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GLOBAL TRENDS ON RESEARCH TOWARDS AGRICULTURE ADAPTATION TO CLIMATE CHANGE

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Abstract

Increasing awareness of the importance of food security and human concerns about the changes that have occurred in ecosystems has led to an increase in research on the impacts of climate change on agriculture. Climate change, a topic addressed worldwide, generates imbalances in the agricultural sector on multiple levels, such as: productivity, profitability and labour requirements. The aim of the present paper is to highlight the importance of approaching the subject related to the impact of climate change on the agricultural sector, at the same time emphasizing the existing connections on different fields of study: strategic management, agronomy, ecology, agricultural practices, agricultural policies. The method used in the research used is bibliographic analysis, with the help of which the process of evaluating the relevant sources of information on the subject of "adaptation of agriculture to climate change" is carried out. The results demonstrate the fact that this theme is increasingly addressed by researchers since 1986, the key words being represented on the one hand by the elements of ecosystems, natural phenomena, but also by the effects felt both at the level of producers and at the level of the whole populations.

Key words: *bibliometric analysis, climate change, agriculture*

INTRODUCTION

Climate change is a change in the global environment, especially changes in average temperature and precipitation, attributable to human emissions of green house gases and human activities. These have negative effects on life and the environment, such as extreme weather events, changes in rainfall patterns, ocean acidification and loss of biodiversity. Urgent action is recommended to reduce emissions and mitigate the effects of climate change [11].

Agriculture is one of the sectors most affected by climate change. The specialized studies that deal with this topic have demonstrated the fact that the damage caused by the climate affects both the plant sector and livestock. generating losses in productivity, profitability and manpower. Food security is clearly threatened by climate change causing instability in agricultural production and changes in markets, food prices and supply chain infrastructure [7].

Agricultural adaptation to climate change refers to how agriculture can be adapted to cope with the negative effects of climate change, such as droughts, floods, extreme heat and temperature fluctuations [2, 9].

These may include technologies such as the use of drought-resistant crops, efficient irrigation, the use of organic fertilizers and pesticides, the use of climate change monitoring and farmer information systems. Collaboration between farmers, researchers and governments is also important to find effective andsustainable solutions to climate change in the agricultural sector [3].

Climate is an important factor in agricultural production. In the last decade, in all fields, there has been an intensification of research regarding the potential impact of the phenomena generated by climate change on the economic results of farms as well as on agricultural productivity [6, 15].

Climate change is one of the most important problems facing the world today and has greatly reshaped or is changing the earth's ecosystems. Of course, climate change has always been an ongoing process on earth, but recently, over the past 100 years or so, the intensity of these changes has increased at a

rapid pace. The average temperature has increased by 0.9 °C since the 19th century due to human activity, and this increase is expected to reach 1.5 °C or more by the year 2050 [10].

Climate change can have a major impact on agriculture by altering weather conditions and rainfall patterns. Changes in rainfall regimes can affect agricultural production by reducing irrigation and personal water use. In addition, heavy rains and floods can destroy crops and cause significant economic losses to farmers. In addition, rising temperatures lead to increased evaporation, which affects crop yields and leads to economic losses [5]. Changes in temperature and precipitation regimes lead to changes in vegetation cycles and changes in harvest time. Climate change can lead to increased pest populations and the emergence of new diseases that can affect crops. On the other hand, floods also have a negative impact, with agricultural and coastal areas affected, as well as access roads and infrastructure [12].

Alan Pritchard used the term "bibliometrics" as early as 1969 and it is considered a statistical and mathematical method applied to books and other publications [13].

Recently, bibliometric research has been frequently used in the specialized literature because it has the ability to illustrate a specific or general field of interest [8]. As seen by Broadus (1987) [1], bibliometrics involves the quantitative study of published works, bibliographic records, or both. Bibliometrics is described as a mathematical and statistical method that transforms the nature and state of written communication [8, 14].

