КОНСУЛЬТАЦИИ

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BIBLIOMETRIC ANALYSIS OF CLIMATE CHANGE RESEARCH: EDUCATION IN WATER USE

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Abstract. *Introduction*. The population has the right to receive information about the resources it consumes. Given the increase in environmental pollution, there is a need to educate everyone about the use of water. This will make it possible to demand its quality and contribute to the adaptation caused by climate change.

Aim. The study *aims* to carry out a bibliometric analysis of water use in the context of climate change.

Methodology and research methods. The PRISMA method was used for this study. The Scopus database was selected because of its multidisciplinary nature. The search term was checked against the UNESCO Thesaurus. The data were analysed using the R-studio software and the Biblioshiny interface.

Results. A total of 1738 documents were analysed and it was verified that the research topic quadrupled its scientific production since 2012. It was found that the highest scientific production is 18 documents per author; with Swiss journals located in Scopus Q1 are the most prominent and prioritising the research topic. It also highlights that the common themes of the papers are water supply, water use efficiency, and water management. In the same vein, the conclusion is that it is necessary to question the unjustified use of water; otherwise, the resource could disappear.

Practical significance. This study demonstrates the need for the population to learn the meaning of responsible water use, which is why it is recommended that education on water use be implemented to counteract the effects of climate change.

Keywords*:* education, climate change, learning, rights, environmental pollution, water scarcity, R-studio software.

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БИБЛИОМЕТРИЧЕСКИЙ АНАЛИЗ ИССЛЕДОВАНИЙ ИЗМЕНЕНИЯ КЛИМАТА: ОБРАЗОВАНИЕ В ОБЛАСТИ ВОДОПОЛЬЗОВАНИЯ

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Аннотация. *Введение.* Население имеет право получать информацию о потребляемых им ресурсах. Учитывая рост загрязнения окружающей среды, необходимо информировать всех об использовании воды. Это позволит требовать улучшения её качества и будет способствовать адаптации, вызванной изменением климата.

Цель исследования – проведение библиометрического анализа водопользования в контексте изменения климата.

Методология, методы и методики. Для этого исследования использовался метод PRISMA. База данных Scopus была выбрана из-за ее междисциплинарного характера. Поисковый термин проверен по тезаурусу ЮНЕСКО. Данные проанализированы с использованием программного обеспечения R-studio и интерфейса Biblioshiny.

Результаты. Авторами проанализировано в общей сложности 1738 документов и подтверждено, что с 2012 года объем научных исследований увеличился в четыре раза. Было установлено, что наивысшая научная продукция составляет 18 документов на одного автора, причем швейцарские журналы, расположенные в Scopus Q1, являются наиболее заметными и приоритетными для темы исследования. Также подчеркивается, что общими темами документов являются водоснабжение, эффективность водопользования и управление водными ресурсами. Сделан вывод о необходимости поставить под сомнение неоправданное использование воды, иначе ресурс может исчезнуть.

Практическая значимость. Это исследование свидетельствует о необходимости усвоения населением значения ответственного водопользования, поэтому рекомендуется проводить просветительскую работу по вопросам водопользования в целях противодействия последствиям изменения климата.

Ключевые слова: образование, изменение климата, обучение, права, загрязнение окружающей среды, дефицит воды, программное обеспечение R-studio.

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ANÁLISIS BIBLIOMÉTRICO DE LA INVESTIGACIÓN SOBRE EL CAMBIO CLIMÁTICO: LA EDUCACIÓN EN EL USO DEL AGUA

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Abstracto. *Introducción*. La población tiene derecho a recibir información sobre los recursos que consume. Dado el aumento de la contaminación ambiental, es necesario educar a todos sobre el uso del agua. Esto permitirá exigir su calidad y contribuir a la adaptación provocada por el cambio climático.

Objetivo. El estudio pretende realizar un análisis bibliométrico del uso del agua en el contexto del cambio climático.

Metodología y métodos de investigación. Para este estudio se utilizó el método PRISMA. Se seleccionó la base de datos Scopus por su carácter multidisciplinar. El término de búsqueda se cotejó con el Tesauro de la UNESCO. Los datos se analizaron utilizando el software R-studio y la interfaz Biblioshiny.

