



Understanding the Link between Population, Agriculture and Carbon Dioxide Emissions: A Bibliometric Analysis of Studies in the Web of Science

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Abstract: *The relationship between population, agriculture, and carbon dioxide emissions has been an issue of concern to scientists and institutions for many years. Concerns about the impact of population growth on the environment and agriculture go back several decades. As the world's population continued to grow, scientists and researchers became increasingly aware of the potential consequences of this growth on food production, resource use, and greenhouse gas emissions. A growing population means higher demand for food. This has increased pressure on agriculture to produce more food, often leading to increased acreage and more intensive farming methods. Intensification involves the increased use of fertilizers, pesticides, and machinery, which can lead to higher greenhouse gas emissions. The goal of this study is to quantify the contribution of agriculture and population growth to carbon dioxide emissions. In this context, 412 papers were found on the Web of Science. Papers in this area often address the role of agriculture in greenhouse gas emissions, including its direct and indirect effects on the carbon cycle. Although most studies were published in 2020, the number of publications has changed over time as regulations in the field have emerged. The data show that the country with the most authors is China, which is recognized as a country with a significant increase in scientific research.*

Keywords: *Agriculture; Carbon Dioxide Emissions; Population; Bibliometric Analysis; Studies.*

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Introduction

Recently, increasing attention has been paid to the sometimes-devastating effects of climate change, as well as to the factors that condition it. The population contributes systematically and in many ways to environmental pollution and degradation. A growing population requires more food and therefore places an increasing burden on the environment. Since agriculture is often considered as one of the main sources of environmental pollution (Al-Ayouty et al., 2021; Appiah et al., 2018, Pachauri et al., 2014, Ministry for the Environment, 2023), we thought it necessary to analyze the importance that scientists and institutions have given over time to the relationship between population, agriculture and carbon dioxide emissions.

The present study aims to perform a bibliometric analysis of the relationship between population, agriculture and carbon dioxide emissions. In this sense, information from the Web of Science was used for the period 1990-2022.

This type of analysis was used to identify trends in research over the past decades, providing a valuable historical perspective. On the other hand, the study includes information on shifts in focus, emerging topics, evolving methodologies, prolific authors, research institutions, and countries that have made significant contributions to the literature. This information can contribute, among other things, to a global understanding of these topics and, not least, to the promotion of collaboration and knowledge sharing in the field.

During the period studied, there have been several studies and research that have examined the relationships between population, agriculture, and carbon dioxide emissions (Kwakwa et al., 2022).

The agricultural sector contributes significantly to carbon dioxide emissions through various processes such as deforestation, livestock production, and fertilizer use. Therefore, a low-carbon agricultural economy is considered the best option for sustainable economic development and also for combating global climate change (Xiong et al., 2016).

These studies are critical to understanding how human activities, particularly in the agricultural sector, contribute to greenhouse gas emissions and impact the environment.

Deforestation for agriculture, particularly for livestock grazing and crop production, releases large amounts of carbon stored in trees and soils into the atmosphere.

In addition, land use changes for agriculture can also result in the loss of carbon sinks such as forests and wetlands that would otherwise absorb carbon dioxide from the atmosphere.

Although agriculture is considered a major contributor to pollution, research in the field shows that there is a reciprocal relationship. For example, agriculture is affected by pollution due to the changing climate from year to year (Aboyitungiye & Suryanto, 2021; Rehman et al., 2021).

Another category of studies focuses on sustainable agricultural practices as a means of reducing carbon dioxide emissions. In this case, it is indicated that sustainable agricultural practices such as agroforestry, no-till, and organic practices can help sequester carbon in soils and reduce emissions using technological innovations (Chang, 2013).

Analysis of the work results shows that there is a clear positive relationship between population growth and carbon dioxide emissions. As the world population increases, the demand for resources and energy also increases, leading to higher emissions.

Other studies (Xiong et al., 2016) concludes that measures such as better mobility planning, increased use of electric vehicles, improved energy generation from renewable sources, and promoting the absorption capacity of carbon sinks are essential in the face of climate change challenges. These measures can play an important role in reducing greenhouse gas emissions and addressing the impacts of climate change (Cruz-Pérez et al., 2022).

It is also emphasized that there are often regional differences in the contributions of population, agriculture, and carbon dioxide emissions (Suh, 2018). Different countries and regions have unique challenges and opportunities when it comes to mitigating emissions. For example, in certain regions or countries, emissions from agriculture are lower than those from transportation or industry (Latif et al., 2020).

Balogh (2019) believes that carbon footprint can be strongly associated with economically less developed countries. A developed country with technology-based agriculture reduces energy consumption and thus carbon emissions (Guo et al., 2022).

Results and Discussions

Website Web of Science found 412 documents which cover the subjects of population and agriculture and carbon dioxide emissions, and which were published between the years 1990 and 2022, all of which were exported and downloaded in a single database in text file format.

