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*Review Article*

# Dimensions and Determinants of Sustainable Public School Catering: A Systematic Literature Review

***Abderrahim Mounssif*[1*], *Abdelmajid Saidi*[2]**

[1] Applied Economics Laboratory, Moulay Ismail University, Meknes, Morocco

[2] Applied Economics Laboratory, Moulay Ismail University, Meknes, Morocco

e-mail: a.mounssif@edu.umi.ac.ma, saidi.abdelmajid@gmail.com

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## ABSTRACT

Public school catering is a key instrument for promoting the sustainability of food systems, yet its analysis remains fragmented. This research proposes an integrated approach to identify the main determinants and dimensions of its sustainability. It highlights the central role of governance, regarded as the keystone of the system, operating through territorial anchoring. A systematic review, conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses method on the basis of 66 studies drawn from Scopus and Web of Science, made it possible to identify four interdependent dimensions: socio-cultural, economic, environmental and governance. The findings indicate that the overall performance of the system depends on the quality of governance, which strengthens territorial anchoring as a lever for sustainable improvement. The study thus proposes an innovative conceptual model and operational guidelines to support public decision-makers in fostering a more resilient and responsible school catering system.

## KEYWORDS

*Conceptual model, Reflexive governance, Sustainable public school catering, Systematic literature review, Territorial anchoring, Territorial food systems.*

## HIGHLIGHTS

- Public school catering can drive food system sustainability.
- Governance acts as the central lever of sustainable transformation.
- Territorial anchoring connects policy, local economy, and sustainability.
- Four interdependent dimensions structure system sustainability.
- A novel conceptual model guides policymakers towards sustainable action.

## INTRODUCTION

Public school catering (PSC) constitutes a strategic policy instrument situated at the crossroads of educational, health, environmental, and economic challenges [1]. Serving more than 459 million children daily across 175 countries [2], it holds an exceptional potential for the concrete implementation of the Sustainable Development Goals (SDGs). By its cross-sectoral nature, PSC simultaneously contributes to the eradication of poverty (SDG 1), food

* Corresponding author

security (SDG 2), health and well-being (SDG 3), and quality education (SDG 4). It also supports gender equality (SDG 5), the reduction of inequalities (SDG 10), responsible consumption (SDG 12), and climate action (SDG 13). This multifunctionality makes it a privileged laboratory for implementing sustainability policies [3].

This role is particularly crucial in a context marked by the limits of the conventional agri-food model, which is largely responsible for climate change and the rise of chronic diseases [4], [5], [6], [7]. In response to these challenges, several international initiatives – such as Brazil's National School Feeding Programme (PNAE) [8], [9], France's EGalim Law (Law for the Balance of Commercial Relations in the Agricultural Sector and for Healthy, Sustainable and Accessible Food for All) [10], and Farm-to-School programmes [11], [12] – reflect a global shift towards more sustainable models of PSC.

However, the scientific literature remains fragmented. Existing studies often address the environmental, social, economic, or political dimensions of sustainability in isolation, without proposing an integrated framework. While some recent systematic reviews focus on specific school-based interventions [13], a comprehensive mapping of determinants and their interrelations is still lacking.

The present systematic review aims to fill this gap. It pursues two main objectives. The first is to identify and categorise the dimensions and determinants of sustainable PSC based on the analysis of 66 studies. The second is to propose an innovative conceptual model. This model places governance at the centre of the system as a structuring variable. Territorial anchoring plays a key role as a mediating mechanism through which governance influences sustainability performance. This conceptual framework thus provides a robust foundation for future empirical research and the development of context-appropriate assessment tools, particularly in middle-income settings.

## METHODES

To achieve the research objective, a systematic literature review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This type of review was selected because it enables a rigorous and comprehensive analysis of the scientific literature through four key stages: identification, screening, eligibility, and inclusion [14], [15].

### Data Sources and Search Strategies

The research question guiding this study was: What are the dimensions and determinants of the sustainability of public school catering? The search keywords used were: ([sustainability OR sustainable development] AND [school catering OR school feeding OR school canteens OR school meals]).

Detailed search strategies were developed for two major interdisciplinary databases, Web of Science and Scopus. These databases were selected for their comprehensive coverage of high-quality, peer-reviewed literature across relevant disciplines, including environmental sciences, nutrition, social sciences, and public policy – deemed sufficient for the scoping purpose of this review. The search was carried out on 7 August 2023. Further details are provided in the Appendix 1.

### Inclusion and Exclusion Criteria

The inclusion criteria comprised studies that identified the dimensions and/or determinants of the sustainability of public school catering. No restrictions were applied concerning publication year or language in order to encompass the broadest possible range of existing evidence on the topic. The exclusion criteria were as follows: (i) Letters, conference abstracts, early access publications, proceedings, commentaries, books, book chapters, notes,

errata, and conference reports. (ii) Studies not related to catering in public schools. (iii) Studies that did not address the research question.

### Study Selection and Data Collection Process

Duplicate records were identified and removed, and all references were managed using Zotero software. The selection process was carried out in two phases. In Phase 1, two reviewers screened the titles and abstracts of all identified references. Articles that did not meet the eligibility criteria were excluded. In Phase 2, the full texts of the remaining articles were reviewed in detail, and only those meeting the inclusion criteria were retained. An independent double-screening of full texts was conducted by the two reviewers using the same criteria. Any disagreement was resolved through discussion. The extracted data were synthesised in **Table 1**, which included the following information: author (s) / year / country, study objective, dimensions and determinants of sustainable public school catering, main findings, and study limitations.

### Risk of Individual Bias in Included Studies

To assess the quality of the studies, regardless of their research methodology, the critical appraisal tools developed by the Joanna Briggs Institute (JBI) **[16]** were employed. Each study underwent an independent evaluation based on the JBI criteria, which use four possible judgements: “yes”, “no”, “unclear”, and “not applicable”. Studies with a “yes” response score below 70% were excluded from the synthesis due to insufficient methodological rigour. Detailed results of this assessment are presented in the **Appendix 2**.

### Data Analysis

A narrative synthesis approach was adopted to identify and categorise the dimensions and determinants of PSC sustainability. This process involved extracting and classifying the determinants within the emerging dimensional framework, which subsequently informed the development of the conceptual model.

## RESULTS

This section presents the main findings of the systematic review, including the study selection process, their geographical and thematic characteristics, and the synthesis of the determinants of PSC sustainability organised around four key dimensions.

### Study Selection

In total, 272 studies were identified, with 124 from Web of Science and 148 from Scopus. After the removal of 90 duplicate articles, 182 studies were retained for preliminary analysis. These were screened based on their titles, abstracts, and keywords to assess their relevance. Thirty-one studies were excluded for not meeting the eligibility criteria.

Full-text screening of the remaining 151 studies resulted in the exclusion of 85 articles deemed irrelevant to the research objectives. At the end of this process, 66 studies were retained for the systematic literature review. The PRISMA flow diagram (**Figure 1**) details this selection process.