Resultados. Se analizaron 1738 documentos y se verificó que el tema de investigación cuadruplicó su producción científica desde 2012. Se comprobó que la mayor producción científica es de 18 documentos por autor, siendo las revistas suizas ubicadas en el cuartil 1 de Scopus las que más destacan y priorizan el tema de investigación. También destaca que los temas comunes de los documentos son el suministro de agua, la eficiencia en el uso del agua y la gestión del agua. En la misma línea, la conclusión es que es necesario cuestionar el uso injustificado del agua, pues de lo contrario, el recurso podría desaparecer.

Significado práctico. Este estudio demuestra la necesidad de que la población aprenda el significado del uso responsable del agua, por lo que se recomienda implementar la educación sobre el uso del agua para contrarrestar los efectos del cambio climático.

Palabras claves: educación, cambio climático, aprendizaje, derechos, contaminación ambiental, escasez de agua, software R-studio.

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Introduction

Environmental pollution is a reality. To deny it is irresponsible and lacking in empathy. F. Moroni et al. and E. Vastag mention that human activities increase the effects of climate change [1, 2]. Ignorance is not a reason not to do things right; concrete actions are needed to avoid its increase. The purpose of this study is to identify trends in scientific production on water use in the context of climate change. This study is important because it will contribute to the learning needed for current and future generations.

The study hypothesises that scientific production has increased in recent decades due to the realisation of water scarcity. There is no global plan to deal with the consequences of this problem. According to J. Janssen, water is scarce and its disappearance is related to the absence of decisions and strategies to counteract the effects of climate change [3]. There is no certainty of sustainability in the coming decades, which is why this study focuses on the use of this resource.

R. G. Taylor et al., K. E. Trenberth, J. L. Hatfield et al., C. Azzeddine et al. and V. Phogat et al. mention that citizens have the right to receive information on freshwater supply, water, and food security, learn how to manage these resources, and have access to quality service for their consumption and family well-being [4–8]. This is a challenge that involves the role of the public sector, since, in most cases, it is the one that manages and supplies the resource to the population.

In this order of ideas, it is necessary to carry out a bibliometric analysis of the topic of study. M. Aria and C. Cuccurullo emphasise that bibliometrics is a tool that can be used in all disciplines [9], so this study is no exception. In this regard, J. Gorraiz mentions that it is important to make decisions about the quality and quantity of research in a given area of knowledge [10]. In other words, the identification of thematic trends will contribute to various projects for the benefit of the population.

The research questions are:

– What is the trend of scientific production on water use?

– Which are the most relevant journals whose scientific output is water use?

– Which are the most relevant authors whose scientific production is about water use?

– What are the most used words that stand out in the scientific production on water use?

The aim is to carry out a bibliometric analysis of the topic of water use in the context of climate change. To do so, the most relevant authors, the thematic evolution, and the most productive journals will be mapped.

The limitation of the present study is that only one database was considered.

Literature Review

J. Franklin mentions that the recognition of limits is the beginning of understanding the effects of climate change [11]. This author emphasises that human acts cannot be unlimited; therefore, the exercise of rights will not be either. It must be understood that freedom is not represented by acts of uncontrolled freedom and that every society has a set of binding rules that make social coexistence viable.

W. Steffen et al., C. D. Tomas et al., and M. C. Urban mention that the integrity of the biosphere is related to the protection of humankind and the continuous assessment or prediction of extinction risks [12–14]. T. R. Karl et al. stress that human action modifies natural variability [15]. This proves the need to bring about changes in consumption habits since irresponsibility exists when the consequences on the environment are not measured.

One detail to take into account is that for years the human act was not measured, probably because it was thought that the environmental consequences were only a matter of local concern, i.e. some countries had to comply and find a solution. This is a serious mistake, which is why W. N. Adger mentions that society must adapt to change, as this is the only way to avoid major damage [16]. R. M. Tshimanga stresses that it is necessary to ensure sustainable development based on human-environment interaction [17]. S. Rasmussen et al. and H. Sun et al. state that decisions should not only take into account landscaping in cities [18, 19]. O. Sunday and K. Mourad mention that, on the contrary, it will be about learning how to increase the productivity of existing resources [20]. F. A. Ward and M. Pulido-Velazquez state that water harvesting and its efficient use in the face of scarcity is a concrete challenge for society [21]. In this regard, these authors agree that it is urgent to educate everyone because climate change directly or indirectly affects everyone. To argue otherwise is a lack of empathy and human values.

