REVIEW ARTICLE

A systematic and bibliometric review on millets as a sustainable solution to global hunger

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Cite this article: Harini S, Vennila MA, Murugan PP, Kavithamani D, Padmarani S, Sivakumar C, Sangeetha M. A systematic and bibliometric review on millets as a sustainable solution to global hunger. Plant Science Today. 2025; 12(sp1): 1-11. https://doi.org/10.14719/pst.9389

Abstract

Millets, often referred to as "climate-smart grains," play a vital role in global efforts to address hunger and malnutrition. This systematic review and bibliometric analysis examine the multifaceted contributions of millets to food security, nutrition enhancement and climate resilience. Globally, millet production reached approximately 30 million metric tons in 2023, with India contributing 41 % (12.2 million metric tons), followed by countries like Niger, China and Mali. Millets are nutrient-dense, containing 7-12 % protein, 2-5 % fat, 65-75 % carbohydrates and 15-20 % dietary fibre. The findings highlight their significance in resource-constrained and drought-prone regions, particularly in Asia and Africa, where millet-focused initiatives have shown promising outcomes. Despite these advantages, challenges such as limited policy support, low consumer acceptance and underdeveloped value chains persist, restricting their widespread adoption. This study identifies regional disparities in millet utilization and emphasizes the need for further research on processing technologies, market development and integration into mainstream dietary practices. By addressing these gaps, millets can play a transformative role in achieving global food security and advancing Sustainable Development Goal 2 (Zero Hunger), offering actionable insights for policymakers, researchers and stakeholders worldwide.

Keywords: bibliometric analysis; climate-smart grains; food insecurity; nutrition-sensitive agriculture; sustainable agriculture goals

Introduction

As the global population continues to grow and the demand for grains rises, adopting sustainable crop alternatives is essential to combat world hunger and enhance farmers' livelihoods. Millets have gained recognition as a promising solution for building resilient agricultural systems and strengthening food security (1). This review article delves into the pressing issues of hidden hunger and malnutrition and explores their alignment with the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption) and SDG 13 (Climate Action) and offering a comprehensive analysis while highlighting the potential of climate-resilient millets. These small-seeded grains play a crucial role in addressing hidden hunger, a form of malnutrition characterized by micronutrient deficiencies despite adequate caloric intake, affecting over to billion people globally. Millets, being rich in iron, calcium, magnesium and fibre, offer a powerful dietary strategy to combat hidden hunger. By promoting nutritional security and enhancing climate adaptability, millets provide a sustainable approach to overcoming these nutritional challenges (2). Millets, often called "smart foods," offer significant health and environmental benefits. They require less water, have a low carbon footprint and are highly climate resilient. While serving as a staple for over 90 million people across Asia and Africa, millets also provide vital insurance for smallholder farmers against unpredictable monsoons (3). Millets help prevent cancer, reduce the risk of cardiovascular disease, limit tumour growth, lower blood pressure, slow fat absorption, delay gastric emptying and increase gastrointestinal bulk. Value-added millet grains as ready-to-eat and ready-to-cook foods provide farmers with an excellent opportunity to boost income generation, stimulate production and foster commercialization, all of which lead to job development, income and nutritional security(4). The Global Food Security Index (GFSI) for 2023 measures food security across four key pillars: Affordability, Availability, Quality and Safety and Sustainability and Adaptation.

As of the GFSI 2023 report, India's rank is 68th and Pakistan's rank is 75th among 113 countries surveyed (5). Based on USDA (2024) statistics, India emerged as the largest producer of millets in 2023, contributing approximately 41 % of the global production with a total output of 12.2 million metric tons. Following India, Niger accounted for 11 % with 3.16 million

metric tons, while China producers included Mali with 1.94 million metrics tons (7 %). This distribution highlights the dominance of Asian and African countries in global millet production, reflecting the crop's importance in food security and climate-resilient agriculture across these regions. With growing global awareness of food choices, millets present a sustainable alternative that supports a healthy and eco-friendly diet. Ongoing research reveals new health benefits and creative ways to integrate millets into contemporary meals. Collaboration among the agricultural sector, food industry and public health initiatives will be vital to fully realize the potential of millets for improving human health (6). Global hunger remains an urgent issue, affecting nearly 800 million people globally, with malnutrition persisting even when caloric intake is adequate. Addressing this challenge demands sustainable, resilient crops like millets, which thrive in arid regions and offer high nutritional value. This article systematically explores millet's potential to mitigate global hunger, focusing on its contributions to food security frameworks, climate resilience and sustainable agricultural practices. The theoretical framework of this review is grounded in the SDGs framework. Millets directly contribute to SDG 2 (By improving dietary diversity, nutrient intake and achieving food security), SDG 12 (By promoting sustainable consumption) and SDG 13 (Through climate adaptation due to drought tolerance). The focus of this study is to explore the diverse aspects of millet-based strategies in addressing global hunger and malnutrition. Specifically, it examines the key components and applications of millet-focused approaches across various sectors, highlighting their potential contributions to food security and resilience. Additionally, it investigates the geographical distribution and implementation of millet initiatives, shedding light on regional disparities and best practices. The study also identifies the primary benefits and challenges associated with millet-based interventions, ranging from nutritional and environmental advantages to policy and market-related obstacles. Finally, it outlines priority areas for future research to enhance the role of millets in combating global hunger, emphasizing the need for innovations in processing, market development and dietary integration to maximize their potential impact. The objectives of the study are to analyse millet-based strategies, their implementation, impacts and future research priorities for hunger alleviation.

Materials and Methods

This study used a mixed-method approach combining Systematic Review Literature (SLR) and bibliometric analysis.

Systematic Literature Review (SLR)

A systematic review, also known as a research synthesis, seeks to compile and present a thorough, impartial summary of multiple relevant studies within a single document (7) .

Undertaking a systematic review serves various important purposes, including:

- Summarizing existing evidence regarding treatment or technology, such as evaluating the empirical benefits and limitations of a specific agile methodology.

- Identifying research gaps that may highlight areas needing further study and exploration.

- Establishing a framework or background to effectively position and inform new research endeavours (8).

