Research Article

Bibliometric and Visual Analysis of Scientific Publications on Climate Change and Animal Health

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Abstract | Climate change has increasingly drawn the attention of researchers and nations, particularly regarding its impact on animal health and welfare. Given the substantial body of literature on this topic, mapping existing documents is crucial to identify dominant themes and guide future research directions. Using the Scopus database, 242 eligible documents published between 2005 and 2024 were analyzed with the Bibliometrix R package and VOSviewer. Globally, publications involved 1,305 authors, with 12 single-authored papers and an average of 5.57 co-authors per article. The five leading contributing countries were Australia, Germany, Italy, the United Kingdom, and the United States. The most prominent institutional affiliations were the University of Veterinary Medicine Hannover (Germany) and Wageningen University and Research (Netherlands), with the most frequent publisher is Animals. In the early period, researchers frequently employed terms such as climate change and non-human, following the earlier emphasis on temperature. After the 2000s, the focus shifted toward livestock health and disease, leading to more frequent use of epidemiology in conjunction with temperature. Over the past five years, animal experiment has also become increasingly prominent. Network analysis revealed that heat stress and animal welfare were the most frequent terms, followed by One Health and livestock. Research on strengthening livestock resilience to climate change emerges as a particularly promising avenue for future inquiry.

Keywords | Climate change, Animal health, Bibliometric analysis, VOS viewer, Visual mapping, Research trend

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INTRODUCTION

Climate change, a global phenomenon that has drawn significant attention over the past decades, refers to shifts in temperature and precipitation patterns (Kim and Lee, 2025). The primary driver of this phenomenon is human activity (WHO, 2009). The United Nations has issued a clear warning that human activities contribute to at least 75% of global greenhouse gas emissions and nearly 90% of all carbon dioxide emissions (United Nations, 2025).

In response, global agreements have been established to achieve the Sustainable Development Goals (SDGs), including specific targets related to climate change. These agreements also serve as a reminder of the ongoing need to build and strengthen both knowledge and awareness of this immense global crisis (United Nations, 2023).

The projected impact of climate change is so immense that it is now considered the greatest global threat of our time (Zhao *et al.*, 2025). Previous studies have documented its effects on water resource degradation (Ahmed *et al.*,

2020; Moon, 2024), drought disasters (Ghazi *et al*., 2025), the spread of infectious diseases (Dalla Vecchia *et al*., 2024; Petrino *et al*., 2025), heatwaves (Basu, 2009), and mental health (Deepak *et al*., 2024; Marinova *et al*., 2025). Even the increasing frequency of storms due to climatic anomalies has been linked to climate change (Morley *et al*., 2025).

The scale of this impact is so vast that many of its manifestations are intangible. Climate change poses a threat to the loss of human traditions connected to nature, which have been shaped over thousands of years (Datta and Kibria, 2025; Zaluchu, 2024). These non-physical heritages are at risk of disappearing within the coming decades.

However, one of the serious impacts of climate change extends beyond human health and also affects animal health (Anikeeva *et al*., 2024). To explain this, Lacetera (2019) states that climate change has both direct and indirect effects on animal health. The direct effects are caused by rising temperatures and heatwaves, leading to livestock heat stress. It is well established that rising temperatures significantly affect livestock productivity (Mirzaie *et al*., 2024; Salem *et al*., 2022). In addition, exposure to environmental heat worsens animals' immune systems (Rogozynski *et al*., 2024) and triggers the production of antioxidants (Sarker *et al*., 2025; Stelios *et al*., 2024). On the other hand, for instance, the lung health of broilers is strongly affected by heat-induced stress (Niu *et al*., 2025).

Although extensive global research has been conducted on the relationship between climate change and animal health, it remains important to consider the future directions and conceptual frameworks in this field, especially in the last 20 years. There is a need to examine the potential research avenues that should be pursued, which can be identified through the synthesis of existing documents. Therefore, mapping current trends is essential to determine key directions and to identify potential areas for future investigation. A comprehensive understanding of the global research landscape will allow existing information gaps to be more clearly recognized and effectively addressed. Bibliometric analysis offers a robust approach to identifying key themes within the field of climate change and animal health, facilitating the examination of research trends and the projection of future research opportunities. This method is particularly valuable for its systematic collection and analysis of existing data, as well as its ability to visualize relationships among publications, authors, and thematic clusters thereby revealing connections that may not be readily apparent through traditional literature reviews.

MATERIALS AND METHODS

Source of data

We collected data from the Scopus database on July 4, 2025. The literature search was conducted using the keywords TITLE-ABS-KEY ("global warming" OR "climate change" AND "animal health" OR "livestock health," OR "veterinary health" OR "animal welfare" OR "livestock welfare," OR "veterinary welfare"). This initial search yielded 456 pieces of literature. The search results were then filtered using the following criteria: (1) written in English; (2) limited to articles; (3) open access; (4) at final publication stage; and (5) between 2005-2024. Following a review of titles and abstracts, only 242 documents were deemed eligible for further analysis. The review process involved both researchers, who cross-verified the documents in accordance with the initial concept of this paper. Although no differences of opinion arose during this activity, it had been planned to seek external input in the event of divergent views.

The raw data from Scopus was then downloaded in its entirety, including information on authors, affiliations, journals, keywords, research areas, citations, titles, abstracts, and funding details.

Data statistics and visualization

The articles downloaded from the Scopus database were then processed. For visual analysis and statistical processing, Microsoft Office Excel 2021, the Biblioshiny package from R, and VOS viewer were used.

Microsoft Office Excel 2021 was used to compute and present the data in graphical form. This was done by inputting the results of the search data from the Scopus database and displaying them as charts. The Bibliometrix R Package was used to map the literature (Aria and Cuccurullo, 2017). In this study, version 4.5.1 was used to analyze the number of publications, citations, evaluate core journals, H-indexes, trending topics, and other relevant metrics. Additionally, the R package was used to generate visualizations of the geographic distribution of the publications.

