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# Climate Change Impacts on Drought: A Bibliometric Analysis (2013-2023)

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**Abstract:** A comprehensive bibliometric analysis was conducted to examine the evolution of scientific research on climate change and drought from 2013 to 2023. A dataset comprising 28,950 peer-reviewed publications was compiled from Web of Science, Scopus, and Google Scholar, followed by rigorous data cleaning and standardization procedures. Analytical tools, including VOSviewer and CiteSpace, were employed to map keyword co-occurrence networks, author collaborations, and citation dynamics. The results revealed that co-authorship patterns were characterized by extensive global collaboration, with the United States (7,565 publications; 99,657 citations) and China (5,552 publications; 36,207 citations) identified as the leading contributors. Prominent institutions such as the Chinese Academy of Sciences (1,945 publications) emerged as central nodes within international research networks. Keyword co-occurrence analysis highlighted dominant thematic clusters, including "ecosystem responses" (12,212 occurrences), "water availability," and "climate models", indicating strong interdisciplinary linkages across environmental, agricultural, and geoscientific domains. Citation analysis pinpointed highly influential journals, with Science of the Total Environment (756 publications in 2013) and Water (Switzerland) (484 in 2014) noted for their substantial academic impact. Notable authors, such as J.J. Camarero (148 documents), were recognized for sustained scholarly contributions. A marked upward trend in publication volume was observed, with annual outputs increasing by 230%, from 1,394 documents in 2013 to 4,597 in 2023, reflecting intensified global attention on climate-induced drought. Funding analysis showed that 22,630 publications acknowledged financial support, predominantly from agencies such as the National Natural Science Foundation of China. Subject area distribution revealed a concentration in environmental sciences (28.5%), agricultural sciences (23.7%), and earth sciences (14.4%), underscoring the multifaceted nature of drought-related climate research. Network visualizations further demonstrated that the United States held the highest total link strength (5,240), followed by China (3,520), suggesting leadership in collaborative intensity. The integration of citation frequencies, publication trends, and thematic evolution provided a robust framework for identifying existing research gaps, informing mitigation strategies, and guiding science-based policy development. The findings underscore the urgency of addressing climate-related drought through enhanced international cooperation and the application of advanced modeling frameworks, while also illustrating the evolving structure of this research domain over the past decade.

**Keywords:** Climate change; Drought; Bibliometric analysis; Sviewer; CiteSpace; Co-authorship networks; Citation trends; Keyword co-occurrence

## 1. Introduction

Analysis has shown that climate change intensifies the frequency, duration, and intensity of droughts, leading to cascading effects on environments, food production, and water security. Bibliometric analyses reveal a rise in interdisciplinary research driven by the need to understand climate-related variables for changing patterns of precipitation, increased temperature levels and their relationship with drought phenomena. The most current research highlights regional risks, particularly in arid and Mediterranean areas, while demonstrating advancements in drought modeling purposes, data collection, and mitigation strategies. Nonetheless, substantial shortcomings persist. While Western regions like Europe and North America have been thoroughly examined, the mechanisms

contributing to drought susceptibility in Southeast Asia, Sub-Saharan Africa, and other climate-vulnerable areas remain insufficiently investigated, despite their distinct monsoonal systems and socio-agrarian dependencies. Secondly, model validation frequently exhibits deficiencies in accurately representing localized hydroclimatic conditions. This study highlights that the mechanisms underlying drought dynamics in monsoonal systems like Southeast Asia remain underexplored. For instance, Indonesia, a region highly vulnerable to El Niño-induced droughts, contributed only 366 documents, starkly contrasting with the United States (7,565) or China (5,552). This disparity overlooks unique hydroclimatic vulnerabilities and socio-agrarian dependencies in marginalized regions, as noted in the limitations section, which highlights biases toward English-language publications and institutional overrepresentation (Yordanov et al., 2020). Drought incidence, intensity, and duration are all greatly influenced by climate change, which is caused by greenhouse gas emissions and human activities (Guo et al., 2008). To successfully address food insecurity, water shortage, and other associated challenges, mitigation and adaptation measures based on understanding the interactions between these two phenomena are necessary (Kotlarz & Bejger, 2024).

Nam et al. (2015) evaluated the impacts of climate change on the patterns and intensity of drought in various places, aiming to estimate and model potential drought conditions in the face of different climate change scenarios, determine the fundamental processes and feedback loops linking drought and climate change, and evaluate the ecological and social effects of droughts brought on by climate change. In addition, tools for drought monitoring and early warning were developed, alongside evaluations of the effectiveness of adaptation and mitigation strategies. Through bibliometric analysis, Islam et al. (2023) concluded that growing patterns of drought frequency and severity may be linked to climate change, mostly in arid and semi-arid regions of the world. Zhou et al. (2011) found that variations in temperature and precipitation patterns cause droughts to worsen and last longer. In addition, hotspots or areas where droughts caused by climate change are particularly likely to occur were identified. Xu et al. (2023) demonstrated that human activities—such as inappropriate water management, land-use changes, and climate change—exacerbate drought conditions. Models and drought indexes were created and verified to improve tracking and forecasting and provide insights into how droughts affect several industries, including water resources, agriculture, and ecosystems. A bibliometric analysis approach can reveal these findings by looking at citation networks, locating highly cited and influential papers, assessing keyword co-occurrences and trends, and mapping the collaborative networks amongst academics and institutions working on this subject. This study emphasizes the urgency and significance of addressing the impact of climate change on drought by synthesizing the noteworthy findings from previous studies (Schwab et al., 2023). This highlights the need for interdisciplinary collaboration, policy interventions, and the development of effective adaptation and mitigation strategies.

Climate change starkly highlights the occurrence of previously unheard-of high temperatures, protracted and intense heatwaves, and other extreme meteorological phenomena throughout Europe and the world, further highlighting the relevance and urgency of research in the real world. The study's primary goal is to evaluate the annual climatic conditions during the previous years and compare them to established norms to make meaningful conclusions regarding the trajectory of climate change indicators (Abdoussalami et al., 2023) More critical points have been accepted for the definitions of drought, making research more sufficient. In addition, one of the study's primary goals is to develop reliable drought indices that can examine drought characteristics in a changing climate (Meshram & Kadu, 2023). Brown et al. (2015) highlighted how long-term climate change directly causes extreme weather events, including drought, to become more frequent and intense. Furthermore, concerningly, due to its impacts on drought in Europe, climate change was found to increase more than double that of the global average over the previous ten decades, with Europe showing the highest growth rate of climate change of any other continent. Osman (2023) proficiently demonstrated the research's significance by stressing the severe effects of climate change on extreme weather events and the hazards to human health that accompany them. After outlining the research goals and evaluating weather conditions, Bharambe et al. (2023) compared them to standards and created reliable drought indicators. In addition, previous research was used to support the assertions about the effects of climate change and the urgent need for more excellent studies in this vital field.

Kone et al. (2024) predicted that drought episodes can become increasingly frequent, prolonged, and severe due to climate change, especially in dry and semi-arid agroecosystems like northern Africa and the Mediterranean and the world in general. However, this presents significant challenges for agricultural sustainability and food security in these vulnerable regions. Drought can negatively impact agricultural productivity and, in turn, food security. Therefore, this is a severe problem. Lima et al. (2023) aimed to determine whether applying a biochar-compost mixture as a soil supplement can help rice plants grown in low-fertility sandy soil, which is a soil characteristic of recently reclaimed land in Asia, Europe, America, and Africa, become more drought-tolerant. The study research postulates that by holding more soil moisture, the amendment could enhance drought stress tolerance and lessen the adverse impacts of drought. Derdour et al. (2023) demonstrated that biochar can reduce greenhouse gas emissions by sequestering carbon while improving crop yield, fertility, and soil quality.

