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Bibliometric analysis of publications on the effect of animal production on climate change from past to present

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Bibliometrics and scientific mapping methods using R software, the biblioshiny web program, Scopus and VOSviewer were used to analyze the works of literature referenced and analyzed by the Web of Science during 1990–2023 in order to provide a thorough overview of the effect of animal production on climate change research from 1990 to 2023. A bibliometric analysis of 6,558 publications that were published on the Web of Science database was done in order to determine which articles, authors, and journals were the most important. It also provided information on future study themes and gaps, as well as present topic trends. The most productive nations are China, the United States, and Australia; the most productive journals are Global Change Biology, The Science of the Total Environment, and Environmental Science and Pollution Research International. The analysis's findings show that, over the course of the study period, there was a noticeable rise in the number of research publications discussing how animal production is impacted by climate change, along with a steady expansion of the study area. The level of cooperation and research projects in this field among nations has increased, which has improved the caliber of publications over time. Important publications, writers, and journals in the area of how animal production affects climate change were also tallied. The problem of animal production and climate change will become significantly more dependent on new data, techniques, and technology.

KEYWORDS

bibliometrics, climate change, animal production, web of science, trend

1 Introduction

The livestock industry is responsible for 14.5% of the world's greenhouse gas emissions, which accelerates climate change. Methane (CH_4), nitrous oxide (N_2O), and carbon dioxide are the primary greenhouse gases produced by farm animals (CO_2). In the animal production sector, energy is used for the transportation of feed, cattle, and animal products. Roughage and concentrated feeds are produced with substantial inputs of water, energy, and chemicals. It is critical for the sustainability and wellbeing of the planet, the ecosystem, and all living things to lessen the influence of the cattle industry on climate change (Yalcin, 2022a).

The most economically advanced nations utilize a lot of fossil fuels, which produces a lot of greenhouse gases, especially carbon dioxide, which contributes to climate change. Human activity also contributes nitrous oxide (N_2O) and methane (CH_4) to the atmosphere

in addition to carbon dioxide (CO_2). These gasses are produced by the usage of nitrogenous fertilizers, rice fields, livestock farms, and municipal landfills. Despite having a potentially extremely strong greenhouse gas effect, methane and nitrous oxide have not been released into the atmosphere in the same quantities as CO_2, and their half-lives are shorter. This indicates that the gas most responsible for climate change is CO_2 produced by human activity (Oyhantçabal et al., 2010).

The livelihoods of millions of people globally, food security, and agricultural productivity are all being threatened by the gradual effects of climate change (IPCC, 2014).

In addition to dramatically raising temperatures and altering rainfall patterns, climate change also modifies the frequency and severity of extreme weather events like floods and droughts. Agricultural productivity is also restricted to varying degrees across the globe (Zseleczky and Yosef, 2014; FAO, 2018).

One of the most important issues facing the world now is climate change, which has profound effects on economies, ecosystems, and human wellbeing (Sikiru et al., 2023). Meanwhile, this global catastrophe is a result of greenhouse gas emissions, specifically methane (CH_4) linked to animal production (McMichae et al., 2007).

In terms of CO_2 equivalent, the agriculture industry is responsible for between 10% and 12% of greenhouse gas emissions worldwide, according to the Panel on Climate Change (IPCC). It accounts for 40% of all anthropogenic CH_4 emissions (from enteric fermentation, manure breakdown, and flooded rice fields) and 65% of all anthropogenic N_2O emissions (from burning biomass, spreading manure, using nitrogenous fertilizers, and agricultural land) (IPCC, 2007). In terms of products, the highest emissions were caused by milk from cows and beef, which accounted for 20% and 41% of the sector's overall output of greenhouse gases (GHGs), respectively. For pigs, the majority of emissions come from the storage of manure and the supply of feed, but for poultry, the majority comes from the supply of feed. The conclusion reached was that efforts to reduce the impact of anthropogenic activities on greenhouse gas emissions should take the cattle sector a little more into account (Sarkwa et al., 2016).

Carbon dioxide equivalent (CO_{2e}), a measure of greenhouse gas emissions into the environment as a result of different animal production practices, has been determined in a study. One of the industries most likely to be impacted by global climate change is livestock. In a country like Turkey, where the rural population outnumbers the urban, it is clear that both cattle and the producers who work in this sector will suffer (Sarıözkan and Küçükoflaz, 2020).

A study conducted in Nigeria aims to determine mitigation techniques to lower greenhouse gas (GHG) emissions and to comprehend the impact that livestock agriculture plays in climate change. The findings indicated that the sector of animal agriculture accounts for about 18%, or about one-fifth, of the greenhouse gas emissions caused by human activity. Climate-changing gases were emitted into the atmosphere throughout almost every stage of the production of meat, eggs, and milk, which could have an adverse effect on the weather, temperature, and ecosystem health. When expressed in carbon dioxide (CO_2) equivalent, the raising of cattle alone produces more greenhouse gases (GHGs) than transportation. In order to decrease greenhouse gas emissions from the farm animal industry, it was imperative to implement significant and immediate adjustments to both consumption patterns and current animal husbandry techniques (Chah and Igbokwe, 2013).

Due to worries about food security and challenges in attaining carbon neutrality within the industry, livestock output has not yet been taken into account in the ambitious "carbon neutrality" strategy. Nonetheless, in comparison to CO_2 and N_2O, CH_4 is a transient climatic contaminant. China and the US issued a joint declaration on expanded climate action at the 26th UN Climate Change Conference of the Parties, which particularly addressed increasing efforts to cut CH_4 emissions. A decrease in CH_4 emissions could lower the atmospheric concentration of CH_4 and counteract the warming effect of other greenhouse gas emissions through cooling (Allen et al., 2021).

Humans, animals, plants, land, water, and air will all be negatively impacted by climate change, particularly global warming. Geographical locations, animal species, and socioeconomic adaptability all affect how extreme weather events, fluctuating precipitation, and high temperatures behave. Changes will occur in the amount and kind of plants needed to feed animals. The health of animals will be negatively impacted by global warming, which will also result in a decline in the supply and caliber of animal products including meat, milk, and eggs. It will therefore result in large financial losses. The decline in animal productivity suggests that there will be a greater scarcity of animal feed (Yalcin, 2022b).

Koneswaran and Nierenberg (2008) state that emissions from the production of farm animals are directly proportional to the quantity of animals raised for meat, eggs, and dairy products. The production of farm animals worldwide is predicted to treble from current levels by 2050. Governments, international organizations, farmers, and consumers all need to pay greater attention to the role that meat, egg, and dairy production plays in the environment because of the effects that animal agriculture has on it. Regulations, production methods, and consumption habits all need to be changed immediately and significantly in order to mitigate and prevent the environmental harms this industry causes.

The necessity of efficiency features and environmental adaptation to lower greenhouse gas emissions in cattle breeding is heightened by climate change. In many global cow populations, increased output has already resulted in a decrease in greenhouse gas emissions. Cattle breeding in developing nations could increase output and adjust to changing environmental conditions with the use of genomic selection (Strandén et al., 2022).

Maintaining the world's rapid economic growth while tackling the global issue of climate change presents a big challenge. The latter is largely attributable to the excessive release of greenhouse gas into the atmosphere as a result of protracted and intensive industrial expansion, as well as the activities in other sectors such as agricultural and livestock production (Semeraro et al., 2023).

This study aims to comprehend the development and patterns of scientific research about the influence of animal husbandry on global warming.

2 Materials and methods

2.1 Materials

The databases selected as the main sources of data for this study were the WOS Core Collection Science Citation Index Expanded (SCI Expanded), Social Sciences Citation Index (SSCI), and Emerging Sources Citation Index (ESCI). Using an advanced search formula with the following criteria animal production methane or carbon dioxide climate change a thorough search pertaining to research on how animal production affects climate change was carried out. A total of 6558 WOS documents were found with this search; the data was current as of 5 December 2023.