VOSviewer is an open-access application developed by Nees Jan van Eck and Ludo Waltman (van Eck and Waltman, 2010). VOSviewer was used to map the index and author keywords of the literature.

RESULTS AND DISCUSSION

Global trend and production

A total of 242 documents were included in this report (Table 1). All of them are articles published between 2005 and 2024.

Table 1: Document's main information.

Description	Results
Main information about data	
Timespan	2005:2024
Documents	242
Annual growth rate %	21.1
Document average age	5.11
Average citations per doc	28.12
References	14117
Document contents	
Keywords plus (ID)	2207
Author's keywords (DE)	900
Authors	
Authors	1305
Authors of single-authored docs	12
Authors collaboration	
Single-authored docs	12
Co-authors per doc	5.57
International co-authorships %	37.19
Document types	
Article	242

Based on the general overview, a mean of 28.12 citations per document was recorded, with an average document age of 5.11 years. Globally, publications on this topic involved 1,305 authors, with 12 documents being single-authored papers, and an average of 5.57 co-authors per paper. Table 1 also shows that nearly 38 percent of the authors were involved in international co-authorship.

Figure 1 presents the annual publication trends. Until 2018, the trend remained relatively flat. However, a notable surge occurred in the following three years, indicating growing interest among researchers. In both 2023 and 2024, publications reached their peak, with 38 documents published each year. Between 2019 and 2024 alone, there were 181 publications, accounting for three-quarters of all works published since 2005. This pattern highlights the increasing intensity of research interest in this topic. Over a span of nearly 20 years of publications, the fluctuations still reflect an average annual growth rate of 21.1%.

Although 68 countries have produced publications on this topic, the majority are dominated only by five countries: Australia, Germany, Italy, the United Kingdom, and the United States of America (USA). Together, these five countries account for 44% of all documents published globally. The distribution pattern of their contributions is illustrated in Figure 2. This clearly reflects a serious issue that holds potential to be addressed in the future. Regions that are likely to be far more vulnerable to climate change, such as those in the tropics, should be more actively included in global research efforts.

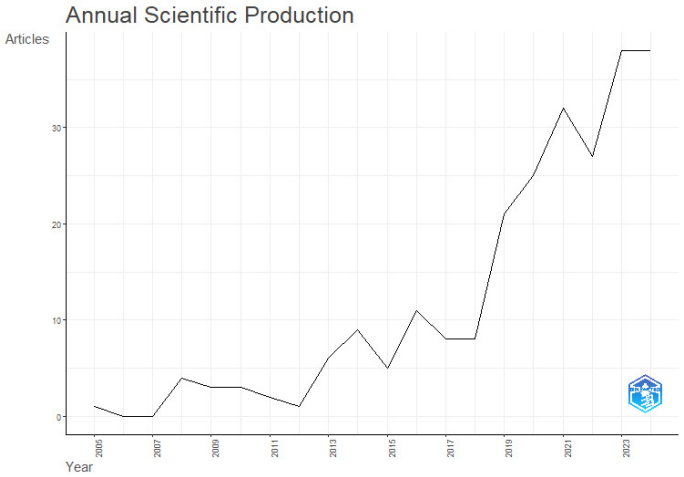

Figure 1: Annual publication (2005-2024).

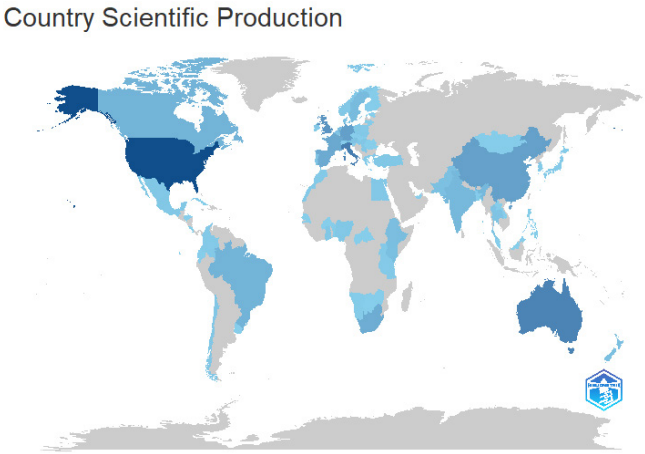

Figure 2: Country scientific production.

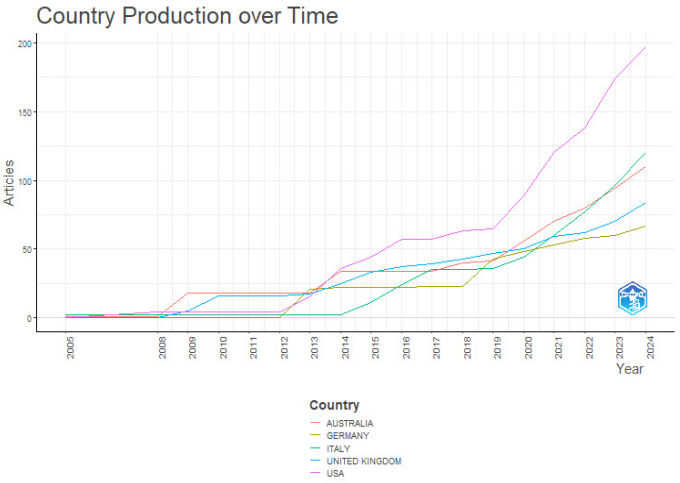

Figure 3: Country scientific production.

Figure 3 illustrates the growth of publications in the five countries with the most significant contributions, showing a general surge over the past five years. The publication patterns vary among these countries. The USA, for example, has dominated document production on this

topic from the outset, consistently surpassing the other four countries through to 2024. In contrast, publication output from Germany and the UK has tended to level off, while Italy and Australia have shown a steady increase in research production on this topic.

