CHALLENGES AND OPPORTUNITIES OF ENVIRONMENTAL SUSTAINABILITY IN THE PUBLIC MANAGEMENT OF SCHOOL CANTEEN SERVICE. ASSESSMENT OF EUROPEAN PRACTICES

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ABSTRACT

To-date public procurement is responsible for 15% to worldwide Greenhouse Gases (GHG) emissions. Within this sector, the average meal provided in school canteen service is responsible for 1.305 kg CO_2-eq, mostly due to food preparation impact, in particular meat production from livestock. Under these perspectives towards a Green Public Procurement represents an essential strategy to support the reduction of GHG emissions related to government activities. Particularly, shifting from a high-impact school canteen service to a greener one is necessary. This paper analyzes some models of school canteen services provided in a sample of public European schools, included the Italian ones, for highlighting the several approaches of environmental sustainability, food policies and public procurement programs adopted by municipalities. Specifically, this study compared the models of school canteen services adopted by some local authorities and the environmental performance achieved, outlining also the reduction of GHG emissions documented by some European countries. In conclusion, the combination of procurement models, food policies and environmental sustainability approaches can support public authorities in the administration of a meal in line with human health, environmental sustainability and economic return, without compromising without compromising the supply chain.

Keywords *- environmental impact, public management, public procurement, school canteen service, sustainability approaches.*

INTRODUCTION

Public sector represents a substantial part of the economy (Neto and Caldas, 2018) and public administration - that deals with the public management of services - employs various administrators, professionals and officials to organize, manage and implement public policies (Eisinger, 2001).

Generally, public management refers to essential public services provided by public administrations to maintain society at a level of well-being. Levels, objectives and tasks

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related to the provision of these services are determined by political and public responsibilities and are not profit-oriented (Moore, 1995, 2013; Christensen and Lægreid, 2011; Lystbaek, et al., 2021).

Amongst several categories of public services, the provision of school canteens is a public service demanded individually by the interested parts (e.g. parents, children, schools). In order to address these needs, local municipalities request a contribution from the user (mostly represented by parents) proportionate to the family income, like Italian system fee calculation is based on the Equivalent Economic Situation Indicator.

Furthermore, school canteen service is configured as essential instrument to guarantee extension of school attendance hours until the afternoon, to ensure the children social development especially for those in greater economic, social and health difficulties, for the consumption at least one healthy and balanced meal every day. Hence, this service represents also a sociality moment amongst students to strengthen the so-called *"soft skills"* (Osservatorio Italiano Conti Pubblici & Save the Children Italia, 2023).

At European level, food system, that includes food provided in school canteens, consists in an important segment that unfortunately emits 10 % of Greenhouse Gas, with almost 70 % of them deriving from the livestock sector (UNSDSN, 2022).

For this reason, in addition to this, speaking always at the European level, the adoption of sustainability approaches contributes to the achievement of environmental and climate objectives. Inter alia, the impact of the food catering is about 1.11–1.50 kg CO_2-eq in terms of Global Warming Potential (GWP) (García-Herrero et al., 2019) and equal to 2.0 kg CO_2-eq of GHG emissions of the average meal (Poinsot et al., 2022), mostly due to food production impact. Not only the authors disputed the importance of reduction of impacts of food production and consumption, but recently government authorities have also highlighted the need to better understand these environmental aspects (Ulaszewska et al., 2017) with the aim to implement good service supply chain management.

Recently, the European Union (EU) has made a strong commitment towards sustainability, also due to promotions shared by several organizations by EU member states (Hoerber et al., 2020).

Particularly, the main European strategies (Green Deal, Farm to Fork, EU biodiversity strategy for 2030) aim to reduce net GHG emissions by at least 55% by 2030 compared to 1990 levels, make food systems fair, healthy and environmentally-friendly, protect nature and reverse the degradation of ecosystems (European Commission, 2020a-b, 2022).

In addition to this, from a quantitative point of view, to-date, for every school-age child are prepared about 500 g of food per day, of which at least 90 g are discarded, about 70 g are not even handled. Therefore, every day each child does not consume at least a total of 160 g in the school canteen. This represents waste food that in most cases is disposed. In general, therefore, on average about 30% of the food is not consumed during the meal, of which 16.7% is waste and 12.7% is intact food that could be reused (Calcagno, 2021).

Furthermore, as also highlighted by SDG number 4 *("Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all")*, it is fundamental provide a healthy, sustainable and appropriate school meals for all children for supporting

food security, public health and environmental sustainability (UN, 2016; Piirsalu et al., 2022).

In addition to this, through the recent Next Generation EU funding program for the Member States for economic recovery after Covid Sars-2 pandemic, many Italian municipalities are submitting projects for the expansion of school services, in particular for canteens and nurseries. Therefore, this study aims at exploring sustainability approaches adopted by school canteen services and providing further insights to build a more sustainable, circular and resilient planet, starting with the production and consumption of sustainable, safe, healthy and zero-waste food production (Campobasso et al., 2024).

Meanwhile, despite the lack of scientific production on the topic analyzed through this paper - as underlined in the next literature review section – the 57.32% of the studies retrieved on Scopus platform analyzed the European context. This interest is also driven by European regulatory context that focused on food sustainability (Lagorio et al., 2018), proposing a directive to reduce food waste (European Commission, 2015) and also launching a platform on food loss and waste (European Commission, 2016) with the aim to identify solutions/practices/policies to prevent food waste. Particularly, 18.30% of the studies focused on Italian school canteens and analyzed several successful food waste reduction projects carried out the school canteens, mainly in northern Italy (Lagorio et al., 2018). Therefore, there is an impellent need for reducing impacts in the school canteen service, especially GHG emissions - picking upon what stated above, and waste food responsible for 14-18% of GWP (García-Herrero et al., 2019). In this regard and considering that half of Italian students attending public schools use the school canteen service as shown in Table 1, it adopted several strategies to reduce food waste in public school canteens (Lagorio et al., 2018).

Table 1: Overview of the attendance of school canteens in Italy (2020-21)

Region	Students attending school canteen (%)
Liguria	86.5
Toscana	87.2
Emilia Romagna	77.8
Piemonte	79.4
Friuli Venezia Giulia	74.8
Lombardia	79.2
Veneto	67.2
Lazio	65.2
Basilicata	51.9
Sardegna	51.3

Marche	42.6
Umbria	42.4
Abruzzo	35.3
Molise	27.4
Calabria	25.3
Puglia	16.9
Campania	21.3
Sicilia	11.2
Trentino Aldo Adige	0
Valle D'Aosta	0
Medium value for Italy	**55.2**

Source: Authors' elaboration on data Osservatorio Italiano Conti Pubblici & Save The Children Italia (2023).

However, some significant differences were found between North and South of the country, and also between one province and another in the same region, as the canteen is a service offered by Municipalities (Save The Children, 2022). Particularly, Liguria shown the highest percentage (86.5%) of usage and Sicily the lowest (11.2%).

For these reasons, given that schools are managed by public bodies, policy actions aimed at consumers, and targeted at public procurement can be envisaged by operating according to green and sustainable approaches (Cerutti et al., 2016; Jungbluth et al., 2016; Cerutti et al., 2018; García-Herrero et al., 2019; Mistretta et al., 2019).

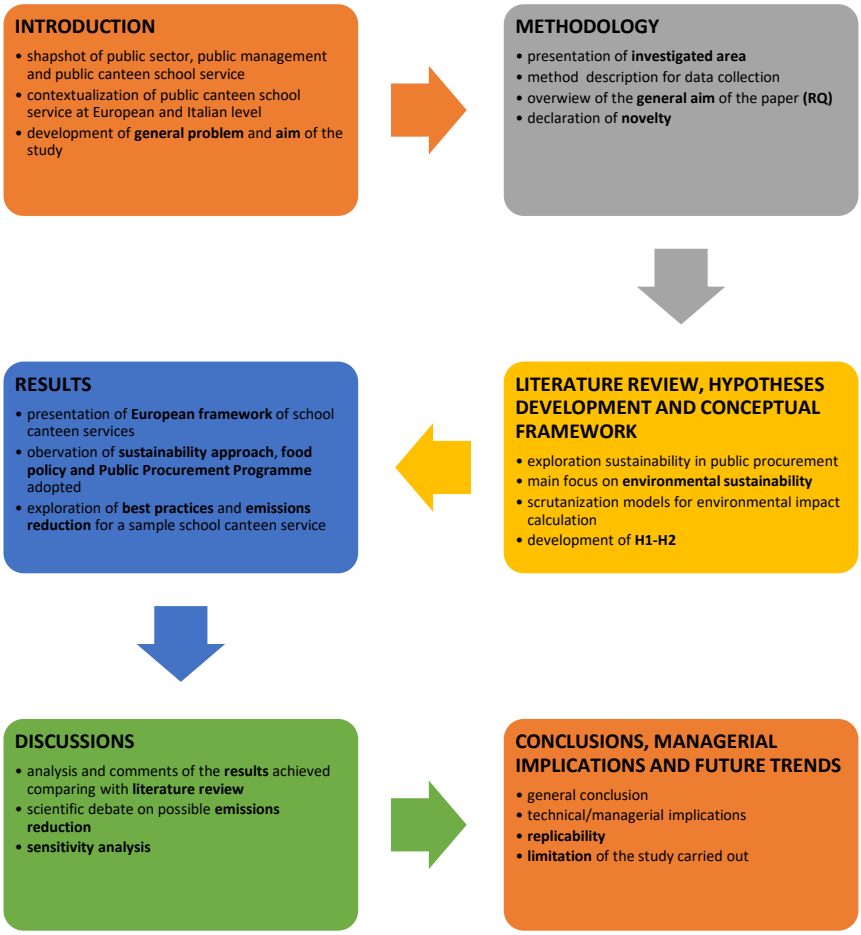
As a continuation of that research line, the authors assessed the lack of scientific production on the topic analyzed through this paper and reported results from the combined keywords. This is the first time that something similar has been developed, from the sampling of some European countries to take a snapshot of the sustainable approaches adopted, to the sensitivity analysis to compare the impacts related with the single school meal provided. All this emphasizes the novelty of this study and the significant contribution it can give to the scientific literature enriching the publications in this journal "International Public Management Review" dedicated to public management assessment.

