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Empowering Future Generations: A Bibliometric Analysis of Food Sustainability Education in Schools

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Abstract

Unsustainable food production and consumption are major drivers of food insecurity, with long-term implications for global sustainability. Despite the growing need for food sustainability education, there is limited literature addressing its development in school curricula. This study aims to evaluate and map trends in food sustainability education research in schools, using Scopus-indexed journals from 1998 to 2024. The findings reveal a marked increase in publications post-2014, highlighting the growing academic interest in this field. The United States made the most significant contribution, with 58 publications accounting for 33% of total citations, followed by the United Kingdom (30 publications, 9% of citations), and Australia (23 publications, 12% of citations). Sustainability (Switzerland, Q1, SJR 0.7) published the highest number of articles, totaling 24 publications and 466 citations, making it the most cited source in the field. Keyword analysis identified key themes such as "sustainability," "education for sustainable development," and "nutrition," while hot topics included the integration of sustainability into school curricula and the role of student engagement in food systems. Despite rapid growth in research, international collaboration remains insufficient, highlighting the need for stronger global partnerships to address food sustainability challenges. This study underscores the importance of incorporating food sustainability education in schools to contribute to achieving the United Nations Sustainable Development Goals (SDGs).

Keywords: Bibliometric analysis; Food sustainability education; SDGs

1 Introduction

Food security is a situation in which all people, at all times, have physical, social, and economic access to sufficient food to meet their dietary needs for a productive and healthy life (Fanzo et al., 2024; Jideani, 2020; Onwe et al., 2024; Taniushkina et al., 2024). Food security is one of the critical global issues that urgently requires attention. If this situation persists, it will lead to food insecurity, a condition in which all individuals face uncertainty or risk of lacking sufficient physical and economic access to adequate food, both in the short term and long term (Inaç et al., 2024; Kompas et al., 2024; Southard & Randell, 2024). Food security is affected by various interconnected issues such as climate change (Habtie et al., 2024; Rehman et al., 2024; Taniushkina et al., 2024; Warsame et al., 2024), which significantly disrupts food production and threatens food availability. Environmental degradation (Abdi, 2020; Mekonen et

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al., 2024; Onyenekwe et al., 2022) resulting from unsustainable farming practices also negatively impacts soil quality and land productivity, ultimately reducing crop yields. Furthermore, nations that heavily rely on food imports (Abay et al., 2023; d'Amour & Anderson, 2020; Sandström et al., 2024) become more vulnerable to fluctuations in global food prices and disruptions in supply chains, which can lead to shortages and price hikes. Conflicts and political instability (Abay et al., 2023; Onyenekwe et al., 2022; Warsame et al., 2024) can disrupt supply chains, destroy agricultural land (Nasibov et al., 2024; Panda et al., 2024), and hinder food production and distribution. Infrastructure limitations (Hoang et al., 2024; Munyanyi, 2013) further exacerbate food issues by hindering the equitable distribution of food. Poverty and economic inequality (Harttgen & Seiler, 2023; Nor & Razak, 2024; Okpala et al., 2023; Upasana, 2023) pose significant challenges, particularly because low-income communities often lack access to nutritious food, which exacerbates the food access gap between social groups. The decline in biodiversity (Crenna et al., 2019; Lanz et al., 2018) increases the risk, as reliance on a limited number of specific crops heightens the potential for crop failure and restricts access to various healthy foods. Furthermore, pandemics or global health crises (Kharroubi et al., 2021; Quintero et al., 2024; Yao et al., 2023) can disrupt food supply chains and economies, further worsening food insecurity. An integrated and sustainable approach is needed to address these issues and ensure the availability of safe and affordable food for all communities.

The United Nations (UN) estimates that by 2050, the global population will reach 9.7 billion people (Nations, 2019), which could lead to a sharp increase in food demand. However, the natural resources used to produce food, such as agricultural land, water, and energy, are becoming increasingly limited. This limitation is expected to pose a serious threat to global food security and the world's ability to ensure safe, affordable, and nutritious food access for all people. The famine occurring in Somalia (Martin-Canavate et al., 2020; Warsame et al., 2024), the hunger in Brazil (Da Mata et al., 2022), the hunger in Kenya (Babu & Dorosh, 2017; Mutea et al., 2022) and the high levels of obesity (Arli et al., 2024; Baskin et al., 2005; Pajuelo Ramírez, 2017; Sebeta et al., 2024) are examples of current food-related issues. Food issues will become a serious, long-lasting concern if not addressed immediately. Efforts to minimize the impact of worsening food insecurity have led to the idea of food sustainability education in schools. In addition, there is a need to explore the extent to which the concept of food sustainability education has been discussed, to design an appropriate food sustainability education model as a preventive measure against long-term food insecurity, starting from schools. Further review of the implementation of food sustainability education is necessary to ensure its effectiveness in addressing long-term food insecurity issues. Therefore, achieving food sustainability will not only guarantee the availability of food for the current generation, but it will also contribute to the preservation of natural resources for future generations. Food availability is a key issue in global efforts to achieve Sustainable Development Goal (SDG) 2, which aims to eradicate hunger and ensure access to sustainable, wholesome, and safe food for all.

Research trends related to food mapping using bibliometric analysis have been widely conducted, including topics such as food management (Guliyev et al., 2024; Nuryana et al., 2024), food security (Fekete, 2024; Ho & Lwesya, 2024; Wei et al., 2025), food vendors (Manoharan & Rangaswamy, 2024), food waste (Samiun et al., 2024; Wulandari et al., 2024), food loss (Mokrane et al., 2023; Wang et al., 2024), food industry (Kumar & Sahoo, 2025; Şimşek et al., 2024), food systems (Diaconeasa et al., 2024; Kalachevska et al., 2022), food safety (Bellia et al., 2022; Xu et al., 2024), food supply (Prakashan et al., 2024; Rejeb et al., 2022), and food consumption (Kristia et al., 2023; Pant et al., 2024). However, to date, there has been no review discussing bibliometric analysis on food sustainability in the field of education published in reputable journals. Reviews addressing food sustainability in education are still limited. In fact, up to this point, there is no bibliometric analysis using the phrase "food sustainability education in schools." Research on this topic is crucial as it significantly contributes to filling the existing gap in the literature.

Although food sustainability has become an in-

creasingly urgent global issue, few studies focus on how education in schools can play a role in addressing this challenge. For instance, a study by Ibragimova et al. (2024) highlights the importance of sustainable food systems as part of the educational curriculum that can educate the younger generation to understand the impact of food consumption patterns on the environment. On the other hand, a study by Koch et al. (2023) shows that food education in schools can raise students' awareness of the importance of sustainability in global food systems. Nevertheless, research specifically addressing the integration of food sustainability into school curricula remains limited. A study by Kluczkovski et al. (2024) suggests the need for educational policies that support the implementation of food sustainability concepts, particularly considering climate change and health challenges.

