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Agricultural drought in the context of climate change: a bibliometric analysis

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ABSTRACT
Objective: To perform a systematic review of the scientific studies carried out about agricultural drought in the context of climate change reported in the last ten years.
Design/methodology/approach: The study was based on the bibliographic review of the referential database Scopus® using the concepts "agricultural drought", "vulnerability" and "climate change".
Results: In the last ten years (2014-2022) the United States, China and United Kingdom stood out in publications on the topic, which are focused on Environmental sciences (33%), Agricultural sciences (22%), Earth sciences (13%), and Social sciences (12%).
Findings/conclusions: The studies published are isolated and there is no conection between the large topics of drought, climate change and vulnerability, thus detecting an area of opportunity to carry out research that unifies these topics.

Keywords: Drought monitor, extreme events, water resources.

INTRODUCTION

Drought is defined as a decrease or absence of rainfall, or else, as meteorological drought (Scarpati and Capriolo, 2016). Concerning the annual index, it happens in a cyclical manner in every climate zone in the world, although with greater intensity and recurrence in arid and semiarid zones (Esquivel, 2002). Drought in Mexico takes place approximately every 20 years and the period can last from one to three years, which alters the water cycle provoking its insufficiency or hydrological drought. This period ends when rainfall normalizes and the normal precipitation index and the functioning of water bodies are recovered (Cerano-Paredes *et al.*, 2009).

Mexico's government, through the Mexican Institute of Water Technology (*Instituto Mexicano de Tecnología del Agua*, IMTA, 2019) points out that droughts are inevitable, unpredictable, without an established trajectory, without well-defined start and finish, recurrent yet not cyclical, and potentially catastrophic.

The causes for drought involve natural factors represented by modifications in atmospheric circulation patterns, variations in solar activity, and phenomena of interaction between the ocean and the atmosphere (Velasco *et al.*, 2005), in addition to anthropogenic factors such as global warming.

According to Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC), it is defined as the modification of climate attributed directly or indirectly to human activity that alters the composition of the world atmosphere and which happens in addition to natural climate variability during comparable periods of time (IPCC, 2013).

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The North American Drought Monitor (*Monitor de Sequía de América del Norte*, SMN-CONAGUA, 2022) classifies drought into: Abnormally dry (D0), Moderate drought (D1), Severe drought (D2), Extreme drought (D3) and Exceptional drought (D4).

Countries such as Canada, the United States and Mexico have worked through the Commission for Environmental Cooperation with the aim of creating greater awareness and expanding the access to early alert systems for drought events, such as the North American Drought Monitor (NADM), which has the objective of describing the drought conditions in North America to allow those responsible for decision-making and citizens equally to understand the vulnerabilities when facing drought and to create resilience in the presence of this phenomenon (Ambiental, 2022).

In Mexico drought is a meteorological phenomenon that has affected agricultural production, impacting primarily the South-Southeast Region of the country. Figure 1 shows the states of the Mexican republic most affected by drought, which are Colima, Michoacán, Guerrero, Oaxaca, Chiapas and Yucatán. These data were determinant for the National Water Commission (*Comisión Nacional del Agua*, CONAGUA) to issue the general agreement for emergency start for the occurrence of severe, extreme or exceptional drought in basins for the year 2022, since out of the 2,471 municipalities of the country, 770 are in some level of drought and 972 are in the stage prior to some level of drought. Consequently, the users of national waters in the municipalities under any drought condition are encouraged to implement Preventive and Mitigation Measures, with the aim of having an efficient use of water (DOF, 2022).

