Sustainable food management systems in pesantren

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Abstract. Pesantren, Islamic boarding schools in Indonesia, play a crucial role in the education and well-being of students, making the implementation of sustainable food systems vital for enhancing food security and nutrition. This study aims to provide a comprehensive bibliometric analysis of sustainable food management systems in pesantren using data from the Scopus database. A total of 112 documents were analyzed using VOSViewer to visualize publication patterns, authorship, research trends, and collaboration networks. The results reveal significant contributions from various countries and institutions, with the United States leading in both publications and citations. The analysis also highlights key thematic clusters, including food security, nutrition, and sustainability. The study concludes that while there is growing academic interest in sustainable food systems in pesantren, specific research gaps remain, particularly regarding the integration of pesantren-specific contexts. This research contributes to the understanding of sustainable food practices in educational settings and provides insights for policymakers, educators, and community leaders to develop effective strategies for sustainable development and health promotion in Indonesia.

1 Introduction

Pesantren, Islamic boarding schools in Indonesia, play a crucial role in the education and upbringing of many of students [1]–[3]. These institutions not only provide religious and general education but also take on the responsibility of ensuring the well-being of their students [4], which includes the provision of food [5], [6]. Given their significant population and the extended period students spend within their premises, pesantren have the potential to

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influence the health and nutritional status of many individuals. Consequently, implementing sustainable food systems in pesantren is vital for enhancing food security and nutrition among students.

Sustainable food systems are those that deliver food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition for future generations are not compromised [7]. This approach involves various components, including sustainable agricultural practices, efficient food distribution, minimizing food waste, and promoting balanced [8]. For pesantren, integrating these principles means adopting practices that ensure a consistent, high-quality food supply while also educating students on sustainable and healthy eating habits.

Many pesantren face challenges related to food management, such as limited resources, lack of access to diverse and nutritious food, and inadequate knowledge about sustainable practices [9]. Often, these institutions rely on donations and local food markets, which can lead to inconsistencies in food quality and availability. Additionally, the traditional focus on staple foods may result in monotonous diets lacking essential nutrients [10]. Addressing these challenges requires a comprehensive strategy that encompasses education, resource management, and community engagement.

Implementing sustainable food systems in pesantren can bring numerous benefits. Firstly, it can improve the health and nutritional status of students, enhancing their academic performance and overall well-being [11]. Secondly, it can foster environmental stewardship among young individuals, teaching them the importance of sustainable practices [12]. Thirdly, by adopting local and sustainable food sources, pesantren can support local economies and reduce their environmental footprint [13]. These benefits highlight the potential of sustainable food systems to create a positive impact that extends beyond the pesantren itself. This review provides a comprehensive understanding of the challenges and benefits of sustainable food systems in pesantren, offering valuable insights for policymakers, educators, and community leaders to develop effective strategies for sustainable development and health promotion in Indonesia using bibliometric analysis.

Integrating sustainable food management systems in pesantren aligns with several Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), and SDG 12 (Responsible Consumption and Production). By ensuring food security and promoting nutritious diets, pesantren contribute directly to improving health outcomes among students. Sustainable practices in food procurement and waste management support responsible consumption and production, reducing the environmental impact of food systems. Furthermore, educating students about sustainability fosters a generation that is more conscious of environmental stewardship and sustainable living. These efforts collectively enhance the sustainability and resilience of food systems, not only within pesantren but also in the broader community, supporting global efforts towards sustainable development.

2 Material and Methods

This study employs a bibliometric analysis to explore the topic using data from the Scopus database. Scopus is chosen for its comprehensive coverage and reliable citation indexing, making it a suitable source for high-quality academic research [14]. The bibliometric method allows for the quantitative assessment of publication patterns, authorship, research trends, and collaboration networks within the specified field.

2.1 Data Collection

The data was collected from the Scopus database on June 23, 2024, using a targeted query. The search terms included keywords such as "Food Systems," "Food Security," "Food Nutrition," "Food Management," and various terms related to educational institutions like "school," "schools," "pesantren," "boarding school," and "Islamic boarding school." This search yielded a total of 112 documents, categorized as follows: 90 articles, 15 book chapters, 6 reviews, and 1 conference paper.