As shown in Figure 1, the number of publications on population, agriculture and carbon dioxide emissions increased from 1990 to 2022 without regularity. The number remained very low from 1990 to 2009, never exceeding 10 and occasionally decreasing a little (and in the interval 1990-1992, it was null). From 2010 to 2020, the number grew significantly, but still fluctuated. It suddenly shot up in 2020, reaching its highest point, then continued to decrease. All in all, there is no cohesive trend. There are a lot of dips in the trend and they occur very randomly. Hence, no clear conclusions can be drawn.

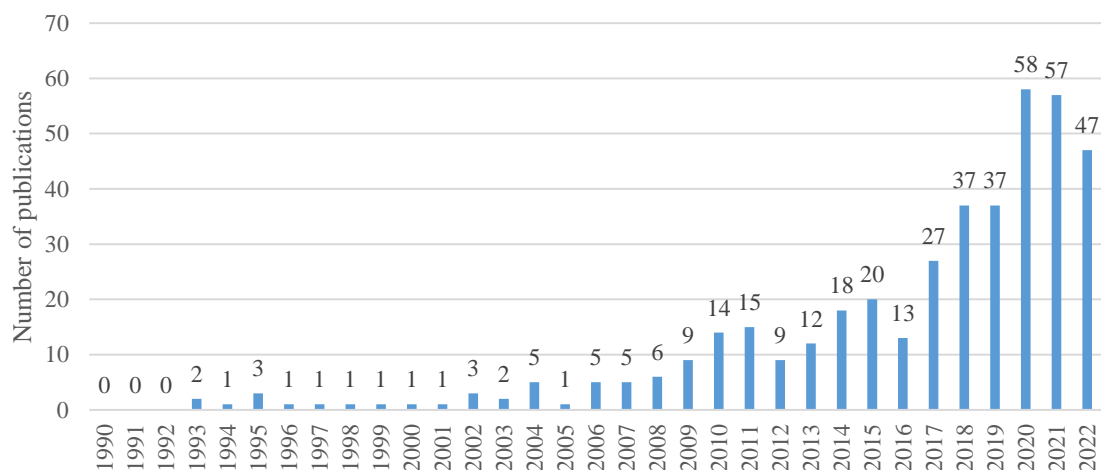


Fig. 1. The yearly evolution of the number of publications on population, agriculture and carbon dioxide emissions from 1990 to 2022

Source: Author’s own research based on a Web of Science database in the Excel program.

As it can be seen, there were periods when the interest of researchers increased. It is important to state that the regulations in the field probably had a positive influence on the number of studies. In 1992, the Rio Declaration laid the foundations for international action to protect the environment and sustainable development. Until now there have been other important regulations such as: the Kyoto Protocol (1997), the United Nations Conference on Climate Change (COP21) - the Paris Agreement 2015, the European Green Pact (2019), the "Fit for 55" Program - The EU's plan for a green transition and others.

Although special attention was paid to the COVID -19 pandemic during the 2020-2022 period, there were more studies on population, agriculture, and carbon dioxide emissions during this period than ever before.

The first study "Land-use, north-south trade, deforestation, and atmospheric carbon interactions" belongs to the authors Jones DW and Oneill RV, dates from 1993 and deals with the effects of land deforestation in agricultural regions. The last published study "Net carbon balance study for selected roads in Tenerife, Canary Islands" was added in December 2022 (Cruz-Pérez et al.).

This database was computed into the VOSviewer program, which counted the number of authors, countries, documents, keywords, organizations and sources. Table 1 presents these results.

Table 1. Unit of analysis

Unit of analysis	Total number of items
Authors	1847
Countries	75
Documents	412
Keywords	2584
Organizations	760
Sources	242

Source: Authors' processing based on data obtained from Web of Science.

For each unit of analysis, the total number of items doesn't change regardless of the type of analysis used. However, the way the items are grouped on the map does change. The type of analysis depends on the type of links used to connect the items.

Four analyses were carried out: co-authorship, co-occurrence, citation and bibliographic coupling.

Co-authorship links refer to links between publications in which two researchers were involved as co-authors.

Co-occurrence links refer to the links between keywords that appear in publications.

Citation links refer to links between two items where one item cites the other.

Bibliographic coupling links refer to links between two items that both cite the same document.

Table 2. Type of analysis

Type of analysis	Unit of analysis	Total number of items
Co-authorship	Authors	1847
	Organizations	760
	Countries	75
Co-occurrence	Keywords	2584
Citation	Documents	412
	Sources	242
	Authors	1847
	Organizations	760
Bibliographic coupling	Countries	75
	Documents	412
	Sources	242
	Authors	1847
	Organizations	760

Source: Authors' processing based on data obtained from Web of Science.

Authors may be referred to as researchers, documents as publications, sources as journals.

The largest item on the map in Figure 2 appears to be Abdul Rehman (labelled as “Rehman, Abdul”), which indicates that he co-authored the most publications on population, agriculture and carbon dioxide emissions.