In addition to contamination, it has been seen that water scarcity places food production systems at risk globally. Something else to be considered is that agriculture in Mexico consumes 70% of the total use of fresh water, so steps should be taken to manage this resource sustainably and intelligently and to help agriculture adapt

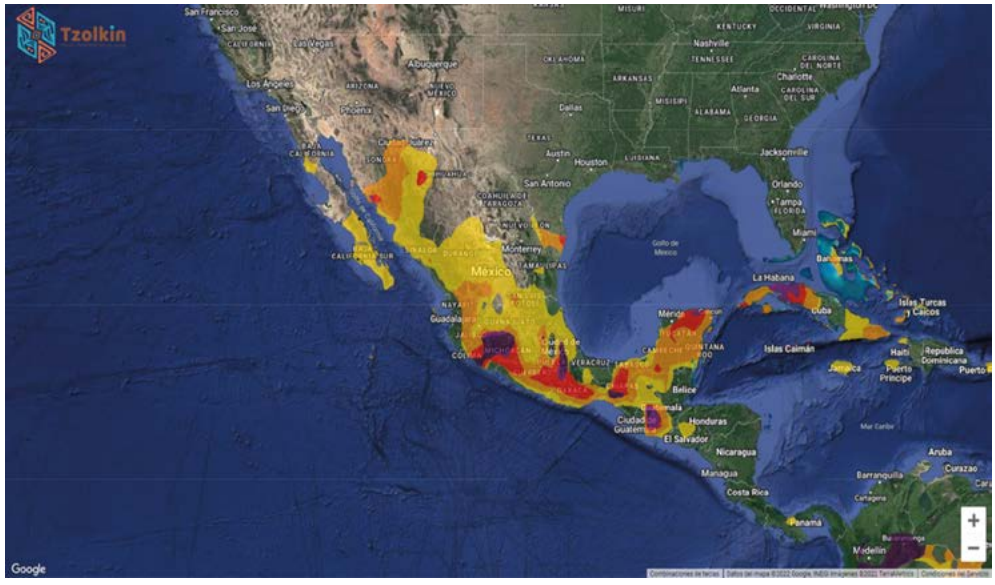

Figure 1. Drought monitor in Mexico, January 1, 2017, to September 30, 2022. Source: Servicio Meteorológico Nacional-CONAGUA 2022.

to climate change (CEPAL, 2012), unlike the water use for domestic use which only represents 10% (FAO, 2013).

Based on this, it is important to revise the theme of drought in Mexico within the context of climate change, in order to reduce the vulnerability and to develop strategies as part of an adaptation process with the aim of making decisions for management and efficiency. Because of this, a bibliometric analysis was carried out with the purpose of identifying and analyzing the studies from the last ten years in the topic of drought in the context of climate change and vulnerability of the agricultural sector.

MATERIALS AND METHODS

A bibliographic review was conducted using the database of Scopus®, exploring the studies carried out around drought in the context of climate change and related to the vulnerability of the agricultural sector.

For this purpose, keywords such as: "*agricultural drought*" were used, and their association with the keywords "*vulnerability*" and "*climate change*".

The search was limited to articles and reviews carried out in the period of 2014 to 2022, and all the documents with this theme in Scopus® were tracked, analyzed and visualized, developing clouds with principal authors, country of origin, and area of knowledge of the scientific journals where these studies have been published.

The data obtained were recorded in a database in Excel and then analyzed with the VOSviewer® 1.6.14 software (Van Eck and Waltman, 2010), through which co-occurrence maps were created, and connectivity of keywords to identify trends and connections of dominions according to the themes to approach drought.

RESULTS AND DISCUSSION

For the period indicated from 2014-2022, 1,221 publications were identified that refer to the keyword "*agricultural drought*"; 6,236 to "*vulnerability*"; and 41,965 to "*climate change*". A total of 435 publications was obtained with the combination of these three keywords (Figure 2).

In 2021 the highest number of publications was found for agricultural drought, 1,050 for vulnerability, and the topic of climate change with the highest scientific production, reaching 7,639 articles. Nevertheless, it must be considered that 2022 had not concluded and the number of articles could possibly be similar. However, when the three themes are related, the production of citations decreases notably reaching only 72 articles, which indicates a low relation of the theme of drought with climate change and vulnerability of the agricultural sector, so there should be more research into the theme although in a context of vulnerability of the drought agricultural sector in the context of climate change.

