the study subject (Batisha, 2023). Furthermore, bibliometric analysis identifies interdisciplinary links that promote the exchange of ideas among linked fields. Still, this strategy might have drawbacks, such as the need to be more impartial toward English-language periodicals and reputable journals, ignoring significant contributions from underrepresented areas or newly established channels. Although applicable, citation counts may only sometimes accurately represent the significance or goals of research, requiring a thorough analysis of the findings. Through the collaborative integration of trend analysis, correlation analysis, rainfall-runoff modeling, and bibliometric techniques, scholars can enhance their comprehension of the effects of climate change on worldwide water resources. This multidisciplinary approach helps develop more efficient and sustainable water management plans in a changing environment by identifying essential knowledge gaps and supporting evidence-based decision-making.

A vital strength of the approach is using an ensemble of multiple climate models to capture some of the uncertainty in future climate projections. The flood bibliometric analysis method simulates a minimum number of articles, review papers, conference papers, and books published under different institutions, countries, and organizations to indicate drought hazards (Choi et al., 2023). The analysis uses a statistical relationship between past drought intensity and reported losses, disaggregated by the financial sector, to estimate economic losses from droughts. Based on historical data from the Scopus database, this empirical approach allows sector-specific vulnerabilities to be accounted for (Kotlarz & Bejger, 2024). Bibliometric analysis is a valuable method for evaluating and measuring the current level of study regarding a particular topic by examining material that has been published (Agodzo et al., 2023). Bibliometrics can provide insights into the development, influence, hotspots, and emerging themes within an area of study by examining features such as publishing trends over time, highly cited works, influential authors, journals, institutions, and keywords. This work aims to perform an extensive bibliometric analysis of studies concerning the effects of climate change on water supplies (Agodzo et al., 2023). Publications on Scopus data can be examined to evaluate the productivity, citations, collaborations, funding sources, and topic clustering of this vital field of climate change research, using data from academic databases such as Scopus. The findings can shed light on essential publications, top universities, nations, and study areas influencing how the impact of climate change on water availability, quality, flooding, droughts, and other hydrological repercussions is perceived. In the end, bibliometric mapping offers a comprehensive picture of the current level of knowledge to drive future research efforts toward more effective water resource management and climate adaptation plans in the face of global warming.

Climate change has a significant impact on the global water supply. It alters the timing of rainfall, making severe natural disasters like floods and droughts more intense and frequent, and reducing the quantity and quality of water available (Van der Pol et al., 2015). These changes must be understood and anticipated by the agricultural sector, human health and safety, environmental protection, and the control of water resources. Bibliometric monitoring and analysis tools have drawn increased attention to studying water concerns related to climate change (Hsieh & Yeh, 2024). Bibliometric methods use VOSviewer analysis as indicators or sensors to assess environmental conditions based on the number of authors studying climate change related to water issues (Gabriele et al., 2022). This could include analyzing countries, institutions, and organizations that have published many articles on climate change's ability to reconstruct past hydrological conditions for water-related applications. It also encompasses monitoring areas, studies, and funding sources to focus on the effects of climate change on vegetation as biosensors of current water quality and quantity.

Using bibliometric indicators offers some potential advantages over conventional physical and chemical monitoring alone. Bibliometric method analysis integrates environmental signals over time, providing a more holistic picture with some bioindicators that can be highly sensitive to specific stressors. Additionally, historic bibliometric data preserved in natural archives like sediments or trees can extend the understanding of environmental baselines before human influences. However, bibliometric methods have limitations, such as complex biological responses, with multiple interacting factors driving observed changes. The sectoral

vulnerability remains constant over time rather than adapting to climate change. There can be significant spatial and temporal variability (Johnson et al., 2023). Establishing quantitative linkages between bibliometric indicators and specific environmental drivers, like climate change, is challenging. Bibliometric investigations can offer essential insights when paired with other data sources and modeling techniques. This study discusses the benefits and drawbacks of employing different bibliometric approaches to examine how climate change is affecting water supplies. In addition, this research points out the most important discoveries made in this expanding field of study, discusses any lingering doubts, points out interesting new approaches and uses, and suggests areas for further investigation. To manage water resources successfully in a quickly changing environment, it is imperative to have a thorough understanding of the potential and constraints associated with bibliometric analysis (Wang et al., 2023b). This study addresses the advantages and disadvantages of current strategies for resolving floods and water scarcity issues. Some key conclusions from the review are as follows: drought frequency and intensity in the Mediterranean and Atlantic regions are expected to rise; agriculture and the energy sector can be disproportionately affected; and rainfall may help some areas experience less water stress while making others experience more (Albatayneh, 2023). A more profound comprehension of dynamic sectoral vulnerabilities, independent and premeditated adaptation mechanisms, techniques, cascade impacts, and ecological impacts is among the future studies that need to be mentioned in the review (Van der Pol et al., 2015). Furthermore, it is acknowledged that a critical obstacle to a deeper understanding and management of the intricate interactions between water shortages and climate change is the integration of climate models with multidisciplinary impact assessments (McClelland, 2023). The review emphasizes the need for context-specific, interdisciplinary approaches to address the complex challenges of flooding and water scarcity brought on by climate change, even though it does not explicitly focus on bibliometric method analysis alone (Stathi et al., 2023). Instead, it offers a thorough overview of knowledge, current initiatives, and research gaps.

1.1 Research Significance

A valuable technique for comprehending the state of research in a particular area, such as climate change and its effects on flooding and water resources, is bibliometric analysis. Researchers can learn about the most influential works and notable authors and develop study fields by examining publications, citations, and other bibliometric indicators. Bibliometric analysis can be used to better evaluate the importance of research on flooding, water challenges, and climate change.

a) The most referenced and significant publications can be found using bibliometric analysis. These widely referenced studies frequently represent ground-breaking work that has dramatically expanded the understanding of the subject or established the groundwork for future investigation. By analyzing these seminal works, scholars can gain a deeper understanding of the fundamental theories, approaches, and conclusions that have influenced the discipline.

b) Researcher and institution collaboration and co-authorship trends can be uncovered through bibliometric analysis. By viewing these networks, researchers can determine well-known research teams, organizations, and nations actively advancing the area. This data may make it easier to collaborate and share knowledge in the future.

c) By examining the frequency and co-occurrence of keywords or concepts in publications, bibliometric analysis can assist in identifying topics and trends in the new research. This can provide insights into recently developed research areas, scientific developments, or cross-disciplinary approaches that are increasingly prevalent.

d) Bibliometric measures, such as citation counts and h-indexes, can assess the effect and influence of specific academics, publications, or organizations. Decisions about funding and resource distribution, as well as evaluations of the significance and contributions of research programs, can all profit from this data.

e) Scholars might find unexplored or understudied topics in a field by examining the corpus of existing literature and bibliometric patterns. This can serve as a roadmap for the following studies and point out possible directions for original research or cross-disciplinary cooperation. When it comes to flooding, water problems, and climate change, bibliometric analysis can shed light on the state of the field, essential publications, and new directions. To solve these urgent global concerns, this information can assist researchers in better comprehending the existing state of knowledge, pinpointing areas for additional investigation, and encouraging collaboration and knowledge-sharing.

2. Literature Review

Globally, society, its economic growth, and the environment are all at risk from the effects of climate change. These phenomena, mainly caused by human activities, cause the weather on Earth to change drastically and quickly (Levin et al., 2024). Economic existence, ecological systems, and humanity are all impacted by climate change. The severity of the issue is highlighted by the increasing frequency and intensity of catastrophic natural disasters, such as storms, flooding, droughts, and extreme weather, which endanger public health, food security, and the stability of the world economy. Scientific research is essential in this context. It allows us to evaluate the effects

of climate change on different natural and human systems and comprehend its intricate dynamics. The principal manner in which climate change influences water resources is through alterations in the hydrological cycles. Weather and precipitation patterns change rainfall's quantity, timing, and magnitude. There's a chance that certain areas would have more extended droughts because of reduced precipitation, while other areas might get heavier rainfall, which would raise the possibility of flooding. This variability in water availability impacts energy production, agriculture, and water for consumption accessibility, making successful utilization of water resources difficult. Moreover, increased sea levels brought on by the disintegration of ice caps and mountains may deplete freshwater availability. This technique has the potential to negatively impact agricultural areas by decreasing the amount of accessible potable water and decreasing crop output and fertility. Floods and habitat degradation are more susceptible to these changes because they are more common in coastal populations. Water quality is also impacted by climate change. Elevated temperatures have the potential to cause increased evaporation rates, which in turn can concentrate pollutants in water bodies (Mahreen et al., 2023).

Furthermore, severe weather conditions like floods and heavy rains can overwhelm stormwater systems, contaminating water sources with sediments, pollutants, and pathogens. Such occurrences pose significant dangers to aquatic ecosystems and human health, necessitating large investments in infrastructure and water treatment to guarantee pure water for use and consumption. Climate change poses severe risks to human populations because of its numerous immediate and secondary impacts on their livelihoods, the availability of food and water, health, and displacement. Global warming and extreme weather events cause an increase in the incidence of heat-related illnesses, respiratory and cardiovascular conditions, and a wider spread of vector-borne infections. Variable precipitation patterns and unpredictable weather can hurt agricultural productivity, threaten food security and increase prices. Farmers and fishermen, for example, who rely on natural resources for their livelihoods, are particularly vulnerable economically, and displacement and climate-induced migration are driven by resource scarcity and environmental deterioration. Furthermore, as traditional modes of existence become unsustainable, communities' social and cultural fabric, especially those of indigenous and rural populations, is in danger. To address these complex issues and safeguard human well-being in the face of climate change, there must be calls for extensive adaptation and mitigation measures, international collaboration, and a dedication to sustainable development (Gude, 2017).

Science provides the resources required to create adaptation and mitigation plans that work, suggesting creative ways to lower greenhouse gas emissions, safeguard delicate ecosystems, and assist impacted communities. In addition to stimulating public discourse and influencing political choices, scientific research offers a strong foundation for creating bold, fact-based climate policy. Within this framework, bibliometrics, the quantitative analysis of scientific literature, is becoming an increasingly helpful instrument for evaluating and comprehending the development of research on climate change. Bibliometric analysis can be used to map the field's scientific landscape and discover emergent research subjects, significant contributors (researchers, institutions, and nations), collaborative networks, and publishing patterns. This method summarizes climate change's worldwide scientific research goals, emphasizing accomplishments, knowledge gaps, and prospective avenues for future investigation (Taseska et al., 2023). Thus, bibliometric analysis is a priceless tool for scientists, decision-makers, and other interested parties engaged in the battle against climate change. It offers them vital information to direct future endeavors and optimize the influence of scientific inquiry on this worldwide issue.