It has been observed that using biochar as a management strategy can help lessen the adverse effects of drought stress on crop output. Hindiyeh et al. (2023) pointed out that the relationship between biochar and the agroecosystem must be carefully considered to get the best outcomes. The study by Rossi & Peres (2023) is

important because agricultural productivity in recently reclaimed low-fertility sandy soils in the world increases, where the salinity of the soil and a lack of fresh water are significant barriers to food security. Because of its strategic significance and suitability as a model plant for monocots, rice was selected as the model crop. By applying a biochar-compost mixture as a soil supplement, Tofu et al. (2023) aimed to improve drought tolerance in rice, a critical crop in the world, and address the urgent problem of drought brought on by climate change. Building on earlier studies on the advantages of climate change, the need for optimization and assessment was addressed according to the setting. Additionally, bibliometric research has demonstrated that improving the ability to monitor and forecast droughts requires developing complex modeling techniques and remote sensing technology. These techniques have helped academics better understand drought's temporal and spatial patterns and estimate future conditions under various climate change scenarios (Faluyi & Irmak, 2023).

The bibliometric analysis highlights the vital need for collaborative efforts to address this grave global issue and emphasizes the significance of studying drought and climate change (Dione et al., 2023). The project has yielded significant findings, including the irrefutable link between drought patterns and climate change, regional vulnerabilities, the multidisciplinary nature of the study, and the use of advanced modeling and monitoring techniques (King et al., 2021). This analysis summarizes available data and provides a solid foundation for the subsequent studies and informed decision-making to mitigate the effects of drought brought on by climate change, which allows for the proactive mitigation of related risks and effects (Meixner et al., 2016). The principal objective of this work is to compile the body of information on the topic using the bibliometric analytic approach. This method enables the identification of notable authors, current research developments, and prestigious publications in the field by evaluating published studies using quantitative and qualitative methods (Eslamian & Eslamian, 2017). In doing so, it offers a thorough grasp of current levels of knowledge and draws attention to any potential gaps or areas that require more research. Essential results from past research highlight the worrisome effects of climate change on global drought patterns (Treidel et al., 2011).

### 1.1 Limitations Using the Bibliometric Analysis Method

One limitation is the potential bias in publication and citation patterns, as some research areas or regions may receive disproportionate attention, leading to an overrepresentation in the literature. At the same time, the tendency to cite well-known or highly influential studies can create citation biases, potentially overlooking important but lesser-cited works. Another limitation lies in the lack of access to unpublished or non-English literature, as bibliometric analyses primarily focus on published, peer-reviewed literature, often favoring English-language publications, which may overlook valuable research findings from unpublished sources or publications in other languages, potentially introducing language and publication biases. Additionally, bibliometric analysis quantitatively measures research outputs and trends. Still, it may need to fully capture the qualitative aspects of the research, such as the depth of theoretical frameworks, methodological rigor, or the nuances of research findings, potentially oversimplifying complex research areas.

Moreover, the temporal scope of the databases or indexing services utilized may restrict the accessibility and availability of bibliographic data; as a result, the analysis might not include the most current articles or promptly identify developing research trends. Furthermore, the proper procurement and incorporation of research from many academic fields may provide difficulties for bibliometric analysis, which could result in an inadequate representation of the total research environment. Naturally, interdisciplinary topics like drought, and global warming span the fields of climatology, hydrology, ecology, agriculture, and social sciences. Lastly, although bibliometric analysis focuses on the quantitative evaluation of research outputs, the larger context in which the research is done may need to be fully considered. Policy concerns, funding availability, research aims, societal demands, and inquiry agendas are a few examples of this context that might affect the focus and direction of the research study.

## 2. Materials and Methods

Climate change is the most significant and crucial worldwide concern, and it profoundly impacts human society, natural systems, and the broader environment. To investigate the scholarly landscape related to this issue, a systematic bibliometric analysis was conducted using the Scopus database. The Scopus database has its own strengths and coverage attributes and was chosen as the primary resource due to its rigorous peer-review standards, comprehensive coverage of high-impact journals, and dependable indexing techniques, ensuring the metadata quality required for bibliometric research. Scopus improved this option by providing comprehensive coverage of foreign journals, particularly from emerging economies and non-English speaking countries, while maintaining stringent quality control measures to eliminate predatory publications. The Scopus database was deliberately incorporated to encompass supplementary academic sources, including conference proceedings, theses, and institutional reports that may be neglected by conventional indexing services, while concurrently omitting grey literature such as unpublished reports, government documents, and non-peer-reviewed materials to uphold

academic integrity. The keyword study topic was rigorously examined across databases to enhance retrieval while ensuring uniformity in conceptual coverage. The terms "climate change impacts on drought" were utilized for search in the database, with field limits applied to the title, abstract, and keyword sections to ensure precision in relevance. Scopus necessitated a revised methodology utilizing simplified keyword combinations because of its less advanced search interface, applying the phrase "climate change impacts on drought" with temporal limitations, and removing patents, citations, and legal papers to concentrate on scholarly publications. This differentiated method mitigated selection bias by optimizing the unique indexing attributes of each database while preserving conceptual uniformity across all search algorithms (Deulkar, 2024).

The subsequent stage involved a systematic, multi-phase data cleaning process. This began with the automatic identification and removal of duplicate records, using document identifiers, title similarity algorithms, and author-journal cross-referencing methods. The dataset was further refined through bibliometric profiling, which included the classification of documents by year of publication, citation frequency, subject area, country of origin, and leading contributors to research on climate change and its impacts on drought. Precise Digital Object Identifier (DOI) matching was employed across all Scopus databases for the initial removal of duplicates. Subsequently, fuzzy matching algorithms were applied to detect near-duplicates exhibiting 95% title similarity and identify the study period of 2013-2023 from the Scopus database, generating a total number of 13,058 documents. This methodology rectified various bibliographic inconsistencies in the standardization process, including variations in author names (managing diverse abbreviation patterns, inclusion/exclusion of middle initials, and cultural naming conventions), journal name standardization (transforming abbreviated titles to full forms and addressing historical name changes), and classification of publication types by separating the duplicate publications and differentiating all types of non-English documents, such as articles (9,676), book chapters (1,277), conference papers (743), books (120), reviews (1,012), conference reviews (143), data papers (15), short surveys (15), and notes (72). Language filtering was an essential aspect of the cleaning protocol, wherein non-English publications were systematically identified through various verification methods, including language field analysis, title translation detection, and abstract language identification utilizing automated language detection algorithms. Non-English publications were recorded for the analysis of geographic and linguistic diversity but were omitted from the primary bibliometric analysis to maintain consistency in citation pattern examination and content categorization, due to the inherent bias favoring English-language citations in international academic databases. Conference abstracts were subjected to stringent quality evaluation according to established criteria, which included a minimum length of 150 words, a description of methodology, the inclusion of quantitative results, and verification of conference ranking through recognized academic conference rating systems. Abstracts failing to meet these standards were systematically excluded to uphold analytical integrity (Yang, 2010).