In details, between 2005 and 2024, Australia published 719 documents, rising from only 2 in 2005–2008 to a peak of 110 in 2024. Germany entered the field in 2013, maintained stable output until 2018, then doubled production in 2019 and reached a total of 462 documents. Italy produced 554 publications, with minimal activity before 2015, then sharply increasing to 120 in 2024. The United Kingdom showed a similar pattern, growing from 3 documents in 2015 to a peak of 84 in 2024. The United States led globally with 1,075 publications, exceeding 100 per year from 2021–2024, with a major surge beginning in 2013. Overall, these patterns indicate that global research attention to this topic has intensified only in recent years and is likely to continue growing.

It is particularly interesting to compare the data from the most cited countries (Table 2). While the USA leads in total publication output, the top positions in citation counts are instead held by Italy and Australia, with 1,106 and 744 citations, respectively. The average citation rate for Italy is twice that of the USA. Aside from Italy and Australia, Germany records the highest average citations among the remaining countries.

Table 2: Most cited countries.

Countries	Total citation	Average citations
Italy	1106	55.3
Australia	744	41.3
Usa	647	21.6
Germany	452	41.1
United kingdom	452	32.3

To illustrate the proximity among countries conducting research on climate change and animal health, a visualization was generated using VOSviewer. As shown in Figure 4, applying a minimum threshold of five documents per country resulted in the formation of four clusters: red, green, blue, and yellow.

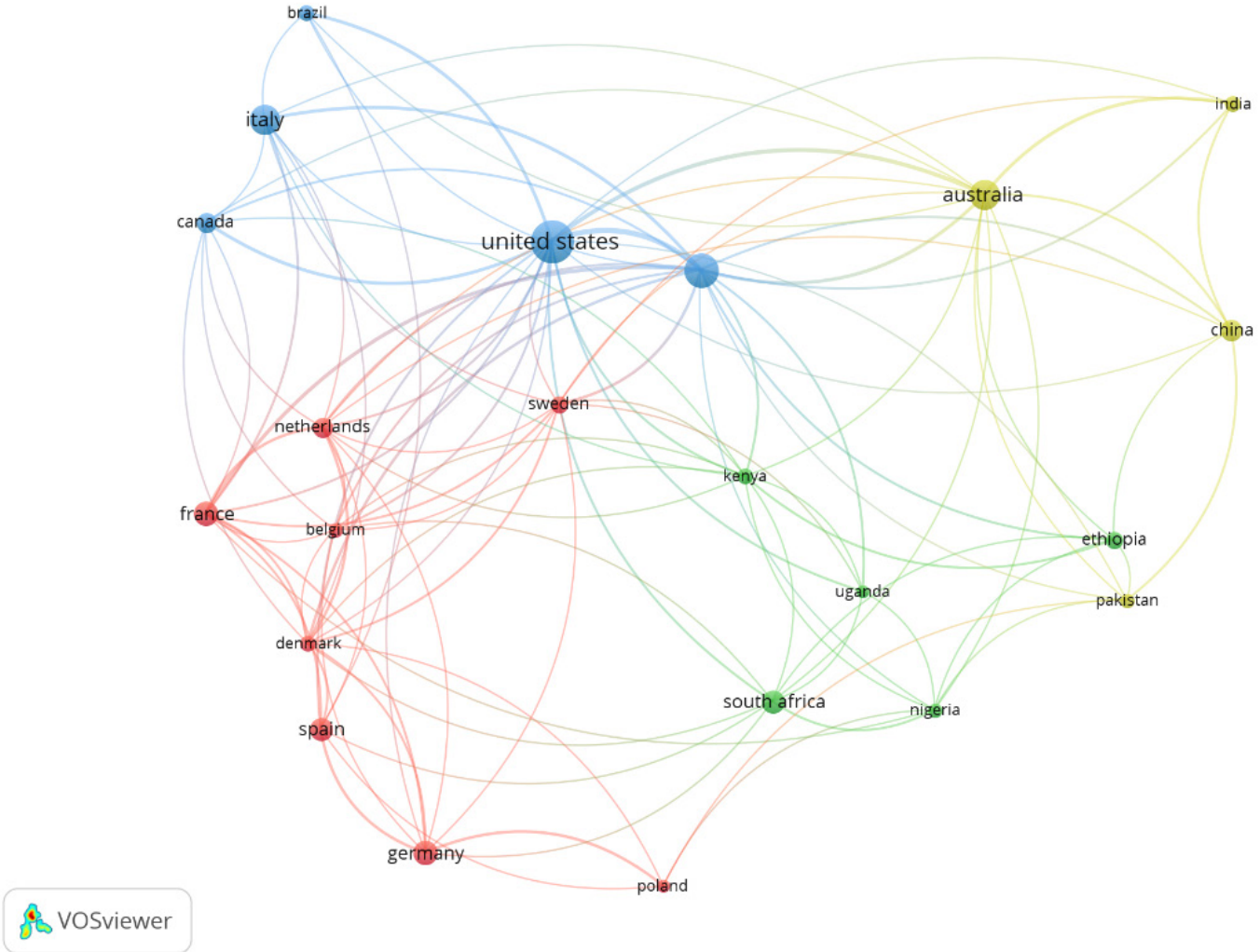

Figure 4: VOSviewer visualization of co-authorship by countries (minimum=5).

The red cluster, comprising eight countries, is dominated by Germany and France, both showing significant contributions within the same cluster. However, the spatial distance between these two countries suggests relatively limited collaboration. The green cluster consists of five countries, led by South Africa, yet the distances among countries in this cluster also indicate weak collaborative ties. The blue cluster contains five countries, with the USA and the UK as leading contributors; here, strong collaboration is evident only between these two nations. The yellow cluster includes four countries, dominated by Australia, which shows relatively limited collaboration with the other members of its cluster.

Such collaboration patterns are likely to influence the advancement of research on this topic in the future. Countries that are newly emerging in this field should seek partnerships with those that have established a strong research reputation, at least since 2005, to accelerate their contributions and impact.