The three journals with the highest number of scientific articles on agricultural drought are: Water Switzerland, Agronomy, and Frontiers in Plant Science. Concerning the theme of vulnerability, they were: Water Switzerland, Plos One, and Frontiers in Marine Science; for the theme of climate change: Water Switzerland, Forests, and Plos One. And, finally, for the relationship of these three themes, that is, vulnerability of agricultural drought in face of climate change, there were: Climatic Change, Science of the Total Environment,

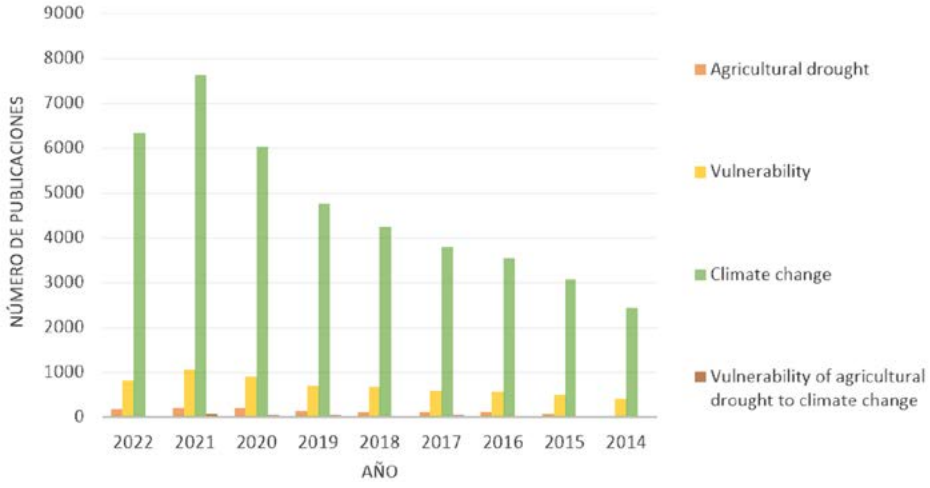

Figure 2. Number of articles on the themes "*agricultural drought*", "*vulnerability*" and "*climate change*" published in the period from 2014 to 2022, consulted on the database Scopus®. Source: Prepared by the authors with data from the search results in Scopus®.

and Climate Change Management. As can be appreciated, these are research themes that are usually published in journals with high impact factor, as well as high impact on the citation of the articles (Table 1).

Evidence shows that the journals that publish these studies are of a high impact factor (IF), led by Remote Sensing of Environment with IF of 13.850 and the journal with lowest IF was Ecosphere with 1.151. Likewise, it was found that the journal with most citations from the contributions performed are Ecology and Evolution with a score of 22.3, and with the highest number of citations, the journal Proceedings of the Royal Society B Biological Sciences with 1.31. This reflects the need for Latin American journals to have a more leading role in publishing scientific studies in this theme, for them to gradually become positioned within this international ranking.

The United States, China and the United Kingdom are the countries with the most articles published on agricultural drought, vulnerability and climate change with 53% of the total (Figure 3), focalized primarily in the environmental sciences, earth and planetary sciences, as well as agricultural and biological sciences.

Figure 3 presents the list of countries that publish scientific articles that connect the three concepts, of which none is Latin American, so this denotes an area of opportunity for Mexican or Latin American JCR journal publications. The main authors that have been published on agricultural drought regarding climate change are presented in Figure 4, as well as their citation rate.

Figure 4 shows that the most cited authors are Opitz-Stapleton, S. from the United States, Trnka, M. from China and Wang, J. from Germany; however, the co-occurrence of the most cited authors are Wang, J. for his article, "Impact of green financing on carbon drifts to mitigate climate change: mediating role of energy efficiency" published in Climate Change Management; Zhang, X. for the article "Sub-diffraction-limited optical imaging with a silver superlens" published in American Association for the Advancement of Science;

Table 1. Main scientific journals with publications about agricultural drought, vulnerability, climate change and vulnerability of agricultural drought in face of climate change obtained from Scopus® from 2014 to 2022.

