

JEL: O33

Original article

DOI: 10.35330/1991-6639-2025-27-5-234-249

EDN: QQOCEO

Efficiency and sustainability in food supply chains: a systematic analysis of scientific literature

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Abstract. Achieving food security and creating a balanced food system to meet the needs of the population is one of the most important socio-economic challenges of any country in the world, which determines the relevance of this study.

Aim. The study is to analyze modern concepts of food supply chain efficiency and sustainability based on a literature review of scientific publications.

Materials and methods. This review includes 44 scientific articles from journals indexed by both Scopus and Web of Science for the period from 2020 to 2024. This study used the PRISMA method to evaluate the identified publications in the field of food supply chain efficiency and sustainability.

Results. The study found that the number of scientific publications increased annually during the analyzed time period, confirming the high significance of this scientific area. Most of the analyzed studies focused on the sustainability of food supply chains and used quantitative research approaches. Continental Europe and Mediterranean Europe are the leading regions in terms of the number of scientific studies in the field of food supply chains.

Conclusion. The results of the presented literature review are important not only for describing the current state of research in the chosen field, but also for identifying the most promising areas for future research.

Keywords: systematic literature review, efficiency, sustainability, food supply, supply chains, logistics management

Submitted on 10.07.2025,

approved after reviewing on 10.08.2025,

accepted for publication on 25.09.2025

For citation. Fikire A.H., Korchagina E.V. Efficiency and sustainability in food supply chains: a systematic analysis of scientific literature. *News of the Kabardino-Balkarian Scientific Center of RAS*. 2025. Vol. 27. No. 5. Pp. 234–249. DOI: 10.35330/1991-6639-2025-27-5-234-249

УДК 658.7

Научная статья

DOI: 10.35330/1991-6639-2025-27-5-234-249

Эффективность и устойчивость цепочек поставок продовольствия: систематический анализ научных публикаций

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Аннотация. Достижение продовольственной безопасности и создание сбалансированной продовольственной системы для обеспечения потребностей населения является одной из важнейших социально-экономических задач любой страны мира, что обуславливает актуальность данного исследования.

Целью исследования является анализ современных концепций эффективности и устойчивости цепочек поставок продовольствия на основе обзора научных публикаций.

Материалы и методы исследования. В этот обзор включено 44 научные статьи из журналов, индексируемых как Scopus, так и Web of Science, за период с 2020 по 2024 год. В этом исследовании использовался метод PRISMA для оценки выявленных публикаций в области эффективности и устойчивости цепей поставок продовольствия.

Результаты. Исследование показало, что количество научных публикаций ежегодно увеличивалось в анализируемый временной период, что подтверждает высокую значимость данного научного направления. Большинство проанализированных исследований были сфокусированы на устойчивости цепочек поставок продовольствия и использовали количественные исследовательские подходы. Континентальная Европа и Средиземноморская Европа являются регионами – лидерами по числу научных исследований в сфере цепочек поставок продовольствия.

Выводы. Результаты представленного литературного обзора важны не только для описания существующего состояния исследований в выбранной области, но и для выявления наиболее перспективных областей будущих исследований.

Ключевые слова: систематический обзор литературы, эффективность, устойчивость, снабжение продовольствием, цепочки поставок, управление логистикой

Поступила 10.07.2025, одобрена после рецензирования 10.08.2025, принята к публикации 25.09.2025

Для цитирования. Фикире А. Х., Корчагина Е. В. Эффективность и устойчивость цепочек поставок продовольствия: систематический анализ научных публикаций // Известия Кабардино-Балкарского научного центра РАН. 2025. Т. 27. № 5. С. 234–249. DOI: 10.35330/1991-6639-2025-27-5-234-249

INTRODUCTION

The efficiency of food supply chains can be defined as the optimal utilization of economic resources from the production of food items to consumption. However, sustainability of food supply chains is the continuous pursuit of fairly, environmentally-conserving, economically viable practices that ensure food security and provide balanced diets for current and future generations. Efficiency and sustainability are deeply intertwined concepts and have no separate goals. Efficient food supply chains must be sustainable, and sustainable food supply chains implicitly are more efficient in their resource utilization. The food supply chain is the entire network of interconnected processes that governs the flows of food items from production to the final consumers for consumption. Food supply chains play a crucial role in global food security, impacting food access, livelihoods, and public health [1]. Sustainable food supply chain management practices, such as waste management, logistics optimization, and fair food distribution, can significantly enhance food security and reduce hunger [2]. FAO, IFAD, UNICEF, WFP and WHO estimated that 811 million individuals worldwide experienced hunger in 2020 [3]. Masters et al. highlighted that 3 billion people struggle to afford nutritious diets due to high food prices, persistent poverty, and income inequality [4]. The leading food-producing countries are the United States, China, India, Brazil, and Russia, producing more than half of the world's food supply. Africa, the Middle East, and Oceania produce only around 10% of the global output [5]. However, the concentration of global food production in a few countries has led to significant disparities in food availability, exacerbating food insecurity in vulnerable regions [6]. This inequality arises from unequal access to agricultural resources, technology, and investment, which are critical for enhancing food production and security [7]. According to Godde et al.,

logistical inefficiencies, variances in quality control, and a lack of traceability lead to considerable waste, undermine consumer confidence, and hinder the ability to respond effectively to market demands and food safety concerns are the challenges of global food supply chain [8]. Abraham et al. stated poor cold chain facilities, transportation and logistics inefficiencies, unsuitable handling equipment, poor road infrastructure, and restricted supply chain partner information sharing are major challenges sustainability of food supply chains [9].

Food supply management faces external disruptions, quality management practices, and evolving consumer expectations that impact efficiency, sustainability, and food quality. Therefore, understanding these challenges is crucial for improving food supply chain operations and ensuring food security [10]. Additionally, environmental, economic, social, and technological factors are the main determinants of the efficiency and sustainability of food supply chains. These are climate change impacts, water usage, pollution, costs associated with production, transportation, waste, fair labor practices, food security, consumer behavior, automation, and data analytics, which play a crucial role in optimizing supply chains [11].

The applications of modern technology and innovation are essential to increasing the efficiency and sustainability of the food supply chain [12]. These advanced technologies create significant enhancements across multiple applications in innovative industries and transportation, leading to creative solutions [13]. Progress in digital technologies, including blockchain, the Internet of Things (IoT), and machine learning, has boosted operational efficiency and sustainability within food supply chains [14, 15]. Advanced technologies help manage waste, enhance traceability, and support the shift from linear to circular economies, ultimately minimizing resource use, waste, and emissions [16].