Bibliometric analysis

Bibliometric analysis is a research method used to examine global research trends within a specific field by analysing the output of academic publications. Bibliometric analysis was performed using the Bibliometric R package and Biblioshiny interface in RStudio (9).

Data Extraction and Analysis

Document Search

The related literature on millet and global hunger alleviation was searched from one of the largest databases, Scopus, an accessible electronic database. The study utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology (Fig. 1) to perform a systematic review of the literature, specifically concentrating on millets and global hunger alleviation. By using a search string, a structured combination of keywords, phrases and Boolean operators (such as AND, OR, NOT) is entered into academic databases to find relevant literature. A search string (Table 1) is designed to systematically capture all potential studies related to a specific research topic by including synonyms, related terms and variations in terminology, which helps to ensure comprehensive and focused results during the initial stage of a systematic review.

To ensure the inclusion of relevant and high-quality studies, specific eligibility and exclusion criteria were established (Table 2). The Scopus database was selected as the primary source due to its extensive coverage of peer-reviewed academic literature. A comprehensive search string was designed using Boolean operators, including keywords such as "millet", "global hunger", "food systems" and "sustainable development goals". The publication period was restricted to articles published between 2018 and 2025 to include recent and relevant research, with earlier works (2014-2017) excluded during the filtering process. The review included studies published exclusively in English, as non-English articles were deemed outside the scope of this analysis.

The subject areas were carefully selected to focus on Agricultural and Biological Sciences and Social Sciences, ensuring relevance to the research objectives, while studies from unrelated fields were excluded. Only articles published in the final stage were considered eligible, while those still in press or available as preprints were excluded. Furthermore, the source type was limited to journal articles to maintain a high standard of rigor, excluding conference proceedings, trade journals and other non-journal sources. Finally, only original research articles were included, with book chapters, editorial reviews and similar document types excluded from the analysis. A total of 99 documents were ultimately included in the review after thoroughly screening records for relevance and assessing full-text eligibility. This final selection was made based on a detailed evaluation of titles and abstracts to confirm their alignment with the predefined inclusion criteria.

This systematic review was conducted using the Scopus database, following the PRISMA framework to ensure a transparent and replicable screening process. In addition, bibliometric analysis was conducted using the Bibliometric R
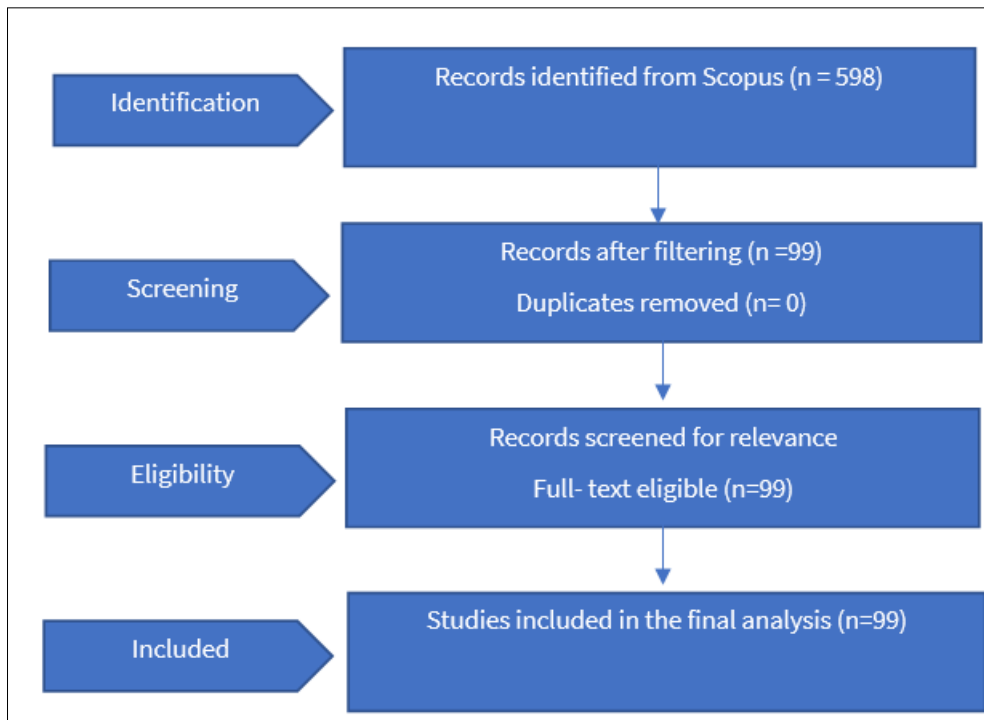
Fig. 1. PRISMA flowchart - Displays the process of literature selection, including the number of records identified, screened, assessed for eligibility and included in the final synthesis.

Table 1. Search string - Presents the keywords and Boolean operators used for database searching to retrieve relevant literature

ALL ("millet" AND "sustainable development goals" AND ("hunger" OR "food systems")) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "MULT") OR LIMIT-TO (SUBJAREA , "HEAL")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (OA , "all"))

Table 2. Criteria, eligibility and elimination - Outlines the inclusion and exclusion criteria, helping to ensure a systematic and unbiased selection of studies

Criterion	Eligibility	Elimination
Scopus database		
Span	After filter - 2018- 2025	Before filter -2014 -2026
language	English	Neglected non-English
Subject area	Agricultural & Biological Sciences & Social Sciences	Neglected non-relevant subjects.
Publication stage	Final stage	Article in press, preprints
Source Type	Only journals	Conference proceedings, Trade journals, etc.
Document type	Published articles	Book chapters, editorial reviews

package and its interface Biblioshiny within R Studio to evaluate publication trends, citation metrics, co-authorship networks and keyword co-occurrences. These methodological and statistical approaches ensured that only high-quality and relevant studies were included in the review, providing a robust and data-driven foundation for the analysis and discussion of the research topic.