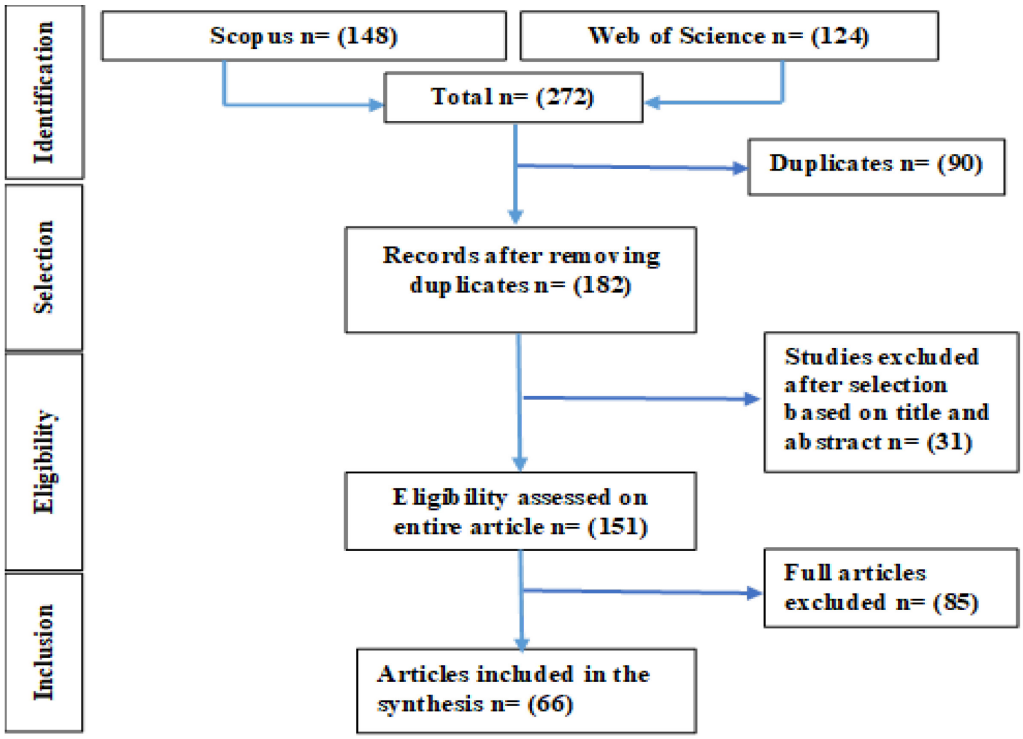


Figure 1. Completed flow diagram summarizing the four steps of the PRISMA method

## Characteristics of Studies Included in the Systematic Literature Review

From a geographical perspective, seventeen studies were conducted in Brazil; eight in Spain; six in Italy; five in Sweden; five were international in scope; four in the United Kingdom; three in Ghana; two in Portugal, two in France, and two in Kenya. One study was identified in each of the following countries: South Africa, Germany, Indonesia, India, South Korea, the United States, Bolivia, the Lao People's Democratic Republic, Finland, and Latin American countries. One study was jointly conducted in Finland and Latvia, and another jointly across Denmark, Finland, Italy, Norway, and Germany.

The analysis of the geographical distribution of studies reveals distinct focal points across regions:

- In Latin America, particularly in Brazil, research primarily focuses on the socio-cultural dimension. Studies examine the impact of school catering programmes on food security, poverty reduction, and social inclusion. These works are embedded within well-structured public policy frameworks, such as the National School Feeding Programme (PNAE) [8], [9].
- In Europe (Spain, Italy, Sweden, France, the United Kingdom), greater attention is paid to the environmental and governance dimensions. European studies explore the carbon footprint of school meals, food waste reduction, vegetarian menus, and governance mechanisms for integrating local and organic products [17], [18].
- In African and Asian countries, the literature primarily highlights educational and nutritional benefits. It also discusses the economic feasibility of school catering programmes. Furthermore, several studies emphasise challenges related to targeting vulnerable populations and ensuring the sustainability of funding [19], [20], [21].

This analysis suggests that research priorities often mirror the developmental challenges and policy frameworks specific to each regional context.

In addition, the majority of publications (49 out of 66) are recent, dating from 2017 to 2023, reflecting the topical nature of this field of study.

Table 1. Overview of studies included in the systematic literature review

| Authors, Year, Country | Study Objective | Dimensions and determinants of sustainable public school catering | Main Results | Study Limitations |
|---|---|---|---|---|
| 1. Kleine and Brightwell, 2015, Brazil | To draw lessons from the Brazilian public procurement programme for school meals | Governance: Strong political commitment, binding regulatory framework (law). Socio-cultural: Participation of local stakeholders, food education. | The Brazilian programme is a successful example of "re-politicisation" of food, using public purchasing power to promote ethical consumption on a large scale. | Lack of ethical mention; limited quantitative analysis. |
| 2. Mistretta *et al.* 2019, Italy | To measure the global environmental impact of school catering via Life Cycle Assessment (LCA) | Environmental: Identification of "hotspots" (production), reduction of Greenhouse Gas (GHG) and energy. | The food production phase is the main environmental "hotspot", more significant than transport or preparation. | Modelled secondary data; no uncertainty analysis. |
| 3. Batlle-Bayer *et al.* 2021, Spain | To assess the environmental and nutritional benefits of low-carbon meals in Barcelona schools | Environmental: Plant-based menus to reduce GHG and land use. Socio-cultural: Improved nutritional quality. | 46% reduction in GHG emissions and 28% in land use; improved nutritional quality. | Secondary data/proxy; no socio-economic analysis. |
| 4. Essuman and Bosumtwi-Sam, 2013, Ghana | To assess the impact of school meals on access to education in rural areas | Socio-cultural: Improved school attendance; effectiveness depends on good targeting. | Improved school attendance, but effectiveness limited by targeting and implementation issues. | Lack of ethical mention; methodology poorly detailed. |
| 5. Ouda *et al.* 2019, Kenya | To assess stakeholder capacities in a school meal project | Governance: Participation and capacity building of actors. Economic: Creation of local jobs. | Identification of critical gaps in logistical and financial capacities for sustainable implementation. | Lack of ethical mention; limited sample. |
| 6. Soares *et al.* 2017, Spain | To analyse practices of purchasing local food in school canteens | Economic: Increased income for local farmers (short supply chains). Environmental: Reduction of food miles. | Mapping the extent of local purchasing; significant differences between regions. | Reporting bias; no control for confounding factors. |
| 7. Borish *et al.* 2017, Kenya | To assess the impact on community capital | Socio-cultural: Strengthened social ties, women's empowerment. Economic: Job creation. Environmental: Agroforestry practices. | Improved social, human, and financial capital of the community, particularly through women's empowerment. | Social desirability bias; subjectivity. |
| 8. Sonnino *et al.* 2014, Brazil | To analyse reflexive governance for food security | Governance: "Reflexive" governance, sustainable political commitment. | Reflexive governance (learning, adaptation) is crucial for the success and sustainability of the programme. | Qualitative methodology only; macro perspective. |
| 9. Cervantes-Zapana *et al.* 2020, Latin American countries | To identify and prioritise benefits of purchasing from family farming | Economic: Increased and stabilised incomes, formalisation. Socio-cultural: Strengthening of organisations (cooperatives). | Prioritisation of economic benefits (incomes, formalisation) and socio-organisational benefits (strengthening cooperatives). | Lack of ethical mention; risk of researcher influence. |
| 10. De Laurentiis *et al.* 2017, England | To quantify the contribution of school meals to climate change and water use | Environmental: Reduction of carbon and water footprint; identification of impactful products (meat, milk). | Carbon footprint of 1.6 Mt $CO_2$ eq/year and water footprint of 21.3 $km^3$/year; meat and dairy as main contributors. | 2009 data; aggregated water footprint. |
| 11. Harris *et al.* 2012, USA | To synthesise knowledge on access to healthy and local food | Governance: Institutional commitment, coordination between services. Economic: Development of short supply chains. | Provision of practical recommendations to facilitate local sourcing (e.g., relaxing tender requirements). | Limited and dated data (2012). |
| 12. Roque *et al.* 2022, International | To review the role of plant-based meals in the food transition | Environmental: Plant-based menus to reduce GHG. Socio-cultural: Education on sustainable food, changing habits. | Proposal of a conceptual framework for plant-based school meals as a lever for food transition. | Non-systematic narrative review; selection bias. |
| 13. Dinis and Guilherme, 2023, Portugal | To analyse farmer engagement in "Farm-to-School" programmes | Economic: Complementary stable incomes. Governance: Logistical coordination, trust relationships. | Identification of key success factors (logistics, trust relationships) and obstacles (paperwork, volumes) for farmers. | Non-random sample; small size. |
| 14. Aurino *et al.* 2023, Ghana | To provide experimental evidence on the cognitive impacts of school meals | Socio-cultural: Improved cognitive abilities and school attendance. | Increase in test scores of 0.12 to 0.16 standard deviations; stronger effects for girls and disadvantaged pupils. | Imperfect implementation; no blind assessment. |
| 15. Vaquero *et al.* 2022, Portugal | To evaluate a field intervention on behavioural sustainability | Socio-cultural: Nutritional education, pupil involvement. Environmental: Reduction of food waste. | Effectiveness in changing behaviours and reducing food waste. | Small sample; no control group. |
| 16. Poinsot *et al.* 2022, France | To scientifically optimise menus for environmental sustainability | Environmental: Reduction of GHG via menu modelling (plant proteins, organic). Socio-cultural: Respect for nutritional intakes. | Design of menus reducing environmental impact by up to 30% while respecting nutritional balance and budget. | Theoretical modelling; no actual consumption. |