Daim (2006) argues that this approach aims to explore, organize and analyze large-scale data from historical inputs to observe unseen patterns, topics that will be easier for researchers to understand [4].

The aim of the paper is to provide an overview of the research carried out on the subject of "adaptation of agriculture to climate change", starting from 1986. Furthermore, by bibliometric analysis, the related fields of interest to the studied subject will be identified, as well as the countries that give special interest to it.

MATERIALS AND METHODS

In order to determine the evolution of the inclusion of the topic related to climate change in the field of research, a retrospective and descriptive bibliometric study was carried out through the Web of Science platform [17].

Through the Web of Science database, scientific articles on a specific topic were exported in text format, and with the help of VOSviewer software, graphical images were generated that included keywords from the publications and their usage by year. Also, images were generated that indicate the countries that attach particular importance to the researched topic.

The results of the search in the database specified above, on the topic "climate change agriculture", returned a number of 21,630 papers, from the year 1986 to the year 2022. The results were sorted by relevance, and the first 1,000 records were exported to Excel as plain text for analysis with Excel and VOSviewer.

RESULTS AND DISCUSSIONS

Numerous studies show the population's concern about climate change, especially among producers who have faced major imbalances in recent years. Thus, the special importance is highlighted by the number of 21.6 thousand scientific works whose key words in the description, title or summary include climate change and agriculture, in the period 1986-2022.

The fields in which these scientific papers were included were represented by environmental science (7.4 thousand papers), environmental studies (2.8 thousand papers), atmospheric science methodology (2.6 thousand papers), water resources (2.1 thousand papers), multidisciplinary geosciences (2 thousand papers), agronomy (1.8 thousand papers), ecology (1.7 thousand papers), green sustainable scientific technology (1.6 thousand papers), multidisciplinary agriculture (1.4 thousand works), etc. Other fields in which papers have been published on climate change in agriculture are biology, agricultural

engineering, horticulture, management, analytical chemistry and biophysics.

Analyzing Figure 1, it can be seen that the maximum number of specialized papers on the subject of interest was reached in 2011 when 77 articles were published. It can be seen that starting from 2007 the number of publications began to increase, being 2.5 times higher than the previous year (41 publishers compared to 16).

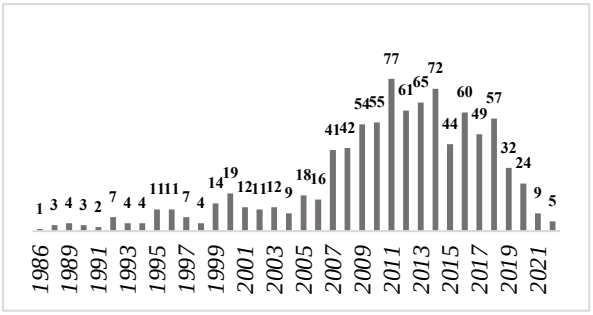

Fig. 1. The number of specialized papers existing in the data base

Source: own processing based on WoS results using Excel.

Even if in recent years, the number of articles written on this topic has decreased, the topic remains topical both for producers and researchers. This is probably due to the fact that new concepts have been developed, attention being directed not so much to the phenomenon itself, but to methods of adaptation and resistance to climate change, the focus being more recently on the development of intelligent farming systems in from a climate point of view, sustainable management of waterresources, maintenance of soil quality in the context of desertification and aridification of the climate in certain regions.

Figure 2 shows words interrelated with climate change, namely adaptation, vulnerability, variability, sensitivity, drought, irrigation, emissions, changes in impact, conservation, biodiversity, foodsecurity, and economic impact. Thus these words are included in 5 clusters as it can beseen in Figure 2.