3. Research Methodology

The research technique uses a thorough bibliometric approach to examine the literature on water-related aspects of climate change. The criteria for selecting data and the methods for processing it were thoughtfully created to guarantee thorough and pertinent outcomes. The primary data source for this study was the Scopus database because of its comprehensive coverage of scholarly articles and ease of use. This choice makes it possible to provide a current and comprehensive field representation. To ensure pertinence in presenting research patterns, the analysis concentrated on articles released in the previous ten years, specifically from 2014 to 2024. This timeline aims to provide enough information for insightful research while catching recent events. The Scopus database was searched using the phrase "climate change related to water issues" to locate pertinent publications. This general but targeted research question guarantees that a variety of papers are included while keeping the topic of the study precise. After this, the search results were exported as a Microsoft Excel (CSV) file, guaranteeing data availability and enabling additional analysis. Refinement and analysis of the gathered data required several steps in the data processing process. Using the built-in analytical capabilities of Scopus, the initial dataset was analyzed to produce an initial picture of the literary landscape. The data was then loaded into the VOSviewer program for a more thorough bibliometric study. The decision to use the VOSviewer was made because of its extensive use in bibliometric and citation research worldwide. This program may build and visualize intricate bibliometric networks while considering relational factors like co-authorship, bibliographic coupling, and source relationships. Using VOSviewer improves the study's repeatability because it is a widely available and well-documented tool in the field.

To give a thorough picture of the state of the field, the analysis concentrated on a few essential topics. These include grouping keywords associated with water and climate change, analyzing author partnerships, and classifying sustainable development. This multifaceted strategy guarantees a comprehensive examination of the topic from multiple angles. Non-English documents, reviews, book chapters, conference papers, and other non-article document formats were eliminated to improve the dataset further. The choice was made to concentrate on peer-reviewed research articles because they usually contain the most recent and meticulously examined scientific information. These methodological decisions make sense since they allow for a systematic, thorough, and repeatable study of the state of climate change research concerning the management of water resources. The research maintains transparency and facilitates future replication or extension by other scholars utilizing well-established bibliometric approaches and commonly used software tools. Through statistical analysis, this method captures the quantitative components of the literature and makes it possible to visualize the intricate linkages throughout the research community. Such visuals can highlight partnerships, patterns, and trends that conventional book review techniques would miss, providing insightful information about the field's history and present situation.

A thorough search and analysis of the literature on using the bibliometric method analysis in comparative studies reveals that over 1,159 articles have been indexed in the Elsevier Scopus database. There is an urgent need to systematically analyze and present a comprehensive overview of the climate change research status and water resources management in the application of review research, given the over 703 non-English documents, reviews, book chapters, and conference papers. Books, editorials, notes, erratums, letters, conference reviews, data papers, and short surveys were analyzed in the Scopus database. Bibliometric analysis is considered a crucial method for investigating and evaluating the scientific literature to demonstrate any subject of study's present expansion and potential future directions (Gyanendra et al., 2022). Consequently, this work presents and examines the research and publication landscape of bibliometric method analysis using various applications, such as VOSviewer, in climate change. Figure 1 shows the techniques for data recovery, screening, and analysis from published documents.

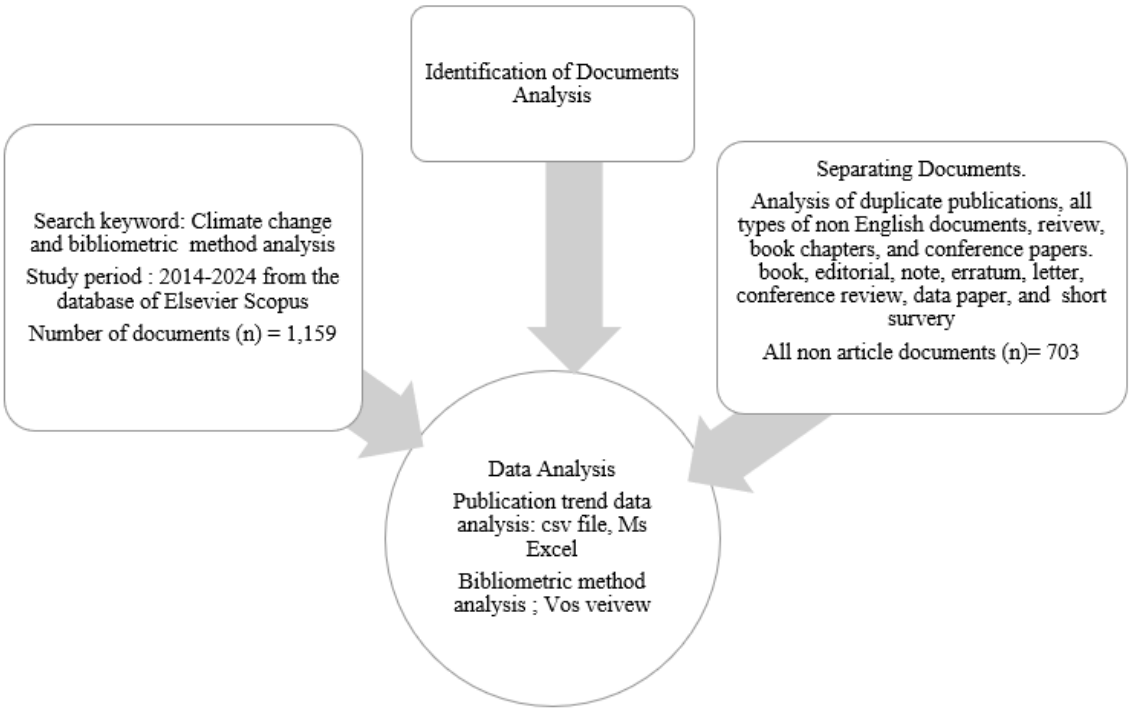

Figure 1. Techniques for data recovery, screening, and analysis from published documents

4. Results and Discussion

4.1 Analysis of Published Documents

Climate change related to water issues has recently gained significant attention as a research area in which VOSviewer and Microsoft Excel were used to perform a bibliometric analysis that looked at research trends in climate change categorization over the previous ten years (2014-2024). The study showed a steady increase in publications on this topic, with 113 articles in 2014 rising to 246 articles in 2022, with an impressive 99% growth over ten years. One thousand eight hundred eighteen (1818) articles and documents were published on climate

change classification using VOSviewer between 2014 and 2024, with 228 review papers, 221 book chapters, 146 conference papers, 49 books, 36 editorials, ten notebooks, five errata, three letters, two conference papers, two data papers, and one short survey being analyzed on the Scopus database.

Figure 2 shows the number of documents published annually with the most significant studies on climate change related to water issues. There is a clear upward trend, with a notable publication surge from 2019 onwards. The early years saw modest output (above 100 articles a year), but papers doubled from 189 in 2019 to 198 in 2020. This growth suggests increasing research attention on categorizing and analyzing climate change-related water issues using bibliometric techniques and VOSviewer software. The field is rapidly developing as a solution to the sustainability of the environment and is gaining prominence globally (Garofalo et al., 2015). The bibliometric analysis indicates growing productivity in applying VOSviewer to climate change-related water issues through analysis and knowledge mapping. This method can advance studies on climate change to support evidence-based planning and decision-making on global warming and water management.

The study uses bibliometric analysis to look at water-related research on climate change, providing a quantitative picture of the field's situation. This methodology enhances conventional literature reviews by highlighting patterns and trends ready to be used in future research on climate change. The research innovates and offers a current view of trends by using cutting-edge bibliometric approaches to this topic. It advances the field by thoroughly understanding the relationships between the various facets of climate change affecting water supplies. The methodology presented in this study improves the transparency and reproducibility of bibliometric investigations in the environmental sciences. It identifies essential ideas, well-known writers, and cooperative networks that can steer the course of future study. Future research ideas include extending the analysis to non-English publications and other document types, comparing the results over various periods, looking into the highly influential papers' methodologies, investigating the relationships between academic research and policy implementation, and combining qualitative review techniques with bibliometric analysis for a more nuanced understanding. This methodology offers significant perspectives for scholars and could influence policy choices about climate change and water resource management.

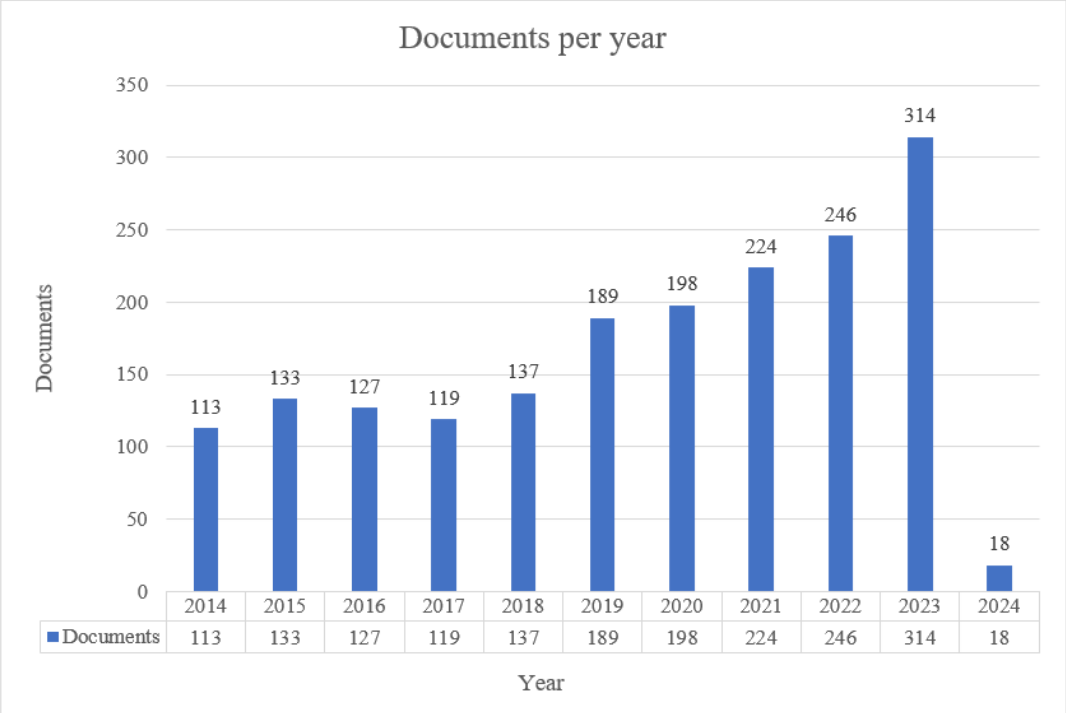

Figure 2. Increase in published documents (2014-2024)

4.2 Highly Cited Publications

A bibliometric analysis tool, such as VOSviewer, was used to process the cleaned dataset, which shows the generated visualizations and metrics to analyze the growth of publications over time. With a participation percentage of 17% and the highest number of published articles (757) on “General Earth and Planetary Sciences,” it stands out significantly from other journals. The leading journals are "Water Resources Research" and "Agricultural and Biological Sciences: Soil Science," with 4407 papers. Approximately half of the publications on this topic are published in these three journals. To examine this in more detail, the annual distribution of the number

of papers published for each publication is shown in Figure 3. The magazine "General Earth and Planetary Sciences" has been a top publication recently. In addition, the publication of works on this topic in 2014 has been greatly aided by the three journals "General Earth and Planetary Sciences," "Water Resources Research," and "Agricultural and Biological Sciences: Soil Science." Therefore, examining research sources can help scholars swiftly identify pertinent research papers from sources and choose an appropriate journal for the future publication of their manuscripts. With an emphasis on soil science and water resources, this study examines highly cited works in earth and planetary sciences. It shows that "General Earth and Planetary Sciences" is the most popular category and that most articles on the subject are published in three journals, indicating the interdisciplinary nature of the research. The primary contributions of the study are found in the way it uses bibliometric tools to illustrate publication trends over time, offering a thorough picture of the state of research and pinpointing the major journals responsible for most of the research output. The analysis recommends the following directions for further research: looking for developing themes in the context of highly cited articles, the geographic distribution of research, and financing sources and how they affect research objectives. The understanding of the area could also be improved by examining how research themes change over time, investigating authorship networks and collaboration patterns, and evaluating how publications affect practice and policy. Researchers can benefit significantly from these analyses, which help shape future research projects and publication plans in the earth and planetary sciences. Table 1 shows the research sources.