Conducting a bibliometric analysis on food sustainability education in schools is crucial for mapping research trends, identifying hot topic issues, and providing insights into the current state and future directions of this field. By examining publication patterns, influential works, and emerging themes, this study will offer a comprehensive overview that helps scholars and policymakers understand the development and impact of research on food sustainability education. This research can support policy changes in education at the local, national, and international levels by providing scientific evidence on the importance of integrating food sustainability education into school curricula. Thus, the purpose of this article is to address the existing research gap, lay the foundation for future probabilistic research, and enhance the quality and quantity of publications in Scopus-indexed international journals. The reviewed publications undergo bibliometric analysis. Using the primary term "Food Sustainability Education in Schools," this analysis explores typology, authors, geographic distribution, historical development, general main sources, alphabetical major journal sources, related publications, and mapping of the field. This analysis will highlight research topics that serve as key variables for each article in the future and provide recommendations for further research.

2 Method

The primary objective of this article was to examine publication trends in food sustainability education in schools. This study utilized bibliometric analysis as the primary research method. Bibliometric analysis has been widely applied in education research (Hudha et al., 2020; Phan et al., 2022; Supriadi et al., 2021). Through bibliometric analysis, it was possible to identify research clusters that drove the development of the field, visualize the overall landscape and connections between these ideas, and gain a systematic and comprehensive understanding of the organizational structure within this subject (Öztürk & Güler, 2021). The initial purpose of bibliometric analysis was to measure academic performance and productivity, particularly regarding the number of documents and citations produced by specific researchers or institutions (Lima & Bonetti, 2020). However, in recent years, bibliometric analysis has also gained widespread use among researchers, not only to measure academic performance but also to explore patterns, relationships, and structures within various fields of study (Dubey et al., 2023; Saregar et al., 2022). In this study, we conducted a bibliometric analysis using scientific articles published in journals and conference proceedings indexed in Scopus. Scopus was chosen as the sole bibliographic data source because it is the largest and most comprehensive database in the social sciences, offering a vast number of high-quality scholarly journals (Codina et al., 2020). Scopus has been proven to be superior to Web of Science and Google Scholar due to its extensive coverage of interdisciplinary fields and journals (Ali et al., 2021). Therefore, Scopus was selected as our primary data source. This study adopts the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology, as proposed by Moher et al. (2009), as illustrated in Figure 1, which outlines the key stages involved in the process.

2.1 Identification

An initial search was conducted on December 10, 2024, in the Scopus-indexed database, yield-

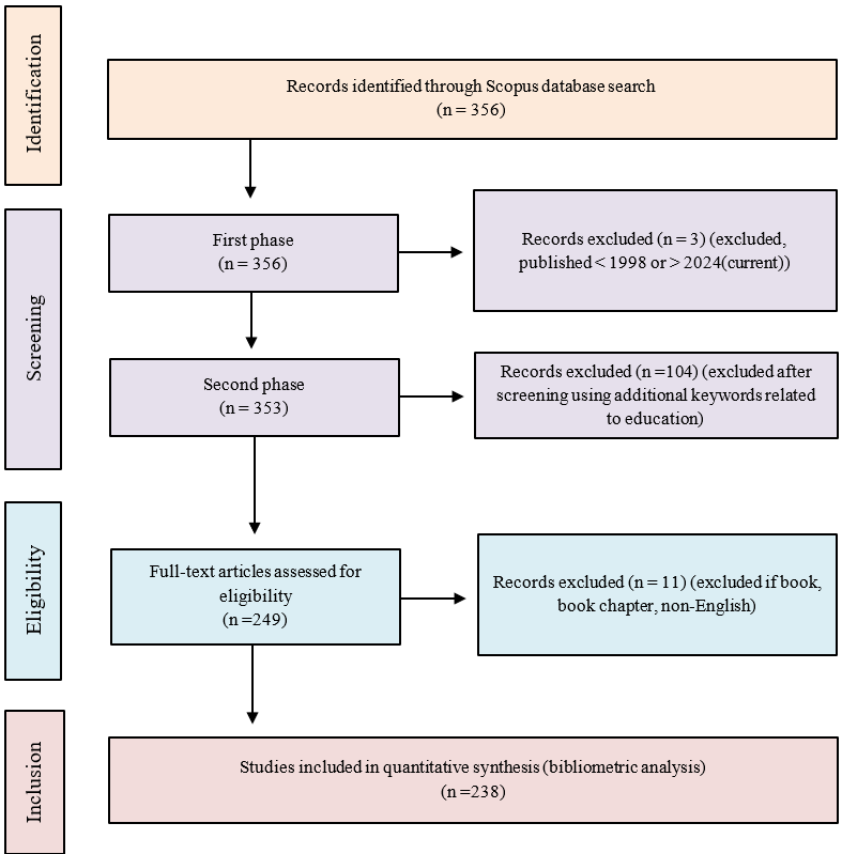

Figure 1: PRISMA Flow Diagram

ing 356 articles published between 1994 and 2024 using the keyword TITLE-ABS-KEY "food sustainability education in schools." All articles added to the Scopus database after this date were excluded from the analysis. These initial findings represent the number of articles relevant to the selected keyword. The data search included source types such as books, book chapters, journal articles, review articles, and conference proceedings.

2.2 Screening

The initial search results of 356 articles were then screened to remove duplicates and to include only articles that met the inclusion and exclusion criteria. The preliminary search revealed that the first paper on food sustainability education in schools was published in 1998; therefore, the analysis was limited to publications from 1998 to December 2024. As a result, the number of papers related to food sustainability education in schools was reduced from 356 to 353.

2.3 Eligibility and Inclusion

After completing the screening process, the research team further refined the search by incorporating additional education-related keywords such as (education), (school), (schools), (health education), (nutrition education), (curriculum), (teaching), (student), (school health service), (learning), (students), (environmental education), (school health services), (primary school), (education for sustainable development), (education program), (secondary education), (ed-

ucational development), (educational status), (higher education), (food education), (school child), (high school), and (sustainability education). This keyword search identified 249 documents, including books, book chapters, journal articles, review articles, and conference proceedings. Subsequently, the research team refined the results by limiting the sources to conference proceedings, journal articles, and review articles, and by filtering for English-language documents. This refinement yielded 238 documents published between 1998 and 2024. To collect all relevant data, these documents were exported in RIS and CSV formats.

In this study, the researchers utilized VOSviewer to analyze large volumes of bibliometric data and generate network data mappings (Bukar et al., 2023). The researchers employed VOSviewer to visualize publication trends over time, allowing for the identification of emerging research areas. It enables the visualization of publication trends over time, which proves useful in identifying emerging research areas (Shkola et al., 2022). Additionally, VOSviewer can create various types of maps, including publication maps, author maps, journal maps, and keyword maps, based on shared networks derived from co-citation networks (Tovar & Reta, 2022).

3 Results and Discussion

The bibliometric review data are sourced from the Scopus.com database. Metadata completeness is enhanced using Zotero software. The most frequently occurring keywords are then easily analyzed. Subsequently, VOSviewer software is employed to visualize the bibliometric map derived from the refined metadata. The bibliometric mapping results selected in VOSviewer include network visualization and density visualization.