2.2 Methods

Research design, data collecting, data analysis, data visualization, and interpretation are the five steps of the process (Zupic and Cater, 2015; Secinaro et al., 2020). It was developed three particular research questions during the research design stage, focusing on three areas: the overall patterns, the published paper status, and the future research trend of spatial accessibility. We decided to make spatial accessibility the main emphasis of our study. The Web of Science databases SSCI, E-SCI, and SCI Expanded were chosen as the research data sources. A literature search yielded 6,558 items in total, which paved the way for the data gathering phase. To ensure the dependability of scientific communication, encourage important research topics, and ensure the accuracy of scientific results, a document type filter was implemented on WOS (Secinaro et al., 2020). Articles, review articles, and data papers were all included in this filter. Additionally, because the research unit is based on years, it used biblioshiny's filter tool to choose papers published between 1990 and 2023 for the study's timeframe in order to preserve consistency. As we moved on to the data analysis phase, R software was used to perform explanatory bibliometric analysis, which produced a large matrix that included every document. Afterwards, VOSviewer and Biblioshiny were used in the data visualization phase to create science maps, nation collaboration networks, and charts. The study's last phase, interpretation, involves extrapolating significant findings and conclusions from the total data gathered during the investigation. Science mapping, a method that makes use of bibliometric instruments to identify patterns in scientific research, was applied in Bibliometrix analysis (Aria and Cuccurullo, 2017). It adds quantitative accuracy to the subjective evaluation of the literature and offers convincing proof of theoretically defined categories in articles (Velasco-Muñoz et al., 2018). Keywords are frequently used in academic publications to categorize their main research questions and topics. These keywords offer a succinct synopsis of the paper's main ideas and are useful instruments for defining both the paper's content and the underlying research question. A criterion of at least five occurrences of each term was set for inclusion in the word cloud analysis in order to produce an accurate depiction of the most commonly occurring keywords (Arnaboldi et al., 2021). Trend topics present a set of themes arranged according to their density on the y-axis and centrality on the x-axis in a two-dimensional space (Cobo et al., 2011). Bradford's law is used in the study to characterize how article titles are distributed in a specific area. According to Singh et al. (2016), there are declining returns when the body of literature is published completely, supporting their claim that the law operates on the basis of centric productivity zones.

The Walktrap algorithm is used to generate the co-occurrence network, which is based on the conceptual structure themes and trends. The normalization approach employed is association. Words that occur together in a document have a network relationship. The various themes in our search field and the related problems are understood through the use of the conceptual structure. It also emphasizes how research has changed throughout time (Pons and Latapy, 2005).

Collaboration network analysis reveals the research partners of the authors for these ideas. The stronger and more intense the bibliometric association between two authors or two studies, the larger the label size and the thicker the line. The number of connections in the study increases with node size (Tang et al., 2021).

3 Results

To ascertain the relationship between animal productivity and climate change, a number of indicators were examined. These indicators comprised a three-field plot, a yearly scientific production, and an overview section with the key data. The sources, which include the most pertinent sources and source dynamics, were also examined. We also clarified which countries and organizations have contributed the most, as well as the level of scientific output in each nation and the strength of international cooperation. Additionally, data taken from the main body of papers was analyzed, including the conceptual structure such as a co-occurrence network trending topics, and the most frequently occurring words (word cloud). It was used Biblioshiny, a web-based interface for Bibliometrix, to produce the data for creating visualizations (Wei and Jiang, 2023) unless we explicitly specified otherwise.

Table 1 presents a brief excerpt from Biblioshiny that encapsulates the main data taken from the combined database. The data that is provided provides a summary of important factors, such as the rate of annual growth, the length of the time under consideration, the quantity of documents that have been gathered, and the sources that have contributed to the data. An analysis was conducted on the 6,558 obtained documents using the R-based application Bibliometrix (version 4.3.1). Based on a comprehensive data analysis and visualisation of 6,558 documents written by 22724 academics in 750 journals published between 1990 and 2023, there has been a large number of research activities on the impact of animal production on climate change. With a 13.41% annual growth rate, it has shown an upward trend.

3.1 Quantity of publication

Figure 1 illustrates the distribution of publications by year on the impact of animal production on climate change in the Web of Science. It is noteworthy that throughout the last 34 years (1990–2023), the publications have shown an irregular growing tendency. It can be seen that, with a peak of publications in 2022 (947), more than half of the chosen articles have

TABLE 1 Main information.

Description	Results
Timespan	1990:2023
Sources (Journals, Books, etc.)	750
Documents	6,558
Annual Growth Rate %	13.41
Document Average Age	6.2
Keywords Plus (ID)	3,191
Author's Keywords (DE)	11551
Authors	22724
Authors of single-authored docs	304
Single-authored docs	328
Co-Authors per Doc	5.85
Journal article	6,250

been published in the last 6 years (2018–2023, 3,643 out of 6,558 papers). This demonstrates how scientists are paying more and more attention to how animal production affects climate change.

3.2 Keywords

In the field, directions and hotspots can be found using keyword analysis. The top ten keywords in the field "effect of animal production on climate change" are listed in Table 2. The most frequently occurring term was "carbon dioxide," with 3,251 occurrences. This was followed by "animals," 2060 occurrences, "methane," 1,555 occurrences, "climate change," 850 occurrences of "cattle," 779 occurrences of "carbon," 770 occurrences of "ecosystem," 729 occurrences of "rumen," 705, occurrences of "animal feed," and 678 occurrences of "diet." In the study of keywords, the cattle type has the most frequency among animal types.

Livestock productivity is highly dependent on the surroundings of the animals. Because the environment provides the necessary inputs (water, solar radiation, and temperature) for plant and animal growth, agricultural production is impacted by climate change. The viability of cattle production systems, ecosystems, and the existence of many species are all seriously threatened by climate change (Moss et al., 2000).

3.3 Word clouds

The most often used terms in the articles are shown in Figure 2. The word clouds approach was used to identify the most popular keywords. Word clouds, a type of data mining technique, are known to display the most frequently used terms in a passage or text. The word in the center, as is well known, displays the most often used word related to that topic. The word is used less frequently as the word size gets smaller and gets farther from the center. The most often searched terms are, according to the findings, carbon dioxide (f=3,251), animals (f=2060), methane (f=1,555), climate change (f=1,373), and cattle (f=850). Furthermore, Figure 3 displays the terms that were most often used in the abstracts of the papers that were examined.

3.4 Authors

Using Web of Science, the ten writers with the most articles have been obtained. Wang Y had the top ranking with 107 articles, trailed by Liu Y at 89, Wang X at 66, Zhang Y at 63, Wanapat M at 60, Wang J at 57, Zhang X at 56, and Dijkstra J at 53 (Figure 4).

R software analysis was used to determine the author's influence and the date the article was published. Since 2001, Dijkstra J has been concentrating on this area, and his publications will be released until 2022. According to Figure 5, he is the author with the greatest experience in this field. Since Wang Y is the most prominent author on a publication about the impact of animal production on climate change, he has made the most contribution in this field. He has dedicated a significant amount of time (2011–2023) to this field of study (Figure 5).

A graphic that uses Lotka's Law to illustrate authors' productivity in the context of the research field under study is shown in Figure 6. The figure displays the standard Lotka's Law distribution, which is defined as having more authors with less publications and fewer authors with more publications. This is to be expected. The differences in the productivity of research across writers in the discipline are reflected in this long-tailed distribution pattern. There could be a number of consequences from the significant percentage of authors who have only a few articles.

3.5 Affiliation

The top ten academic institutions and organizational connections that provide the greatest contributions to the study of how animal agriculture affects climate change are shown in Table 3. The universities with the most scientific contributions in the area of how animal production affects climate change are Pennsylvania State University in University Park, United States; it is followed by Western Sydney University in Penrith, Australia, and Khon Kaen University in Khon Kaen, Thailand. Universities from all around the world are expressing interest in conducting research in this field.

Figure 7 displays the findings from the analysis of the affiliations the writers are a part of. The number of documents reviewed determines how the number of publications changed throughout the course of the analysis. The top five affiliations in terms of publications are displayed.