Table 1. Research sources

Research	Journal Articles	Issue Categories	Publisher	Number of Publications	Participation Percentages
(Jiang et al., 2014)	Rocky desertification in Southwest China: Impacts, causes, and restoration	General Earth and Planetary Sciences	Elsevier	757	17%
Manfreda et al., 2018)	On the use of unmanned aerial systems for environmental monitoring	Water Resources Research	Wiley-Blackwell	628	14%
(Taylor & Owens, 2009)	Sediments in urban river basins: A review of sediment–contaminant dynamics in an environmental system conditioned by human activities	Agricultural and Biological Sciences: Soil Science	Copernicus	469	11%
(Fuller et al., 2022)	Pollution and health: A progress update	The Lancet Planetary Health	Elsevier	458	10%
(Van Nguyen & Ferrero, 2006)	Meeting the challenges of global rice production	Water (Switzerland)	Elsevier	398	9%
(Chen et al., 2015)	Assessmentof past, presentand futureenvironmentalchangeson the Tibetan Plateau	Multidisciplinary	Science China Press	383	9%
(Chan et al., 2018)	“Sponge City” in China—A breakthrough of planning and flood risk management in the urban context	Land Use Policy	Elsevier	330	7%
(Lawrence et al., 2016)	The Land Use Model Intercomparison Project (LUMIP) contribution to CMIP6: Rationale and experimental design	Geoscientific Model Development	Copernicus	287	7%
(Nguyen et al., 2019)	Implementation of a specific urban water management-Sponge City	Science of the Total Environment	Elsevier	251	6%
(Mardani et al., 2017)	A review of multi-criteria decision-making applications to solve energy management problems: Two decades from 1995 to 2015	Renewable and Sustainable Energy Reviews	Elsevier	250	6%
(DeNicola et al., 2015)	Climate change and water scarcity: The case of Saudi Arabia	Annals of Global Health	Levy Library Press	196	4%

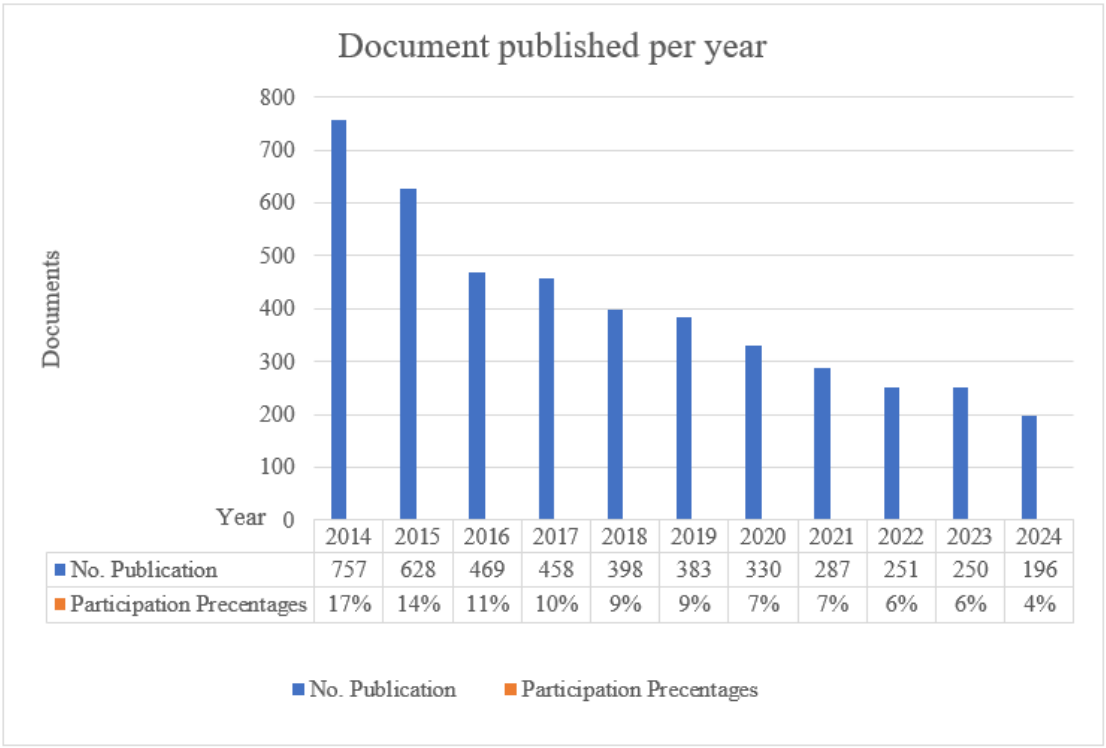

Figure 3. Journals with at least ten published articles

4.3 The Highest Subject Area on Climate Change-Related Global Water Issues

Table 2 shows the analyzed research sources and thoroughly examines research publications from 2014 to 2024, including various topic areas. It emphasizes the relative contributions of each field to the corpus of knowledge as a whole and offers insightful information about how scholarly output is distributed across fields. Among all topic areas, environmental science has the most papers (1,002 publications), accounting for a substantial 29% of all publications. This shows how environmental issues are becoming increasingly important and how long-term solutions to global crises like pollution, resource depletion, and climate change are sought (Levin et al., 2024). The second-ranked field, social sciences, includes academic areas such as political science, anthropology, and sociology, with 428 publications, or 12% of the total. This demonstrates the value of the social sciences in comprehending and resolving complicated societal concerns, nuanced community dynamics, and human behaviors.

With 392 articles and a total of 11%, earth and planetary sciences, which studies the planet and its place in the cosmos, comes in second. The knowledge of Earth's natural resources, geological processes, and complex interactions with nearby celestial planets has greatly benefited from this discipline. With 378 papers, agricultural and biological sciences comprise about 11% of the total. It is an important field that includes agriculture, related fields, and the biology of plants and animals. This highlights these sectors' significance for advancing biotechnology, tackling the problem of global food security, and fostering environmentally friendly agricultural methods. Three hundred papers, or 9% of the total, come from diverse engineering disciplines, which propel technical innovation and problem-solving. Biochemistry, genetics, and molecular biology (106 articles, 3%), computer science (91 publications, 3%), energy (168 publications, 5%), and medicine (125 publications, 4%) are a few additional notable disciplines of study. These fields are at the forefront of scientific inquiry, significantly contributing to biotechnology, IT, healthcare, and renewable energy advances.

It is significant to note that the table encompasses a broad range of subject areas, from more recent, interdisciplinary fields like decision sciences (24 publications, 1%), multidisciplinary fields, and emerging fields to established academic fields like mathematics (32 publications, 1%) and arts and humanities (30 publications, 1%). This diversity reflects the depth and range of scholarly research and the growing significance of interdisciplinary teamwork in tackling complex global issues. Table 2 shows the percentage of full publications for each subject area and the total number of publications. This statistic facilitates additional analysis and comparisons by providing insightful information about the relative progress and completion rates of research projects within each discipline. This extensive table is a valuable tool for scholars, decision-makers, and interested parties, offering a thorough picture of how academic production is distributed throughout different fields. It can guide resource allocation, collaborative efforts inside and across disciplines, and strategic decision-making, eventually advancing knowledge and advancing research for answers to global concerns.

Table 2. Subject categories of research papers using the bibliometric analysis approach (2014-2024)

Subject Area	Total Publications (TP)	Percentage of Complete Publications (%TP)
Environmental science	1002	29%
Social sciences	428	12%
Earth and planetary sciences	392	11%
Agricultural and biological sciences	378	11%
Engineering	300	9%
Energy	168	5%
Medicine	125	4%
Biochemistry, genetics and molecular biology	106	3%
Computer science	91	3%
Business, management and accounting	78	2%
Economics, econometrics, and finance	61	2%
Physics and astronomy	38	1%
Multidisciplinary	34	1%
Mathematics	32	1%
Arts and humanities	30	1%
Chemical engineering	29	1%
Materials science	29	1%
Chemistry	26	1%
Decision sciences	24	1%
Immunology and microbiology	18	1%
Pharmacology, toxicology and pharmaceutics	9	1%
Psychology	9	1%
Veterinary	7	1%
Health professions	6	1%
Neuroscience	5	1%
Nursing	5	1%

This analysis in Table 2 above offers valuable insights into the distribution of scholarly output across various disciplines, highlighting the interdisciplinary nature of climate change research. With the comparative analysis, existing theories, and practices, the findings align with the growing recognition of climate change as a complex, multifaceted issue requiring input from diverse fields. A precise percentage distribution offers a data-driven perspective on the relative engagement of different fields in climate change research. This approach allows for a keener understanding of interdisciplinary efforts and can help identify areas where collaboration may have unexpected connections. Future studies could delve deeper into the qualitative aspects of these publications, examining the specific topics, methodologies, and impacts within each discipline. This could reveal emerging trends or gaps in the research landscape. A longitudinal analysis comparing these findings to earlier periods could illuminate how the focus of climate change research has evolved, potentially identifying shifts in priorities or approaches. Examining the level of cooperation between these different fields of study may shed light on how well interdisciplinary approaches work to solve climate change issues. Examining how research outputs are distributed geographically may help identify places with an underrepresentation of categories of climate change research and highlight regional variations in research focus. Finally, examining the impact factors and citation patterns of publications across these disciplines could help assess the relative influence and reach of different fields in shaping climate change discourse and policy.

4.4 Titles of the Source Journals

Table 3 shows the data in the journal titles, years, citations, and document titles. This explanation gives an overview of climate change related to water issues in the world. First, this research study looks at the paper's column, which lists journal article titles or subjects about climate change and its effects on water resources. In Table 3, the opening entry "Water Switzerland" suggests that the following piece probably examines the problems with water and the effects of climate change in the context of Switzerland and the world at large. Next, the studies under "Sustainability Switzerland" indicate that this piece explores sustainability issues more broadly, including environmental, economic, and social aspects, emphasizing Switzerland. "Science of the Total Environment," another significant entry in the paper's column, alludes to an extensive investigation into the intricate interactions among water systems, climate change, and the ecosystem.

In addition, the column features headings like "Journal of Environmental Management" and "IOP Conference Series Earth and Environmental Science," which direct readers to articles that present research findings or

discussions from conferences or journals devoted to environmental sciences and management techniques. Articles that examine the relationship between ecological difficulties, such as climate change and water-related challenges, and public health concerns are identified by titles such as "Frontiers in Environmental Science" and "International Journal of Environmental Research and Public Health." The "Journal of Hydrology" item proposes a particular focus article on the hydrological elements of climate change, looking at how it affects rivers, water cycles, groundwater systems, and other related phenomena.