3.1 Typology

The document type is the first indicator analyzed in this study. The data source is the Scopus database, with the data already sorted. Based on the keyword food sustainability education in schools, the authors identified five document types: conference proceedings (conference articles), journal articles, book chapters, books, and review articles. The quantity and percentage of each document type are presented in Figure 2. The data presented in Figure 2 is essential for providing readers with comprehensive information regarding the quantity and percentage of documents associated with the keyword "Food Sustainability Education in Schools," categorized by "document type" in the database. To ensure that the information presented in this study remains unbiased, the researchers selected only documents classified as review articles, conference proceedings, and journal articles for bibliometric analysis using VOSviewer. The authors believe that focusing on these three document types provides broader insights into bibliometric trends related to the keyword food sustainability education in schools. From these three metadata sources, the researchers identified 238 documents as highly relevant to the specified keyword.

3.2 Historical Development

The second indicator analyzed over time is the historical development of document sources related to the term. The first document in the database containing the keyword Food Sustainability Education in Schools was published in 2000, even though the search period began in 1994. This document discusses a framework for healthy elementary school canteens (Puts & Mattrow, 2000). Over time, the number of documents has steadily increased, reflecting diverse perspectives within the framework of sustainable food education. The growth in the number of documents associated with the term has shown a consistent upward trend through December 2024. Figure 3 illustrates the growth trend every four years. The first article related to food sustainability education in schools was published between 1998 and 2001. Two documents from this period can be considered pioneers in studying food sustainability education in schools. The number of publications grew significantly between 2010 and 2014, with 37 documents published during that time. Since then, the number of published documents has consistently increased, with 2023–2024 being particularly productive, as 70 articles were published in just

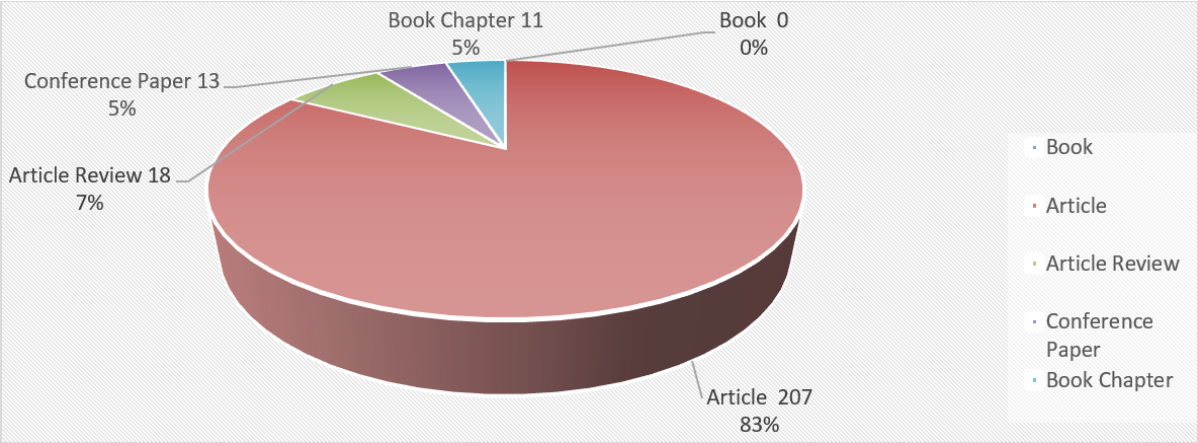

Figure 2: Data Source Distribution by Document Type

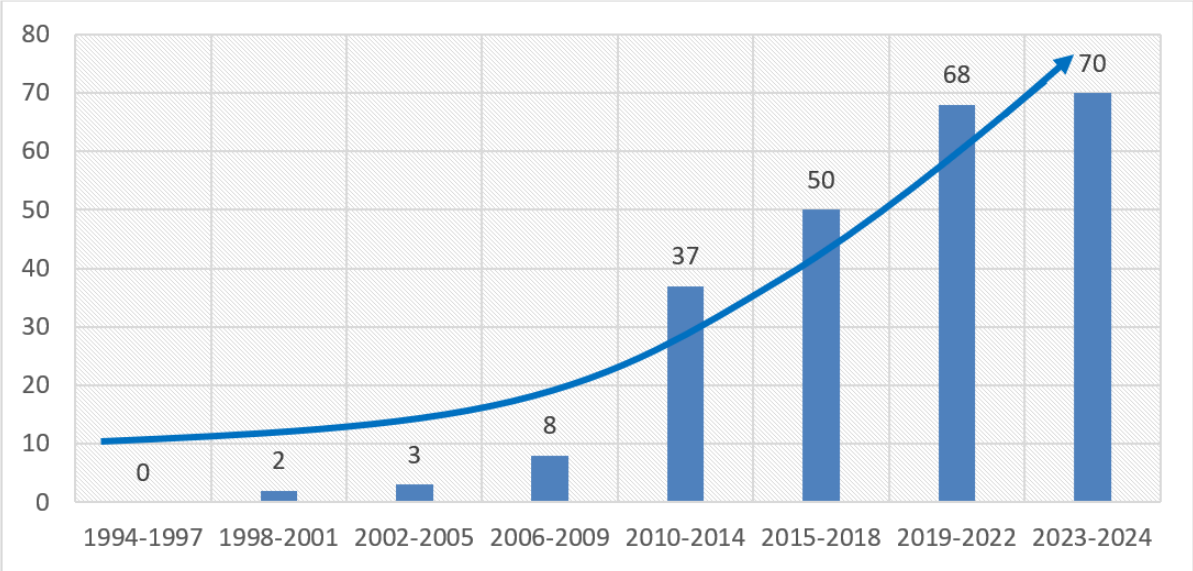

Figure 3: Number of Documents from the Scopus Database Associated with the Keyword Food Sustainability Education in Schools for the Past Four Years. Retrieval of data on December 10, 2024

the last two years. This suggests that research on Food Sustainability Education in Schools has continued to gain traction over time, offering opportunities for further investigation and the discovery of new insights in this field.

3.3 Geographic distribution

In this analysis, the country of origin is considered only once in the calculation, even if multiple authors from the same country contributed to the article. This approach enables a better understanding of each country's position regarding publishing articles on food sustainability education in schools. Figure 4 presents the top 10 countries of origin for the authors, based on the number of publications.

According to Figure 4, the bar chart presents data from Scopus on the top 10 countries with the most documents related to food sustainability education in schools. The United States leads with 58 documents, indicating its dominant research output in this field. The United Kingdom follows with 30 documents, while Australia ranks third with 23 publications. Other countries contributing significantly include Italy (16 documents), Portugal (15), Sweden (13), Brazil (12), Germany (12), Canada (9), and Spain (9). The variation in document counts suggests that research on food sustainability education in schools is concentrated in a few leading countries, with the United States showing the highest engagement. This distribution highlights the regional emphasis on food sustainability education, potentially influenced by policy priorities, educational frameworks, and research funding. The presence of European and South American countries indicates a growing global interest in integrating food sustainability topics within school curricula. Subsequently, we will analyze the citation count of documents based on their country of origin, and the relevant graph is presented in Figure 5.