Examining the data in Figure 7, it is evident that the five universities that publish the most on the topic have published

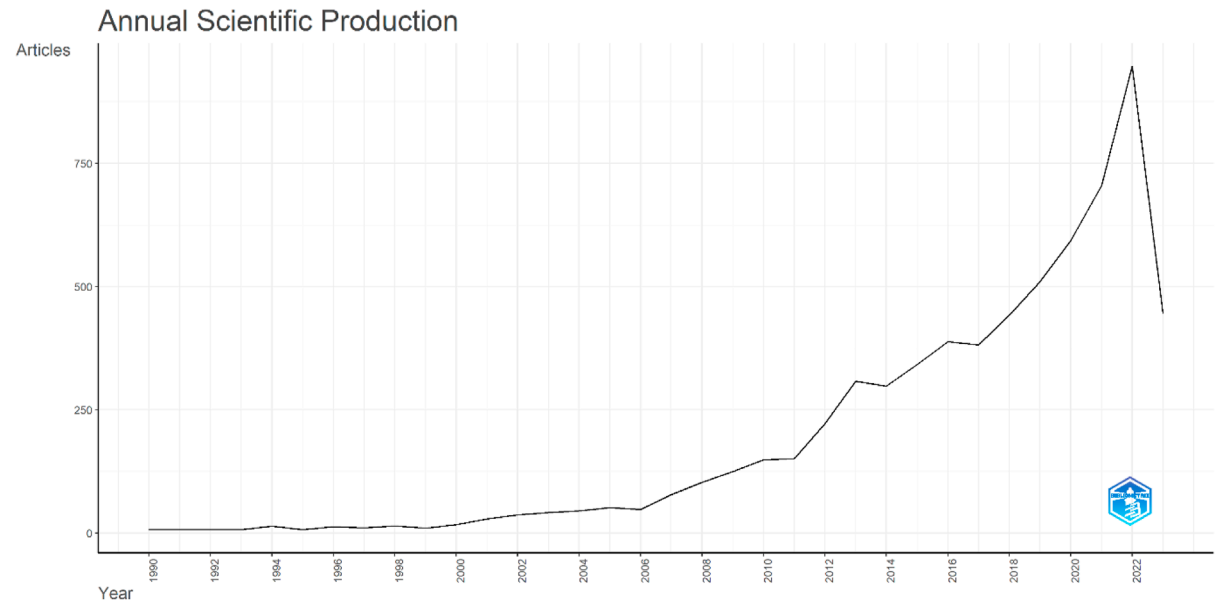

FIGURE 1
Annual scientific production.

TABLE 2 Top 10 keywords regarding effect of animal production on climate change.

Terms	Frequency
Carbon dioxide	3,251
Animals	2060
Methane	1,555
Climate change	1,373
Cattle	850
Carbon	779
Ecosystem	770
Rumen	729
Animal feed	705
Diet	678

more often, particularly in recent years. As seen by the growth in recent years, "The Pennsylvania State University" is the most prolific institution, followed by "Hawkesbury Institute for The Environment, Western Sydney University, Penrith".

3.6 Most relevant sources

The top ten publications that publish on the subject of how animal production affects climate change are shown in Table 4 and Figure 8. The Bibliometrix package (4.3.1) in the R programming language was used to collect the data that are provided in. The quantity of papers published determines the importance. The Science of the Total Environment (f=370) and Global Change Biology (f=310) are placed second and third, respectively, after Environmental Science and Pollution Research International (f=504).

Journals can be classified into multiple zones based on the quantity of articles they include, as per Bradford's law. According to Bradford's law of scattering, the primary sources of information for knowledge management studies are the following: Animal: An International Journal of Animal Bioscience, Animals: An Open Access Journal From MDPI, Proceedings of The National Academy of Sciences of The United States of America, The Science of The Total Environment, Global Change Biology, Journal of Dairy Science, Plos One, Journal of Animal Science, Journal of Environmental Management, and Environmental Science and Pollution Research International (Figure 9).

3.7 Trend topics

Figure 10 shows an extract from Biblioshiny that shows the evolution of hot subjects and offers important insights into the latest research activities (or direction) between 2017 and 2020. "Quality of life," "economic development," "renewable energy," "technology," "China," "greenhouse gases," and "environmental pollution" were the identified trending subjects based on the gathered material. According to this analysis, a significant portion of climate change researchers continue to concentrate primarily on finding effective ways to modify carbon dioxide. While the focus of the articles published between 2002 and 2004 was on climate change, including policy making and ionophores, the focus of the current publications has switched to keywords like "renewable energy" and "qualify of

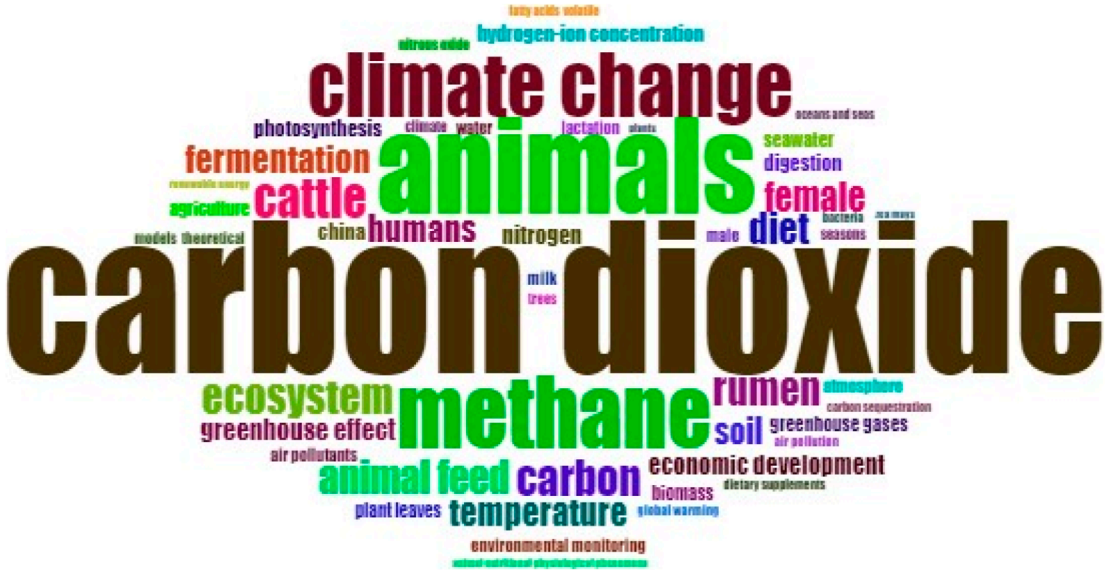

FIGURE 2
Words cloud.

FIGURE 3
Word tree map of analyzed articles' abstracts.

life" in tandem with the global concerns associated with climate change. In recent years, research has frequently included terms related to nutrition, digestion, animals, methane, carbon dioxide, and climate change.

3.8 Thematic map

A thematic map highlighting commonly occurring keywords in animal production affects climate change research that were determined from author keywords is presented in Figure 11. This study has found two clusters, with the top three sentences representing each cluster.

Basic themes, located in the lower-right quadrant, have a significant centrality but low density, indicating their significance as foundational study topics and essential to the development of the discipline. "Animals, methane, and cattle" are among the subjects covered in this quadrant.