2.2 Search Query

The specific search query used was: (TITLE ("Food Systems") OR TITLE ("Food Security") OR TITLE ("food Nutrition") OR TITLE ("food management") AND TITLE (school) OR TITLE (schools) OR TITLE ("pesantren") OR TITLE ("boarding school") OR TITLE ("islamic boarding school")). This query was designed to capture a broad range of literature pertinent to sustainable food systems in the context of pesantren and other educational institutions, ensuring a comprehensive overview of the existing research.

2.3 Data Analysis

The collected data was then analyzed using VOSViewer, a software tool for constructing and visualizing bibliometric networks. VOSViewer facilitates the creation of maps based on network data, which can include journals, researchers, or individual publications [15]. The software also allows for the visualization of co-authorship, co-citation, and bibliographic coupling networks, providing a detailed view of the research landscape.

3 Results and Discussion

The importance of sustainable food systems in pesantren cannot be overstated, as these institutions play a crucial role in shaping the dietary habits and health of a significant portion of the population. This study delves into the academic landscape surrounding this vital topic. It presents a detailed examination of countries, affiliations, and contributing authors, tracks the trend of themes based on keywords, and provides an in-depth concept analysis related to food management in pesantren. This study offers valuable insights into the current state of research, highlighting key contributors and emerging trends, and setting the stage for future advancements in sustainable food practices within educational settings.

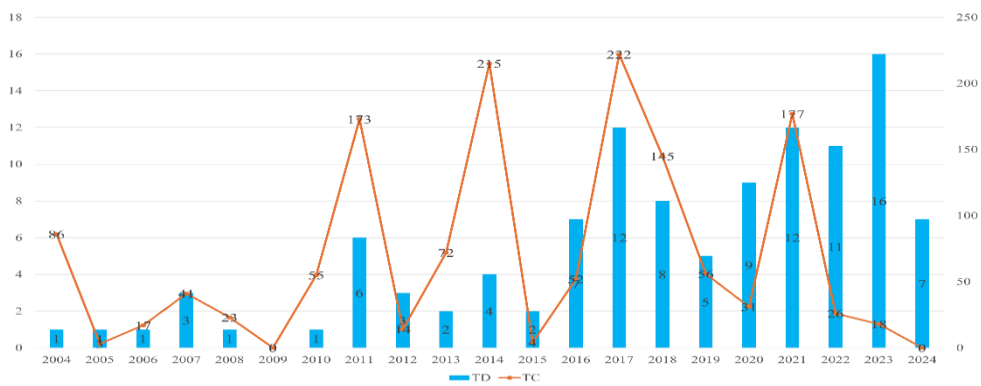

Fig. 1. Trends in publication and citation growth from 2004-2024.

Figure 1 illustrates the trends in total documents (TD) and total citations (TC) related to food systems in pesantren over the period from 2004 to 2024. The initial years (2004-2011) show sparse publications, with notable citation counts in 2004 and 2011, indicating high impact despite low publication numbers. From 2012 to 2014, there is a noticeable increase in publications, peaking in 2014 with 4 publications and an extraordinary 215 citations, marking rising academic interest. The period from 2015 to 2021 shows fluctuations with peaks in 2017 and 2021, each with 12 publications, and significant citation counts in 2017 (222) and 2021 (177), suggesting influential works. Recent years (2022-2024) show a surge in publications, with 16 in 2023, although citation counts remain low, likely due to the recency of these publications. These trends underscore the growing importance and recognition of this research area, highlighting its significance in addressing food security and sustainability in educational settings.

3.1 Countries, Affiliations, and Contributing Authors

In understanding the academic discourse on this topic, it is crucial to examine the countries, affiliations, and contributing authors involved in the research. Analysing these factors provides insights into the geographical distribution of research efforts, the collaborative networks that drive scholarly work, and the key institutions and researchers leading the field. Table 1 presents data on the top 10 countries and institutions contributing to publications on food systems in pesantren, highlighting their respective total publications (TD) and citations (TC). The United States leads significantly with 40 publications and 729 citations, indicating its dominant role in this research area. This high citation count suggests that publications from the United States are highly influential. Australia, with 11 publications and 64 citations, and Brazil, with 10 publications and 139 citations, follow as the next most prolific contributors. The United Kingdom also stands out with 10 publications and 235 citations, reflecting substantial academic activity and influence.