The final stage of the research methodology involved comprehensive data analysis. Publication trend data were first extracted and imported from CSV files into VOSviewer for bibliometric interpretation and visualization. A structured set of inclusion criteria was then applied to establish a rigorous analytical framework, ensuring that only publications specifically addressing the intersection of climate change and drought impacts—through empirical studies, theoretical models, or comprehensive review methodologies—were retained for analysis. Publications were included if they demonstrated clear research objectives regarding climate change-drought relationships, employed systematic methodologies (quantitative modeling, statistical analysis, experimental design, or systematic review protocols), offered original findings or novel theoretical contributions, and were published in peer-reviewed journals from 2013 to 2023 to ensure temporal consistency and reflect the latest decade of research advancements. Supplementary inclusion criteria required that publications demonstrate adequate methodological transparency, offer clear definitions of drought parameters (including meteorological, agricultural, hydrological, or socioeconomic types), and specify geographical or temporal scope to enable meaningful comparative analysis across various climate regions and time periods. The exclusion criteria were methodical, eliminating publications that did not adhere to academic rigor, including non-peer-reviewed materials (working papers, institutional reports, policy briefs, and popular science articles), duplicate publications identified through cross-database comparison, publications devoid of clear methodological frameworks or research questions, and those offering solely anecdotal or opinion-based content without empirical substantiation. Technical exclusions encompass publications deficient in comprehensive bibliographic metadata (missing author information, publication dates, or journal identifiers), articles shorter than four pages (excluding substantial research content), and publications that analyzed climate change or drought independently without exploring their interconnected dynamics. Editorial materials, book reviews, conference announcements, and correspondence were systematically excluded to focus on substantial research contributions, ensuring that the final dataset comprised a cohesive collection of high-quality academic publications suitable for comprehensive bibliometric analysis, which could reliably clarify research trends, knowledge gaps, and emerging themes in climate change-drought impact research (Xu et al., 2024). This research sheds light on essential authors, seminal works, new directions in the field, and areas of potential knowledge that need to be explored. Ultimately, this will help shape future investigations and policy choices concerning methods for mitigating drought and adapting to a rapidly changing climate (Orimoloye et al., 2021).

## 3. Results and Discussion

### 3.1 Documents Published by Year

A bibliometric study of the research papers on climate change and its effects on drought published between 2013 and 2023 is shown in Figure 1 Grading the patterns and trends in this field of study during the last ten years requires a grasp of this analysis. Figure 2 unmistakably demonstrates a notable rise in the number of papers published on this subject yearly, demonstrating the increased significance and focus on studying the connection between drought and climate change. The number of documents published rose from 1,394 in 2013 to 4,597 in 2023, a significant growth of more than 230% in just ten years. This figure offers a mathematical foundation for additional bibliometric analysis, such as determining the essential contributors to this field of study, i.e., authors, organizations, or nations. It can also make it easier to analyze co-authorship patterns, citation networks, and primary research groups or clusters focusing on drought and climate change issues. This bibliometric analysis provides a crucial starting point for researchers working in this area by providing information on the state of the field, directing future studies, and easing the synthesis of current research to deepen the understanding of the crucial connection between drought and climate change (Rockström et al., 2009).

A compelling visualization of the research trends and patterns in the last ten years on climate change and its effects on drought can be seen in the supplied bibliometric analysis, which highlights this research subject's growing importance and urgency by demonstrating the notable increase in the yearly number of documents published on this issue. The steady growing trend indicates the severe effects of climate change on global drought patterns and the increased focus and efforts made to comprehend and lessen these effects. Furthermore, this analysis is valuable because it helps researchers spot gaps, emerging themes, or areas that need more inquiry within the existing literature (Lorenzo-Lacruz et al., 2010). By analyzing publishing trends, scientists can develop novel research goals and hypotheses, guaranteeing that their work stays current and tackles the most urgent problems associated with drought and climate change occurrences. Crucially, the vast number of papers released throughout time constitutes a treasure trove of information and conclusions from numerous academics and organizations across the globe (Ma et al., 2023). Using an exhaustive examination and amalgamation of extant literature, scholars can expand upon prior research, discern trends, and derive significant deductions that bolster an enhanced comprehension of the intricate interplay between drought and climate change. Additionally, the bibliometric analysis makes it easier to explore the research landscape further. It helps identify influential authors, organizations, or nations significantly contributing to this field. The research community can collaborate and exchange knowledge by using it to analyze co-authorship patterns and citation networks and identify essential research groups or clusters focusing on drought and climate change elements. This bibliometric analysis provides researchers in this field with an invaluable foundation, providing insights into the state of the field, directing future studies and easing the synthesis of current knowledge to advance the collective understanding of the crucial relationship between drought and climate change, ultimately influencing strategies and policies to mitigate and adapt to these urgent global challenges (Dejene et al., 2023).