At this point, it is necessary to reflect on the domestic actions taken by countries. In this respect, C. Payus et al., K. Huang et al. R. Schäffer et al. mention that water management policy contributes to the objective allocation to meet the various supply-related needs [22–24]. T. Nakayama states that water quality is the basis for demanding recognition of the rights of the population and, in turn, expresses the obligation not to waste this resource [25]. F. Schneider mentions that not taking it into account would generate disorder in management, care, and ecological awareness [26]. R. Khanal et al., L. Liang et al. and Ö. Yazici state that the importance of recognising the proper use of water resources will provide sustainability over time [27–29]. The aforementioned authors focus on prioritising water care with the sustainability of this resource, which is a great success; however, it is not always possible to find a state response that effectively and transversally presents a solution.

So, if there are doubts about government initiatives to protect this natural resource, is it possible that every citizen is concerned about self-education? In this regard, V. Re mentions that education on the use of water is a right of the population that includes understanding the correct distribution and supply, and how to avoid health problems and migration due to drought, among others [30].

P. F. Ricci mentions that citizen participation is proof of social inclusion and engages citizens in developing strategies to improve access to water [31]. A. A. Ogundeji et al. and N. R. Haddaway et al. state that it is important to remember that adaptation to climate change must be politically supported. In this way, policymakers will promote guidelines that allow for sustainable development aligned with industrial, domestic and agricultural water demand [32, 33]. These authors emphasise the need to implement mechanisms to disseminate knowledge and the consequences of water misuse.

Methods

Selected Database

The Scopus database was selected. According to N. Donthu et al., this database is characterised by its multidisciplinary nature, which is why bibliometric analysis based on the quantitative method is feasible [34].

Protocol Used

The PRISMA 2020 matrix protocol was used to review the articles. The Scopus database was considered for its representativeness in scholarly information[1].

Method Used

The content analysis method was considered. The present study was considered to be a bibliometric, descriptive, cross-sectional-retrospective study.

Search Strategy

Scopus: (TITLE-ABS-KEY ("climate change" AND "water management" OR "water supply" OR "water quality" OR "water resource" OR "water" AND "water use"). The initial result was 5778 documents.

Procedure Used

The procedure for the final sample collection is detailed below:

1. Identification of search terms

The terms "climate change" AND "water management" OR "water supply" OR "water quality" OR "water resource" OR "water" AND "water use" were selected, resulting in 5778 articles.

2. Thesaurus identification

The term climate change was found to be the main term in this research and is registered in the UNESCO (United Nations Educational, Scientific and Cultural Organisation) Thesaurus[2].

3. Identification of inclusion and exclusion criteria

The inclusion criteria were established as follows: a) Type of document: articles; b) Documents up to 2021, and 2022 were not considered because they were not finalised; c) Open Access documents; d) Language: English; e) Publication status: final; and f) Type of source: Journal. The following were considered as exclusion criteria: i) articles in press, ii) articles not related to the research topic, and iii) articles in languages other than English, resulting in 1738 documents.

4. Scopus Search Identification

The search took into account the title, abstract, and keywords.

5. Identification of the objectives

[1] Elsevier. Why choose Scopus. Scopus Benefits. Elsevier Solutions [Internet]. 2022 [cited 2023 Jun 15]. Available from: https://www.elsevier.com/solutions/scopus/why-choose-scopus

[2] Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura [Internet]. Tesauro de la UNESCO; 2022 [cited 2023 Jun 15]. Available from: https://vocabularies.unesco.org/browser/thesaurus/es/page/concept4559 (In Spanish)

The main objective was to conduct a bibliometric analysis of water use in the context of climate change. The specific objectives were: i) to analyse exponential growth, ii) to identify the most productive journals, iii) to identify the most prolific authors, and iv) to identify the most used words in scientific production.

6. Identification of the tool used

We considered analysing the data using the R-studio 4.1.0 software, the bibliometrix package, and the Biblioshiny interface. The 1738 documents extracted from Scopus in BibTex format were processed in Biblioshiny.