Citations of a document reflect its prominence and significance as a reference within the academic community. Documents with more citations are considered more influential within a specific field. Figure 5 shows that authors from the United States dominate with the largest contribution, accounting for 33%. This dominance reflects the availability of greater resources for educational and sustainability research, as well as strong policy support in the education sector to address sustainability issues (Liu & Curtin, 2024). Australia contributes 12% of the total citations, placing it in second place. Australia plays an important role in this topic, although not as much as the United States. There may be an integrated approach between educational policies and food sustainability in schools in Australia, such as the Food Education and Sustainability Training (FEAST) program (Karpouzis et al., 2024). Brazil contributes 11% and ranks third, highlighting the country's significant role in research on food sustainability in schools. This may be related to challenges faced by Brazil, such as climate change and food security issues (Toromade et al., 2024), which drive the focus on this topic. The United Kingdom and Spain contribute 9% and 7%, respectively, indicating that although they do not contribute as much as countries with higher contributions, both countries still play a role in discussions on food sustainability. Italy also contributes 7%, equal to Spain, signaling that the country is also involved in this field. Portugal and Canada each contribute 6%, showing that both countries also contribute, albeit with a smaller percentage. Germany, with a contribution of 5%, shows more limited influence but still plays a role in global research on food sustainability. India, with the smallest contribution of 4%, shows that despite facing significant challenges related to food security (Hira, 2025), research on food sustainability education in schools remains limited. Overall, Figure 5 reflects the dominance of developed countries in this research, although other countries also make significant contributions to the discussion of food sustainability in education.

An interesting observation is that in Figure 4, Sweden ranks among the top six countries based on the number of documents but is absent from the list of the top 10 countries by citation count. Meanwhile, India, which was previously not included in the top 10 list based on the number of documents, holds the 10th position in terms of citation count. It is important to note that the number of citations does not necessarily correspond to the volume of documents originating

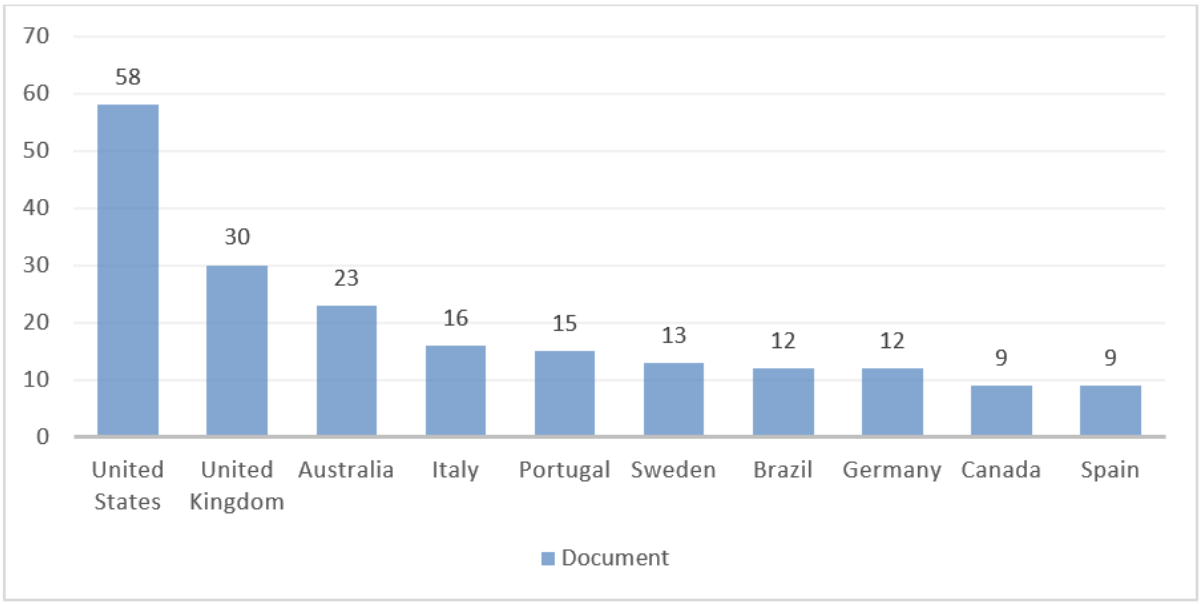

Figure 4: Data from Scopus on the Top 10 Countries with the Most Documents Pertaining to Food Sustainability Education in Schools

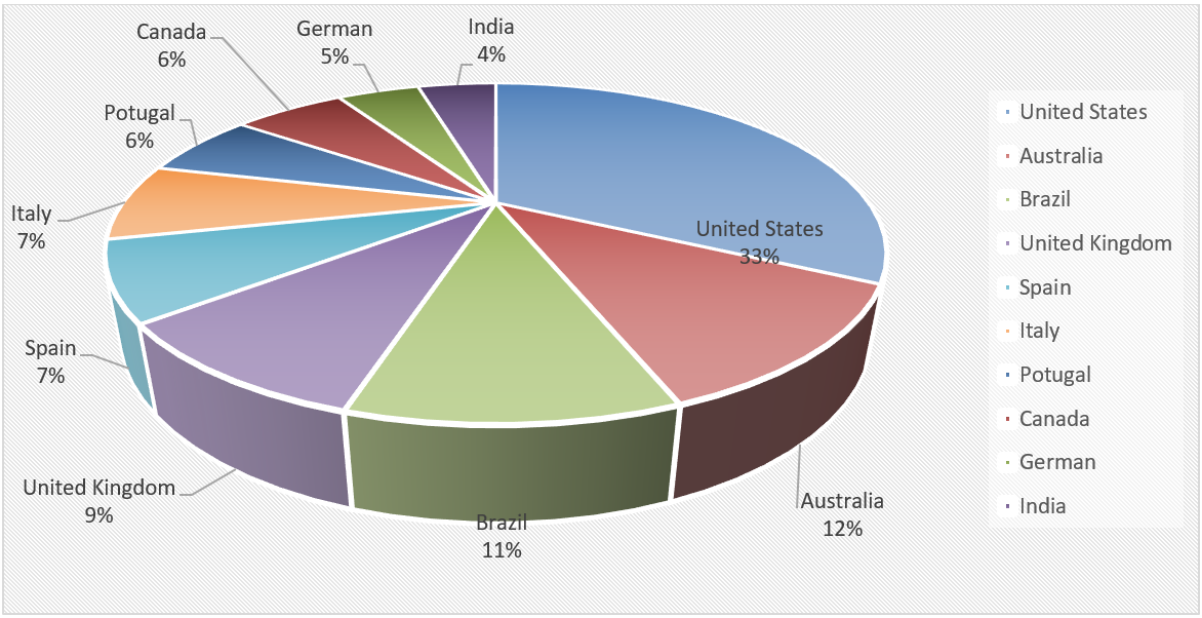

Figure 5: Data from Scopus on the Top 10 Countries with the Most Citations Pertaining to Food Sustainability Education in Schools

from a particular country. This discrepancy may arise because not all documents from a country receive citations from other researchers. This section presents the distribution of articles related to the keyword across various countries, along with their citation networks, as shown in Figure 6.

