Journal of Infrastructure, Policy and Development 2024, 8(12), 5819.
https://doi.org/10.24294/jipd.v8i12.5819

Review

Navigating food security challenges: A comprehensive analysis, gaps, and future directions

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CITATION

Makhanova A, Serikbekuly A, Tulembayeva A, Smagulova G. (2024). Navigating food security challenges: A comprehensive analysis, gaps, and future directions. Journal of Infrastructure, Policy and Development. 8(12): 5819. https://doi.org/10.24294/jipd.v8i12.5819

ARTICLE INFO

Received: 16 April 2024
Accepted: 28 June 2024
Available online: 31 October 2024

Abstract: In the context of contemporary global challenges such as the COVID-19 pandemic, geopolitical conflicts, and climate change, food security assumes particular significance, being an integral part of national security. This study aims to investigate the interplay between food security and national security systems, with a focus on identifying gaps in the literature and determining directions for further research. The study conducted a systematic literature review on food security and national security systems employing a rigorous and transparent process. The qualitative analysis is grounded in the quantitative one, encompassing studies from Scopus. The examination of the selected peer-reviewed articles revealed several methodological and thematic limitations in existing research: i Geographic imbalance: There is a predominant focus on developed countries, while food security issues in developing countries remain insufficiently studied; ii Insufficient explication: There is a lack of research dedicated to managerial and economic aspects of food security in the context of national security; iii Methodological constraints: There is a predominance of quantitative methods and retrospective/cross-sectional studies. Recommendations include developing comprehensive strategies at both global and national levels to enhance food stability and accessibility.

Keywords: food security; economic grows; accessible food; SLR, bibliometric review; gaps in research
JEL Classification: Q18; Q54; O13; Q56

1. Introduction

Food security is a crucial issue that affects millions of people worldwide, despite advancements in agricultural technology and food distribution systems. According to the Food and Agriculture Organization (FAO, 2022), food security is defined as having access to sufficient, safe, and nutritious food to maintain a healthy and active life at all times. In 2022, the World Food Programm (WFP, 2023) reported that approximately 900 million people did not have enough to eat, and 2.4 billion people experienced moderate or severe food insecurity. The absence of food security not only threatens individual well-being but also can lead to destabilization and social unrest, posing a threat to national security and sustainable development.

The contemporary dimensions of food security are multifaceted and complex, involving a range of socio-economic, environmental, and political factors. The FAO outlines four key pillars of food security: availability, access, utilization, and stability. These pillars collectively address the need for sufficient food production, equitable distribution, proper dietary intake, and resilience to economic and environmental shocks.

Ensuring food security is particularly challenging for vulnerable communities and countries. Factors such as poverty, conflict, and lack of infrastructure heighten the risks faced by these populations. The interconnectedness of the global food system introduces various uncertainties, including climate change, economic fluctuations, and technological advancements, making food security a dynamic and crucial research area. Addressing food security issues requires a systemic approach that takes into account various factors such as economic, social, environmental, and political considerations.

Existing literature on food security explores diverse aspects, highlighting the complexity of the issue. However, there is a scarcity of comprehensive review articles that systematically analyze and synthesize the current state of knowledge in this field. This research aims to address this gap by conducting a thorough analysis of contemporary food security literature, focusing on identifying existing knowledge gaps and proposing future research directions.

Through a systematic review, this research aims to answer three key questions:

Q1: What is the current state of knowledge on food security in the scientific literature?

Q2: What gaps in the literature on food security require further investigation?

Q3: What additional questions should be considered for a more comprehensive understanding of food security?

Addressing food security is essential for improving the quality of life for affected individuals and alleviating the societal burden associated with food insecurity. A comprehensive understanding of the challenges and opportunities in food security can guide the development of effective strategies and policies to ensure sustainable and equitable food access for all.

2. Literature review

Several Systematic Literature Reviews (SLR) have been conducted on the topic of sustainable development of food security. The previous studies were searched in the Scopus database. First, in the Scopus database's "Title, Abstract, Keywords" field, we entered "food AND security AND exploratory AND literature AND review." As a result, we obtained 30 works. The first article was published in 2004. In terms of work types, the majority were categorized as "Article" (18), followed by "Review" (7) and "Conference Paper" (3). Regarding knowledge domains, Agricultural and Biological Sciences led with ten articles, followed by Social Sciences (10) and Business, Management, and Accounting (7). Scholars from Brazil, Canada, Indonesia, the United States, and the United Kingdom primarily conducted SLRs on this topic.

Evaluation of existing literature revealed a predominance of studies with limited scope and focus. They primarily centered on promoting policy interventions (Calloway et al., 2023), regulating food systems, evaluating specific components of food security like the Household Food Security Survey Module (HFSSM) (Marzuki and Jais, 2020), and identifying factors that hinder food security (Marzuki and Jais, 2020). Notably, comprehensive reviews often concentrated on the impact of climate change on agricultural production and food security (MacNabb and Fletcher, 2019; Senyolo et al., 2017). Other reviews addressed themes like biotechnologies, medicine,

and public health. At the same time, a recent surge in research has investigated the influence of various challenges on the efficiency and effectiveness of food supply chains. Gurrala and Hariga (2022) reviewed diverse research sources related to issues affecting the efficient functioning of Food Supply Chains (FSC). In their work, the authors analyzed research models. Most of the selected publications (Er et al., 2022; Unger et al., 2021) are based on the results of literature reviews. Only after this, they chosen thematic research based on secondary data. Only 4 of the 30 selected works conducted a literature review on food security and related factors. Cooper et al. (2020) assessed spatial variations. They provided a summary of identified themes, Wahbeh et al. (2022) identified drivers and food security policy, and Rost and Lundälv (2021) reviewed existing research and literature on food insecurity.

The authors identified that Systematic Literature Reviews (SLR) on the research topic were discussed and demonstrated a minimal problem analysis. The review demonstrates a noticeable need for more comprehensive research and a fundamental gap in this area, raising questions about the underlying reasons for this lack of attention and stressing the need for further investigation. Irani and Sharif (2016) identified the origin of food security and related factors. In this research, there are no empirical works.

According to Fernandes and Samputra (2022), food security can be achieved when it is pursued simultaneously with macroeconomic growth. In a comprehensive analysis, Fernandes and Samputra (2022) explored the connection between food security and economic growth. They utilized various databases (Google Scholar, ScienceDirect, Elsevier, and JSTOR) and covered studies from 2004 to 2021. Their research revealed a noteworthy gap in the empirical understanding of this relationship. While 76.92% of the studies supported a potential correlation between food security and economic growth, further investigation is needed.