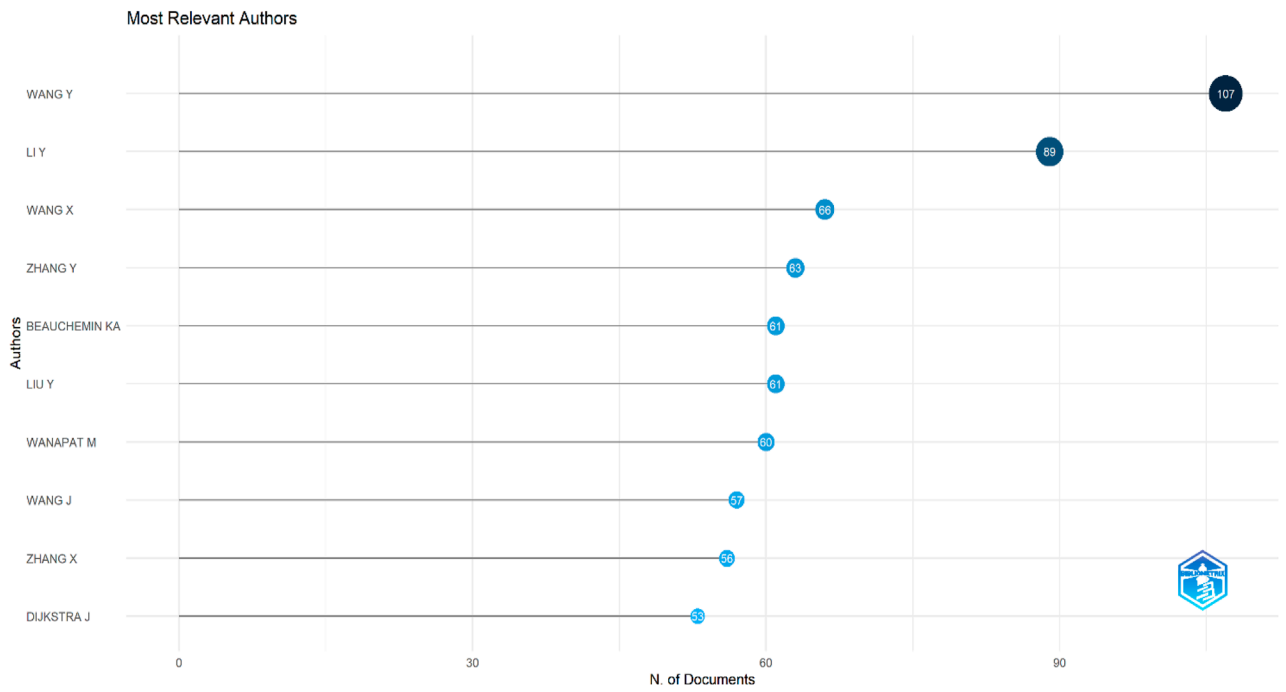

FIGURE 4
Most relevant authors.

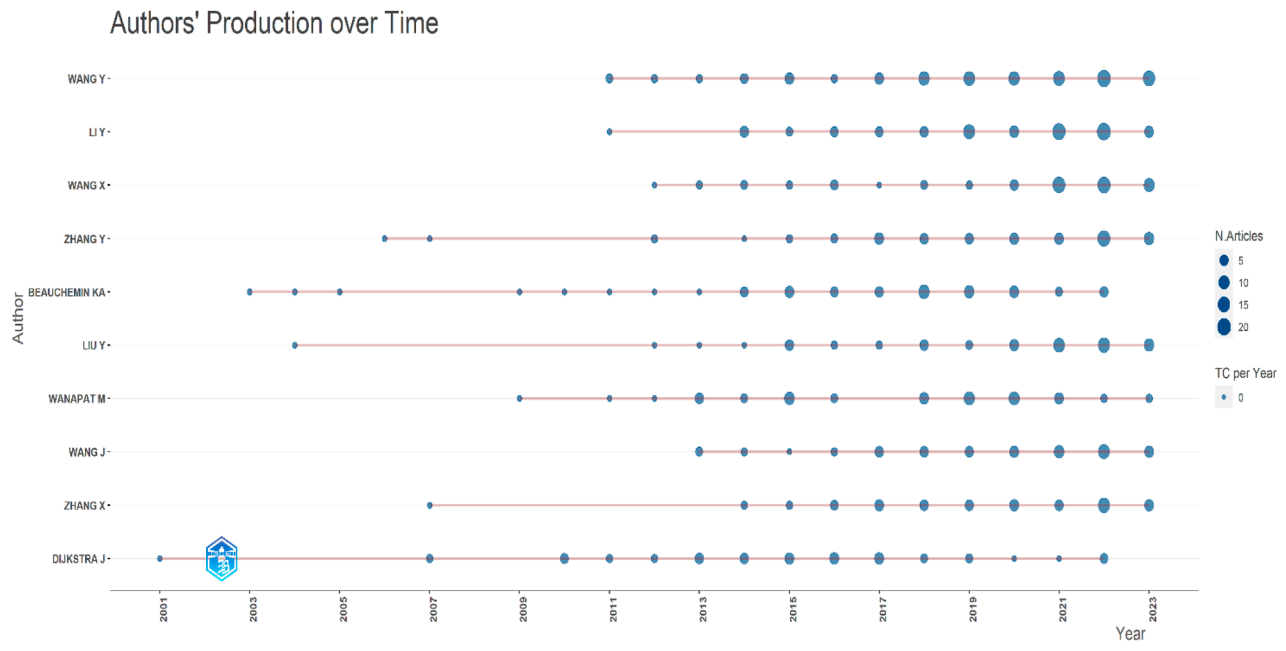

FIGURE 5
Authors' production over time.

Niche themes, or the upper-left quadrant, are characterized by low centrality and high density. Topics that fall into this quadrant include "carbon dioxide, climate change, and carbon," all of which are extremely detailed, underrepresented, and changing quickly.

3.9 Co-occurrence network

Figure 12 s co-occurrence network illustrates how the influence of animal production on research on climate change have changed over time. The size of each network node corresponds to the

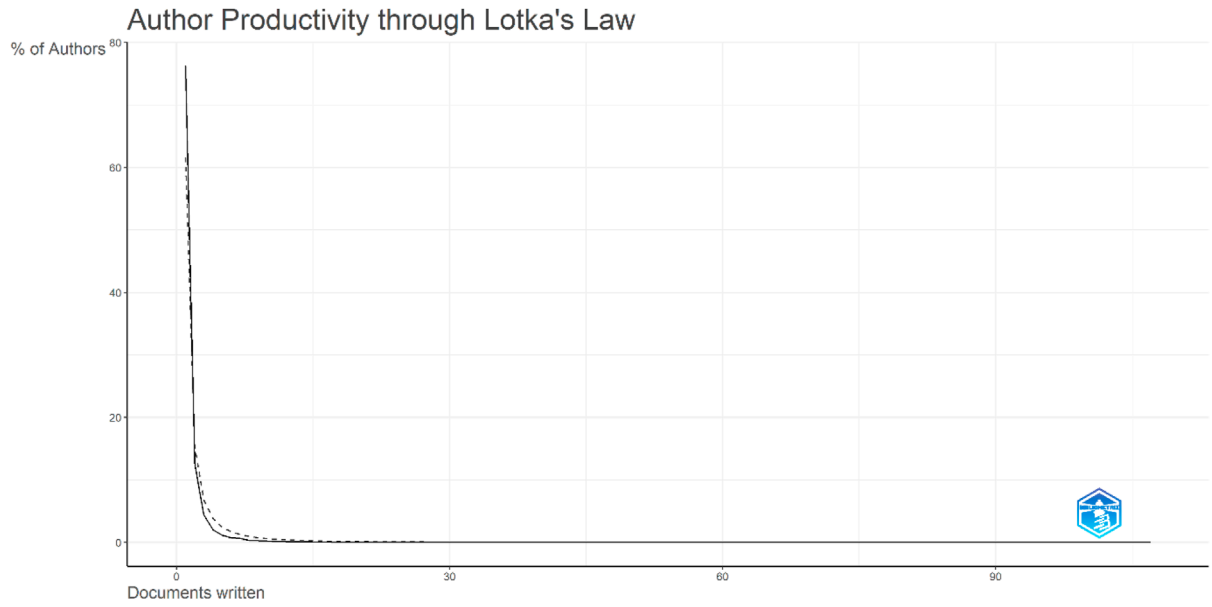

FIGURE 6
Author productivity through Lotka's law.

TABLE 3 Most relevant affiliation.

Affiliation	Articles
N/A	145
Department of Animal Science, The Pennsylvania State University, University Park 16802	59
Hawkesbury Institute for The Environment, Western Sydney University, Penrith, New South Wales, Australia	54
Tropical Feed Resources Research and Development Center (Trofrec), Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand	52
Tropical Feed Resources Research and Development Center (Trofrec), Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen, 40002, Thailand	48
Hawkesbury Institute for the Environment, Western Sydney University, Locked Bag 1797, Penrith, Nsw, 2,751, Australia	42
University of Chinese Academy of Sciences, Beijing, China	34
General Coordination of Earth Science (CGCT), National Institute for Space Research (INPE), São José Dos Campos, Brazil	31
Hawkesbury Institute for the Environment, Western Sydney University, Penrith, Nsw, Australia	29
State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing 100193, China	29

Cases with no identifiable papers are denoted by "N/A."

degree of the term or study topic it represents. It is evident from the first cluster that a few keywords, including "carbon dioxide," "climate change," "carbon," "hydrogen-ion concentration," and "nitrogen," were concentrated around this term. The "animals" component of the second cluster includes the following topics: "fermentation," "methane," "cattle," "female," "rumen," and "animal feed". Especially, because it serves as a network link, "animals" is crucial to this cluster.