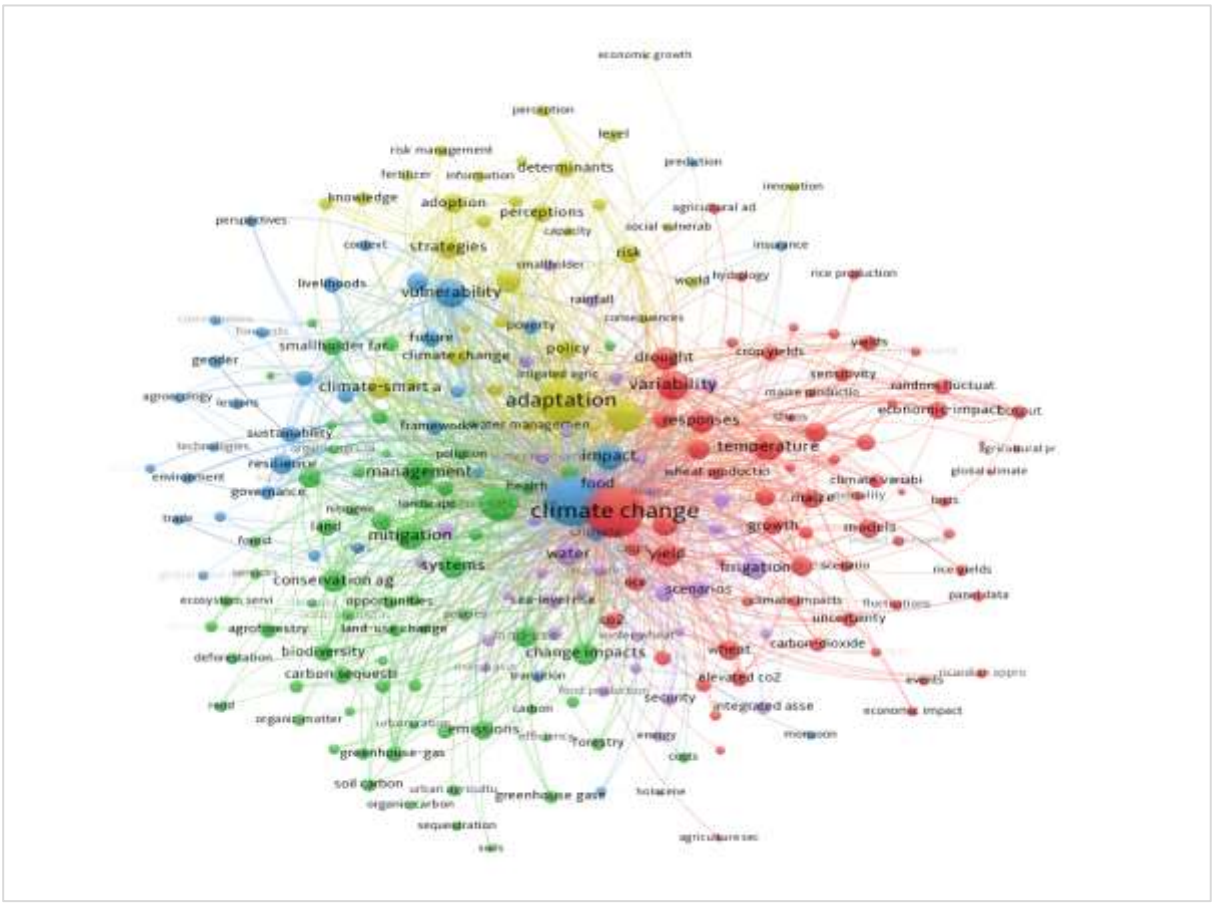

Fig. 2. Connectivity of key words used (climate change, agriculture) with other related terms

Source: own processing based on WOS results using VOSviewer.

The 1st cluster refers mostly to temperatures, drought, variability, yields, carbon dioxide emissions, global climate, climate variability, crops, focusing on the production of wheat, rice, peas, but also on the impact that climate change has on producers such as uncertainty, stress, sensitivity, events, economic impact, fluctuations and responses. Cluster 2 includes terms such as outlook, vulnerability, environment, sustainability, organic, future, trade, global food, forecasting, resilience, government, livelihoods, technologies, agrotechnologies, community.