Manikas et al. (2023) conducted a comprehensive review of 78 articles to assess how researchers measure and monitor food security. Their analysis showed an overreliance on “household-level calorie sufficiency” (22%) as the sole indicator, despite alternative options like “dietary diversity” (44%) and “experience” (40%) being more informative. Worryingly, “utilization” (13%) and “stability” (18%) dimensions are rarely considered, with only three studies encompassing all four key aspects. Adding to these concerns, Matthew et al. (2020) identified a mismatch between research locations and food insecurity areas. Applying thematic analysis, the review found that early studies mainly addressed global issues and economic policies, potentially neglecting specific regional needs.

A research literature review helped identify food security issues requiring stakeholders’ attention. However, it underscores the need for additional research on human and organizational factors.

3. Methodology

This section presents the research design, which consists of three stages. A similar methodology was used in works by Briner and Denyer (2012), Hatab et al. (2019), and Fink (2013) (**Figure 1**).

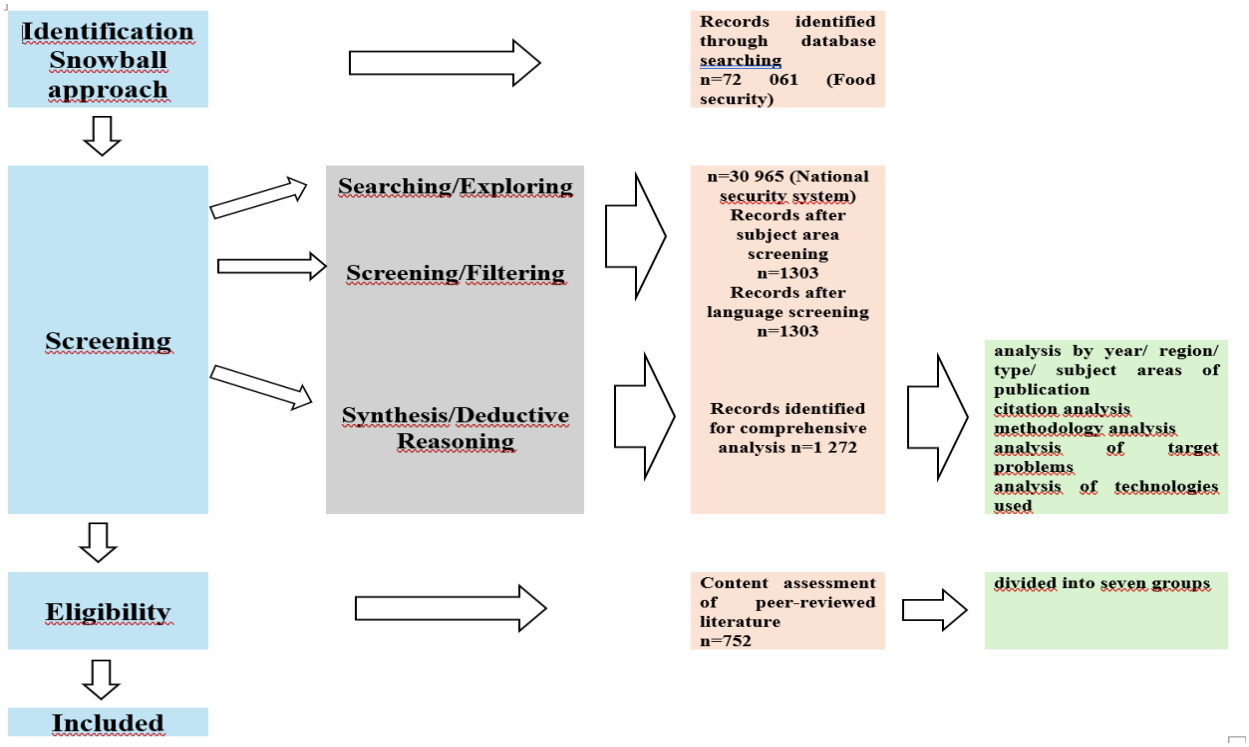

Figure 1. Research design.

To identify the accuracy of bibliographic studies, the review used a «snowball» literature search method to identify relevant keywords used in the food security and homeland security systems literature (Hatab et al., 2019).

Scholarly works from the Scopus database based on defined criteria like data-driven conclusions and context of food security.

Quantitative analysis consists of three levels:

Level 1: Selecting database (Scopus chosen for its extensive collection). At this level, search and exploration are conducted. Since the Scopus database includes references and citations from peer-reviewed literature, this research seeks to utilize Scopus databases in its analysis (Zhidebekkyzy et al., 2019). According to Hasanah et al. (2023), the Scopus database was utilized to encompass scholarly publications from publishers worldwide based on scientific rigor and criteria. A search strategy based on the keywords of the articles was used to extract the initial set of articles.

The selection of Scopus-indexed publications for this review is based on the extensive coverage and rigorous indexing standards of the Scopus database, which ensures the inclusion of high-quality research articles. Additionally, the use of a single database like Scopus provides uniformity and standardization of data, which is crucial for conducting accurate bibliometric analysis and comparing results.

Level 2: Identifying search terms (“snowball” method for related keywords). At this level, screening is performed first, followed by filtering selected articles.

Level 3: Synthesis and deductive reasoning. Analyzing selected articles:

a) Distribution by year, region, publication type, and subject area.
b) Analysis of the most cited publications.
c) Adopted research methodologies.
d) Utilized technologies.

The findings of this investigation are described in more detail in the quantitative analysis.

4. Results and discussion

This section outlines the main results of quantitative and qualitative research.

4.1. Quantitative analysis

4.1.1. Searching/Exploring

A publication search was conducted with a restricted period for a more in-depth study, and there is an explanation for this. Over the past 23 years, the number of publications on "food security" has increased significantly; this is the main reason for choosing the period 2000–2023. Previously, from 1924 to 1999, the number of publications was up to 100 per year.

The first article related to food security was published in 1977. Information processing, automation, and electronics developments have led to changes in American society, particularly in food, along with their challenges and opportunities (Coates, 1977). This article has been cited 11 times. No published research exists from 1977 to 1990. The number of publications was low, with a maximum of 6 per year on average from 1990 to 2009. From 2009 to 2016, there was a significant increase in published papers, from 24 to 88, respectively. Research in business, management, and accounting (BMA) started being actively published in 2017 (Zhidebekkyzy et.al., 2019). This is associated with an interest in various states of food security, their impact on social and economic determinants, and promoting resilience to climate impacts to ensure food security and nutrition. Recent publications on Sustainable Development Goal 2 (SDG 2) have primarily focused on achieving "Zero Hunger" (Task 1) and addressing all forms of malnutrition (Task 2). Many studies analyze the underlying factors contributing to observed trends, emphasizing undernutrition as a critical indicator of hunger severity.

In addition, since 2017, researchers have increasingly become interested in accessing safe and nutritious food in sufficient quantities. To this end, the "Food Insecurity Experience Scale" (FIES) has been actively used to assess the prevalence of acute food insecurity. Notably, the number of publications in this area reached 6,188 in 2021, highlighting the growing research interest in achieving SDG 2. Similarly, this year, there are 265 publications in BMA.