The previous study has been focused on a single theoretical foundation. These are measuring food system sustainability, efficiency, and integration, food supply chains, and food loss at the regional and country level. For instance, Demelash & Alemu employed a multi-dimensional approach method analysis to measure food system sustainability in Ethiopia [17]. Efficiency and integration in the food supply chain were used to analyze stochastic frontier analysis methods of analysis [18]. Chrisendo et al. employed statistical analysis to analyze the socioeconomic factors of global food loss [19]. There are not enough studies conducted by integrate both efficiency and sustainability of food supply chains. Thus, studying the efficiency and sustainability of food supply chains is crucial to analyze food supply chain efficiency and sustainability to support resource utilization, decrease environmental effects, and enhance social and economic benefits. Additionally, many studies have failed to incorporate econometric methods or regression analysis. As a result, these hinder the identification of causal relationships between efficiency measures and sustainability outcomes. Incorporating regression analysis could enhance the robustness of findings and provide valuable insights for policymakers and practitioners seeking to promote sustainable practices in various sectors. The main objective of this study is to analyze the concept of efficiency and sustainability in the context of food supplies and to stress the gaps that have been identified in the existing research on food supply chains in order to emphasize the necessity of further investigation. With this in mind, it is possible to point to the directions for further research for other scholars to open new areas for research, solve existing problems, and create new approaches. This approach helps build academic knowledge, policy making, and practical implications to support more efficient and sustainable food supply chains worldwide.

SUMMARY OF EMPIRICAL LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Table 1 provides a comprehensive overview of the key contributions in food supply chain literature, stressing their focused area, key findings, methodology, gaps, and scope of the study. Based on the review of most of the previous studies focused on the sustainability of food supply

chains. However, limited studies have been conducted on the efficiency of food supply chains. They employed qualitative, quantitative, and mixed research approaches. The main finding of the study are internal factors, development of roadmaps, effective communication and educational campaigns, compliance and technology traceability systems improve, diversification strategies, increased reliance on local input production, and shifts in consumer behavior, clean technologies, stakeholder engagement, and supply chain coordination are factors that affect sustainability of food supply chains. However, enhancing the integration with suppliers increases the efficiency of food supply chains.

Table 1. Literature review related to the efficiency and sustainability of food supply chains

Authors and year	Focused area	Key finding	Methodology	Gaps	Scope
Gürül et al., 2024 [20]	Sustainability food supply chains	The internal sustainability performance of the focal food supply chains is better than the external one	Mixed research approach	Not fully capture internal and external perspectives	Food firms, Istanbul
Mendes et al., 2024 [21]	Integration of sustainability into the food supply chain	Nature Farming is a specific style of agriculture that is distinct from other currents of alternative agriculture	Qualitative research approach	Doesn't incorporate differentiated agri-food chains such as milk or meat production in the study.	Nature Farming poultry production, Brazil
Bezat-Jarzębowska et al., 2024 [22]	Integration of the Food Supply Chain	Enhancing integration with suppliers and buyers can significantly improve efficiency within the food chain	Quantitative research approach	Only develop a conceptual framework	Theoretical model
León Bravo et al., 2021 [23]	Sustainable food supply chain	Develops a roadmap with five levels of progress, considering the groups of practices implemented and the type of assessment applied.	Qualitative research approach	The analysis was concentrated in a particular country	Design a roadmap for the food supply chain
Handayati & Widyanata, 2024 [24]	Sustainable food supply chain	Effective communication and educational campaigns, including the use of social media, can Enhance public awareness and understanding of waste management	Qualitative research approach	Generalizability and scalability	Food waste management model, Bandung Regency
Masengu et al., 2025 [25]	Sustainable food traceability	Compliance and technology traceability systems improve food safety performance.	Quantitative approach	Food safety and supply chain resilience	Oman food industry
Nchanji & Lutomia, 2021 [26]	Sustainability of the agri-food supply chain	Diversification strategies, increased reliance on local input production, and shifts in consumer behavior played a crucial role in enhancing agri-food supply chains	Mixed-Methods Approach	agri-food supply chains	During the period of the global pandemic
Silva et al., 2025 [27]	Sustainable food supply chain	Clean technologies, stakeholder engagement, and supply chain coordination are factors that affect sustainability and the complexity of the food supply chain.	Quantitative research approach	Not fully incorporated, influencing the complexity of the FSC	Relationship between sustainability and influence on the complexity of food supply chains

Figure 1 indicates that food supply chains consist of both efficiency and sustainability. There is a bidirectional relationship between efficiency and sustainability. Whereas, enabling factors affect both efficiency and sustainability of food supply chains. These are technological innovations, policy and governance, stakeholder collaboration, and geographical context that pushed the food supply chains towards greater efficiency and sustainability of food supply chains. The outcome of the combined strategies is cost reduction, modernization of food supply chains, and enhancement of both efficiency and sustainability across the globe.