Theme	Publication	Number of publications	Impact Factor	CiteScore
Agricultural Drought	Water Switzerland	163	3.53	4.8
	Agronomy	53	3.949	3.9
	Frontiers in Plant Science	53	6.627	8.0
	Agricultural Water Management	43	6.611	8.8
	Plos One	42	2.776	5.3
Vulnerability	Water Switzerland	429	3.530	4.8
	Plos One	419	2.776	5.3
	Frontiers in Marine Science	145	5.247	5.2
	Ecological Indicators	136	6.263	8.4
	Forests	116	3.282	4.0
Climate Change	Water Switzerland	2602	3.530	4.8
	Forests	1437	3.282	4.0
	Plos One	1292	2.776	5.3
	Frontiers in Marine Science	1136	5.247	5.2
	Ecology and Evolution	1087	3.167	22.3
Agricultural Drought Vulnerability due Climate Change	Climatic Change	22	4.743	7.1
	Science of the Total Environment	17	10.753	14.1
	Forests	14	3.282	4.0
	Regional Environmental Change	13	4.704	7.4
	Sustainability Switzerland	12	3.889	5.4

CiteScore: Measures the average of citations received by document published in the journal. Source: Prepared by the authors with data from results from the search in Scopus®.

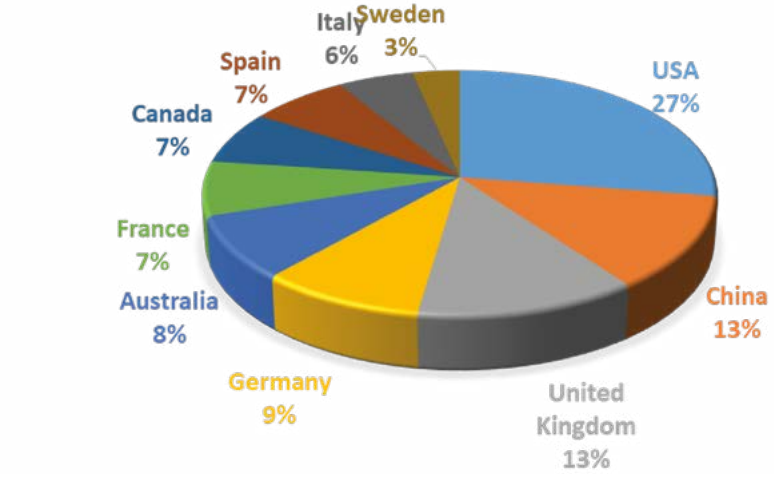

Figure 3. Main countries that publish studies on agricultural drought, vulnerability and climate change. Source: Prepared by the authors with data from results of the search in Scopus®.

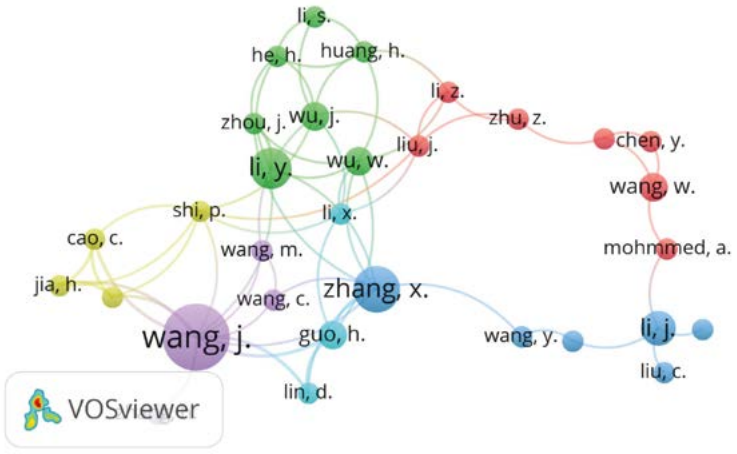

Figure 4. Citation of authors of scientific articles on the vulnerability of drought in the presence of climate change. Source: Prepared by the authors with support from VOSviewer® sotfware.

and Li, Y. for his article "Global Monsoon Dynamics and Climate Change" published in The Annual Review of Earth and Planetary Science.