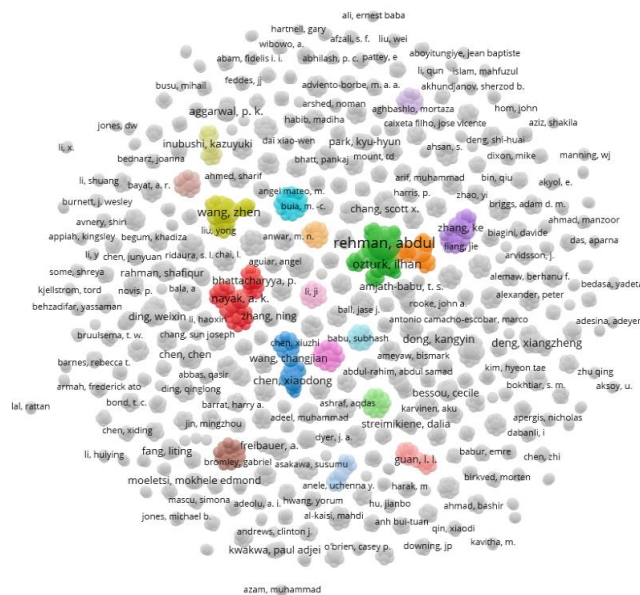


Fig. 2. Network map of 1847 authors with co-authorship links

Source: Authors’ own research based on Web of Science in VOSviewer.

As shown in Figure 3, many of the authors who contributed to publications on population, agriculture and carbon dioxide emissions worked at the Chinese Academy of Sciences (labelled as “Chinese Acad Sci” on the map). A significant number of people also worked at Agriculture and Agri Food Canada (“Agr & Agri Food Canada”) and Henan Agricultural University (“Henan Agr Univ”).

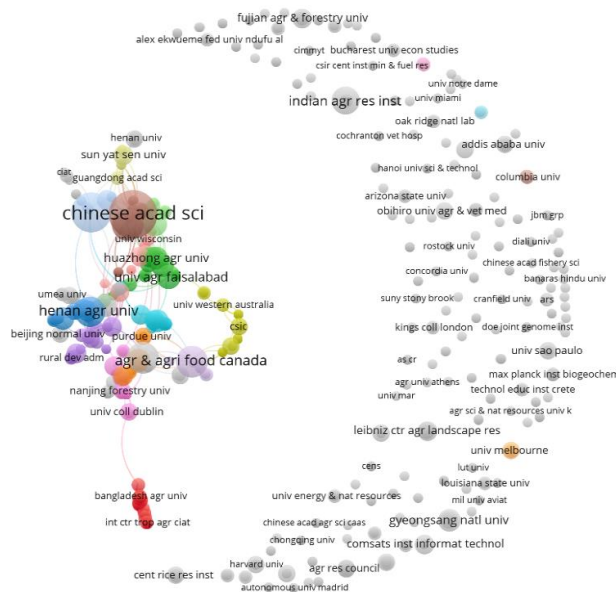


Fig. 3. Network map of 760 organizations with co-authorship links

Source: Authors’ own research based on Web of Science in VOSviewer.

The analysis of the countries of origin of the co-authors provides information about the social structure. As it can be seen in Figure 4, a lot of the researchers who co-authored a publication on population, agriculture and carbon dioxide emissions with another researcher come mainly from China (or People's Republic of China, labelled “peoples r china”), which is recognized as a country with significant growth in scientific research and publishing, contributing substantially to academic literature.



Fig. 4. Network map of all 75 countries with co-authorship links

Source: Authors’ own research based on Web of Science in VOSviewer.

Since it is difficult to get any further reading of the map in Figure 4, because most of the items are so close apart, a second map was downloaded, showing the largest set of connected items, which provides a close-up at the previous map. As it can be seen in Figure 5, the only significant country of origin other than China is the USA.

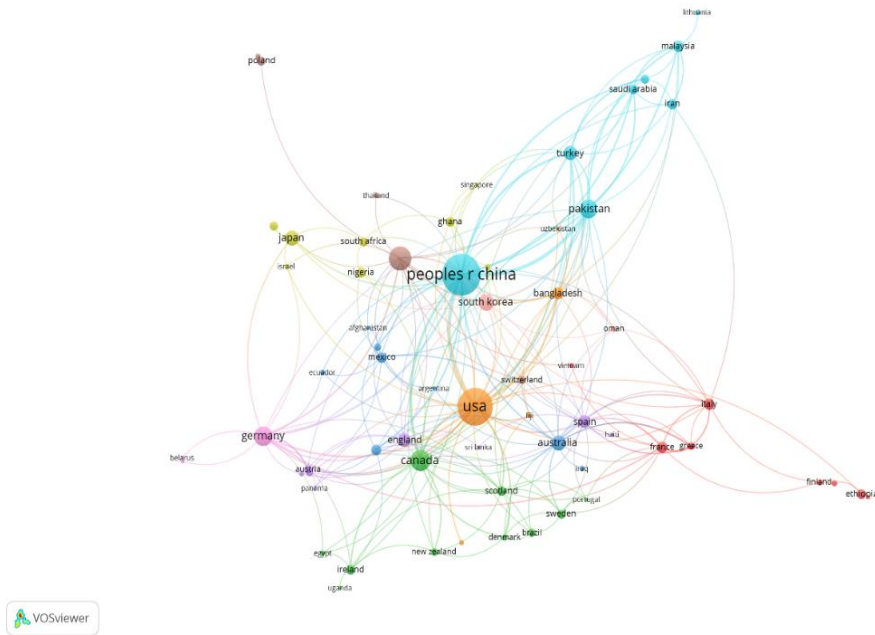


Fig. 5. Network map of 67 of the 75 countries with co-authorship links

Source: Authors' own research based on Web of Science in VOSviewer.