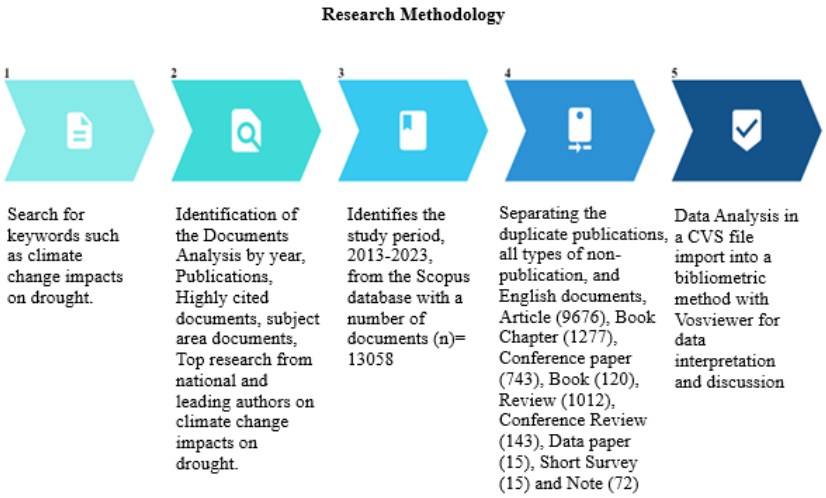


**Figure 1**. Data analysis method used in the Scopus database

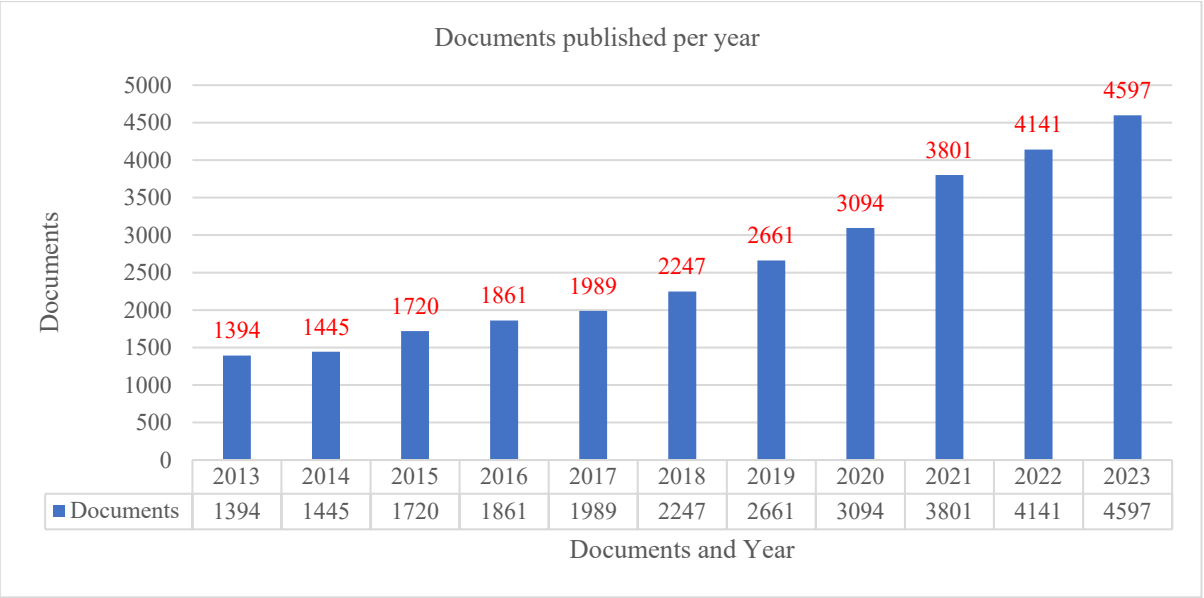


**Figure 2.** Increased documents published per year from 2013 to 2023

### 3.2 Highly Cited Documents

**Table 1.** Annual distribution of highly cited documents (2013-2023)

| Year | Documents Per Year by Sources | Issue Categories | Publisher | Number of Publications | Participation Percentage |
|---|---|---|---|---|---|
| 2013 | Science of the Total Environment | Environmental science | Elsevier | 756 | 18% |
| 2014 | Water (Switzerland) | Water science and technology | Multidisciplinary Digital Publishing Institute (MDPI) | 484 | 12% |
| 2015 | Global Change Biology | General environmental science | Wiley-Blackwell | 427 | 10% |
| 2016 | Forest Ecology and Management | Agricultural and biological sciences | Elsevier | 399 | 10% |
| 2017 | Forests | Agricultural and biological sciences | MDPI | 378 | 9% |
| 2018 | Frontiers in Plant Science | Agricultural and biological sciences: plant science | Frontiers Media SA | 377 | 9% |
| 2019 | Journal of Hydrology | Environmental science: water science and technology | Elsevier | 355 | 9% |
| 2020 | Sustainability (Switzerland) | Social sciences: geography, planning and development | MDPI | 327 | 8% |
| 2021 | Environmental Research Letters | Medicine: public health, environmental and occupational health | Institute of Physics Publishing | 319 | 8% |
| 2022 | Agricultural and Forest Meteorology | Agricultural and biological sciences: forestry | Elsevier | 307 | 8% |
| 2023 | International Journal of Climatology | Earth and planetary sciences: atmospheric science | Wiley-Blackwell | 288 | 7% |

Table 1 thoroughly summarizes the state of the research on drought and climate change from 2013 to 2023. The significance of this research area, possible research goals, and significant findings from previous studies are all clarified by this analysis, which is essential because it focuses on the contributions and participation of various disciplines according to their percentages. First, by displaying the rising number of publications over time, the table illustrates the expanding importance of this subject of study. Notably, environmental science contributed 18%

of the articles in 2013, highlighting how crucial it is to comprehend the intricate relationships between drought and climate change in the context of environmental systems. Furthermore, the persistent representation of fields like biological sciences and agriculture (e.g. 10% in 2016 and 9% in 2018) indicates the pressing need to investigate how drought affects food security, crop yields, and ecosystem health.

Second, by highlighting the well-known publications and topic categories in this discipline, the table helps researchers identify possible study goals. Elsevier, for example, a prominent publisher in environmental research and water science and technology, has regularly produced important works, accounting for 18% in 2013 and 9% in 2019 of all publications. This pattern points to current research areas and possible collaborations in different fields, all essential for comprehending the intricate relationships between drought, water resources, and climate change. Additionally, the fact that fields like the social sciences (8% in 2020) and medicine (8% in 2021) are involved emphasizes how multidisciplinary this field of study is. To inform comprehensive measures for adaptation and mitigation, these contributions highlight the significance of looking at the socioeconomic effects of drought and any potential health implications for vulnerable groups.

Table 1 showcases the most frequently referenced papers each year and offers insights into essential conclusions from previous research. For instance, the International Journal of Climatology has 7% of articles in 2023. This indicates that atmospheric science has made significant strides in understanding and projecting drought patterns and climate change. Furthermore, the continued attempts to investigate the effects of drought on water resources and forest ecosystems are reflected in the consistent engagement of disciplines like forestry (8% in 2022) and water science and technology (12% in 2014). The development of practical plans to control water shortages and lessen the impact of drought on delicate ecosystems depends on their contributions. Researchers can use this bibliometric analysis as a valuable tool to help them navigate the large body of literature, spot research gaps, investigate multidisciplinary connections, and compile essential findings from previous studies. Researchers can better understand the current state of knowledge, formulate pertinent research objectives, and contribute to developing effective strategies to address the urgent challenges posed by climate change and drought by utilizing this thorough analysis and considering the relative contributions of different disciplines. Figure 3 shows the citation trends on climate change and drought from 2013 to 2023.

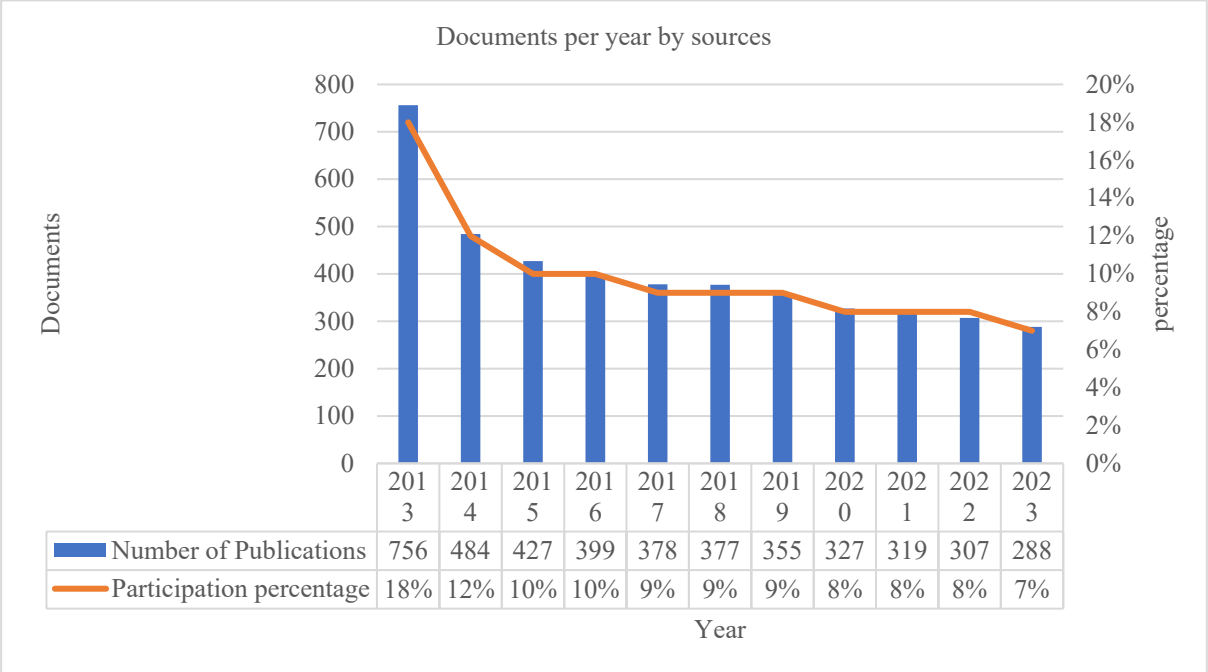


**Figure 3.** Citation trends on climate change and drought (2013-2023)

### 3.3 Documents by Subject Area

A thorough bibliometric study of research articles from 2013 to 2023 on the topic of climate change and its effects on drought is presented in Table 2 Understanding the importance of the study, its goals, and the noteworthy conclusions from previous research in various subject areas depends on this approach. According to the table, the study records are divided into 27 subjects, ranging from dentistry to environmental science. This classification emphasizes the research's multidisciplinary nature because drought and other effects of climate change are not limited to a single field of study. According to the data, the top three subject areas adding to the body of knowledge

on this topic are earth and planetary sciences (14.4%), agricultural and biological sciences (23.7%), and environmental science (28.5%). The finding is crucial as it clarifies the intricate relationship between drought and climate change. This relationship has broad consequences for multiple domains, such as agriculture, water resources, ecosystems, and human welfare. Researchers can obtain insights into the breadth and depth of information available and discover potential gaps or areas that require more inquiry by analyzing the distribution of research publications across various subject areas (Dejene et al., 2023). Giving a thorough picture of the body of research on climate change and its effects on drought is one of the main goals of this bibliometric analysis. Researchers can successfully handle this global challenge by identifying the most prolific topics and prospective collaborations or interdisciplinary approaches by assessing the research output across subject areas.