3.10 Collaboration network

Figure 13 shows the co-authorship network for research on the implications of livestock production on climate change. The author network's eight separate clusters show how well various research groups collaborate with one another. The connections between the orange, green, purple, blue, and red clusters imply that the authors in these groups collaborate often. Within their network, some authors Wang Y and Wang J, for example, have published publications more regularly. Dijkstra J, Kebreab E, Weisbjerg MR, and Hristov AN; Wang M, Beauchemin KA, and Wang R; Morgavi DP and Martin C; Lee SS, Patra AK, and Yu Z are among the other active writers in their collaborative structure. In general, the analysis of collaborative networks sheds light on how animal production affects climate change.

3.11 Country/region networks

China, the United States, and Australia had the most publications among the nations with the highest levels of scientific output in related subjects, as shown in Figure 14 and Table 5.

The degree of publication activity in a given region is shown by the intensity of the blue hue on the nation map; a darker shade of blue indicates a higher number of published papers. On the globe, the red connecting lines represent collaborations between nations; larger lines denote more frequent collaboration. Table 5

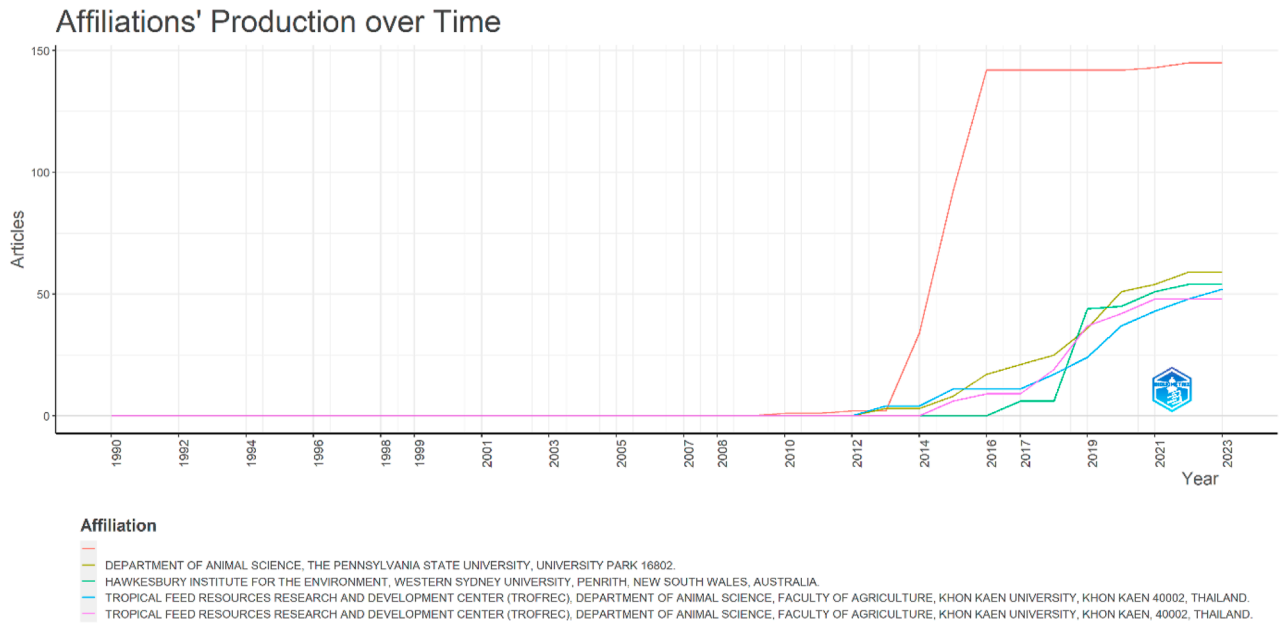

FIGURE 7
Affiliations' production over time.

TABLE 4 Most relevant sources.

Sources	Articles
Environmental Science and Pollution Research International	504
The Science of The Total Environment	370
Global Change Biology	310
Journal of Dairy Science	275
Plos One	210
Journal of Animal Science	196
Journal of Environmental Management	186
Animal: An International Journal of Animal Bioscience	151
Animals: An Open Access Journal From MDPI	147
Proceedings of The National Academy of Sciences of The United States of America	142

lists the country/region collaborations according to the frequency of collaboration, using the Bibliometrix program (version 4.3.1). With 184 relationships, China and the United States exhibited the highest amount of collaboration, followed by the United States and Australia with 143 partnerships and China and Australia with 103 partnerships, according to the results.

3.12 Three field plot

Sankey diagrams, or three-field plots, are used in Figure 14 to illustrate the relationships among research themes, affiliations, and publishing sources (Riehmann et al., 2005). The figure efficiently displays the pertinent scientific subjects that affiliations publish on for each publication. The three main areas of research in this field are methane, rumen fermentation, and climate change. Researchers have focused a great deal of emphasis on these subjects because they are essential to the advancement of earth science understanding. The most eminent academic institutions involved in this field of study are the University of California, Western Sydney University, Aarhus University, Nanjing Agriculture University, and Khon Kaen University. These universities have significantly advanced the field, and peers and business experts value the research they provide. The analysis concluded that the best journals to publish research in this field are Nature, The New Phytologist, and Global Change Biology. These esteemed journals are renowned for disseminating top-notch research that expands our understanding of earth science. This data can help researchers choose which journals will best serve their interests and improve the exposure and significance of their work. A thorough overview of the distribution of study topics across various universities and the journals they choose to publish in is given by the plot in Figure 15, which offers insightful information about the trends and patterns of this field's research. The results have the potential to guide future investigations and joint ventures, resulting in field progress and the creation of long-term remedies for environmental problems.

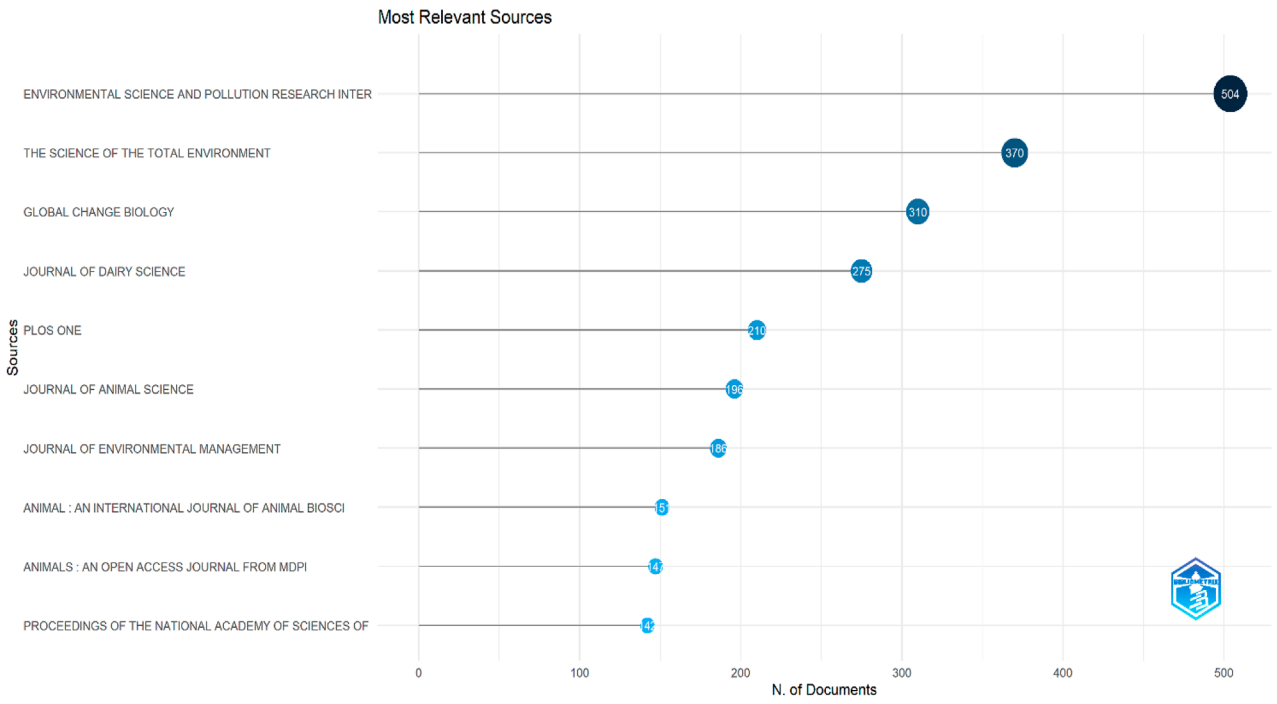

FIGURE 8
Most relevant sources.