The remainder of this paper is structured as follows (Figure 1). After having introduced the public sector and the management of the school canteen service, the authors of this paper contextualized the European level, focusing on Italian case (Section 1); in Section 2 they outlined the underlying methods for data collection, sample building, literature search and developed general question. Subsequently, in Section 3 results of this bibliographical analysis and hypotheses development are included. Instead, in Sections 4 the

authors included the results of the sample observation highlighting sustainability approaches, food policies and procurement characteristics. Moreover, Section 4 includes the collection and the characteristics of the clusters observed by sample investigation focusing on lengths of school days per year and average cost per meal in euros per day and the analysis of the environmental performance achieved by some European countries, in terms on GHG emissions reduction.

Finally, in section 6 they presented the concluding remarks, limitations, including managerial implications and possible further research trends.

Figure 1: Roadmap of the paper structure



Source: Authors' elaboration.

METHODOLOGY

Area investigated

With the aim to address the objectives of the current paper, the authors scrutinized scientific literature, technical reports and data related to public management sector. Particularly, they analyzed the school canteen service provided to European students following Neto and Caldas (2018) methodology, including the Italian ones: hence, they matched

different sources of data and information with the aim of providing a general and more representative framework, despite having few studies available in the literature and analyzing a recent topic.

Therefore, to address the objectives of the study and specifically in order to select the area investigated - as basis for analysis, since it is not easy to analyze all the European countries and their cities due to their large number, the authors of this paper followed a punctual methodology:

a) Firstly, they used a quantitative analysis with the aim of identifying the most analyzed European Countries by scientific literature.
b) Subsequently, they identified 384 documents published in the last ten years focused on the topic of school canteen service (using the following query on Scopus platform *"school AND canteen AND service"*) and in line with the main topic considered by the authors of this paper.
c) Thirdly, they adopted an exclusion criterion, limiting the analysis on the 384 articles previously identified, and excluding reviews (6), book chapters (2), book (1), conference paper (1).
d) Thereafter, they contemplated some areas of analysis, in line with the topic of the study, such as: Environmental Sciences (58), Agricultural and Biological Sciences (42), Social Sciences (25) distributed on 164 papers.
e) Finally, the authors of this paper considered exclusively the following areas in the European countries, such as Italy, Spain, Sweden, United Kingdom, Portugal, Netherlands, Finland, due to the greater number of scientific products, equal 95 articles. Precisely, this sample that includes 95 publications was not considered to carry out a literature review – given that it is not the principal goal of this study - but rather to build a sample of European geographical areas of greatest interest for studies and developing the research question.

Furthermore, with the aim of focusing on the holistic approaches used by Italy and its public administrations, main area of interest of the authors of this study involved in the GRINS - PNRR project[1],

a) they refine the bibliometric analysis defining another general query ("school AND canteen AND service") and setting the following keywords: “school AND canteen AND service AND Italy AND LCA”.
b) After collecting the results returned by the search, they analyzed the unique four papers published, three in in 2018-2019 and one 2024, in line with the main topic of this study, that focused on the use of Life Cycle Assessment (LCA) approach in the supply chain of school canteen service in Italy. Particularly, the papers have been elaborated by Cerutti et al. (2018), García-Herrero et al. (2019), Mistretta et al. (2019) and recently by Campobasso et al. (2024).
c) Conversely, using “school AND canteen AND service AND Italy AND LCC” not emerge studies on the application of the Life Cycle Costing (LCC) approach in the Italian context of canteens.

d) The unique published study that consider these two approaches, LCA and LCC, in combination for analyzing the food waste at school, focusing the environmental and cost impact of a canteen meal was developed by García-Herrero et al. (2019).

Accordingly, the authors of these selected papers (European and Italian sample as shown in Table 2) focused to environmental sustainability approaches, food policies and public procurement programs adopted by the schools. Particularly, within this analysis the authors of this paper focused on Italian case since this represents the country with the highest numbers of studies, equal to 30 and the main area of interest of the authors of this study involved in the GRINS - PNRR project.

Table 2: Sample of European countries most considered by scientific literature (2020-25)

Country	Number of publications
Italy	31
Spain	18
Sweden	14
Portugal	11
United Kingdom	8
Netherlands	7
Finland	6
TOTAL	**95**

Source: Authors' elaboration.

Lastly, with the aim of integrating the sampling previously conducted with data from the literature, some school canteen management plans related to some countries already present in the sample just mentioned were consulted with the aim of creating a critical mapping and being able to conduct comparisons. Finally, this method addressed the objective related to the Table 3 building.

Data

The authors gathered several data, after consulting reports, websites, papers, on school procurement service at European level, with a focus on Italian school canteen service, with the aim to present a snapshot of similarities and differences in public management models in school canteens services. Particularly, this study aims to compare the models of school canteen services adopted by some local authorities and the environmental per-

formance achieved, outlining the reduction of GHG emissions documented by some European countries. Therefore, with the aim to address the objective of this paper, the authors matching several data as previously detailed. Particularly, through the consulting of the technical reports published by Piirsalu et al. (2022), used firstly for the kind of observed variables and, after for the punctual data included for some European school canteen services, the authors of this paper considered for each Country and the related Municipality, the Sustainability Approach adopted and, in particular, the environmental one, the Food policies and the category of Public Procurement program adopted by public authorities.

Subsequently they contemplated the lengths of school year (days), the number of states/public schools and kindergartens, the number of students in schools and children in kindergartens who use the canteen service, the average cost per meal (indicated in euros).

Lastly, the authors of this paper collected other data and information related to the countries aforementioned with the aim to conduct a critical selection of information, extend the sample to a reasonable number of observations and conduct comparisons.

Through this frame of information collected, the authors compared the practices adopted by a sample of European countries for showing the improvements achieved in school canteen service chain.

Method

For this purpose, the authors followed the methodology proposed by Neto and Caldas (2018), examining the GPP schemes for those EU Member States that include environmental criteria in public procurement of food products and catering services or publish guidelines for this purpose and that were analyzed in the report by Piirsalu et al. (2022). Particularly, this analysis aims to display the progress achieved towards greater sustainability of procurement for school canteen service.

In this paper, two main categories of procurement models have been included, in particular the centralized procurement model and the decentralized procurement model have been observed with respect to the environmental sustainability approaches adopted **(H1)** and the possibility of supporting the reduction of environmental impacts **(H2).** Methodologically, considering some European countries such as Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Italy, Spain, Sweden, the authors of this paper focused on some local school canteen services provided by local institution. The choice of cities and educational institutions was inspired by Piirsalu et al. (2022). This analysis focused on the approaches that the different local administrations adopted for the distribution of hot meals in school and kindergartens: the comparison carried out is useful to highlight the differences in management, efficiency and effectiveness in management, good practices and attention to sustainability. In terms of novel approach, this study offers the opportunity of understanding the positive/negative effects of one category of procurement rather than another.

Furthermore, from the perspectives of the models considered, five ideal categories of governance have been included in the literature, distinguished in:

1. centralized governance,
2. decentralized governance,
3. public-private governance,
4. interactive governance and
5. self-government (Driessen et al., 2012).