Authors' affiliations

Table 3 presents the top ten author affiliations that have published research on this topic. While Figure 1 shows that the countries with the highest contributions are Australia, Germany, Italy, the United Kingdom, and the United States of America, an analysis based on institutional affiliation reveals a different pattern. The University of Veterinary Medicine Hannover in Germany and Wageningen University and Research in the Netherlands emerge as the leading affiliations for authors publishing on this topic. Notably, several other top affiliations are located outside the five previously discussed countries, including the University of Pretoria in South Africa, the Limnological Institute of the Siberian Branch of the Russian Academy of Sciences in Russia, and the University of the Basque Country (UPV/EHU) in Spain, all of which are listed among the top ten relevant affiliations.

This indicates that institutional interest in this topic is widely distributed. It also highlights the potential for expanding collaborations and conducting more targeted research addressing the specific conditions of each institution's respective region.

Table 3: Top 10 affiliation.

Affiliation	Country	Articles
University of Veterinary Medicine Hannover	Germany	16
Wageningen University and Research	Netherlands	16
The University of Melbourne	Australia	15
University of Pretoria	South Africa	15
Purdue University	USA	14
University of Foggia	Italy	14
University of Sydney	Australia	13
College of Veterinary Medicine and Biomedical Sciences	USA	12
Limnological Institute Siberian Branch of The Russian Academy of Sciences	Russia	11
University of The Basque Country (Upv/Ehu)	Spain	11

Document sources

Of the 242 documents analyzed, ten journals were identified as the top sources. The journal *Animals* ranked first, followed by *PLOS One* in second place and *Frontiers in Veterinary Science* in third (Table 4). Among these ten journals, four are categorized under "animal" and another four under "zoology." Only two journals fall into the Q2 category, and Animals is the most frequent publisher. Publications on animal health and welfare are naturally

Table 4: Document's sources.

Journal	Number of publication	Category	SJR/ Quartiles	H Index
Animals	17	Animal Science and Zoology; Veterinary (miscellaneous)	0.733/ Q1	95
Plos one	11	Multidisciplinary	0.803/ Q1	467
Frontiers in veterinary science	10	Veterinary (miscellaneous)	0.783/ Q1	85
Animal	9	Animal Science and Zoology	1.040/ Q1	133
Oie revue scientifique et technique	7	Animal Science and Zoology; Medicine (miscellaneous)	0.442/ Q2	102
Sustainability (Switzerland)	6	Computer Networks and Communications; Hardware and Architecture; etc	0.688/ Q1	207
Agriculture (Switzerland)	4	Agronomy and Crop Science; Food Science; Plant Science	0.704/ Q1	84
International journal of environmental research and public health	4	Health, Toxicology and Mutagenesis; Pollution; Public Health, Environmental and Occupational Health	0.919/ Q2	229
Scientific reports	4	Multidisciplinary	0.874/ Q1	347
Animal frontiers	3	Animal Science and Zoology; Food Animals	0.799/ Q1	55

concentrated in journals with a clear focus on these topics. However, connections to human health issues and the emergence of new technologies have broadened the scope, leading to coverage in journals not exclusively dedicated to animal research. PLoS One, for instance, has provided substantial space for publications on this topic. This also reflects the increasing diversity of disciplinary perspectives from which researchers approach the subject.

Term analysis

Term analysis shows that the earliest emerging terms were animals and animal disease (2009), with animal disease continuing to appear through 2023. In subsequent years, terms such as prediction, disease carrier, and food industry appeared (2010). As research in this field diversified, new terms emerged, including risk assessment, animal husbandry, and disease transformation in 2012–2013.

During the 2019–2023 period, researchers frequently used terms such as climate change and non-human, following the earlier introduction of temperature. The focus on livestock health and disease also led to more frequent use of epidemiology, often in conjunction with temperature, while animal experiment became increasingly common through 2024.

This trend pattern illustrates the themes that have emerged in animal health research with recent developments showing a shift toward more specific topics. The term *temperature*, for example, has emerged prominently over the past five years, reflecting efforts to examine temperature patterns and their relationship to animal health, as reported by Singh *et al.* (2024) and De Prekel *et al.* (2024).

Keywords and network analysis

By focusing specifically on author keywords and setting a minimum occurrence threshold of 4, a total of 30 keywords were identified, as visualized in the network presented in Figure 6.

The analysis identified six distinct clusters (Table 5). Among all keywords, the most frequently used terms were heat stress and animal welfare. The next most prominent term was one health, followed by livestock. The growing body of research and publications on climate change and animal health reflects increasing concern among researchers worldwide. From the documents analyzed, it is evident that, in addition to disparities in research capacity, the evolving directions of study present valuable references for future investigations.

Table 5: Most frequent author index keywords per cluster.

Cluster color	Keywords	Occurrences
Red cluster	Heat stress	31
Green cluster	One health	17
Blue cluster	Live stock	13
Yellow cluster	Adaptation	6
Purple cluster	Climate change	2
Cyan cluster	Animal welfare	25