4.1.2. Screening/Filtering

During the search process, 30,965 documents matching the search criteria were found. Furthermore, the search was restricted by selecting articles in English for several reasons (Hasanah et al., 2023; Lopes et al., 2021; Supriharyanti and Sukoco, 2023). Firstly, the international academic community — most crucial research and scientific articles in the Scopus database are in English. Secondly, the quality and reputation of publishers - many prestigious and highly-rated scientific publishers are based in English-speaking countries and publish their articles in English. The initial list of articles was further refined by subject area. A systematic search and verification process selected 1,272 articles for comprehensive analysis. The **Table 1** presents the

search results for the primary keywords for further detailed analysis. The selected articles will be analyzed based on qualitative and quantitative aspects.

Table 1. Size of the research sample.

№		"Food security"	"National security system"
1	Total number of publications in Scopus	72,061	30,965
2	By the established selection criteria.	3208	1303
3	Publications in English	3094	1272

4.1.3. Synthesis/deductive reasoning

Distribution/Grouping of Articles. Using the keyword "Food Security" in the Scopus database, 70,061 publications were identified.

Figure 2 showcases the explosion of studies exploring the link between food security and national security. Remarkably, 98% of "General" category articles appeared between 2004 and 2023, reflecting the intensifying scholarly attention to this urgent topic.

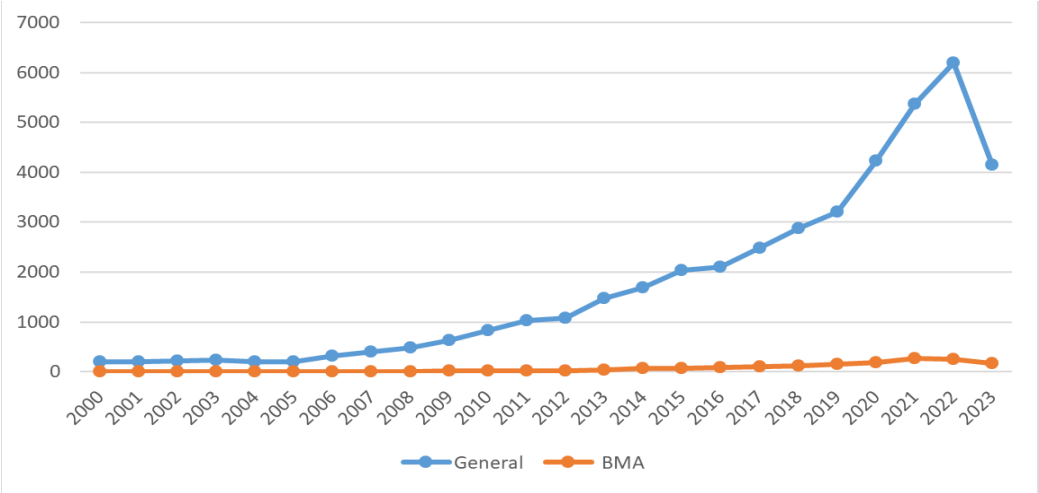

Figure 2. Number of publications divided by year.

Emerging challenges surrounding population growth, food demand, consumer preferences, and new anxieties about sustainability and food security have sparked interest among scientists and researchers in seeking innovative means and methods to ensure adequate food security management. This emphasizes the critical role research plays in tackling these contemporary problems.

Globally, research on food security shows stark geographical imbalances. **Figure 3** reveals that the United States dominates with 7826 publications, followed by China (4923), India (3677), and the United Kingdom (3497). Notably, while Kazakhstan ranks 74th overall, surprisingly climbs to 15th in food security research, highlighting its dedicated focus within the country. However, **Figure 3** also exposes a concerning gap: regions like the Middle East, South America, and many Asian nations, facing significant food security challenges, contribute minimally to the research landscape. This necessitates collaborative efforts to address these regional disparities and optimize global food security solutions.

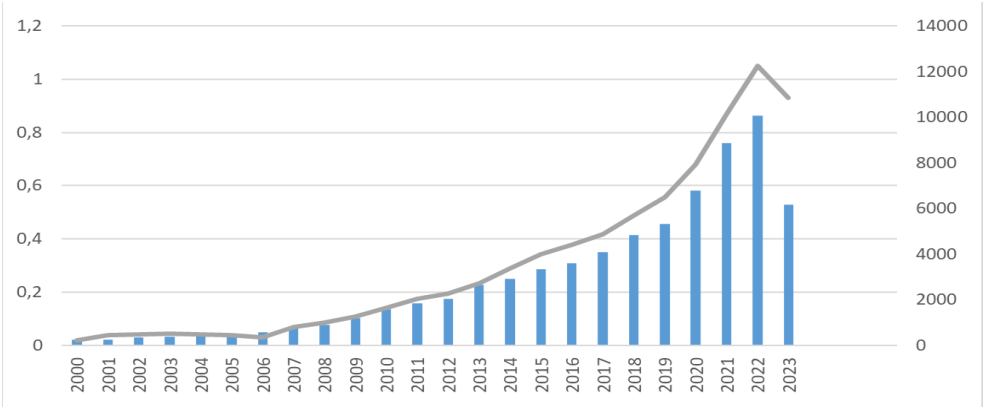

Figure 3. Segmenting the overall category of publications by type, specifically "Article," and organizing them by the year of publication in Scopus.

For comparison within the Eurasian Economic Union (EAEU) countries, the breakdown is as follows in **Figure 4**: the share of Russian scientific publications during this period was 2.5% (1,220) (16th place in the ranking), Belarus—0.07% (20) (133rd place), Armenia—0.04% (7), Kyrgyzstan—0.01% (34) (121st place).

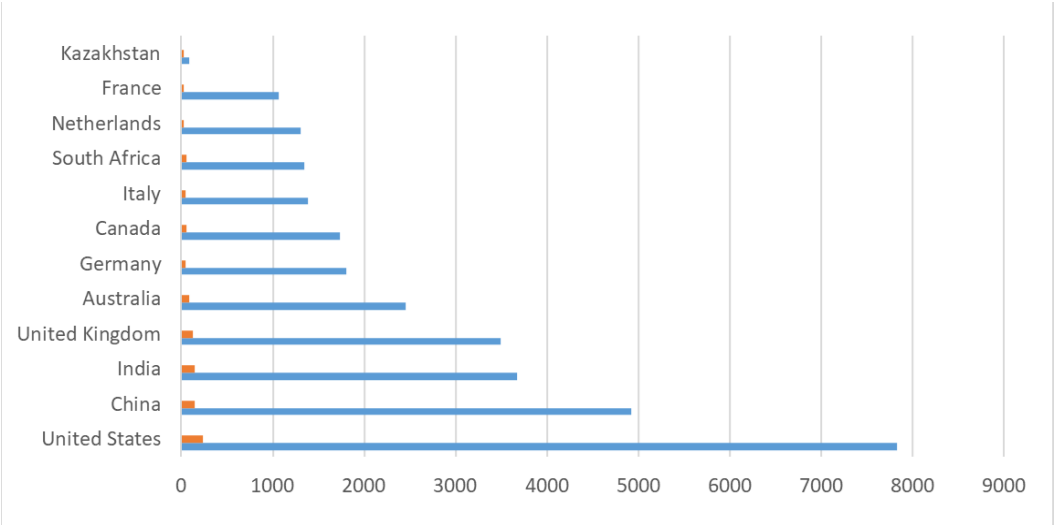

Figure 4. Distribution of articles by geographical origin.