The financial institutions to carry out research in the theme of vulnerability and drought in face of climate change are represented primarily by the National Sciences Foundation, the National Natural Sciences Foundation in China, and the Chinese Academy of Sciences (Figure 5).

Figure 5 shows that within the financing institutions there is not a Mexican one, although there is one institution from Latin America, the Conselho Nacional de Desenvolvimento Científico e Tecnológico del Ministerio de Ciencia, Tecnología e Innovación from Brazil. The co-occurrence map was obtained after the search in the Scopus® database, combining the three keywords (vulnerability, agricultural drought and climate change), obtained a

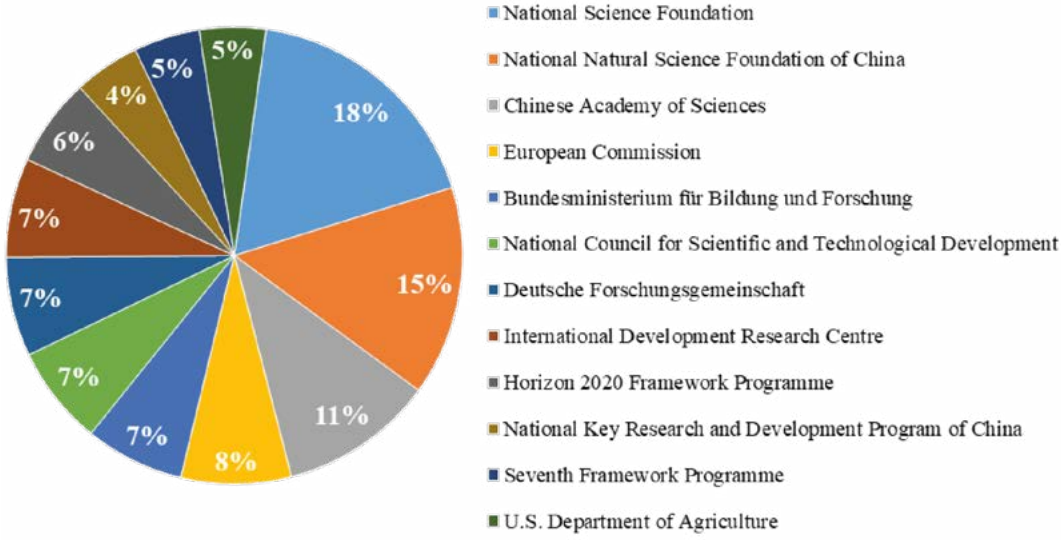

Figure 5. Financing institutions to perform research on the theme of vulnerability of drought in face of climate change. Source: Prepared by the authors with data from search results in Scopus®.

total of 435 articles. An area of opportunity was found to continue with the research on agricultural drought with relation to other themes, and that this is a scientific area of global interest.

In the co-occurrence map, nodes can be seen that determine the importance of keywords within the network. As the nodes are larger, the co-occurrence or citation within a set of data are higher. The distance between two circles represent affinity, and the closer they are the higher affinity. The lines represent the level of co-citation. It can be seen that there is a great affinity of climate change and vulnerability and agriculture (Figure 6).

Figure 6 denotes that the "climate change" and "drought" nodes are the largest. However, it stands out that the studies of seasonal agriculture are related with themes such as food security, sustainability, and vulnerability; and also that the social analysis (psychology) is at its height, the same as themes of technology development for water supply, among others.