In addition, the research in journals with titles like "Environmental Research Letters" and "Journal of Cleaner Production" probably explores environmental research and cleaner production tactics meant to lessen the adverse effects of climate change on water resources and encourage sustainable practices. Finally, the paper "Environmental Science and Policy" suggests a piece that bridges the knowledge gap between science and policymaking, providing insights into creating successful plans and policies to deal with water-related issues brought on by climate change. The journal title column includes various publications from different fields, such as hydrology, public health, sustainability, environmental science, water science and technology, and cleaner production. This diversity highlights how interdisciplinary climate change and water concerns require input from various academic disciplines.

It should be explicitly stated in Table 3, as usually, the "citations" column provides a quantitative measure of how frequently each article has been cited or referenced in subsequent scholarly works. An article's effect and influence within the educational community are typically indicated by the number of citations it receives. A higher citation count suggests that the article's conclusions or insights have been widely acknowledged and expanded upon by later studies. Last, the year's column covers a sizable time frame, including publications from the previous ten years and into the future. Examining trends and advancements in water and climate change research during this period offers a thorough grasp of how the subject has changed and shows possible future possibilities. This table provides a broad overview of the academic discourse surrounding water and climate change issues. However, a deeper analysis of the individual articles and their specific findings would be required to fully understand the nuances and contributions of each study to the larger field of research.

As shown in Figure 4, the water resource and climate change research field underwent significant changes from 2014 to 2024, which can be illuminated by the bibliometric analysis. Combining several research streams from several disciplines, it innovates by giving a thorough picture of the field's evolution over ten years. The study makes a substantial contribution by highlighting the most influential works and disclosing patterns in research focus and publication frequency. Subsequent investigations could probe more into the content analysis of highly cited articles, broaden the bibliometric study's purview, analyze the geographic distribution of research, investigate financing sources, and investigate collaborative networks. These methods would improve the comprehension of the central concepts, techniques, and driving forces influencing the discipline. The data shows how concerns about water resources and climate change are being more integrated into larger frameworks for sustainability, indicating a greater understanding of the intricate, multidisciplinary nature of these problems. This pattern points to a move toward more all-encompassing strategies for tackling the effects of climate change on water. This publication is helpful for academics and policymakers navigating the quickly changing topic of climate change and water resources because it offers an overview of the most critical research. It lays the groundwork for more focused study and well-informed choices in this crucial environmental science and policy field.

Table 3. The top 10 research articles in terms of citation counts (2014-2024)

Documents	Journal Title	Citations	Year
Water Switzerland	Water Science and Technology	120	2014
Sustainability Switzerland	Sustainability and the Environment	80	2015
Science of the Total Environment	Environmental Science	72	2016
IOP Conference Series Earth and Environmental Science	General Environmental Science	38	2017
Journal of Environmental Management	Waste Management and Disposal	37	2018
Frontiers in Environmental Science	Environmental Science: General Environmental Science	35	2019
International Journal of Environmental Research and Public Health	Medicine: Public Health, Environmental, and Occupational Health	28	2020
Journal of Hydrology	Environmental Science: Water Science and Technology	26	2021
Environmental Research Letters	Environmental Science	28	2022
Journal of Cleaner Production	Social Sciences for Development	25	2023
Environmental Science and Policy	Environmental Science: Management, Monitoring, Policy, and Law	28	2024

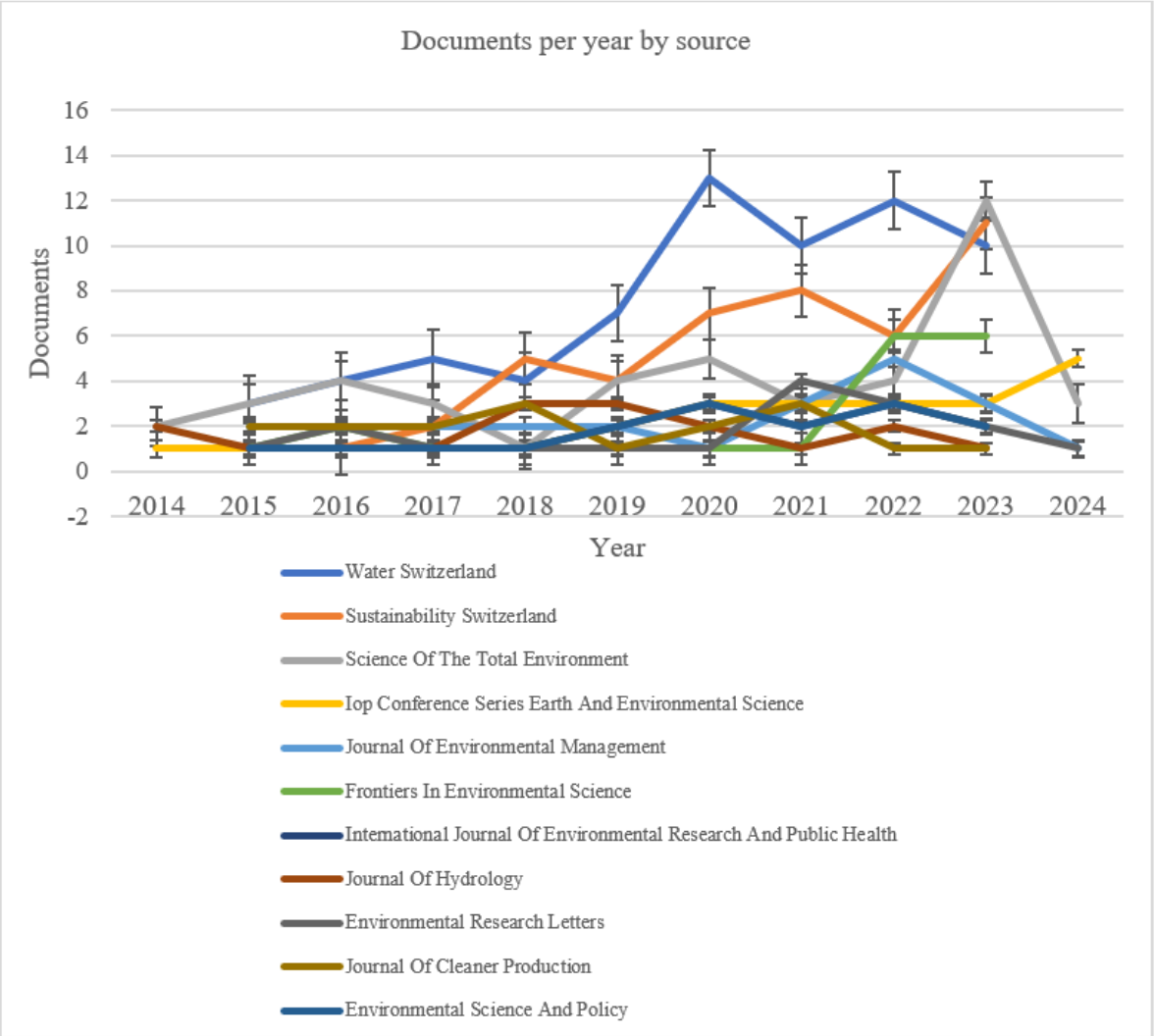

Figure 4. Top source titles for articles on bibliometric research (2014-2024)

4.5 Top Authors/Researchers

With an emphasis on water-related concerns, Table 4 and Figure 5 provide information about the leading authors and researchers in climate change studies. These components are necessary to comprehend the influential studies and viewpoints influencing the debate and comprehension of this critical subject. The issue of climate change is intricate and diverse, affecting many facets of the globe, including water systems, and carrying significant implications (Shah et al., 2023). Water is an essential resource that keeps life alive, and climate change's effects significantly impact its distribution, quality, and availability. Comprehending these complex interrelationships is crucial in formulating efficacious approaches to alleviate and adjust to the obstacles presented by evolving climate change. The prominent writers and researchers who, via their published works, have significantly advanced this field are highlighted in Table 4. It lists their quantities of documents, citations, and a metric called "total strength," which is probably a composite indicator of their effect and influence on the scientific community. Table 4, which includes a list of the authors' home nations, also sheds light on the geographical diversity of these writers. Nicolle Rutherford, Mary Ann Rempel-Hester, Courtney Arthur, and Alan J. Mearns all get the highest total strength score of 15, indicating their broad awareness and significant impact. Even though they are from various nations, Australia and the United States, respectively, their combined efforts have improved the understanding of how water supplies are affected by climate change.

Lei Li from the United Kingdom, Ayoub Sharifi from the United States, Jun Xia from China, S. Ahmad from India, M.N. Azra from France, and M.S. Babel from Spain are among the other well-known writers in Table 4. Their varied experiences and viewpoints highlight how global this issue is and how successful collaboration can be in finding a solution. The top 10 authors and their corresponding countries of origin are graphically shown in Figure 5, which enhances Table 4 as well. The global breadth and relevance of these renowned scholars' work are

highlighted by this graphical representation, which makes it easier to appreciate their regional dispersion. By looking at the contributions made by these writers and the nations they represent, researchers may learn more about the significant figures influencing this critical field of research and information transfer. To maintain resilience and sustainability in these difficulties, their combined efforts have illuminated the complex links between climate change and water systems, influencing policy decisions, mitigation initiatives, and adaptation measures.

Furthermore, the range of viewpoints and methodologies these writers represent highlights how interdisciplinary climate change research is. Considering climate change, tackling water-related issues requires a thorough comprehension that transcends conventional discipline boundaries (Etchebarne et al., 2023). Knowledge from several disciplines, such as environmental science, hydrology, climatology, and social sciences, should be integrated into this understanding. But Table 4 and Figure 5 are a potent reminder of the global research community's combined efforts to improve the understanding of the complex interactions between water systems and climate change. The amount and breadth of knowledge generated can be better appreciated by recognizing and comprehending the contributions of these eminent authors. Researchers can then use this knowledge to build practical solutions for protecting water resources in a fast-changing environment (Huang et al., 2023).