| Authors, Year, Country | Study Objective | Dimensions and determinants of sustainable public school catering | Main Results | Study Limitations |
|---|---|---|---|---|
| 17. Tugoz and Bertolini, 2016, Brazil | To analyse economic viability for family farming | Economic: Economic viability of family farms, creation of rural jobs. | Demonstration of the economic viability of the model for small farmers with stable income increase. | Very low generalisability; local context. |
| 18. Balem *et al.* 2021, Brazil | Theoretical synthesis on school feeding programmes | Governance: Strong legislative and policy framework. Socio-cultural: Food and nutritional education. | Highlighting the complexity and political dimensions of sustainable PSC via the Brazilian example. | No original empirical data. |
| 19. Blondin *et al.* 2022, USA | To evaluate the impact of "Meatless Monday" | Environmental: Reduction of carbon and water footprint. Socio-cultural: Acceptance by pupils. | 29% reduction in carbon footprint and 17% in water footprint without decrease in pupil participation. | No control group; confounding factors. |
| 20. Osowski and Fjellström, 2019, Sweden | To analyse the ideology of the Swedish school meal | Socio-cultural: Education on taste, health, and sustainable development. Governance: Integrated political vision. | The meal as a tool for social and democratic education, not just nutritional. | No new empirical data. |
| 21. Lehtinen, 2012, Finland | To study sustainable food procurement | Environmental: Consumption of organic and local food. Economic: Support for local economy. | Trust and informal relationships are essential for sustainable and local purchasing. | Possible subjectivity; limited generalisation. |
| 22. Sonnino, 2010, United Kingdom | To explore food relocalisation processes | Governance: Coordination of actors. Economic: Development of short supply chains. | Warning against the "localist trap" and advocacy for a relational and multi-scale approach. | Lack of explicit ethical procedures. |
| 23. Perez-Neira *et al.* 2021, Spain | To evaluate agroecological policies to mitigate climate change | Environmental: Massive reduction of GHG via vegetarian menus and short supply chains. | Scenario combining local sourcing and vegetarian menus allowing a reduction of over 80% in GHG emissions. | Single focus on GHG; estimated transport data. |
| 24. Oostindjer *et al.* 2017, International | To examine the viability of school meals as a sustainability tool | All: Synthesis of determinants. | Conclusion that school meals are a viable and powerful tool for improving health and sustainability. | Unbalanced presentation; non-systematic review. |
| 25. Valente *et al.* 2023, Brazil | To study the implementation of the PNAE and its sustainability | Governance: Municipal commitment. Economic: Income for farmers. | Documentation of positive socio-economic impacts (incomes, jobs) and persistent challenges (logistics). | No ethical mention; low reflexivity. |
| 26. Jones *et al.* 2012, England | To evaluate a sustainable food education programme | Socio-cultural: Nutritional and environmental education. | Improvement in pupils' knowledge and food behaviours towards sustainable eating. | No randomisation; desirability bias. |
| 27. Constanty and Zonin, 2016, Brazil | To analyse the sustainability of the PNAE via a case study | Governance: Participation, transparency. Socio-cultural: Strengthened social ties. | Illustration of the PNAE's potential for social and economic transformation for family farmers. | Lack of researcher reflexivity. |
| 28. Dahmani *et al.* 2022, France | To compare vegetarian and non-vegetarian meals | Environmental: Reduction of carbon footprint. Socio-cultural: Improved nutritional quality. | Carbon footprint of vegetarian meals 40% to 60% lower; better nutritional quality with more fibre, less saturated fat. | Theoretical data; single environmental indicator. |
| 29. dos Santos *et al.* 2022, International | Systematic review on sustainable practices | All: Exhaustive synthesis of determinants. | Provision of a complete map of evidence-based recommendations and practices. | Publication bias; Brazilian overrepresentation. |
| 30. Volanti *et al.* 2022, Italy | To calculate the carbon footprint of school meals | Environmental: Assessment of carbon footprint/meal. | Average carbon footprint of 1.63 kg $CO_2$ eq. per meal; animal proteins contributing about 75% of the impact. | No uncertainty analysis; specific context. |
| 31. Peano *et al.* 2022, Italy | To evaluate diets via nutrition and environment | Environmental: Environmental impact of vegan dish. Socio-cultural: Compared nutritional quality. | Environmental impact of vegan dish 83% lower than meat dish; differences in nutritional intakes. | Single setting (one canteen); no sensitivity analysis. |
| 32. Valencia *et al.* 2021, Brazil | To analyse implications for gender equity | Socio-cultural: Women's empowerment. Economic: Increase in their incomes. | Improvement in women farmers' empowerment (access to resources, decision-making power). | Restricted sample size; no multivariate model. |
| 33. Soares *et al.* 2021, Spain | To identify facilitating factors for local purchasing | Governance: Coordination, policy support. Economic: Short supply chains. | Identification of key political, technical, and social factors for success (e.g., political will, logistics management). | Lack of reflexivity; 2015 data. |
| 34. Colombo *et al.* 2019, Sweden | To optimise supply integrating multiple dimensions | All: Mathematical optimisation to reconcile cost, nutrition, GHG, waste. | Menus reducing costs by 3%, carbon footprint by 12%, and waste by 6%, while maintaining nutritional intakes. | No uncertainty analysis; missing sustainability aspects. |