When only the keyword vulnerability was used, 6,236 articles were obtained; then, the co-occurrence analysis was conducted and it could be seen that there is a great affinity between vulnerability and climate change, although it is far from keywords such as drought and agriculture (Figure 7). This indicates that the drought is related to the phenomenon of climate change.

Figure 7 shows that there is a principal node, that of vulnerability, which is related with resilience, sustainability, and decision-making. In turn, it stands out that the decision-making node is directly related to climate models and assessment methods. Regarding the keyword agricultural drought, 1,221 articles were obtained and from the co-occurrence analysis it was seen that there is great affinity with agriculture and climate change. However, great affinity was not found with the word vulnerability (Figure 8).

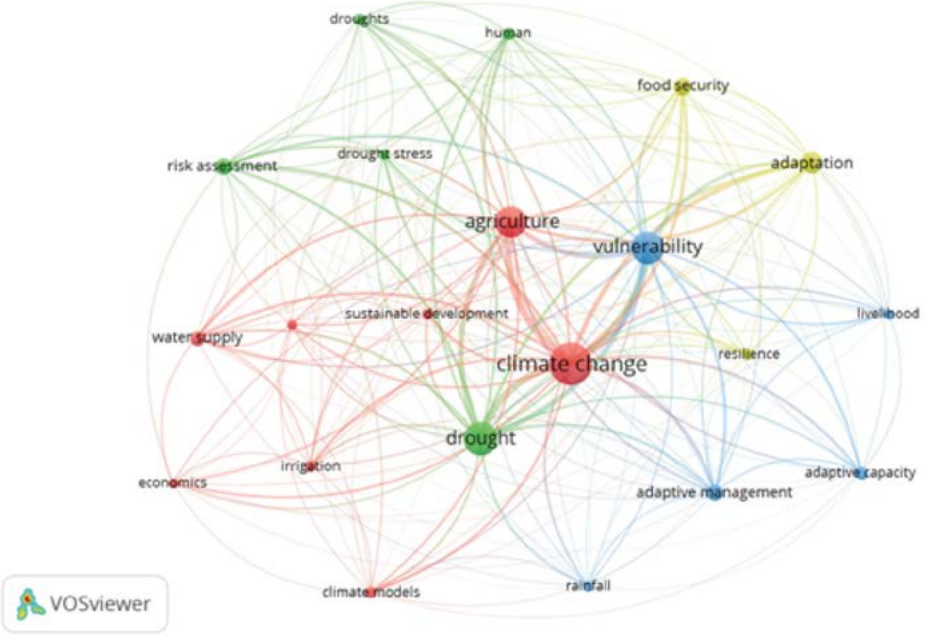

Figure 6. Co-occurrence network from the database of drought vulnerability in face of climate change. Source: Prepared by the authors with support from the VOSviewer® Software.