Cluster 3 is associated with adaptation, strategies, smart agriculture, fertilizers, information, risks, perceptions, determination, capacity, knowledge, risk management, policy.

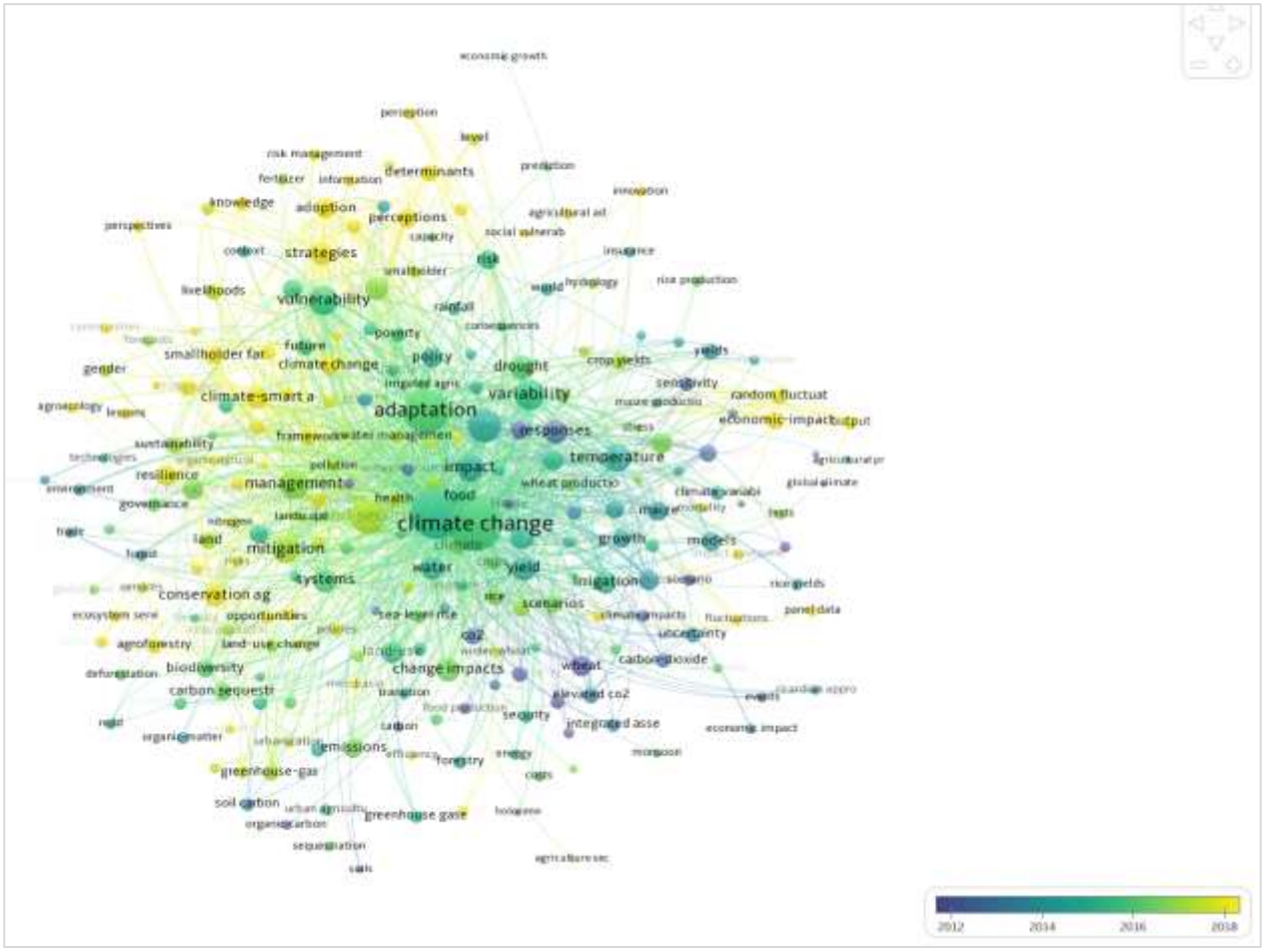

Fig. 3. Linkage of climate change in agriculture with other related terms by year
Source: own processing based on WOS results using VOSviewer.