Results and Discussion

A total of 1738 documents were analysed, the oldest was written in 1991 and the annual growth rate is 17.76%. Based on this information, a bibliometric analysis of water use in the context of climate change was conducted.

Table 1

Total citations

Year	N	Mean TC per art	Mean TC per year	Citable years
2021	270	4,40	4,40	1
2020	256	10,11	5,06	2
2019	205	19,82	6,61	3
2018	177	20,35	5,09	4
2017	150	36,22	7,24	5
2016	149	40,68	6,78	6
2015	119	50,13	7,16	7
2014	77	39,05	4,88	8
2013	83	75,25	8,36	9
2012	58	54,41	5,44	10

It can be seen that in the last 10 years the issue of water use in the context of climate change has grown exponentially. The result quadrupled since 2012, the continuous growth is evident and in the last 2 years, it has been moderate.

Three Fields Plot and Source Impact

The three-field diagram shown in Figure 1 consists of three sections: author (left column), journal name (middle column), and author keywords (right column). It is important because, through the connection of grey lines, the thematic trend and the sources of publication can be seen. From this background, the continuity of the research topic is possible.

For example, J. Liu published 18 articles and his highest output was in 2020. For his part, author Y. Wang published 18 articles and his highest output was in 2019 and 2020. Likewise, X. author Li published 16 articles and his highest output was in 2019 and 2020.

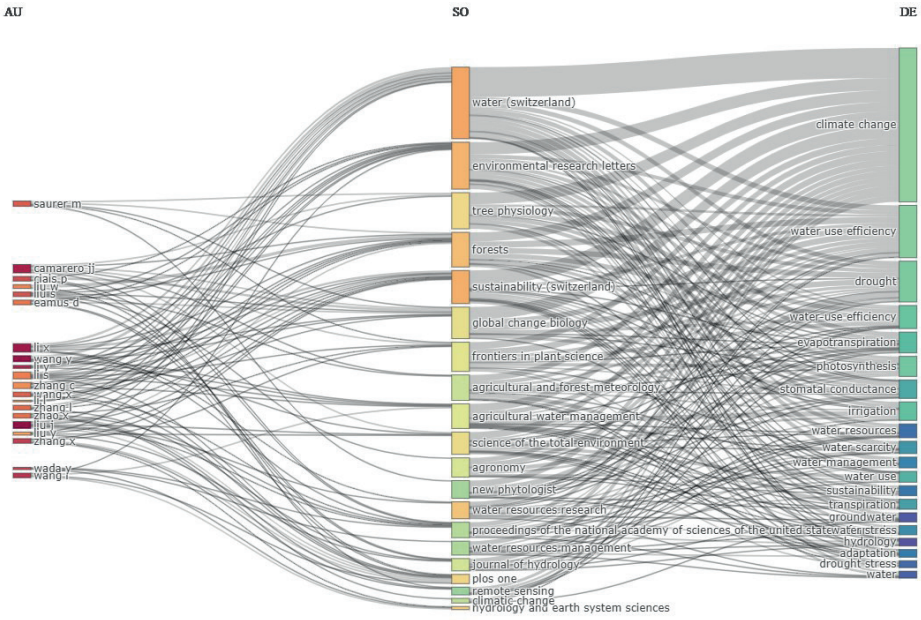

Fig. 1. Three fields plot

The 3 journals that contributed the most and stand out for their impact: are Water (Switzerland), Sustainability (Switzerland), and Environmental Research Letters which are indexed in Scopus Q1, as shown in Figure 2.