Table 1. Countries and affiliations contributing to publications

Top 10 Countries					**Top 10 Institutions**			
No.	**Country**	**TD**	**TC**		**No.**	**Organization**	**TD**	**TC**
1	United States	40	729		1	University of Embu	2	9
2	Australia	11	64		2	Tufts university	2	12
3	Brazil	10	139		3	University of Wollongong	2	
4	United Kingdom	10	235		4	ADRO	1	11
5	Canada	9	126		5	Agricultural Sciences (UFRA)	1	3
6	Iran	6	94		6	ASEC	1	11
7	Spain	6	106		7	AISD	2	1
8	France	4	20		8	ANSTO	1	0
9	Kenya	3	10		9	Barbara Hardy Institute	1	4
10	Mexico	3	20		10	Bataan Peninsula State University	1	2

The list of top contributing institutions shows a diverse range of organizations from various countries. The University of Embu in Kenya and Tufts University in the United States are tied at the top with 2 publications each, but their citation counts vary, with Tufts University having 12 citations compared to University of Embu's 9. The University of Wollongong in Australia also has 2 publications, though its citation count is not specified. Notably, institutions like the Adventist Development and Relief Organization and the Agricultural Sciences Education and Communication in the United States, despite having only 1 publication each, have garnered 11 citations, indicating high-impact research. Although the food management system in schools is interesting, it does not seem to be a

significant trend in Islamic boarding schools. This is evident from the fact that countries with pesantren/Islamic boarding schools are not frequently mentioned in Table 1.

Table 2. Contributing Authors

No.	Author	TD	TC
1	Broad GM	2	6
2	Gaddis JE	2	12
3	Lee S	2	0
4	Njura HJ	2	9
5	Sadegholvad S	4	37
6	Adeomi AA	1	7
7	Ahmad NSS	1	4
8	Alaimo K	1	26
9	Arnés E	1	14
10	Arteaga I	1	43

Meanwhile, from the perspective of contributing authors, Table 2 shows the top 10 contributing authors. Overall, they have published 17 documents with a total of 158 citations. The average number of citations per author is 15.8, while the average number of documents per author is 1.7. The author with the most citations is Arteaga I, with 43 citations, and the author with the highest number of documents is Sadegholvad S, who has published 4 documents.

3.2 The trend of themes based on keywords

Figure 2 presents a visualization of thematic trends based on keywords in the research on food systems in pesantren, created using VOSViewer. The keywords are grouped into four clusters, each representing different thematic areas within the broader research field. Cluster 1 (Red) - Food Insecurity and Sustainability: This cluster is centered around the theme of food insecurity, with related keywords including "food system," "public policy," "education," "sustainability," and "students." This indicates a focus on how educational initiatives and public policies can address food insecurity, particularly in school settings. Cluster 2 (Green) - Food Security and School Programs: The second cluster focuses on food security, linking it with school-based programs such as "school feeding," "school food systems," "school food," and "school breakfast program." This cluster highlights the role of school initiatives in ensuring food security, emphasizing the importance of structured programs in promoting sustainable food systems within educational institutions. Cluster 3 (Blue) - Nutrition and Policy.

Cluster 3 revolves around nutrition, connecting it with keywords like "adolescent health," "academic performance," "child nutrition," "food sovereignty," and "school lunch." This cluster suggests an emphasis on the nutritional aspects of food systems in schools and the impact of policies on health and academic outcomes. The inclusion of "Korean school lunch policy" points to specific case studies or policy analyses within this thematic area. Cluster 4 (Yellow) - Health and Inequalities: The fourth cluster includes keywords related to health and inequalities, such as "health inequalities," "children," "adolescents," and "school canteens." This cluster indicates a focus on the disparities in health outcomes and access to nutritious food among different student populations, highlighting the importance of addressing these inequalities within the context of school food systems.