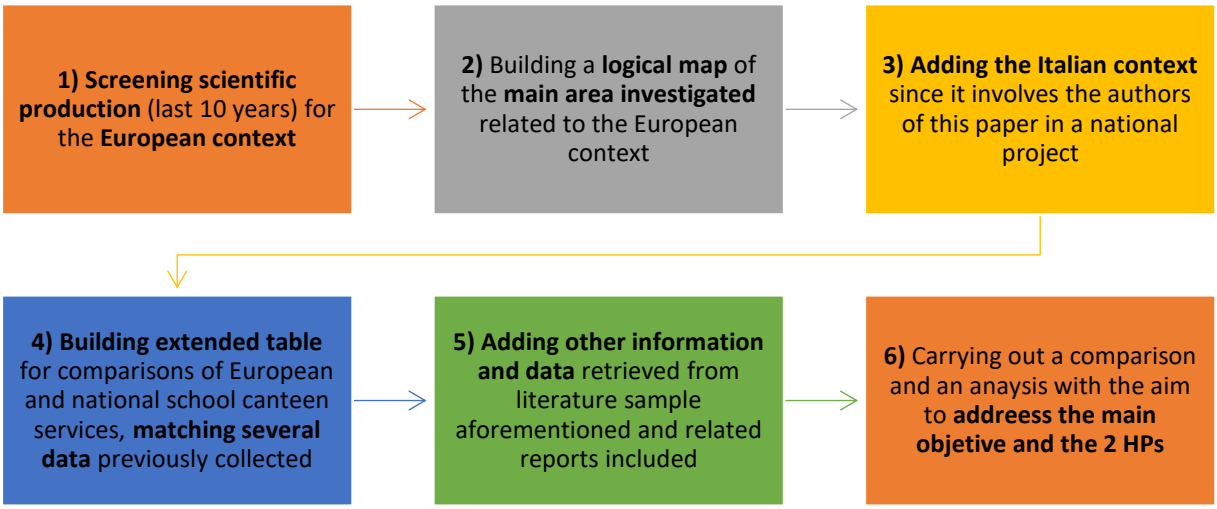
However, although there are different classifications of governance models, in this article the authors focused on centralized and decentralized public procurement model. Hence, the current study aims to:

1. examine the models of canteen services provided in a sample of European countries, from primary and secondary schools (Table 3); and
2. determine if compliance with the adopted sustainability policy has improved the sustainability profile of school catering service menus (Tables 3-4-5).

In conclusion, after the analysis of the school canteen services provided by some European local authorities, the authors of this paper investigated:

1. the procurement models adopted,
2. the environmental sustainability approach adopted in support to the reduction of environmental impacts.

Figure 2: Steps for the methodology used for sample building and observation



Source: Authors' elaboration.

In conclusion and under these evaluations, this study aims at exploring the environmental sustainability approaches linked with the management of public canteen services for school students, by carrying out a comparative analysis of a sample European countries and focusing on some Italian schools (General Research Question). Therefore, this application provides new insights for environmental management in public school canteen services and proposes further suggestions to public administrations involved to manage an efficient green public procurement, delivering healthy and sustainable meals. Thus, this

study, replicable for other contexts, provides innovative viewpoints to manage production and supply chain of public-school canteens, to build a more sustainable, resilient future and address the SDGs.

LITERATURE REVIEW, HYPOTHESES DEVELOPMENT AND CONCEPTUAL FRAMEWORK

To-date, numerous regulations are stimulating the adoption of new integrated approaches of public procurement school canteen services, with the aim of achieving greater levels of sustainability (Bizarro and Ferreiro, 2022) although the environmental sustainability of this context emerges in few studies included in indexed scientific literature.

Particularly, using the following queries on Scopus platform:

a) "school AND canteen AND sustainability AND environmental",
b) "school AND canteen AND service AND sustainability AND environmental",
c) "school AND canteen AND service AND sustainability AND environmental AND Europe",
d) "school AND canteen AND service AND sustainability AND environmental AND Italy"

were identified respectively by 35, 22, 1 and 4 papers.

For these reasons, with the aim of filling the gap related to this topic - as emerged by aforementioned quantitative analysis on Scopus - and providing current insights on sustainability in school canteens, the authors of this paper developed a replicated method of analysis.

Overall, this paper carried out an exploratory study that analyses the use of environmental sustainability criteria in public procurement of school catering services in the EU context. Consequently, through the analysis includes in this paper, the authors compared the environmental best practices adopted by different European countries in order to presents the outcomes related to different school meal delivery models. Within the European system of school canteens, the authors of this paper selected the Italian context because this has aroused more interest and has been considered by most of the published scientific studies.

Considering that the literature review purpose is to organize and identify models, best practices, innovations in articles already published recently, the authors of this paper provided a snapshot of current evidences (Noguchi, 2006; Sönnichsen and Clement, 2020). Therefore, in order to provide a literature review related to the topic investigated for presenting the recent marks related to environmentally sustainable public procurement in school canteen services, the authors of this papers analyzed a sample of the scientific publications edited in the last ten years for the European countries, using the as abovementioned platform such as Scopus. It emerged a fair amount of studies focused on public procurement, canteen services and environmental sustainability.

Generally, sustainability is considered as strategic in public procurement and fundamental lever for promoting sustainable development of the economy, processes and administra-

tions. Generally, as also Campobasso et al. (2024) underlined, the scientific literature investigated the environmental and socioeconomic dimensions of sustainability in the food sector, in any case focused on technological, energy, and nutritional assessments.

For these reasons, this study aims to make a contribution in this direction, thus helping to further enrich the scientific literature currently available on environmental sustainability along the school canteen service chain.

For research contextualization reasons, consistently with the aim and scope of this study, the authors carried out a review of different sustainable approaches in public procurement named Green Public Procurement (GPP), sometimes Sustainable Public Procurement (SPP). That was done by the authors to provide a synthesis of the specialized literature, with the aim of creating a valuable sample of articles in line with the topic considered. Therefore, the authors of past publications used the GPP approach when they mainly focused on supporting environmentally sustainable consumption and production models, conversely, SPP considered a more extensive approach including environmental, social, health, socio-economic aspects in procurement, as underlined by Molin et al. (2021).

Moreover, technically GPP is used for purchasing services and products in the public sector with a reduced environmental impact. Nonetheless, the purpose of the GPP is also to implement sustainability at a broader level (economic, social and environmental) in public procurement, such as the food sector and public-school canteens, analyzed in this study.

For this reason, GPP is also used as keyword in several combination, matching the following others as European countries AND Public-school food procurement (PSFP) AND canteen AND service, AND environmental AND sustainability on two platforms (Scopus and WoS) and analyzing the studies that are most relevant to the topic of the proposed study.

For completeness of information, in this study, the authors focused just on environmental sustainability with the aim to present best practices and level of reduction of GHG emissions in the context of school canteen services provided in public schools.

After these considerations, the authors presented the results of the literature review. The authors performed the bibliographical search in all fields of Scopus with the aim to achieve a high scientific impact for this article, and presented the results.

Overall, as emerged in literature, to-date food procurement system in public schools represents a key factor for the sustainable policies that the national governments are adopting for the transition towards sustainability. However, despite this reason, policy makers and public administration should design sustainable models that support the use of short supply chains, characterized by local producers and organic production (Tregear et al., 2022).

Analyzing the scientific production according to the geographical observation approach, and focusing on the European level, it was found that Chiaverina et al. (2023) analyzed the French public administrations considering the linkage among nutritional quality and carbon footprint of school menus delivered in 2020 in more than 10,001 Parisienne municipalities. Likewise, in 2022 Tregear et al. (2022) analyzed the primary school catering service provided in five European countries, with the aim of comparing different models

of school meal provision considering the environmental, economic and nutritional aspects. The results showed that carbon emissions can be reduced from 0.95 kg CO_2-eq. to 2.41 kg CO_2-eq. per meal by adopting low-carbon food waste disposal methods and by reducing the amount of ruminant meat on menus, which is responsible for large part of the emissions. In terms of policies adopted, Góralska-Walczak et al. (2023) shown that level of education and place of residence influence knowledge and awareness of environmental, biological and nutritional issues. Particularly, it was found that an appropriate education program provided to policy makers and managers on public procurement and food service sectors makes benefits for designing green, sustainable and less environmental impact procurements. Moreover, considering that Public School Food Procurement (PSFP) represents a key factor in food and nutrition security, over the last decade, scholars and public institutions are planning sustainable food procurement in schools that include the use of organic foods, specially to ensure a good level of health of young people users of canteen services (Filippini et al., 2018).

Furthermore, with the aim to ensure a greater achievement of environmental sustainability, such as the reduction of greenhouse gas emissions, food waste, waste water, etc., it has emerged that the involvement of the canteen committee represents a fundamental lever in the school catering service chain (Galli et al., 2014).

Matching other words synonym as Green Public Procurement (GPP), Public-school food procurement (PSFP), canteen, environmental and sustainability on two platforms such as Scopus and WoS, and analyzing the most relevant studies on the topic of the proposed study, it emerged the influence of GPP approach in food products sector and, in particular, in catering services (Neto and Caldas' 2018).