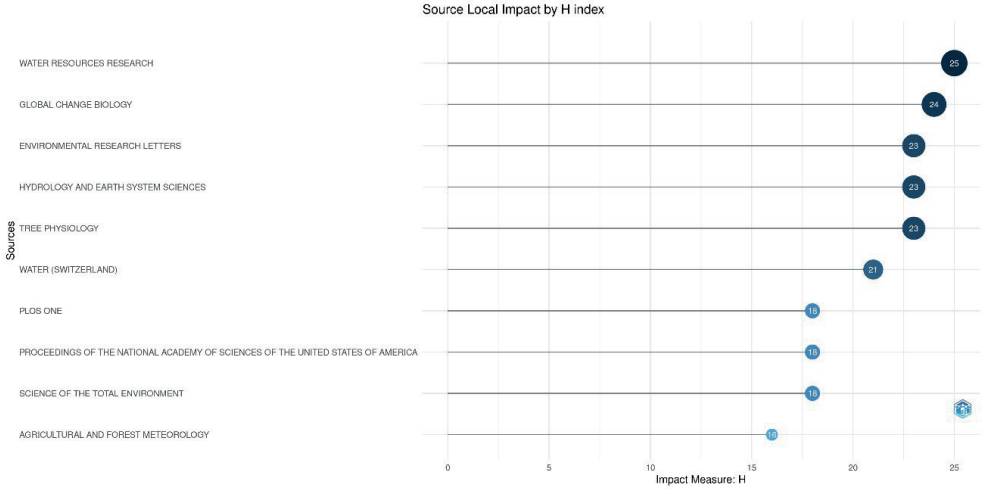

Fig. 2. Source impact

In terms of "author keywords", the 3 most used terms are climate change, water use efficiency, and drought, which show the projection of the research topic.

Most Relevant Sources and Source Growth

Figure 3 shows the number of articles published by the top 10 journals related to the topic of water use in the context of climate change, all of which are ranked in Scopus Q1, thus proving the prioritisation of publication.

In first place, there is the journal Water (Switzerland) identified with ISSN 2073-4441, and, in tenth place, there is the journal Global Change Biology identified with ISSN 1354-1013.

The 10 journals are supported by publishers MDPI (1st, 2nd, and 4th places), IOPscience (3rd place), Wiley (5th and 10th places), Copernicus (6th place), Plos (7th place), Oxford University Press (8th place), and Elsevier (9th place). The UK is the country that stands out for the journals it publishes in this ranking.

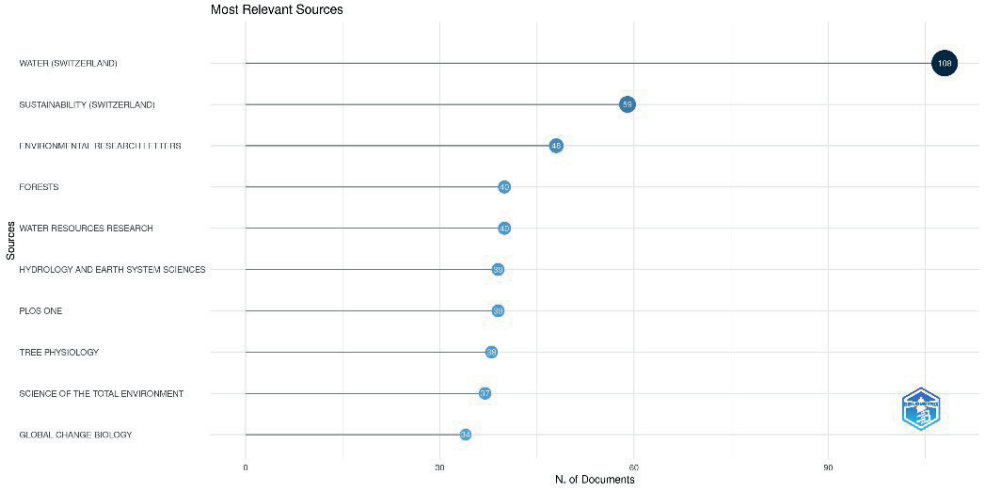

Fig. 3. Most relevant sources

Figure 4 shows that from 2020 to 2021 there was a slight increase related to the research theme. In the journals Water (Switzerland) and Sustainability (Switzerland), the increase is visible.

