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Circularity and sustainability in food supply chains, actions to achieve food waste reduction – Case study of the Public Catering Service Provider of Budapest

**Körköröség és fenntarthatóság az élelmiszer-ellátási láncokban,
intézkedések az élelmiszer-hulladék csökkentésére – Esettanulmány a
budapesti Étkeztetési Szolgáltató Gazdasági Szervezetről**

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INTRODUCTION

Our world is marked by global environmental challenges, resource scarcity, and rising concerns about the sustainability of our consumption patterns. Within this, the food supply chain emerges as a critical area where change is both urgent and realistic.

The importance of sustainability in food supply chains cannot be overstated. As the global population continues to grow rapidly, and climate change threatens the stability of ecosystems, the obligation of protecting our food systems (all of the processes and infrastructure involved in feeding the population) becomes clear. Sustainable food supply chains are vital not only for the preservation of our natural resources but also for ensuring food security, reducing greenhouse gas emissions, and fostering resilience.

One fundamental concept that I will investigate is the concept of circularity. The circular economy model is a solution for a sustainable food future. It seeks to transform linear, wasteful practices into regenerative systems where resources are conserved, waste is minimized, and value is maximized. Within the context of food supply chains, circularity represents the transformative shift from a "take-make-waste" approach to one that emphasizes recovery, recycling, and the regeneration of resources, thereby minimizing the burden on the planet.

In this research of sustainability and circularity, I will focus and examine one part of the food industry, the public catering service sector, where potential changes could be made. The analysis will be about the public catering service provider of Budapest (Étkeztetési Szolgáltató Gazdasági Szervezet, ÉSZGSZ) and its supply chain to get a better insight into the public catering sector. They have already taken steps to reduce food waste and promote sustainable practices within schools. By understanding the dynamics of the recent system, practical solutions could be formed that have the potential to shape the future of food supply chains and make further recommendations.

I. THE CHALLENGE OF FOOD WASTE

I.1. Global issue

Global focus on the problem of food loss and waste (FLW) has significantly increased in recent years (FAO, 2019). This heightened attention is evident through various national and international initiatives, programs initiated by both businesses and non-profit organizations, extensive media coverage, and the growing volume of research studies and reports produced by academic communities. The importance of this issue is also underscored by its inclusion in the United Nations Sustainable Development Goals (SDGs). Target 12.3 within the SDGs aims to reduce global per capita food waste at the retail and consumer levels by 50% and minimize food loss within production and supply chains by 2030 (FAO, 2020). The magnitude of the FLW problem stems from both its scale – approximately one-third of food intended for human consumption, totaling 1.3 billion tonnes annually, is lost or wasted according to the widely-recognized estimate (Gustavsson et al., 2011) – and its core connection to the significant global challenges we face. These challenges include food security, climate change, and the sustainable management of resources and the environment (FAO, 2019). FLW occurs at various points throughout the food supply chain, spanning from initial production on farms to food processing and manufacturing facilities, through retail and distribution centers, and, ultimately, in homes and dining establishments across all sectors of society (see Figure 1). The interconnected food supply chain involves numerous elements and stakeholders that interactively contribute to food usage and the issue of FLW (Dou & Toth, 2021).