Results and Discussions

Based on the Main Information and Publication Trend Analysis (Table 3), a bibliometric analysis was conducted on a dataset spanning the years 2018 to 2025, comprising 99 documents sourced from 72 journals and other academic platforms. The analysis revealed an annual growth rate of -9.43 % (Table 3), indicating a declining trend in publication volume over the study period. This downward trend may be attributed to several factors, including the relatively narrow scope of millet-related research compared to major and commercial crops, which continue to dominate agricultural research agendas. Additionally, the limited suitability of millets for cultivation across regions and disruptions from the COVID pandemic. The average age of the documents was 1.82 years, reflecting a focus on relatively recent research. Each document received an average of 10.61 citations, highlighting their significant academic impact, with a total of 8,372 references cited across the dataset. Regarding document content, the dataset contained 473 "Keywords Plus" and 436 authors' keywords, showcasing diverse thematic coverage and highlighting key research trends. The authorship analysis identified contributions from 609 researchers, with only four single-authored documents, emphasizing the collaborative nature of the field. The average number of co-authors per document was 6.32 and 44.44 % of the publications involved international collaborations, underlining the global nature of the research community.

Table 3. Main Information and publication trend analysis - Summarizes key metrics such as the number of publications per year, document types and sources, indicating research growth over time

Main Information About Data	
Timespan	2018:2025
Sources (Journals, Books, Etc.)	72
Documents	99
Annual Growth Rate %	-9.43
Document Average Age	1.82
Average Citations Per Doc	10.61
References	8372
Document Contents	
Keywords Plus (ID)	473
Author's Keywords (DE)	436
Authors	
Authors	609
Authors Of Single-Authored Docs	4
Authors Collaboration	
Single-Authored Docs	4
Co-Authors Per Doc	6.32
International Co-Authorships %	44.44
Document Types	
Article	99

All 99 documents analysed were journal articles, underscoring the emphasis on peer-reviewed publications in this field. These findings provide valuable insights into the research landscape, illustrating its collaborative and interdisciplinary nature, along with its alignment with contemporary scientific priorities.

The components and applications of millet-based strategies across different sectors

The word cloud highlights the critical role of millet-based strategies in addressing global hunger across various sectors. Food security stands out as a central focus, showcasing millets' ability to provide reliable and nutritious food, particularly for vulnerable communities. Their contribution to sustainable development and climate change adaptation highlights their resilience in drought-prone and marginal environments. Millets support smallholder farmers by boosting agricultural production, enhancing crop yields through intercropping and integrating into agroforestry systems. Innovations in biotechnology and plant breeding have further improved millet varieties, making them high-yielding and climate-resilient. Additionally, millets play a crucial role in addressing nutrition challenges, with applications in cooking and germination for value-added food products. Overall, millets offer a comprehensive solution that connects food security, agricultural sustainability and climate resilience, positioning them as a key resource in combating global hunger.

The geographical distribution and implementation of millet-focused initiatives

The collaboration world map provides a clear representation of millet-focused initiatives distributed and implemented globally. Notably, strong collaborations are observed between India, a key player in millet cultivation and various regions such as the United States, Europe, Africa and parts of Asia. This highlights India's pivotal role as a research, innovation and implementation hub for millet-based strategies. The map also shows active participation from developed nations, such as the U.S. and European countries, in supporting millet-focused research, technology transfer and policy development, fostering global partnerships. Africa, another region significantly affected by food insecurity, emerges as a critical area for implementation, with collaborations aimed at leveraging millets for food security and sustainable agriculture. These partnerships demonstrate a multi-regional effort to share knowledge, technology and resources to address global hunger through millet cultivation. Overall, the map reflects the interconnected nature of millet initiatives, emphasizing the role of international collaborations in scaling millet-based solutions to diverse socio-economic and climatic contexts.
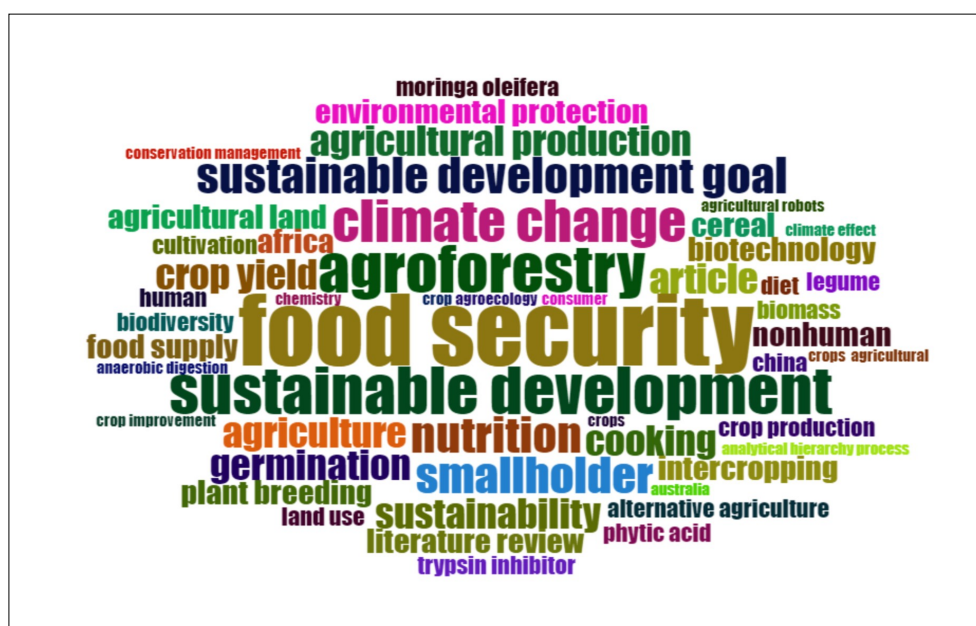