Additionally, despite the limited interest in literature on the topic as underlined in the above sections, the Italian context has been analyzed considering other approaches close to: environmental dimension of the school canteen service, environmental sustainability as declared by Agenda 2030 (UN, 2016), combined analysis of sustainability of school canteens according to holistic approaches that fall within Life Cycle Thinking, such as LCA (Life Cycle Assessment).

Furthermore, amongst the scholars it was found that García-Herrero et al. (2019) used LCA and LCC (Life Cycle Costing) in combination to estimate environmental impacts and cost of food provided in a school canteen, focusing mainly on some Italian schools.

In the same year, De Giacomo et al. (2019) studied some public institutions located in different countries to evaluate the linkage between GPP and LCC approaches. However, the same authors revealed that GPP is crucial to introduce the general life cycle approach in public procurement. Also, Barbini et al. (2020) supported the adoption of sustainable products in public projects. Especially, the authors considered GPP as key element to identify environmental and economic impacts of construction products, but also as a reference for other project phases such as operation and end of life. Subsequently, Pouikli (2021) described the hypothetical transition of public procurement as policy tool for promoting a green and inclusive growth (UN, 2016). Subsequently, Fregonara et al. (2022) emphasized the importance of LCC use and total CO_2 emissions quantification to estimate global costs in public procurement according to a sustainable perspective.

Recently, Orfanidou et al. (2023) highlighted the benefits related to the green products purchase in public procurement and the LCC implementation in a long-term perspective, focusing on the Hellenic context. Finally, the recent study published in 2024 by Campobasso et al. investigated the environmental burdens related to a local canteen for university students, performing comparative LCAs of a series of meal combination scenarios offered to consumers on a weekly basis.

For completeness of the literature analysis, these holistic approaches aforementioned (LCA, LCC) have not been considered in this first study because they will be the subject of future application studies that some authors are conducting.

In the modest published literature, in addition to holistic approaches for assessing the sustainability, past scholars have also considered some procurement models. Particularly, Ferraresi et al. (2023) highlighted that the centralization of procurement (managed and implemented from headquarters) could reduce inefficiencies linked to corruption and therefore achieve a reduction in public spending.

Furthermore, at Italian level, centralized purchasing centers for goods and products have already been in place for several years. This is the centralized body, named "Consip", where public administrations can proceed with centralized purchases (Best et al., 2017). Furthermore, "Consip" - the first central purchasing body in Italy – represents the first best practice in Europe that receive the ISO 9001:2008 quality certification for the purchasing processes of goods and services.

However, despite this modest scientific production, this section is useful to improve the contextualization of the problem, to establish a basis for research, demonstrating how the current scientific interest presented by the authors diverges or fills the gaps of previous studies. Through this section it is also possible to support broad discussions on the public management of canteen services and environmental sustainability, providing new insights or perspectives to these debates.

Considering the methodology approach, the authors of this paper followed Neto and Caldas (2018) and reviewed the sustainability approach for EU Member States that included environmental criteria within the public catering services or publish guidelines/technical sheets to that purpose. In addition to this, speaking always at the methodological level, the authors followed Friedländer and Kersting's approach who in 2022 proposed an exploratory study to analyze scope, drivers, benefits but also limitations in the research field investigated, addressing some approaches, practices and perspectives in the same way (Friedländer and Kersting, 2022).

Hence, the research is based on the following two hypotheses derived from general research question proposed at the end of Methodology section. Particularly:

(H1) The lack of a legal framework on sustainable development policies prevents the adoption of environmentally acceptable approaches and practices,

(H2) The use of a centralized or decentralized procurement model encourages the adoption of innovative sustainability approaches.

RESULTS

In this section the authors presented step-by-step the results from the whole assessment carried out.

Use of holistic approaches (LCA, LCC, ELCC)

From a general review of the literature on the general topic it was found that governments and local public administrations, responsible of school canteen services, can assess environmental impact, food consumption costs and food waste in the public-school canteens by applying LCA, Environmental LCC and visual waste assessment (García-Herrero et al., 2019).

In this context, along this service delivery chain, each phase can be analyzed, from ingredient procurement to waste management, identifying environmental impacts, costs and food waste (García-Herrero et al., 2019). Particularly, the comprehensive food production phase generates an impact on the environment equal of 70% (Mistretta et al., 2019), and the most quantitatively relevant influence is due to the use of animal-based foods (especially by read meat) and the use of energy for food preparation (García-Herrero et al., 2019). Furthermore, the second point along the service chain that accounts high impacts is represented by food preservation and cooking phases. In fact, the energy used for cooking and preserving food (heat and electricity) is a significant share of the overall impact on global energy demand and global warming (Mistretta et al., 2019). Instead, food transport generates a high impact in terms of photochemical oxidation equal to 5% (Mistretta et al., 2019).

In addition to this, speaking always at LCA level, Mistretta et al. (2019) analyzed different scenarios and potential strategies to improve the environmental sustainability of the food service and of the food supply in general (Mistretta et al., 2019). Moreover, by integrating the LCC analysis is possible to highlight the most expensive phases, which as emphasized by the literature and is linked to the cost of labor for meal preparation (García-Herrero et al., 2019).

Therefore, as supported by the literature, even if limited, the opportunity to integrate the different analytical tools (e.g. LCA, LCC) provides the basis for designing and evaluating the improvement actions carried out by different public canteens at different levels (García-Herrero et al., 2019).

In spite of this, the reductions of environmental impacts and costs can be achieved by introducing some changes in meal composition and preparation, analyzing policy frameworks, promoting a better balance between environmental, nutritional and budget variables, and considering the cooperation with other figures with the aim to prevent and reduce food waste (García-Herrero et al., 2019).

Finally, the constant stakeholders' involvement supports the public managers to monitor progress and disseminate possible future improvements at any time (Lagorio et al., 2018).

Models of school canteen services

Focusing on a sample of countries located in European area, as shown in Table 3, it was found an expanded context of public management for the school meals provision. Particularly, starting by Piirsalu et al. (2022) report focused on the procurement and distribution of meals in schools, it emerged several differences amongst the countries included in their application, such as Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Italy, Spain and Sweden.

Analyzing sustainability approaches and food policies adopted at country level, several European member states promoted the use of organic products in school canteens. Particularly, some Northern Europe countries, such as Denmark and Sweden, introduced some measures to increase the consumption of organic products by proposing a political strategy (Daugbjerg, 2023).

Actually, as emerged from Table 3, in the Danish and Austrian schools, for example Vienna and Copenhagen local authorities promoted organic food consumption. Amongst this policy, it is served almost 90% of seasonal organic food in Denmark and almost 30% in Austria. Moreover, public schools located in Ghent and Leuven, in Belgium, adopted a food policy focused on organic products, vegetarian options and seasonal food.

Instead, the preparation of meals can take place differently, even if centralized procurement has been adopted at a local level by many member countries. In Vienna, schools' meals are prepared in centralized kitchens, where food is cooked, chilled and delivered to schools. Conversely, in Tallinn schools procure their own catering and the purchasing processes are centralized at the level of several schools.

Moreover, the authors of this paper underlined also the municipalities that use a digitalized approach into procurement process. Particularly:

a) in some Belgian schools is used an open and digitalized procurement procedure,
b) in some Danish school the process is completely digitalized,
c) in Estonia some educational institutions preferred open and fully digitalized procedure, in France the centralized[2] procurement.

Moreover, some decentralized[3] procedures can be digitalized: among these,

a) Dordogne municipality, in France, used an open procurement and digitalized procedure.
b) Conversely, in Germany the procurement process chosen is decentralized, organized by school and not digitalized.
c) Contrariwise, Italian schools, such as those in Milan municipality, must use minimum environmental criteria (MEC or in Italian CAM) established by the Ministry (MASE, 2024) and it is forbidden the use of the lowest price as criterion for awarding contracts.

Moreover, Belgian schools preferred business-to-business (B2B) platforms to organize the procurement process for purchasing dairy products through supplier platforms. In particular, the city of Ghent brought together food producers and farmers in an online shop, determined selling price provided for ordering, delivery and payment flow and managed the logistics. This approach gave the city access to more producers, allowing chefs to

propose more creative menus and allowed producers to sell their short supply chain products directly through the platform and deliver them to centralized catering and kitchens (Defranceschi et al., 2023).

Sustainability approaches and food policies adopted

Analyzing and comparing data included in Table 3, focusing on Italian clusters, it was found that food programs objectives adopted in Italy, for example by the municipality of Milan, are derived from a public consultation covering the following five priorities related to food policy:

1) ensuring healthy food and water for all citizens,
2) promoting sustainability of the food system,
3) promoting food education,
4) fight against food waste and
5) supporting scientific research in agri-food sector.

Particularly, the contractor company of the Milanese canteen schools service is committed to raising awareness in schools on the topic of nutrition and encouraging the consumption of fruit mid-morning in primary schools.

Instead, Fano, in the Marche region, adopted some good practices:

6) energy saving interventions in school kitchens and
7) use of micro-filtered water dispensers.