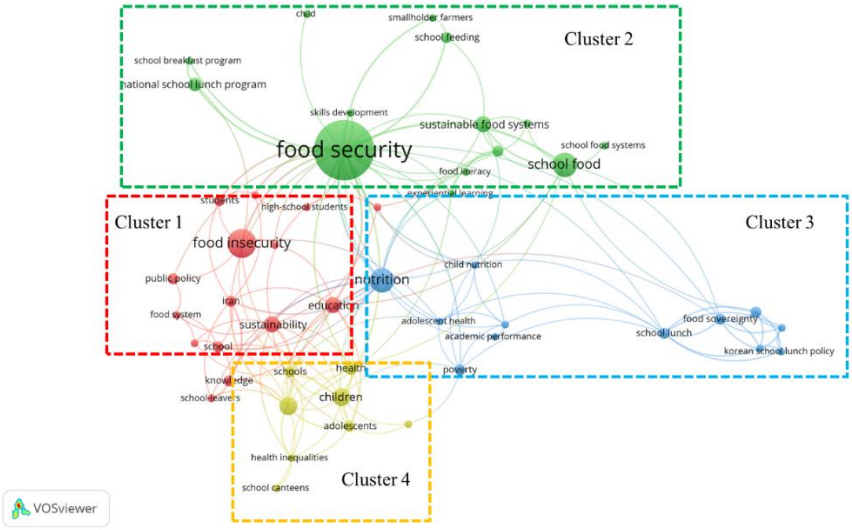

Fig. 2. Thematic trends based on the keywords.

Meanwhile, the evolving themes in Figure 3 (overlay visualization) have significant implications for sustainability and food management in pesantren. Early emphasis on "sustainability" and "food systems" underscores the importance of adopting sustainable practices in food management within these institutions. As the research focus shifts to "nutrition" and "health," it highlights the need for pesantren to ensure that their food systems contribute positively to the health and well-being of students. Recent interest in "school food" and "sustainable food systems" suggests practical steps and policy interventions that pesantren can adopt to enhance food security. The keyword "food insecurity" points to the challenges that need addressing, making it clear that pesantren must implement comprehensive strategies to manage food sustainably and ensure all students have access to nutritious meals. This holistic approach is crucial for fostering an environment that supports both the educational and physical development of students, ultimately contributing to the broader goal of sustainability in educational settings.

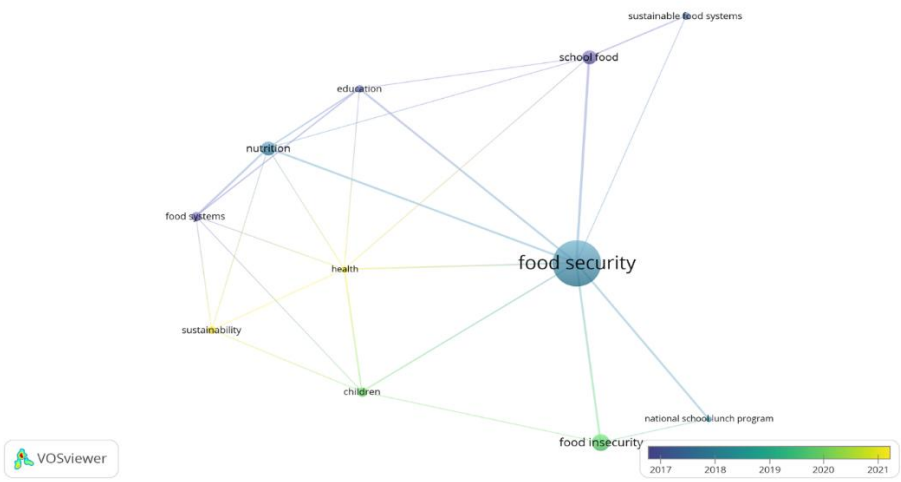

Fig. 3. Overlay visualization based on author keywords

Pesantren-Specific Analysis: Notably, the term "pesantren" or related keywords are absent from the thematic clusters presented in Figure 3. This indicates a gap in the current bibliometric analysis where the specific context of Islamic boarding schools has not been adequately explored. Pesantren are unique in their cultural [16], religious [17], and operational contexts [18], which can significantly influence food systems and nutrition within these institutions [19]–[21]. Future research should focus on integrating the context of pesantren into these thematic areas, examining how their specific characteristics impact food security, nutritional outcomes, policy implementation, and health inequalities. For instance, integrating sustainable food education in religious contexts can align well with promoting stewardship and ethical considerations, which are central to many religious teachings [22]. Additionally, understanding the role of cultural and religious factors in shaping food practices can help in designing more effective nutrition education programs [23]. Examining these aspects would provide a more comprehensive understanding of sustainable food systems in pesantren and contribute to more targeted and effective interventions [24].