Fig. 2. Word Cloud - A Visual representation of the most frequently used keywords in the selected articles was created using Biblioshiny, highlighting core themes and research focus.
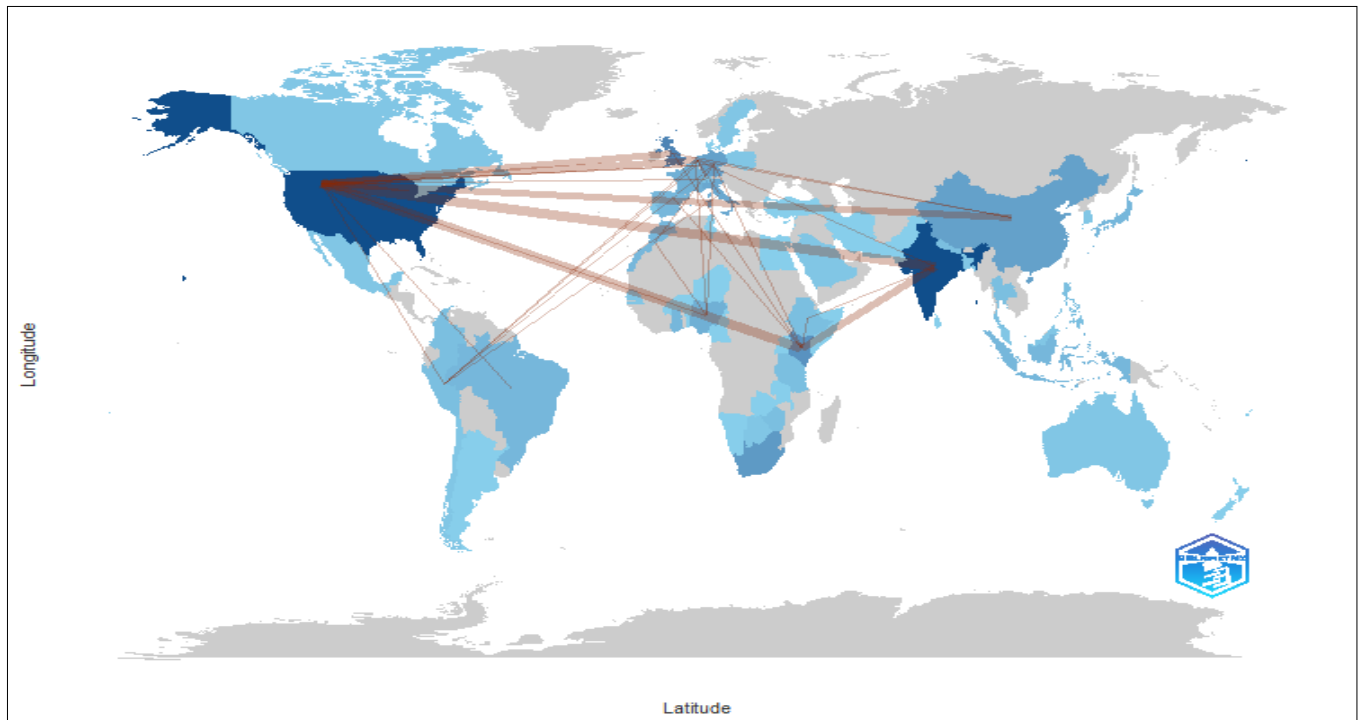
Fig. 3. Collaboration World Map - The map shows global research collaborations, with darker blue indicating stronger ties with India, lighter shades showing weaker links and grey areas denoting no collaboration.
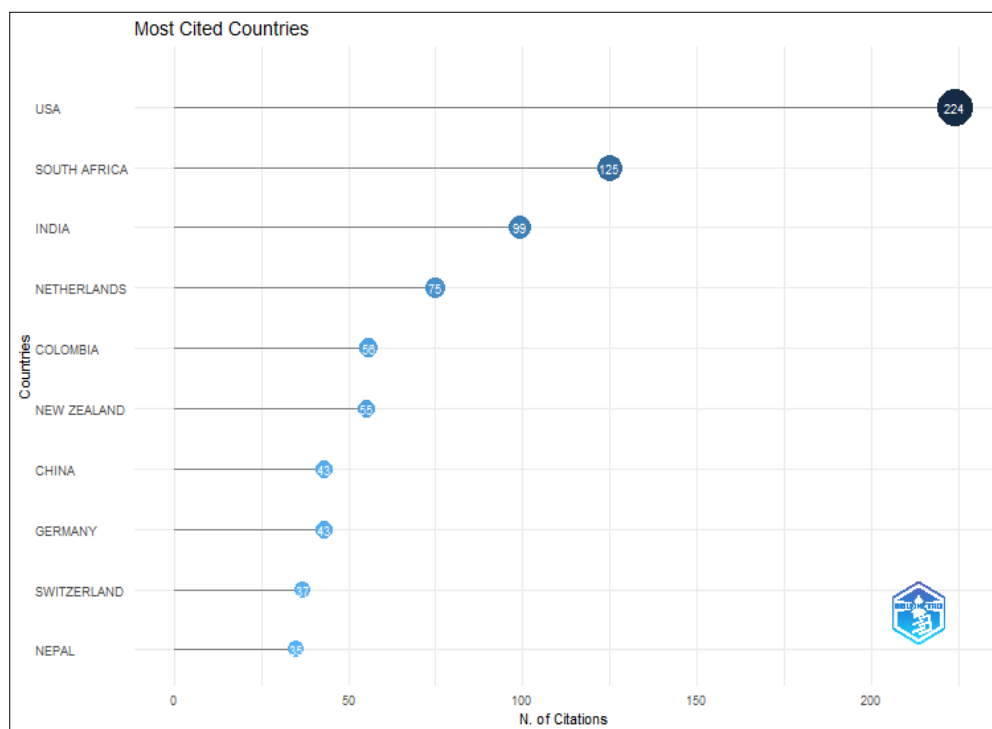

Fig. 4. Most Cited Countries - highlights countries with the highest citation impact in the field.

Table 4. Most cited countries with average article citations - Lists countries with the highest total citations and calculates the average citations per article, reflecting research influence.

Country	Tc	Average Article Citations
USA	224	24.9
South Africa	125	31.2
India	99	6.6
Netherlands	75	25
Colombia	56	14
New Zealand	55	55
China	43	8.6
Germany	43	14.3
Switzerland	37	37
Nepal	35	17.5

The "Most cited countries" chart highlights the distribution and influence of millet-focused initiatives across key regions. The USA leads significantly with 224 citations, indicating its dominant role in driving millet-related research, technology development and policy discussions on a global scale. India follows with 125 citations, underscoring its central position as both a research and implementation hub for millet cultivation, given its agricultural and socio-economic dependence on this crop. China (99) and Nigeria (75) also emerge as critical contributors, reflecting their engagement in leveraging millets for food security and sustainable agriculture, particularly in regions facing food insecurity. African nations such as Ethiopia (58) and Kenya (38) show active research engagement, reinforcing millets' role as a climate-resilient crop in the Global South. European contributions from Germany (43) and France (43) indicate scientific collaborations focused on advancing millet research for global application. This distribution highlights a strong research network between developed and developing nations, with knowledge dissemination and collaboration serving as key drivers for implementing millet-based strategies globally.