The VOSviewer network visualization map illustrates the connections between countries based on the number of documents and citation distribution related to food sustainability education in schools. The size of each node represents the number of publications from a country, while the thickness of the connecting lines indicates the strength of collaboration between countries. The color gradient, ranging from blue to yellow, green, and red, signifies the publication timeline, with earlier contributions shown in blue, intermediate ones in green and yellow, and the most recent ones in red.

The United States occupies a central position with the largest node size, indicating its dominant role as the primary contributor in this research field. Additionally, the United Kingdom holds a strategic position with an extensive collaborative network spanning multiple countries, demonstrating its role as a key hub in the global scientific community. Countries such as Australia, Sweden, and Portugal also show significant contributions by forming closely-knit regional collaboration clusters. The thickness of the connecting lines between countries reflects the intensity of collaboration, with particularly strong ties observed between the United States and the United Kingdom, as well as between Australia and Finland. Meanwhile, countries with smaller nodes, such as Greece, Croatia, and Ethiopia, indicate more limited involvement in this research area.

The temporal distribution of research activity reveals that the blue color represents earlier or initial contributions, as seen in countries like Ireland, Japan, and Austria. Green and yellow indicate intermediate research activity, primarily between 2015 and 2020, evident in countries such as Australia, Finland, and Sweden. Red represents the most recent and current publications, reflecting studies conducted during the period 2022-2024, as observed in countries like the United States, India, Germany, and France. This color gradient provides an overview of the evolution and trends in research activity among countries over time, highlighting which countries were early pioneers in this field and which have become increasingly active in recent years.

Overall, this bibliometric analysis demonstrates the dominant position of the United States in this field, with Australia, Portugal, and Sweden also playing significant roles. The strong international research networks depicted in this visualization reflect a global interest in advancing food sustainability education, with increasing contributions from European and developing countries. This trend underscores the growing recognition of food sustainability as a critical component of education systems worldwide.

3.4 Main sources

The article compiles information from 207 journals, 18 review articles, and 13 distinct proceedings. The discussion primarily centers on the 207 journals, most of which pertain to food sustainability across various disciplines, including social sciences, health, environmental science, nursing, agriculture, biology, education, and others. Table 1 displays the ten journals that have published the most articles concerning food sustainability education in schools.

The data on the ten journals with the most documents related to Food Sustainability Education in Schools highlights the key publication venues contributing to this research area. The SJR index (Scimago Journal Rank) for 2023 and the number of published documents are used to assess the journals' impact and relevance. Among the listed journals, Sustainability (Switzerland) leads with 24 published documents and an SJR index of 0.7 (Q1), indicating its significant role in disseminating research on food sustainability education. This aligns with its broad interdisciplinary focus on sustainability-related topics, making it a primary outlet for research in this field. The International Journal of Environmental Research and Public Health follows, with 10 documents and an SJR index of 0.8 (Q2), reflecting its influence in public health and environmental studies. Similarly, BMC Public Health (1.2, Q1), which has published six doc-

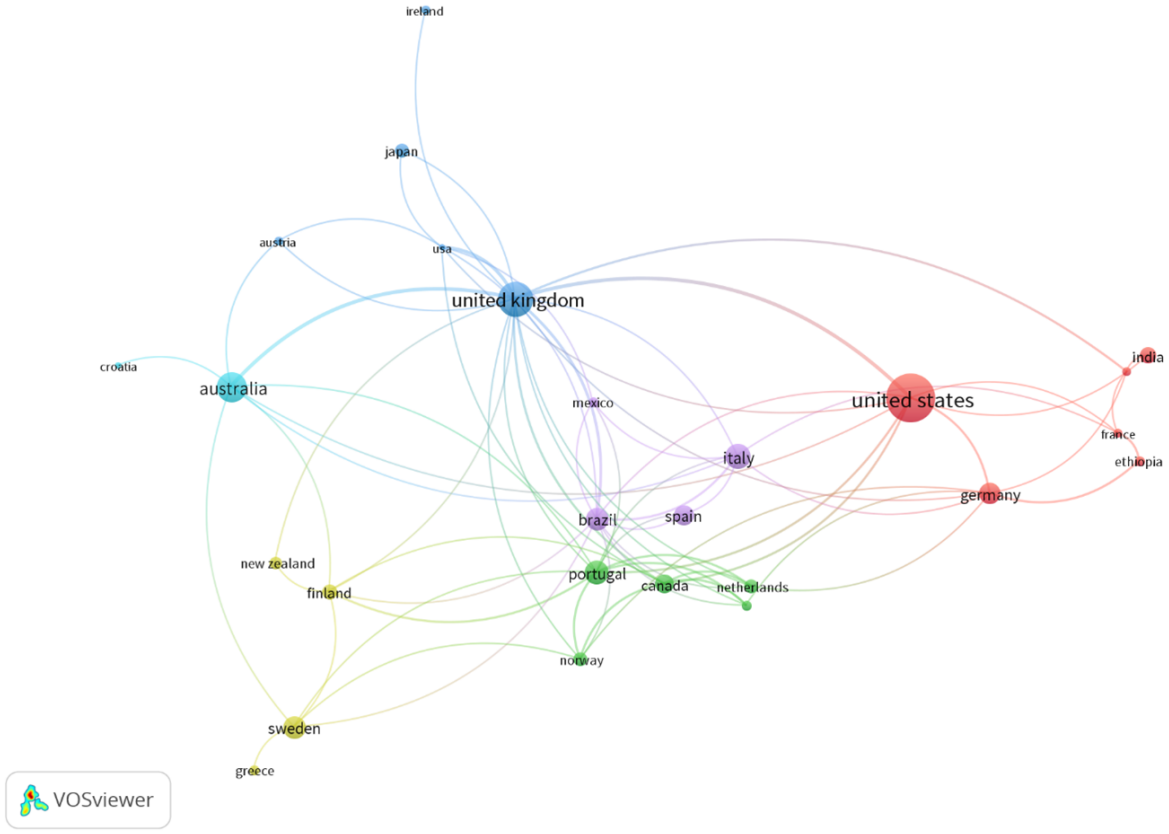

Figure 6: The Connection Among Countries According to the Quantity of Documents and Citation Distribution Pertaining to the Keyword

Table 1: Ten Journals with the Most Documents (Food Sustainability Education in Schools)