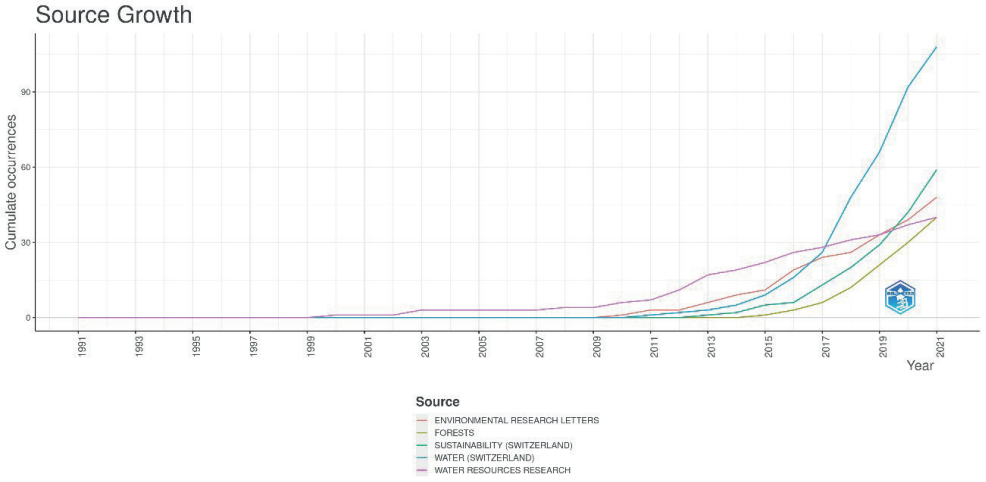

Fig. 4. Source growth

Figure 5 shows that the top three most relevant affiliations are with the University of California (USA), the University of Chinese Academy of Sciences (China), and the Institute of Geographic Sciences and Natural Resources Research (China).

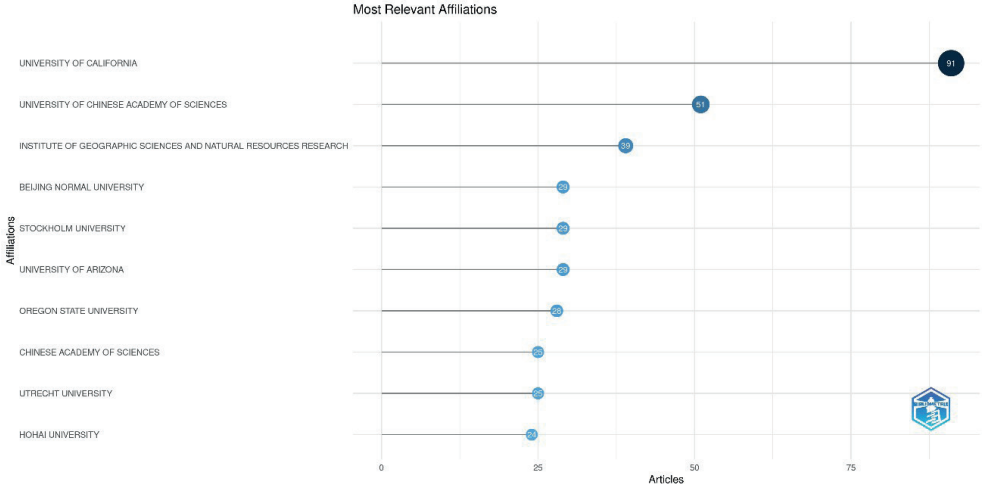

Fig. 5. Most relevant affiliations

Most Relevant Author

Figure 6 shows the 10 authors who stand out on the topic of water use in the context of climate change. In this list, the average number of articles published is 15. The most relevant author on the subject of research is J. Liu.