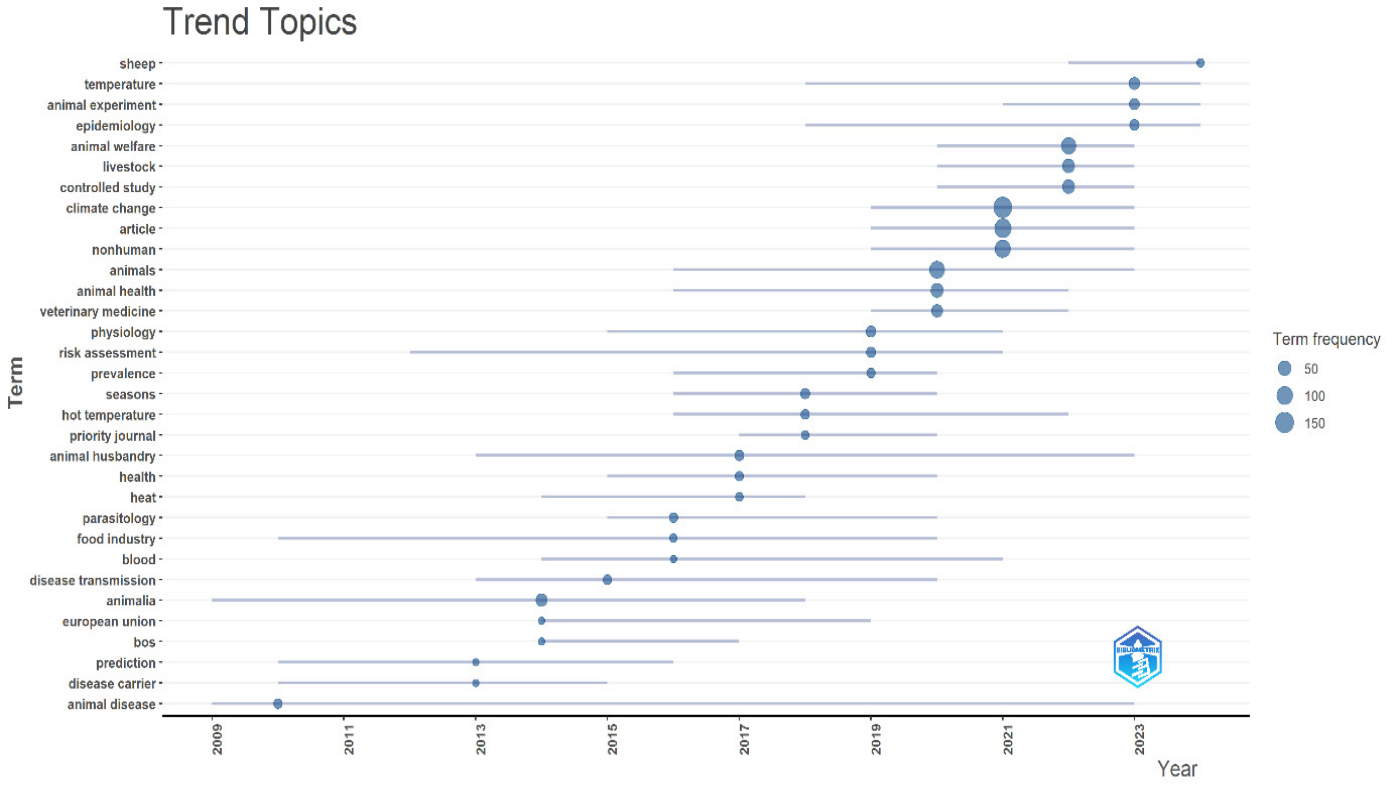

Figure 5: Timeline of research trends.

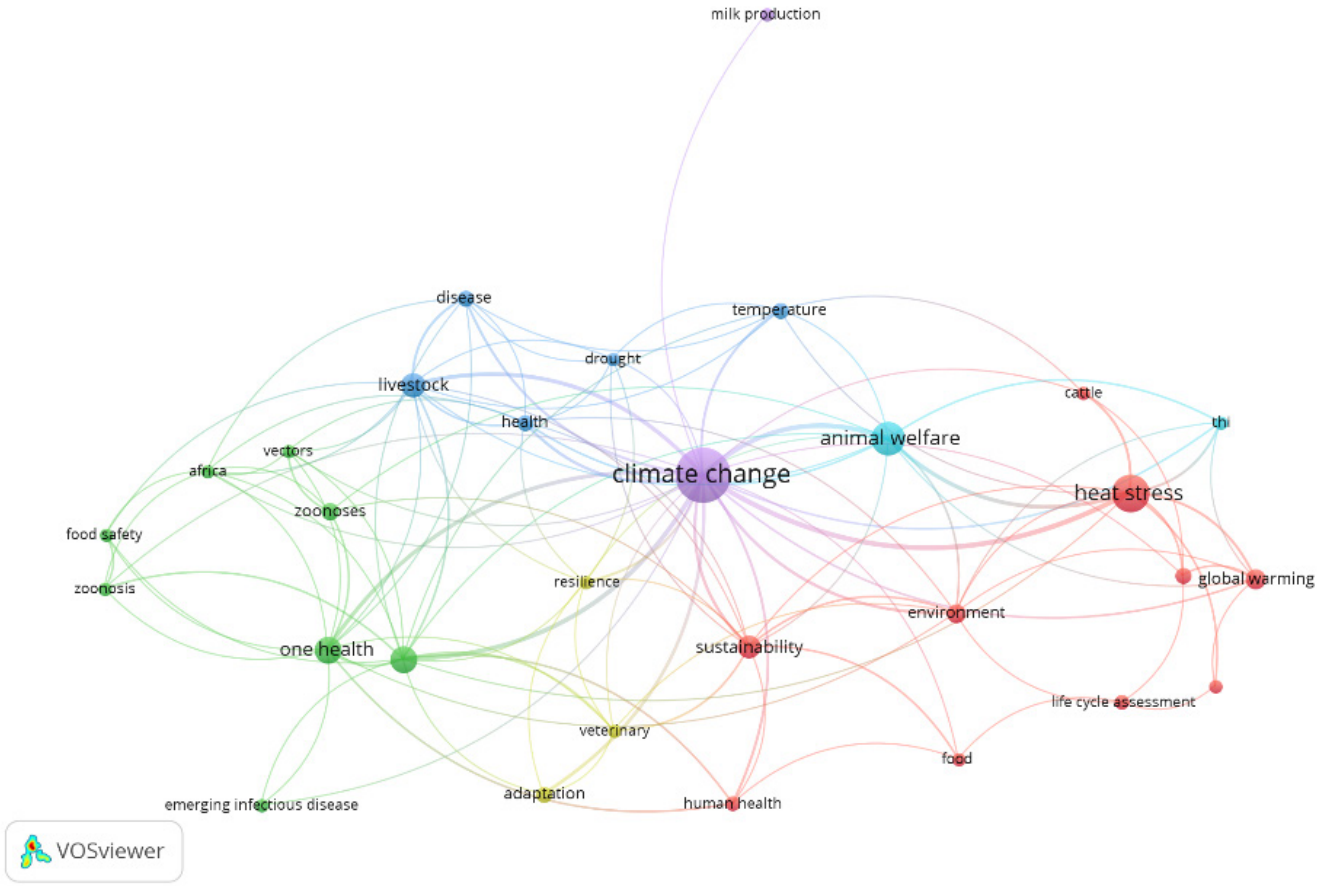

Figure 6: VOSviewer visualization of author keywords.