| Authors, Year, Country | Study Objective | Dimensions and determinants of sustainable public school catering | Main Results | Study Limitations |
|---|---|---|---|---|
| 35. Roy *et al.* 2018, India | To explore supplier participation for sustainability | Governance: Coordination with the supply chain. | Highlighting challenges of integrating small informal suppliers into sustainable chains. | Lack of reflexivity; single case study. |
| 36. Otsuki, 2011, Brazil | To analyse partnerships for a green economy | Governance: Stakeholder engagement.<br>Socio-cultural: Strengthening of cooperatives. | Multi-stakeholder partnerships are essential for an inclusive green economy. | Poorly detailed methodology; researcher role not explicit. |
| 37. Dos Santos *et al.* 2019, Brazil | To describe an organic farming project in rural schools | Environmental: Consumption of organic products.<br>Socio-cultural: Education, community involvement. | Demonstration of the feasibility of a low-cost participatory project and its educational benefits. | No statistical analysis; uncalibrated instruments. |
| 38. Wittman and Blesh, 2015, Brazil | To link public procurement and food sovereignty | Socio-cultural: Food sovereignty, autonomy.<br>Economic: Equitable incomes. | The PNAE can contribute to food sovereignty and sustainable rural development. | Lack of ethical mention; restricted sample. |
| 39. Santana *et al.* 2017, Brazil | To explore markets for urban agriculture | Economic: Income for urban farmers.<br>Environmental: Reduction of food miles. | Identification of potential and obstacles (regulatory, technical) for urban and peri-urban agriculture. | No statistical analysis; self-reported data. |
| 40. Nogueira *et al.* 2021, Portugal | To assess the nutritional quality of school lunches | Socio-cultural: Nutritional quality, fight against ultra-processed foods. | Evidence of excess salt and saturated fats in meals compared to recommendations. | Convenience sampling; one week analysed. |
| 41. Kluczkovski *et al.* 2022, Brazil | To simultaneously assess environmental and nutritional impact | Environmental: Environmental footprint.<br>Socio-cultural: Nutritional quality. | Successful combination of assessments to identify healthy, low-environmental-impact menus. | Limited sample size; limited generalisation. |
| 42. Kretschmer *et al.* 2014, International | To propose a framework for a sustainable supply chain | All: Holistic framework identifying critical factors. | Provision of a systematic framework for designing sustainable programmes. | Lack of ethical considerations; limited validation. |
| 43. Girardi, 2019, Brazil | To analyse policy coherence with the 2030 agenda | Governance: Political-institutional commitment, policy coherence. | Demonstration of a high level of PNAE policy coherence with the SDGs. | Subjectivity of analysis; lack of reflexivity. |
| 44. Galaa and Saaka, 2011, Ghana | To identify key factors for a sustainable school feeding programme | Governance: Financial viability, community engagement. | List of success factors like leadership, community participation, and effective logistics. | Vague analysis process; lack of reflexivity. |
| 45. Mercado *et al.* 2018, Bolivia | To analyse small farmers' adaptation to standards | Socio-cultural: Involvement of small producers.<br>Governance: Adaptation of rules. | Farmers develop creative strategies to navigate conflicting institutions. | Limited generalisation; beneficiary perspective absent. |
| 46. Simon *et al.* 2023, Spain | To evaluate the food-environment-health-cost "quadrilemma" | All: Integrated modelling to arbitrate cost, GHG, nutrition, acceptability. | Optimised scenario reducing costs by 10%, carbon footprint by 21%, and improving nutritional score by 5%. | No uncertainty analysis; single nutritional indicator. |
| 47. De Laurentiis *et al.* 2019, United Kingdom | To develop an LCA-based decision support tool | Environmental: Tool to reduce GHG.<br>Governance: Decision aid for authorities. | The Environmental Assessment Tool for School Meals (EATS) tool is applicable and useful for local authorities and canteen managers. | Restricted environmental scope; limited validation. |
| 48. Palumbo *et al.* 2018, Italy | To explore change through co-production | Governance: Coordination, communication, and co-production. | Co-production fosters ownership and sustainable organisational change. | Case selection poorly justified; method poorly detailed. |
| 49. Grivins *et al.* 2018, Latvia/Finland | To analyse navigation between regulations | Governance: Flexibility and adaptation of rules, coordination. | Success depends on actors' ability to interpret and adapt rules locally. | Lack of reflexivity; no ethical mention. |
| 50. Colombo *et al.* 2020, Sweden | To test sustainable meals via an optimisation analysis | All: Practical implementation of optimised menus for cost and GHG. | Implementation leading to a 15% reduction in carbon footprint and 16% in food costs, without affecting nutrition. | No control group; short period. |
| 51. Colombo *et al.* 2021, Sweden | To identify barriers and facilitators for implementation | Governance: Organisational factors, competencies.<br>Socio-cultural: Engagement of pupils/parents. | Identification of barriers like lack of time, skills, and communication. | Low pupil participation rate; no teachers. |
| 52. Løes and Nölting, 2011, Nordic Countries | To analyse the increase in organic consumption | Environmental: Strategies to increase the share of organic products.<br>Governance: Political commitment. | Synthesis of effective strategies (progressive introduction, work on costs) for introducing organic products. | Limited scale validation; approximate quantitative data. |
| 53. Valencia *et al.* 2019, Brazil | To structure markets for resilient agriculture | Economic: Increased and stabilised incomes.<br>Socio-cultural: Involvement of cooperatives. | Public markets structure more resilient and diversified agricultural systems. | No randomisation; initial group differences. |