What makes the research topic relevant in the country? In China, "food security" is the cornerstone of socio-economic stability and the most critical issue for the global food market. In 2014, India passed the "National Food Security Act," which aims to make subsidized food available to those in need to combat hunger and improve food security (Narayanan, 2015). The law influenced the intensity of research in food policy and security, stimulating academic and applied studies on the effectiveness and impact of this initiative on the level of food security in the country. According to the data from the UK Food Standards Agency (2023), food security is high, with 93% of households being food insecure. However, 8% of households need help accessing food. The main issues include rising food prices, inflation, and a decrease in people's incomes. The Government will only address this shortly for some parts of the UK. These questions raise the relevance of research on food security in the UK.

In the Asia-Pacific region (APR), there is significant progress in ensuring food security, but challenges persist. Achievements such as reducing hunger levels, increasing Gross Domestic Product (GDP), and promoting agricultural development can be acknowledged. However, issues persist, including unequal access to food, climate change, and land degradation, posing a threat to food security by diminishing soil fertility. Collaborative efforts among the region's countries, including implementing modern resource management methods and support for scientific research, can enhance food security in the Asia-Pacific region (Timme, 2013; Wahbeh et al., 2022).

Despite the absence of worsening water deficits and progress in reducing greenhouse gas emissions in many capitals, food security in Australia remains a serious issue requiring a comprehensive approach. Urgent measures must be taken to protect the country's food system and ensure access to food for all.

SCOPUS consolidates publications across 28 subject areas (Zhidebekkyzy et al., 2019). The analysis confirms a significant research gap in managerial and economic dimensions of "food security" within the "national security" context.

While **Figure 5** shows diverse areas contributing to food security research, "Agricultural and Biological Sciences" dominates with 16,894 publications. Other fields like "Environmental Science" and "Social Sciences" have substantial contributions, yet areas like "Business, Management, and Accounting" (1752) and even broader "Economics, Econometrics, and Finance" (3689) show limited focus on this specific angle. Our content analysis found only 25 publications directly exploring food security's managerial and economic dimensions within national security. This underscores the urgent need for more research from these perspectives to address this critical issue comprehensively.

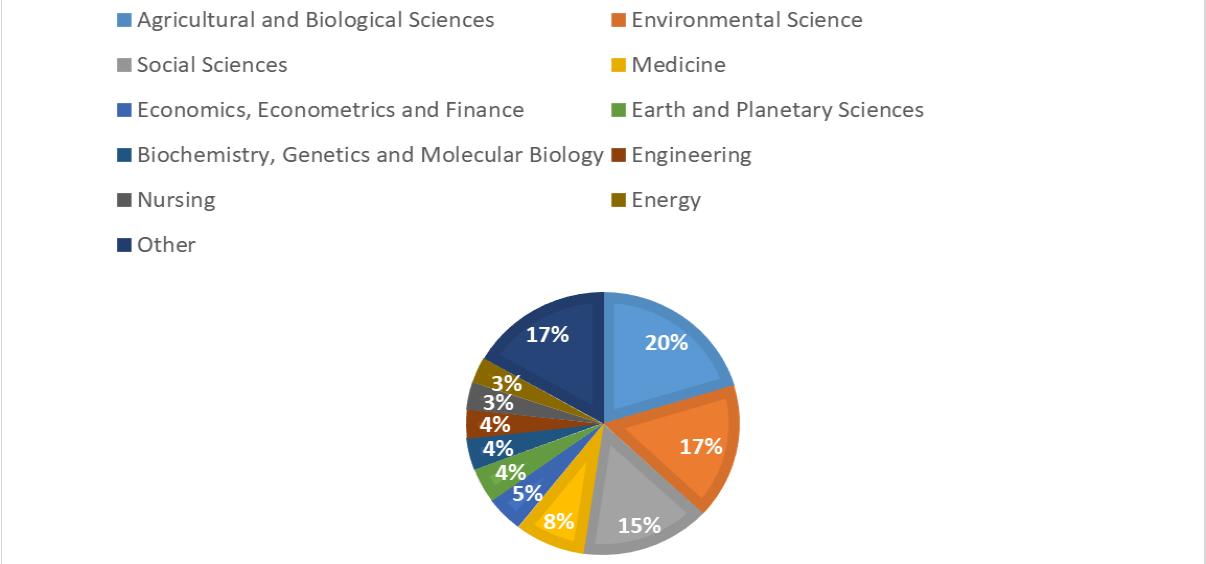

Figure 5. Analysis of publication activity in Scopus by subject areas.

Figure 5, based on our research, depicts the distribution of publications across various subject areas within Scopus. Among all categories, "Agricultural and Biological Sciences" has the most published works.

While fields like "Environmental Science" and "Social Sciences" have significant contributions, other areas like "Business, Management, and Accounting" (BMA) show a considerably lower focus on food security within the national security context.

Delving deeper into the BMA category, we analyzed highly cited articles (150 citations or more). Only 32 articles out of the chosen 1272 studies have more than 100 citations and only eight, as shown in **Table 2**, boast over 200 citations. This highlights the potential need for more focused research on food security within BMA compared to other domains.

Table 2. Detailed citation analysis in Scopus.