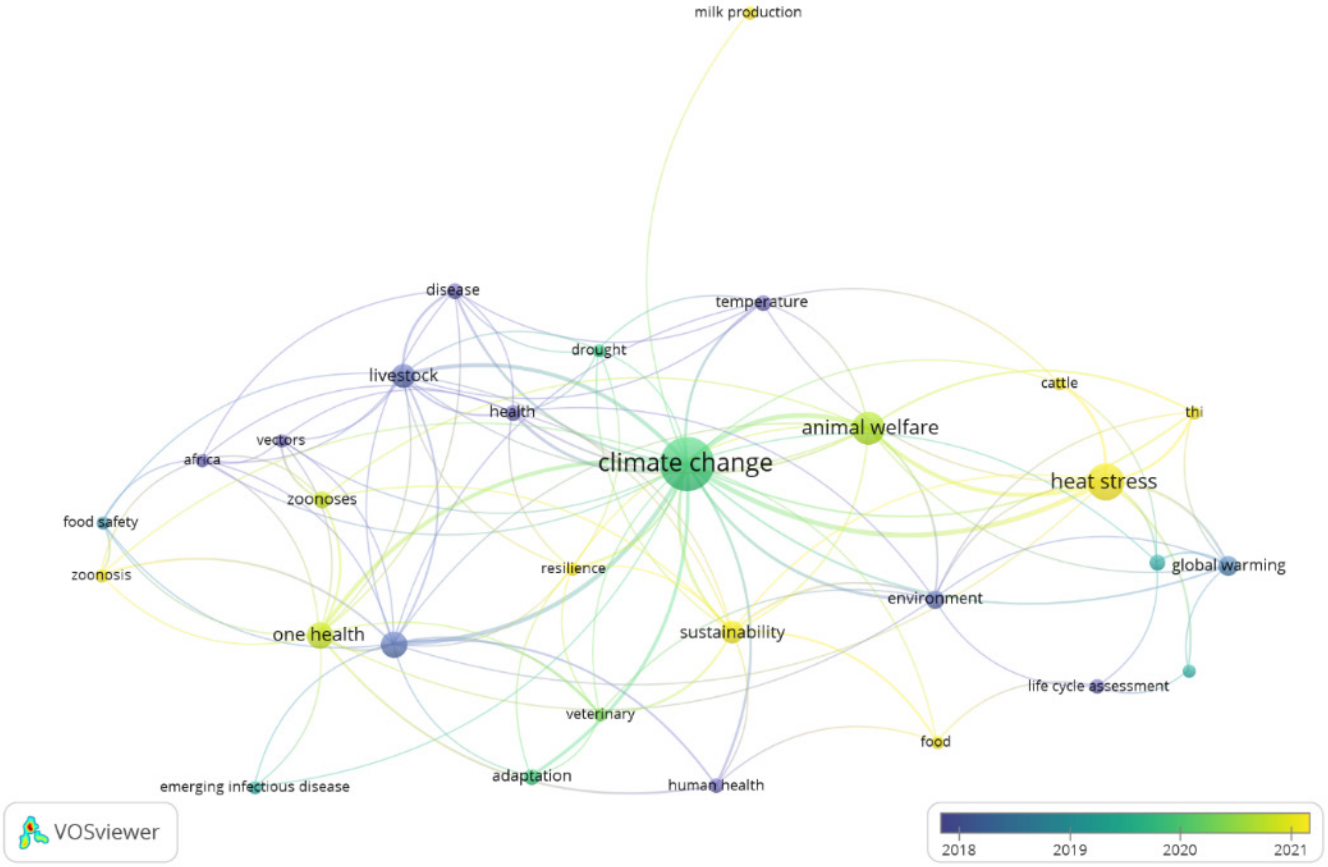

Figure 7: VOSviewer visualization of keywords trend topics.

Climate change and animal health/welfare are issues that affect all humanity and the shared ecosystem. It is well established that climate change has altered the face of the Earth. Ironically, this situation is irreversible and has permanently transformed the environment, even under the most conservative scenarios, due to the slow pace of global efforts to control the planet's temperature (Abbass *et al*., 2022; Hansen *et al*., 2025; Zhang *et al*., 2024, 2025). The complexities arising from land use, industrialization, and technological advancements have led to serious issues concerning the Earth's surface temperature (Zhang *et al*., 2025). The increasing of land temperatures are causing stress on the environment and ecosystems in general (Byrne *et al*., 2024; IPCC, 2022).

In turn, the impact of climate change extends not only to humans but also to animals (Testai, 2024). Heat stress has been one of the dominant research topics in recent years. One of the most frequently cited documents on the impact of rising temperatures on animal health is the work by Lacetera (2019), published in animal frontiers, which outlines several serious consequences of heat stress in animals, including metabolic alterations, oxidative stress, immune suppression, and mortality. Another important real-world report on this impact can be found in the work of McKeon *et al.* (2009), set in livestock farms in northern Australia, which concluded that heat stress has severe consequences for both animal production and ecosystem functioning. Compelling evidence of climate change impacts on animal health is also provided by Gauly *et al.* (2013), who reported that livestock centers, particularly in Central Europe, have experienced production declines. Increasing temperatures have been associated with decreased productivity in laying hens on commercial poultry farms (Kamal *et al*., 2024). Similarly, dairy production in cattle has declined as a result of increasingly uncontrollable temperature fluctuations (Allen *et al*., 2015; West *et al*., 2003). Looking ahead, the impacts of heat stress are likely to remain an active area of research, as temperature changes become increasingly erratic. Unpredictable climate patterns now affect animal health and welfare globally, including in regions that may not have previously been exposed to extreme temperatures.