Figure 6 shows that the most important keywords of population, agriculture and carbon dioxide emissions are “co2 emissions”, which means that population and agriculture are related to carbon dioxide emissions by default. Other important keywords include “carbon dioxide” and “methane”.

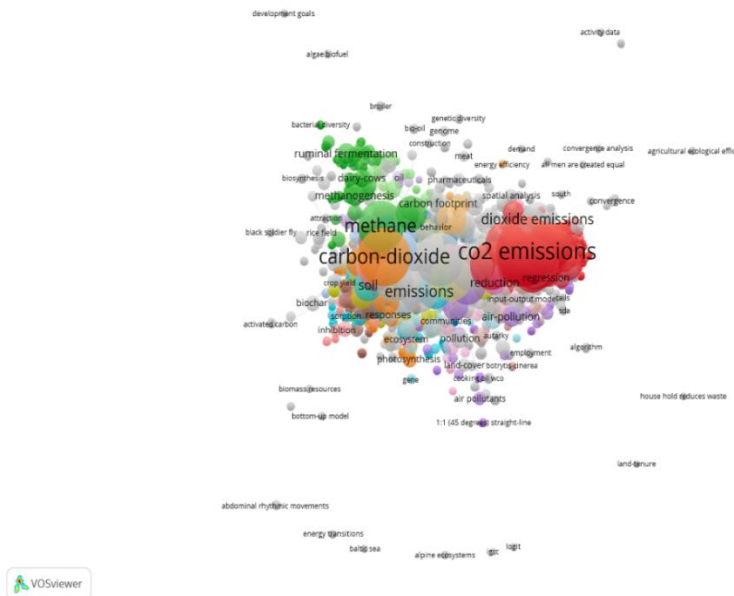


Fig. 6. Network map of 2584 keywords with co-occurrence links

Source: Authors' own research based on Web of Science in VOSviewer.

Since it is difficult to get further reading of the map in Figure 6, because most of the items are too close apart, a second map was downloaded, showing the largest set of connected items, which provides a close-up at the previous map. As it can be seen in Figure 7, other significant subtopics include “impact”, “greenhouse gas emissions”, “climate change”, “co2 emissions”, “methane emissions” and “renewable energy”. The highlights the fact that agriculture decisively

influences the increase in the emission of carbon dioxide, as well as nitrous oxide, greenhouse gases and methane.

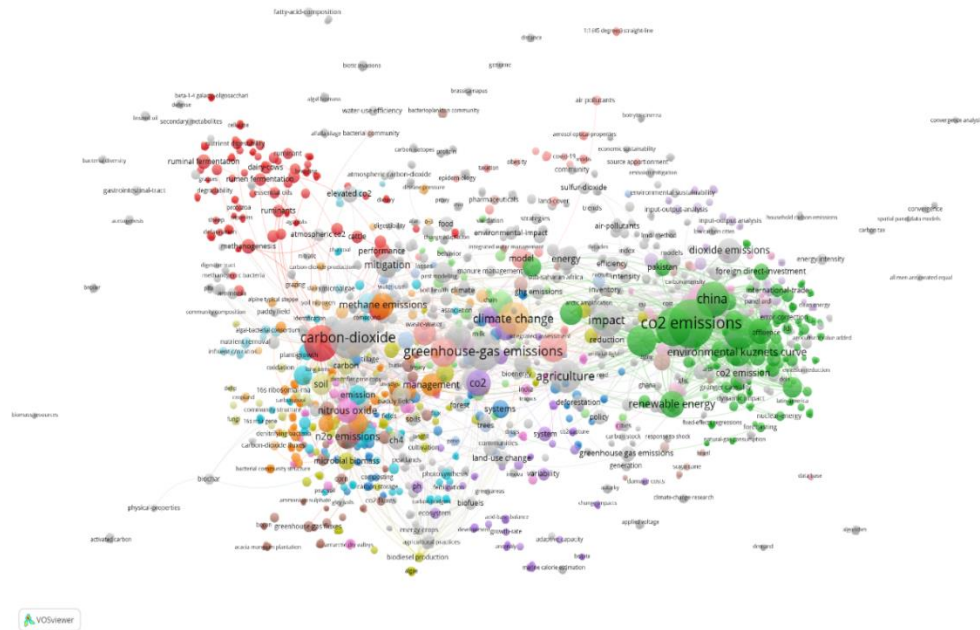


Fig. 7. Network map of 2527 of the 2584 subtopics of population, agriculture and carbon dioxide emissions

Source: Authors’ own research based on Web of Science in VOSviewer

As shown in Figure 8, the documents on population, agriculture and carbon dioxide emissions which cited one another the most are Snyder (2009), Tol (2009), Janzen (2004), Avnery (2011), Liu (2018) and Auffhammer (2008).