**Table 2.** Documents by subject area

| Subject area | Documents | Percentage |
|---|---|---|
| Environmental science | 14,965 | 28.5% |
| Agricultural and biological sciences | 12,439 | 23.7% |
| Earth and planetary sciences | 7,540 | 14.4% |
| Social sciences | 3,716 | 7.1% |
| Biochemistry, genetics and molecular biology | 2,845 | 5.4% |
| Engineering | 2,376 | 4.5% |
| Energy | 1,212 | 2.3% |
| Medicine | 1,160 | 2.2% |
| Multidisciplinary | 995 | 1.9% |
| Computer science | 985 | 1.9% |
| Economics, econometrics and finance | 615 | 1% |
| Arts and humanities | 508 | 1% |
| Immunology and microbiology | 440 | 1% |
| Physics and astronomy | 435 | 1% |
| Business, management and accounting | 427 | 1% |
| Chemistry | 364 | 1% |
| Chemical engineering | 292 | 1% |
| Decision sciences | 292 | 1% |
| Mathematics | 291 | 1% |
| Materials science | 232 | 1% |
| Veterinary | 100 | 1% |
| Pharmacology, toxicology and pharmaceutics | 91 | 1% |
| Neuroscience | 88 | 1% |
| Psychology | 51 | 1% |
| Health professions | 39 | 1% |
| Nursing | 32 | 1% |
| Dentistry | 2 | 0.5% |
| Undefined | 2 | 0.5% |

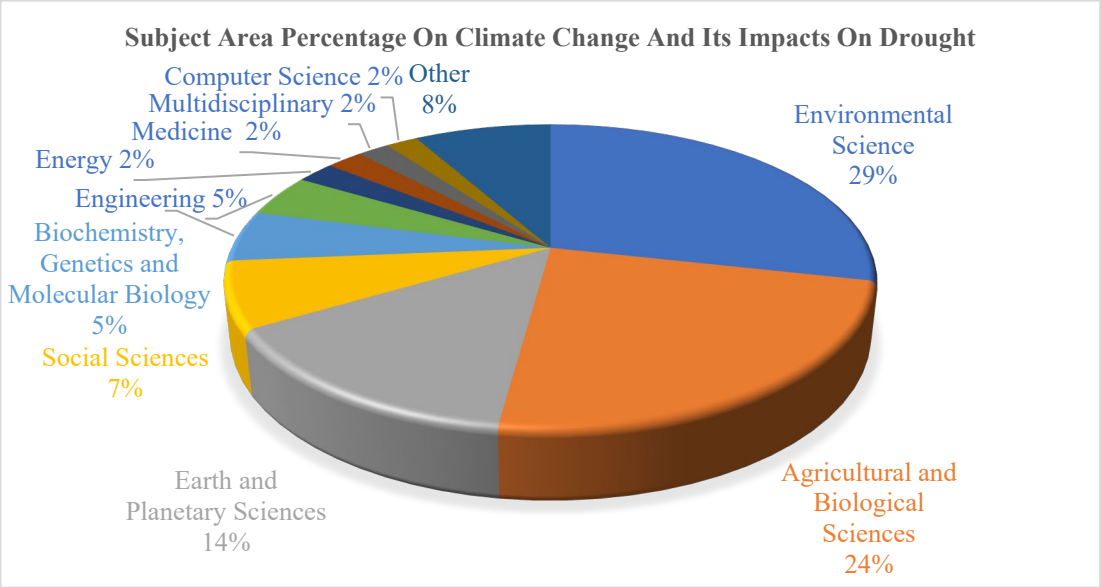


**Figure 4.** Pie chart of the subject area on climate change and its impacts on drought

Additionally, the analysis can highlight essential findings from previous studies that could guide future paths for investigation, choices for public policy, and plans for mitigating risks. For example, research on earth and planetary sciences may help us understand the underlying climatic processes and projections. At the same time, research on environmental science and agricultural and biological sciences may provide insight into drought's ecological and agricultural effects. It is significant to note that the table only provides the total number of papers and percentages by subject area; it does not discuss any study's precise conclusions or revelations. A more thorough analysis and synthesis of the literature in each topic area would be required to understand the noteworthy findings thoroughly. This bibliometric analysis is an invaluable tool for academics, policymakers, and stakeholders trying to mitigate the effects of climate change and solve the difficulties of drought, as it offers a quantitative perspective of the research landscape. It provides a springboard for additional research, teamwork, and the creation of potent plans of action to tackle this urgent worldwide problem. Figure 4 shows the pie chart of subject area on climate change and its impacts on drought.

### 3.4 Leading Research Countries

A bibliometric study of research on climate change and its effects on drought for ten years, conducted in multiple nations, is presented in Table 3 This analysis makes it possible to understand the worldwide research landscape and the contributions made by various countries in tackling this pressing environmental issue. This research is necessary because it can measure and evaluate the amount of science produced, the number of citations, and the degree to which research studies are connected. This helps to identify areas of interest and possible gaps in knowledge. The table displays the total link strength, how interconnected research papers are, the number of documents published, and citations received for each nation. These measurements shed light on the goals of the study, important discoveries, and the overall effect of previous research on drought and climate change. With the most documents (7,565) and citations (99,657) among all nations, the United States leads the pack and has significantly contributed to this field of study. China comes in second with 5,552 documents and 3,520 total link strength, indicating that its research activities are well integrated. The other noteworthy contributors are Germany, the United Kingdom, Australia, Spain, and India.

**Table 3.** Leading research countries

| Countries | Documents | Citations | Total Link Strength |
|---|---|---|---|
| United States | 7,565 | 99,657 | 5,240 |
| China | 5,552 | 36,207 | 3,520 |
| Germany | 2,484 | 38,515 | 3,381 |
| United Kingdom | 2,160 | 72,239 | 3,368 |
| Australia | 2,095 | 25,868 | 2,369 |
| Spain | 1,838 | 22,905 | 2,233 |
| India | 1,716 | 30,163 | 2,020 |
| France | 1,462 | 18,563 | 1,723 |
| Canada | 1,309 | 17,844 | 1,613 |
| Italy | 1,276 | 19,349 | 1,600 |
| Brazil | 1,092 | 12,981 | 1,453 |
| Switzerland | 959 | 11,372 | 1,331 |
| South Africa | 834 | 13,422 | 1,180 |
| Netherlands | 812 | 10,599 | 1,066 |
| Iran | 641 | 15,000 | 994 |
| Sweden | 590 | 8,789 | 971 |
| Pakistan | 549 | 7,264 | 923 |
| Japan | 518 | 9,329 | 834 |
| Portugal | 513 | 10,480 | 798 |
| Czech Republic | 496 | 5,714 | 758 |
| Austria | 488 | 8,680 | 708 |
| South Korea | 488 | 5,232 | 698 |
| Belgium | 462 | 4,245 | 685 |
| Mexico | 449 | 6,749 | 593 |
| Poland | 395 | 6,710 | 548 |
| Turkey | 370 | 4,779 | 546 |
| Indonesia | 366 | 4,532 | 533 |
| Ethiopia | 359 | 3,772 | 525 |
| Chile | 345 | 4,291 | 517 |
| Denmark | 344 | 2,995 | 511 |
| Russian Federation | 339 | 3,910 | 509 |