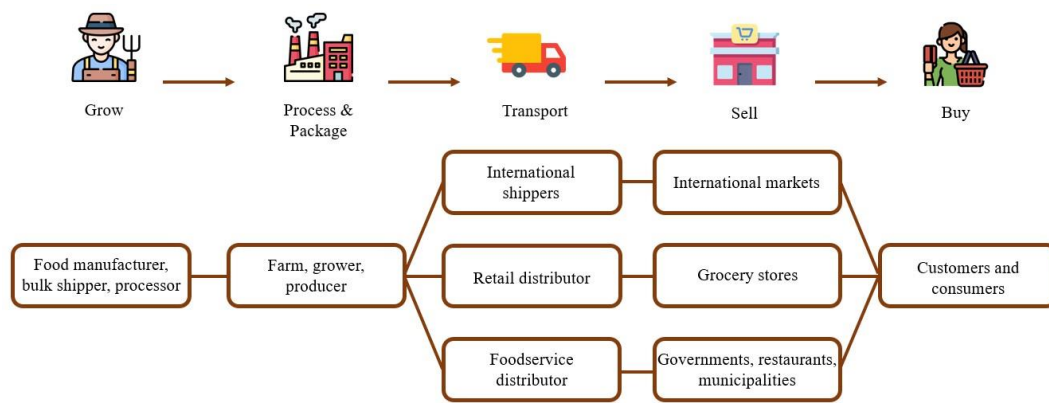


Figure 1
Food Value Chain
Adapted from: Food Marketing Technology, 2021

I.2. Food loss and waste

Food is wasted throughout the entire value chain, extending from the initial stages of agricultural production to the final household consumption (FAO, 2011). It's important to note that there's often confusion surrounding the terminology "food waste" since there exists a distinction between food loss and food waste. Food losses refer to the reduction in both the quantity and quality of food during the early phases of the food supply chain, ultimately diminishing the amount of food suitable for human consumption. Factors such as inadequate storage, transportation issues, or natural spoilage contribute to these early-stage losses. These losses encompass the unavoidable wastage that occurs at various junctures in the food supply chain, extending from the very origins of food production on farms to the moment it reaches the consumer's plate. On the other hand, food waste tends to be more closely associated with the later stages of the supply chain, particularly within the realms of retail and household activities. Food waste in these contexts involves the disposal of edible food that remains unsold in grocery stores, discarded leftovers, or items reaching their expiration dates and being discarded at the household level. The sources of food waste are diverse, ranging from over-purchasing and spoilage due to inadequate preservation methods to consumers discarding products prematurely based on expiration dates or aesthetic standards (Chiaraluce et al., 2021; Parfitt et al., 2010).

I.3. Magnitude of wasting

According to the Food Waste Index of 2021 (FAO, 2021), our world generates a staggering 931 million tonnes of food waste annually. Of this, households account for 569 million tonnes, while the remaining share is attributed to the food service sector (244 million tonnes) and the retail sector (118 million tonnes). On average, households worldwide produce 74kg of food waste per person each year and this remains fairly consistent across various income groups of countries, which concludes that extensive progress is needed to tackle the problem. The index report highlights that if food loss and waste were a nation, it would rank as the third-largest contributor to greenhouse gas emissions globally. The nations with populations exceeding one billion unsurprisingly record the highest absolute quantities of food waste.

On Figure 2, it can be seen that China disposes of an estimated 91.6 million tonnes annually, closely followed by India at 68.8 million tonnes. The United States, with 19.4 million tonnes of food waste, ranks a bit lower. In Europe, France and Germany annually produce between five and six million tonnes.