| Authors, Year, Country | Study Objective | Dimensions and determinants of sustainable public school catering | Main Results | Study Limitations |
|---|---|---|---|---|
| 54. Balzaretti *et al.* 2020, Italy | To improve sustainability via portion sizes | Environmental: Reduction of food waste.<br>Socio-cultural: Nutritional adjustment. | Portion adjustment allowing an 11.5% reduction in food waste and better nutritional adequacy. | Estimated portions; unexplained regional differences. |
| 55. Studdert *et al.* 2004, Indonesia | To evaluate community school feeding during a crisis | Socio-cultural: Food security.<br>Governance: Community involvement. | Provision of an effective food safety net and strengthening of social cohesion during the crisis. | Social desirability bias; no direct impact measure. |
| 56. Braun *et al.* 2018, Germany | To identify gaps for organic vegetable supply | Environmental: Supply/demand gap for local organic.<br>Economic: Structuring of supply chains. | Identification of a "local gap" between agricultural supply and canteen demand, requiring better structuring. | Lack of ethical mention; limited reflexivity. |
| 57. Elinder *et al.* 2020, Sweden | To evaluate the OPTIMAT™ intervention | All: Multi-criteria optimisation. | Confirmation of Study 50 results on the effectiveness of optimisation for improving sustainability. | No control group; short period. |
| 58. Antón-Peset *et al.* 2021, Spain | To promote food waste reduction | Environmental: Reduction of waste via weighing and awareness.<br>Socio-cultural: Active pupil involvement. | Interventions leading to a 20 to 30% reduction in food waste in participating schools. | Small sample; no randomisation. |
| 59. Galli *et al.* 2014, Italy | To analyse co-production via parents involvement | Governance: Active participation of parents and civil society. | Civic participation improves the quality, acceptability, and sustainability of the service. | Participation bias; limited generalisation. |
| 60. Mensah and Karriem, 2021, South Africa | To explore potential for rural livelihoods | Economic: Income for small farmers.<br>Socio-cultural: Reduction of rural exodus. | Unexploited potential to transform rural livelihoods, but persistent inclusion challenges. | Restricted sample; selection bias. |
| 61. de Souza *et al.* 2023, Brazil | To analyse PNAE purchasing profiles | Economic: Characterisation of purchases.<br>Governance: Transparency. | Development of a typology of municipal purchasing profiles, showing great heterogeneity. | Problematic sample size; limited generalisation. |
| 62. Chaves *et al.* 2023, International | Systematic review on challenges for family farming | Economic: Synthesis of economic barriers/opportunities.<br>Governance: Governance challenges. | Synthesis of logistical, governance, and capacity challenges for the inclusion of family farmers. | Publication bias; Brazilian overrepresentation. |
| 63. Schwartzman *et al.* 2017, Brazil | To analyse the political construction of the PNAE | Governance: Political process, engagement, social movements. | The PNAE is the result of a dynamic and conflictual political process, driven by social movements. | Lack of reflexivity; limited farmer perspective. |
| 64. de Sousa *et al.* 2015, Brazil | To reflect on sustainable menus | Socio-cultural: Advocacy for sustainable menus.<br>Environmental: Local and organic products. | Argumentation in favour of integrating sustainability into menus and local purchasing. | No empirical method; limited contribution. |
| 65. Gómez-Ramos and Gonzalez, 2023, Spain | To evaluate the contribution of "green" public procurement | All: Multi-dimensional benefits (environment, local economy, social). | "Green" procurement generates environmental, economic (for local producers), and social (education) benefits. | Lack of farmer input; subjectivity of evaluation. |
| 66. Baek and Radziwon, 2023, South Korea | To study a sustainable agri-food ecosystem | Governance: Close collaboration between all actors.<br>Economic: Innovation, shared value creation. | The Korean ecosystem demonstrates the importance of close collaboration and open innovation among all actors. | Small sample; very specific context. |

As shown in **Table 1**, the detailed presentation of the main findings of the reviewed studies highlights the dimensions and determinants of PSC sustainability. This analysis underscores the diversity of methodological approaches and geographical contexts, while revealing the recurrence of certain key factors.

To synthesise these findings and provide an integrated perspective, **Figure 2** groups the major determinants of PSC sustainability according to its four interdependent dimensions: environmental, economic, socio-cultural, and governance.

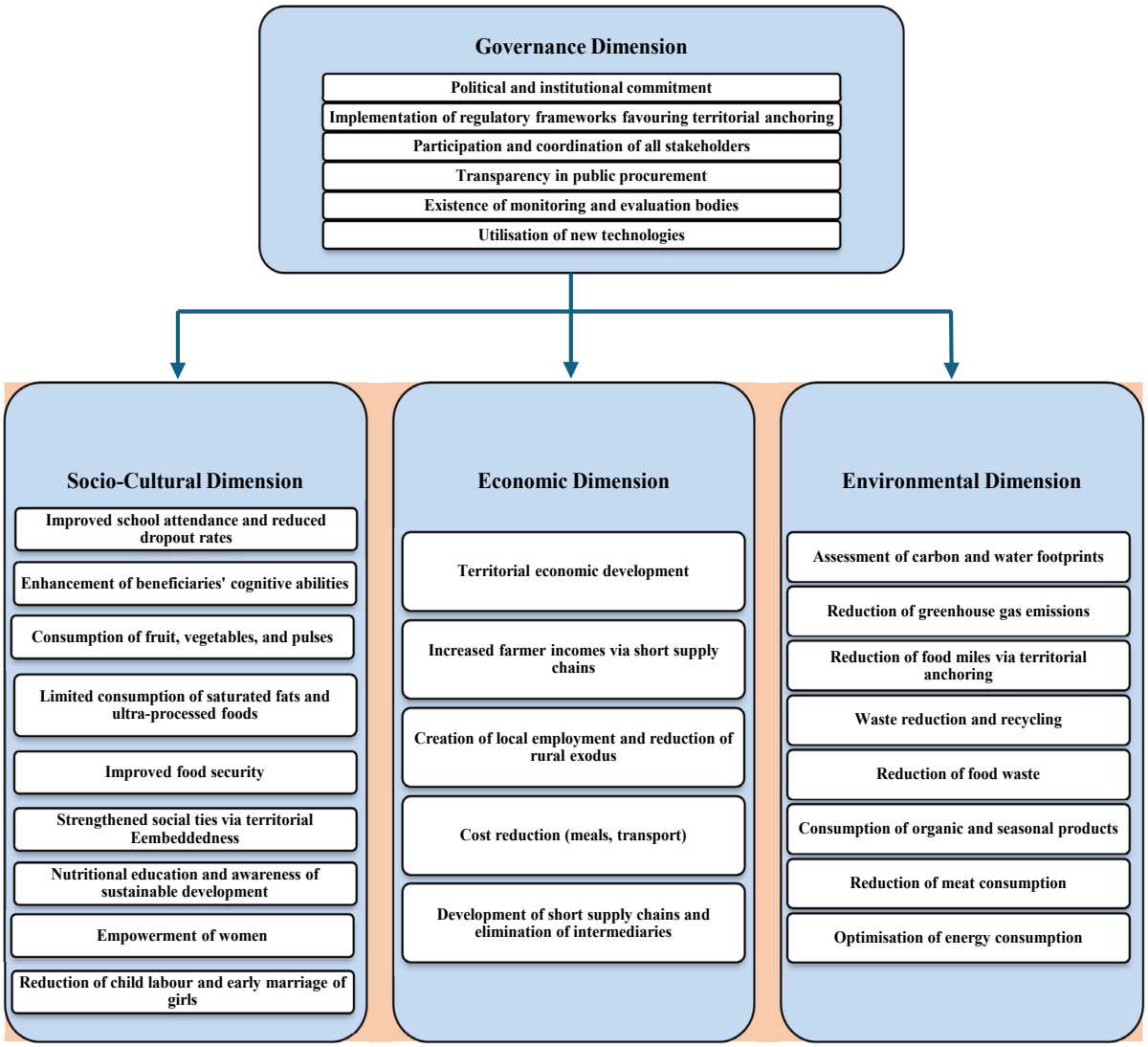


Figure 2. Determinants of sustainable public school catering by dimension

## DISCUSSION

The systematic analysis enables a move beyond a linear vision of sustainability in PSC towards the proposal of an integrated conceptual model. This model posits that the overall sustainability of the service emerges from a complex causal chain, in which territorial anchoring plays a central mediating role, while governance acts as the structuring variable.

### Governance: A Lever for Innovation in Sustainable Public School Catering

Governance constitutes one of the main pillars of PSC sustainability. It relies above all on strong and coherent political and institutional commitment at all territorial levels (national, regional, and local). This is an essential condition for the success of any reform [22], [11], [18], [23], [24], [25], [26], [27], [28], [29]. The Brazilian and French experiences demonstrate that robust legislative frameworks and sustained institutional support are indispensable prerequisites for initiating a genuine transition [9], [28], [30], [31], [32]. However, the relocalisation strategies implemented within PSC reforms are often interpreted in a reductive manner, equated with mere neoliberal decentralisation. Yet, far from contradicting sustainability objectives, these strategies can, on the contrary, strengthen the role of the State in regulating the agri-food system and pave the way for new development trajectories grounded in economic equity and social justice [33].

