



A Bibliometric Analysis of Sustainable Livestock Systems: Soil and Plant Health Perspectives

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Abstract: This Bibliometric analysis evaluates research on sustainable livestock systems, emphasizing plant and soil health, and examining the major trends in publications and partnerships. Analyzing 104 published articles from 2013 to 2024, the study reveals a significant increase in publication trends since 2016, peaking in 2021. An average of 5.8 authors per article reflects a strong inclination toward collaborative research—significantly higher than the 1.4–1.6 average in social sciences and humanities, and more aligned with biomedical and environmental sciences, where five or more authors are common. Despite this, co-authorship networks remain fragmented, lacking interdisciplinary collaborations essential for holistic solutions. The United States leads as a central research hub, maintaining collaborations with China and Brazil, though geographic and language clustering affect partnerships. Most studies were published by prestigious journals such as *Science of the Total Environment* (7 articles), *Journal of Environmental Management* (5), and *Agriculture Ecosystems and Environment* (9), with the majority available as open access. The study underscores the crucial role of open access in disseminating knowledge and fostering sustainable agricultural practices worldwide. It highlights the importance of incentivizing interdisciplinary research and fostering international collaboration. Establishing platforms for knowledge sharing, funding applied research, implementing supportive policy frameworks, investing in stakeholder training, and creating monitoring systems are essential actions. These will ensure effective and adaptive initiatives to bridge collaboration gaps and address challenges in sustainable livestock systems. These efforts contribute to resilient livestock systems, climate mitigation, biodiversity enhancement, and foster global collaboration—core elements of SDGs 2, 13, 15, and 17.

Keywords: Sustainable livestock systems; soil health; plant biodiversity; grazing management; environmental sustainability.

1. Introduction

Sustainable livestock systems have garnered significant attention in recent years due to their important part in promoting environmental sustainability, improving soil health, and enhancing plant biodiversity. These systems aim to balance agricultural productivity with ecological integrity by mitigating the negative impacts of conventional livestock farming, such as biodiversity loss, soil degradation, pollution, and greenhouse gas emissions. Numerous studies have demonstrated that sustainable practices like rotational grazing reduce stocking rates and improve pasture management, thereby

enhancing soil health, nutrient cycling, and encouraging diverse vegetations, making them a vital component of resilient agricultural landscapes [1,2].

The link between livestock management and soil health is particularly significant to support the growing need for sustainable food systems. Livestock contribute to these systems by providing manure, a critical source of natural fertilizer, and serving as draft animals to boost productivity in regions with low mechanization. However, overgrazing, improper land use, and poor soil management have been the reason the concerning soil erosion and nutrient depletion in many agricultural regions. Researchers have explored innovative grazing strategies that can increase productivity without compromising soil health [3,4]. For instance, rotational grazing has improved soil aeration and prevented soil compaction, resulting in healthier soil that supports diverse vegetation [5]. Recent bibliometric reviews also highlight the role of technology and ecological restoration in improving soil processes under sustainable grazing regimes [8,10]. Plant Biodiversity supports sustainable livestock systems through ecosystem functions such as nutrient cycling, water retention, and pest control. Studies highlight that integrating diverse forage species within grazing systems increases resilience against drought, diseases, and other environmental stressors [6,7]. The interconnectedness of livestock management and plant health is thus a key area of study in order to advance sustainable agricultural practices. Moreover, sector-wide collaboration among livestock stakeholders has been shown to drive innovation and improve biodiversity outcomes in grazing landscapes [13].

Despite the growing number of studies focusing on sustainable livestock systems, a persistent gap in interdisciplinary and international collaboration remains. Co-authorship networks are fragmented, which usually focus only on specific subject areas. The lack of international and interdisciplinary collaborations limits the development of comprehensive solutions to complex issues faced by sustainable livestock systems. Bibliometric analyses of agrifood transitions and SDG-related research emphasize the importance of cross-disciplinary partnerships to address these gaps [9,12]. Strengthening these networks is essential for fostering innovation and achieving sustainability targets. Recent bibliometric reviews of plant-based feeds and forage research from 2013 to 2024 further reinforce this gap, revealing fragmented co-authorship networks and limited collaboration between major contributors such as the United States and China. Thematic trends emphasize forage quality, crop resilience, and interdisciplinary integration across agriculture, environmental science, and animal production. Institutions like Lanzhou University and the USDA Agricultural Research Service emerged as key drivers of innovation, highlighting the importance of robust infrastructure and international partnerships to accelerate progress in sustainable livestock systems [21]. To address these limitations, this study introduces a novel analytical framework that integrates bibliometric mapping with thematic evolution analysis, offering deeper insights into interdisciplinary linkages and emerging research frontiers.

This study will provide an in-depth analysis of sustainable livestock systems research from 2013 to 2024. It identifies key contributors, research clusters, and emerging topics related to soil and plant health within sustainable livestock systems. By mapping the evolution of research in this area, this study provides a more integrated approach to sustainable livestock research. This study's findings can guide future research efforts and policy decisions to enhance environmental, economic, and social outcomes in sustainable agriculture. Recent bibliometric studies suggest that fostering interdisciplinary collaboration is essential for holistic sustainability planning in livestock systems [11,14]. Aligned with the United Nations Sustainable Development Goals (SDGs), this study contributes to several key global targets. It supports SDG 2: Zero Hunger by promoting sustainable food production systems and resilient agricultural practices that enhance soil and plant health. It advances SDG 15: Life on Land through the conservation of biodiversity and the sustainable use of terrestrial ecosystems, particularly in grazing landscapes. By addressing climate-resilient livestock practices and reducing environmental degradation, the study aligns with SDG 13: Climate Action. Finally, by emphasizing the importance of interdisciplinary and international research collaborations, it contributes to SDG 17: Partnerships for the Goals, fostering innovation and integrated approaches to sustainability planning.

The study aims to systematically analyze bibliometric patterns in sustainable livestock systems. Specifically, the study seeks to identify citation trends, highlighting influential works and emerging research trajectories. Additionally, it aims to map co-authorship networks, identifying key contributors and

collaborative relationships that shape the field. Another critical focus is the exploration of significant keywords, particularly those related to soil health, plant biodiversity, and grazing management, to uncover thematic concentrations within existing literature. Furthermore, the research examines the distribution of articles based on dimensions such as study type, authorship patterns, and source journals, providing insight into the structural characteristics of scholarly output. By addressing these objectives, the study contributes to a deeper understanding of research impact, collaboration dynamics, and thematic evolution within the domain of sustainable livestock systems.

2. Materials and Methods

The bibliometric analysis was conducted using peer-reviewed academic publications focused on sustainable livestock systems. The study aimed to identify patterns in authorship, keyword co-occurrence, institutional contributions, and thematic clusters. Articles were sourced exclusively from the Scopus database, selected for its comprehensive indexing of high-impact journals across agricultural and environmental sciences. While Scopus offers extensive coverage, its indexing bias toward English-language and high-impact journals may underrepresent regional or non-English contributions. This could influence geographic collaboration patterns and thematic diversity observed in the results. It is acknowledged that reliance on a single database may have excluded relevant literature indexed in other platforms such as Web of Science and Dimensions. Future studies should consider multi-database triangulation to enhance comprehensiveness and reduce selection bias.

Search strings were developed through a structured process combining preliminary scoping reviews of existing literature, expert consultation to refine thematic focus, and application of Boolean logic using ChatGPT to assist in generating and refining initial keyword combinations based on thematic relevance and co-occurrence patterns observed in prior studies. The final Boolean search strings were manually reviewed and adjusted to ensure precision and reproducibility. The search was conducted on July 12, 2024, using the Boolean combinations applied to titles, abstracts, and keywords: “sustainable livestock systems” AND “soil health” AND “plant biodiversity”, “grazing management” OR “rotational grazing” AND “sustainable agriculture”, “soil conservation” AND “pasture management” AND “biodiversity” OR “ecosystem services”, “sustainable livestock systems” AND “carbon sequestration” AND “environmental sustainability” and “regenerative agriculture” OR “organic farming” AND “rangeland management” AND “soil erosion”.