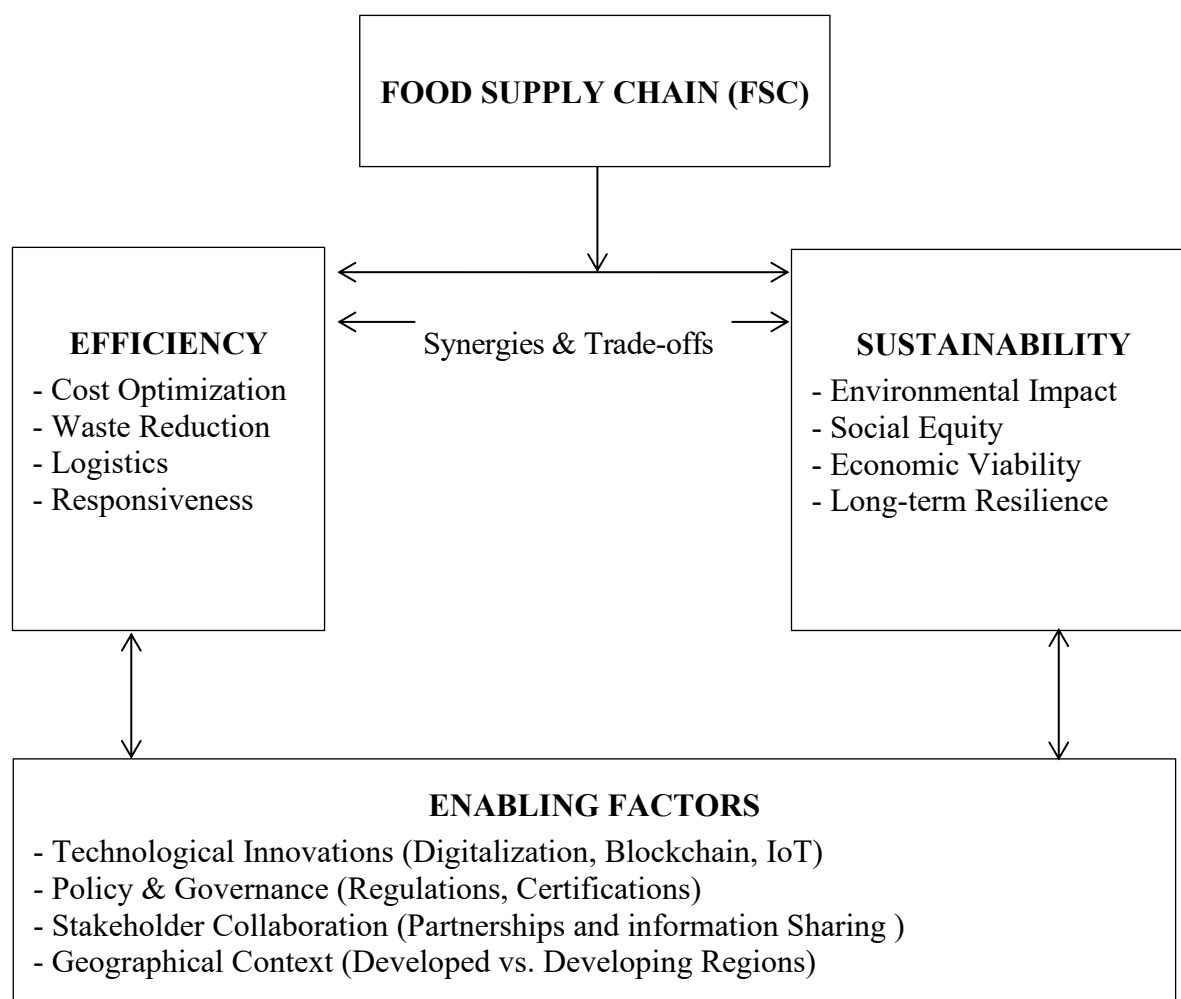


Fig. 1. Conceptual framework for analyzing efficiency & sustainability in food supply chains
Source: adapted from [3, 28] and modified with empirical literature

METHODOLOGY

SEARCH STRATEGIES AND DATA COLLECTION PROCESS

This systematic article review aims to explore the concepts of efficiency and sustainability in the context of food supplies and provide a comprehensive review of the structure and networks of food supply on a global scale. This provides a comprehensive perspective and several insights for additional research in diverse new business scenarios. A systematic review offers a robust methodology for objectively analyzing evidence, effectively managing numerous scholarly publications, and creating a sophisticated framework for research topics. It enhances the overall evaluation of current knowledge and identifies gaps for future research opportunities [29]. These

studies collectively emphasize the importance of identifying research gaps and employing appropriate methodologies to address them in various fields. This systematic literature review explores multiple aspects of research methodologies and gaps in different fields [30]. Systematic literature reviews follow a structured method to synthesize evidence on a specific research question. Standard procedures include defining the research question and eligibility criteria, conducting a comprehensive literature search, selecting relevant studies, extracting data, assessing study quality, and synthesizing findings. Figure 2 depicts the flow of literature searching strategies. These methodologies enable researchers to integrate existing knowledge, identify gaps, and propose future research agendas in efficient and sustainable food supply chains. A systematic review should begin with a peer-reviewed procedure and clearly state its methodological follow to established reporting guidelines of preferred reporting items for systematic reviews and meta-analyses (PRISMA) [31]. This study used PRISMA recommendations [32].