The effectiveness of such governance also depends on a participatory and collaborative approach, engaging all stakeholders at multiple scales – public authorities, local governments, schools, local producers, and families. This dynamic of co-production and multi-level coordination transforms PSC into a genuine driver of territorial development [34], [35], [36], [37], [20], [38], [39], [24], [40], [22], [41], [42], [43], [31].

Within this framework, the transparency of mechanisms governing the participation of local farmers in public procurement processes emerges as a structuring factor. It promotes their economic and territorial inclusion while reducing the risks of elitism or exclusivity [44]. Thus, PSC governance is not limited to a simple redistribution of competences. It entails a reconfiguration of relationships among actors and a collective accountability around shared objectives of sustainability and social justice.

In parallel, digital technologies are emerging as a strategic lever for the modernisation, efficiency, and transparency of governance. They enable more responsive and evidence-based management [13]. These digital tools support the implementation of a "reflexive governance 2.0" [45], characterised by continuous evaluation and broad stakeholder participation. The EATS decision-support tool illustrates this dynamic [46], allowing for the modelling of the environmental and social impacts of food choices within PSC. Furthermore, the integration of digital technologies facilitates multi-actor connectivity, strengthening coordination among schools, families, and territories [47] [11] [24]. The Swedish example is particularly illustrative [48]: a dedicated mobile application allows parents to monitor, in real time, the meals served to their children, avoiding dietary redundancies and fostering nutritional coherence at home. Such innovation demonstrates that digital technology is not merely a management tool but a vector of territorial anchoring and systemic sustainability, linking the educational, family, and productive spheres within a unified logic of integrated governance.

**Territorial Anchoring: A Central Mediation Mechanism**

Territorial anchoring emerges as the mediating variable through which governance exerts its most significant and comprehensive effects. It constitutes the operational lever that translates political intent – often supported by digital tools – into tangible outcomes through short supply chains and the strengthening of local agriculture. Once activated, this anchoring generates simultaneous and synergistic effects across the three pillars of PSC sustainability.

Economic performance. Despite certain controversies regarding the sustainability of short supply chains [49], [50], several studies confirm their positive impact on territorial economic development [51], [30], [52], [21], [20], [53], [44]. By prioritising local procurement, PSC directly supports farmers' incomes through stable and equitable market outlets [51], [44], [38], [54]. It generates local employment, curbs rural exodus [35], [52], [21], and contributes to the structuring of resilient agri-food sectors [54], [34]. In Brazil, several authors have shown that public procurement based on proximity strengthens the robustness of territorialised agricultural systems [54]. Moreover, local sourcing enables the optimisation of operational costs by reducing transport and storage expenses, without compromising the nutritional value of meals [51]. Economic rationalisation can also be enhanced by reducing red meat consumption [55] and combating food waste [56], [1], thereby reinforcing the overall viability of PSC.

At the macroeconomic level, PSC represents a sector with high added value [9], [57]. By ensuring free meal provision, as is the case in Morocco [58], PSC acts as a tool for social redistribution, improving the income of disadvantaged households [52]. It also reduces healthcare expenditures by promoting balanced nutrition [17], [59]. However, these benefits rely on close coordination between public institutions, producers, and canteen managers [36], [54], [60], [32].

Socio-cultural performance. Territorial anchoring strengthens the socio-cultural dimension of PSC sustainability by consolidating the connection to the land and supporting food education [17], [56], [61]. Integrating local and seasonal products [51], [26], [30] enhances the health status of diners, reducing obesity and chronic diseases [52], [59], [17]. However, these effects require strict adherence to nutritional guidelines [62], [63], [1] and may only become apparent in the long term [48].

Furthermore, PSC improves educational outcomes (by 0.12 to 0.16 standard deviations in a randomised trial) [64], attendance, and cognitive abilities, particularly in disadvantaged areas [52], [41], [27], [19], [35], [64]. It supports inclusive and equitable education [65], [31], while reducing school dropout rates, child labour, and early marriage among girls [27]. Nevertheless, the effectiveness of these programmes depends on accurate beneficiary targeting [19], adequate financial resources [35], and compliance with nutritional quality standards [59].

PSC also functions as a social safety net, contributing to household food security when multi-level collaboration is established among food system actors [45], [20], [66], [44]. Despite challenges related to local production – such as seasonality, limited volumes, or the lack of cooperatives [27], [45] – this model promotes the reduction of rural poverty [60], [67]. It strengthens economic autonomy, particularly among women farmers [53], [67]. It also reinforces social ties between producers and consumers [54]. These interactions contribute to greater dignity in agricultural labour and foster broader social inclusion [61], [68], [69].

Moreover, PSC serves as a collective learning space where food traditions, sustainability challenges, and ethics intersect. Although reconciling health and culinary identity may present complexities [9], PSC relies on concrete educational initiatives to promote sustainable behaviours. Activities such as school gardens and the procurement of organic and seasonal products are notable examples [70], [68], [39], [48]. These initiatives encourage sustainable eating by reducing waste, valuing local products, and raising pupils' awareness of taste [48], [71]. The knowledge gained frequently extends beyond school to influence family practices [48]. In this dynamic, approaches inspired by behavioural economics, such as "nudge" strategies, provide complementary levers for steering pupils' food choices towards more sustainable practices without explicit constraint [13]. Furthermore, by reconnecting young people with nature, these initiatives enhance environmental awareness and contribute to a higher quality of life [70]. Nevertheless, such strategies must be reinforced through staff training in sustainable development and structured political support [39].

Environmental performance. Territorial anchoring serves as a key lever for reducing the ecological footprint of PSC. By promoting short supply chains and local, organic, and seasonal production, PSC limits environmental impacts. The adoption of plant-based menus further strengthens this dynamic [72]. Such choices enable significant reductions in greenhouse gas (GHG) emissions—up to 46% [73], 83% per dish [74], and more than 80% per meal [18]. They also contribute to a 28% reduction in land use [73] and a decrease in food waste ranging between 11.5% and 30% [75]. Moreover, by addressing the food production phase – responsible for a large share of global warming [5] – PSC stands out as a tangible instrument of ecological transition [57]. This environmental pathway is reinforced through the combination of sustainable food practices, such as:

- recycling waste [68], [75] and reducing food waste [68], [73];
- reducing packaging [18] and food miles [71];
- decreasing meat [62], [68], [55], [76], [77], [74], [78] and dairy consumption [76];
- rationalising energy use through eco-efficient technologies [57] [62] [55] [68];
- promoting environmental awareness through school gardens [26], [70] and staff training [22].

Thus, by combining territorial anchoring, ecological innovation, and sustainable food practices, PSC becomes a tangible driver of environmental transition – reducing climate impacts while strengthening the resilience of local food systems.

## Towards an Integrative Conceptual Model of Sustainable Public School Catering

This analysis makes it possible to formalise an integrative conceptual model (**Figure 3**) in which governance constitutes the independent variable. Territorial anchoring represents the central mediating variable. Economic, environmental, and socio-cultural performance form the final mediating variables, which simultaneously act as independent variables. Sustainable public school catering (SPSC) represents the dependent variable.