The 4th cluster emphasizes food security and the environment, being interconnected with biodiversity, management, migration, urbanization, environment, deforestation, conservation, sustainable agriculture, ecological agriculture, impact of changes, small producers,
rural agriculture, agroforestry, pollution, carbon, emissions, forest.

The 5th cluster includes terms such as economy, security, energy, sea level rise, water basins, water resources, small producers, precipitation (Figure 2).

Furthermore, Figure 3 shows the links between the key words used in the data base search and other related terms that have been used over time in different publications. Thus, in 2012 and 2013, studies focused on water resources, carbon dioxide, economic impact, environment, trade, food production, scenarios, organic carbon, uncertainty, responses, integration, rise ofsealevel.

In 2014 and 2015, the key words used in specialist papers were yields, water, technologies, transition, models, growth, temperatures, impact, science.

In 2016 and 2017, the spectrum of key words interconnected with climate change expanded, using terms such as biodiversity, water, precipitation, drought, land use, sustainability, adaptation, vulnerability, impact of changes, management, migration, risks, systems. Later in 2018, the focus shifted to the use of adaptation practices, with the main topics being smart climate, strategies, adaptation, foodsecurity, health, information, agroecology, perception, vulnerability, conservation, crop production, risks, impact economic, fluctuations, fertilizers (Figure 3).