Journal name	**SJR index (SCImago, 2023)**	**Number of Documents**
Sustainability (Switzerland)	0.7 (Q1)	24
International Journal Of Environmental Research And Public Health	0.8 (Q2)	10
BMC Public Health	1.2 (Q1)	6
Journal Of Cleaner Production	2.1 (Q1)	5
Appetite	1.3 (Q1)	5
Public Health Nutrition	0.9 (Q2)	4
Nutrients	1.3 (Q1)	4
Journal Of Nutrition Education And Behavior	0.7 (Q2)	4
Health Education	0.7 (Q1)	4
Journal Of School Health	0.7 (Q1)	3

Table 2: Top Ten Journals by Citation Count (Food Sustainability Education in Schools)

Journal name	**SJR index (SCImago, 2023)**	**Number of Citations**
Sustainability (Switzerland)	0.7 (Q1)	466
BMC Public Health	1.2 (Q1)	268
Journal of the American Dietetic Association	Discontinued since 2011	228
Appetite	1.3 (Q1)	224
Journal Of Nutrition Education And Behavior	0.7 (Q2)	157
Preventive Medicine	2 (Q1)	145
Public health nutrition	0.9 (Q2)	142
Waste Management	1.7 (Q1)	137
Journal Of Cleaner Production	2.1 (Q1)	136
Critical Reviews in Food Science and Nutrition	1.9 (Q1)	135

uments, and Public Health Nutrition (0.9, Q2), with four documents, demonstrate the strong intersection between food sustainability education and public health research. Journals with a high impact factor, such as the Journal of Cleaner Production (2.1, Q1) and Appetite (1.3, Q1), each with five documents, emphasize the role of sustainable food systems and behavioral aspects in education. The presence of Nutrients (1.3, Q1) and Journal of Nutrition Education and Behavior (0.7, Q2), both with four documents, underscores the importance of nutrition education in the discourse of food sustainability. Additionally, Health Education (0.7, Q1) and Journal of School Health (0.7, Q1), each contributing four and three documents, respectively, highlight the integration of food sustainability topics within broader health and education discussions. Overall, the data suggests that research on food sustainability education is distributed across various disciplines, including sustainability, public health, nutrition, and education. While journals with higher SJR indexes (e.g., Journal of Cleaner Production and Appetite) contribute valuable high-impact research, Sustainability (Switzerland) remains the dominant publication outlet in terms of the number of published articles. This pattern indicates a growing academic interest in integrating food sustainability principles into education and public health frameworks.

Table 2 shows that the number of documents does not correlate with the number of citations. For example, the International Journal of Environmental Research and Public Health ranks second in terms of the number of documents, with 12 documents. However, based on citations, it has only 78 citations and is not included in the top 10. In contrast, the Journal of the American Dietetic Association, with just one document (Robinson-O'Brien et al., 2009) has 228 citations, ranking in the top three. This is noteworthy, especially considering that only a single document was published concerning the keyword. Despite this, the journal has garnered more citations than the International Journal of Environmental Research and Public Health, which published 10 documents, BMC Public Health, which published six documents, and the Journal of Cleaner Production, which published five documents. This may suggest that the paper published in this journal was a groundbreaking contribution to Food Sustainability Education. Three additional journals have published only one document but are ranked in the top 10 based on citations for the keyword: Preventive Medicine (Hoelscher et al., 2004), which achieved a sixth-place ranking, Waste Management (Pinto et al., 2018), which ranked eighth, and Critical Reviews in Food Science and Nutrition (Oostindjer et al., 2017), which ranked tenth. Meanwhile, Sustainability (Switzerland) is identified as the journal with the most published documents, aligning with its status as having the highest number of citations. This finding highlights that articles published in highly cited jour-

nals serve as key references for researchers' publications across various countries. The qualification level of the journals serving as primary references for the topic discussed in this paper is 80% at the Q1 level. This demonstrates that the documents published in the journals listed in Table 1 are internationally reputable sources, making them highly suitable as primary references for relevant research.

3.5 Authors and Relevant Publications

A comprehensive analysis of documents on Food Sustainability Education in Schools reveals that 1,064 authors have contributed papers on this topic, based on data from the Scopus database. In documents with multiple authors, each author is considered a distinct entity. As a result, each author is acknowledged in all articles where their name appears. Notably, 46 authors have published at least two documents, while 15 of these authors have produced at least three records, as illustrated in Figure 7.

Figure 7 highlights the focus of the authors' publications on the theme of food sustainability education in schools. The five most productive authors on this topic are Salmon (Gray et al., 2018; Jones, Dailami, Weitkamp, Kimberlee, et al., 2012; Weitkamp et al., 2013), Orme (Jones, Dailami, Weitkamp, Salmon, et al., 2012; Jones, Dailami, Weitkamp, Kimberlee, et al., 2012; Weitkamp et al., 2013), Margerison (Aydin et al., 2021, 2022; Kempler et al., 2024), Booth (Aydin et al., 2021, 2022; Kempler et al., 2024), and Worsley (Aydin et al., 2021, 2022; Sadegholvad et al., 2017), each contributing three documents. Meanwhile, the highest citation count on this topic is 133, achieved from two papers by Ronto, Pendergast, Harris and Ball (Ronto et al., 2016, 2017). Figure 8 presents the overlay display of relationships among author clusters, each containing at least two papers.

There are three clusters shown in Figure 8 related to the overlay visualization of impact factors among authors. The first cluster (Ball Cluster) consists of 8 authors who are closely linked, while the second cluster (Aydin Cluster) consists of four authors. The colors represent the impact factors based on the authors. The Ball Cluster has the highest impact factor compared to the Aydin Cluster.

3.6 Co-occurrence map with author keywords related to Food Sustainability Education in Schools

An intriguing area to investigate is the distribution of study subjects about the primary issue of Food Sustainability Education in Schools. Based on an analysis using VOSviewer, 122 related keywords were identified. The network visualization from VOSviewer regarding the associated variables is shown in Figure 9, along with the most frequently appearing keywords and the network, starting from the strongest, in Food Sustainability Education research, as presented in Table 3. Based on the co-occurrence keyword analysis displayed in Figure 9, several research trends and key topics emerge from the existing clusters. Sustainability is a highly dominant topic, encompassing keywords such as food systems, food sustainability, sustainable development, and sustainability education. Research in this field focuses on how sustainability can be integrated into food systems (Donner et al., 2024), education (Norton & Lignou, 2024), and public policy (Hennchen & Schäfer, 2024; Teixeira et al., 2024). In addition, there is a strong trend related to nutrition and nutrition education. Keywords such as nutrition education, food education, children, adolescents, and diet quality indicate that this research topic largely revolves around how education can influence the eating habits and health of children and adolescents. This research covers health issues related to obesity (Sabet & Böhm, 2025), healthy eating patterns (Karpouzis et al., 2024; Kempler et al., 2024), and children's nutrition problems (Franchini et al., 2024; Langner et al., 2024). Furthermore, education is an important aspect linked to various topics. Keywords such as school food, education for sustainable development, and food literacy show that sustainability education is increasingly becoming a part of curricula. This research focuses on how sustainability topics can be integrated into educational programs (Kluczkovski