Table 4. Top 10 authors with their countries

Author	Documents	Citations	Total Strength	Countries
Arthur, Courtney	5	77	15	Italy
Mearns, Alan J.	5	77	15	Australia
Rempel-Hester, Mary Ann	5	77	15	Canada
Rutherford, Nicolle	5	77	15	Germany
Li, Lei	5	90	12	United Kingdom
Sharifi, Ayyoob	6	183	10	United States
Xia, Jun	6	107	8	China
Ahmad, S.	3	78	9	India
Azra, M.N.	3	56	11	France
Babel, M.S.	3	85	10	Spain

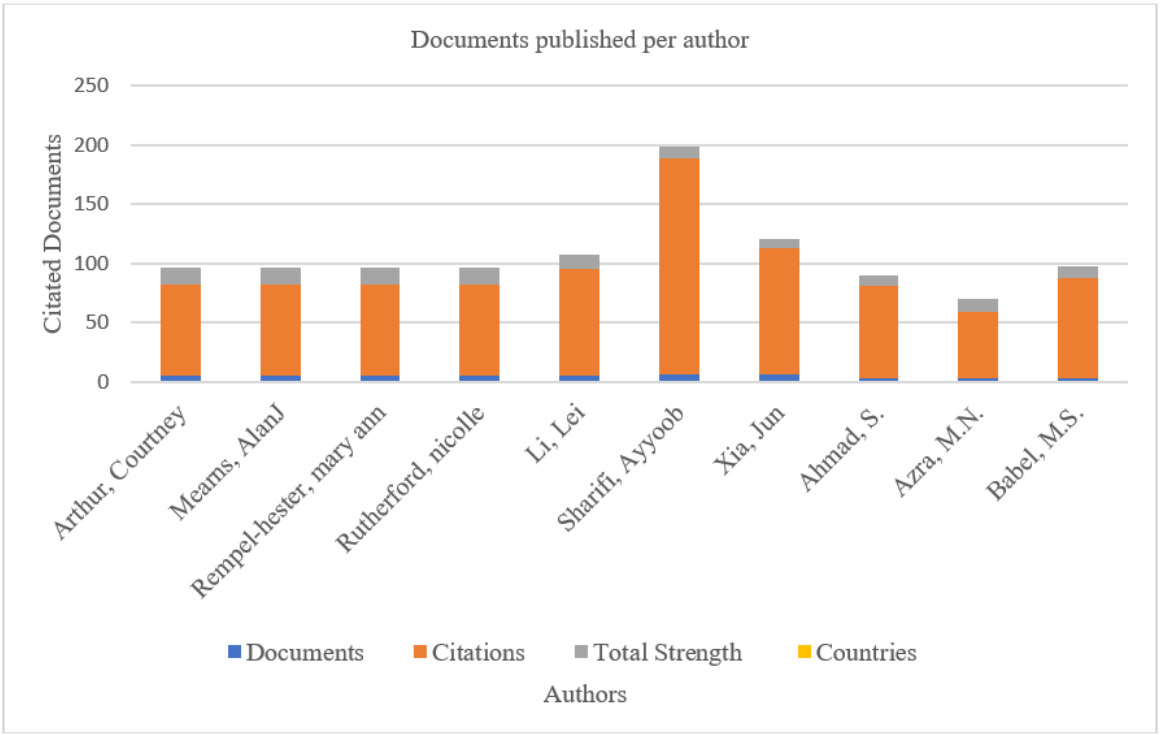

Figure 5. Top 10 authors with published documents per country

Table 4 provides valuable insights into the leading authors and researchers in climate change studies, mainly focusing on water-related issues. It introduces a novel "total strength" metric to evaluate author impact, offering a potentially more nuanced view than traditional bibliometric measures. The analysis emphasizes how multidisciplinary and international climate change research is and how important it is to have a variety of viewpoints when tackling complex environmental problems. The primary contributions of the study comprise an

extensive synopsis of the leading writers, their geographic dispersion, and the multidisciplinary character of their output. Finding important roles and possible partners in the field requires this knowledge. To build on this foundation, future research could explore temporal trends in authorship, conduct network analyses of collaborations, perform thematic analyses of research topics, assess real-world policy impacts, investigate interdisciplinary integration, and examine funding patterns. These directions would further enhance researchers' understanding of the dynamics and influential factors in climate change research on water systems, ultimately contributing to more effective strategies for addressing this global challenge.

4.6 Current Affiliations Shown in Most of the Research

Table 5 and Figure 6 present that most of the research shows current affiliations and thoroughly summarize the affiliations currently engaged in water and climate change research. The table lists the eminent organizations, academic institutions, and governmental bodies contributing to this study area. It also lists the quantity of documents (research papers, reports, etc.) linked to each affiliation and the proportion of each group's involvement that it has contributed. With 84 contributions and a 15% participation rate, the Chinese Academy of Sciences is the most active affiliate, demonstrating its significant role in water and climate change research. With 32 documents and a 6% participation rate, the CNRS Centre National de la Recherche Scientifique is well-known in this sector. The Ministry of Education of the People's Republic of China and the University of Chinese Academy of Sciences provide significant contributions, with 22 and 27 documents and participation rates of 4% and 5%, respectively.

Table 5. Current affiliations shown in most of the research

Affiliations	Documents	Participation Percentage
Chinese Academy of Sciences	84	15%
CNRS Centre National de la Recherche Scientifique	32	6%
University of the Chinese Academy of Sciences	27	5%
Ministry of Education of the People's Republic of China	22	4%
Universidade de São Paulo	18	3%
Consiglio Nazionale delle Ricerche	17	3%
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences	17	3%
INRAE	17	3%
Wageningen University & Research	16	3%
ETH Zürich	16	3%
University of Melbourne	16	3%
Griffith University	16	3%
UNSW Sydney	15	3%
IRD Institut de Recherche pour le Developpement	15	3%
National Oceanic and Atmospheric Administration	14	2%
University of Waterloo	13	2%
Delft University of Technology	12	2%
University of Leeds	12	2%
Beijing Normal University	12	2%
Aarhus Universitet	12	2%
United States Geological Survey	11	2%
University of Florida	11	2%
University of California, Davis	11	2%
University of Washington	11	2%
Commonwealth Scientific and Industrial Research Organisation	11	2%
CIRAD	11	2%
Sapienza Università di Roma	11	2%
Xinjiang Institute of Ecology and Geography Chinese Academy of Sciences	11	2%
Northwest Institute of Eco-Environment and Resources	11	2%
Environment and Climate Change Canada	10	2%
Consejo Superior de Investigaciones Científicas	10	2%
University of KwaZulu-Natal	10	2%
University of Tehran	10	2%
The University of Tokyo	10	2%
University of Exeter	10	2%
European Commission Joint Research Centre	10	2%

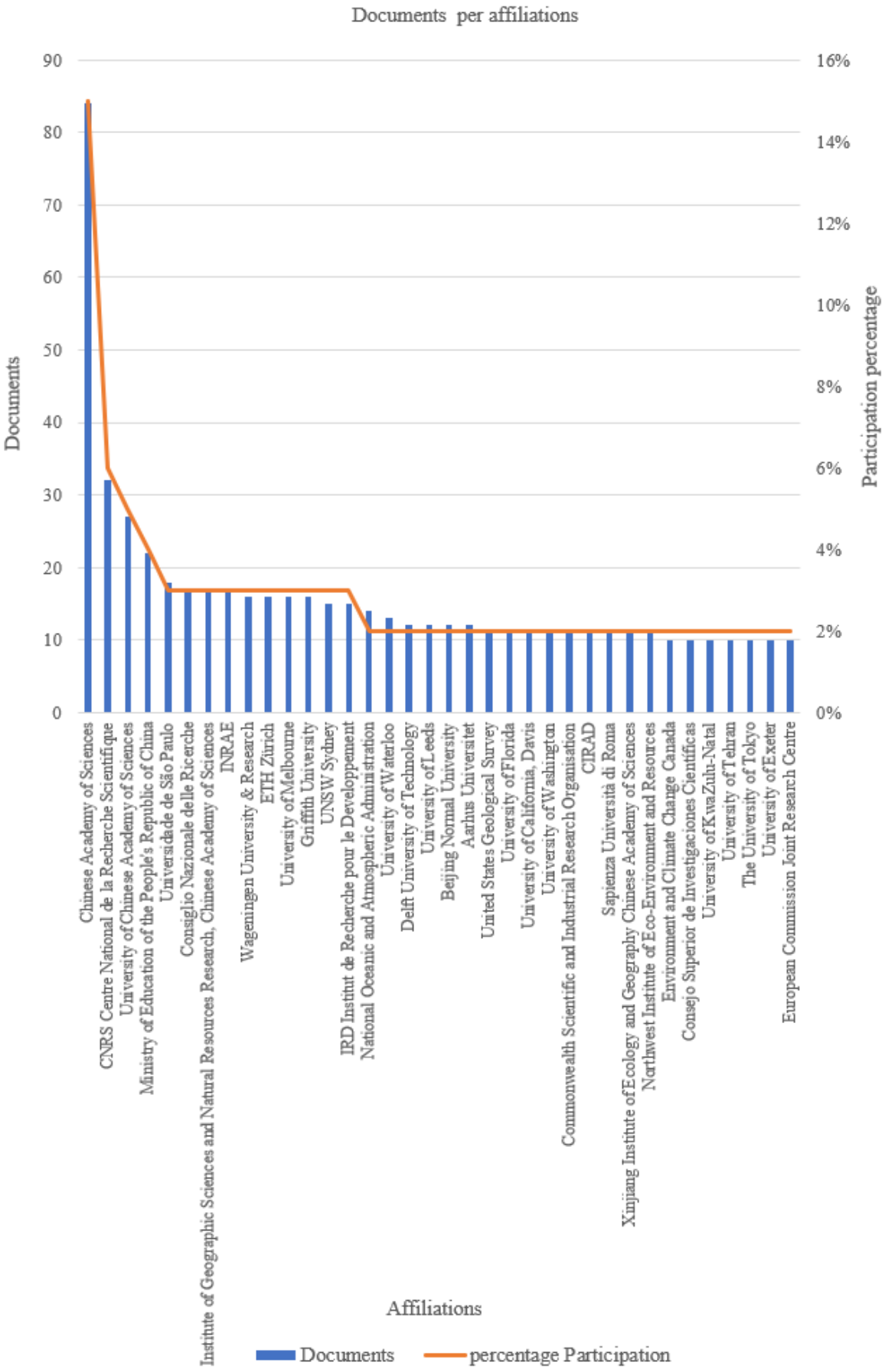

Figure 6. Histogram of current affiliations shown in most of the research

Well-known organizations, such as ETH Zürich, Wageningen University & Research, Consiglio Nazionale dell Recherche, Universiade de São Paulo, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, INRAE, and INRAE, have all contributed significantly, with an average of 16-18 documents per affiliation and a participation rate of 3%. The National Oceanic and Atmospheric Administration, Griffith University, UNSW Sydney, University of Melbourne, and IRD Institut de Recherche pour le Development contributed about 15 documents, with participation rates ranging from 2% to 3%. Each of these groups has contributed significantly to the process. Other notable organizations include the United States Geological Survey, University of Florida, University of California, Davis, University of Washington, Commonwealth Scientific and Industrial Research Organization, Xinjiang Institute of Ecology and Geography (Chinese Academy of Sciences), University of Waterloo, Delft University of Technology, University of Leeds, Beijing Normal University, Aarhus Universiteit, CIRAD, Sapienza Universität di Roma, and Northwest Institute of Eco-Environment and Resources. With a participation rate of 2%, each of these institutions has supplied between 10 and 13 documents. Many affiliations, including prestigious research institutions, universities, and government agencies from different countries, have actively contributed to studying climate change and its impact on water resources. Their level of participation and document contributions reflect their respective areas of expertise and research focus.

As shown in Figure 6, this research comprehensively analyzes institutional contributions to water and climate change studies, revealing the global landscape of scientific efforts in this crucial field. It highlights the dominance of Chinese institutions, notably the Chinese Academy of Sciences while showcasing significant contributions from European and North American organizations. The study's innovative approach combines document counts with participation percentages, providing a nuanced view of institutional engagement beyond mere publication numbers. The findings underscore the international and multidisciplinary nature of climate change research, reflecting the complexity of the issues. By including a diverse range of institutions from various countries, the study contributes to a more holistic understanding of global research capacities and potential areas for collaboration. To build on this foundation, future research could explore temporal trends in institutional contributions, analyze collaboration networks, investigate thematic specializations, assess policy impacts, and examine the relationship between research output and factors such as funding or regional climate vulnerabilities. Such efforts would further enrich the understanding of the dynamic landscape of climate change research and inform more effective global strategies to address environmental challenges.