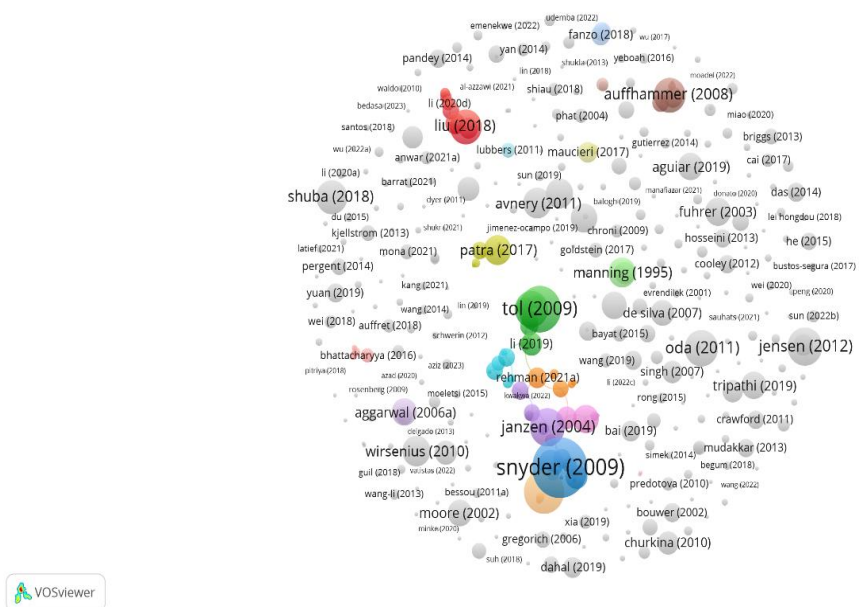


Fig. 8. Network map of 412 documents with citation links

Source: Authors’ own research based on Web of Science in VOSviewer.

Figure 9 shows that a lot of the documents on population, agriculture and carbon dioxide emissions which cited one another belong mainly to the journals titled Journal of Cleaner Production.

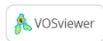
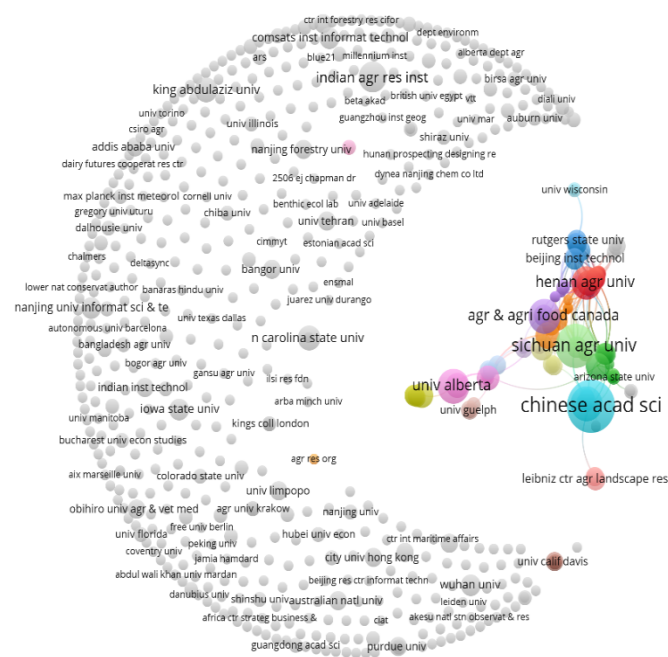


Fig. 11. Network map of 760 organizations with citation links

Source: Author’s own research based on Web of Science in VOSviewer.

A lot of the authors who contributed to publications on population, agriculture and carbon dioxide emissions and who cited one another in those publications come mainly from China - “peoples r China” (Figure 12).

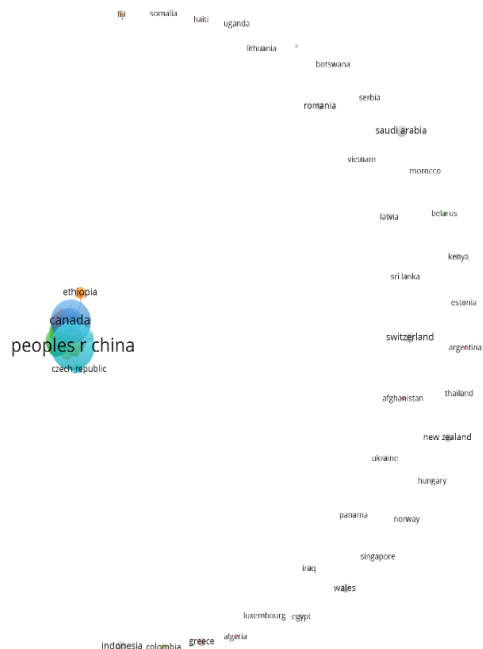


Fig. 12. Network map of all 75 countries with citation links

Source: Authors’ own research based on Web of Science in VOSviewer.

The map in Figure 13 (consisting of the largest set of connected items) is a close-up of the map in Figure 12, which shows that besides China, USA is the only other significant origin country with the authors who contributed to publications on population, agriculture and carbon dioxide emissions and who cited one another in those publications.