Specifically:

a) contracting authorities must require contractors to commit to replacing existing lamps in all kitchens with latest-generation CE-certified LED lamps and to install infrared motion sensors in areas less frequented by staff and,
b) in order to reduce and remove plastic and packaging associated with the consumption of bottled water, the city has introduced refectories equipped with water dispensers with a certified filter.

Furthermore, in nurseries, mineral water supply is provided only in glass bottles - no plastic bottles are allowed. Lastly, this city located in the Marche region, also added ambitious organic requirements for the meals offered, including the use of 100% organic jam, cereals, flour, fresh fruit, milk, legumes, extra virgin olive oil, pasta, tomato sauce, eggs, fresh and frozen vegetables, fruit juices, yogurt, and at least 50%, by weight, of the beef from organic production, in accordance with EC Regulation No. 2007/834 and its implementing regulations.

Always speaking at Italian level, and in particular for the island level, in Sardinia, in particularly for the Nuoro municipality, food represents a communication tool to convey social and cultural values. To this end, the technical specifications used to contract the school catering service require that the contractor propose eight thematic menus with DOP and IGP products (i.e. Protected Designation of Origin and Protected Geographical Indication) (Defranceschi et al., 2023). At the same level, Czech Republic considered the integration of food education fundamental in the context of school canteen service.

Furthermore, in terms of the use of environmental impact indicators, data included in Table 3 underlines that Czech Republic, Denmark, France, Germany and Italy assessed the environmental impact through some indicators such as GHGs emissions and CO_2 quantification.

Instead, almost all the countries included in the sample consider a short supply chain approach to be fundamental, to promote the use of local production and at the same time reduce the environmental impacts associated with the transportation of raw materials.

Table 3: Results of sample investigated for European school canteen services in the context of public procurement

Country	Sustainability approach	Food policy	Public Procurement program
Austria	• Smart City Strategy and Klimafahrplan based on **SDGs of the UN Agenda 2030**	• food action plan 30% of organic food	• **centralized within the municipality** • food prepared in centralized kitchens and delivered to schools
Belgium	• Mandatory technical specifications as award criteria • Promotion healthy and sustainable food • **sustainable agriculture** • preventing food loss and re-use of surpluses	• promotion of organic products, vegetarian and plant-based options, seasonal foods • use of labels • minimization waste and food waste • food policy (Food Connects) • promotion use local small-scale farmers • reduction of animal-based food/protein • short supply chain	• food purchases centralized within the municipality • open and digitalized procurement procedure • each school procures food and catering through tenders
Czech Republic	• **No legal framework of the policy governing for sustainable development** • short supply chain • use of organic ingredients • support local small-scale farmers • SMEs and seasonality • **CO_2 quantification**	• **No legal framework of the policy governing food procurement** • non-binding recommendations for school food providers • use fresh, seasonal and regionally sourced ingredients • integrating food education	• no public procurement by the municipalities • each school manages the meals and is responsible for its own procurement • **school food procurement decentralized**
Denmark	• Food and **sustainability policies** • goals for climate protection • promotion use organic food • less food wastes • healthy meals for all citizens • gold food seasonal 90-100% organically grown • climate-friendly lunch focus on food waste use • low carbon emission transportation • **GHGs indicators**	• mandatory environmental/social criteria (organic food, vegetarian and plant-based options, free-range animal products, seasonal food, and	• **centralized within the municipality** • process completely digitalized • two different models for school meals food schools: - prepared in large on-site production kitchen) - Eat School Meals (produced in large central kitchen)
Estonia	• **No legal framework of the policy governing for sustainable development** • mandatory (national/regional) environmental/social criteria • food waste reduction indicators	• **No legal framework of the policy governing food procurement** criteria for food education activities (for pupils and kitchen staff) • increasing rate of organic ingredients in school meals, seasonality, environmental impact of food procurement	• schools procure catering service themselves • **procurement processes centrally for multiple schools at a time** • open procedures and fully digitalized
France	• **Sustainability aspects** of the procurement process during market analysis • promotion health and sustainability • **mandatory environmental and social criteria** • use of labels of quality, origin and organic farming • tender documents for using plant-based options • free-range animal products • eco-friendly cleaning products • low carbon emissions transportation • solutions to food waste from the contractors • ECOCERT label • 100% organic and local products • systemic approach for connecting real "nutritional" needs of school canteens with local food production • planning phases of inter-organizational procurement, qualification criteria and technical specification • use of eco-friendly cleaning products • low-carbon transportation • minimization waste • **measuring environmental impact of food procurement (CO_2 quantification)**	• **No legal framework of the policy governing food procurement** • two vegetarian meals each week - one entirely vegetarian option daily in schools • meals typically pre-cooked and served later as a hot meal increase of local products and shorten supply chains • increase its share of organic products to 75% and local supply to 50% by 2026 • all meals cooked with raw materials • seasonality of the products • promotion of nutritional aspects of the meals • reduction salt and sugar in meals using more spices • preference for local and organic products, organic foods, vegetarian and plant-based options, free-range animal products • promotion seasonality of foods	• **municipality owned centralized kitchens** used and managed by private center cooks and delivers meals to schools • each school has its canteen where meals cooked freshly every day • **food supply in schools decentralized** - each middle school manages procurement according guidelines set by the Department. procurement procedure open, • digitalized and lower than the national threshold • promotion of health and sustainability criteria in procurement process

Germany	• local small-scale farmers and SMEs • seasonality • **measuring the environmental impact of food procurement (CO_2 quantification)** • **GHGs indicator** • organic ingredients • local small-scale farmers and SMEs • seasonality • reduction of animal-based food/protein shift, measuring environmental impact of food procurement (e.g., **CO_2 quantification**) • shortening supply chain	• **No legal framework of the policy governing food procurement** • vegetables, vegetarian alternatives, fruit and available twice a week at afternoon snack time • cold meals, such as sandwiches, available on request for excursions • regional, seasonal and ecological food in all schools and kindergartens • integration of local farmers and producers and improve logistics	• **municipality's centralized kitchen** and distributed by an affiliated in-house catering company • each school responsible for organizing its own catering service • **procurement decentralized and organized** by school or public-private partnership company that manages the school • procurement processes not digitalized • municipality recommendations for tender and procurement process
Hungary	• sustainability requirements in tenders in technical specification • seasonality • opportunities for local small-scale farmers and SMEs • measuring environmental impact of food procurement • shortening the supply chain	• **No legal framework of the policy governing food procurement** • EU-funded FOODCLIC project • DIVINFOOD project • two meals served - main meal for lunch, and a snack in morning or afternoon • education of animal-based food	• provider of catering services in schools financed by the municipality and parents • food service provider must procure food and related services • **centralized food supply within the municipality** • procurement fully digitalized and open procedure
Italy	• health and sustainability promoted in tender documents • mandatory (national/regional) environmental/social criteria • organic and seasonal food • labels and use of energy-efficient equipment environmentally friendly cleaning products • small farmers • low carbon transport activities • environmental impact assessment **GHG**s)	• school meal includes a hot or cold lunch and an afternoon snack • program for offering mid-morning fruit that the schools can implement voluntarily • no breakfast offered • in kindergartens provided meals: hot lunch and afternoon snack	• school meals provided by a municipal-owned catering company (municipal agency for school canteens) company responsible for procuring food • **some schools have an internal kitchen, others served by a centralized kitchen** • partner service provider has 24 external cooking centers and 81 kindergartens have an on-site kitchen • use Italian Public Contracts Code • minimum environmental criteria (CAM) • prohibition on using the lowest price as a criterion for awarding contracts.
Spain	• rate of organic ingredients • opportunities for SMEs • measuring the environmental impact of food procurement • shortening the supply chains	• 20 different menus reviewed periodically • prevention, control of overweight and obesity in children and adolescents • reduction of animal-based foods • special or alternative menu for health, religious or cultural reasons	• each school procures its own food and catering and establishes terms of tenders considering national and regional requirements • at least 40% fresh seasonal fruit and vegetables • organic products in a percentage equal to at least 3% of total purchase • menus adapted for specific intolerances, etc.
Sweden	• school restaurant plan, prepare, cook and serve meals, • reduction of the overall impact of the food minimization of the footprint of food production in the region and country local small-scale farmers and SMEs • measuring the environmental impact of food procurement, • Shortening the supply chain	• more plant-based menus • nutrition according to the recommendations of the Swedish Food Agency • meat and fish on the menu once or twice a week and vegetarian meals at least twice a week • breakfast, lunch and afternoon snack in both schools and nursery school • Reduction of animal-based food	• centralized procurement • digital food procurement managed by the city's procurement unit • meals prepared and served in schools or in centralized catering, in a centralized kitchen within the municipality

Source: Authors' elaboration on data Piirsalu et al. (2022), Smart City Strategy Vienna (2022), Defranceschi et al. (2023), Unica - Scuola in Chiaro (2025) and sample developed by the authors of this paper.