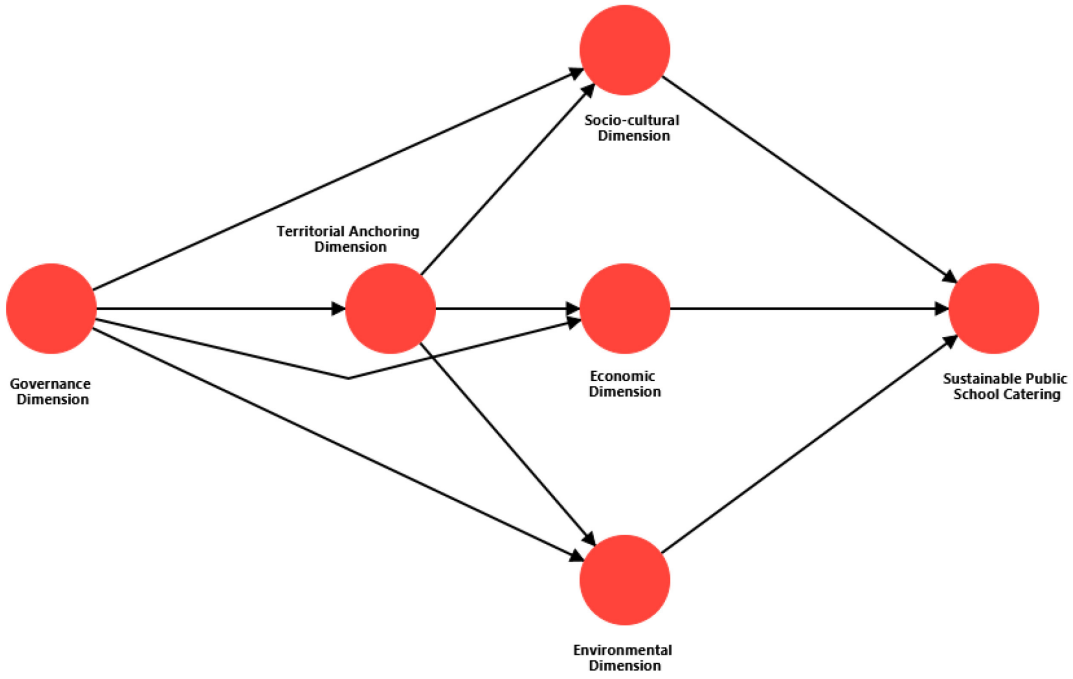


Figure 3. Conceptual model of sustainable public school catering

In this model, governance based on principles of reflexive governance **[79]**, and grounded in stakeholder theory **[80]** and structuration theory **[81]**, **[82]**, facilitates and optimises the establishment of a robust territorial anchoring. The latter – analysed through the proximity approach **[83]** and the social construction of territories theory **[83]** **[84]** – operates via a dual mediation mechanism. On the one hand, it exerts direct mediation by influencing each of the three performance dimensions: economic, socio-cultural, and environmental. On the other hand, it produces indirect mediation, where its impact on overall sustainability occurs through its prior influence on these performance dimensions.

Furthermore, these three dimensions interact dynamically within an integrative theoretical framework, which draws upon several theoretical approaches, including:

- For the economic dimension: the value chain framework **[85]** and the sustainable public procurement paradigm **[86]**.
- For the environmental dimension: the relocalisation of food systems approach **[87]** **[88]** and circular economy theory **[89]**.
- For the socio-cultural dimension: the social and solidarity economy **[90]** and social cognitive theory **[91]**.

Thus, it is the dynamic interaction among these three dimensions—supported by governance and territorial anchoring – that ultimately determines the level of overall system sustainability.

## CONCLUSION

This systematic literature review achieved two main objectives. First, it rigorously identified and mapped the determinants of sustainable public school catering across four dimensions: socio-cultural, economic, environmental, and governance. Second, and more importantly, it proposed a new conceptual model positioning governance as the central structuring variable and territorial anchoring as the key mediating mechanism influencing sustainability outcomes.

Based on these findings, several operational recommendations can be formulated for policymakers and territorial managers:

- Strengthen governance: Establish multi-level and participatory governance frameworks for PSC, including the creation of territorial observatories bringing together elected officials, state services, farmers, parents, and civil society actors.
- Structure territorial anchoring: Introduce mandatory clauses for local and organic sourcing in public procurement for school catering, with progressive targets (e.g. 50% sustainable products, including 20% organic, following the example of the EGalim Law). Develop digital platforms to facilitate networking and logistics between local producers and canteen managers.
- Integrate PSC into Climate and Health Policies: Include the transition of school canteens as a priority action in Territorial Climate-Air-Energy Plans and National Nutrition and Health Programmes, highlighting their contribution to reducing GHG emissions and improving public health.
- Address economic barriers: Allocate part of PSC budgets to initial investments that generate long-term savings (e.g. kitchen equipment for processing raw products, waste-monitoring software). Experiment with innovative financing mechanisms to support the transition.
- Harness behavioural and digital levers: Train canteen staff in behavioural economics principles to guide food choices without coercion. Use digital tools to enhance transparency and educate pupils and families.

Admittedly, this research relies primarily on two databases – Scopus and Web of Science. This methodological choice ensures rigour but also presents a significant limitation. The exclusion of grey literature, including institutional reports, Non-Governmental Organisation evaluations, and policy documents, restricts the scope of the analysis. Yet, a substantial portion of relevant work on SPSC is not published in peer-reviewed academic journals.

Nevertheless, despite this limitation, the study represents a fundamental step for both research and public action. It provides a solid theoretical foundation for the development of composite indicators aimed at assessing the sustainability of PSC. Initially, these indicators could rely on equal weighting across dimensions, later evolving towards differentiated weighting, determined through mixed-method approaches.

Finally, this research lays the groundwork for an operational conceptual framework capable of supporting future empirical studies. Such studies could test and refine the proposed model, particularly in territorial contexts that remain underexplored.

## NOMENCLATURE

### Abbreviations

| | |
|---|---|
| LCA | Life Cycle Assessment |
| EATS | Environmental Assessment Tool for School Meals |
| JBI | Joanna Briggs Institute |
| EGalim Law | Law for the Balance of Commercial Relations in the Agricultural Sector and for Healthy, Sustainable and Accessible Food for All |

| | |
|---|---|
| SDGs | Sustainable Development Goals |
| PNEA | Brazilian National School Feeding Programme (Programa Nacional de Alimentação Escolar) |
| PRISMA | Preferred Reporting Items for Systematic Reviews and Meta-Analyses |
| PSC | Public School Catering |
| SPSC | Sustainable Public School Catering |
| GHG | Greenhouse Gas |

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## APPENDIX

Appendix 1. The search strategy

| Research question | What are the dimensions of sustainable public school catering and their determinants? | |
|---|---|---|
| Database consulted | Scopus | Web of Science |
| Date of consultation | August 7, 2023 | |
| Keywords used | ([sustainability OR sustainable development] AND [school catering OR school feeding OR school cateer OR school canteens OR school meals]) | |
| Search within | Article title, Abstract, Keywords | All fields |
| Document type | Limited to Article and Review.<br>Not : Book chapter or Conference paper or Note or Book or Erratum or Conference review | Limited to Article and Review.<br>Not : Letter or Meeting Abstract or Early Access or Proceeding Paper |
| Year of publication | No publication date limit | |
| Language | No language limit | |
| Subject area | Limited to:<br>Agricultural and biological sciences<br>Social sciences<br>Nursing<br>Environmental science<br>Health professions<br>Engineering<br>Psychology<br>Energy<br>Medicine<br>Business, management and accounting<br>Immunology and microbiology<br>Multidisciplinary<br>Decision sciences | Limited to:<br>Environmental sciences<br>Nutrition dietetics<br>Green sustainable science Technology<br>Food science technology<br>Environmental studies<br>Public environmental Occupational health<br>Engineering environmental<br>Agricultural economics policy<br>Health care sciences services<br>Health policy services<br>Multidisciplinary sciences<br>Behavioural sciences<br>Agriculture multidisciplinary<br>Development studies<br>Economics |
| Identified studies | 148 | 124 |

Appendix 2. Quality assessment of the studies according to the Joanna Briggs Institute criteria

Table Legend
- ✓ = Criterion met = Yes
- ✗ = Criterion not met = No
- ? = Insufficient information = Unclear
- NA = Not applicable

Assessment conducted by two independent reviewers with consensus for disagreements.