4.7 Leading Research Nations

Table 6 and Figure 7 illuminate the global phenomena of research projects that aim to solve the profound mysteries entwined with climate change and water, the essential element that sustains the planet. The "documents" column shows the unwavering commitment of scholars from many different countries. The "citations" column, however, reveals the depth of influence, as it is through the respectful citations of colleagues that the actual value of these works is consecrated. The "total link strength" is a measure that shows the complex web of interconnection that ties this field together. It reveals the intricate channels through which knowledge travels, highlighting the hub of intellectual activity and elevating the countries whose contributions impact the state of science worldwide.

With its massive research output and the echoing effects of its impact, the United States, a towering colossus atop this realm, casts a huge shadow. It is not, however, alone in its heroic watch; countries such as China, the United Kingdom, and Germany remain shining examples, their scholarly output radiating importance throughout the scientific universe. This magnificent tableau is more than just a collection of the past's most significant moments; it is a call to reflect on the work's immense relevance to the future. Hidden within are priceless revelations, lights to guide explorers as they forge ahead into the unexplored waters of climate change's unstoppable march. This examination provides invaluable wisdom by exposing the geniuses contributing to the current understanding of climate change. This allows researchers to collaborate effectively and capitalize on the combined creativity of the world's most brilliant brains. Furthermore, this study reveals that the areas in which the desire for knowledge still needs to be satisfied force researchers to go forth and plant new branches of research, guaranteeing that every detail is noticed in the unrelenting search for the truth.

Perhaps most importantly, this opus clarifies the fundamental threads that tie the scientific community together, the complex networks that allow information to spread, nourish receptive minds and inspire the exploration of new horizons. Following these paths gives us access to a priceless compass that can be used to build symbiotic partnerships, promote intellectual exchange, and construct knowledge structures that cut across the boundaries of any one country or field. This piece illuminates the path forward as the effects of climate change on essential water resources loom progressively larger. It is a clear call to action for scholars, decision-makers, and anyone who would protect the source of life to come together and form a grand covenant strengthened by the combined knowledge of all nations and driven by a common goal of resilience in the face of unchangeable climate change solutions. The researchers can only hope to weave a masterpiece in climate change and water resource management. In this world, the delicate balance between climate and water is preserved, and the fragile threads that sustain all life remain eternally unbroken thanks to such a concerted effort guided by the lessons learned from this exquisite

tapestry of climate change (Rheinheimer et al., 2023). Figure 8 shows the leading research nations in network visualization.

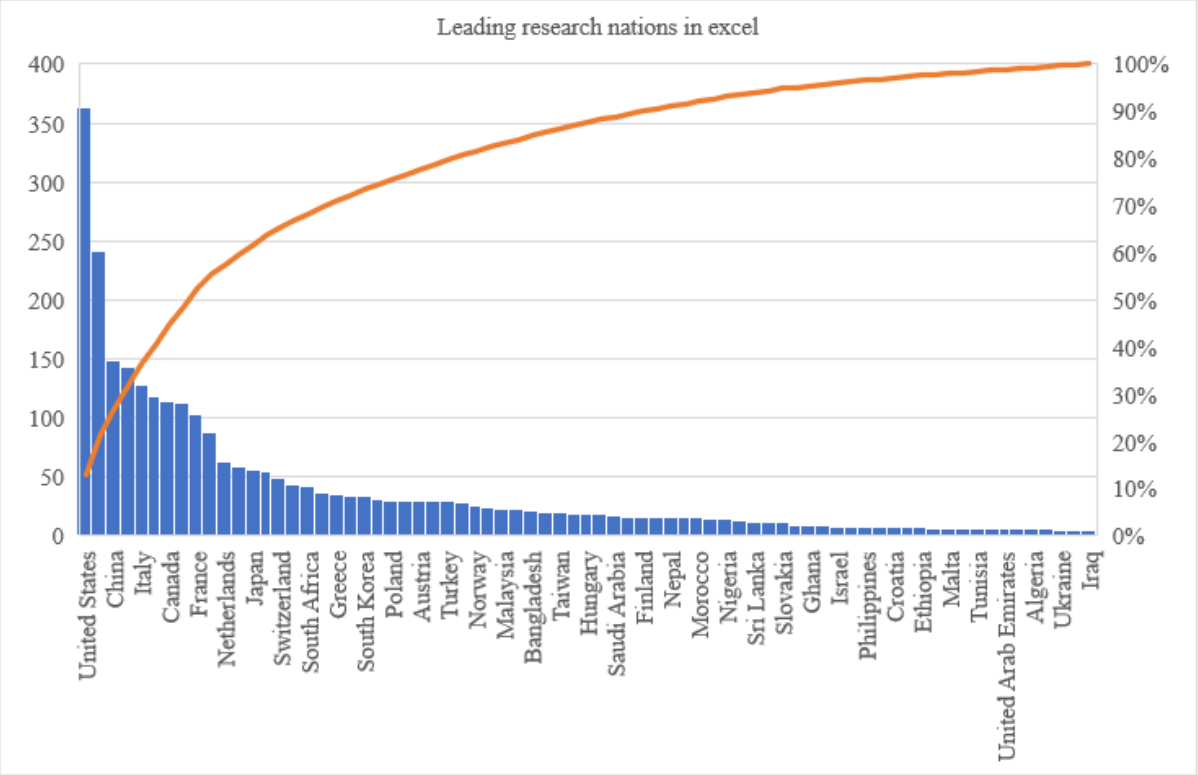

Figure 7. Leading research nations on climate change-related global water issues in excel

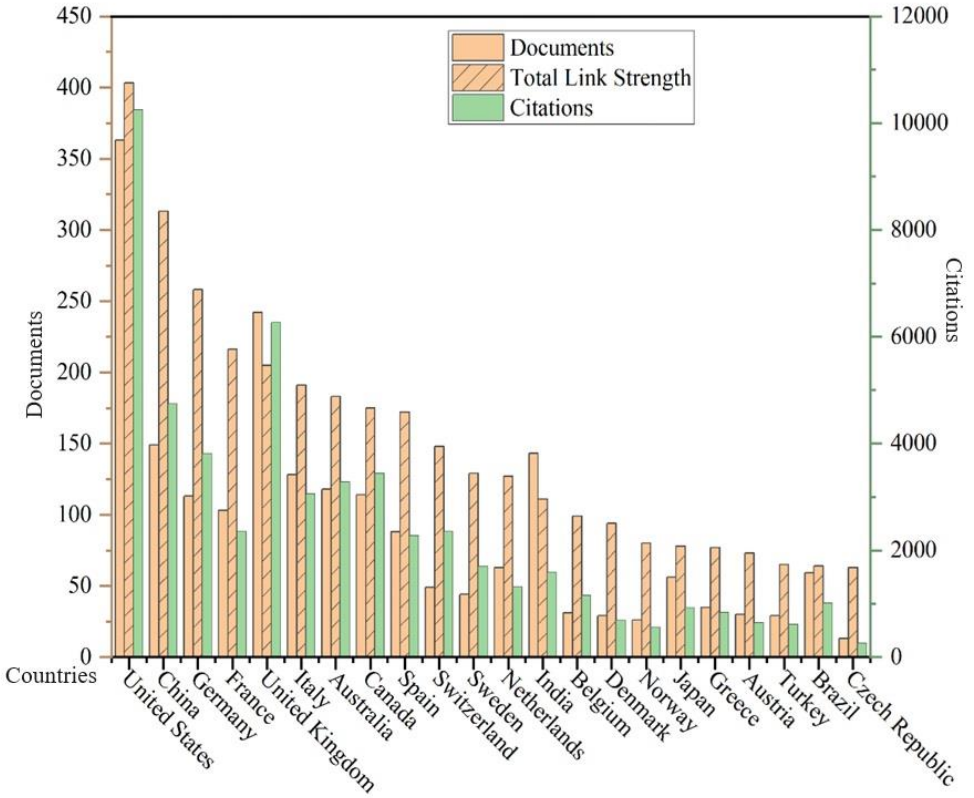

Figure 8. Leading research nations in network visualization

Table 6. Leading research nations

Countries	Documents	Citations	Total Link Strength
United States	363	10250	403
United Kingdom	149	4746	313
Germany	113	3816	258
France	103	2350	216
China	242	6264	205
Italy	128	3054	191
Australia	118	3276	183
Canada	114	3443	175
Spain	88	2278	172
Switzerland	49	2352	148
Sweden	44	1705	129
Netherlands	63	1308	127
India	143	1583	111
Belgium	31	1153	99
Denmark	29	687	94
Norway	26	559	80
Japan	56	927	78
Greece	35	837	77
Austria	30	646	73
Turkey	29	613	65
Brazil	59	1013	64
Czech Republic	13	266	63
Portugal	30	562	62
Mexico	24	786	60
South Africa	42	430	53
Romania	14	257	43
Pakistan	33	378	42
Russian Federation	28	397	42
Iran	54	455	40
Malaysia	23	484	40
Kenya	15	231	38
South Korea	33	229	34
Egypt	20	348	33
Finland	16	277	33
Israel	8	243	33
New Zealand	16	640	33
Poland	30	449	33
Bangladesh	21	341	26
Indonesia	37	194	26
Saudi Arabia	17	381	25
Ukraine	5	194	26
Viet Nam	22	309	25
Serbia	9	38	24
Slovakia	11	35	22
Thailand	19	258	21
Ireland	12	39	20
Malta	6	35	20
Sri Lanka	12	135	19
Chile	19	110	18
Hungary	19	488	18
Nigeria	14	467	18
Philippines	7	455	18
Zimbabwe	6	76	18
Hong Kong	15	171	16
Nepal	15	206	16
Morocco	15	120	15
Peru	6	106	12
Argentina	7	41	11
Colombia	8	170	11
Croatia	7	98	11
Ecuador	7	139	11
Tunisia	6	71	9
Ethiopia	7	132	8
Ghana	9	115	8

Taiwan	20	218	8
Jordan	6	77	7
Singapore	9	263	7
Uganda	6	7	5
United Arab Emirates	6	20	5
Algeria	6	53	4
Iraq	5	29	3
Kazakhstan	5	65	3
Bulgaria	6	2	3

4.8 Leading Funding Organizations

For upcoming resilience research, this study thoroughly describes the funding agencies and papers about climate change and water-related concerns. Global funding organizations are interested in improving resilience to climate change's consequences, particularly in water-related issues (Porębska et al., 2023). The funding of studies to increase understanding and develop strategies for lessening and mitigating the effects of climate change depends heavily on these organizations. The National Natural Science Foundation of China (NSFC) leads this study and has supported 105 publications on climate change. Because of its dedication to furthering science, the NSFC is positioned to significantly contribute to climate change resilience, particularly regarding water-related issues. The National Science Foundation (NSF) is closely trailing in the United States, having provided funding for 49 publications. Through its research grants, this prestigious organization fosters creative solutions in response to the pressing need to address the effects of climate change on ecosystems and water supplies. The European Commission and its Horizon 2020 Framework Program have also made significant contributions, which have financed 33 and 43 documents, respectively. These actions demonstrate how committed the European Union is to solving environmental challenges worldwide, particularly climate change's effects on water systems.