Legend: Smart City Strategy and Klimafahrplan model and strategy used in Austria in the city of Vienna for becoming a model climate city, SMEs = Small and medium-sized enterprises, ECOCERT Label= French organic agricultural products certification label, FOODCLIC project= EU-funded project (2022-2027) for an integrated approach to transform urban food environments and food systems, DIVINFOOD project= funded from EU's Horizon 2020 research and innovation program with the aim to develop food chains that value under-utilized agrobiodiversity, CAM= criteri ambientali minimi (minimum environmental criteria)= environmental requirements with the aim to identify the best design solution, product or service from an environmental perspective throughout the life cycle, taking into account market availability.

For completeness, methodologically, the sample observed and included in Table 3 is not representative of all the administrations and provinces located in the territory but only of a part, as indicated in Table 4 within which the observed clusters are indicated. However, the sample covered by Table 3 represents the most important best practices adopted by the representative countries of the sample.

Table 4: Collection and characteristics of clusters observed by sample investigation

Country	Lengths of school year (days)	Average cost per meal (euros/day)	Cluster observed
Austria	180	4.133/day	Vienna
Belgium	175	5.55/day (children) 6.55/day (students)	Ghent (EF) (North West)
	182	n.a.	Leuven (BF) (Est)
Czech Republic	n.a.	1.20/day	n.a.
Denmark	200	3.00/day (for school) 4.00/day (for children)	Copenhagen
Estonia	175	1.56/day (for student) 1.90/day (for children)	Tallin
France	140	7.30/day	Lyon
	180	8.00/day	Dordogne
Germany	200	4.00/day (for student) 2.70 (for children)	Essen
	190	4.80/day	Nuremberg
Hungary	180	1.27/day	Budapest
Italy*	200	4.23/day	Milan (North)
	200	3.79/day	Fano (PU) (Central)
	200	3.75/day	Nuoro (NU) (Islands)
Spain	181	3.68/day	Valencia
Sweden	200	0.96/day	Malmö

Source: Authors' elaboration on data Cittadinanza Attiva (2020), Piirsalu et al. (2022), Smart City Strategy Vienna (2022), Defranceschi et al. (2023), Comune di Fano (2024), Unica - Scuola in Chiaro (2025) and sample developed by the authors of this paper.

*Italy: rate for meal/day calculated based on the indicator of the economic situation of the family unit. In table the average value.

Particularly, according to data included in Table 4, related to a greater specification of the organizational characteristics that public management of school canteens must observe, it emerged some differences: in the length of the school calendar, and in the unit cost of the meal, considering a minimum of 140 days in Lyon in France and a maximum of 208 in Sweden, with a minimum of 0.96 euros/day in Czech Republic and a maximum of 8 euros/day in France in Dordogne. However, for simplification of the analysis, the average values considered is equal to: for the average lengths of school year (in days) 183 day, and for the average cost per meal is equal of 3.82€/day/student. Clearly these differences affect organization, cost management and related environmental impacts.

Environmental performance

After presenting the overview of the policies adopted by the sample of school located in the European countries for the food canteen services, as shown in Tables 3 and 4, the authors of this paper assessed some good practices implemented with the aim to observe improvements in environmental performance achieved over the years since certain specific mitigation measures were implemented.

Firstly, it emerged that food supply provided according to sustainability criteria included a variation of criteria that range from the share of organic food to the use of specific quality labels (Piirsalu et al., 2022).

Particularly, these approaches were documented in some schools in Czech Republic, Denmark, France, Germany, Italy, Spain and Sweden (Table 3). Furthermore, the Swedish municipality of Malmo achieved 40% reduction in GHGs emissions (Table 5).

Moreover, several local authorities promoted a climate-friendly lunch, such as Leuven in Belgium, Copenhagen in Denmark, Lyon and Dordogne in France, Essen and Nuremberg in Germany, Budapest in Hungary, Milan, Fano and Nuoro in Italy, Valencia in Spain and Malmö in Sweden. Others authorities, such as Leuven in Belgium, Copenhagen in Denmark, Dordogne in France and Tallin in Estonia, encouraged the use food waste reduction approach.

Contrariwise, the quantification of environmental impact of food procurement is adopted by Czech Republic (CO_2 quantification), Copenhagen and Milan (GHG emissions indicator), Dordogne, Essen, Nuremberg (CO_2 quantification), Tallin (food waste reduction indicator). Moreover, Malmö in Sweden measures the environmental impact of food procurement at general level, on the contrary, Valencia in Spain does not evaluate the environmental impacts of its purchases.

Table 5: Snapshot of environmental performances achieved by some countries

Country	Municipality	t_0 (year)	t_1 (year)	Reduction (CO_2 %)	Policy	Source
Italy	Milan	2015	2021	42.89	+ legumes, + recipes with cereals and vegetables, extra virgin olive oil, -red meat, zero plastic, short supply chains	Comune di Milano (2023)
Sweden	Malmö	2020	2022	40	serve portions desired by student use leftovers as ingredients for other meals the next day	Malmö Stad (2023); Sundin et al. (2023)
France	Marseille and several French municipalities	2020	2022	14-19	+ vegetarian meals, + alternating meat and fish with vegetarian "protein dishes"	French School Canteen Service (2020); Poinsot et al. (2022); UNESCO (2022)
Denmark	Copenhagen, Ghent	2010	2022	15	- food waste, + organic food, - animal protein, shorter food supply chains, reduced transport, + plant-based diet	Nordman et al. (2024); Ruge et al. (2023)

Source: Authors' elaboration.

Finally, through the assessment of data includes in Table 5, the authors carried out a comparison of some best practices adopted by Italy, Sweden, France and Denmark in the context of a centralized procurement for the provision of school meals as shown in Tables 3 (column Sustainability approach, Food policy and Public Procurement program) and Table 4. The investigation shown that sustainability approaches, food policies and, in any case, particular innovative elements in the purchasing and procurement process, allowed a reduction of environmental impacts from 14 to 43%. Particularly, the schools placed in the municipality of Milan in Italy documented the best performance in reduction of emissions (43%) within 6 years, the lowest reductions were recorded by France (14-19%) within 2 yeas.

Thus, the municipality of represented the most sustainable canteen that reduce environmental impacts in 6 years more than other members[4] in Europe: this service has emitted 5.92 $kgCO_2$-eq. for every 1,000 kcal cooked, compared to a European average of 10 $kgCO_2$-eq. and an international average of approximately 25 $kgCO_2$-eq. (Comune di Milano, 2023). Moreover, in 2024, the 70% of menu organic and 32% of the products provided used kilometer zero ingredients and processed foods (Comune di Milano, 2024). Instead, the Swedish city of Malmö documented a reduction of 40% in 2022, compared to the 2020 level (Malmö Stad, 2023). Conversely, for France and Denmark the scholars

- authors of the current paper - observed a low reduction level respect Italy and Sweden, respectively equal of 14-19% and 15%.

Lastly, after compared data included in Table 4 with data included in Table 5, the authors of this study underlined that probably a centralized school canteen procurement allows to reach good levels of emission reduction. Particularly, the reductions demonstrated by Italy, Sweden, France and Denmark are from 14 to 43% (Table 5). Specifically, these results reply to hypotheses 1 and 2 formulated at the end of the methodology section.

Furthermore, compared with literature outcomes, the reduction of meat consumption, consistent with the nutritional needs of a balanced and varied diet, could significantly contribute for improving the environmental sustainability of the school catering service (Mistretta et al., 2019). Hence, public administrations involved in the procurement of school canteens can support the use of renewable energy technologies and/or the purchase of energy-efficient household appliances, to improve the environmental sustainability of the food sector and, in a broader perspective, to achieve the EU's energy and climate objectives (Mistretta et al., 2019).

However, as Mistretta et al. (2019) stated, the adoption of local food sources would significantly reduce the environmental impacts of the transport phase.

For this reason, public authorities should perform an ex-ante assessment of potential strategies to be adopted to improve the environmental sustainability of different economic sectors involved in public procurement.

Furthermore, the LCA tools adoption allows: to account, through a holistic and systemic approach, the consumption of primary energy and other environmental impacts, to identify GHG emissions and the main area of intervention and the most effective strategies (Mistretta et al., 2019).

After this comparison with literature, the authors of this study underlined that sustainability policies focused on the meals production phase have a good effectiveness in reducing impacts, even if the GHG emissions of this phase are highly uncertain, as Cerutti et al. declared in 2018.

Furthermore, the same research group indicated that the reduction of meat consumption and the food production from organic farming have the potential to reduce the carbon footprint (Cerutti, et al., 2018).

Additionally, switching to a low-impact energy mix (for example electricity with higher shares of renewable energy sources that have low emissions and therefore low Carbon Footprint) - rather than focusing interventions on machinery (e.g. household appliances) - could lead to greater environmental sustainability for the school canteen service. Finally, reducing waste would also lead to an improvement in Carbon Footprint (Cerutti et al., 2018).