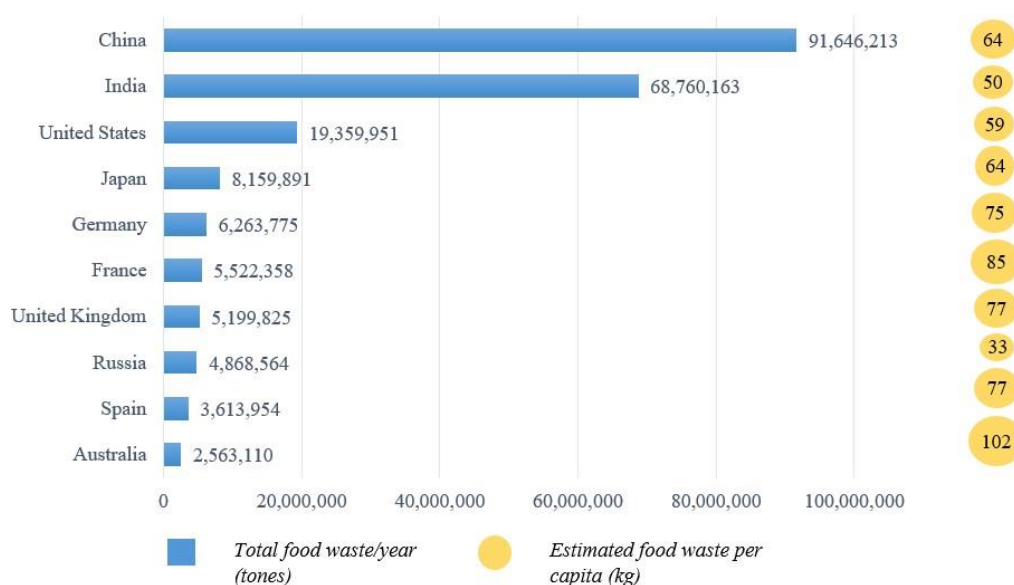


Figure 2
Total annual household food waste produced in selected countries
Adapted from: UNEP, 2021

However, the picture shifts when examining waste per person. Diagram 1 depicts that the average Indian household discards 50kg of food each year, while in the United States, this figure rises to 59kg. Interestingly, although Australia's total food waste appears relatively modest at 2.6 million tonnes per year, the per capita waste, as indicated by the index, is notably high at

102kg per household per year. In contrast, Russia generates an estimated 4.9 million tonnes of household waste annually, with a lower per capita waste rate of 33kg.

Overall, increasing food waste is becoming a global issue regarding food security, which needs us to address its impact on the environment, economy, and society all at once. To reduce these effects, it's vital to create a more eco-friendly way of supplying food. Therefore, the concept of the Circular Economy (CE) has recently emerged as a response to the current linearity of the food supply chain (Ada et al., 2021).

II. UNDERSTANDING CIRCULAR FOOD SUPPLY CHAINS

The concept of a Sustainable Supply Chain (SSC) represents a transformative approach to business operations, where the supply chain functioning aligns with the principles of sustainability. The SSC is defined as a supply chain whose business operation is such that current demand does not affect future demand (Carter & Rogers, 2008). In other words, a supply chain functions collaboratively across environmental, social, and economic dimensions to protect the planet's future, enhance social well-being, and drive economic growth in its operations. The sustainability embedded in the supply chain is closely linked to the principles of CE (Kumar et al., 2022). It embodies a sustainable paradigm with the goal of constructing a system that is naturally regenerative and restorative in its design (Seuring & Müller, 2008). Figure 3. depicts, that the ‘take-make-waste’ approach of linear economy, which is still commonly used in every industry generating million tons of waste, is replaced by the concepts of reducing, reusing, and recycling, achieving zero or little waste generation. CE within the Food Supply Chain (FSC) can be defined as the reduction of food waste at different levels of the food chain, the efficient utilization of by-products and food waste, the recycling of nutrients, the reutilization of packaging, and dietary adjustments aimed at minimizing environmental impact (Pannila et al., 2022).