It can be acknowledged that the impacts of climate change on diseases affecting animals have long been observed. A review by Rahman *et al.* (2020) concluded that climate change is a significant contributor to the spread of zoonoses, which in turn affects livestock health. The effects on these animals occur because climate change influences the presence and vulnerability of animals as hosts, the pathogenicity of disease agents, and the disease transmission models in animals (El-Sayed and Kamel, 2020; Muniz *et al*., 2025). Under global climate change conditions, the ability of pathogens to invade livestock increases exponentially (Elsohaby and Villa, 2023; Imamura *et al*., 2014). Any decline in animal health inevitably impacts humans, either directly or indirectly (Babo Martins *et al*., 2024; Rojas-Downing *et al*., 2017), as animals also share health risks with humans. In other words, certain diseases are often shared between animals and humans. This situation should be a key concern in the future, where animal health could serve as an early indicator to predict potential health issues in humans (Plön *et al*., 2024). As presented in Figure 5, interesting trend topics are related to mapping human health risks in accordance with temperature changes. Although information on this matter may already exist, examining the speed of decision-making in response to such risks becomes an important area of study.

Since 2005, efforts to protect animals in livestock production have also been one of the focal points of published research. Various comprehensive modifications have been recommended (Chauhan *et al*., 2023). More recently, reports have highlighted the use of machine learning to monitor temperature (Perez-Garcia *et al*., 2024) and the intensive development of nanotechnology to prevent production decline (El-Raghi *et al*., 2023). From this standpoint, it is evident that there is a need to explore more specific and experimental research opportunities on this topic. This underscores the importance of researchers and institutions building collaborative networks. It is not impossible that a global partnership will be required to protect animal health and welfare through joint research efforts.

One of the emerging concepts in the publication trend on climate change and animal health over the past five years is one health. This approach emphasizes that humans are not the sole focus of health interventions. In addition to human health, it is also essential to improve animal health and the quality of ecosystems (Ellwanger *et al*., 2021; Pacheco-Zapata *et al*., 2024). One health introduces a new paradigm in which health management must be carried out collectively, recognizing that humans coexist with animals in the same environment. Consequently, impacts on one component will inevitably affect the others (Adisasmito *et al*., 2022). Given that humans live alongside animals and ecosystems, the integration of these three components must be a key concern (Dean *et al*., 2023; Rawat *et al*., 2024). Looking ahead, the extent to which the one health concept is implemented in accordance with the specific variability of each region presents a highly compelling research focus. This is especially the case if the application of one health can be integrated with the use of advanced technologies available today. This topic is highly relevant and merits deeper investigation in future studies.

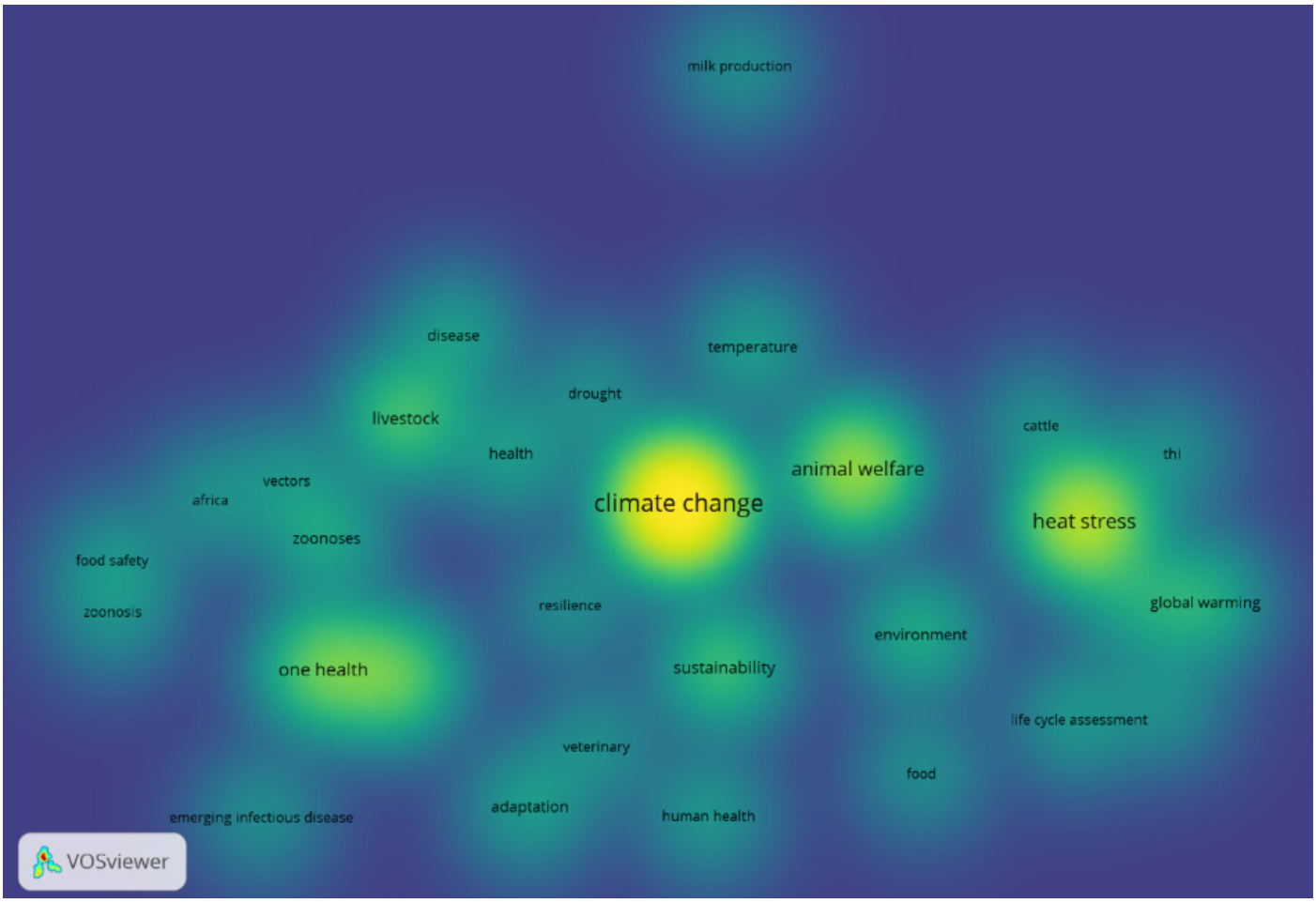

Figure 8: VOSviewer visualization of trend topics density.