These results address to the hypotheses 1 and 2 included at the end of the methodology section. After all, this analysis can be replicated focusing on other regions/countries/continents in order to select the “best practices” at public management level and stimulate public/private/ producers and consumers in achieving of the best environmental performances.

DISCUSSIONS

This paper encourages the identification of potential strategies to improve the environmental sustainability along the school canteen service chain. Particularly, as literature and technical review shown in the last five years, even despite the modest quantities, some positive effects have been documented through the use of the specific approaches: in particular, some of them can reduce the spending per capita for products/services.

Furthermore, literature review shown that a centralized public procurement system is effective in reducing inefficiencies related to procurement management (Ferraresi et al., 2021). On the contrary, the adoption of a non-centralized procurement system can increase the probability of non-linear management between clients and supplier companies as underlined by Prud'homme (1995) and Tanzi (1996) almost 30 years ago. Likewise, the adoption of a centralized purchasing model also favors the supply of organic foods (as documented by Sweden) in which the central government sets objectives and monitors the results achieved at a local/regional level (Lundqvist, 2001 and 2004; Baker and Eckerberg, 2007; Granberg and Elander, 2007; Daugbjerg, 2023). However, it is not possible to argue a priori that one model rather than another favors a reduction in environmental impacts, but certainly a more intelligent and fitted management can be effective for the health of schoolchildren, environment and costs of public finances.

Moreover, analyzing the effects of the policies adopted in some local case, in Northern Italy, in the city of Turin, it was found that the most effective policies are those that concern the production phase. Furthermore, always in the school canteens of Turin, it is confirmed that the reduction of meat consumption and the use of organic farming lead to a high Carbon Footprint reduction (Cerutti et al., 2018).

Moreover, as emerged from Tables 3, 4 and 5 analysis, Sweden adopted a centralized public procurement in the digital form managed by the unit located in the local institution. This unit is a designated person who deals exclusively with public food procurement. Contrariwise, the meals: 1) are prepared and served in schools, or 2) are prepared in centralized catering or 3) in a centralized kitchen, located in the municipality.

On the contrary, as past literature shown, at the Italian level it has emerged that a centralized national procurement can reduce the costs associated with errors in the procedures: in particular, centralization reduces: a) the risk that public officials do not possess the skills, 2) that they are not discouraged from minimizing costs and 3) the increase in prices due to the non-linear and transparent management of the contract (Bandiera et al., 2009).

Methodologically, despite the complexity and uncertainty of modeling analyses through LCA, it is an indispensable requirement for developing sustainable plans for public procurement (Cerutti et al., 2018). Furthermore, further efforts are needed for developing a more complete databases on food production chains in order to advance the robustness of the explorations and consequently of the deductions and recommendations (Mistretta et al., 2019).

Therefore, central and local public authorities and other stakeholders involved along the supply chain could advantage from management performs and climate policies by conducting scientific evidence (Mistretta et a., 2019. For example, in the context of GPP

strategies for the public catering sector, public managers could adopt combined LCA-LCC approaches with the aim of increasing environmental sustainability while reducing service costs.

Thus, LCA approach allowed local authorities to classify and prioritize possible actions. Additionally, the adoption of policies towards sustainability, and the operation within GPPs, contributed to achieving significant reductions in environmental impacts, especially in terms of carbon footprint (Cerutti et al., 2018).

Furthermore, considering the need to consider different phases of the school catering service, from production to waste disposal and aiming to achieve environmental sustainability and circularity of the service, the tools generated based on LCA, LCC, etc., or specific for collective catering systems, can support equally public/private managers and suppliers.

However, these instruments should be usable without the need for specialists, so that they can be included in tenders along with other aspects, such as price and quality of food. Where instead it is preferable to entrust the management to expert managers, it is necessary to provide adequate and ad hoc training (Cerutti et al., 2018). This conclusion is confirmed by the authors of this study and the past literature (Cerutti et al., 2018; Góralska-Walczak, et al., 2023) because they believe that specific training is a fundamental element to overcome the difficulties of operating in contexts with long service chains full of many phases.

To-date, the adoption of the LCA approach - as suggested by Mistretta et al. (2019) and as confirmed by the authors of this study - ensures to account in a systemic and holistic approach the consumption of primary energy, other environmental impacts, greenhouse gas emissions and to identify the main area of involvement and the most actual strategies to achieve better environmental sustainability. Finally, the integration of the LCC approach also highlights the crucial role of labor costs required for meal preparation (García-Herrero et al., 2019).

As highlighted by Cerutti et al. (2018) and according to the methodology carried out by the authors of this analysis, this study is methodologically replicable since it compares data included in technical reports with scientific literature and regulations. Precisely, in this case this comparison has been applied to the specific case of school catering, but it can be applied not only to other public catering services, such as hospitals, but also to private catering services for refectories, cafeterias, restaurants, canteens and bars with the aim to emerge pros/cons of adopting centralized/decentralized models in procurement towards to sustainability levels.

In conclusion, the possibility of realizing a public procurement with centralized, digitalized management, which uses combined Life Cycle Thinking approaches, which respectively determine environmental and sustainability requirements, training and updating public administration managers, is the best solution to reduce environmental impacts, respect health and support management costs.

Lastly, from the international level, comparing the European public procurement issue with the context of other continents, it emerged that also in China, sustainable public

procurement (SPP) represents an important element of public policy and a market-based tool to achieve sustainable development.

In particular, the results obtained from the study conducted by Zhang et al. (2022) with the results collected in Table 2 referred to the European, it is highlighted that:

1. from a model point of view:
    a. China adopts a multi-level, hierarchical and centralized sustainable public procurement system,
    b. European public procurement is mostly decentralized and EU member states enact their own national laws and formulate policies for cases below the threshold of the directives.
2. From a regulatory point of view:
    a. in 2004, in Europe two EU directives on sustainable public procurement were introduced, which outline the sustainability policies, principles and requirements that should be adopted in SPP,
    b. In China, however, the Chinese Law on Bidding (1999), the Law on Public Procurement (2002), and the Law on Promoting Cleaner Production (2002) are the legal basis for sustainable public procurement.
3. In the context of school canteen service:
    a. European public procurement is mostly decentralized and EU member states enact their own national laws and formulate policies for cases below the threshold of the directives,
    b. China's PP is centralized and comprises all purchases for public service units (for all public institutes, universities and schools).

Moreover, as declared in the results of the Italian study carried out by Campobasso et al. (2024) for Southern Italy university canteens, the salmon-based menu generates the highest environmental impact due to the supply chain. Furthermore, the red meat-based menu also generates high environmental impacts due to the farming chain.

However, as also underlined by Vadder et al. (2023) in their study, a greater awareness to contexts is needed so that this can represent an even more important determining factor in the reforms that each European country must foresee, also in reference to a more sustainable management of the school canteen supply chain as emerged from this study.

Overall, the results collected through this study results provide a clear reply to the general research question declared at the beginning of the paper.

SENSITIVITY ANALYSIS

The sensitivity analysis displays the variation of GHG impacts with respect to four different dietary models provided in Italy and one in Spain as shown in Table 5.

Table 6: Sensitivity analysis of some dietary models

N.	GWP impact ($kgCO_2$ eq/lunch-meal	Dietary model	Main evidences	System boundaries	Source
1	1.43	Italian (Milano, Abbiategrasso)	food preparation and cooking in centralized kitchens, prepared meals distributed to schools standard menu, which includes meat and fish	production, transport, storage, cooking and waste treatment	Mistretta et al. (2019)
2	1.67	Italian (Turin)	cooking hubs standard menu, which includes meat and fish	production, transport, cooking and waste from packaging	Cerutti et al. (2018)
3	1.11-1.50	Italian (Ferrara, Cento)	catering service centralized in cooking center within the municipality Mediterranean diet	cradle to grave production, transport, cooking and waste from packaging	García-Herrero et al. (2019)
4	3.74	Italian (Apulia)	food preparation and cooking in centralized kitchens, prepared meals distributed to schools eight menus complying with Healthy Eating Guidelines and catering-service managers	cradle to grave production, transport, cooking and waste from packaging	Campobasso et al. (2024)
4	1.26	Spanish	Spanish school dietary guidelines Mediterranean diet	cradle to gate food production, transportation, and cooking	Martinez et al. (2020)

Source: Authors' elaboration.

Particularly, considering several scenarios of environmental impact assessment of school canteen services included in the past literature, the authors of this paper developed Table 6 for showing the reduction in impacts achieved by a sample of Italian school canteen, compared with the performance achieved in the Spanish context. The aim of this section is to display best and worst scenario. Particularly, best scenario is represented by the Spanish cluster that shifted from the current Spanish pattern towards the Mediterranean dietary. This food policy and dietary model allowed to quantify only 1.26 kg CO_2-eq for

a meal served in a day and other beneficial for health. As Sáez-Almendros et al., (2013) demonstrated the Mediterranean dietary pattern results in a lower environmental impact due to the consumption of more plant-derived products and less animal products.