The benefits and challenges identified in studies on millet-based approaches

The bibliometric analysis highlights critical studies addressing millet-based approaches to hunger alleviation, shedding light on the primary benefits and challenges. The references span diverse fields, emphasizing the importance of sustainable agricultural practices, food security and environmental resilience. Remote Sensing of Environment has a high citation impact with 94 total citations, 15.67 citations per year (TC per Year) and a normalized citation value (Normalized TC) of 3.72, highlighting its relevance to integrating Earth observations into the SDGs framework (10). In Journal of Disaster Risk Studies has received 70 citations (10 TC per Year, Normalized TC 1.57), reflecting its importance in indigenous knowledge adaptation to climate change (11). In Biological Conservation, it examines motivations behind tree planting and boasts 61 citations (15.25 TC per Year, Normalized TC 3.81), emphasizing biodiversity and carbon implications (12). Agricultural and Food Economics has significantly contributed to understanding sustainable

agriculture in Northern Ghana, with 55 citations (18.33 TC per Year, Normalized TC 3.67) (13). In Nature Food on circularity and sustainability in food systems has 45 citations (22.5 TC per Year, Normalized TC 7.88), indicating its critical influence on sustainable global food systems (14). Climate and Development has 43 citations (8.6 TC per Year, Normalized TC 2.76), evaluating climate change impacts on crop yields in Sub-Saharan Africa. (15). People and Nature explores the underutilized potential of tropical tree-sourced foods with 37 citations (7.4 TC per Year, Normalized TC 2.38) (16). In Plants, People, Planet, ties millets to the UN's SDGs and has accrued 37 citations (12.33 TC per Year, Normalized TC 2.47)(17).

Agricultural Systems evaluates the impact of COVID-19 on major cereal crops in West Africa, garnering 34 citations (8.5 TC per Year, Normalized TC 2.13) (18). In Nature Plants, ex-situ conservation of crop landraces, with 33 citations (11 TC per Year, Normalized TC 2.2) (19). Sustainability highlights the potential of traditional food crops with 28 citations (4.67 TC per Year, Normalized TC 1.11) (20). NJAS-Wageningen Journal of Life Sciences examines farmer field schools with 25 citations (5 TC per Year, Normalized TC 1.61) (21).

Frontiers in Sustainable Food Systems has 21 citations (5.25 TC per Year, Normalized TC 1.31) (22). Research on crops on intercropping in a changing climate has received 19 citations (9.5 TC per Year, Normalized TC 3.33) (23). In Food and Nutrition Bulletin discusses the acceptability of moringa-based complementary foods, with 19 citations (2.71 TC per Year, Normalized TC 0.43) (24). In Food Policy, it focuses on innovation in nutrition-sensitive food systems and has 19 citations (3.17 TC per Year, Normalized TC 0.75) (25).In Agricultural Systems examines agricultural landscapes with 17 citations (5.67 TC per Year, Normalized TC 1.13) (26). Lastly, Sustainability discusses consumer willingness-to-pay for sustainable aquaculture products with 17 citations (2.83 TC per Year, Normalized TC 0.67) (27). The data underscores the significance and impact of diverse research contributions to agriculture, sustainability and food systems. These studies collectively underscore millet's role as a resilient crop in hunger alleviation, while also addressing challenges such as low awareness, inadequate policy support and market constraints. The research field highlights both
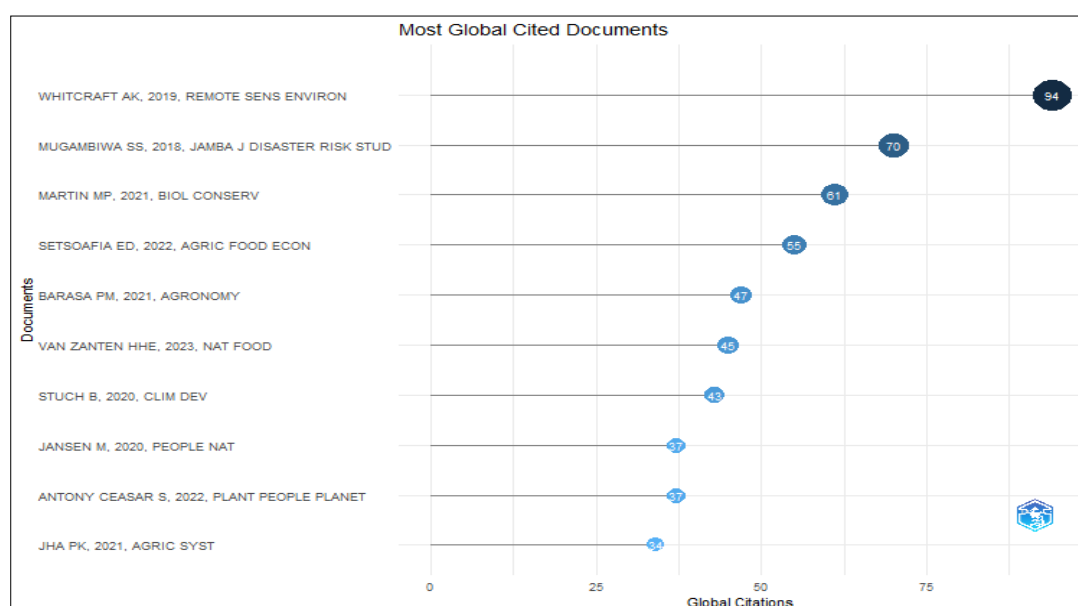

Fig. 5. Most globally cited documents - Shows the most impactful individual papers based on total global citations.