№	Document's name	Authors	Source	Year	Citations
1	Food waste matters-A systematic review of household food waste practices and their policy implications	Schanes, K., Dobernig, K., Gözet, B.	Journal of Cleaner Production, 182, 978–991	2018	655
2	Modeling the blockchain-enabled traceability in agriculture supply chain	Kamble, S.S., Gunasekaran, A., Sharma, R.	International Journal of Information Management, 52, 101967	2020	427
3	Tourism and water use: Supply, demand, and security. An international review	Gössling, S., Peeters, P., Hall, C.M., Lehmann, L.V., Scott, D.	Tourism Management, 33(1), 1–15	2012	419
4	Product safety and security in the global supply chain: Issues, challenges, and research opportunities	Marucheck, A., Greis, N., Mena, C., Cai, L.	Journal of Operations Management, 29(7–8), 707–720	2011	349
5	Nitrogen and phosphorus losses and eutrophication potential associated with fertilizer application to cropland in China	Huang, J., Xu, C.-C., Ridoutt, B.G., Wang, X.-C., Ren, P.-A.	Journal of Cleaner Production, 159, 171–179	2017	346
6	Water-energy-food nexus: Concepts, questions and methodologies	Zhang, C., Chen, X., Li, Y., Ding, W., Fu, G.	Journal of Cleaner Production, 195, 625–639	2018	288
7	The effects of China's cultivated land balance program on potential land productivity at a national scale	Song, W., Pijanowski, B.C.	Applied Geography, 46, 158–170	2013	248
8	Key sustainability challenges for the global phosphorus resource, their implications for global food security, and options for mitigation	Chowdhury, R.B., Moore, G.A., Weatherley, A.J., Arora, M.	Journal of Cleaner Production, 140, 945–963	2017	205

Although from different perspectives, all cited articles focus on food security and national security issues. Despite the diversity of topics, all these articles share a common goal - ensuring sustainable and safe access to food. The results of these studies support the previously stated statement about the need for additional research from economic and managerial perspectives. More attention should be paid to management and economic issues: Technical, environmental, or social aspects dominate in the presented articles.

Additionally, we calculated the annual citation count for each article, revealing that some articles with a high overall citation count have a low annual citation count.

She accepted/Used Research Methodologies. **Table 3** presents various research methodologies adopted for the analysis, forecasting, identification, and prevention of threats to food security.

Table 3. Proportion of articles using different research approaches.

Category	**% dist.**
Analytical diagnostics	15.4%
Methods of generalization and synthesis, scientific abstraction	13%
Expert analysis, survey	15.4%
Regression analysis	12.6%
A systematic approach, comparative analysis	9.1%
Benchmarking	6.41%
Empirical analysis	5%
Other	23%

Quantitative methods, as illustrated in **Figure 6**, were nearly twice as prevalent as qualitative methods, with 39% of studies utilizing quantitative approaches compared to 21% for qualitative approaches. Furthermore, approximately 41% of the reviewed articles were solely based on literature sources. In 16% of the works, the authors applied a comprehensive approach, combining qualitative and quantitative methods. Primary data collection tools were predominantly secondary data (41%).

While most studies relied on theoretical frameworks, only a tiny portion (5%) employed empirical research methods, highlighting a potential lack of knowledge derived from real-world experience.

More data from such studies could explain the low percentage of empirical research methods (Gurrala et al., 2022). However, with recent advancements in data science, additional research in this direction can be expected.

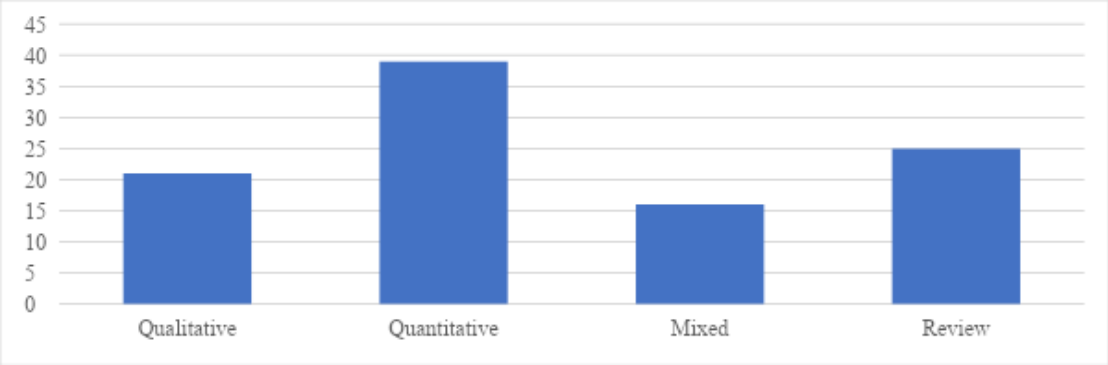

Figure 6. Research methods and design of peer-reviewed articles.

Analysis of study design revealed that prospective plans were infrequently used (7%); the proportion of studies with a longitudinal design was 13%. Retrospective plans (50%) and cross-sectional studies (29%) proved the most common. These results indicate a prevalence of studies analyzing past events compared to those examining phenomena in dynamics or predicting their development.

Problems solved/targeted. A list of articles on solved/targeted food security problems is presented in **Table 4**.

Table 4. List of articles on solved/target problems.

Category	**% dist. 752**
Food security	40.2%
Food Supply	28.5%
Agriculture	15.15%
Sustainable Development	15%
Climate Change	8.4%

While 70% of recent articles commendably address sustainability, safety, and food insecurity, a gap exists in exploring areas like Agrarian Policy, Agricultural Development, and Economic Analysis. These underrepresented themes are crucial for understanding factors like efficient resource allocation, policy effectiveness, and market dynamics within the agro-food system.

Technologies and approaches used. **Table 5** presents various technologies that enhance transparency, traceability, quality, safety, and sustainability in ensuring food security.

Table 5. List of articles on technological adaptations.

Category	**% dist.**
Artificial Intelligence (AI)	35.1%
Internet of Things (IoT)	21.15%
Emergy-Data Envelopment Analysis (EM-DEA)	16.64%
Blockchain and Integrated blockchain (IB)	14.89%
Remote sensing technology	2%
Smart/Intelligent Packing	1.26%
Other	8.96%

Table 5 highlights various technologies that play a crucial role in food security. For instance, blockchain ensures transparent and verifiable food sourcing, tracing products from farm to fork and minimizing fraud. Similarly, IoT sensors monitor storage conditions and detect early signs of spoilage, reducing waste and optimizing resource management. These technologies ultimately contribute to a more secure and sustainable food system for national stability. The EM-DEA approach, which combines energy and data envelopment analysis, was recently developed and has also gained popularity for assessing Resource Use Efficiency (RUE) and sustainability.

The absence of international consensus on sustainability reporting requirements (what, when, and where) creates challenges in assessing sustainability performance. A group of authors investigated different sustainable forecasting methods for the food industry (Hishaueva et al., 2017; Zaure et al., 2018;). Research by Hishaueva et al. (2017) emphasizes the value of the scenario approach in analyzing diverse trends within the food sector.

Quantitative Analysis Conclusion. Global research on food security shows significant imbalances dominated by developed countries: the US, China, India, and the UK's leading contributors. Gaps in regions facing significant challenges: Middle East, South America, and many Asian nations contribute minimally. Managerial and economic aspects under-researched: "Agricultural and Biological Sciences" dominates (16,894), and "Business, Management and Accounting" (BMA) has limited focus (1752). Only 25 of 1272 studies directly explored BMA and national security. Highly cited BMA articles focus on broader food security, not the national security angle. Research methodologies: Quantitative methods are most frequent (39%), retrospective (49%), and cross-sectional (32%) designs are most common. Technologies and approaches: Blockchain, IoT, and AI play crucial roles in transparency, traceability, quality, safety, and sustainability.