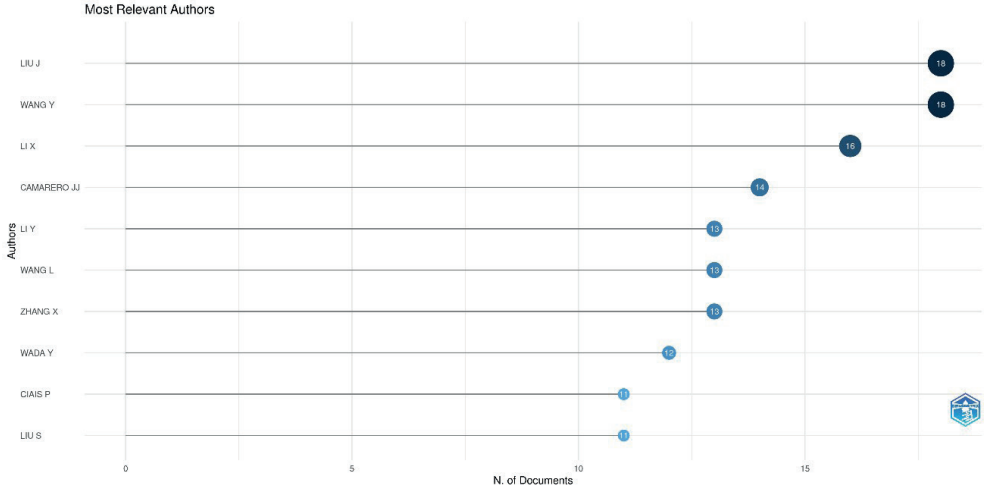

Fig. 6. Most relevant author

Figure 7 also shows the productivity of the authors. The most cited article "Water conservancy projects in China: Achievements, challenges, and way forward" by J. Liu was co-authored with other researchers and was published in the journal Global Environmental Change in 2013. This article has so far reached 238 citations.

The most cited article "Change in terrestrial ecosystem water-use efficiency over the last three decades" by Y. Wang was co-authored with other researchers and was published in the journal Global Change Biology in 2015. This article has so far reached 161 citations.

The most cited article "Differentiating drought legacy effects on vegetation growth over the temperate northern hemisphere" by X. Liu was co-authored with other researchers and was published in the journal Global Change Biology in 2018. This article has so far reached 159 citations.

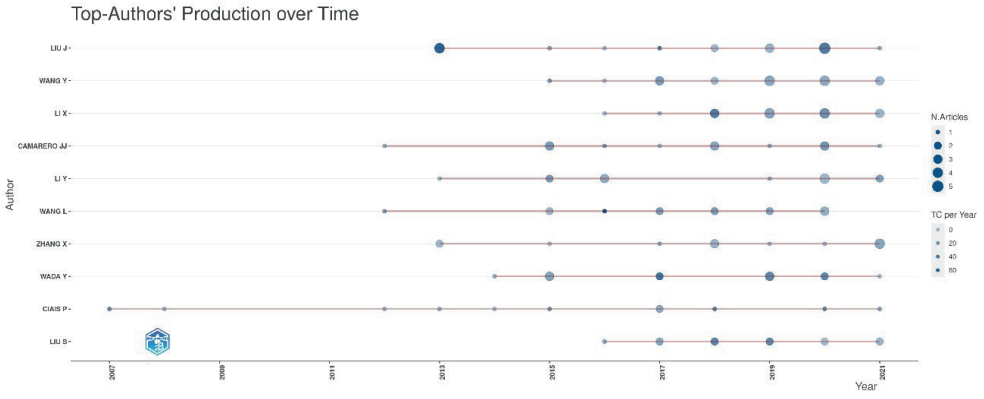

Fig. 7. Top author's productivity

Word Climate Change

Figure 8 shows the trend when using the terms "climate change", "water use", "water supply", "water use efficiency", and "water management".

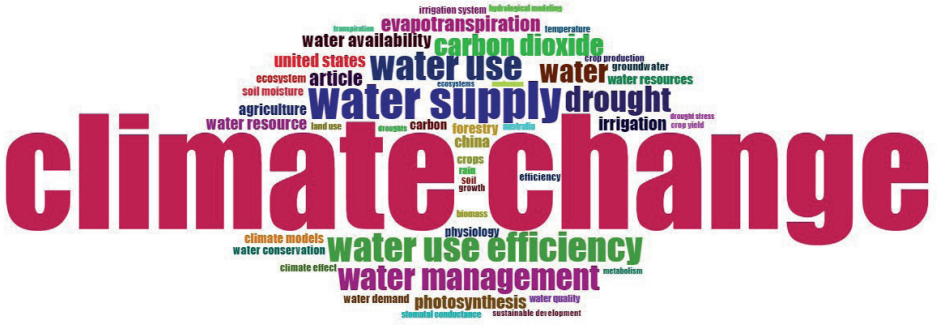

Fig. 8. Word cloud

Figure 9 shows 3 clusters: in red, the term climate change predominates, and the use of efficiency stands out. The green colour is dominated by the term water use and highlights water supply. The blue colour is dominated by the term water and highlights the ecosystem.