Table 7. The most funding organizations

Funding Sponsors or Organizations	Documents
NSFC	105
NSF	49
European Commission	43
Horizon 2020 Framework Programme	33
National Key Research and Development Program of China	27
Chinese Academy of Sciences	23
Natural Sciences and Engineering Research Council of Canada	20
Seventh Framework Programme	20
CNPq	19
Fundação para a Ciência e a Tecnologia	17
BMBF	15
CAPES	15
NASA	15
DFG	14
Horizon 2020	14
European Regional Development Fund	13
JSPS	13
NOAA	13
NERC	13
National Research Foundation of Korea	12
Ministry of Science and Technology of the People's Republic of China	11
FAPESP	10
U.S. Department of Energy	10
U.S. Environmental Protection Agency	10
Fundamental Research Funds for the Central Universities	9
Ministerio de Economía y Competitividad	9
Ministry of Science and Technology, Taiwan	9

China's National Key Research and Development Program has assisted with 27 documents demonstrating the country's dedication to creating resilient plans to address water-related difficulties brought on by climate change. Comparably, the funding of 23 publications by the Chinese Academy of Sciences shows how the country is tackling this critical problem in many ways. The Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) emphasizes the importance of this topic in South American and Iberian contexts. Three organizations have shown their dedication to advancing climate adaptation research: Germany's Bunde ministerium für Bildung und Forschung (BMBF), Brazil's Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), and the

United States National Aeronautics and Space Administration (NASA) have all contributed 15 documents. Table 7 shows the most funding organizations. Figure 9 shows the number of documents funded per organization.

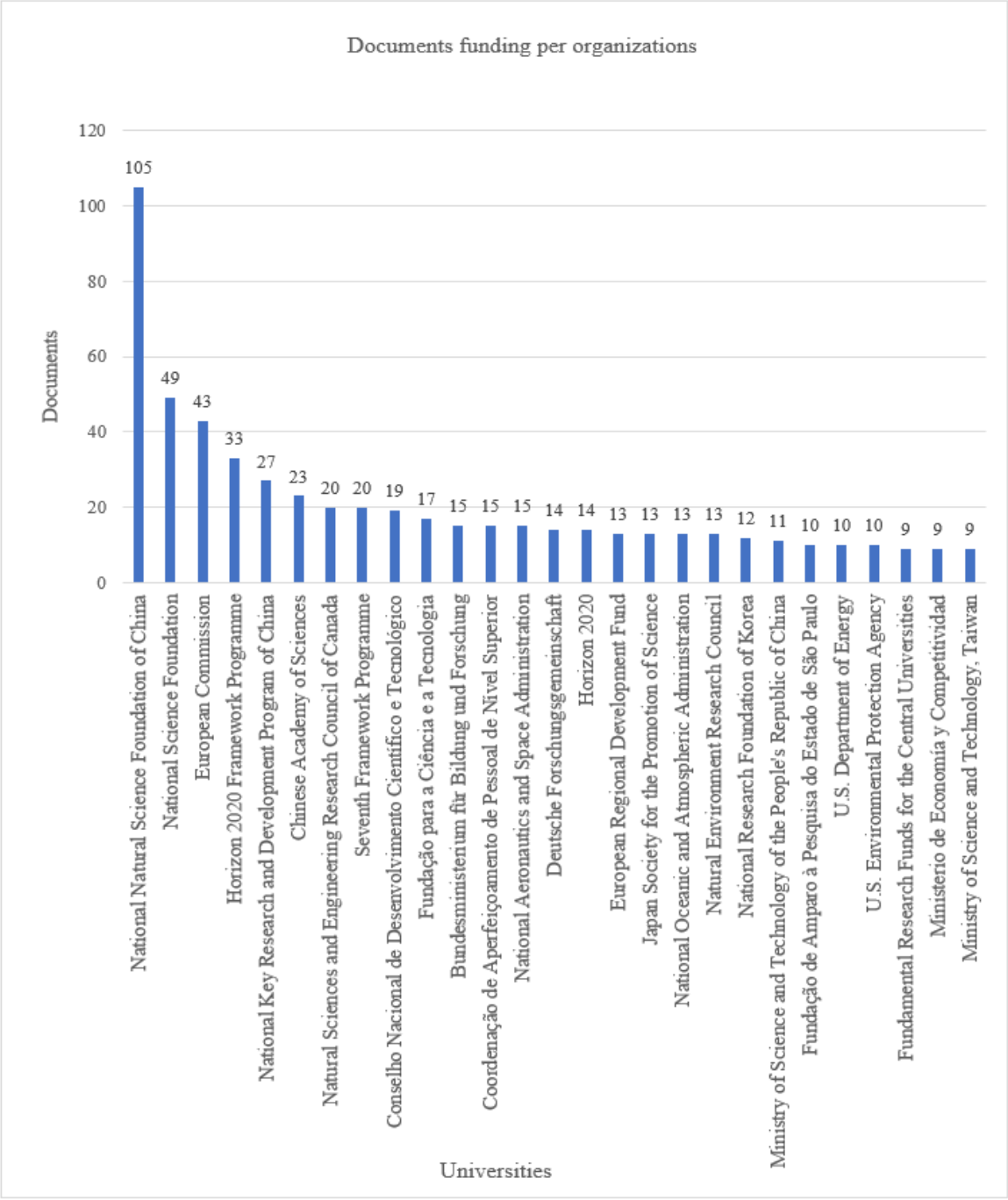

Figure 9. Number of documents funded per organization

Europe continues to be a leader in this field, as seen in Figure 9. The Horizon 2020 project and the Deutsche Forschung Gemeinschaft (DFG) in Germany have given assistance to 14 documents. The European Regional Development Fund has also made significant contributions by financing 13 publications to enhance climate resilience. Thirteen papers from the United States National Oceanic and Atmospheric Administration (NOAA), Japan's Japan Society for the Promotion of Science (JSPS), and the United Kingdom's Natural Environment Research Council (NERC) emphasize the issue's global reach and the requirement for collaboration to find a solution. The Korean National Research Foundation has funded 12 papers, indicating the country's commitment to researching climate resilience, particularly water-related issues. Eleven documents have been invested by the People's Republic of China's Ministry of Science and Technology; ten by the Brazilian Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP); ten by the United States Department of Energy; ten by the United

States Environmental Protection Agency; nine by China, nine by Spain's Ministerio de Economía y Competitive; this is just one of the additional noteworthy authors.

The broad spectrum of financing organizations and their contributions to climate change resilience, especially regarding water issues, highlights how seriously this critical challenge is being taken worldwide. These organizations' combined efforts support creative research, worldwide cooperation, knowledge exchange, and the creation of all-encompassing plans to improve the authors' readiness for the effects of climate change and the consequences of global warming. Globally, the impact of climate change is getting worse, and these funding organizations' continued support can be crucial to advancing scientific knowledge, guiding policy decisions, and ultimately safeguarding water supplies and ecosystem resilience for coming generations (Slayi et al., 2023). Researchers and policymakers can collaborate to develop practical solutions that support sustainable water management practices and improve the capacity to respond to the challenges posed by a rapidly changing global climate, utilizing these organizations' knowledge and resources (Yusoff et al., 2023).

4.9 Co-Occurrence Analysis of Keywords

For future research on resilience to climate change, this study undoubtedly explains it in excellent order without leaving out the keyword occurrences, number of occurrences, or total strength. The different colors in Figure 10 show the highest to the lowest documents regarding climate change related to water issues. The findings of a co-occurrence analysis of keywords linked to water and climate change issues are shown in Table 8 and accompanying Figure 10. The term with the highest overall strength is "climate change," indicating that it plays a significant part in the examined documents. This keyword dominates the analysis, highlighting climate change's importance in water-related research and upcoming resilience studies. The term "article," which comes next, implies that scholarly articles or publications were used for the analysis. This emphasizes how scholarly and research-focused these research papers are. To face the difficulties posed by climate change and ensure water security, the keyword "water management" maintains a prominent place, highlighting the significance of appropriate water management practices. With a high total strength, the term "human" indicates that human components and effects are considered when discussing climate change and water management. This term includes problems with communities, human populations, and the socioeconomic aspects of water-related problems. Both "water supply" and "water quality" rank highly, which indicates worries about access to and availability of water and the possible consequences of climate change on water quality. These terms are essential for comprehending the potential effects on water supplies and creating resilience plans (Slayi et al., 2023).

Other popular search terms include "sustainable development," "humans," "nonhuman," "environmental impact," "water resources," "water," "risk assessment," "environmental monitoring," "priority journal," "water pollution," "ecosystem," "groundwater," "sustainability," "rivers," "drought," "land use," "agriculture," "climate effect," "water conservation," "biodiversity," "water availability," as well as "rain." These keywords cover many topics, including sustainable land use practices, groundwater management, ecosystem health, environmental monitoring, and the effects of climate change on biodiversity and water availability. The overall strength of each keyword is shown by a different color in Figure 10, with larger bars denoting greater relevance or importance within the examined documents. Identifying important themes and areas of attention is made more accessible by this network visualization graphic depiction in the VOSviewer application, which makes it simple to compare the relative importance of the keywords.

This study offers a thorough co-occurrence analysis of keywords associated with water and climate change challenges, providing insightful information about current trends and emphasis areas in this subject. The study's conclusions support current views that emphasize climate change's crucial role in water problems while underlining the issue's complexity. The overwhelming presence of "climate change" as the keyword with the highest total strength highlights the term's crucial role in water studies, which aligns with the expanding topic of scientific evidence about the profound effects of climate change. The rise in popularity of "water management" indicates the growing acceptance of adaptive approaches to tackle water-related issues brought on by climate change, consistent with modern resilience theories. The study is innovative because it takes a comprehensive approach, covering a wide range of linked concerns, from ecosystem health and sustainable development to pollution and availability, particularly water-related challenges. This all-encompassing viewpoint advances the understanding of the intricate relationships between water systems and climate change. The research also emphasizes the human element, with "human" having a high overall strength rating. This aligns with contemporary developments in climate change research that integrate ecological and social viewpoints, acknowledging the interdependence of natural and human systems in addressing climate resilience. Investigating the chronological evolution of these keyword associations might benefit future research since it may show how the field's focus has changed over time. Furthermore, examining geographical differences in keyword prominence may provide information on specific impacts of climate change and methods for adaptation. Overall, the analysis offers insightful information on the essential topics and ideas in the documents, emphasizing the connections between water management, environmental impacts, climate change, and sustainable practices to improve resilience for

future studies (Taseska et al., 2023).