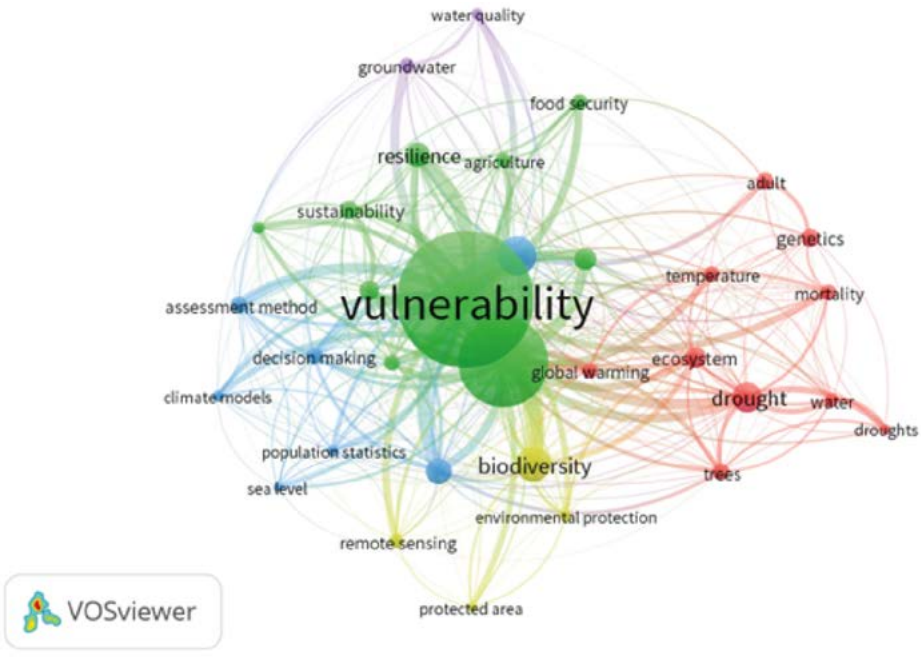

Figure 7. Co-occurrence network of the vulnerability database. Source: Prepared by the authors with support from the VOSviewer® software.

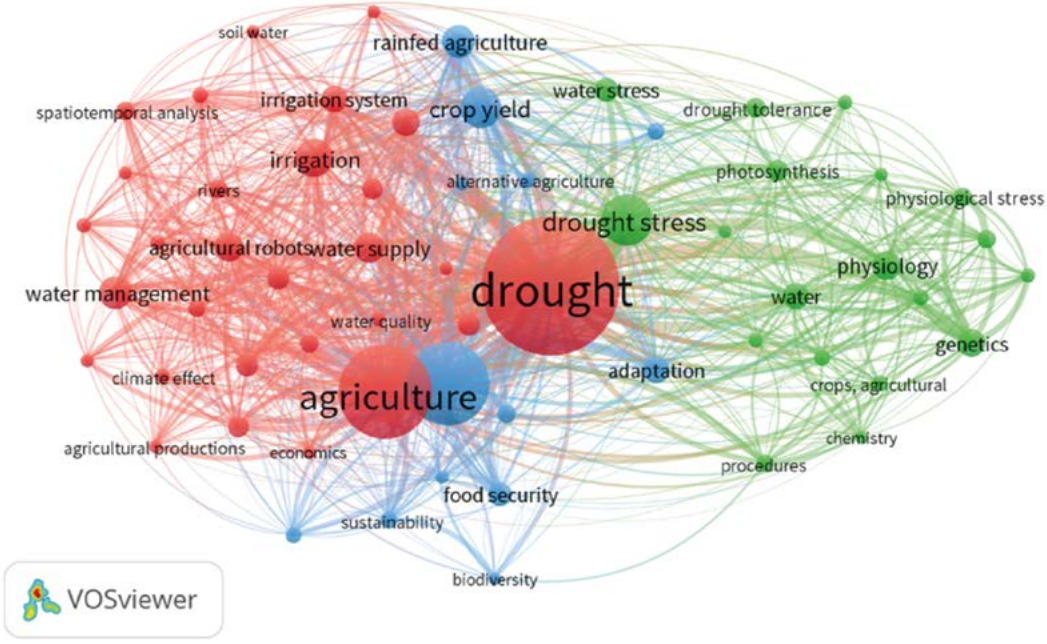

Figure 8. Co-occurrence network of the agricultural drought database. Source: Prepared by the authors with support from the VOSviewer® software.

Figure 8 shows that the principal node of drought is related with agriculture, climate change and stress from drought. These studies are developed with multidisciplinary approaches since the most outstanding node of drought is directly related with the effect of

climate, economy, irrigation, water management, agricultural production, water qualities, supply, climate effect, and space-time analysis. Based on this, there is a great field to carry out studies with inter- and trans- disciplinary approach in order to generate a theoretical-conceptual background to cover more drought scenarios.

Finally, 41,965 citations were obtained for the word climate change and from the co-occurrence analysis it was seen that there is great affinity with drought and agriculture. However, there was not great affinity with the word vulnerability (Figure 9).