These countries have generated many papers and received numerous citations, demonstrating the worldwide significance and acknowledgment of their research outcomes. The degree to which research from various nations relates and develops upon one another is shown by the overall link strength measure. High overall link strength scores are found in countries like the United States, China, Germany, and the United Kingdom, indicating a cooperative and multidisciplinary approach to tackling the problems caused by climate change and its effects on drought. Additionally, the table illustrates the contributions of developing countries, like Pakistan, Iran, Brazil, and South Africa, highlighting the global significance of this research and the necessity of cooperative efforts to lessen the effects of climate change on drought conditions globally. This bibliometric analysis offers a thorough overview of the research landscape by examining the nations, documents, citations, and total link strength. This helps researchers, policymakers, and stakeholders identify areas of strength, possible collaborations, and areas that may need more attention to effectively address the urgent challenges of climate change and its impacts on drought. Figure 5 shows the network visualization of leading research countries in VOSviewer.

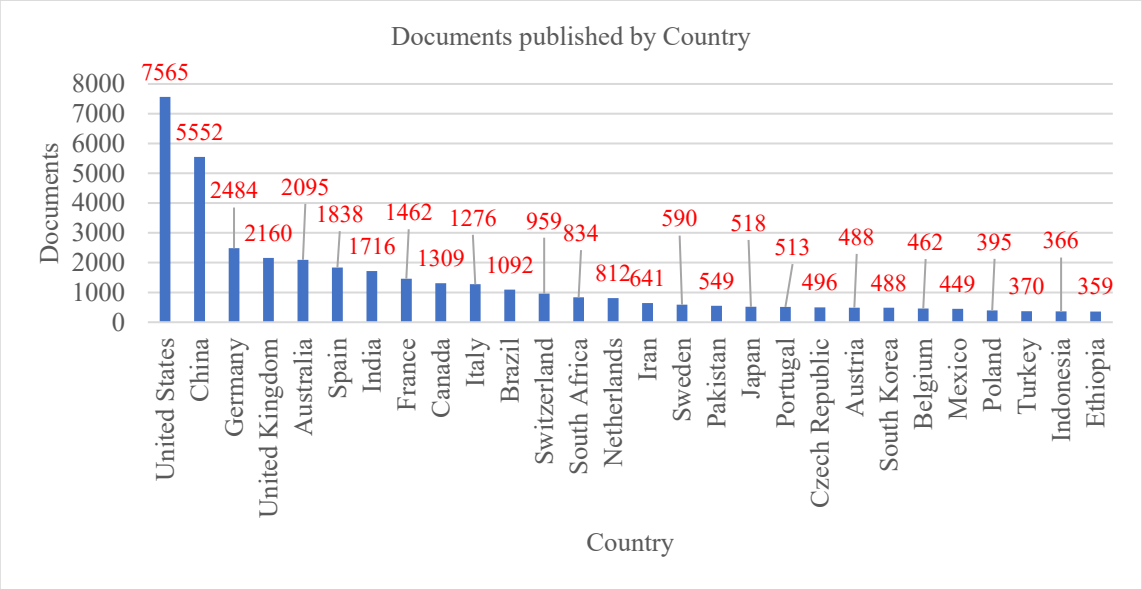


**Figure 5.** Network visualization of leading research countries in VOSviewer

### 3.5 Leading Affiliations

**Table 4.** Leading affiliations on climate change and its impacts on drought

| Affiliations | Documents |
|---|---|
| Chinese Academy of Sciences | 1,945 |
| University of Chinese Academy of Sciences | 827 |
| Ministry of Education of the People's Republic of China | 650 |
| CNRS Centre National de la Recherche Scientifique | 631 |
| Consejo Superior de Investigaciones Científicas | 557 |
| INRAE | 546 |
| Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences | 445 |
| Beijing Normal University | 424 |
| United States Geological Survey | 402 |
| USDA Forest Service | 378 |
| Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL | 365 |
| The University of Arizona | 336 |
| Wageningen University & Research | 331 |
| Commonwealth Scientific and Industrial Research Organisation | 307 |
| University of California, Davis | 295 |
| ETH Zürich | 292 |
| Columbia University | 287 |
| Nanjing University of Information Science & Technology | 276 |
| China Meteorological Administration | 266 |
| University of California, Berkeley | 265 |
| Colorado State University | 261 |

Table 4 presents a bibliometric analysis of affiliations and their publications on climate change and drought. This analysis is crucial as it highlights the leading institutions contributing to this pressing global issue, enabling the identification of significant contributors, collaborations, and knowledge gaps. Chinese institutions like the Chinese Academy of Sciences emerge as top contributors, along with universities and research organizations from countries like the United States, France, Spain, and intergovernmental agencies. Institutions with expertise in relevant fields like geography, natural resources, and meteorology are well-represented, underscoring the interdisciplinary nature of this research. The analysis provides a comprehensive overview of the institutional landscape, facilitating collaborations, research trend assessment, and prioritization of resources for impactful initiatives. With 1,945 documents, the Chinese Academy of Sciences emerges as the most prolific organization, demonstrating China's substantial contribution to this field of study. Figure 6 shows the histogram of leading research affiliations on climate change and its impacts on drought.