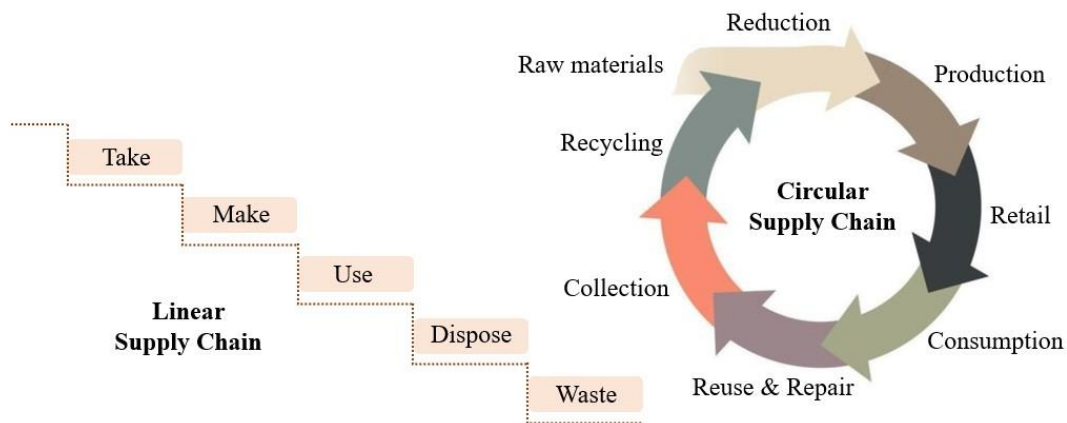


Figure 3
Linear and circular supply chains
Adapted from: Siemens, 2023

II.1. Shifting from linearity to circularity

The agri-food supply chain (AFSC) has experienced substantial consequences due to the application of linear economy practices, leading to resource scarcity and considerable levels of food loss and wastage (Esposito et al., 2020). The shift from the traditional linear economy to circular economy becomes necessary due to the linear model's oversight of natural and human resources, including social capital. CE, in this context, not only attributes economic value to resources but also recognizes their environmental and social significance. (Govindan & Hasanagic, 2018). Beyond economic considerations, literature emphasizes the role of circular economy in minimizing waste and mitigating the environmental impact of economic development. Fourthly, it strives to enhance economic, social, and environmental values, departing from the sole pursuit of economic gains (Despoudi & Dora, 2020). Lastly, at the macro level, CE systems demonstrate greater resilience by reducing reliance on external resources (Geng & Doberstein, 2008). The common point in most definitions is the closed flow of materials and the utilization of materials across multiple stages. In summary, these five points explain the objectives of circular economy.

II.2. The 3R principle

The 3R principles refer to reduction, reuse and recycle. They represent a set of practices aimed at minimizing the environmental impact of consumption, promoting efficiency in resource use, and contributing to overall sustainability.

II.2.1.Reduction

Reduction stands as the primary principle among the 3Rs, which is about reducing resource consumption and the generation of waste through enhanced design or management during both production and consumption phases (Despoudi & Dora, 2020). The objective of the reduction principle is to enhance practices at the production stage, thereby diminishing the arrival of materials and energy into the production and consumption stages. Consequently, the reduction principle directs businesses to prioritize material and energy conservation and waste reduction at the initial stages rather than concentrating extensive efforts on recycling or waste

disposal post-generation. Enterprises can employ various measures to adhere to the reduction principle, including the utilization of environmentally friendly raw materials, adoption of eco-friendly production methods, rationalization of packaging design, and crafting more compact and lightweight product designs. Additionally, enterprises can strengthen their application of the reduction principle by improving their ecological efficiency, recognizing that ecological efficiency also positively influences the other two principles (Despoudi & Dora, 2020).

From the consumer side, there is a difference between reduction methods according to a research conducted at the University of Arizona. They created two main categories of consumptions: 1) reduced consumption, encompassing actions like repairing rather than replacing older items, abstaining from impulse purchases, and refraining from buying unnecessary goods; and 2) "green buying," which involves purchasing products designed to minimize environmental impact, such as items made from recycled materials (Helm et al., 2019). It was discovered that more materialistic individuals were unlikely to partake in reduced consumption. However, materialism did not appear to affect their likelihood of practicing "green buying." This difference may stem from the fact that "green buying" still allows materialists to satisfy their desire for acquiring new possessions, unlike reduced consumption, which challenges mainstream consumption patterns and is arguably more significant from a sustainability standpoint. Participants who reported fewer materialistic values were significantly more inclined to embrace reduced consumption. This behavior, in turn, correlated with higher levels of personal well-being and lower psychological distress. Contrarily, while green buying may carry some environmental benefits, albeit to a lesser extent than reduced consumption, it was not found to enhance consumer well-being (Helm et al., 2019). Despite the expectation that engaging in environmentally conscious purchasing patterns might provide a sense of satisfaction, this was not evident in the findings. According to Helm (2019) the lesson for consumers is to reduce consumption and not just buy green products. In other words, not buying is the greenest way of buying.