A total of 104 articles were filtered after applying criteria to focus on articles ranging from 2013 to 2024, in the English language, and within the subject areas of Agricultural and Biological Sciences and Environmental Sciences. This final count reflects the saturation point at which thematic patterns and co-authorship networks stabilized, ensuring both relevance and analytical depth. To validate the search strategy, a manual screening of titles and abstracts was performed to ensure relevance and consistency with the study’s objectives. The filtered articles were exported in CSV format and analyzed using VOSviewer version 1.6.20 (October, 2023). This software was selected for its effectiveness in visualizing complex data, robust capability in mapping co-authorship networks, keyword occurrences, and identifying research clusters, thereby providing a comprehensive overview of the research landscape and thematic evolution within the field of sustainable livestock systems.

3. Results and Discussion

The result section consists of two subchapters; the first one describes the VOSviewer computations, and the second part is about the ratio of documents per year, per year by source, by author, by affiliation, by country/territory, by type, by funding sponsors, and by subject area.

3.1 Result of VOSviewer computations

3.1.1 Co-Authorship Analysis

The co-authorship analysis (Figures 1- 3) highlights researchers such as Dong Shikui, Richard Teague, and Sarah E. MacDonald, whose contributions were thematically distinct - focusing on soil health, plant biodiversity, and grazing management- but largely isolated. This fragmentation suggests that comprehensive

solutions to sustainable livestock challenges may be constrained by limited interdisciplinary collaboration. Temporal analysis from 2019 to 2023 shows that Richard Teague maintained a consistent focus on adaptive grazing and ecosystem services, while Dong Shikui expanded into broader ecological and land-use dynamics. These shifts highlight the importance of continuous engagement and the need for the emergence of new collaborators in the field. However, the lack of interconnected networks raises concerns about knowledge and the synthesis of ideas. Fragmented co-authorship networks limit innovation and the development of scalable solutions for soil degradation, biodiversity loss, and sustainable grazing. Strengthening interdisciplinary ties is essential for advancing holistic livestock sustainability. As emphasized by Mittal and Bansal, cross-disciplinary collaboration is essential for holistic sustainability approaches, enabling the integration of ecological, technological, and social dimensions [14].

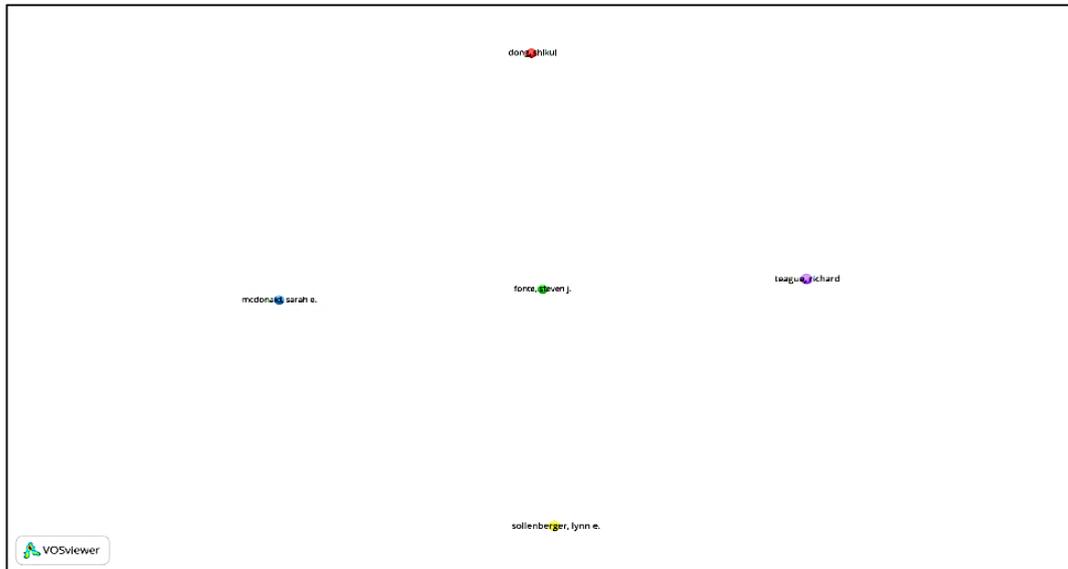


Figure 1. VOSviewer Network Visualization of Co-Authorship

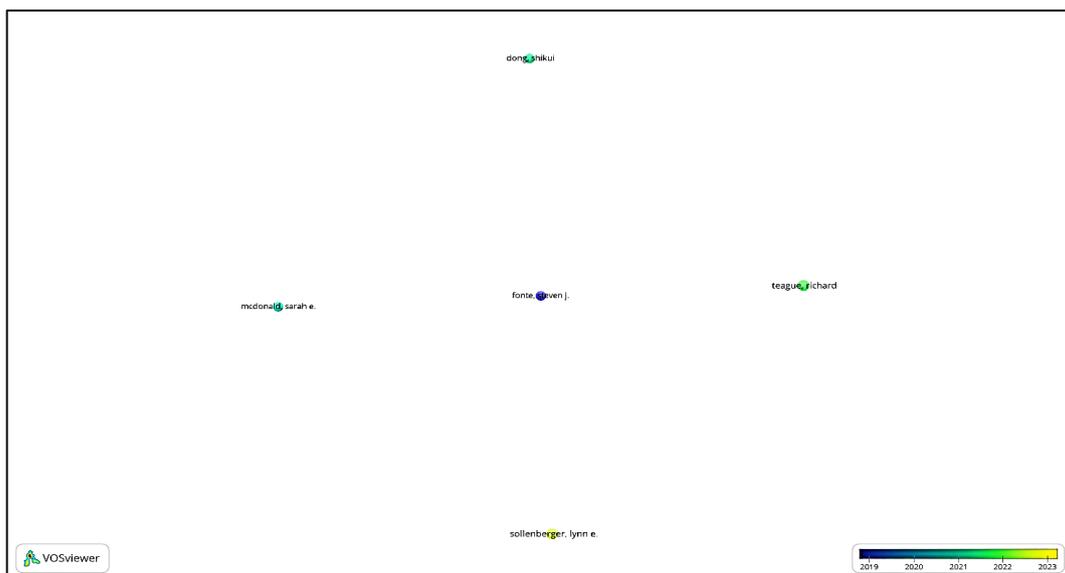


Figure 2. VOSviewer Overlay Visualization of Co-Authorship

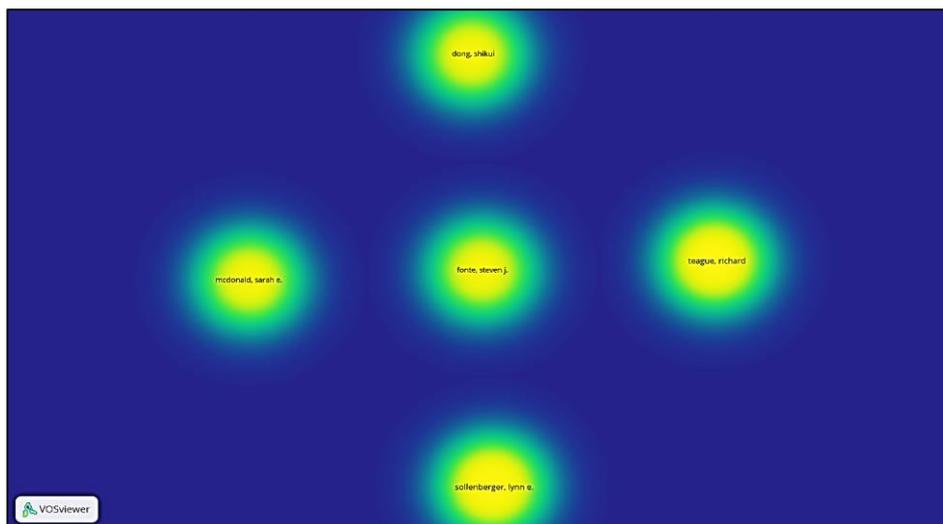


Figure 3. VOSviewer Density Visualization of Co-Authorship

3.1.2 Co-Authorship between countries

The network of research collaborations through co-authorship between countries in Figures 4, 5 & 6 has shown that the United States dominates plant-based feed and forage research, with strong connections to countries like China and Brazil forming central nodes in the global research landscape. While other countries like Australia and the United Kingdom are influenced by geography and language, forming clusters. Many other nations exhibit sparse connections, indicating limited international collaboration and underrepresentation in global research efforts. The changing temporal overlay from 2019 to 2024 shows that the nature of collaboration was still evolving. Recent articles show activity from countries Brazil and Spain, while earlier collaborations involved China, Germany, and the United Kingdom. This significantly suggests that clusters with the same geographical distributions, language, and historical identity have recognized contributions to the field, but also highlights the limited cross-cluster engagement. Limited international collaboration may result in regionally siloed policies and missed opportunities for knowledge transfer. For example, adaptive grazing techniques developed in the US may not be easily adopted in Southeast Asia without collaborative validation and localized adaptation. Encouraging more inclusive and diverse co-authorship networks could enhance the sharing of knowledge and innovation, leading to comprehensive solutions for soil degradation, biodiversity loss, and sustainable grazing practices. Strengthening global research connectivity is essential for designing adaptable livestock systems across diverse agroecological zones.