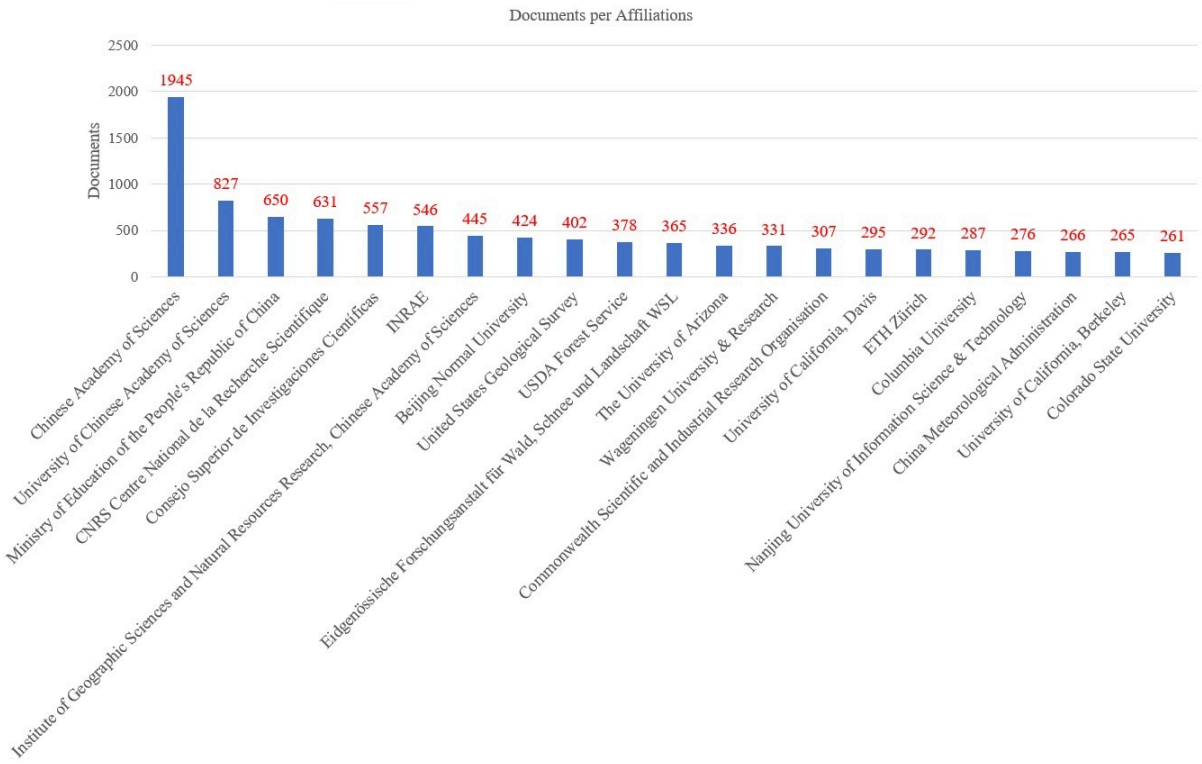


**Figure 6.** Histogram of leading research affiliations on climate change and its impacts on drought

### 3.6 Leading Authors

A bibliometric examination of the prominent writers and their published works on climate change and its effects on drought is given in Table 5. This analysis is critical since one of the most crucial global issues that needs immediate attention and practical answers is climate change and its effects, such as drought. Finding the most prolific writers about drought and climate change studies is the primary goal of this study. By showcasing these crucial scientists and their bodies of work, the study hopes to promote cooperation, information exchange, and the growth of scientific understanding in this critical field. Moreover, it is invaluable for scholars, decision-makers, and interested parties who want to acquire and share information on this vital subject. This research reveals several well-known writers who have contributed significantly to the area. J.J. Camarero is the most prolific writer, having penned 148 publications. A few additional well-known names are J. Peñuelas, P. Ciais, V.P. Singh, and W.R.L. Anderegg. The works of these authors probably offer essential new information and insights into how drought is affected by climate change, laying a solid basis for additional research and comprehension. Additionally, the analysis can assist in identifying new directions in research as well as areas that need more study. It can also help identify possible joint ventures among writers about relevant subjects. Future study orientations can be determined using this information, guaranteeing that the most urgent problems and unsolved issues surrounding drought and climate change are the focus of attention. This bibliometric analysis highlights the authors and their published works and is a valuable tool for future research strategies and resource allocation optimization. Figure 7 shows the network visualization of leading research authors.

**Table 5.** Leading authors on climate change and its impacts on drought

| Authors | Documents |
|---|---|
| Camarero, J.J. | 148 |
| Peñuelas, J. | 84 |
| Ciais, P. | 70 |
| Singh, V.P. | 58 |
| Anderegg, W.R.L. | 55 |
| Gazol, A. | 50 |
| McDowell, N.G. | 47 |
| Trnka, M. | 47 |
| Rigling, A. | 46 |
| Vicente-Serrano, S.M. | 46 |
| Pretzsch, H. | 43 |
| Smith, M.D. | 42 |
| Gessler, A. | 41 |
| Linares, J.C. | 41 |
| Cook, B.I. | 40 |
| Jentsch, A. | 40 |
| Bräuning, A. | 39 |
| Büntgen, U. | 39 |
| Beierkuhnlein, C. | 37 |
| Leuschner, C. | 37 |
| Meir, P. | 37 |
| Lloret, F. | 36 |
| Malhi, Y. | 36 |
| Sangüesa-Barreda, G. | 36 |
| Bugmann, H. | 35 |
| Knapp, A.K. | 35 |
| Ogaya, R. | 35 |
| Sánchez-Salguero, R. | 35 |
| Seager, R. | 34 |
| Cherubini, P. | 33 |
| Eslamian, S. | 33 |

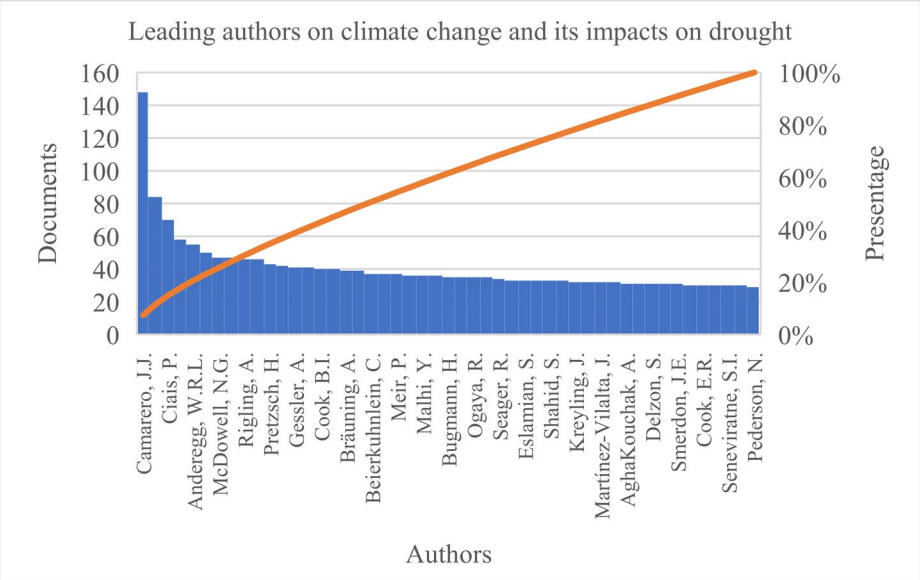


**Figure 7.** Network visualization of leading research authors

### 3.7 Top Keyword Occurrences

Table 6 illustrates the importance and applicability of this study issue by providing a bibliometric analysis of keyword occurrences associated with climate change and its effects on drought. The table shows the frequency of keyword occurrences throughout ten years of study and their overall link strength measure of the keywords' relevance and interconnectedness within the research topic. With 12,212 occurrences and a solid overall link strength of 135,921, the keyword "climate change" has the highest occurrence, highlighting the significance of climate change in this field of study. The keyword "drought" is the second most often appearing one, with 9,704 occurrences and a total link strength of 121,073, suggesting a considerable emphasis on how drought conditions are impacted by climate change. A few more noteworthy keywords that have solid links and high occurrences include "ecosystem", "precipitation", "rain", "human", "water supply", "evapotranspiration", "drought stress", "forestry", "soil moisture", "climate models", and "climate effect". These keywords draw attention to the wide range of topics included in the study, including vegetation responses, water availability, ecosystem dynamics, and the impact of climate models on drought forecasts.

The table offers insightful information on the study's goals and essential conclusions from previous research. Keywords like "ecosystem", "vegetation", "water management", "physiology", "seasonal variation", "trees", "temperature", "remote sensing", "global warming", "rivers", "land use", "soil", "water availability", "photosynthesis", "spatiotemporal analysis", and "rainfall" have a high frequency and strong links, indicating that the research aims to comprehend the intricate relationships between climate change and drought and their effects on a range of environmental factors, including ecosystems, water resources, plant physiology, and spatial and temporal patterns. This bibliometric analysis, taken as a whole, provides a thorough summary of the state of the research, emphasizing the importance of researching drought and climate change, the goals of the studies, and the wide range of results from previous research. The information in the table highlights the significance of this research in tackling the problems caused by drought and climate change, as well as its potential benefits for formulating mitigation, adaptation, and sustainable resource management plans.