Table 8. Keyword occurrences

Keyword Occurrences	Number of Occurrences	Total Strength
Climate change	1043	12054
Article	157	3925
Water management	236	3349
Human	138	3228
Water supply	160	2907
Water quality	138	2570
Sustainable development	180	2398
Humans	94	2166
Nonhuman	61	1894
Environmental impact	84	1790
Water resources	136	1726
Water	113	1717
Risk assessment	84	1682
Environmental monitoring	62	1655
Priority journal	58	1602
Water pollution	79	1601
Ecosystem	60	1558
Groundwater	95	1545
Sustainability	142	1532
Rivers	87	1485
Drought	99	1436
Land use	77	1314
Agriculture	77	1301
Climate effect	71	1205
Water conservation	74	1204
Biodiversity	87	1164
Water availability	64	1065
Rain	56	1039

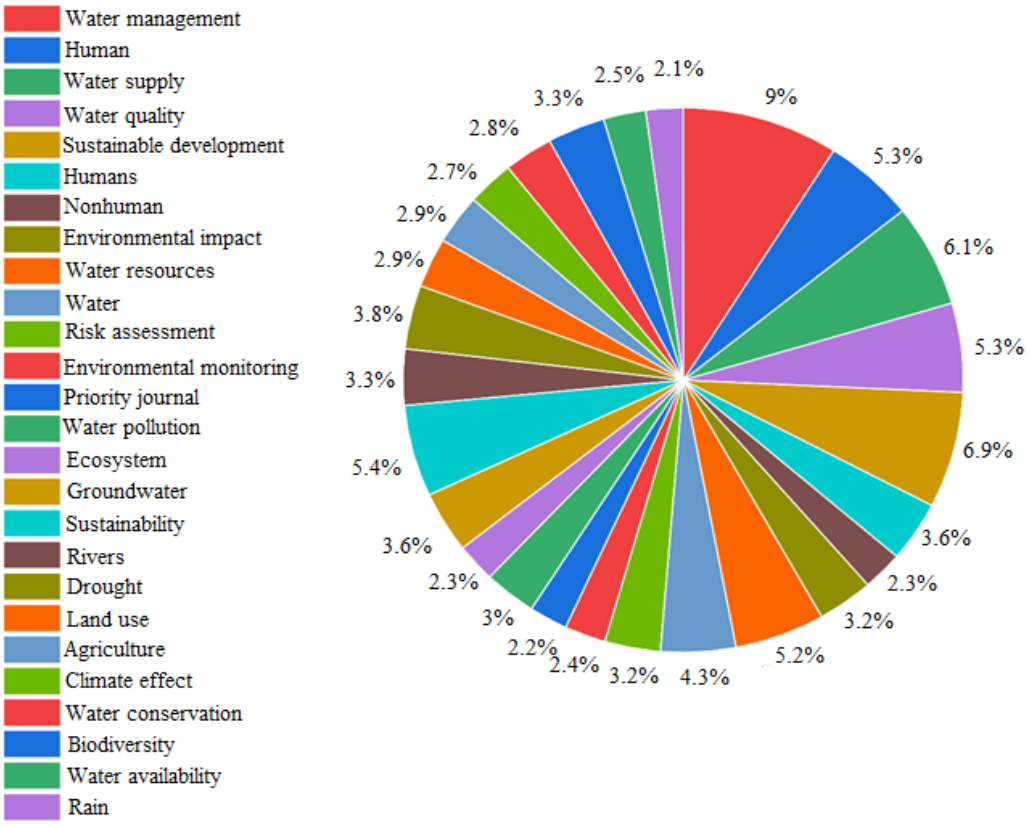

Figure 10. Network visualization of keyword occurrences

5. Limitations and Prospective Paths

Although it is extremely helpful to use bibliometric techniques to investigate climate change and its effects on water resources, those techniques have limitations. The study can unintentionally ignore essential insights from other sources and linguistic settings by concentrating only on English-language articles and using the Scopus database as its only source of information. This restricted focus may need to be extended to understand how research on the topic is seen globally. Moreover, the focus on highly cited papers may need to pay more attention to new ideas and developing patterns seen in the less cited literature, even though it may capture influential work. Given the study's narrow selection of bibliometric methodologies, a more in-depth analysis is possible. Increasing the number of methodological tools in the toolbox may produce more trustworthy and consistent outcomes, providing a more thorough grasp of the field of study. Furthermore, the broad classification of subjects without thoroughly examining groups limits comprehension of the complex connections among important domains like risk assessment, environmental monitoring, and sustainable development objectives. By addressing these constraints, future research could significantly improve the researchers' understanding of climate change's impacts. A more comprehensive understanding of the area would be possible using a wider range of document types and data sources than Scopus. A fully global view of sustainability studies would be captured by including publications written in many languages. Expanding the focus to encompass a more diverse array of publications, even ones with fewer citations, may reveal up-and-coming patterns and inventive methodologies that need to be noticed. On the other hand, a more comprehensive range of bibliometric approaches would produce more complex and trustworthy findings, providing a more in-depth understanding of research trends and partnerships. Lastly, a thorough examination of each of the individual categories of climate change, water management, sustainable development, environmental impact, groundwater, drought, and biodiversity would shed light on the intricate relationships among these crucial fields and possibly open new directions for cross-disciplinary study and real-world sustainability applications.

These limitations must be recognized and addressed to improve knowledge and create practical plans for strengthening resistance to the water-related problems brought on by a changing climate. The intrinsic complexity of biological reactions to environmental stressors is one of the most significant limits. It can be challenging to determine specific causal correlations between bibliometric markers and particular drivers, such as climate change, due to the complex web of interactions between different biotic and abiotic elements. Because hydrological systems and ecosystems are dynamic and constantly changing in response to a wide range of stimuli, it is challenging to identify and measure the effects of a single issue, like climate change, on water resources. Moreover, considerable temporal and regional variability in bibliometric indicators can impede the establishment of reliable quantitative relationships between these indicators and environmental variables. Hydrology, terrain, and climate impact the intricate spatial patterns and temporal dynamics that define water systems and their ecological processes. The results obtained from the bibliometric analysis may provide uncertainties and difficulties in interpretation and generalization due to this heterogeneity. The assumption that sectoral vulnerability stays constant over time rather than adjusting to the effects of climate change is another flaw noted in the document.

This presumption might not fully capture the dynamics of the natural world, as people and sectors frequently use adaptation methods and modify their activities in response to shifting environmental conditions. An insufficient understanding of the vulnerabilities and resilience of different sectors to water-related difficulties exacerbated by climate change may result from failing to account for these adaptive capacities. The statement also recognizes the significant challenge of combining multidisciplinary impact assessments with climate models, which is necessary for more thorough comprehension and management of the intricate relationships between water scarcity and climate change. Integration of climate models and impact assessments is complex since they frequently function in distinct discipline silos.

Despite its shortcomings, the paper offers insightful analysis and identifies promising directions for further study on water and climate change challenges. One of the main recommendations is the necessity of context-specific, interdisciplinary approaches to handle the complex difficulties of flooding and water scarcity brought on by climate change. These problems cut across academic lines and necessitate integrating expertise from several disciplines, including policy studies, ecology, hydrology, climatology, and the social sciences. A more profound comprehension of the dynamic sectoral vulnerabilities and the strategies used by various sectors to adjust to the effects of climate change on water supplies can be facilitated by interdisciplinary collaborations. Researchers can better understand the complex interactions between natural systems, human activity, and climate change by combining a variety of viewpoints and approaches. This can result in more comprehensive and successful outcomes. To overcome this constraint, researchers from various disciplines must collaborate and share their expertise to create comprehensive frameworks that capture the complex relationships between these concerns.

6. Conclusion

Due to its disruption of the hydrological cycle and increase in the frequency and severity of extreme weather

events such as storms, floods, and droughts, climate change poses a severe danger to the security of water supplies worldwide. This thorough research shows the importance of comprehending and managing the intricate links between climate change and water resources to assist adaptation initiatives, sustainable water management techniques, and flood risk reduction measures. To understand how climate change affects hydrology and flood dangers, this study emphasizes the importance of bibliometric analytic methods such as trend analysis, correlation studies, rainfall-runoff modeling, flood frequency analysis, and multivariate statistical approaches. The review recognizes the inherent limitations of these methods, which include the assumption of static sectoral vulnerability over time, the complexity of biological responses to environmental stressors, and the spatiotemporal variability in hydrological systems, even though these methods provide essential insights. The paper highlights the necessity of multidisciplinary, context-specific methods incorporating information from several disciplines, including the social sciences, hydrology, climatology, ecology, and policy studies. Such cooperative initiatives can help advance knowledge of the dynamic sectoral vulnerabilities, strategies for adaptation, cascade effects, and ecological responses to water difficulties brought on by climate change. The analysis acknowledges the major challenge of integrating interdisciplinary impact assessments with climate models. This integration is essential to understanding the complex interactions between water shortages and climate change. To overcome this hurdle, multidisciplinary cooperation and the creation of thorough frameworks that capture the intricate connections between these related problems are needed. The text also emphasizes the significance of ongoing research projects and financial assistance from different institutions, such as government agencies, international organizations, and national science foundations. This consistent investment can protect water supplies and ecosystem resilience in a fast-changing climate. It can also advance scientific knowledge and direct policy decisions. This study concludes by comprehensively reviewing knowledge, research trends, and prospects for water-related concerns and climate change. It draws attention to how quickly these problems must be solved via interdisciplinary thinking, collaboration, and blending different fields of expertise. By recognizing the shortcomings of the current paradigm and embracing novel approaches, researchers, policymakers, and stakeholders can collaborate to develop practical solutions that promote sustainable water management practices and strengthen resistance to the water-related effects of global climate change.

The critical funding for future research is the effectiveness of bibliometric analytic methods in understanding climate change impacts on hydrology and flood risks while acknowledging their limitations. Multidisciplinary, context-specific methods incorporating information from the social sciences, hydrology, climatology, ecology, and policy studies are required. The shift in climate change research focuses on understanding the climate system to develop climate technologies and regulations, covering a broader range of topics such as environmental health, rivers, and groundwater. The rapid growth of climate change vulnerability research since 2014, with water resource-related issues being a key focus area. The significant increase in the volume of climate change research from 2014 to 2024 reflects growing global interest in addressing this issue. The strong impact of climate change on groundwater resources, with projections showing reductions in recharge in arid and desert areas. Based on these findings, this study suggests several policy recommendations and directions for future research, aiming to a) encourage multidisciplinary collaboration and the development of comprehensive frameworks to capture the intricate connections between related issues such as water scarcity and climate change; b) encourage interdisciplinary thinking and teamwork to create workable solutions that improve sustainable water management techniques and increase resistance to the effects of climate change on water; c) implement education programs on responsible water use to counteract the effects of climate change; d) foster more scientific collaboration between developed and developing countries to address climate change challenges globally; e) develop adaptive approaches based on a thorough understanding of potential climate uncertainties, combining short-term and long-term plans, and considering factors such as robustness, flexibility, reliability, and vulnerability to climate change; f) expand research on the impacts of climate change on groundwater resources, particularly in arid and desert areas where recharge reductions are projected to be severe; and g) integrate climate change research with studies on environmental health, rivers, groundwater, and the circular economy to address the broader impacts on sustainable development, social and economic factors, and carbon sequestration.

Author Contributions

Formal analysis and writing of the manuscript, Abraham Ayuen Ngong, conceptualization; data curation; Nursetiawan Nursetiawan and supervision, Jazaul Ikhsan.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

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