LITERATURE SEARCHING STRATEGIES

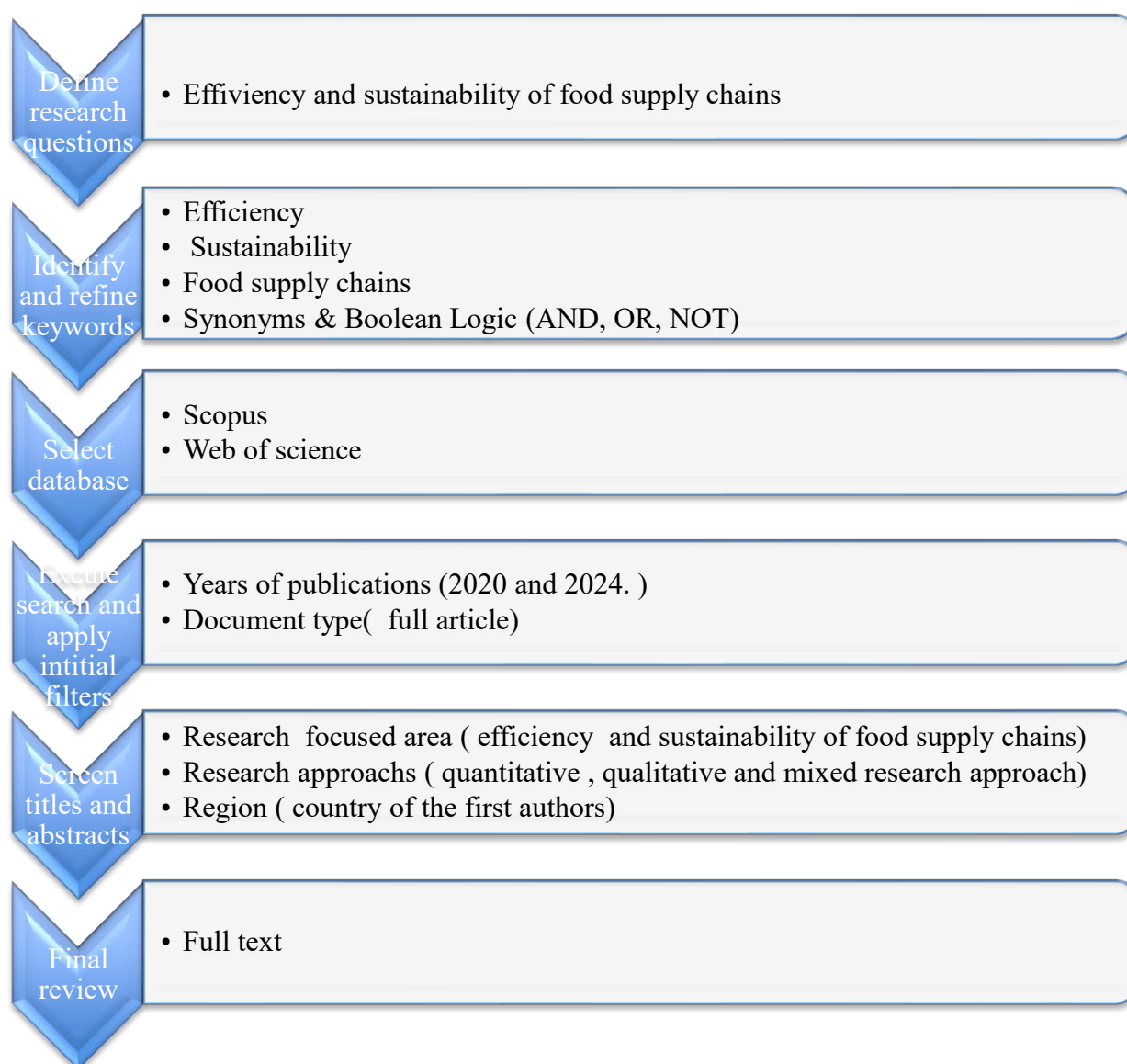


Fig. 2. Literature searching strategies

THE SYSTEMATIC REVIEW PROCESS FOR THE CLASSIFICATION OF ACADEMIC PUBLICATIONS

The number of research articles was further reduced by selecting only academic journals for the review. The research papers excluded from the review are out of the subject areas and are not written in English, such as reviews, book chapters, conference papers, books, editorials, and conference reviews. After removing these articles, 44 remained in Scopus and 4 in the Web of Science, automatically filtered from the databases.

In the "Identification" stage, an initial pool of records was gathered from Scopus and Web of Science databases. Specifically, 1232 records were initially identified, including contributions from Scopus (643 records) and Web of Science (589 records). Before further analysis, a significant number of records (1184) were automatically removed because they were deemed ineligible by automation tools, demonstrating an effective preliminary filter. In the "Screening" stage, the records were evaluated exactly to remove irrelevant papers and duplicates based on their titles. After this refinement, 48 records remained from both databases. An additional exclusion process was conducted, where 1 record was removed due to open access restrictions. The remaining 47 reports were evaluated for "eligibility" in the following step. During this assessment, 3 records were excluded due to duplication problems. Finally, highly quality and relevant 44 studies were included in the final body of the investigated literature review.

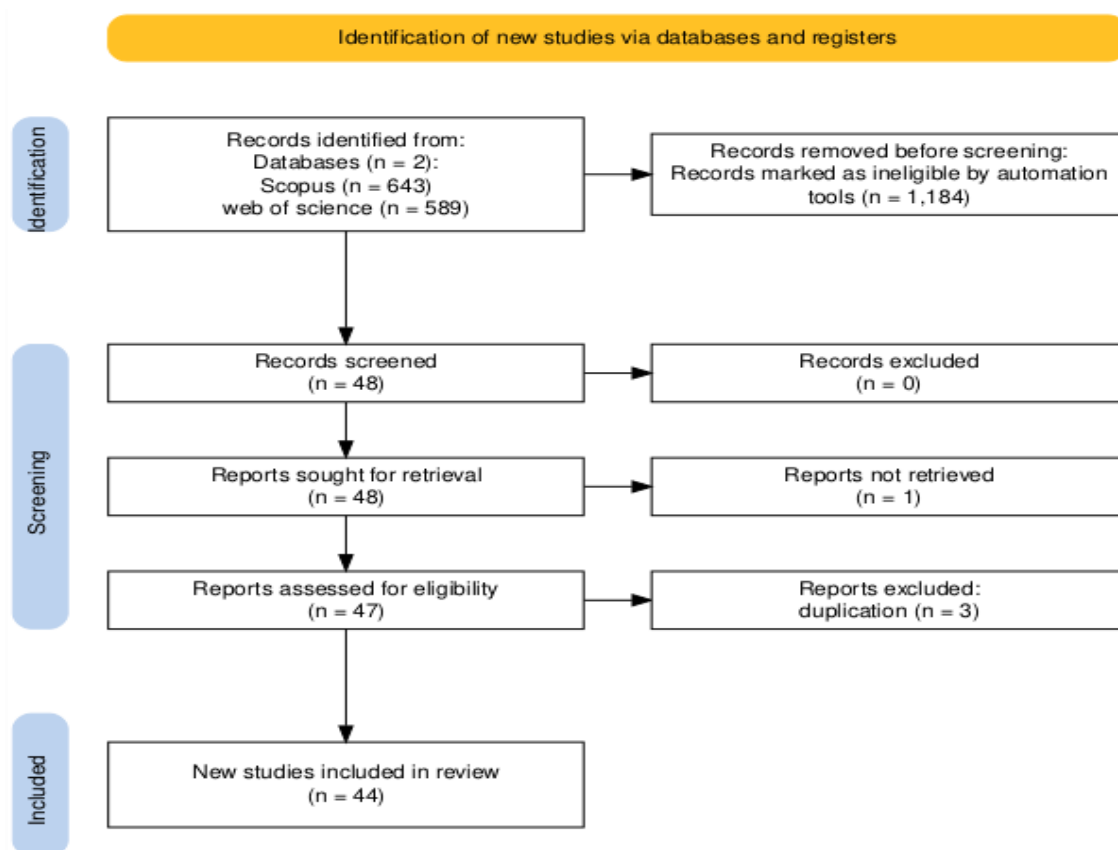


Fig. 3. PRISMA flow diagram of the study selection process

RESULT AND ANALYSIS DESCRIPTIVE STATISTICS

The following sections present, discuss, and analyze all the identified papers, detailing their various aspects and features.

YEAR-BASED NUMBER OF PUBLICATIONS

Figure 4 shows a year-based classification of the food supply chains from 2020 to 2024. The number of journal publications is approximately 6 in 2020. Moving to 2021, the count is 7, with a small increase observed. There is a notable rise, with the publication count increasing to about 8 in 2022. This upward trend declined in 2023, when the number of publications reached approximately 7. Finally, the number of journal publications again rose in 2024, when the number of publications reached 16. The figure implies the upward publication trend from 2020 to 2022, with some fluctuation in 2023, and again increased in 2024, on the efficiency and sustainability of food supply chains.