4.2. Qualitative analysis

Review and analysis of peer-reviewed research

For further investigation, we narrowed down the document type in the "general" category to "articles" and selected articles in the English language. The search yielded 752 works. Building upon the quantitative analysis, the qualitative study incorporates additional perspectives from Scopus-sourced research. The 752 chosen articles underwent a comprehensive analysis based on three critical criteria: (i) the research question or problem being addressed, (ii) the theoretical framework and specific context of the research, and (iii) the findings, implications, and conclusions derived from the study. Analysis categorized articles into seven thematic groups (multi-group inclusion; see **Table 6**). To gain a deeper understanding of the theoretical orientations and research focus within each thematic group, the following subsections offer detailed discussions.

Research Focus: More than 300 papers are devoted to the Sustainable Development of the FSC. Further, a significant number of studies reveal the problems of food security. There is increasing attention to the influence of COVID-19 on agriculture and food security. The pandemic has caused disruptions in food supply chains, decreased incomes, disrupted healthcare systems, and increased the number of

people experiencing food insecurity. Okolie and Ogundeji (2022) conducted a literature review examining the influence of COVID-19 on agriculture and food security. The annual growth of publications is about 56.64%. A scarcity of research exists, with only two articles exploring the connection between "food security" and "national security" Markina et al. (2018) scrutinized "national security" and its components, pinpointing food security in the supply chain as one of its principal elements.

Table 6. Conducting a content analysis of the reviewed literature.

Topic groups	Key findings	Synthesis of results	Key studies
Group 1. Development of the FSC	The main task is to monitor the quality of food products throughout the supply chain and track their physical movement until they reach the end consumers.	1) Incorporating blockchain and other intelligent technologies into the food industry carries noteworthy societal implications. 2) Enhancing collaboration among producers, suppliers, processors, distributors, and retail outlets enhances effectiveness, minimizes expenses, upholds quality production standards, and enhances consumer satisfaction.	Dutta et al. (2020); Gourisetti et al. (2019); Mangla et al. (2021); Biswal et al. (2018); Bechtsis et al. (2022)
Group 2. Problems of ensuring food security	1) The emergence of food security and related factors enables organizations, enterprises, policies, and stakeholders to strive to study and understand this significant social issue. 2) Six concepts underlying the issues of ensuring food security have been formulated. 3) Food security is often a matter of access to food (e.g., due to poverty) rather than availability. 4) Dietary patterns and food demand are linked to socio-economic variables. 5) Issues of food security are closely connected to the loss of agricultural land.	1) It is assumed that information regarding these factors can help decision-makers in communities, organizations, and enterprises better understand them, enhancing food security. Subsequently, relevant strategies or policies may emerge and develop, allowing for the prioritization of strategic and operational interventions at the national, regional, or sectoral levels. 2) Food security is often viewed as the final element in the cause-and-effect chain, i.e., as a result of preceding processes. 3) The issue of food security often becomes a subject of discussion in the future.	Kuokkanen et al. (2017); Zghurska et al. (2023); Pingali (2003)
Group 3. COVID-19 and Food Security	In all countries worldwide, models of the food system have been identified to support food policies, including food security. The assessment of the relationships between socioeconomic factors, food security, and dietary diversity has been explored before and during the COVID-19 pandemic. Studies have also been conducted on the relationship between COVID-19 and agricultural production and food security.	1) Pandemics disrupting agriculture cause supply and demand imbalances, hindering all aspects of food security: food availability, affordability, utilization, and stability. 2) Extraordinary rules of Covid-19 exacerbated the lack of food security, leading to transformative innovations in food management. 3) Insufficient agricultural production activities pose threats and risks to food security systems.	Collins and Ogundeji (2022) Elsahoryi et al. (2020). Nchanji and Lutomia (2021)

Table 6. (*Continued*).

Topic groups	Key findings	Synthesis of results	Key studies
Group 4. The impact of climate and climate change on food security		1) Strengthening climate-relevant research: This means investing in scientific studies that address issues like improving crop resilience to changing weather patterns, developing climate-smart agricultural practices, and exploring adaptation strategies for grain production.	Han (2023). Fuss et al. (2015). Lu (2019)
Group 5. The impact of geopolitical relations on the national food security system is a highly relevant topic across various domains.	1) The Russian-Ukrainian conflict has hurt the global grain market, as Russia and Ukraine account for 28%, 26%, and 15% of the world's share of wheat, barley, and corn, respectively. 2) The reduction in imports due to the Russian-Ukrainian conflict affects the bankruptcy of other exporters and adverse shocks caused by the decrease in imports.	1) The adverse impact of geopolitical relations and the human factor, causing disruptions in grain trade, creates a spatially uncorrelated distant connection between agricultural production and trade behavior. 2) The study suggests that increases in perceived geopolitical threats, as reflected in the GPR Threat subindex, can lead to price hikes in these agricultural commodities. 3) The war in Ukraine will make the global grain supply system more fragile, increasing import demand for significant grain producers in North America and Europe. 4) Ukraine's future trade strategy and the EU will need to adapt to the bloc's new approach of Open Strategic Autonomy.	Micallef et al. (2023). Pugachevska et al. (2023); Fedulova et al. (2023)
Group 6. Government Support, Internal Policies in Ensuring Food Security	In many countries, the issue of food security still needs to be solved due to the need for more implementation of various general economic and specific measures to enhance the food system's resilience.	In all countries, specialized government bodies have been established and developed in the agro-industrial sphere, performing regulatory and protective functions for the agricultural sector and the agricultural food market.	Maxwell and Slater (2003); Mokwena et al. (2023)
Group 7. Innovation in agriculture: the key to sustainable development	The conditions and mechanisms of strategic development and sustainable growth in agriculture, where innovation and digital technologies serve as the locomotive and main driving force, are highlighted. The continuous renewal of resource potential positively influences the dynamics of sustainable growth, and a more qualitative and innovative modernization of production factors enhances the positive trend of these indicators.	The dominant political goals of intelligent specialization in Central and Eastern European countries include sustainable innovations, public health and safety, and crucial technologies to promote sustainable farming practices, build a bio-based economy, and guarantee safe and secure food supplies.	Adenle et al. (2019) Khalatur et al. (2023) Nurakhova (2017) Shvets et al. (2023)