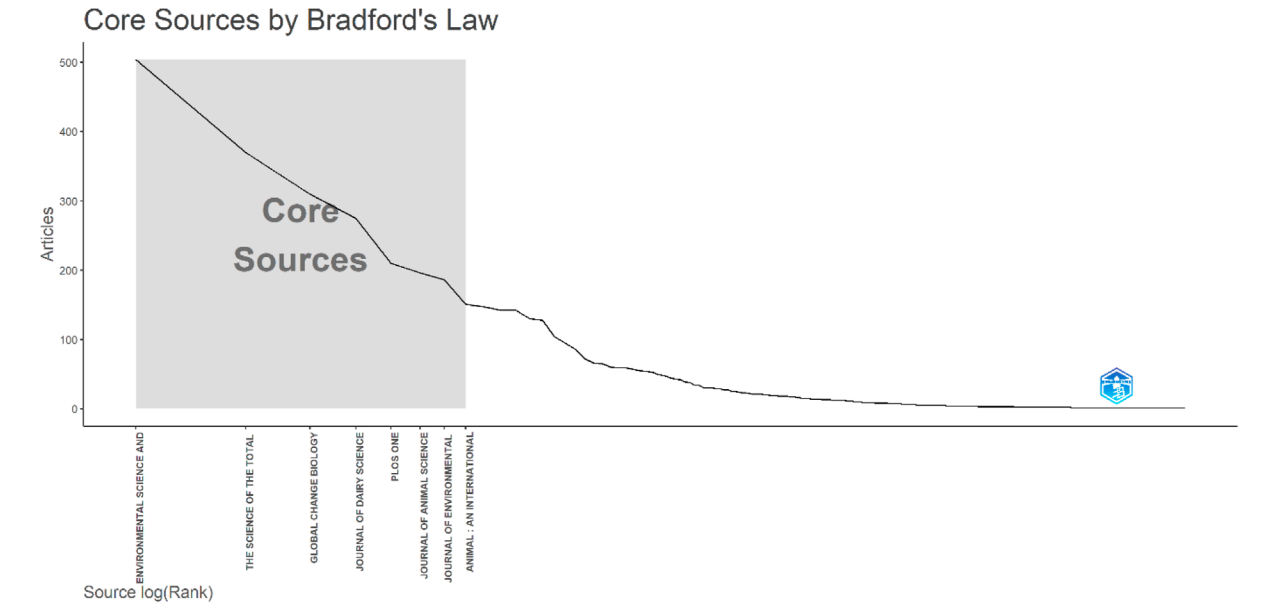

FIGURE 9
Distribution of titles based on Bradford's law.

4 Discussion

Previous studies (Xie et al., 2020; Wang et al., 2021; Guo et al., 2023; Jiang et al., 2023; Yang et al., 2023; Wang et al., 2024) have had authors concentrate on particular journals, but this endeavor covers publications related to animal production and climate change.

The United States, China, Australia, Canada, Germany, and France are the nations that generate the greatest amount of scientific study on animal genetic resources and climate change. These results are in line with what Vieara and McManus, (2023) found in their investigation. However, Sikiru et al. (2024) was partially similar to the results in their study. Asian nations, particularly those in China and Latin America,

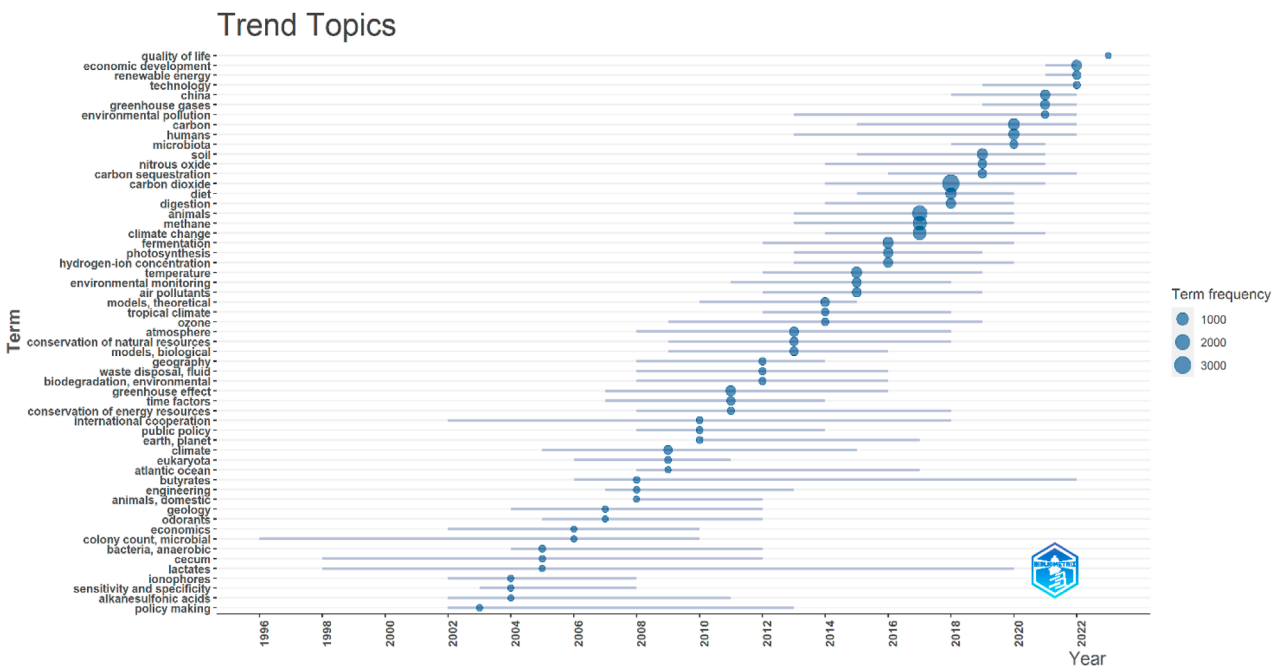

FIGURE 10
Trend topics.