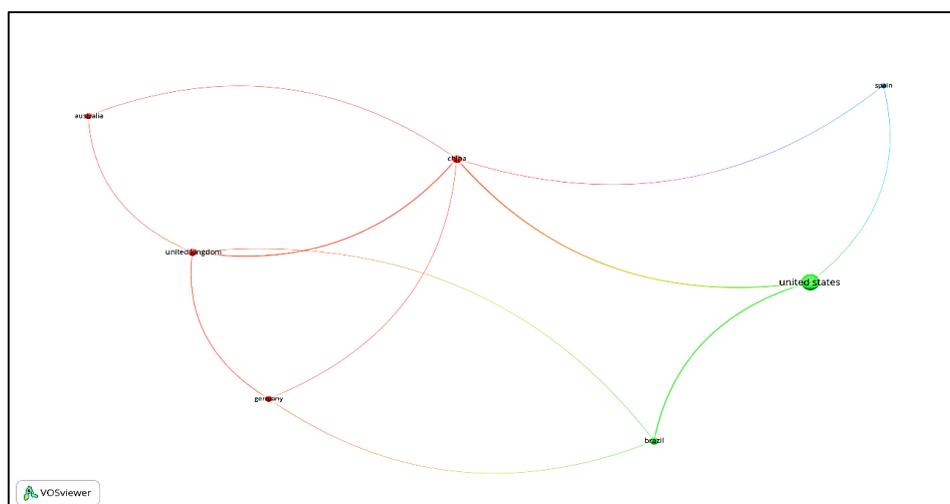


Figure 4. VOSviewer Network Visualizations of countries

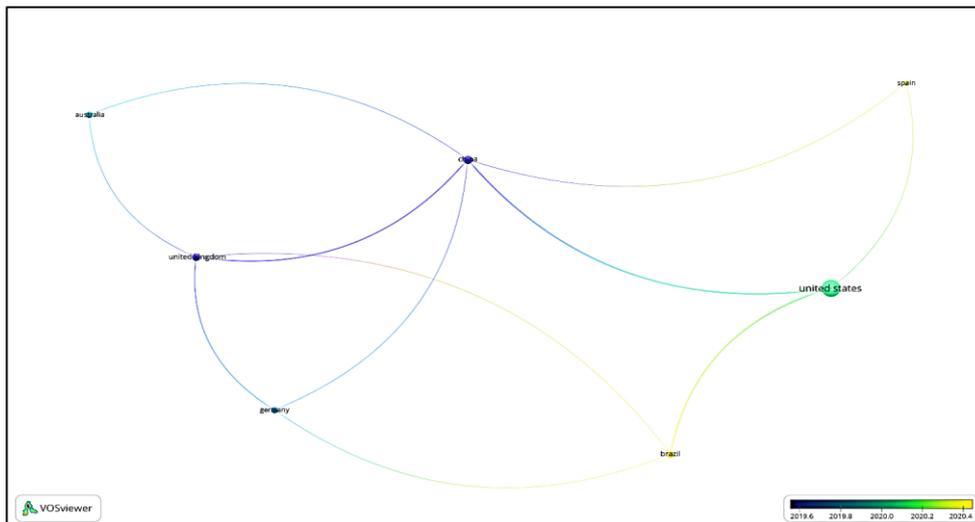


Figure 5. VOSviewer Overlay Visualization of countries

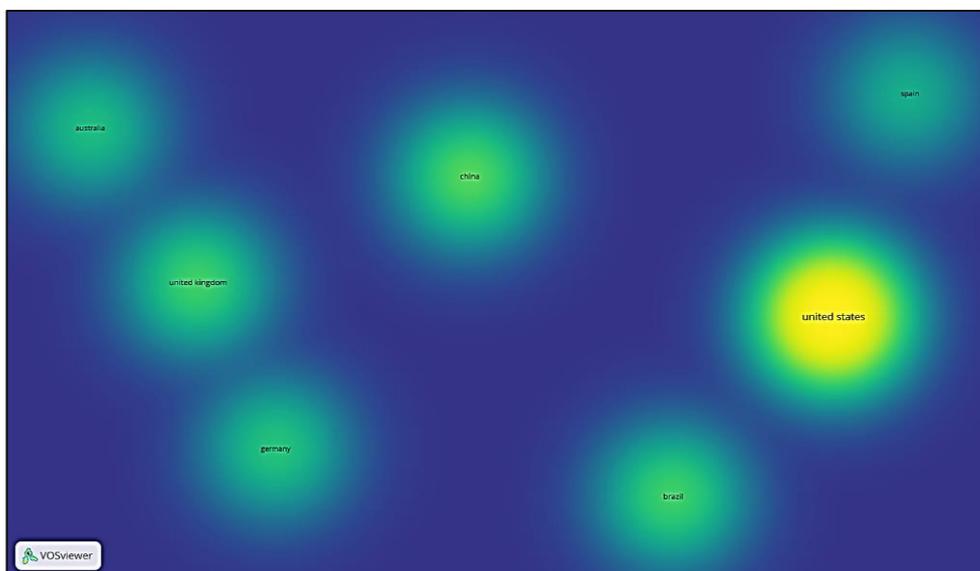


Figure 6. VOSviewer Density Visualization of countries

3.1.3 Keywords Co-occurrence

The density visualization of keywords co-occurrence in Figure 9 reveals that “grazing management” is the most prominent word, frequently co-occurring with “ecosystem services” and “biodiversity.” This pattern reflects the dominant research focus on land use practices, pasture systems, and livestock–environment interactions. While “grazing management” anchors productivity-focused studies—such as pasture rotation, stocking rates, and land use optimization—“ecosystem services” bridges ecological and agricultural domains, and “biodiversity” reflects conservation-oriented themes. Overlay visualizations (Figures 8 and 11) show a temporal shift: earlier studies emphasized grazing practices, while recent ones focus on biodiversity. “Ecosystem services” consistently links these themes, reinforcing its role as a conceptual bridge. Their positioning in the visualization suggests more peripheral thematic roles, often linked to ecological outcomes or broader sustainability frameworks rather than direct agricultural interventions. This fragmentation underscores the need for interdisciplinary research to bridge conceptual and methodological gaps. Integrated policy frameworks that align grazing practices with biodiversity and ecosystem service goals are essential. Embedding ecological indicators—such as nutrient cycling, water regulation, and carbon sequestration—into livestock planning can help balance productivity with long-term sustainability.