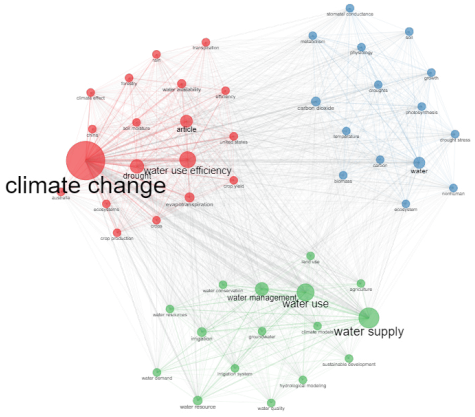

Fig. 9. Co-occurrence network

Figure 10 shows that the terms “climate change” and “water supply” have been present since 1991, which justifies the growth of the thematic trend.

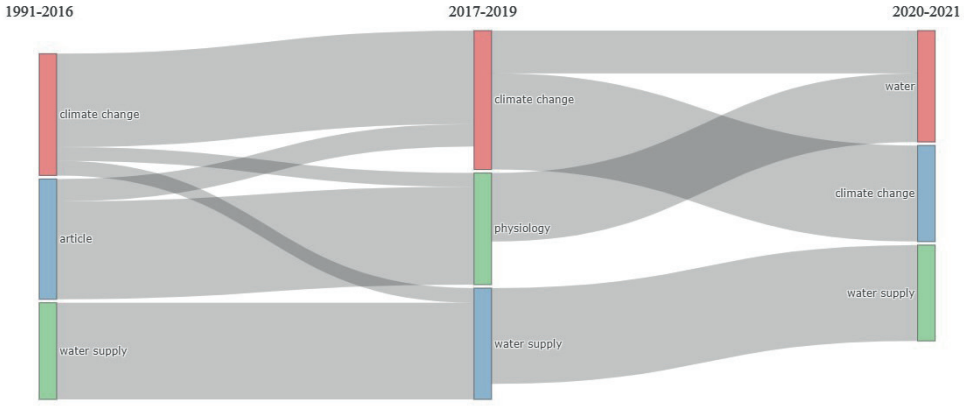

Fig. 10. Thematic evolution

Water use is linked to climate change, as water scarcity will become increasingly evident unless we learn how to supply, distribute, or manage it. This situation has

been of concern to society not only in the last decade. On the contrary, the first recorded research dates back to 1991 and expresses the responsibility to act to preserve it for the benefit of future generations.

The bibliometric analysis was carried out based on 1738 documents. It can be seen that in 2021 the research topic continued to grow, which is a sign to deepen and develop alternative solutions to avoid the scarcity of this resource. It should be remembered that water is a vital element for human subsistence and that the supply is not equitable in the world.

Water education is vital and represents a line of research that could be further explored. Responsible and appropriate actions are complementary aspects of everyday life. It is important to review which human activities should be modified in the face of inappropriate use of this resource.

It is remarkable to recognise the exponential growth of the terms "climate change" and "water supply" since 1991. This pairing focuses attention on the sustainable development of water resources. The number of citations and the concern of countries such as the USA and China to promote research in this field emphasise the need for appropriate water use in the context of climate change. It is important to recognise that water scarcity is a real problem and that uncontrolled water scarcity will affect everyone without exception.

Conclusion

Water scarcity and the appropriate use of this resource are projected as a research topic that will continue to grow exponentially. In the last 30 years, several studies showed this to be the case, and it is, therefore, necessary to analyse human activities in the context of climate change.

The most productive journal on the topic of water use in the context of climate change is Water (Switzerland) identified with ISSN 2073-4441 belonging to the MDPI publishing house.

The most prolific author on the topic of water use in the context of climate change is J. Liu and he co-authored the research entitled "Water conservancy projects in China: Achievements, challenges, and way forward", which has 238 citations.

The unjustified use of water in everyday or industrial activities must be questioned. Human irrationality contributes to the disappearance of this resource. The right of access to water and its quality requires reasonable action in the supply, distribution, or management of this resource. This is a pending task that requires concrete action in the short term.

Education and appropriate use of water is a line of research that needs to be investigated to propose alternative solutions to the effects of climate change.

Limitation

Only the Scopus database was considered. It is recommended that for future research, various databases should be included in order to reflect the integral analysis of the topic studied.

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