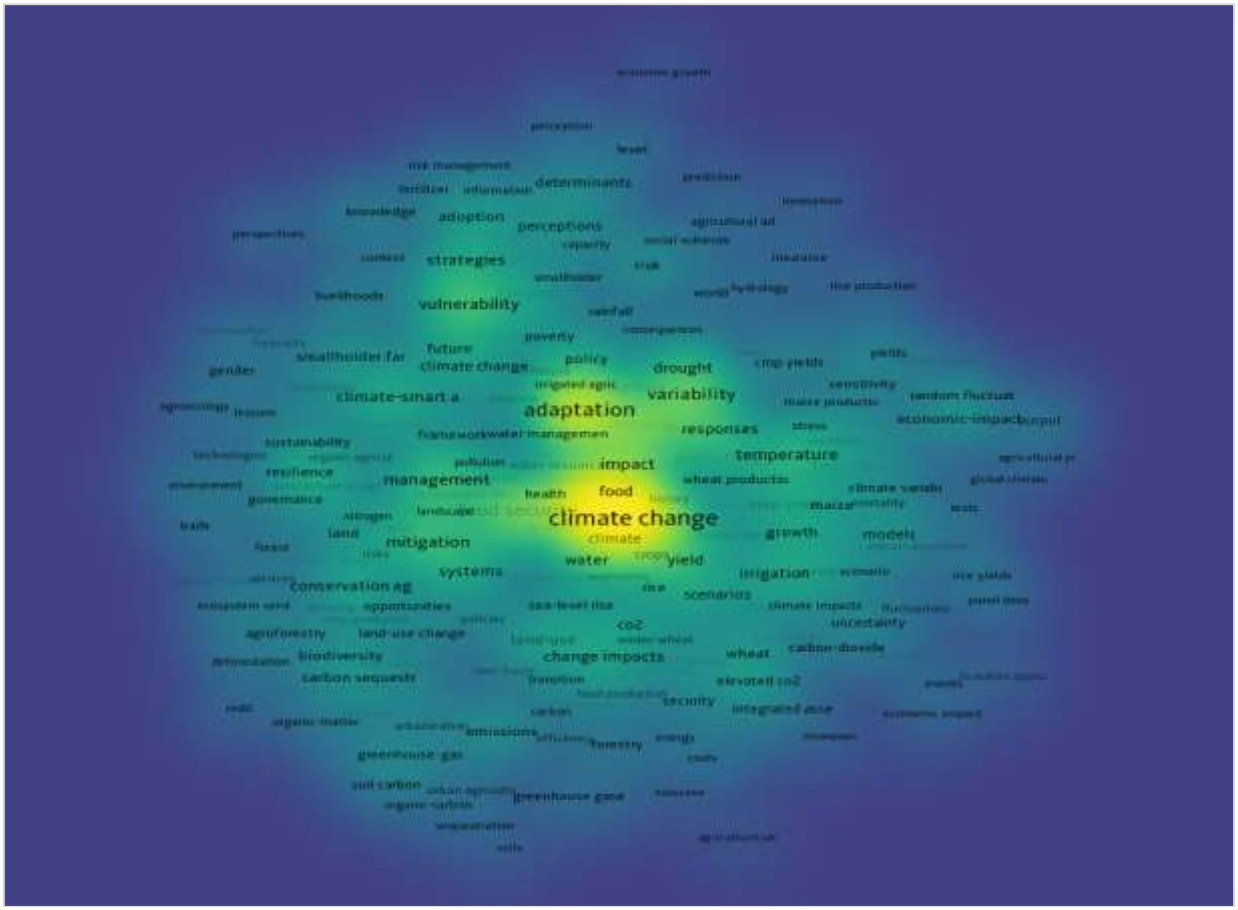

Fig. 4. Graphic representation of key words density
Source: edited by authors based on WOS results using VOSviewer.

In Figure 4, the density of key words is presented, which is represented by a color, and this color depends on the number of articles made in the vicinity of the node. Thus, the yellow color shows the key words that are most frequently used, while the blue color shows the least-used words in specializedworks.

It should be noted that there are groups of words such as "climate change", "adaptation", "vulnerability", "agriculture" and "foodsecurity" which frequently returned among the basic key words in the literature (Figure 4).

Analyzing the frequency of co-authors per country, we can observe the degree of relationship between the countries most interested in research on the specified topic.

In Figure 5, different colors can be seen on the map, illustrating the diversification of research directions. Large nodes are countries of particular interest in our study, and connections between nodes represent cooperative relationships. The distance between the nodes and the thickness of the connections represent the level of cooperation between the nodes (Figure 5). The United States of America, together with England,

Austria and Germany, pay special attention to the analyzed topic. It is also noted that Germany, Belgium, Poland, the Netherlands, Sweden show a high degree of cooperation. On the above map, Romania is missing, showing the low degree of cooperation with the other countries shown on the map (Figure 5).