3.3 Concept Analysis Related to Food Management in Pesantren

Developing a robust concept related to sustainable food management in pesantren is crucial for fostering both environmental stewardship and the health and well-being of students (Figure 4). Central to this framework is food management in pesantren, which expands into various critical areas such as the importance of school food systems, the nutritional impact of these systems, their sustainability, and effective waste management practices. The model further breaks down into specific elements necessary for creating sustainable food systems in schools, including customized nutrition plans, menu modifications and procurement strategies, environmental changes and nudges, and the provision of healthy and sustainable meals. This comprehensive approach not only addresses the practical aspects of food management but also underscores the importance of a holistic strategy in promoting sustainable and health-promoting food systems in pesantren.

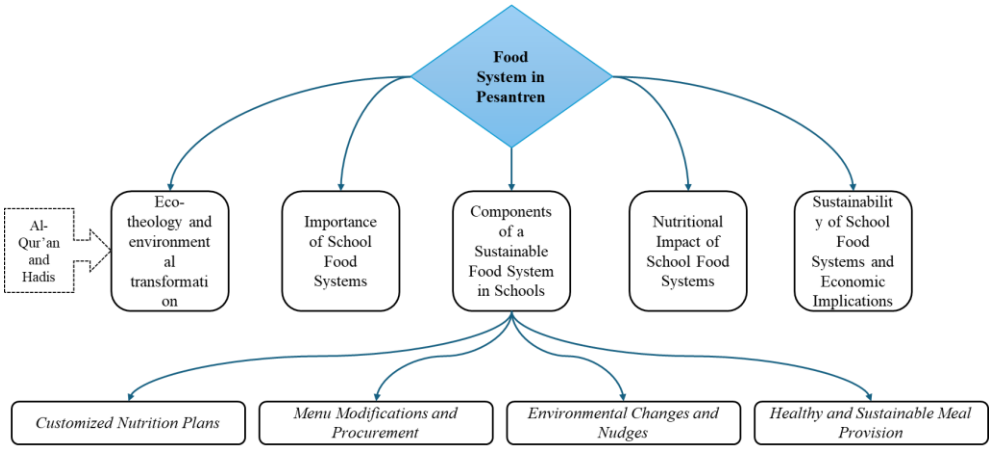

Fig. 4. Food system in pesantren concepts.

3.3.1 Eco-theology and environmental transformation

Eco-theology has shown significant potential in influencing environmental transformation through the integration of religious principles with practical environmental actions [25]. Research highlights that perspectives derived from the Quran, for instance, can effectively

motivate individuals and communities towards eco-friendly practices, thereby mitigating environmental crises and addressing social challenges simultaneously [26], [27] . This blend of spiritual guidance and environmental stewardship not only enhances the ecological consciousness among followers but also fosters a holistic approach to environmental sustainability that aligns with religious teachings [28].

The impact of eco-theology extends beyond individual actions to influence broader environmental policies and community initiatives [29]. By framing environmental care as a faith-based imperative, religious institutions can mobilize significant support for sustainability efforts within their communities [30]. This approach not only strengthens the resolve of believers to engage in environmentally responsible behaviors but also positions religious organizations as key players in the global movement towards ecological sustainability. By leveraging the moral authority and extensive reach of religious institutions, eco-theology can catalyze transformative environmental actions that resonate deeply with spiritual values and communal commitments [31].

Integrating eco-theology into food management in pesantren can significantly enhance environmental stewardship and sustainable practices within these religious educational institutions. By leveraging religious teachings from the Quran that emphasize the importance of caring for the Earth, pesantren can promote sustainable food systems that align with both spiritual and ecological principles [32], [33]. This integration can help pesantren lead by example, demonstrating how faith-based communities can contribute to global sustainability efforts while adhering to their religious values.