G1 Development of the FSC. Food security is closely intertwined with national security and the supply chain, constituting a crucial component for ensuring stability and resilience within a country. Several aspects substantiate this correlation: i-conomic Stability (Nugroho et al., 2022): Problems with getting food to people can

cause economic upheaval; ii- social stability: food shortages can result in social unrest and tension. Hunger and food unavailability can spark protests and disturbances, posing a potential threat to social Stability and national security; iii- Supply Chain Security: disruptions in the supply chain can cause sudden changes in the availability of products. As global food security becomes a significant political issue, the structure and optimization of critical agricultural supply chains are gaining increased importance. Blockchain holds enormous potential for transforming supply chain functions, from the origin of the supply chain, reengineering business processes to enhancing security. In recent years, there has been a significant increase in the number of scientific works devoted to the study and analysis of the application of blockchain technology in various aspects of supply chain management (Kumar et al., 2022; Rainero and Modarelli, 2021; Tse et al., 2017). Dutta et al. (2020) conducted a review of 178 pieces of literature on the implementation of blockchain in supply chains, and Gourisetti et al. (2019), among others, Mangla et al. (2021) analyzed the impact of "Integrating Blockchain in Supply Chain Operations" on transparency, traceability, and security. Biswal et al. (2018) examined the impact of RFID technology on supply efficiency and optimization. Bechtsis et al. (2022) examined how cybersecurity and other security aspects affect the resilience and reliability of supply chains; iiii -national health: food security is directly linked to the health of a nation. Food shortages or poor-quality products can spread diseases, increasing the burden on healthcare and threatening the health of citizens (Gardas, 2019; Van Hoyweghen et al., 2021).

Besides, the authors have identified vital correlation approaches based on a range of scientific research and concepts in the field of food science and economics:

Integrated Approach to Supply Chains. Studies such as Aji and Joni's (2020) work underscore the importance of an integrated approach to supply chains for ensuring food security. The author underscores the necessity for efficient collaboration among all participants in the supply chain to guarantee a stable and accessible food supply.

a) Risks and Vulnerabilities in Supply Chains. Research by Bertolozzi-Caredio et al. (2023) raises questions about risks and vulnerabilities in supply chains, such as climate change, natural disasters, and geopolitical factors. These elements can significantly impact food security through the distortion of supply chains.
b) Technological Innovations in Supply Chains. Scientific articles, including the study by Tse et al. (2017) and Mangla et al. (2021), discuss the role of technological innovations in strengthening supply chains. Instance, Mutanov et al. (2020) based on their research, suggest that the use of system-dynamic modeling and online supply chain management optimizes and improves distribution processes in the supply chain. This contributes to increased efficiency, traceability, and quality management of products, which are crucial for ensuring food security.

Thus, a scientifically grounded correlation exists between food security and supply chains, where efficiency, risk management, innovations, and resilience are crucial in ensuring stability and food accessibility.

G2 Problems of ensuring food security. The second largest group in the studied materials is 70 papers on the problems of ensuring food security. Within this category (G2), the literature delves into various aspects of food and dietary patterns,

encompassing shifts in food preferences, habits, and the structures of food distribution systems. As per the current synopsis, the research within this category frequently establishes connections between food security challenges and alterations in land usage and vegetation coverage (Gumma et al., 2011). Moreover, it frequently examines the depletion of agricultural lands (Shi et al., 2016; Wu et al., 2011; Zdruli, 2014), often attributing the lack of food security to these underlying dynamics.

Kuokkanen et al. (2017) identified increasing returns processes that became inefficient and increased the circularity of the food system. Research by Kuokkanen et al. (2017) identified three interconnected areas, production, policy, and institutions, that create resistance to transitioning towards sustainable food systems, even within the broader context of supply chain challenges. The study emphasizes the need for greater consistency and joint efforts across different EU policies related to food security (Sonnino et al., 2014).

Wu et al. (2011), in their research, proposed an approach that integrates biophysical, social, and economic factors for a spatially explicit assessment of potential future risks of food insecurity on a global scale. Isaac et al. (2023) conducted a thematic study on various methods of analyzing national trends in food insecurity. One of the methods identified the dynamics of national food security. Research by Zghurska et al. (2023) revealed a complex and intensifying interplay between marginalization, education, and health, all of which have a non-linear influence on food insecurity and malnutrition. The study emphasizes that achieving sustainable food security at the national level requires improving the population's health and transforming current food consumption models, particularly within households and their reliance on imported foodstuffs.

Unlike studies that view food insecurity solely as a lack of food availability, this research emphasizes the crucial role of access in understanding the issue. Crush and Frayne (2011) argue that access primarily hinges on an individual's or household's ability to afford food, influenced by three key factors: income, food prices, and the location of food outlets. However, Korth et al. (2014) caution that increasing income does not automatically translate to improved food security. This additional income needs to be spent on purchasing more food, particularly nutritious options, which depends on the "calorie elasticity of income" concept.

Pingali (2003) outlines the challenges surrounding food security through five primary objectives: guaranteeing sufficient food and nutrition for urban populations, eradicating rural poverty and persistent food deficits, redefining agriculture within the global landscape, tackling the hurdles related to accessing technologies, and advocating for the sustainable stewardship of natural resources within food systems.

G3 COVID-19 and Food Security. The study by Okolie and Ogundeji (2022) examines the consequences of the COVID-19 pandemic on both economic and food security. Using Web of Science and Scopus, they examine serious situations caused by the pandemic and conclude that COVID-19 poses a severe threat to the stability of food systems. However, the research output was uneven across years, with 2020 contributing 38.5% and 2021 accounting for 37.9% as of April 2021.

The authors propose a four-step method for combining databases for bibliometric analysis. This method allows for various analyses, such as studying collaboration

networks and connections between authors. The method is implemented using the net2VOSviewer tool in the Rstudio environment.

Existing studies cover the impact of the pandemic on food security and agriculture (Elsahoryi et al., 2020; Nchanji and Lutomia, 2021), but a comprehensive analysis of knowledge in this area through literature reviews needs to be more comprehensive.

G4 The impact of climate and climate change on food security. Growing concerns about future food security stem from climate change projections. While many studies focus on crop yield impacts, changes in yield variability might have an even more significant effect.

Over 100 studies have investigated the link between climate and food security. Han (2023) concluded that global climate change would impact agricultural production worldwide, leading to changes in food prices and social well-being. Werner et al. (2014) linked climate change and water scarcity to rising food insecurity and environmental stress.

Most studies conclude that climate change harms global food security, exacerbating poverty, hunger, and malnutrition, with developing countries and marginalized communities most affected. Fuss et al. (2015) proposed a model highlighting the need for overproduction to meet minimum food supply needs under climate variability.

Further research is needed to use environmental impact assessments to identify inefficiencies in the food supply chain and develop a more sustainable system.