The livestock industry generally provides meat and food for human consumption. The sustainability of this system is at risk if animal health is compromised. Therefore, there is no alternative but to manage livestock health effectively, as it is closely linked to human needs (Kyriazakis *et al*., 2024; Marinova *et al*., 2022). Humans heavily rely on animal-derived food products (Lin *et al*., 2024). Thus, the paradigm of animal health must be understood within the broader context of sustaining life, not only for animals but also for humans (Perry *et al*., 2018). However, existing reports highlight the threats posed by climate change to this condition (Reynolds *et al*., 2015). This is particularly concerning, as the primary sources of food and protein intake for humans still largely come from animals (Barr *et al*., 2025; Merlo *et al*., 2024; Verma *et al*., 2025). Therefore, future research should continue striving to safeguard humanity's need for meat and other animal-based foods, even as the world currently faces instability in supply stocks. This represents a significant burden for global researchers in their efforts to protect humanity's own interests.

Referring to Figures 7 and 8, the thematic mapping of documents to date is clearly visible. Themes such as climate change, global warming, heat stress, and animal welfare have evolved into well-established areas of study. Consequently, efforts to detect the spread of diseases in livestock remain a promising avenue of research, particularly for strategically important animals such as cattle, sheep, and poultry. Likewise, research aimed at enhancing livestock resilience to climate change presents a highly promising field to pursue in the future.

Limitations

Although bibliometric analysis is useful for identifying publication trends, it must be understood that there are several limitations that should be taken into account to avoid overinterpreting the results. These limitations stem, among other things, from the dependence on the database used in this case, solely the Scopus database. Each database has its own journal coverage, meaning that publications from certain regions or in certain languages may be overlooked. It is therefore important to use other databases, such as Web of Science or PubMed, or to employ a combination of existing databases in order to obtain more comprehensive information.

Likewise, most reputable databases prioritize English-language publications, which leads to the underrepresentation of important research published in local languages. In some cases, researchers from English-

speaking countries may circulate their findings only within their own academic networks, further reinforcing a substantial bias.

Bibliometric analysis also focuses more on measuring the quantity of publications, citations, and collaboration networks rather than the quality of research methodology or the real-world impact of the findings. Consequently, a highly cited article does not necessarily have high validity or relevance; in some cases, citations arise from controversy or errors that have been widely critiqued. Citation counts may also be influenced by factors unrelated to research quality, such as self-citation, exclusive collaboration networks, or the popularity of a given topic within the academic community.

In addition, the publication process itself requires time from research to print, meaning that bibliometric data often reflect trends from several years prior rather than current conditions. This presents a limitation when such data are used to inform policies that require real-time evidence, for example, in anticipating emerging zoonoses or responding to critical new trends.

Finally, bibliometric analysis may fail to capture the precise terminology for a given topic. This is particularly true for interdisciplinary research such as the present topic. Variations in terminology, journal categorization, and key definitions can significantly affect the mapping and interpretation of research themes.

As a literature review, the results presented here should serve as an initial reference to explore the mapped studies further. The visualizations and analyses offered in this paper should not be interpreted as in-depth analytical outcomes. In examining the shifts in terminology, we did not perform statistical significance testing on word co-occurrence patterns. Therefore, the word trends presented should be understood without inferential proof. Future research could strengthen these findings by applying statistical approaches to validate the co-occurrence relationships.

CONCLUSION AND RECOMMENDATION

The mapping of documents on the topic of climate change and animal health indicates that research efforts in this field have progressed substantially. Between 2005 and 2024, document production has reached a point that may not yet represent its peak. While relatively few countries and institutions currently dominate the field, this is expected to expand in parallel with the growing significance of climate change impacts. Several key recommendations emerge from this analysis: (1) Future research should prioritize collaboration between countries and research institutions to address this topic. Climate change will inevitably affect all nations, making strong and well-structured international relationships essential. (2) Future studies should also emphasize the intensification of efforts to safeguard animal health through advanced technologies and experimental approaches. These initiatives must be accompanied by effective technology transfer to countries in need, ensuring equitable capacity-building worldwide. Finally, mapping research trends is indeed important; however, policy and on-the-ground interventions are equally necessary. Therefore, future studies should also focus on mapping these aspects.

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NOVELTY STATEMENT

Employing advanced bibliometric tools, this study integrates co-citation, co-occurrence, and thematic evolution analyses to provide a multidimensional mapping of the research landscape. Beyond mapping the intellectual structure of the field, the bibliometric approach also uncovers recently emerging underexplored themes, such as climate-resilient livestock systems and the integration of emerging technologies while offering strategic foresight for shaping future research directions.

AUTHOR'S CONTRIBUTION

Cashtri Meher: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, resources, software, supervision, validation, visualization, writing original draft, review and editing, project administration.
Fotarisman Zaluchu: Conceptualization, data curation, formal analysis, methodology, supervision, writing original draft, review and editing.

Generative AI and AI-assisted technology statement

The authors declare that no Generative AI was used in the creation of this manuscript.

Conflict of interest

The authors declare that there are no conflicts of interest in this study. The authors also declare that this study was not conducted using any funds or financial support from any individual or organization.

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