Table 5. Top Nineteen most globally cited documents with total citations, TC per year and Normalized TC - detailed view of influential publications including metrics like Total Citations (TC), TC per year and normalized citation counts to assess long-term impact

Paper	DOI	Total Citations	TC per Year	Normalized Tc
Whitcraft, A.K., 2019 (10)	10.1016/J.Rse.2019.111470	94	15.6666667	3.71751412
Mugambiwa Ss, 2018 (11)	10.4102/Jamba. V10i1.388	70	10	1.57303371
Martin Mp, 2021 (12)	10.1016/J.Biocon.2021.109224	61	15.25	3.8125
Setsoafia Ed, 2022 (13)	10.1186/S40100-022-00216-9	55	18.3333333	3.66666667
Van Zanten Hhe, 2023 (14)	10.1038/S43016-023-00734-9	45	22.5	7.88321168
Stuch B, 2020 (15)	10.1080/17565529.2020.1760771	43	8.6	2.76428571
Jansen M, 2020 (16)	10.1002/Pan3.10159	37	7.4	2.37857143
Antony Ceasar S, 2022 (17)	10.1002/Ppp3.10254	37	12.3333333	2.46666667
Jha Pk, 2021 (18)	10.1016/J.Agsy.2021.103107	34	8.5	2.125
Ramirez-Villegas J, 2022 (19)	10.1038/S41477-022-01144-8	33	11	2.2
Adhikari L, 2019 (20)	10.3390/Su11195236	28	4.66666667	1.10734463
Van Den Berg H, 2020 (21)	10.1016/J.Njas.2020.100329	25	5	1.60714286
Argumedo A, 2021 (22)	10.3389/Fsufs.2021.685299	21	5.25	1.3125
Maitra S, 2023 (23)	10.31830/2348-7542.2023.Roc-1020	19	9.5	3.32846715
Boateng L, 2018 (24)	10.1177/0379572117708656	19	2.71428571	0.42696629
Glover D, 2019 (25)	10.1016/J.Foodpol.2018.10.010	19	3.16666667	0.75141243
Leroux L, 2022 (26)	10.1016/J.Agsy.2021.103312	17	5.66666667	1.13333333
Yi S, 2019 (27)	10.3390/Su11061577	17	2.83333333	0.67231638

opportunities and barriers in leveraging millet for sustainable food systems.

The trend topics chart provides insights into the evolving focus areas of millet-based approaches to hunger alleviation. Food security and sustainability emerge as dominant themes, highlighting the primary benefit of millets in addressing global hunger while promoting long-term agricultural and environmental resilience. Topics like nutrition emphasize millets' role in combating malnutrition through their rich nutritional profile. Climate change and smallholder farmers indicate the challenges of adapting millet cultivation to climate-resilient practices and empowering smallholder farmers who are critical stakeholders in millet production. Crop yield and agroforestry reflect ongoing efforts to optimize millet productivity and integrate it into diverse farming systems. Additionally, cooking and germination point to post-harvest applications and value-added products as opportunities to enhance millet consumption. Overall, the chart reveals that while millets offer substantial benefits in food security,
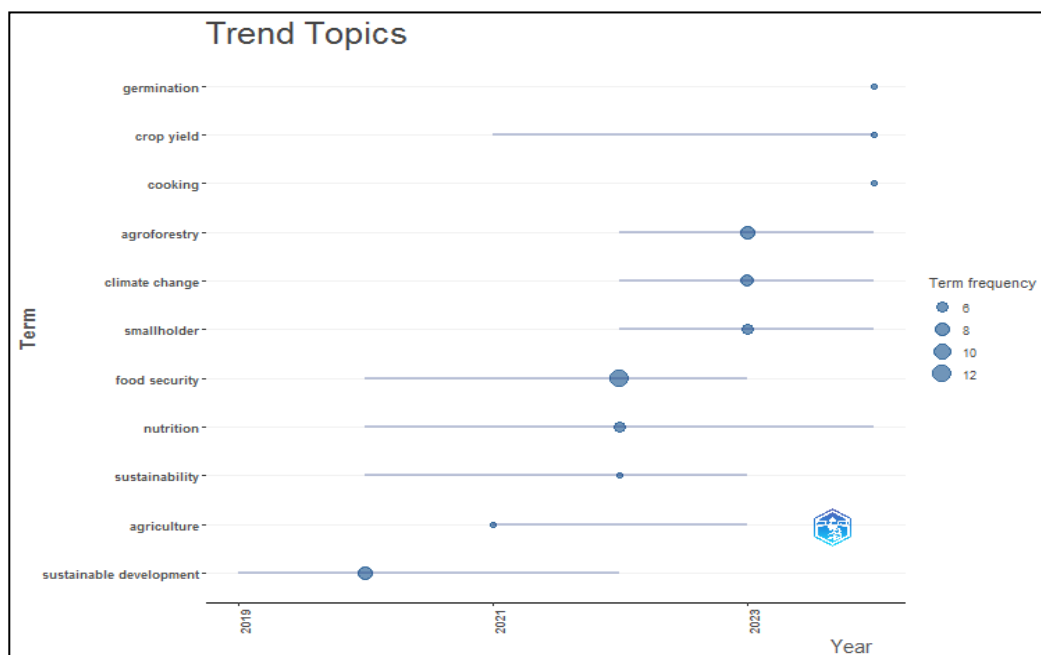

Fig. 6. Trend Topics - Visualizes the evolution of research topics over time, revealing emerging trends and shifting focus areas.

sustainability and nutrition, challenges such as adapting to climate change and improving productivity remain significant areas of focus.