On the contrary, worst scenario documented 1.67 kg CO_2-eq for a meal served in a day in the school canteen service provided in Italy in the Turin municipality and composed by standard menu, which includes meat and fish.

Therefore, as shown in Tables 3, 4 and 5 and as stated by the Intergovernmental Panel on Climate Change (IPCC, 2020), balanced diets, with plant-based foods (whole grains, legumes, fruits and vegetables, nuts and seeds) and animal-based foods produced in resilient, sustainable and low-GHG emission systems, represent important opportunities for climate change adaptation and mitigation (IPCC, 2020).

CONCLUSIONS, LIMITATIONS, MANAGERIAL IMPLICATIONS AND FUTURE TRENDS

With the aim to presents the outcomes related to different school meal delivery models, the authors of this paper proposed a method to explore the procurement in public management. This is a recent and relevant topic in the public and scientific debate, supported by the presence of a sector of public administration with a significant potential for environmental and social impact. Particularly, this study analyzed some canteen services in public schools in a sample country located in Europe.

After this analysis, some differences emerged in the procurement approaches used (centralized, decentralized, digitalized and open) as mainly the promotion of the use of organically grown foods and the waste reduction.

The results presented in the previous section underlined that the adoption of centralized procurement could reduce environmental impacts along the service delivery chain. Therefore, a centralized procurement could favor the creation of a sustainable contract, focused to the impacts on the atmosphere, towards the reduction of waste, the use of local and organic products and reduce time and costs for the public contract and related management (Figure 2).

Furthermore, this study stimulates public administrations and local authorities to provide a sustainable procurement agreement focusing on emissions, cost reduction and safety and health in the context of school canteen service.

Currently, there are several tools that can help local authorities to build tenders for providing a sustainable school canteen service, including Life Cycle Thinking approaches (LCA, LCC, Environmental LCC) (Figure 2).

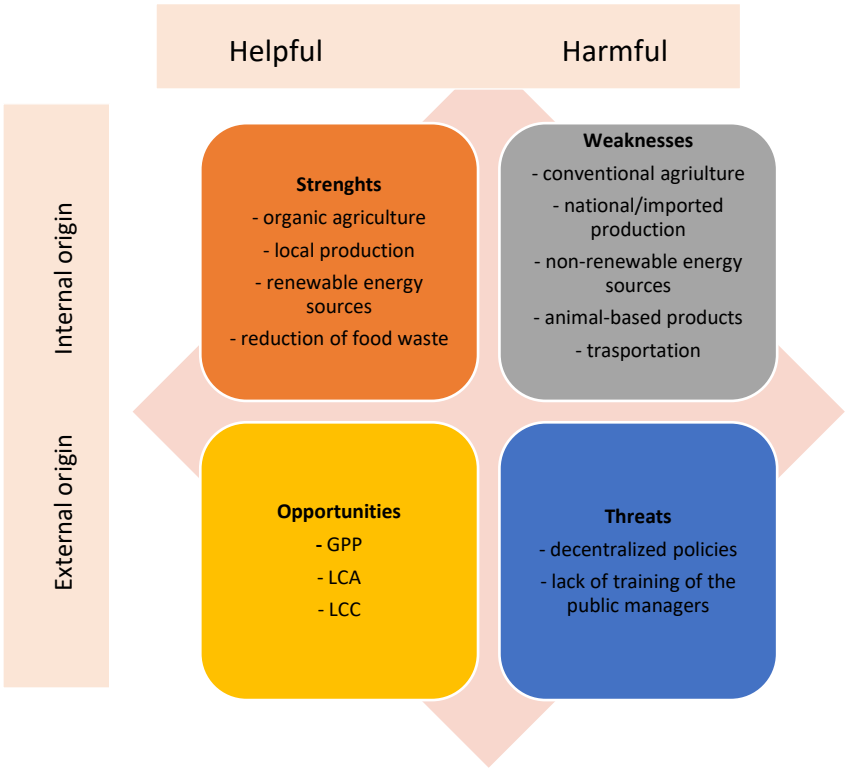
Furthermore, GPP is a general policy, applied indiscriminately to all forms of public procurement even if there is currently scarce literature on GPP in the context of sustainability and this tool represents an opportunity for achieving environmental sustainability by for local/central governments (Figure 2). Alongside, GPP approach represents a limit and a notable difficulty in studying the methodologies investigated over the years by the scientific literature to evaluate the environmental impacts in public procurement: it is mainly a terminological difficulty, since sometimes the scholars used the term GPP, other times

they analyzed the sustainability, other times they focused on the linkage with other approaches. Therefore, the studies published in the past scientific literature can hardly be compared.

As also mentioned above, some studies analyzed the linkage between GPP and Life Cycle Sustainability Assessment (LCSA), between GPP and LCA, between GPP and LCC and between GPP and (S-LCA: social LCA).

Instead, an important limitation is due to lack of local LCA and LCC databases. Particularly, for improving the robustness of the investigations, and consequently the deductions and recommendations, it is necessary build a complete database on food production that consider punctual local production, preparation and consumption. Furthermore, an important limitation consists in the use of the adjective "centralized", in the most of case referred to the procurement phase through a central purchasing body, as in the Italian school canteen procurement. In others cases, the adjective "centralized" referred to centralized kitchens/cooking centers that supply multiple municipalities and multiple educational institutions.

Figure 3: Challenges and opportunities in the context of environmentally sustainable school canteen service



Source: Authors' elaboration.

Therefore, in order to design centralized environmentally sustainable public-school canteen services, public/private administrations could invest in training of their employees operating in the sector/chain (Figure 2).

This study contributes to provide analytical tools for achieving a more sustainable food sector, in the framework of the EU climate and energy objectives, considering the strategies aimed at reducing the impact of food production, crucial and priority for intervention in the food supply chain.

Moreover, in the context of GPP strategies for the public catering sector, public managers could adopt combined LCA-LCC approaches with the aim of increasing environmental sustainability while reducing service costs.

This is why the authors of this study propose future investigations to compare the influence that the different LCA, LCC, ELCC, SLCA approaches can generate on costs and impacts in centralized, decentralized, digitalized and open procurements.

In conclusion, in this context, it emerged a thin line of difference between GPP and SPP, even if all procurement, especially centralized ones, focus on the environment, health, nutrition, revenues, therefore in the broadest sense of sustainability, not only from environmental point of view. Moreover, the *"bureaucratic system"*, complete of regulations and detailed phases, represent a barrier that must be overawed if central governments impose the achievement of climate and sustainability goals. Also, at Italian level the implementation of a combined approach LCA-LCC, a more in general the Life Cycle Thinking approaches, in a centralized procurement process, not only for school canteen meals but in general, is included in the guidelines of the PNRR, with the aim to launch economically, environmentally and socially sustainable procurement.

In conclusion, despite some limitations mentioned above regarding the scientific production related to the topics of the present study, the results are in line with most of the available literature. Finally, thanks to the comparative methodology adopted in this study, the results and the replicable approaches can support public administrations and private companies involved in the process of selecting the most environmentally, economically and healthily sustainable food scenarios.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Tiziana Crovella: Writing – original draft, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Nicola Minafra: Writing – review & editing, Investigation, Data curation. Annarita Paiano: Conceptualization, Funding acquisition, Project administration, Supervision, Validation.

ACKNOWLEDGMENT

"This study was funded by the European Union - NextGenerationEU, Mission 4, Component 2, in the framework of the GRINS -Growing Resilient, INclusive and Sustainable project (GRINS PE00000018 - CUP H93C22000650001). The views and opinions expressed are solely those of the authors and do not necessarily reflect those of the European Union, nor can the European Union be held responsible for them".

NOTES

[1] GRINS – PNRR - Growing Resilient, Inclusive and Sustainable – Piano Nazionale di Ripresa e Resilienza, with the aim to "produces economic, political, social and data-driven science, to provide evidence that is useful in orienting public politics, not only the city's religion, but also its influence in contested, comprehensive decisions, contributing to a more resilient, inclusive and sustainable growth of the country" (GRINS, 2025).

[2] Centralized procedure: activities of acquisition of goods, services and works on behalf of other administrations or public bodies with the aim of improving the efficiency of public spending, promoting the aggregation of demand and reducing the costs and times of tender procedures.

[3] Decentralized procedure: purchasing management model and supply management decisions distributed across different units, departments, or locations within an organization.

[4] "Milan, Copenhagen, Madrid, Ghent, New York, Washington DC and Toronto, participates in the initiative by evaluating the results of the gradual changes made to the menus from 2015 to today, in particular regarding the promotion of plant-based proteins, through the introduction of more vegetables and legumes (Comune di Milano, 2024)".

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ISSN 1662-1387