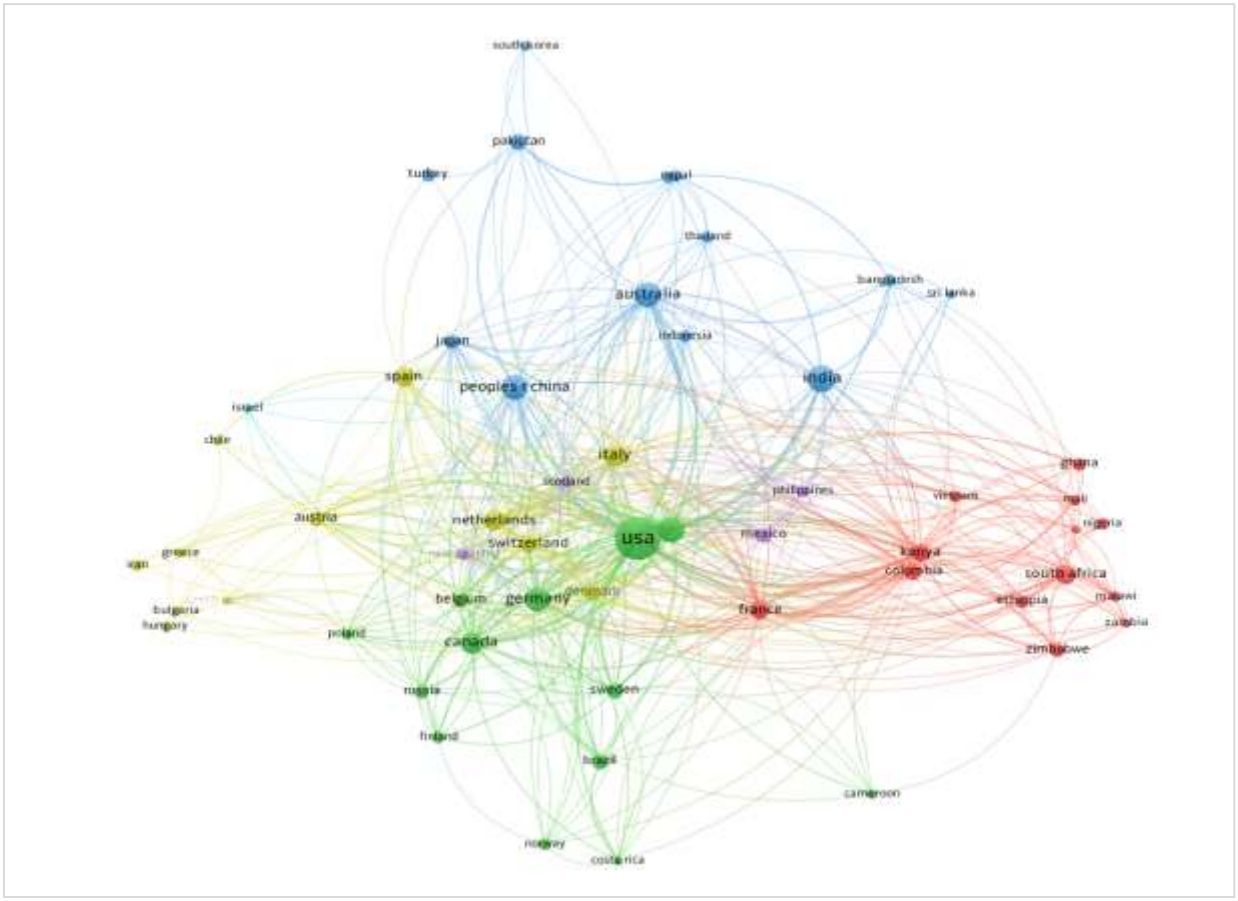

Fig. 5. Graphic representation of co-author countries
Source: edited by authors based on WoS results using VOSviewer.

The past 20 years have seen both the highest global temperatures and the highest number of natural disasters. Is possible that the impact of climate change on agriculture to be uneven across the world. In the future, increased drought is likely to reduce agricultural production in some regions while other may benefit from climate change by extending the growing season—plants will have more time to grow, flower, and bear fruit.

CONCLUSIONS

The paper analyzed theimportance of the research topic "climate changes, agriculture", the articles published in the period 1986-2022 being analyzed.

The numerous specialized works identified show the increased interest in the study of these phenomena at the level of the agricultural sector, from the point of view of the impact on productions and generated incomes.

Following the analysis, the results show that since 2006, the number of researches has doubled from 16 publications per year to over 40 publications per year.

Moreover, the frequency of related words used confirms that climate change is a key element for food security, environment, sustainability, health and economic impact.

Thus, we can affirm the fact that the subject related to climate change and the agricultural sector is a topic researched at a global level for the food safety of the population, but also the environment, biodiversity and sustainability, concerns that directly affect producers, being illustrated by key terms

encountered in there search such as sensitivity, vulnerability, adaptation, risk, uncertainty, economic impact and production fluctuations.

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