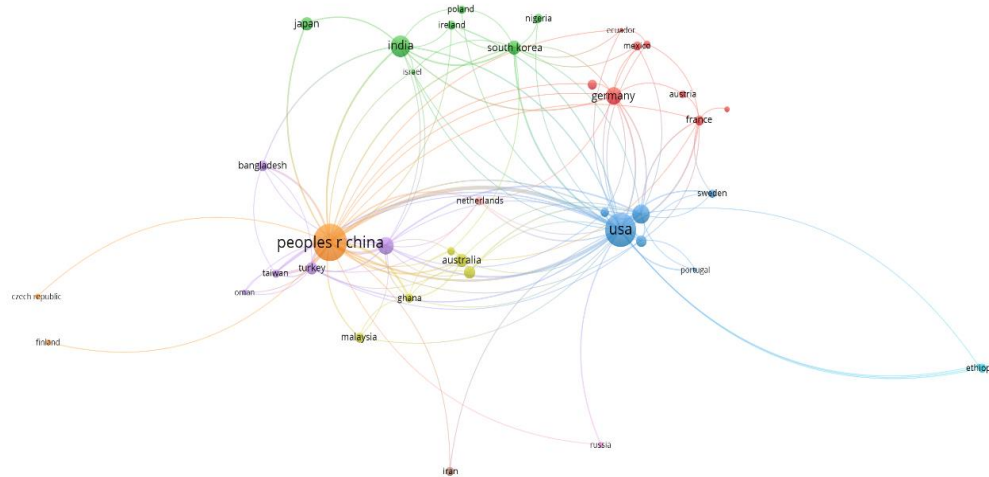


Fig. 13. Network map of 40 of the 75 countries with citation links

Source: Authors' own research based on Web of Science in VOSviewer.

As shown in Figure 14, the document on population, agriculture and carbon dioxide emissions which cited the same document(s) the most is Snyder (2009).

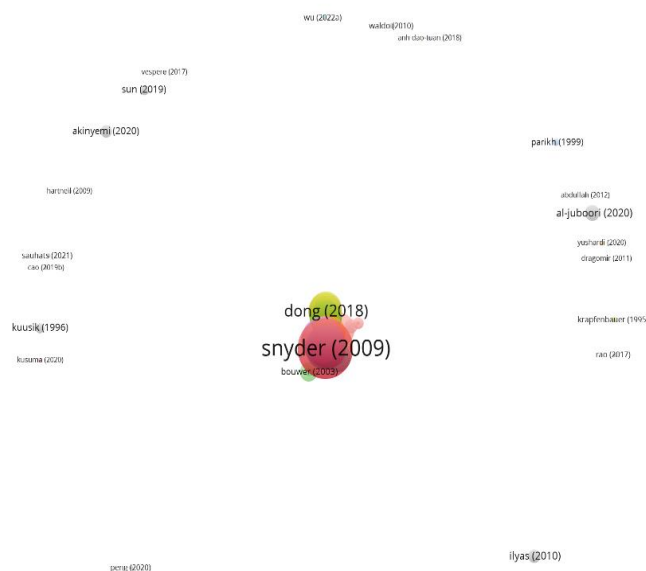


Fig. 14. Network map of 412 documents with bibliographic coupling links

Source: Authors' own research based on Web of Science in VOSviewer.

Figures 15 shows that many of the sources on population, agriculture and carbon dioxide emissions which cited the same document(s) belong in the journal titled Journal of Cleaner Production.

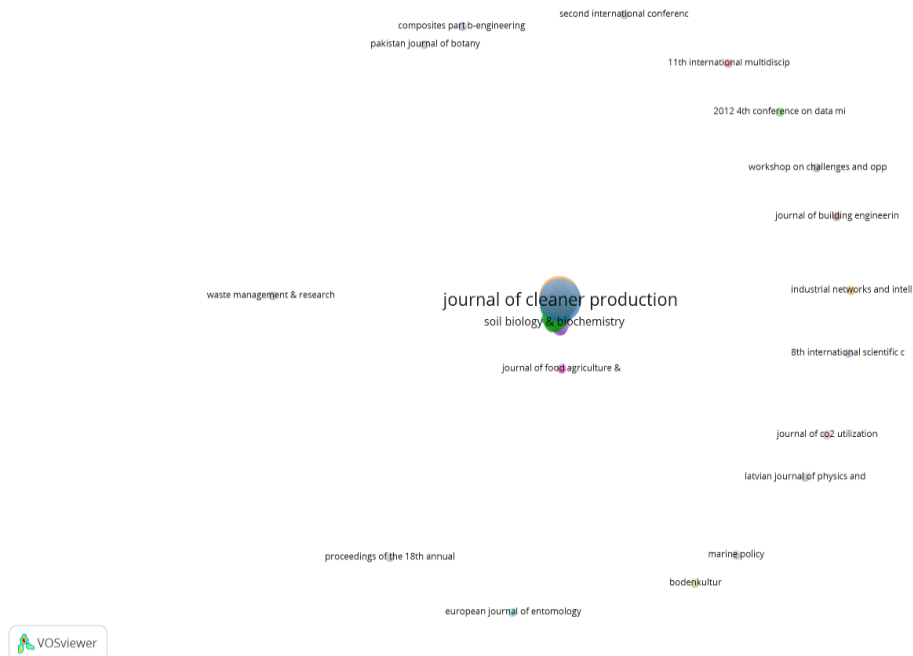


Fig. 15. Network map of 242 sources with bibliographic coupling links

Source: Author’s own research based on Web of Science in VOSviewer.