3.3.2 Importance of School Food Systems

School food systems are essential for improving the dietary habits and overall health of children. Implementing sustainable practices in food production, distribution, and management within schools ensures that children receive nutritious meals that support their growth and development [34]. Research indicates that school programs focusing on sustainable food systems, such as the Food for Life Partnership, have successfully promoted healthier eating habits among students by integrating nutritional education with practical experiences like cooking and gardening [35]. This holistic approach not only improves students' dietary intake but also raises awareness about the importance of sustainability in food choices.

Moreover, operationalizing sustainable food systems in schools can address broader public health concerns, including food insecurity and chronic diseases. A study in Canadian schools highlighted the benefits of integrating sustainable food system strategies into educational policies and practices, showing that such initiatives can significantly improve students' nutritional intake and foster a culture of environmental stewardship [11]. The impact of school food systems extends beyond individual health benefits to include social and economic advantages. School meal programs, particularly those that focus on local procurement and sustainability, support local economies and reduce the environmental footprint of food production and consumption. For instance, schools engaged in sustainable food procurement practices contribute to the local economy by sourcing food from nearby farms, thereby reducing transportation emissions and supporting local agriculture [36].

Integrating these principles into food management in pesantren (Islamic boarding schools) can have profound benefits. Given the unique cultural and religious contexts of pesantren, incorporating sustainable food practices aligned with Islamic teachings on stewardship can enhance both the nutritional quality of meals and environmental awareness among students. This holistic approach aligns well with the values of eco-theology and can lead to significant positive impacts on both the community and the environment.

3.3.3 Components of a Sustainable Food System in Schools

Understanding the components of a sustainable food system in schools is crucial for fostering both the health and academic success of students. By implementing tailored nutrition plans, modifying menus and procurement processes, and introducing environmental nudges, schools can significantly enhance dietary habits and sustainability practices. Therefore, discussing these components is essential for developing effective strategies that integrate health, education, and sustainability within school environments.

Customized Nutrition Plans

The Creating Health Environments for Schools (CHEFS) program emphasizes the importance of customizing nutrition plans to enhance the nutritional content of school meals [37]. By tailoring meal plans to meet the specific dietary needs of students, schools can ensure that children receive balanced and nutritious meals that support their growth and academic performance [38]. This approach not only addresses individual nutritional requirements but also incorporates sustainability by including local and seasonal produce, thereby reducing the environmental impact of food production and distribution.

Menu Modifications and Procurement

Interventions in school food systems often include modifying existing menu items and improving food procurement processes to ensure healthier options are available. Successful collaboration with food service organizations is crucial for implementing these changes effectively [39]. By sourcing ingredients from local farms and incorporating more whole foods, schools can reduce their carbon footprint and support the local economy. The Food for Life Partnership program demonstrated that reforming school meal procurement and preparation can lead to higher fruit and vegetable consumption among students, highlighting the importance of integrating sustainability into school food systems [35].

Environmental Changes and Nudges

Implementing environmental changes and nudges within the school food environment can significantly influence children's food choices towards healthier options [40]. Simple interventions, such as rearranging the cafeteria layout to make healthy foods more accessible or using visual cues to promote nutritious choices, can encourage students to select better meals. A study on sustainable school food systems found that such environmental modifications, coupled with educational initiatives, can effectively promote healthier eating behaviors among children [34].

Healthy and Sustainable Meal Provision

Ensuring that school food systems include a policy equity perspective is essential for providing all students with access to at least one healthy and sustainable meal per day [41]. This involves developing policies that prioritize the inclusion of nutritious, sustainably-sourced foods in school menus. Programs like the Sustainable School Program (SSP) in Bahia, Brazil, which implemented low-carbon meals in schools, demonstrate that integrating environmental considerations into meal planning can significantly reduce greenhouse gas emissions while maintaining nutritional adequacy [42].

By customizing nutrition plans that align with Islamic dietary laws (QS Al-A'raf: 31), modifying menus to include local and organic foods, implementing environmental nudges to encourage healthier eating, and ensuring policy equity, pesantren can enhance the health and well-being of their students while promoting environmental sustainability. These strategies not only improve nutritional outcomes but also align with religious teachings on stewardship and care for the environment, making them highly relevant and impactful in the context of pesantren.