G5 The impact of geopolitical relations on the national food security system is a highly relevant topic across various domains. A particularly pertinent example is the geopolitical relations between Ukraine and Russia. Liu et al. (2023) researched the potential consequences of the Russo-Ukrainian conflict for global food security. Their findings suggest that the conflict may exacerbate existing vulnerabilities in the global food system, particularly for low-income countries heavily reliant on grain imports, increasing the risk of supply chain disruptions and potentially jeopardizing their food security. According to Micallef et al. (2023), the Russo-Ukrainian conflict has influenced agricultural product prices, as both countries are significant producers of agricultural goods. Empirical results also demonstrated how the Granger GPR Threat subindex affected future prices of soybean oil, coffee, wheat, and oats. In their study, Kovalova et al. (2023) identified that the Russo-Ukrainian conflict revealed a lack of emergency implementation of food security tools and an analysis of the current situation. Pugachevska et al. (2023) observed a significant surge in newly implemented trade restrictions, particularly export restrictions, initially triggered by the COVID-19 pandemic and subsequently exacerbated by the war in Ukraine. The study also noted a gradual but consistent rise in import restrictions, impacting 9% of global imports by the end of 2022.

Furthermore, the war in Ukraine prompted increased export restrictions on food, feed, and fertilizers as countries grappled with food security challenges. Fedulova et al. (2023) investigated the potential impacts of rapid economic restructuring and a global shift toward prioritizing agriculture in today's uncertain world. Their findings suggest that these trends could lead to undesirable outcomes, including a decline in

economic growth rates or a highly unpredictable situation with various possible development paths.

G6 Government Support, Internal Policies in Ensuring Food Security. Aiking and de Boer (2004) highlight the need for democratizing environmental decision-making within transnational food corporations. They believe this is crucial for ensuring sustainable food production practices globally. This is part of the broader ideal of multi-level governance, encompassing both governmental and private interests. Research by He et al. (2019) and Guo et al. (2023) emphasizes the crucial role of both the extent of arable land and access to irrigation in ensuring a country's ability to achieve food security.

Researchers across the board, including Rutten et al. (2016), Boratyńska et al. (2017), Maggio et al. (2016), and Gani (2020) advocate for utilizing trade policies to tackle food security concerns in diverse settings, regardless of development status. For example, some propose developing infrastructure-focused strategies, particularly in agricultural logistics, or improving the efficiency and quality of transport logistics. Others emphasize the importance of government trade policies and support for the private trade sector. Additionally, recommendations include the removal of tariff and non-tariff barriers, with some researchers suggesting implementing policies that encourage dependable maritime connectivity and transport logistics.

Several authors have put forth political recommendations to reduce food waste and, consequently, ensure food security. According to Xu et al. (2020), governments should actively contribute to shaping a sensible societal view on food consumption, especially by encouraging the consumption of simple foods, particularly in the public catering sector. They also proposed implementing relevant policy measures to stimulate the adoption of sustainable consumer habits, which, as the authors claim, has significant implications for reducing food waste and enhancing food security (Xu et al., 2020).

G7 Innovation in agriculture: the key to sustainable development. In terms of the number of articles, the more researched areas include monitoring innovative activities, developing innovative infrastructure that informs enterprises about the results of various research, and providing specialized recommendations on various aspects of agricultural production and financial incentives for the activities of the agro-industrial complex. A study by Adenle et al. (2019) suggests that low-tech methods might be better for ensuring people have enough to eat in the long run, even if they produce less food. This is because these methods require less labor and give communities more control over their use, unlike some advanced technologies. Kuznetsova et al. (2019) highlight the importance of these factors in addressing food security. In their study, Saginova et al. (2017) identified the processes of formation and development of modern production technologies for competitive agricultural products based on nanotechnologies. The study presents the potential of nanotechnologies in enhancing the viability of animals and poultry, improving their productivity, and enhancing the economic efficiency of production. The processes enabling improving the quality of agricultural products in crop production and obtaining environmentally friendly food products for human consumption were also identified. Khalatur et al. (2023) emphasize the critical role of implementing innovative management practices in the agro-industrial sector. They argue that such innovations are essential for achieving

modernization and keeping the sector up-to-date and competitive. Sustainability: Ensuring environmentally responsible practices. Meeting growing demand: Producing enough food to meet the needs of a growing population. The study calls for further research and investment in developing and implementing these innovative practices. Additionally, the authors provide examples of successful innovations from various countries, showcasing the potential benefits of adopting such approaches.

The food industry is crucial in ensuring national food security and economic growth in the agricultural sector, its primary supplier. By adopting a competitive marketing strategy, companies can establish a consistent behavioral model that aligns their goals and resources, ultimately securing long-term success. Nurakhova (2017) proposes a three-level strategic management framework (corporate, functional, and instrumental) for developing effective marketing strategies within an enterprise. As noted by Ramazanova et al. (2019), an effectively designed import substitution policy in the agricultural sector is a potential tool for improving food security at the national level.

Qualitative analysis highlights the need for further research on the link between food security and national security. Authors argue that understanding this connection is crucial, as population nutrition levels reflect overall economic development. Historically and presently, food production remains the backbone of direct and general production, impacting social stability, economic viability, and national government structures.

Analysis of peer-reviewed articles revealed two prominent research themes. Food security and supply chains received the most attention, with nearly 40% of articles delving into this crucial relationship. 16% of studies explored this connection and its implications for agricultural production and food security. Resource use, food security, and agricultural production: Surprisingly, only 7% of articles addressed this vital tripartite interaction. Notably, most studies focused on resource efficiency within the food supply chain and its environmental impact, targeting sustainability goals.

Additionally, the analysis highlighted the interconnectedness between Groups 3 and 5: The stringent measures related to COVID-19, coupled with pre-existing food security concerns, spurred the exploration of innovative solutions in food management, emphasizing the need for transformative approaches.

5. Conclusion

The conclusions emphasize the critical importance of global food security for both individual well-being and national security in the face of the world's increasing population and environmental challenges. Based on an extensive analysis of scientific publications, the study identified vital directions and gaps in existing research, highlighting the necessity of integrating technological innovations, sustainable practices, and political strategies to strengthen food security globally.

However, this study has some limitations. The primary limitation is the reliance on available literature, which may have missed some unpublished studies or studies not indexed in the Scopus database. Additionally, while the study attempts to cover a broad range of topics related to food security, it may not capture all the nuances of

regional and local contexts, which are crucial for a comprehensive understanding of the subject.

Future research should focus on addressing these limitations by incorporating a wider range of data sources and considering the specific contexts of different regions and localities. Further studies could also explore the impact of emerging technologies and innovative practices on food security and evaluate their effectiveness in various settings. Additionally, research should examine the interconnectedness of food security with other aspects of national security and explore interdisciplinary approaches to address the complex challenges in this field.

The results of this study can be applied in a broader context, particularly for communities and countries experiencing significant food insecurity. By understanding the current state of knowledge and identifying key gaps, policymakers, researchers, and practitioners can develop targeted strategies and interventions to improve food security in vulnerable populations. This holistic approach is essential for achieving sustainable development goals and ensuring food security for all.

Funding: This study has been financed by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP196093/0222).

Conflict of interest: The authors declare no conflict of interest.

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