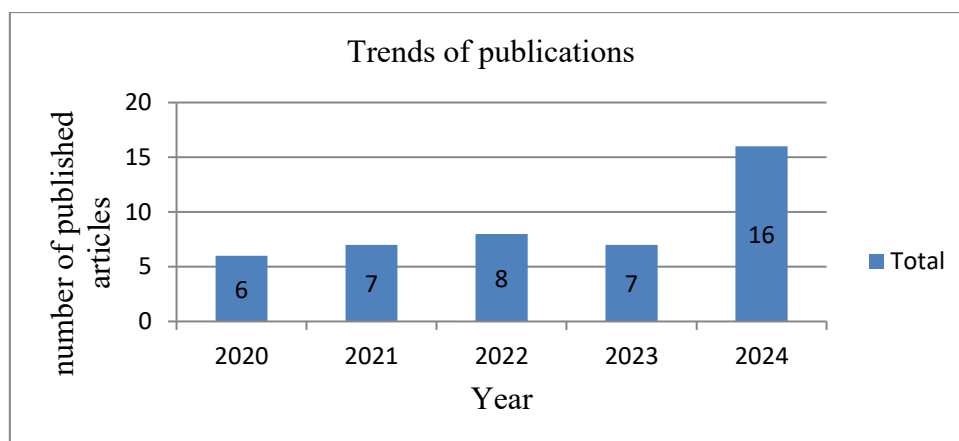


Fig. 4. Year-based classification of the number of publications
Source: developed by the authors

CATEGORIZATION OF PUBLICATIONS BASED ON DATABASE SYSTEMS

Figure 5 shows the distribution of publications by database, specifically comparing Scopus and Web of Science. According to the figure, most publications (93%) are indexed by Scopus. This indicates that Scopus is the predominant indexing service used for these publications, suggesting higher visibility and possibly a preference for this database among researchers in efficiency and sustainability food supply chains. By comparison, Web of Science indexes 7% of published articles. This rate is lower than Scopus but still significant and demonstrates the importance and hope of research expansion by many indexing services.

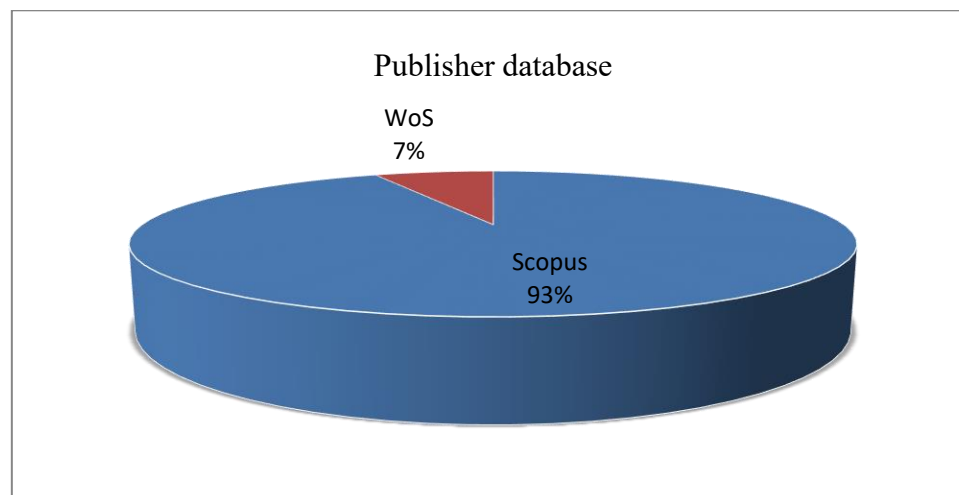


Fig. 5. Categorization of publications based on the database
Source: developed by the authors

CATEGORIZATION OF PUBLICATIONS BASED ON THE COUNTRY OF THE FIRST AUTHORS

Figure 6 indicates the categorization of publications based on the country of first authors, illustrating various contributions from various countries. The United Kingdom and Italy are the most significant contributing countries, with 16% and 14% papers published as first authors. These countries lead in the research related to the efficiency and sustainability of the food supply chains, indicating a strong research presence and interest in their countries. Following these, Germany, Denmark also show considerable contributions, with 9%, 7%, publications, respectively. Serbia, South Africa, and Australia have 5% publications each. This suggests these countries are actively engaged in related research, although to a lesser extent than the top contributors. Several other countries provide moderate contributions, including Sweden, Romania, United Arab Emirates, Turkey, China, Chile, Sri Lanka, Iran, Brazil, India, Indonesia, Serbia, Taiwan, Turkey, Ukraine, Greece, England, Bulgaria, and the United States, each contributed 2% of the publication. These countries demonstrate a balanced interest in this study area. Although their individual contributions are small collectively they contribute to worldwide research efforts in efficiency and sustainability food supply chains.