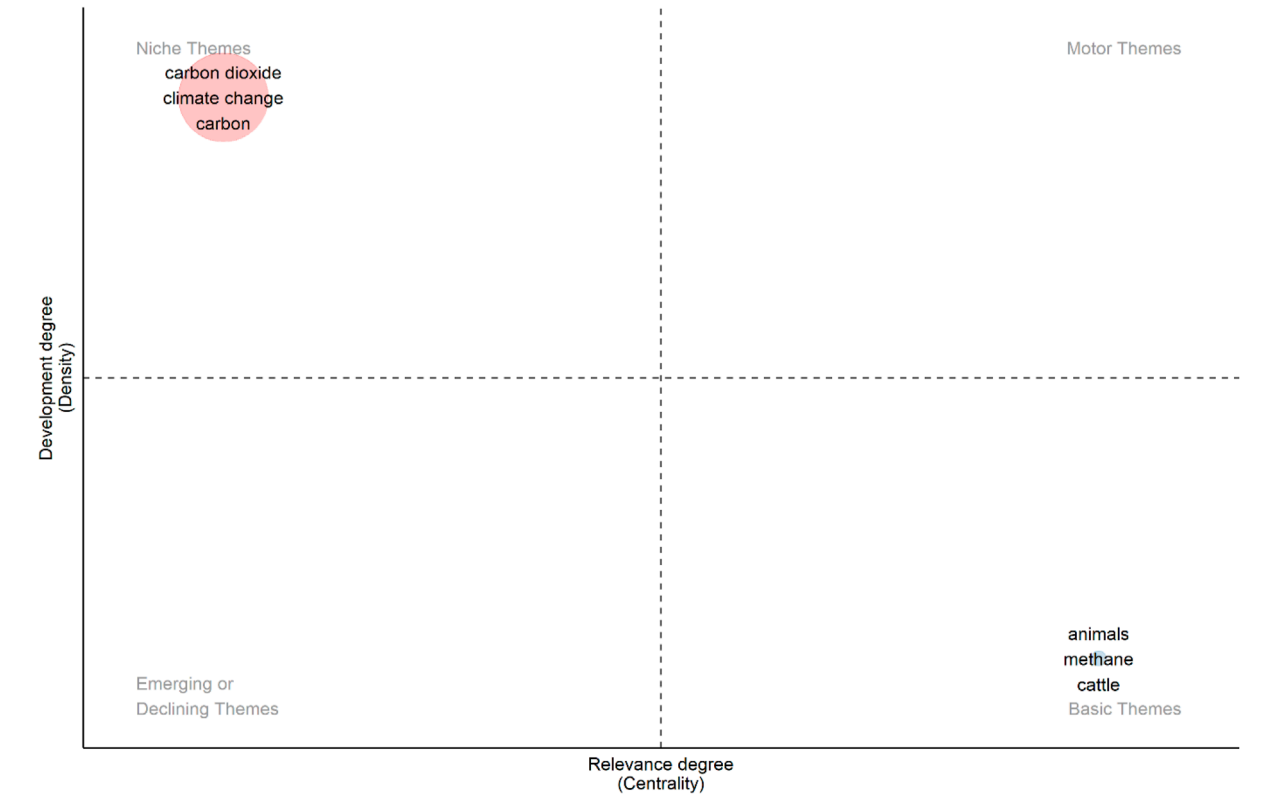

FIGURE 11
Thematic map of publications related to animal production affects climate change.

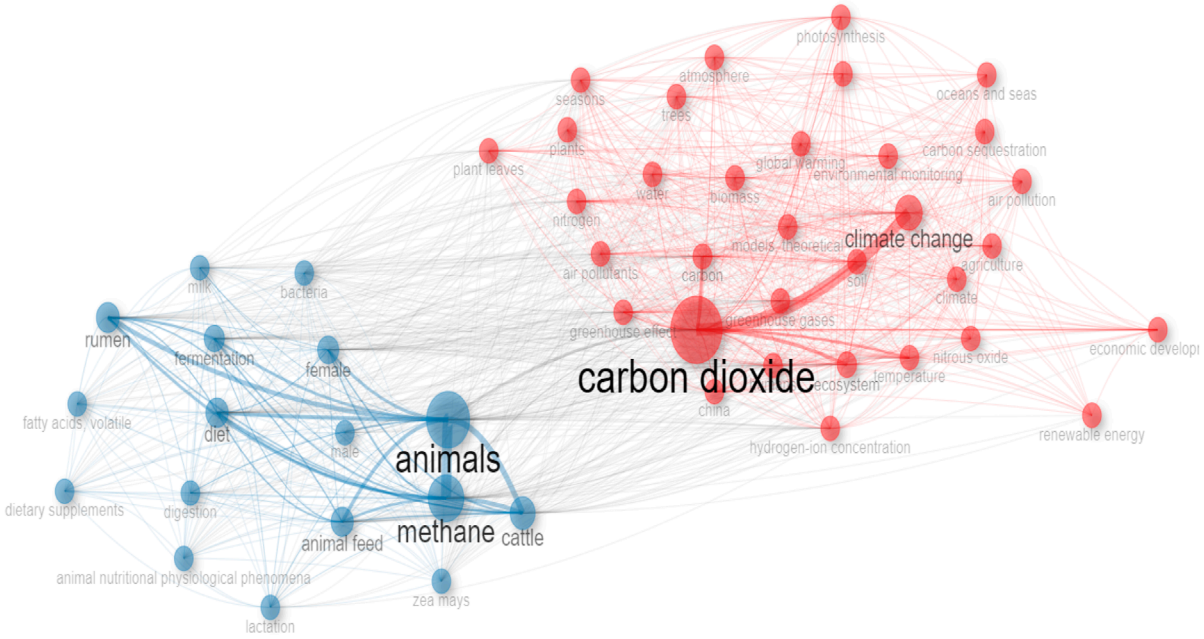

FIGURE 12
Co-occurrence network.

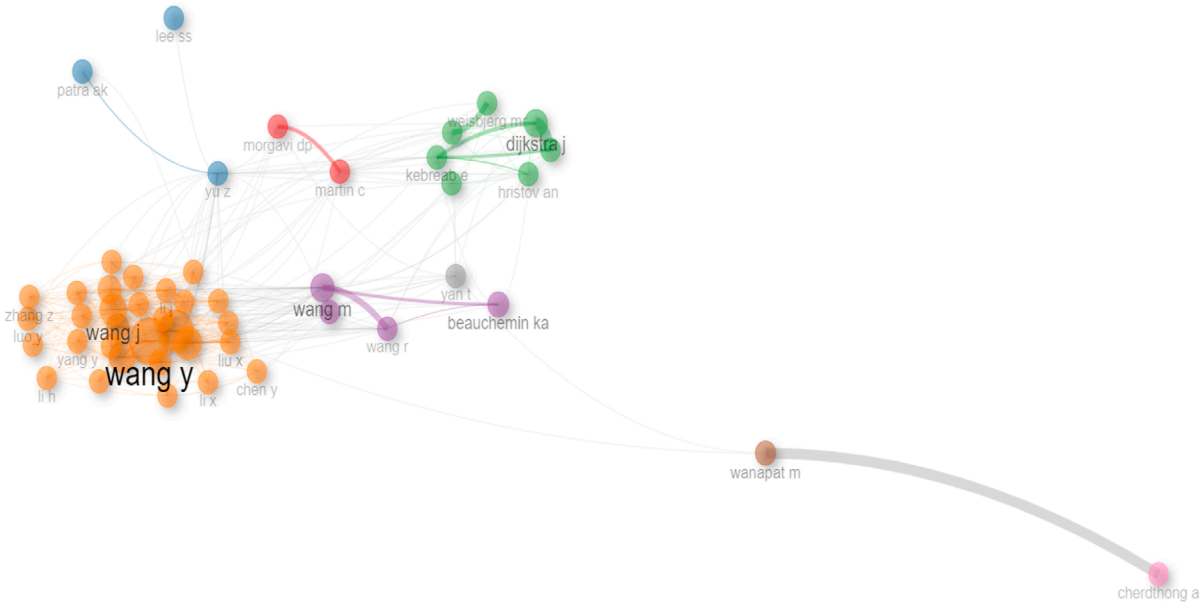

FIGURE 13
Collaboration network.

have quietly but steadily made their way into the climate change research scene since 2018. China has emerged as a leading global producer and consumer of agricultural products (Zhao et al., 2021). The nation has also made significant investments in agricultural research and extension, and it possesses the largest research and extension systems globally (Deng et al., 2021).

Wang Y, Wang J, Dijkstra J, Wang M, and Martin C are at the top of the bibliographic coupling of writers. The information gathered differs from the findings of the research conducted by Vieira and McManus, (2023).