The VOSviewer Network Visualization (Figure 7) further illustrates this convergence. Studies by Dey et al. [15], Kumar et al. [16], and Rao et al. [17] demonstrate the dual economic and ecological benefits of forage alternatives, multifunctional legumes, and the LivestockPlus framework—each integrating grazing management with ecosystem service enhancement. Recent bibliometric clusters also reflect emerging interdisciplinary themes. Kibria et al. [18] link cereal-based agriculture in South Asia to greenhouse gas emissions and biodiversity concerns, while Bo et al. [19] show how mixed cropping systems improve forage quality and plant–soil health. Attia et al. [20] explore phytochemical feed additives as sustainable inputs that support livestock health and indirectly enhance ecosystem services. To translate these insights into practice, policymakers and funding agencies should support interdisciplinary research clusters that explicitly link agronomic practices with ecological outcomes. This could include joint calls for proposals across agriculture and environment ministries, or the development of livestock sustainability frameworks that embed ecosystem service metrics. Such approaches would enable climate-resilient, biodiversity-enhancing livestock systems aligned with global sustainability goals.

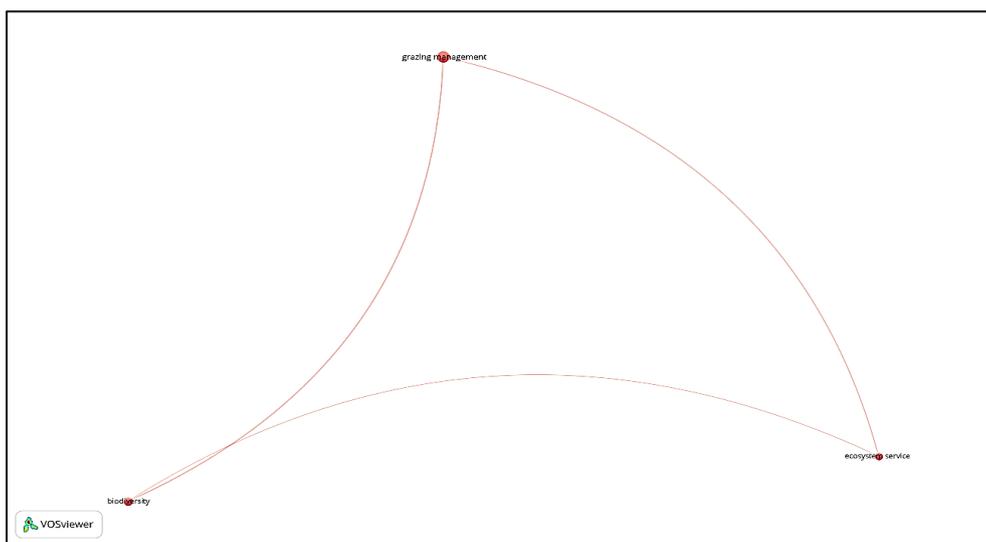


Figure 7. VOSviewer Network Visualization of keywords

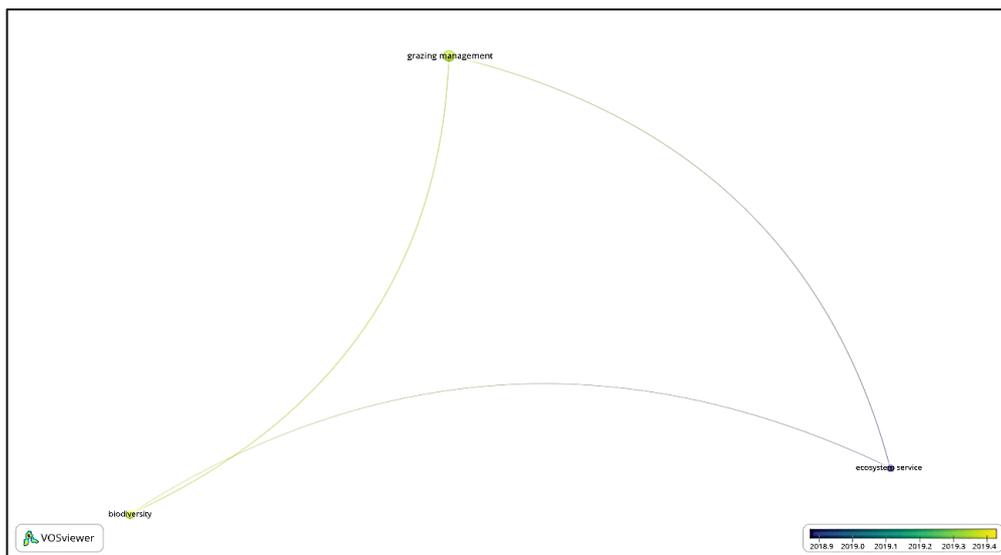


Figure 8. VOSviewer Overlay Visualization of keywords

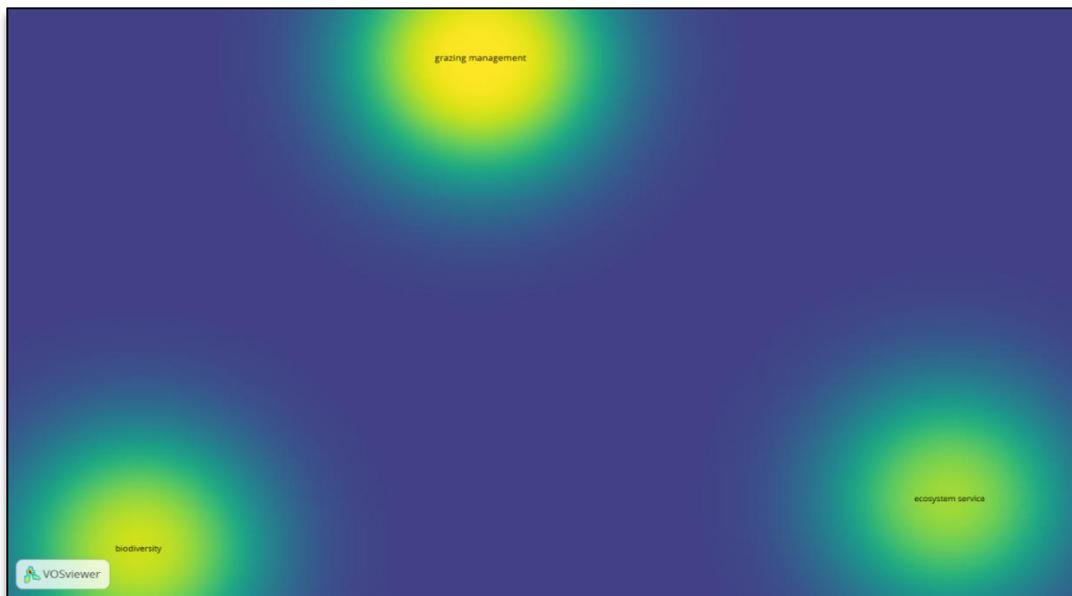


Figure 9. VOSviewer Density Visualization of keywords

3.1.4 Author Keywords

The three highlighted clusters of keywords are “grazing management”, “biodiversity”, and “ecosystem service”. The string of colors connecting these keywords in the VOSviewer Network Visualization (Figure 10) illustrates their co-occurrence and thematic prominence, with yellow areas indicating the high relevance and frequency of the two keywords (Figure 12). The central positioning of the keyword “ecosystem service” indicates that it conceptually bridges the connection between the two keywords, forming a relationship. This suggests that most of the studies evaluate how grazing management practices influence “ecosystem services” that eventually affect “biodiversity”. The strength of these connections emphasizes the degree of association in research contexts, which indicates the strong interdisciplinary nature of these themes. The Overlay Visualization (Figure 11) reveals that “grazing management” was associated with earlier studies, while “biodiversity” is linked to recent ones. “Ecosystem services” consistently bridge this temporal and thematic gap, highlighting the evolving focus on grazing practices and their impacts on “biodiversity” and ecosystem processes. This also highlights the evolving integration of ecological and agricultural research, where ecosystem services serve as a mediating framework to connect land use practices with conservation outcomes. These insights have direct implications for sustainable livestock policy and management. Integrating ecosystem service metrics into grazing policies enables decision-makers to assess trade-offs between productivity and ecological resilience. For example, pasture strategies that enhance soil health and water retention can simultaneously support biodiversity goals. Embedding such indicators into land use zoning, livestock incentive schemes, and biodiversity monitoring frameworks can ensure agricultural interventions align with broader sustainability targets. This integration is critical for advancing sustainability science, enabling researchers and policymakers to co-design interventions that balance agronomic performance with long-term ecosystem integrity.