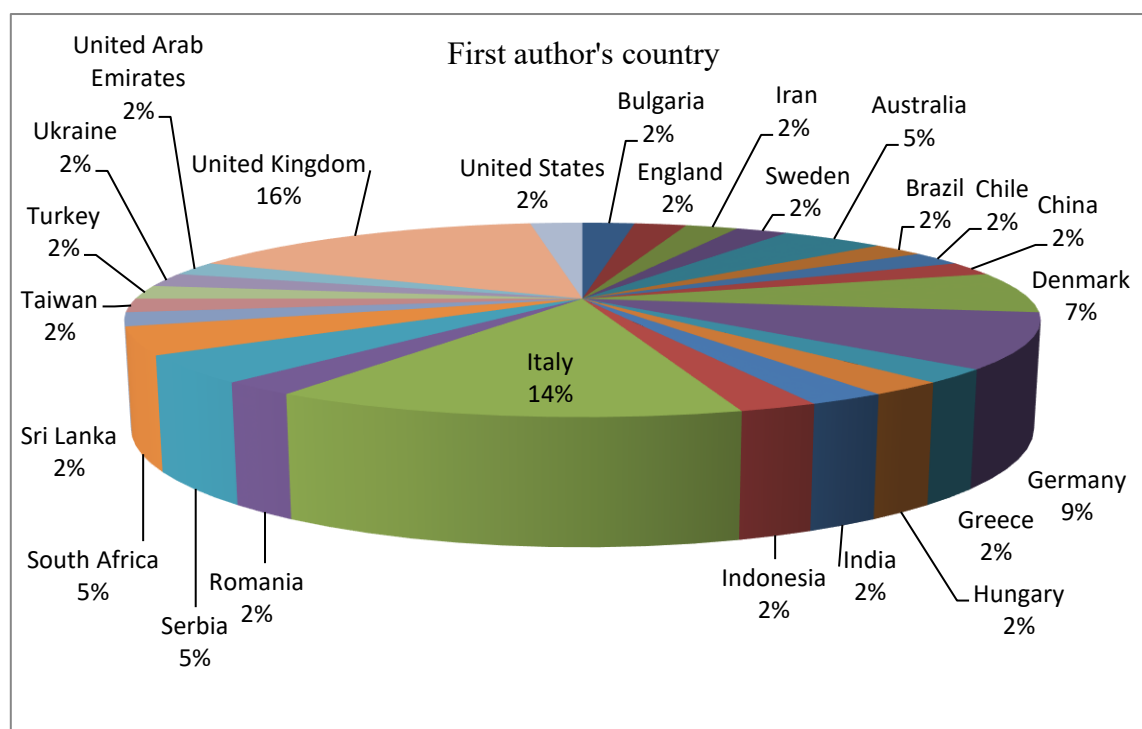


Fig. 6. Categorization of publications based on the country of first authors
Source: developed by the authors

CATEGORIZATION BASED ON RESEARCH APPROACHES

Figure 7 displays research article publication categories based on several research approaches. It presents 22 articles that employed a quantitative research approach (questionnaires and surveys). Whereas the qualitative research approach (interviews, case studies, focus groups, and narratively described in words) also shows a significant representation, with 21 publications. This indicates that the previous studies used a qualitative research approach to understand and address food supply issues. And 1 mixed research approach. This result suggests that an interdisciplinary and multifaceted approach is required to address food sustainability and efficiency issues. Each method brings a unique perspective and set of tools, from qualitative and quantitative to mixed approaches and both theoretical frameworks to empirical analyses.

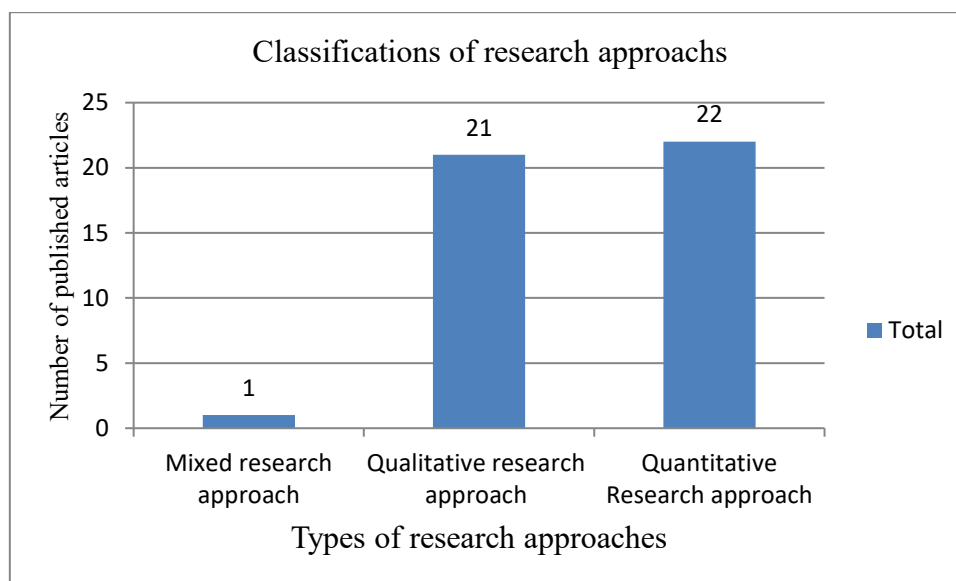


Fig. 7. Categorization based on research approaches
Source: developed by the authors

KEYWORDS USED SEARCH IN EFFICIENCY AND SUSTAINABILITY OF FOOD SUPPLY CHAINS

Figures 8 and 9 indicate the keywords related to the efficiency and sustainability of food supply chains. The food supply chains are the most frequently used keywords, which indicate a strong focus on food supply chains. Digitalization and blockchain play a great role in addressing the increasing problems of food supply chains. It underscores the critical importance of food supply chains as a research area, the growing influence of digital technologies, and the diverse yet sometimes fragmented nature of inquiry into the efficiency and sustainability of food supply chains. Simulation, life cycle assessment, food waste, and carbon emission are also significant keywords, which are concerned with the efficiency and sustainability of food supply chains. Additionally, logistics, farming, climate, resources, and environment highlight the connection between food production and ecological factors.