Future research priorities to enhance millet's potential in hunger alleviation

The thematic map illustrates the landscape of research themes related to millet's role in combating global hunger, providing guidance for future efforts. Motor themes such as food security, climate change and SDGs are highly developed and central, indicating their critical importance in millet research and their potential for driving impactful solutions. In the basic themes' quadrant, topics like agroforestry, nutrition and sustainable development are foundational but require further exploration to deepen their relevance and application. The niche themes quadrant, including plant breeding and regional-specific topics like Africa and crop improvement, highlights specialized areas with potential for targeted innovations. Meanwhile, emerging or declining themes such as conservation management and alternative agriculture indicate under-researched areas that may need revival or reassessment. Future research should prioritize integrating climate resilience and nutrition with
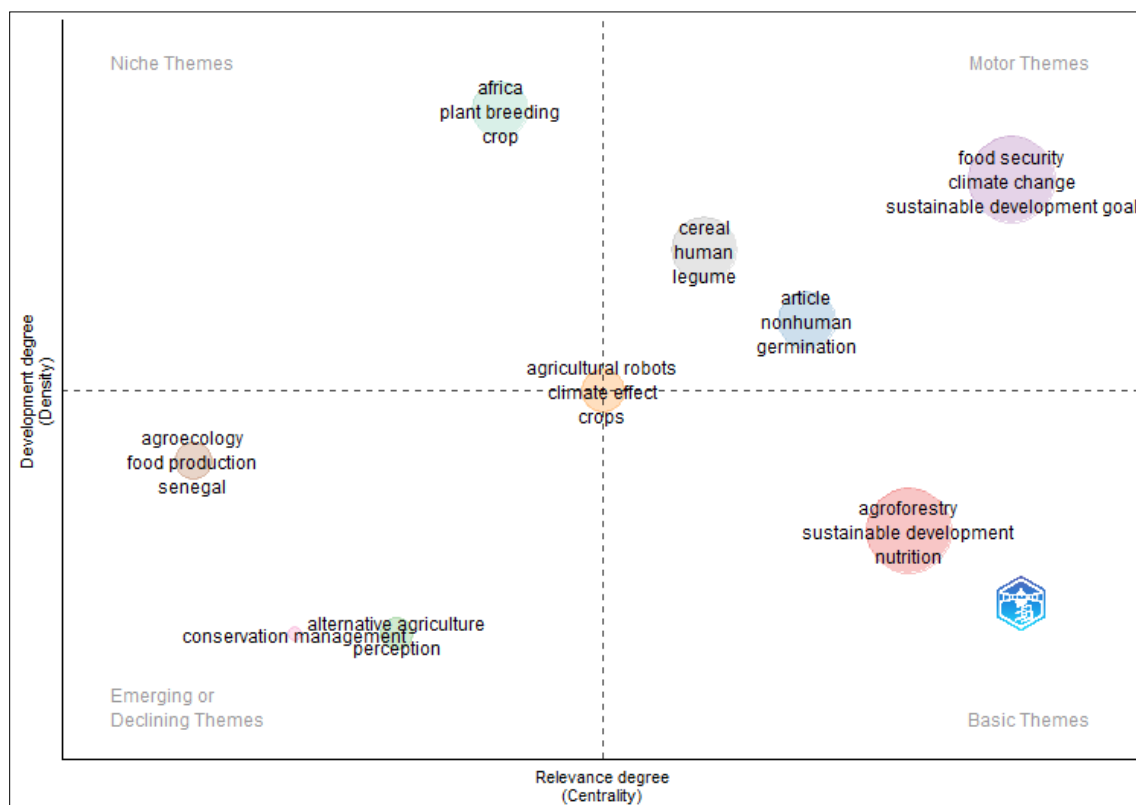

Fig. 7. Thematic Map - Displays themes based on co-word analysis, classified into four quadrants: motor themes, basic themes, niche themes and emerging/declining themes.
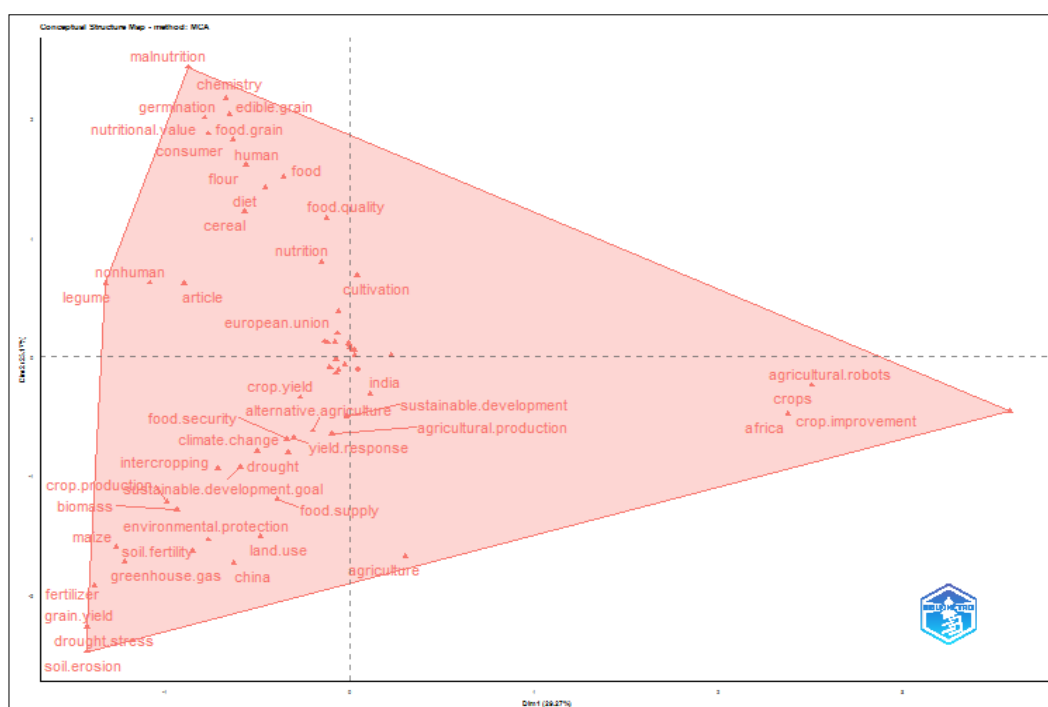

Fig. 8. Factorial Analysis - Uses Multiple Correspondence Analysis (MCA) or similar techniques to map clusters of related terms, authors, or themes.

sustainable farming practices while expanding niche innovations and revisiting emerging themes to address global hunger effectively through millet-based strategies.