3.3.4 Nutritional Impact of School Food Systems

The nutritional impact of school food systems is substantial, playing a critical role in shaping children's dietary habits and overall health. Studies have shown that school food programs, significantly improve the dietary quality of foods consumed by children at school. These programs ensure that students have access to nutritious meals, which in turn supports their growth, development, and academic performance [43]. Moreover, school nutrition policies have been effective in improving the overall food environment within schools. Policies that set nutrition standards and regulate the availability of healthy versus unhealthy food options have shown positive impacts on students' dietary intake. For example, a systematic review found that school nutrition policies often lead to increased availability of healthier foods and decreased availability of less healthy foods, thereby promoting better eating behaviors among students [44].

These improvements in the school food environment are crucial as they directly influence the nutritional quality of students' diets, helping to combat food insecurity and reduce the risk of obesity and related chronic diseases. Integrating these insights into food management in pesantren can yield significant benefits. By adopting similar nutrition policies and standards, pesantren can enhance the dietary quality of meals provided to students, promoting their health and academic success. Furthermore, these practices align with the principles of sustainability and stewardship emphasized in Islamic teachings, making them highly relevant for pesantren settings.

3.3.5 Sustainability of School Food Systems and Economic Implications

Interventions such as designing more sustainable school lunch menus, reducing food waste, incorporating sustainable food system education through school gardens, and dietary interventions with environmental components can significantly enhance the sustainability of school food systems. For instance, school food programs that incorporate locally sourced, organic produce not only reduce the carbon footprint associated with food transportation but also support local agriculture and economies [34]. These programs also educate students on the importance of sustainable eating habits, thereby fostering a culture of environmental stewardship from a young age. School food services can play a pivotal role in transforming the food system to be healthier and more sustainable.

By prioritizing the production of meals based on sustainable nutrition principles, schools can reduce their environmental impact while providing nutritious food to students. This includes integrating seasonal and local produce into school menus and minimizing the use of processed foods. The Think&EatGreen@School project in Vancouver is an excellent example of how educational and policy interventions at the school level can drive food system sustainability, food security, and food sovereignty [45]. To further support the sustainability of school food systems, specific legislation and policies are needed. These should include guidelines for sustainable procurement, waste management, and the integration of environmental education into school curriculums. A case study from Brazil's national school feeding program highlights the importance of policy in promoting sustainability and supporting local economies [46].

With approximately a third of food intended for human consumption wasted through the food supply chains, the loss of embedded resources is receiving increasing global attention [47]. The total production value of global food waste (FW) is estimated at $1 trillion, increasing to $2.6 trillion when social and economic costs are considered [48] and the greenhouse gas (GHG) emissions associated with the FW supply chains account for 6.8% of global emissions [49], [50]. In their Sustainable Development Goals, the United Nations have stated a target to half the per-capita food waste at the retail and consumer levels by 2030 [51].

In the context of pesantren, integrating sustainable food management practices can have profound benefits. By adopting sustainable nutrition plans, reducing food waste, and educating students about environmental stewardship, pesantren can improve the health and well-being of their students while supporting environmental sustainability. The successful implementation of these practices in pesantren can serve as a model for other educational institutions seeking to enhance their sustainability efforts.

4 Conclusion

The bibliometric analysis of sustainable food management systems in pesantren highlights the significant role these institutions play in promoting food security and nutrition, aligning with several Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), and SDG 12 (Responsible Consumption and Production). The study reveals increasing academic interest, with key contributors from countries like the United States and Australia, and thematic trends focusing on food insecurity, sustainability, nutrition, and school food systems. By adopting sustainable practices such as customized nutrition plans, menu modifications, environmental nudges, and sustainable meal provisions, pesantren can enhance student health and academic performance while fostering a culture of sustainability and environmental stewardship. Integrating eco-theology further aligns these practices with religious teachings, promoting holistic development. These efforts not only support local economies but also contribute significantly to achieving the SDGs, providing a model for other educational institutions to enhance their sustainability initiatives.

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