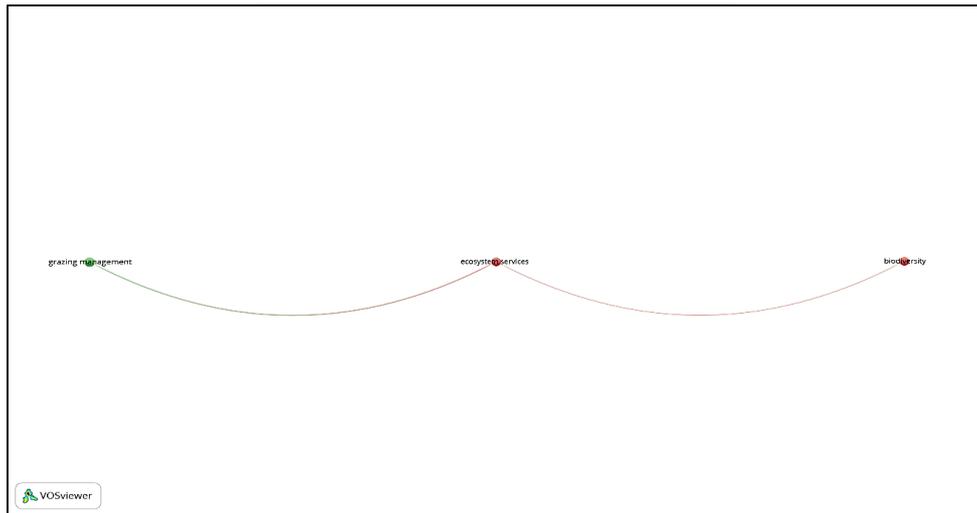


Figure 10. VOSviewer Network Visualization of author keywords

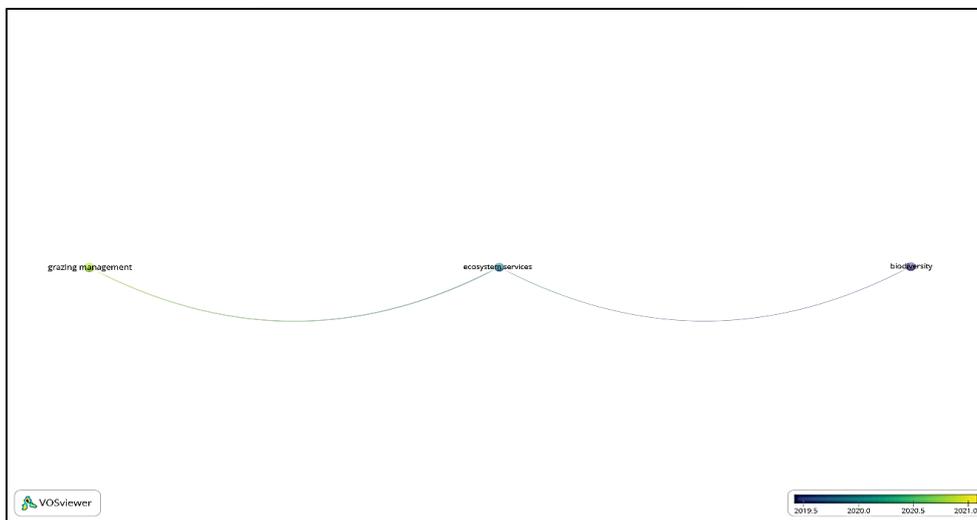


Figure 11. VOSviewer Overlay Visualization of author keywords

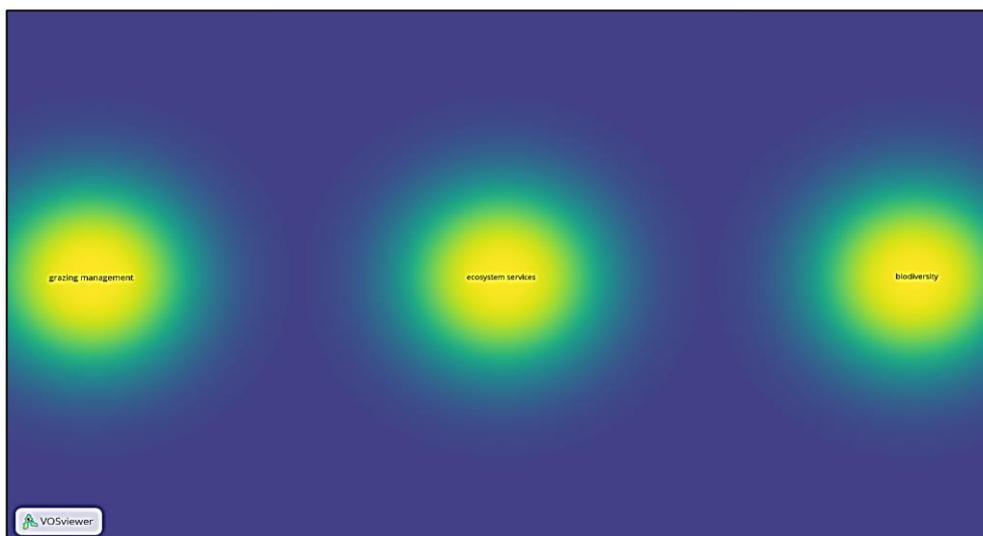


Figure 12. VOSviewer Density Visualization of author keywords

3.2 Ratio of documents per year, per year by source, by author, by affiliation, by country/territory, by type, by funding sponsors, and by subject area

3.2.1 Documents per year

The publication trends for articles focusing on sustainable livestock systems have shown significant fluctuations over the years, as shown in Figure 13. Initial output was low, with only two (2) articles in 2013 and 2015, which doubled to four (4) by 2014. There was a substantial increase in 2016, with the number of articles reaching 11. For the year 2017-2018, the number of publications remained at 8 per year, indicating a sustained scholarly interest. In 2019, the number of articles slightly declined to 7 and gradually rebounded to 11 by 2020. CY 2021 marked the peak of publication with 14 publications, the highest recorded in the dataset. From 2023 to the present, the number of articles has stabilized at 13 per year.

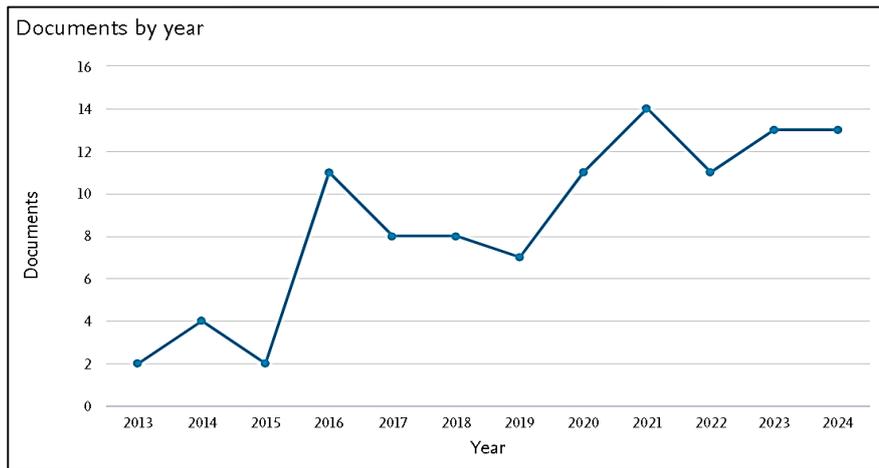


Figure 13. Ratio of documents per year

3.2.2 Documents per year by source

Figure 14 shows that from 2013 to 2024, the Top 5 Publishers of articles related to sustainable livestock management have been consistent in their contributions to the field. Top of the list was “Agriculture Ecosystems and Environment, having a total of 9 contributions. Followed by “Science of the Total Environment” with 7 publications. The “Journal of Environmental Management” and “Rangeland Ecology and Management” have 5 articles each, and lastly, “Geoderma” has 4 published articles throughout the years. This distribution highlights the sustained engagement of key environmental science journals in advancing research on sustainable livestock systems. The steady output across these sources suggests a stable and interdisciplinary interest in the topic, with each journal contributing to different facets of ecological, soil, and rangeland management.