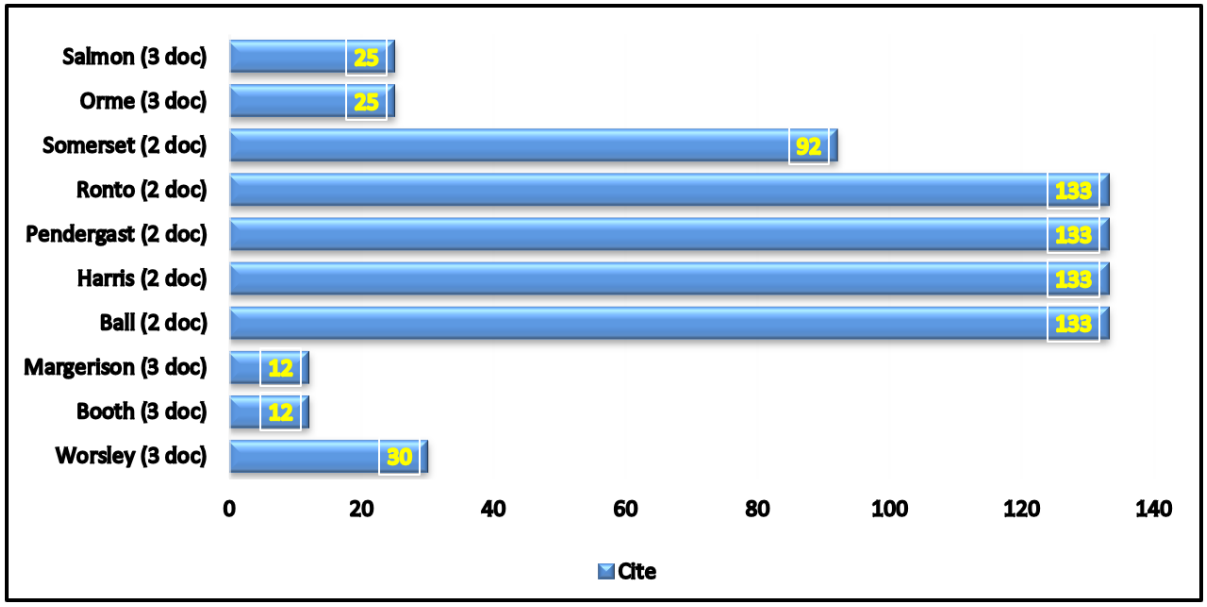

Figure 7: Ten Authors with the Most Citations and Documents

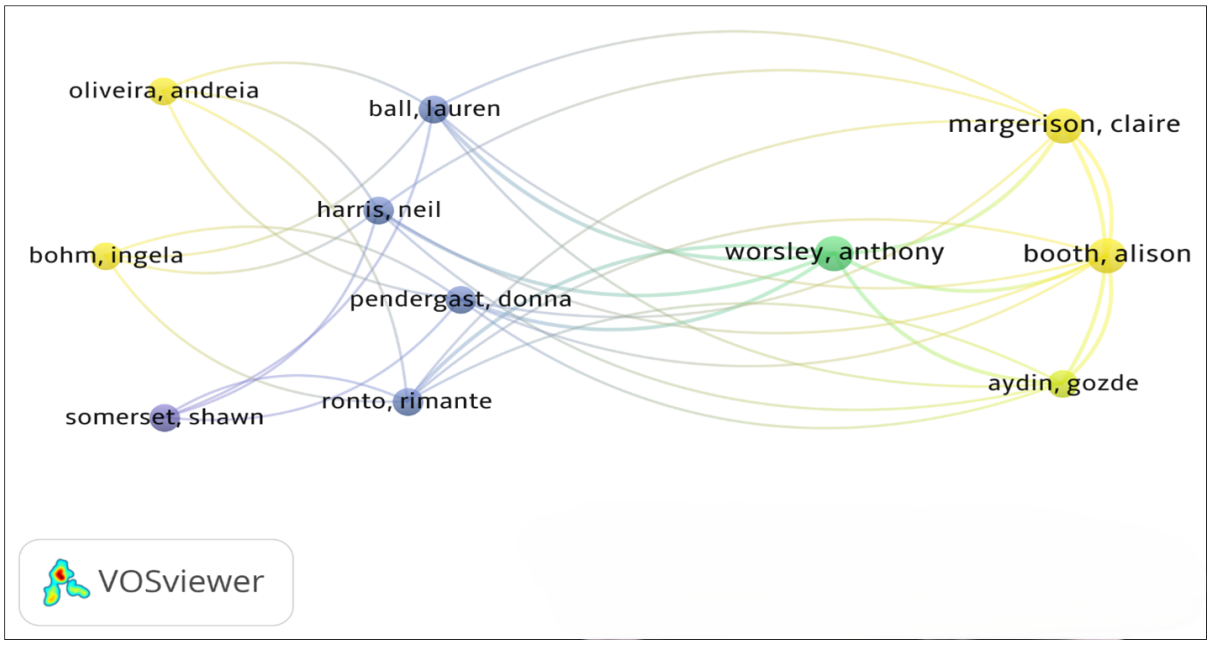

Figure 8: Author Cluster Distribution and Impact Factor Overlay Visualization

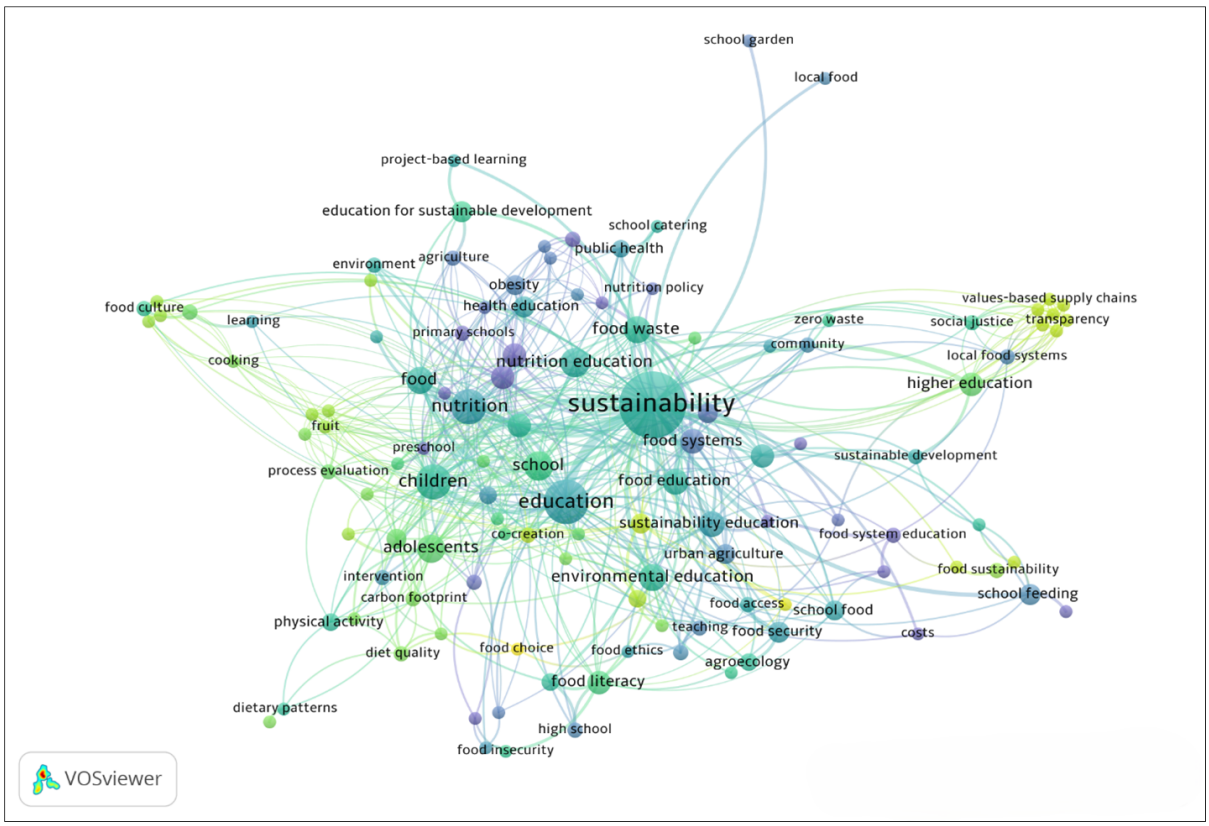

Figure 9: Analysis of Co-occurrence Keywords

et al., 2024; Mideksa et al., 2024). It is also related to curriculum development that supports learning about sustainable food systems (Smith et al., 2022).

Food systems also emerge as a central focus in this analysis, with clusters including keywords such as food security, school catering, community, and food access. Research in this area addresses challenges in ensuring equitable access to nutritious and sustainable food. Topics such as local food systems (Glassey et al., 2023) and food ethics (Panatsa & Malandrakis, 2024) also appear, indicating a growing concern for sustainability in food distribution and ethics in food consumption, which need to be considered in public policy and daily practices. Additionally, there are topics related to social justice, such as social justice and food justice. This research explores how food systems can be developed to ensure fairness for farm workers (Campbell et al., 2023) and to address social inequalities (Hoinle & Klosterkamp, 2023). Lastly, health education and physical activity are also interconnected topics, with keywords such as physical activity, health education, and obesity. Research in this field emphasizes the importance of integrating health education and healthy lifestyle habits into educational curricula, as well as efforts to tackle obesity and public health issues through healthy lifestyles (Grosso et al., 2024). The following are the number of variables most frequently associated with food sustainability education, as shown in Table 3.

Table 3 shows the number of variables most frequently associated with food sustainability education, providing an overview of the main topics often discussed in this research. Sustainability emerges as the most frequently mentioned vari-

able, with 68 occurrences, indicating that sustainability is the central theme in food sustainability education. This is followed by Education, with 28 occurrences, highlighting the important role of education in supporting food sustainability. The variables Children and Nutrition, each with 17 occurrences, indicate a primary focus on children and nutrition-related issues in food sustainability education.

Additionally, several other variables appear with lower frequency but remain important, such as School and Nutrition education, which each appear 12 times, demonstrating that schools and nutrition education are key contexts in food sustainability education. Adolescents appear 11 times, emphasizing the influence of adolescence on the formation of sustainable eating habits. The variables Food waste and Environmental education each appear 10 times, indicating attention to food waste management and the importance of environmental education in food sustainability.

Other variables related to this topic, such as Food literacy, Health promotion, and School meals, each appear 7 times, underscoring the importance of understanding food and its impact on health. Variables related to Health, Schools, Higher education, and Food security appear 6 times, reflecting the broader relevance of food sustainability education in both schools and higher education. Finally, variables like Obesity, Diet, and School gardens appear 5 times, indicating that, although these topics are important, they are discussed less frequently in food sustainability education.