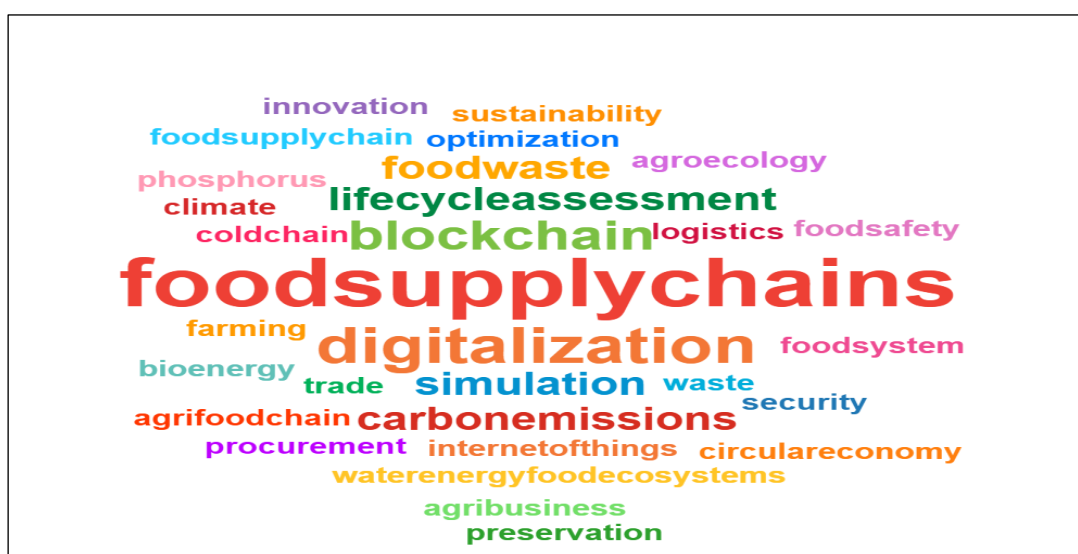


Fig. 8. Word cloud keywords from review papers
Source: developed by the authors

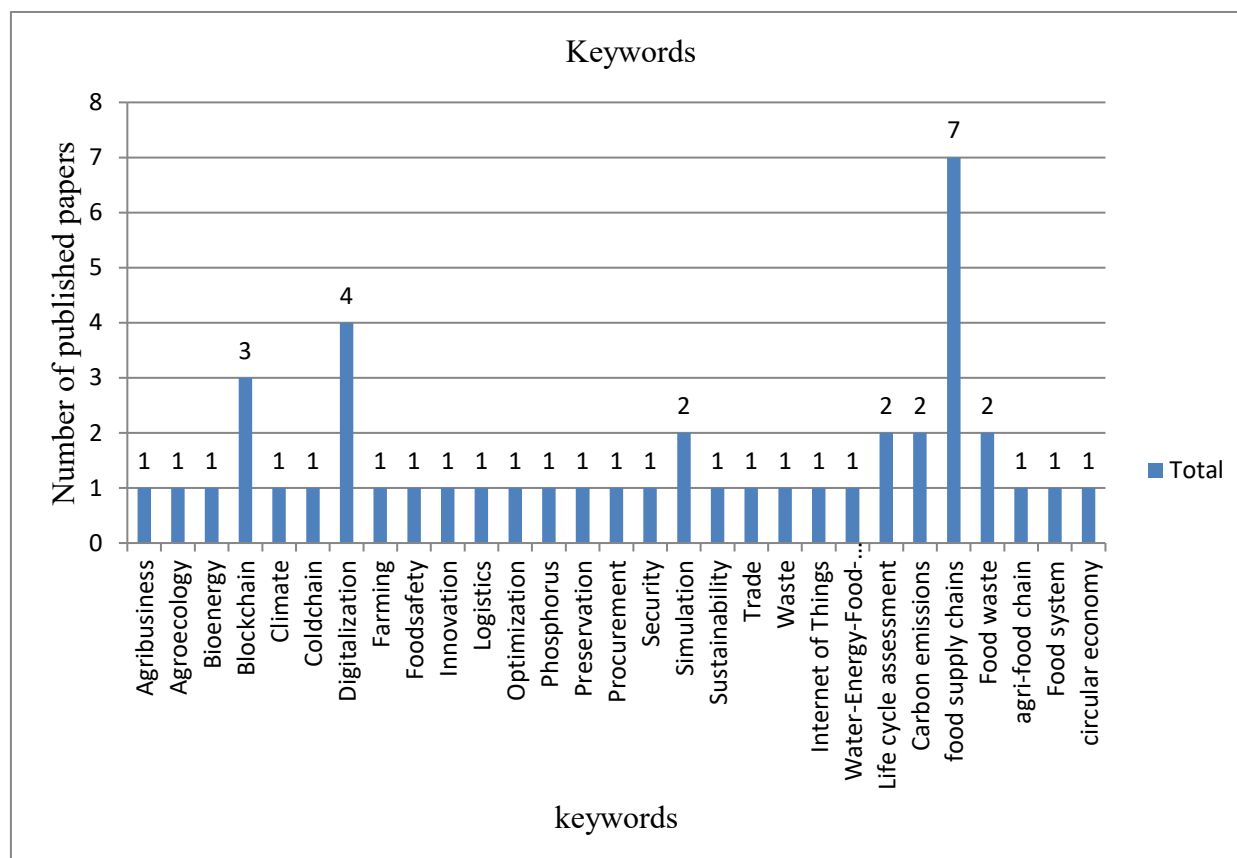


Fig. 9. Keywords in efficiency and sustainability of food supply chains, frequencies of mentions in the reviewed papers
Source: developed by the authors

RESEARCH PUBLICATIONS CATEGORIZATION BASED ON REGION

The research publications can be categorized by region to better understand the focus and distribution of scientific inquiry across various geographical areas. It is very important to analyze the research outputs through the regional council so that stakeholders can identify collaborative opportunities, funding needs, and strategic priorities to enhance the impact of global research.

Figure 10 depicts the proportional contributions of various locations to the total continents. Continental Europe dominated the survey, accounting for 27% of the total published articles. Following this, Mediterranean Europe has the second-largest percentage (16%), indicating that they are also a significant contributor. Eastern and Central Europe is close behind, accounting for 14% articles. Scandinavia contributed (9%). Other major regions, including Africa, Australia, East Asia, Latin America, the Middle East, and South Asia, contribute 4% of publications. This indicates a considerable equal publication contribution. Meanwhile, NIS and Russia, and North America are 2%. These regions collectively account for less of the entire distribution. Despite their smaller individual contributions, they collectively contribute to the overall distribution.

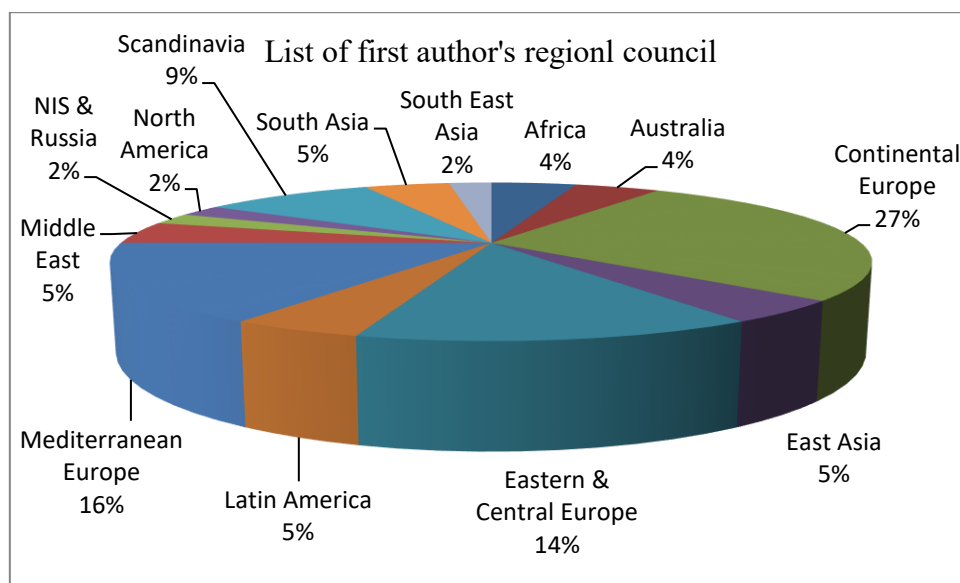


Fig. 10. Research publications categorization based on region
Source: developed by the authors

Research-focused areas

Figure 11 shows that of the studies reviewed, 55% of the studies focused on to sustainability of food supply chains, while the remaining 45% of them focused on to efficiency of food supply chains. This implies most of the studies were focused sustainability of food supply chain concepts.