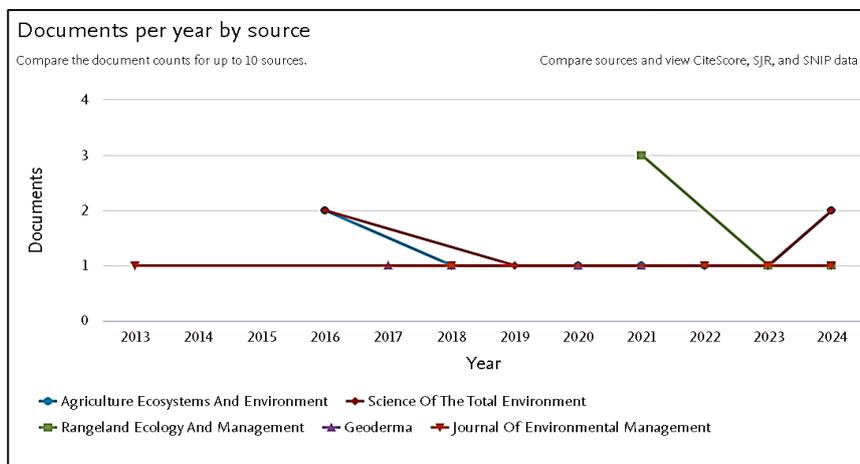


Figure 14. Ratio of documents per year by source

3.2.3 Documents by author

Here are the top 15 authors who published related articles on sustainable livestock systems, as shown in Figure 15. Note that while the dataset includes 15 authors, Figure 15 only displays the top 10 based on document count. The Top leading author was Sollenberger, L.E., with 4 publications focusing on sustainable grazing systems and forage management. Following Sollenberger, L.E., was Teague, R., also with 4 publications, renowned for the studies of holistic management practices and their impact on soil health and livestock sustainability. With 3 publications, the line was followed by Dong, S., whose articles contribute to the livestock production and environmental interactions in pastoral systems, Fonte, S.J., with a focus on soil fertility, sustainable agriculture practices, and integration of livestock systems, and McDonald, S.E., who focuses on biodiversity and sustainable livestock systems. The remaining authors such as Ashworth, A.J. (nutrient management and environmental impact of livestock farming), Byck, P. (sustainable livestock practices and socio-economic aspects of livestock systems), Engle, D.M. (grassland management and its role in sustainable livestock production), Farias, G.D. (innovative farming techniques and their applications in livestock systems), Franzluebbbers, A.J. (soil health, carbon sequestration and sustainable grazing system), Fu, B. (landscape ecology and sustainable land use practices involving livestock's), Fuhlendorf, S.D. (rangeland ecology and sustainable management of grazing lands), Gao, J. (land management and environmental impacts of livestock farming), Haney, R.L. (soil health assessment and the role of livestock in sustainable agriculture), Hovick, T.J. (wildlife-livestock interactions and ecosystem management) composes the top 15 with 2 publications each. The average of 5.8 authors per article in this dataset reflects a moderate level of collaboration in sustainable livestock systems research. This figure is notably higher than typical averages in social sciences and humanities (1.4–1.6 authors per publication), and more aligned with collaborative norms in environmental and biomedical sciences, where multi-authorship is common. These disciplinary patterns are consistent with science-wide author metrics reported by Ioannidis et al. [22].

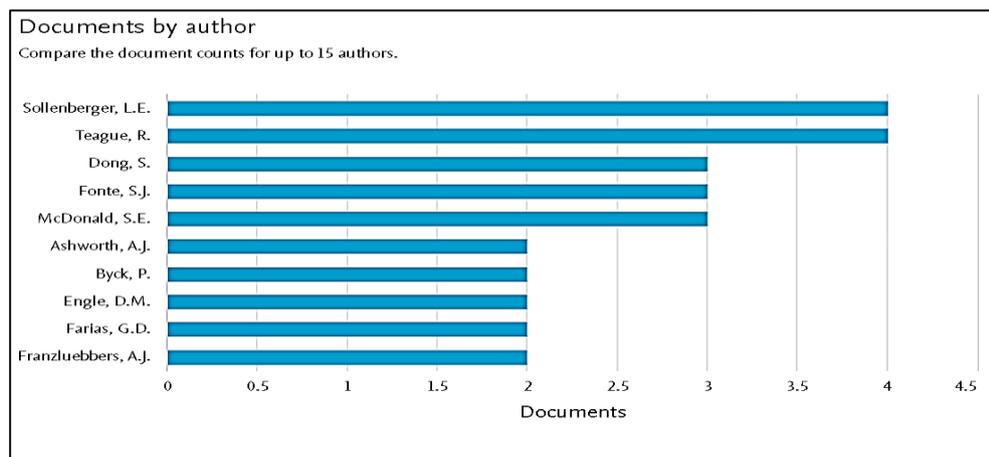


Figure 15. Ratio of documents by author

3.2.4 Documents by affiliation

From 2013 to 2024, numerous institutions have made notable contributions in the researches in sustainable livestock systems. The Top 10 known contributors are shown in Figure 16 with their document counts. It shows that the USDA Agricultural Research Service has published a total of 9 research documents showing their strong commitment to advancing agricultural practices and sustainability. It was followed closely by Texas A&M AgriLife Research with 8 publications and the United States Department of Agriculture, which contributed 6 documents, highlighting their active participation and support in sustainable agriculture. Other notable institutions were NSW Department of Primary Industries (5 articles), Colorado State University (5), Wageningen University and Research (4), Oklahoma State University (4), University of Florida (4), Texas A&M University (4), and Lanzhou University (4). Note that while the dataset includes more affiliations, Figure 16 highlights only the top 10 based on document count. This distribution reflects a diverse and international

research landscape, with institutions from North America, Europe, Asia, and Oceania actively shaping the discourse on sustainable livestock systems.

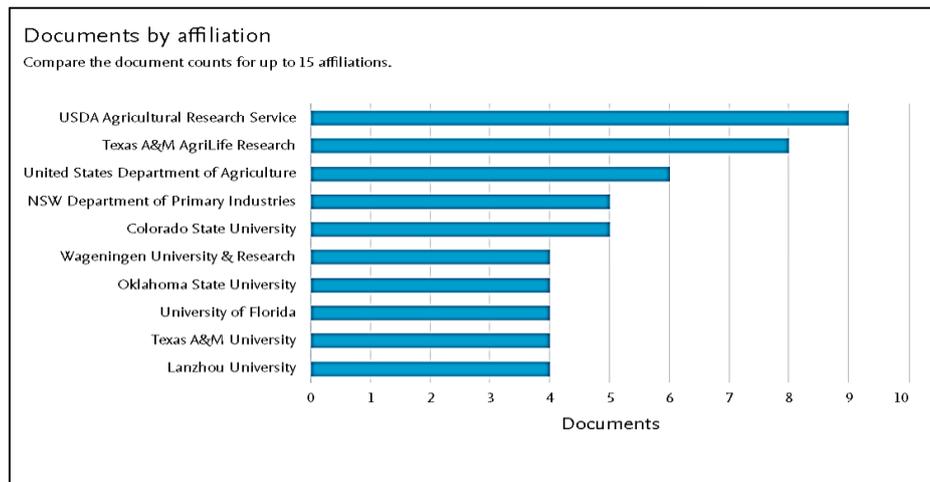


Figure 16. Ratio of documents by affiliation

3.2.5 Documents by country

Various countries have contributed significantly in researches on sustainable livestock systems. As shown in Figure 17, the United States, as the highest contributors had published 51 documents, followed by China with 14 published documents. These underscore their commitments to advancing sustainable agriculture practices amidst the rapid agricultural development. Brazil (11) and the United Kingdom (10) also share their dedication to sustainable agricultural research and integration of such in the vast livestock industries. Both Australia and Germany had contributed 8 documents each, showcasing their innovative practices and policy-driven approaches. Other countries also take part in contributing, such as Spain (6 documents), Argentina (4), the Netherlands (4), and lastly Colombia (3), which is still emerging. Note that Figure 17 highlights only the top countries based on document count. This illustrates the global commitment to sustainable livestock practices and is significant in addressing global agricultural sustainability concerns across diverse ecological and socio-economic contexts.