As shown in Figure 16, the researcher who contributed to documents on population, agriculture and carbon dioxide emissions and who cited the same document(s) most often is Abdul Rehman (“Rehman, Abdul”).

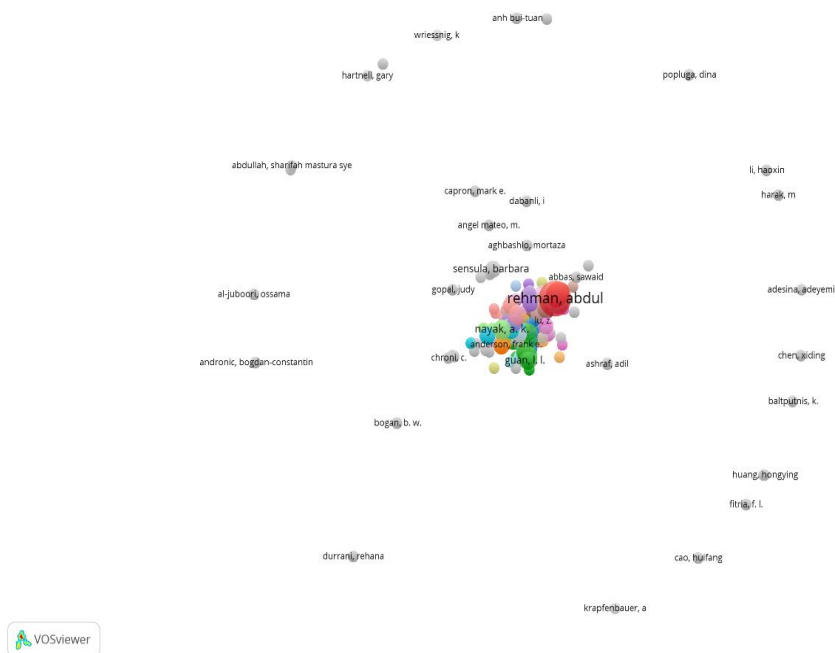


Fig. 16. Network map of 1847 authors with bibliographic coupling links

Source: Authors’ own research based on Web of Science in VOSviewer.

As it can be seen in Figure 17, a large number of authors who contributed to documents on population, agriculture and carbon dioxide emissions and who cited the same document(s) worked predominantly at the Chinese Academy of Sciences (“Chinese Acad Sci”).

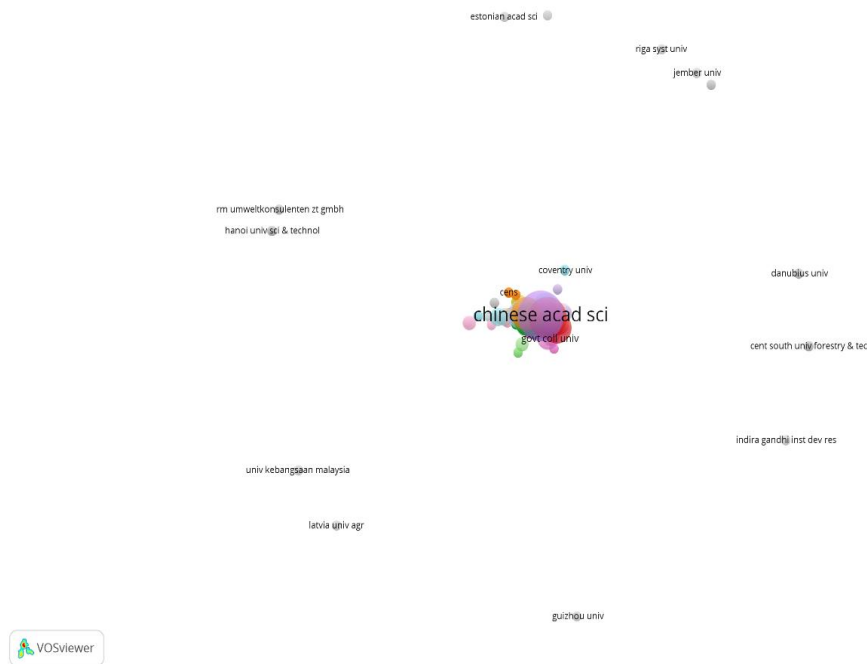


Fig. 17. Network map of 760 organizations with bibliographic coupling links

Source: Author’s own research based on Web of Science in VOSviewer.

It is interesting to note that another important subtopic is “China”. The item belongs to the green cluster, which also contains the most important keyword “co2 emissions”. It suggests that most of the publications on population, agriculture and carbon dioxide emissions came from China.