Figure 9 shows that the climate change node is related with drought, climate models, and biodiversity. However, when the vulnerability node is located, it is found far from the network, showing more relation with themes such as ecosystem service, agriculture and food security. One of the great attributes of this Vosviewer® tool is that it can identify the areas of opportunity for research development. Therefore, further research is suggested in themes of drought vulnerability in the context of climate change.

CONCLUSIONS

During the last ten years, few scientific studies have been developed on the vulnerability of agricultural drought in the context of climate change, which has been identified through the bibliometric analysis. The leading countries in the development of this theme are the United States, China and the United Kingdom. Therefore, it is an area of opportunity for researchers and scientific journals from Latin American countries so they can enter the ranking of the ten countries that address this global problem.

As strategy for Mexico to be strengthened as one of the main countries to develop this type of studies, as well as managing the financing that fund these studies, it is advisable to

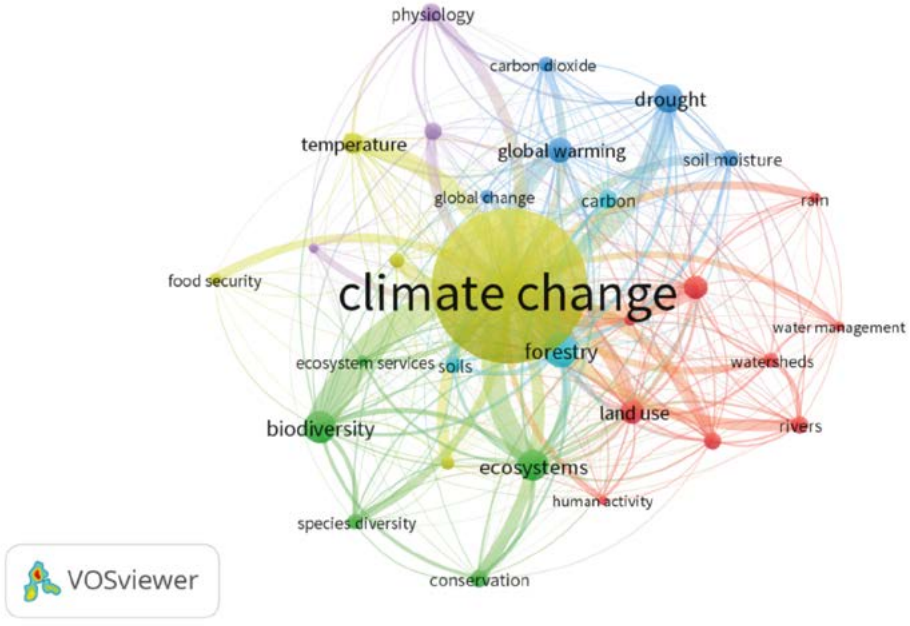

Figure 9. Co-occurrence network of the climate change database. Source: Prepared by the authors with support from the VOSviewer® software.

follow the trends from the United States, taking advantage of the relationship and binding monitoring that arises from the North America Drought Monitor. That is, if Mexico supports the recommendations in the practice about establishing the state of emergency from the occurrence of drought, but it also participates in scientific studies to gradually have a part in the global participation.

Presently, the theme of vulnerability from agricultural drought in the context of climate change integrates multidisciplinary studies such as earth and planetary sciences, biochemistry, genetics, molecular biology, computer sciences, engineering, neuroscience, economic and social sciences; therefore, it is advisable to reach inter- and trans- discipline and to broadly understand these concepts and problems.

As a challenge, it is considered that the periods of drought increase due to climate change, which is why it is necessary to carry out studies that delve into aspects such as vulnerability, resilience, and adaptation actions; in order to adopt practices and strategies to manage the water resource, and as consequence, to reduce the vulnerability in food production in the country without compromising the deterioration of the water resource, which is increasingly scarcer due to its high demand.

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