The factorial analysis map highlights the interconnected themes critical for advancing millet's role in addressing global hunger. Key clusters centre on malnutrition, nutrition and food quality, underscoring their pivotal importance in leveraging millets for dietary and nutritional security. Topics like crop improvement, climate resilience and sustainable agricultural practices indicate the need for research to enhance millet productivity and adaptability in the face of climate change. Emerging dimensions, including agricultural robots and intercropping, suggest technological integration and resource-efficient farming as future priorities. The prominence of themes like soil fertility, drought stress and land use emphasize the environmental sustainability aspect of millet cultivation. Overall, future research should align these interconnected domains to develop comprehensive strategies, combining technology, nutrition and sustainability to maximize millet's impact on hunger alleviation.

The Reference Publication Year Spectroscopy (RPYS) graph highlights the temporal evolution of foundational literature related to millet research. A sharp rise in citations after 2000 indicates growing scholarly interest in millets, reflecting their increasing relevance to global challenges such as hunger, climate change and sustainable agriculture. The peak around 2015-2020 suggests a surge in critical studies during this period, likely driven by global awareness of food security and nutrition. Future research should build on this momentum, focusing on interdisciplinary approaches that integrate advances in agronomy, nutrition science and policy frameworks to amplify millet's potential in combating hunger and ensuring resilience in food systems.

Limitations

The study is limited by its exclusive reliance on the Scopus database, which may have resulted in the omission of relevant studies

indexed in other databases such as Web of Science, PubMed, or AGRIS. Furthermore, the inclusion criteria were restricted to peer-reviewed journal articles published in English between 2018 and 2025, potentially introducing language and publication bias. The exclusion of conference proceedings and preprints may have led to the omission of emerging, region-specific, or foundational research. To enhance the comprehensiveness and representativeness of future reviews, upcoming researchers are encouraged to adopt a multi-database search strategy, include multiple languages where feasible and consider integrating grey literature and non-journal sources. This broader approach can provide a more holistic understanding of the topic and minimize potential biases in the analysis.

Conclusion and future perspectives

Millets offer immense potential to transform food systems by contributing to nutrition security, climate resilience and sustainable agriculture. Their nutrient-rich profile supports dietary diversity and addresses hidden hunger, while their resilience to drought and low-input farming makes them suitable for marginal environments. Value-added millet products also offer economic benefits to smallholder farmers. However, underutilization persists due to inadequate policy support, limited market development and low public awareness. Several National and International initiatives such as the International year of millets (2023), The National Food Security Mission (NFSM), Intensive Millets Promotion (INSIMP) and Smart Food initiative in India , the Our Millet project in South Korea have aimed to boost millet cultivation, processing and consumption. While these programmes have laid a strong foundation, their impact can be enhanced through continuous evaluation, targeted implementation and stronger awareness building across stakeholders. To unlock their full potential, future research should focus on scalable processing technologies, policy advocacy and socio-economic impacts of millet promotion. This systematic and bibliometric review extends beyond understanding strategies, offering a broader
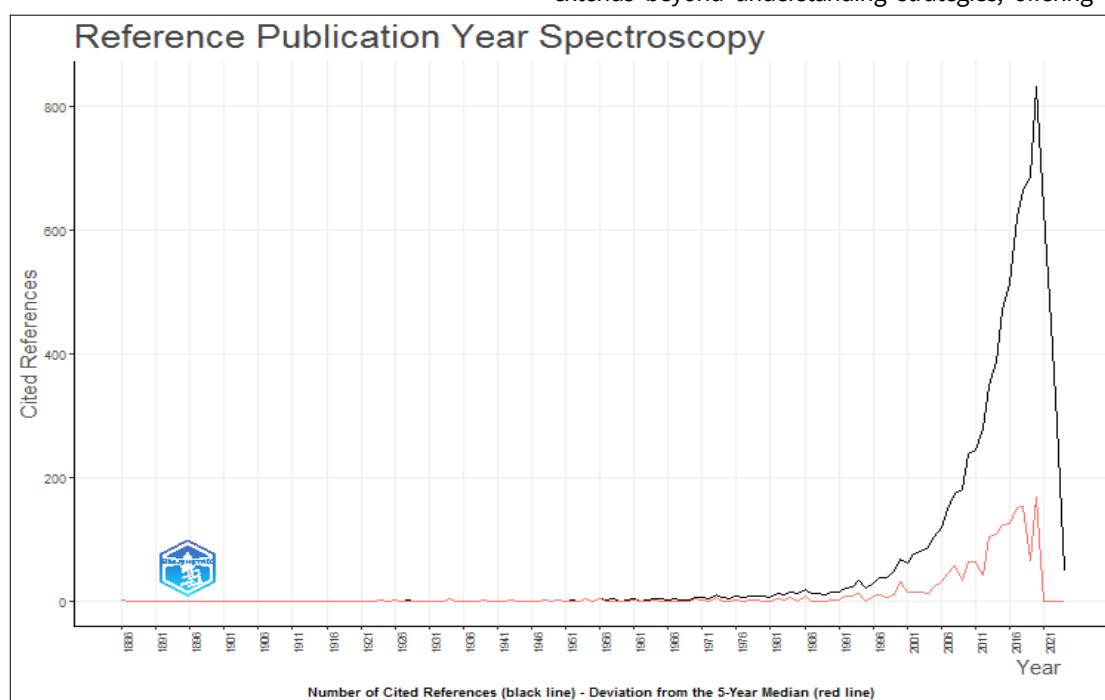

Fig. 9. The RPYS shows the historical roots of the research field by plotting the frequency of cited references by their publication year.

view of how millet research is evolving globally and examining trends, collaboration networks, citation patterns and influential contributors. Such insights are critical for evidence-based policy formulation and investment in millet-based solutions. Strengthened international cooperation and cross-sectoral policy engagement are key to realizing the full potential of millets in achieving Zero Hunger.

Acknowledgements

Authors' contributions

HS carried out the statistical design and performed the software analysis. VMA carried out the Idea and concept framework and drafted the manuscript. MPP carried out the layout of design for the study. KD participated in the experimental planning. PS conceived of the study and participated in its design and coordination. SC participated in the sequence alignment. SM revised and edited the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.