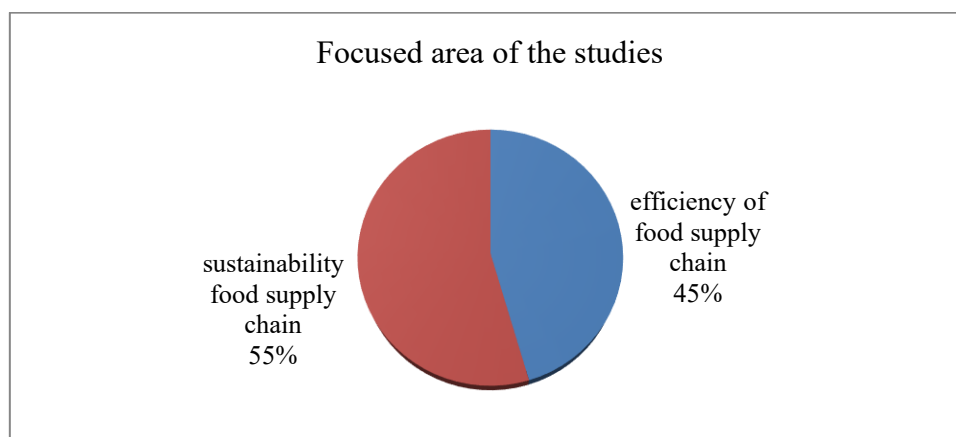


Fig. 11. Categorization based on focused areas
Source: developed by the authors

EFFICIENCY OF FOOD SUPPLY CHAINS

The concept of efficiency of food supply chains focuses on operational optimization, cost reduction, and waste minimization. Assessing efficiency and integration among stakeholders is crucial for enhancing performance, reducing costs, and improving the overall efficiency of food supply chains [18]. High gross national income per capita, high employment in agriculture, access to electricity in rural areas, and export volume index are socio-economic factors of global food loss [19].

An increase in the efficiency of supply channels in the commodity distribution system leads to a decrease in the coefficient of the link in commodity movement and inventory availability. It is necessary to increase the efficiency of supply chains in each link and reduce the share of retail trade in gross turnover [33]. Market competitiveness, knowledge and skill development, resource efficiency,

and technologies are essential for increasing the marketability of agricultural products and agri-food supply chains [34]. The application of innovative packaging strategies can deliver an important contribution to reducing the amount of food losses and ensuring sustainable food production [35].

SUSTAINABILITY OF FOOD SUPPLY CHAINS

The sustainability of food supply chains is centered on environmental, social, and economic challenges confronted global food system. Social, environmental, and economic; food and nutrition dimensions are the determinants of the sustainability of food systems [17]. Sustainability of the European agri-food supply chain of the European Union countries has been influenced by economic, social, and environmental factors [36]. Modeling the sustainable supply chain network design for food-agricultural industries is the most effective way through the financial dimension, the use of high technology in the production, and the presentation of various citrus forms using intermediate and conversion industries [37]. The sustainability of the food supply system is a growing concern about the inputs (e.g., water, fertile soil, fossil fuels, and chemicals) and working resources (e.g., land and labor) required for industrial food production, and its associated supply chain structure has become scarcer and hence more expensive. At the same time, the by-products of these farming and supply chain activities (e.g., farm runoff and greenhouse gas emissions) have often created negative externalities on the environment and human health [38].

This review shows that investigating the problems of both efficiency and sustainability of food supply chains is crucial in reducing environmental, social, and economic factors and optimizing output, minimizing cost, and reducing wastage and food loss.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

This study provides an exhaustive investigation of defining efficiency and sustainability ideas in the context of food supplies. This review develops a conceptual framework that explains the structural relationship among efficiency, sustainability, and food supply chain networks across the globe. To achieve the objective of the study, the researchers used the preferred reporting items for systematic review and meta-analysis (PRISMA) and inclusion and exclusion criteria. The study followed time zone and publication selection, the systematic review process for classification of academic publications, classifications based on database, research approach, keywords, and geographical area to categorize a standardized systematic approach. It is common to develop a systematic review and clearly explain the procedure for selecting research articles from different databases [31]. These reflect a highly selective and structured approach to ensure that only quality and pertinent studies constitute the final body of researched literature. The review shows an annual increase in journal publications from 2020 to 2024. This implies a growing recognition of the importance of food supply chains. Furthermore, it has become a global concern, attracting the attention of numerous experts who want to address these crucial issues. In these studies, the Scopus indexing system is more crucial in accessing research articles in food supply chains than the Web of Science indexing system.

The United Kingdom and Italy's first authors play a leading role in researching food supplies more than other countries. This implies that those countries provide more significant research budgets for food supply problems. Besides, Continental Europe was the prominent region in food supplies, followed by Mediterranean Europe. The systematic literature review reveals that a wide range of intentions to research on the sustainability of the food supply chain in various parts of the world. The future study should be focuses on improving efficiency of food supply chains. This review shows that the quantitative research approach is widely used. this study recommended that future studies should use mixed research approaches to comprehensive understanding and develop new theories about the efficiency and sustainability of food supply chains. The academic and

research communities must pay attention to make the food supply chains environmentally, socially, and economically sustainable and efficient by integrating the concepts. This study invites researchers to study the global multi-sectoral development of food supplies.

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Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

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

Вклад авторов:

Фикире А. Х. – подбор методического инструментария, практическая апробация и описание;
Корчагина Е. В. – научное руководство исследованием, постановка целей и задач.

Contribution of the authors:

Fikire A.H. – scientific supervision of the study, setting the goals and objectives of the study;
Korchagina E.V. – selection of methodological tools, practical testing and description.

Финансирование. Исследование проведено без спонсорской поддержки.

Funding. The study was performed without external funding.

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