**Table 6.** Keyword occurrences

| Keyword Occurrences | Occurrences | Total Link Strength |
|---|---|---|
| Climate change | 12,212 | 135,921 |
| Drought | 9,704 | 121,073 |
| Articles | 1,780 | 40,673 |
| Droughts | 1,658 | 29,455 |
| Nonhuman | 1,061 | 25,549 |
| Drought stress | 1,631 | 23,168 |
| Forestry | 1,327 | 21,744 |
| Soil moisture | 1,284 | 19,799 |
| Climate models | 1,247 | 19,222 |
| Ecosystem | 910 | 18,090 |
| Precipitation | 975 | 17,660 |
| Rain | 1,052 | 17,649 |
| Human | 913 | 17,494 |
| Water supply | 988 | 17,094 |
| Evapotranspiration | 1,047 | 17,016 |
| Climate effect | 1,112 | 16,315 |
| Ecosystem | 888 | 16,148 |
| Water | 837 | 15,501 |
| Precipitation (climatology) | 1,125 | 15,486 |
| Vegetation | 830 | 14,207 |
| Water management | 936 | 13,707 |
| Physiology | 760 | 13,707 |
| Seasonal variation | 739 | 13,621 |
| Trees | 688 | 12,865 |
| Temperature | 716 | 11,750 |
| Remote sensing | 891 | 11,508 |
| Global warming | 925 | 11,423 |
| Rivers | 660 | 11,251 |
| Land use | 606 | 10,613 |
| Soil | 536 | 10,552 |
| Water availability | 604 | 10,422 |
| Photosynthesis | 601 | 10,077 |
| Spatiotemporal analysis | 737 | 10,023 |
| Rainfall | 808 | 9,771 |

The span style of blue represents the figure that uses bibliometrics to analyze existing research on climate change's impact on drought, and the span of green is significant for understanding current knowledge and research gaps; the span style of orange color is the key objective for identifying influential publications and findings. The span style purple also aims to reveal research trends, collaborations, and emerging topics. The red span represents previous studies highlighting increasing drought frequency, climate change links, and severe impacts, and the span-style teal color represents the synthesizing of prior work that can guide future research priorities and policymaking in this critical area Figure 8 shows the network visualization of keyword occurrences.

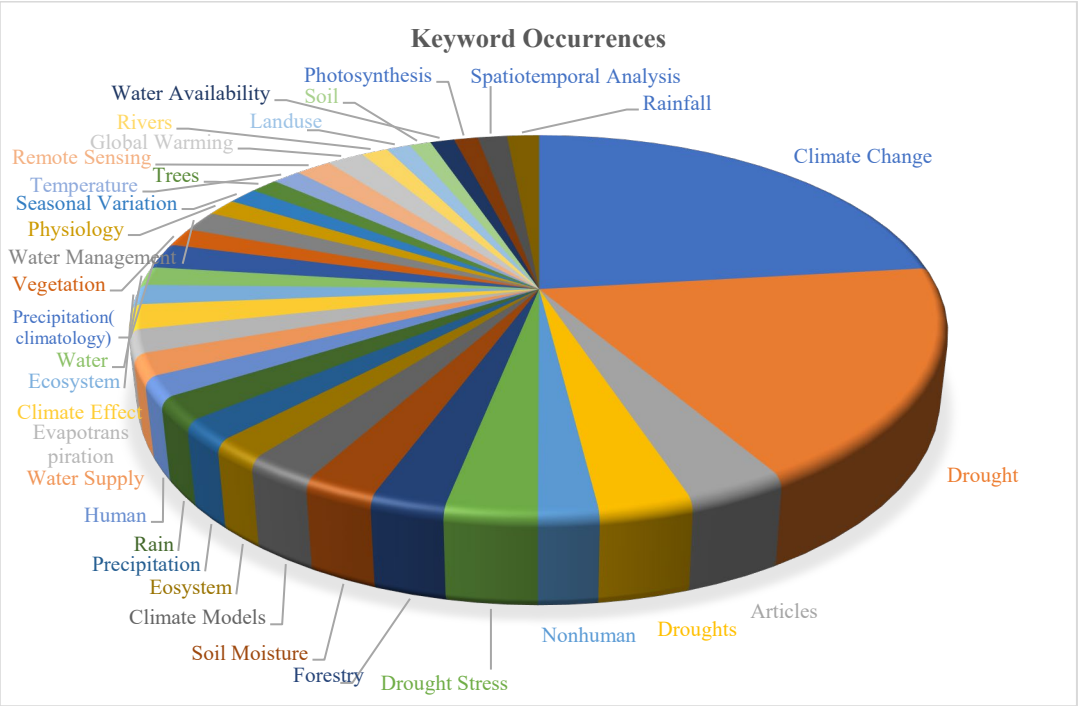


**Figure 8.** Network visualization of keyword occurrences

## 4. Conclusion

The region-specific priorities outlined above demonstrate a comprehensive approach to drought resilience. These include leveraging localized assessments for Southeast Asian smallholders through vulnerability mapping and climate-socioeconomic integration. In Sub-Saharan Africa's arid regions, irrigation systems have been optimized using solar-powered drip technology, while in Mediterranean and North African low-fertility zones, soil moisture retention strategies have been scaled using biochar-compost amendments. Simultaneously, efforts have been made to strengthen global research equity by fostering collaborative networks that address geographic biases. This involves enhancing model validation through region-specific drought indices and localized data integration. Policy frameworks have been implemented to mainstream bibliometric findings into national adaptation plans, and satellite-based early warning systems have been deployed in data-scarce regions. Moreover, traditional knowledge from Indigenous communities has been integrated with modern agroecological practices, aligning all interventions with international frameworks such as the compound risk assessments of the Intergovernmental Panel on Climate Change (IPCC), the targets of Sustainable Development Goals (SDG) for zero hunger and climate action, and the proposed Global Drought Resilience Charter. Together, these efforts aim to transform research insights into actionable and equitable climate adaptation strategies.

Over the past ten years, the study's thorough bibliometric analysis has yielded essential insights into the critical research on climate change and its increasing impacts on global drought patterns. This research effectively illustrates the growing urgency and significance that the international scientific community is attributing to this field of study, as seen by the constantly rising number of publications each year. With significant contributions from top research nations, including the United States, China, Germany, and the United Kingdom, the network visualization demonstrates the wide-ranging international cooperation and substantial investments to address this urgent environmental issue. The examination pinpoints significant establishments, including the Chinese Academy of Sciences and esteemed universities from different nations, propelling multidisciplinary studies to progress understanding in this field. By highlighting well-known writers and their academic works, the study encourages possible partnerships and the sharing of knowledge among specialists around the globe. Most importantly, the analysis of keyword occurrences demonstrates the complex nature of the research goals and essential conclusions.

High-frequency terms such as “drought”, “ecosystem”, “precipitation”, “climate change”, and “water supply” have brought attention to the complex interactions between socioeconomic effects, environmental systems, water resources, and climatic elements investigated. These results highlight the critical need for coordinated strategies, creative modeling methods, and state-of-the-art remote sensing technologies to track, predict, and lessen the harmful consequences of drought made worse by climate change. This bibliometric analysis has produced a thorough quantitative evaluation of the literature, highlighting significant works, new trends, partnerships, and possible knowledge gaps. It provides a solid foundation to direct future research goals, advise policy-making, and build efficient adaptation and mitigation methods by combining noteworthy findings from earlier studies. Ultimately, this vast corpus of work demonstrates the scientific community’s resolute dedication to tackling one of the most urgent environmental issues for halting climate change’s severe and pervasive effects on global drought patterns.

**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 no conflict of interest.

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