Figure 9 and Table 3 reflect that food sustainability education is related to various aspects, ranging from sustainability, education, health issues, to the environment, all of which play an important role in shaping the understanding and practices related to food sustainability in schools and communities. These aspects may also be influenced by geographic location, where the location of a region (country) could potentially be a factor affecting awareness of studying food sustainability education. Therefore, further research is needed to explore the correlation between geographic location and the development of food sustainability education research in schools. Future research on food sustainability education will be highly beneficial, especially in the context of Society 5.0, which emphasizes enhancing social interactions through collaboration.

Table 3: Most Frequently Associated Variables Related to Food Sustainability Education

No	*Variable*	Occurrences
1	Sustainability	68
2	Education	28
3	Children	17
4	Nutrition	17
5	School	12
6	Nutrition education	12
7	Adolescents	11
8	Food waste	10
9	Environmental education	10
10	Food education	9
11	Sustainability education	9
12	Food systems	8
13	Food literacy	7
14	Health promotion	7
15	School meals	7
16	Health	7
17	Schools	7
18	Higher education	7
19	Food security	6
20	School feeding	6
21	Health education	6
22	Education for sustainable development	6
23	Obesity	5
24	Diet	5
25	School food	5
26	School gardens	5
27	Curriculum	4
28	Public health	4
29	Food system education	3
30	Diet quality food access	3
32	Environment	3
33	Food service	2
34	Food choice	2
35	Food insecurity	2

4 Conclusion

This study provides new insights into the development of food sustainability education in schools by analyzing the metadata of literature from Scopus-indexed journals. The key contribution of this paper lies in its comprehensive mapping of research trends, highlighting the growing emphasis on food sustainability education within classroom settings. It reveals that while significant progress has been made in integrating food sustainability into school curricula, there is

a notable gap in addressing its connections to educational management, curriculum design, assessment tools, and the use of learning media. This study emphasizes the urgent need for an expanded research scope to include these aspects and to strengthen the role of schools in mitigating food insecurity, a critical global challenge with profound health and societal implications.
Furthermore, this study contributes to the literature by identifying the limited international cooperation in food sustainability education research. It calls for the establishment of a global research network to foster collaboration across both developed and emerging nations. Such cooperation is essential for addressing the complex, multifaceted challenges of food sustainability on a global scale.
For future studies, it is recommended that researchers broaden the scope of food sustainability education to include diverse educational contexts, from formal to informal settings, and explore how these approaches can be integrated across various educational levels. Future research should also investigate the effectiveness and impact of food sustainability education in practice, focusing on its long-term benefits for students and communities. In addition, interdisciplinary research incorporating food systems, environmental education, and policy analysis could provide valuable perspectives on how to enhance food sustainability education at the school level.
This study has several limitations. The bibliometric analysis was conducted using data from the Scopus database, which may not capture all relevant literature. Additionally, the focus on food sustainability education in schools leaves out the broader context of informal and community-based education. Finally, while the study provides insights into publication and citation trends, it does not delve deeply into the practical effectiveness of food sustainability education. These limitations highlight important areas for future research to further explore and address.

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