1. Randomized controlled trials (1 study) - JBI checklist

| Study | 1. True randomisation | 2. Allocation concealed | 3. Groups similar baseline | 4. Participants blind | 5. Providers blind | 6. Assessors blind | 7. Groups treated identical | 8. Complete follow-up | 9. ITT analysis | 10. Consistent outcomes | 11. Reliable outcomes | 12. Appropriate stats | 13. Appropriate design | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aurino *et al*. 2023 | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 11/13 | High |

2. Quasi-experimental studies (6 studies) - JBI checklist

| Study | 1. Cause-effect clarity | 2. Similar participants | 3. Similar treatment | 4. Control group | 5. Multiple measurements | 6. Complete follow-up | 7. Consistent measurement | 8. Reliable measurement | 9. Appropriate stats | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Blondin *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 9/9 | Excellent |
| Jones *et al.* 2012 | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | ✓ | 8/9 | High |
| Colombo *et al.* 2020 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 9/9 | Excellent |
| Valencia *et al.* 2019 | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | ✓ | 8/9 | High |
| Elinder *et al.* 2020 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 9/9 | Excellent |
| Antón-Peset *et al.* 2021 | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 8/9 | High |

3. Qualitative research (29 studies) - JBI checklist

| Study | 1. Philosophy congruence | 2. Methodology-question | 3. Methodology-data | 4. Methodology-analysis | 5. Methodology-interpretation | 6. Researcher position | 7. Researcher influence | 8. Participant representation | 9. Ethical practice | 10. Conclusions from data | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Essuman and Bosumtwi-Sam, 2013 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | 7/10 | High |
| Sonnino *et al.* 2014 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Harris *et al,* 2012 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Roque *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |

| Study | 1. Philosophy congruence | 2. Methodology-question | 3. Methodology-data | 4. Methodology-analysis | 5. Methodology-interpretation | 6. Researcher position | 7. Researcher influence | 8. Participant representation | 9. Ethical practice | 10. Conclusions from data | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Balem *et al.* 2021 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Osowski and Fjellström, 2019 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Lehtinen, 2012 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 10/10 | Excellent |
| Sonnino, 2010 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✗ | ✓ | 8/10 | High |
| Oostindjer *et al.* 2017 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Valente *et al.* 2023 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | 7/10 | High |
| Constanty and Zonin, 2016 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | 8/10 | High |
| Soares *et al.* 2021 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | 8/10 | High |
| Roy *et al.* 2018 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | 8/10 | High |
| Otsuki, 2011 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | 8/10 | High |
| Wittman and Blesh, 2015 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | 7/10 | High |
| Kretschmer *et al.* 2014 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Girardi, 2019 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Galaa and Saaka, 2011 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Mercado *et al.* 2018 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| De Laurentiis *et al.* 2019 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Palumbo *et al.* 2018 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Grivins *et al.* 2018 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Colombo *et al.* 2021 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 10/10 | Excellent |

| Study | 1. Philosophy congruence | 2. Methodology-question | 3. Methodology-data | 4. Methodology-analysis | 5. Methodology-interpretation | 6. Researcher position | 7. Researcher influence | 8. Participant representation | 9. Ethical practice | 10. Conclusions from data | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Braun *et al.* 2018 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | 7/10 | High |
| Galli *et al.* 2014 | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ? | ✓ | ✓ | ✓ | 8/10 | High |
| Mensah and Karriem 2021 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Schwartzman *et al.* 2017 | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | 8/10 | High |
| de SOUSA *et al.* 2015 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | ✓ | 9/10 | High |
| Baek and Radziwon, 2023 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 10/10 | Excellent |

4. Analytical cross-sectional studies (11 studies) - JBI checklist

| Study | 1. Clear inclusion | 2. Detailed setting | 3. Valid exposure | 4. Standard outcomes | 5. Confounding identified | 6. Confounding addressed | 7. Reliable outcomes | 8. Appropriate stats | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|
| Soares *et al.* 2017 | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | 7/8 | High |
| De Laurentiis *et al.* 2017 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Dinis and Guilherme, 2023 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Dahmani *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Volanti *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Peano *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Valencia *et al.* 2021 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Nogueira *et al.* 2021 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Kluczkovski *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Balzaretti *et al.* 2020 | ✓ | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ | 7/8 | High |
| de Souza *et al.* 2023 | ✓ | ✓ | ? | ✓ | ✓ | ? | ✓ | ✓ | 6/8 | High |

5. Systematic reviews (2 studies) - JBI checklist

| Study | 1. Clear question | 2. Appropriate inclusion | 3. Appropriate search | 4. Adequate sources | 5. Appropriate appraisal | 6. Independent appraisal | 7. Minimal extraction errors | 8. Appropriate synthesis | 9. Publication bias assessed | 10. Supported recommendations | 11. Appropriate research directives | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| dos Santos *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 11/11 | Excellent |
| Chaves *et al.* 2023 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 11/11 | Excellent |

6. Mixed methods studies (9 studies) - JBI checklist

| Study | 1. Clear justification | 2. Appropriate design | 3. Effective integration | 4. Adequate analysis | 5. Limitations addressed | 6. Rigorous implementation | 7. Conclusions from both | 8. Coherence between components | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|
| Kleine and Brightwell, 2015 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Ouda *et al.* 2019 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Borish *et al.* 2017 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Cervantes-Zapana *et al.* 2020 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Vaquero *et al.* 2022 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Dos Santos *et al.* 2019 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Santana *et al.* 2017 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Studdert *et al.* 2004 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |
| Gómez-Ramos and Gonzalez, 2023 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 8/8 | Excellent |

7. Economic and modeling studies (8 studies) - JBI checklist

| Study | 1. Clear question | 2. Comprehensive alternatives | 3. Relevant costs/outcomes | 4. Established effectiveness | 5. Accurate measurement | 6. Credible valuation | 7. Time adjustments | 8. Incremental analysis | 9. Sensitivity analysis | 10. Comprehensive results | 11. Justified conclusions | Score | Quality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mistretta *et al.* 2019 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |
| Batlle-Bayer *et al.* 2021 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |
| Poinsot *et al.* 2022 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |
| Tugoz and Bertolini, 2016 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |
| Perez-Neira *et al.* 2021 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |
| Colombo *et al.* 2019 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |
| Simon *et al.* 2023 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |
| Løes and Nölting, 2011 | ✓ | ✓ | ✓ | NA | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | 9/11 | High |

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