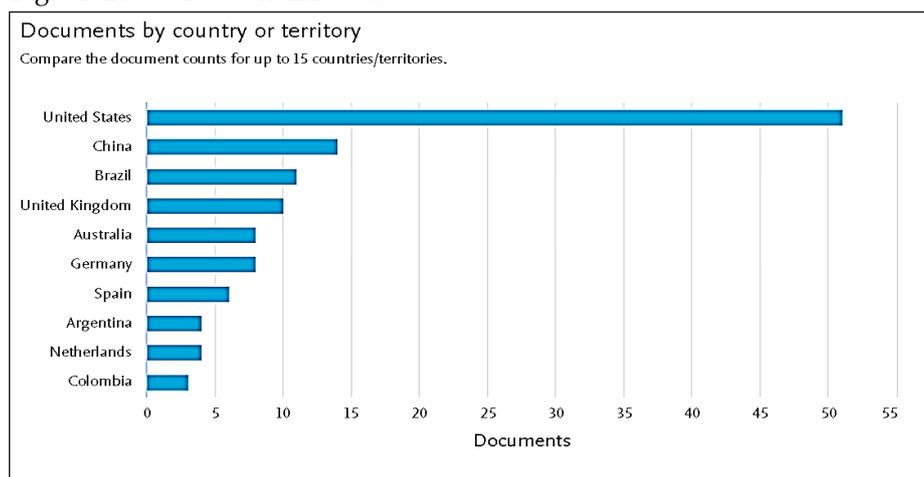


Figure 17. Ratio of documents by country

3.2.6 Documents by type

All documents used in this bibliometric analysis was 100% research articles with a varying range of formats, reflecting diverse methodological approaches and findings as shown in Figure 18. This uniformity in document type reflects a strong emphasis on the empirical and theoretical contributions within the field of sustainable livestock systems. The majority of these research papers were original research papers written to

present new data, insights from experiments, field studies, and modeling approaches that explore the ecological, agronomic, and socio-economic dimensions of livestock sustainability. These studies often investigate topics such as grazing management, soil health, biodiversity impacts, carbon sequestration, and integrated farming systems. While the dataset is composed entirely of articles, it is important to note that some of these also include review-type content, which forms a significant part of the literature.

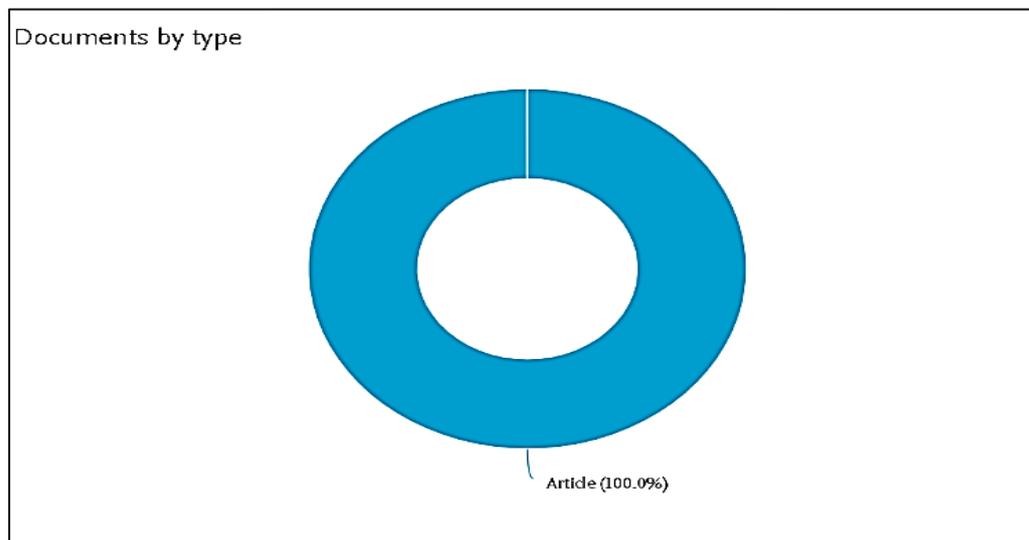


Figure 18. Ratio of documents by type

3.2.7 Documents by subject area

The articles published from 2013 to 2024 relative to sustainable livestock systems span an array of subject areas, reflecting the interdisciplinary nature of the field. The most prominent subject area, as shown in Figure 19, is Agricultural and Biological Sciences with 71 published documents, followed by Environmental Science with 70 contributions. Together, these two areas dominate the research landscape, highlighting the critical role of sustainable practices in agriculture and their impact on environmental aspects. Most studies in these areas focus on soil health, biodiversity, ecosystem services, and innovative farming systems. The Social Sciences, with 9 documents, emphasize the socio-economic aspects of sustainable livestock systems. These studies explore community engagement, farmers' behavior and acceptability, community engagement and policy implications. It illustrates the importance of social dynamics in the adoption and long-term success of sustainability interventions. The field of Biochemistry, Genetics, and Molecular Biology has also published 8 documents that explore the genetic and molecular mechanisms that influence livestock health and productivity, including the development of new disease-resistant varieties. Various areas such as Neuroscience (4 documents), Decision Science (3 documents), Energy (3 documents), Veterinary Science (2 documents), Computer Science (1 document) Earth and Planetary Sciences (1 document), Economics, and Finance (1 document) and Multidisciplinary (1 document) shows that researches in sustainable livestock systems does not only confine to a single discipline rather it also intersects with fields like data analysis, earth sciences, economic sustainability, and integrated multidisciplinary approaches.