According to Filho et al. (2022), three groups were identified by bibliometric analysis. The first of the three clusters shows how closely agricultural yields, temperature, effects,

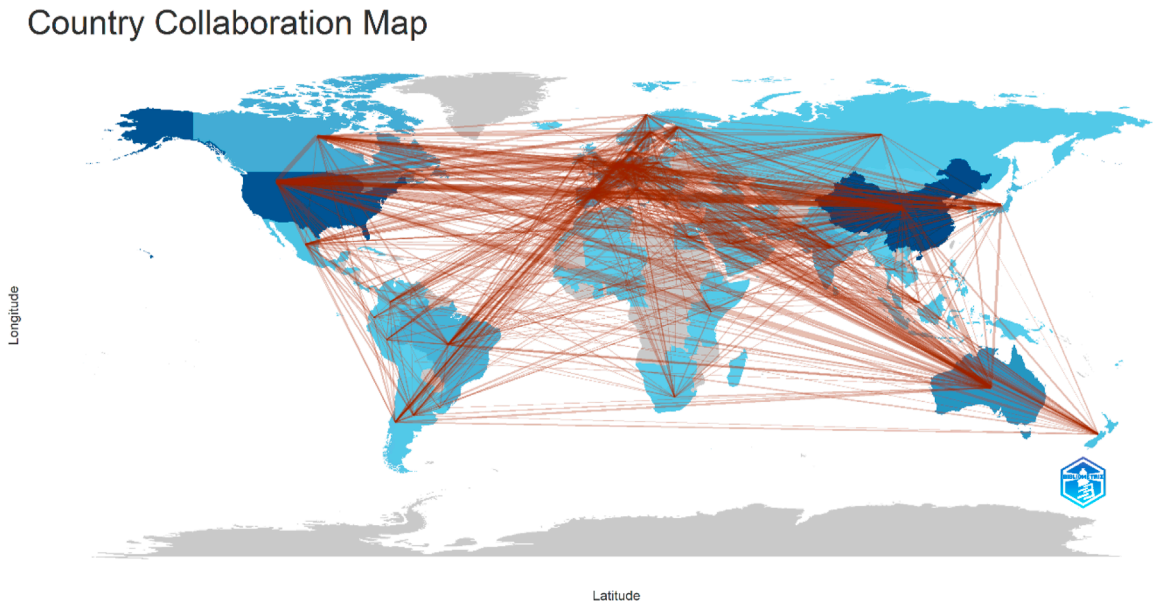

FIGURE 14
Country collaboration map.

TABLE 5 The cooperation among countries.

From	To	Frequency
China	United States	184
United States	Australia	143
China	Australia	103
United States	Canada	89
United States	Germany	88
United States	France	77
China	Pakistan	71
China	Canada	64
Australia	Germany	57
Germany	Switzerland	54

and climate change are related. Food security, agriculture, and adaptation are related in a second cluster. Resilience, diversity, and farmers make up the second cluster. Crops, irrigation, water resources, production, and the dimensions of adaptation, farmers, and vulnerability are all impacted by climate change. Nutrients, carbon sequestration, sustainability, biodiversity, and ecosystem services are all included in the third cluster. There was a variation in the findings of this investigation.

Increased N fertilizer applications during the warmer winter months would make up for decreased summer production, but it is evident that this strategy could well increase total N_20 emissions. Future climate change projections in many parts of the world indicate warmer winters with increased growth potential, but drier summers with more variable rainfall and extreme heat (Cullen et al., 2009).

Results from a study using synthetic N application showed that there will be a roughly 25% long-term rise in N_2O emissions as a result of climate change. Thus, it was discovered that the climate sensitivity of N_2O emissions accounts for roughly 8%–25% of the long-term trend utilizing two separate constraints (modeling and planetary boundary layer measurements and sensitivity analysis). (Griffis et al., 2017). Even while the growing use of synthetic nitrogen is the primary cause of the long-term trends in N_2O emissions (Crutzen et al., 2008; Reay et al., 2012), the significant interannual variability of N_2O emissions observed and the trends predicted by the models indicate that positive feedbacks related to climate change will play a significant role.

The Lacombe location regularly showed larger cumulative N_2O losses from treatments receiving summer urine compared to the control plots. Remarkably, only 260 g N ha^{-1} was released after the June 2010 urine-N treatment, despite a significant rise in mineral N (relative to the water-filled pore space levels of August 2011). This is probably due to colder and drier soils. Indirect N_2O losses and N immobilization dynamics were proposed as future research subjects (VanderZaag et al., 2011; Liu et al., 2020). These factors are anticipated to alter N_2O emissions in response to the timing of animal excreta application in dry regions.

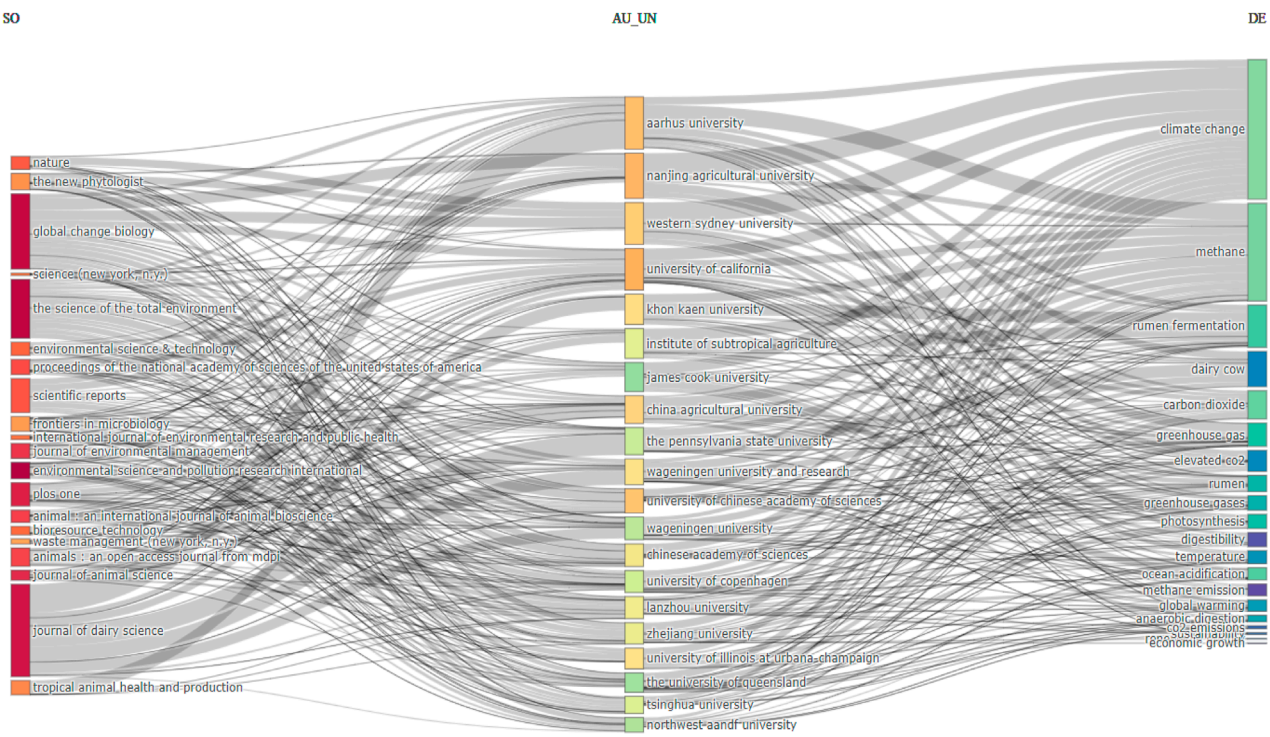

FIGURE 15
A Sankey diagram showing the respective affiliations by publication source and research topics.

5 Conclusion

A bibliometric analysis of articles in the Web of Science database was conducted regarding the effects of animal production on climate change. The Web of Science database had 6,558 papers spanning the years 1990–2023. The distribution of the papers that have been published in the Web of Science database was looked at in terms of years, study fields, institutions, publications, and keywords. Based on the investigation, two clusters of academic works performed between 1990 and the present were identified. With an average of 5.85 writers per document, author collaboration on this topic is widespread. In addition, a word analysis of papers in the field showed that the terms “carbon dioxide,” “animals,” “methane,” “climate change,” “cattle,” “carbon,” “ecosystem,” “rumen,” “animal feed,” and “diet” are most often used. The results show a significant increase in research on animal production and climate change over the previous 20 years, with industrialized nations such as China, the US, Australia, and others clearly at the forefront of the area. In addition to evaluating important publications, this analysis provides insightful information for future studies on carbon dioxide, climate change, carbon, animals, methane, and cattle. The results of this bibliometric analysis give scholars a thorough understanding of the relationship between animal production and climate change, offering suggestions for future research directions and partnerships.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The writers will provide the raw data without delay in support of the article’s conclusion. Requests to access these datasets should be directed to senolcelik@bingol.edu.tr.

Ethics statement

The manuscript presents research on animals that do not require ethical approval for their study.

Author contributions

SC: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Software, Validation, Visualization, Writing–original draft, Writing–review and editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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