In fact, as it can be seen in Figure 18, an analysis of the countries of origin of the authors who wrote publications on population, agriculture and carbon dioxide emissions indeed shows China (labelled on the map as “peoples r China”, which stands for “People's Republic of China”) to be the most significant.

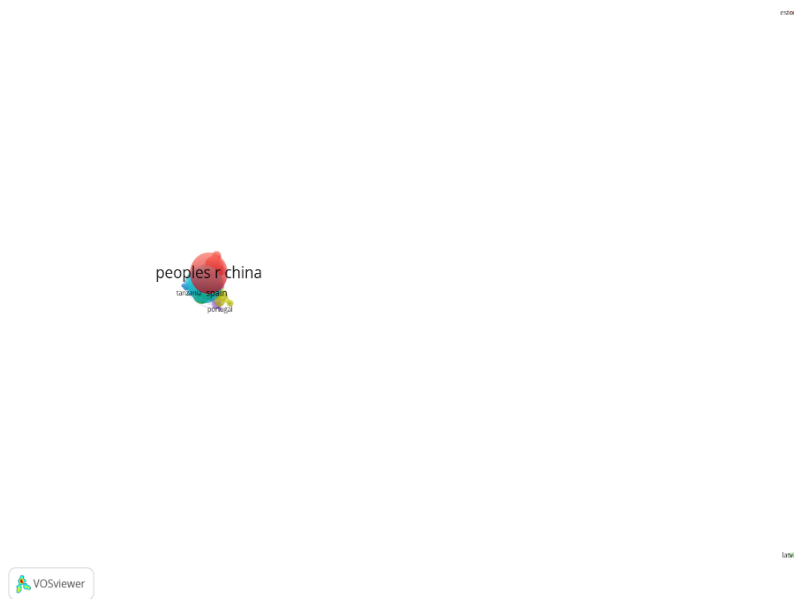


Fig. 18. Network map of all 75 countries with bibliographic coupling links

Source: Authors' own research based on Web of Science in VOSviewer.

The map in Figure 19 (consisting of the largest set of connected items) is a close-up of the map in Figure 18, which shows that besides China, the USA, followed by India and Canada, are the other significant origin countries with the authors who contributed to publications on population, agriculture and carbon dioxide emissions and who cited the same document(s).

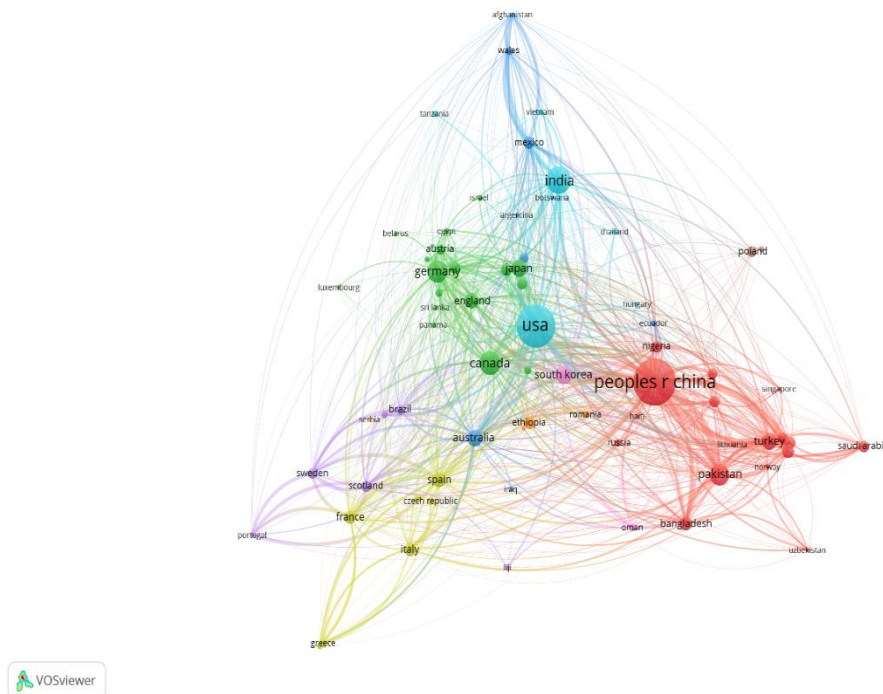


Fig. 19. Network map of 73 of the 75 countries with bibliographic coupling links

Source: Author's own research based on Web of Science in VOSviewer.

Conclusions

Over time, the importance of managing the impact of population growth and agriculture on carbon emissions has become clear, as they are an essential component of climate change mitigation strategies. Sustainable agricultural practices, crop diversification, and reduced reliance on fossil fuels in agriculture have been suggested as ways to reduce environmental impacts.

Concerns about the relationship between population, agriculture, and carbon dioxide emissions have also influenced policy decisions. Governments and international organizations have taken steps to promote sustainable agriculture, support family planning initiatives, and raise awareness of the environmental impacts of population growth.

Overall, the relationship between population, agriculture, and carbon dioxide emissions is a complex and significant area for research and policy consideration. As understanding of climate change and its drivers continues to evolve, it is likely that scientists and institutions will continue to emphasize the importance of addressing these interrelated factors in the quest for a more sustainable and resilient future.

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