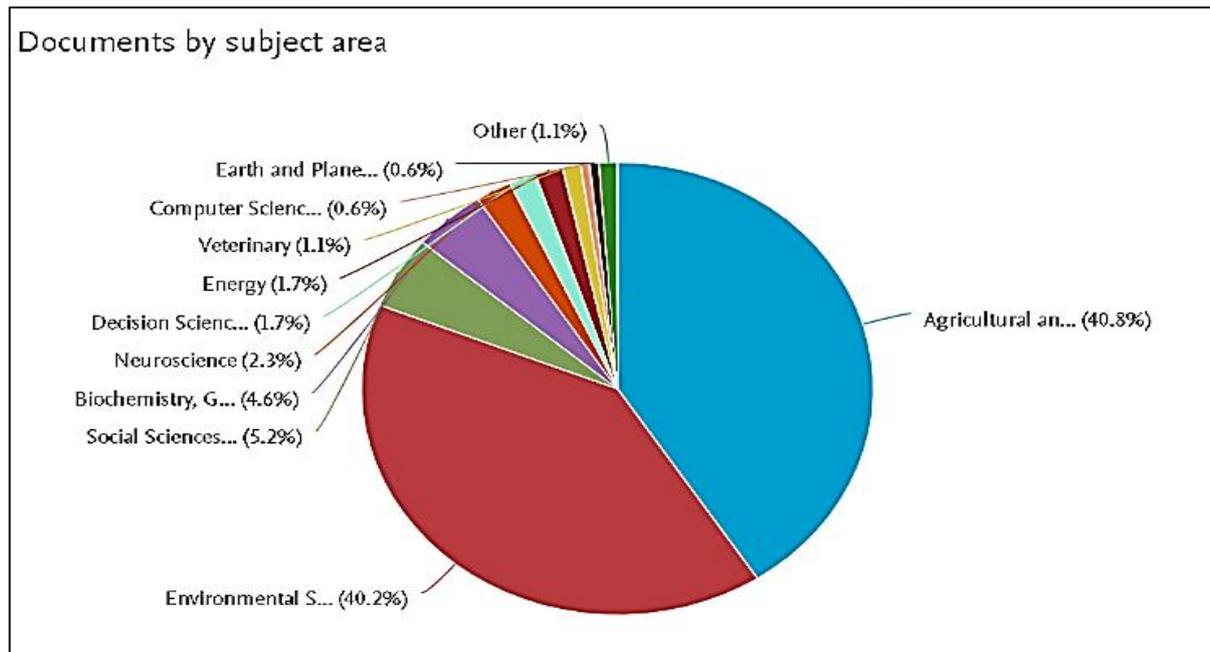


Figure 19. Ratio of documents by subject area

3.2.8 Documents by funding sources

Various funding sponsors have played a very important role in the advancement of research on sustainable livestock systems. As shown in Figure 20, the U.S. Department of Agriculture (USDA) leads the list with 14 funded documents, reflecting its strong commitment to promoting sustainable agricultural practices, ecological stewardship, and innovation in livestock management. This leadership is consistent with the USDA’s long-standing support for integrated farming systems and climate-resilient agriculture. It was followed by the National Natural Science Foundation of China with 8 documents, highlighting China’s growing investment in sustainable land use and livestock-environment interactions. The National Institute of Food and Agriculture has funded 7 documents emphasizing the improvement of food production systems while maintaining ecological balance. The Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) in Brazil contributed 5 documents in advancements of academic research and the sustainability of the livestock system. Other significant contributors include the Agricultural Research Service with 4 documents, Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research) with 4 documents. China’s Ministry of Science and Technology and the National Key Research and Development Program have also contributed 4 documents each, showcasing their comprehensive research efforts. This funding landscape reveals a strong international commitment to sustainable livestock systems, with support spanning North America, Asia, South America, and Europe. It also underscores the importance of multi-level collaboration—from national agencies to academic institutions.

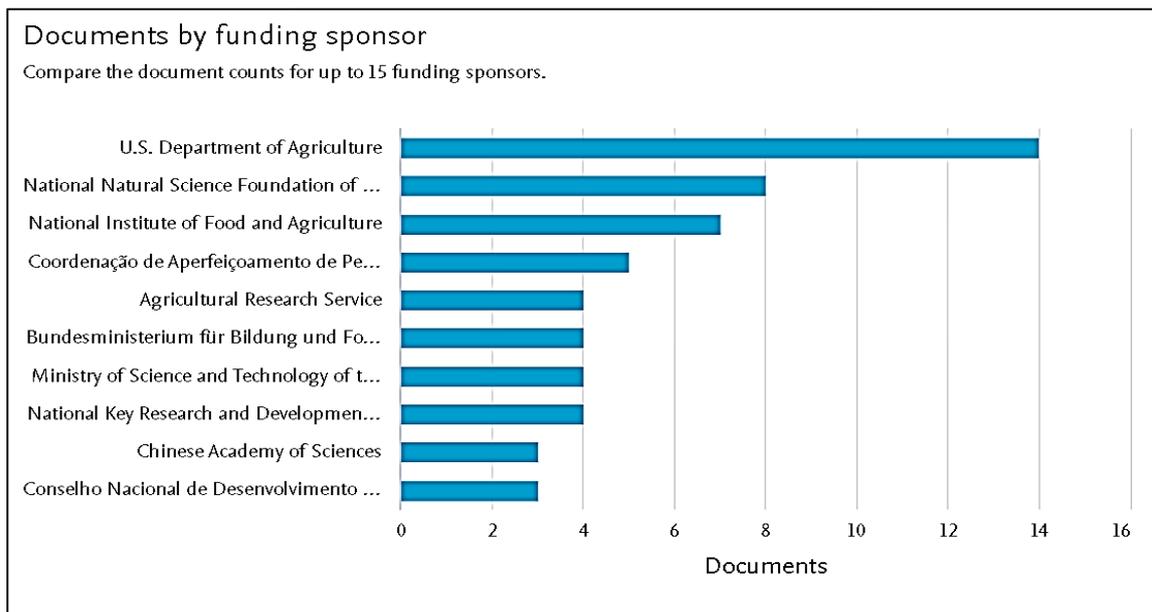


Figure 20. Ratio of documents by funding sources

4. Conclusions

This Bibliometric analysis focuses on several critical aspects of sustainable livestock research. The analysis shows that the co-authorship network is fragmented, where authors prefer to work alone within specific subject areas such as soil health, plant biodiversity, and grazing management. This lack of interdisciplinary collaborations has become a challenge in the development of a holistic solution to complex issues faced by sustainable livestock systems. As shown in Figure 15, the average of 5.8 authors per article is indicative of moderate collaboration, is significantly higher than the 1.4–1.6 average in social sciences and humanities, and is more aligned with biomedical and environmental sciences, where five or more authors are common. Notably, the involvement of other authors continues to decline while their focus shifted. However, between 2019 and 2023, there was a notable increase in active participation, indicating renewed interest in collaborative and thematic expansion. Geographically, the United States remains a central hub of research, maintaining strong collaborations with countries like China and Brazil. However, geography and language clustering also affect these collaborations, with countries such as the United Kingdom and Australia forming confined clusters. This pattern is visualized in Figure 16, which shows author affiliations and geographic clustering, highlighting the need for cross-regional integration. The keyword analysis highlights the top 3 used keywords, which are “grazing management”, “biodiversity”, and “ecosystem service”. These three keywords, although interconnected, also suggest three different foci. Grazing management is tied to agricultural and land-use practices, biodiversity to ecological diversity and conservation, while ecosystem services are linked to the sustainable benefits of the ecosystem to humans. Figures 9 and 11 show that “ecosystem services” bridge the temporal and thematic gap between earlier grazing-focused studies and more recent biodiversity research. This convergence underscores the importance of interdisciplinary approaches that integrate ecological indicators into livestock planning. The dominance of “grazing management” underscores its crucial role in maintaining soil health, ensuring pasture productivity, and supporting livestock welfare. Effective grazing management helps mitigate overgrazing, soil erosion, and biodiversity loss, which are essential for sustainable agriculture. This focus also reflects the need to adapt livestock systems to climate change, emphasizing innovative techniques like rotational grazing and holistic management. These findings align with the subject area distribution in Figure 19, where Agricultural and Biological Sciences and Environmental Science dominate the literature. The top contributor in the field was the “Agriculture Ecosystems and Environment” with 9 contributions, followed by publishers such as “Science of Total Environment”, “Journal of Environmental Management”, “Rangeland Ecology and Management”, and “Geoderma”. These publishers showed consistency in their contributions over the years. Prominent authors include Sollenberger, L.E.,

Teague, R., Dong, S., Fonte, S.J. McDonald, S.E., Ashwort, A.J., Byck, P., Engle, D.M., Farias, G.D., Franzluebbbers, A.J., Fu, B., Fuhlendorf, S.D., Gao, J., Haney, R.L., and Hovick, T.J., affiliated with institutions such as United States Department of Agriculture (USDA) Agricultural Research Service, Texas A&M AgriLife, United States Department of Agriculture (USDA), showing a strong commitment to advancing agricultural practices and sustainability. Overall, this analysis underscores the critical need for a collaborative and integrated approach to sustainable livestock systems research. Policymakers and funding agencies can take several specific actions to address the gaps in collaboration and research focus in sustainable livestock systems. Firstly, policymakers and funding agencies should incentivize interdisciplinary research by establishing grant programs that reward collaboration among researchers from diverse fields such as agriculture, ecology, economics, and social sciences, fostering comprehensive approaches to sustainability challenges. Promoting international partnerships by developing funding schemes that encourage cross-border research, particularly between countries with different geographical and cultural backgrounds, can enhance global knowledge exchange and innovation. Moreover, allocating funding to studies exploring the interconnectedness of emerging keywords like "grazing management," "biodiversity," and "ecosystem services, as identified in Figures 9 and 11. Support for knowledge-sharing platforms—such as international conferences, workshops, and online forums - can foster dialogue and co-creation of solutions. Practical research on farming techniques, tools, and technologies should be prioritized to ensure real-world impact. In addition, investment in education and training programs for farmers, researchers, and policymakers is essential to raise awareness about the importance of sustainable agriculture and provide the necessary skills and knowledge to implement effective practices. Establishing systems to monitor and evaluate the impact of funded projects and policies will ensure the effectiveness of initiatives and allow for adjustments based on feedback and results. By taking these actions, the funding agencies and policymakers can bridge the gaps in collaboration and research focus, leading to more integrated and effective solutions for sustainable livestock systems.

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