II.2.2.Reuse

The reuse principle supports the repeated utilization of products or their packaging in their original or various forms, aiming to postpone their transformation into waste prematurely. Additionally, this principle emphasizes the extension of the service life of products whenever

possible. By adhering to the reuse principle, companies stand to conserve significant resources, reduce the need for labor, and minimize energy expenditure in the production of new products or components and packaging (Castellani et al., 2015). However, companies are required to put more effort into this principle. Companies should not only design products with prolonged service life but also strategize on encouraging consumer recycling and reuse of products or packaging (Prendeville, 2014). For this reason, it becomes apparent that the principle of reuse imposes specific requirements on enterprises, while its success is closely linked to the attitude and active involvement of consumers. In the execution of the reuse principle, the engagement of all stakeholders is essential, requiring active participation from consumers in the recycling and reuse of products and packaging (Despoudi & Dora, 2020).

II.2.3.Recycle

The recycle principle involves the comprehensive recycling of waste through their reprocessing, aiming to transform them into valuable resources and thereby diminish the production of non-recyclable waste (Ying & Li-jun, 2012). Recycling is executed through two distinct methods: primary recycling and secondary recycling. Primary recycling involves the recycling and processing of waste to create new products or packages identical to the original, such as the utilization of scrap steel to manufacture new steel (Henshaw et al., 1996). On the other hand, secondary recycling involves employing waste as raw materials for other products with different properties, without considering the original properties of the waste. The recycling principle serves to control the end of the waste generation, enabling the reintegration of waste into the production or consumption stages and concurrently reducing potential environmental pollution. However, a potential pitfall emerges when a company excessively prioritizes the recycling process and achieves positive outcomes, potentially leading to a diminished focus on waste reduction efforts (Despoudi & Dora, 2020).

Anticipated to surpass 9 billion by the close of 2050, the global population's growth imposes a 70% escalation in worldwide food production for the attainment and sustenance of food security (Fogarassy et al., 2020). Subsequently, the imperative adoption of the CE model is emphasized to decrease waste and loss across the supply chain and achieve food security (Borrello et al., 2017; Cheng et al., 2019), eventually to the establishment of a zero-waste supply chain model. Furthermore, the projected outcome of CE integration includes the generation of an annual

economic value amounting to 1.8 trillion EUR by 2030. Consequently, the shift towards the CE is forecasted to not only be economically efficient but it will also contribute to environmental conservation and address societal concerns (Pannila et al., 2022).

III. CHALLENGES AND BARRIERS

Shifting towards CE is acknowledged as a highly favorable approach for attaining both economic and environmental sustainability. Nevertheless, the restructuring of conventional linear supply chains into Circular Supply Chains (CSCs) poses significant challenges for companies and governmental bodies. In the context of circular supply chain management, agri-food suppliers often discover themselves inadequately positioned to capitalize on the opportunities it presents. This is primarily due to the complex nature of the task. A supplier faces near-impossible challenges in overhauling the entire value chain to embrace CE practices. This complexity arises from the food characteristics through the involvement of multiple stakeholders to consumer behavior.

From the research of Gokarn and Kuthambalayan (2017) there are eight main groups of challenges that should be highlighted that agri-food suppliers may face when shifting to circularity. These can be seen in Table 1 below.

1.	Food characteristics
2.	Supply chain uncertainty
3.	Information technology
4.	Supply chain partnerships
5.	Operational capability
6.	Consumer behavior
7.	Food policy and regulation
8.	Supply chain networks

Table 1
Challenges for food suppliers
Adapted from: Gokarn & Kuthambalayan, 2017

The primary challenge within the agricultural and food supply chain is attributed to food characteristics, encompassing four key elements: perishability, quality variation, seasonality, and bulkiness. Freshly harvested or produced food items are typically both bulky and perishable. The bulkiness of these items presents challenges in terms of physical handling and transportation, while their perishable nature limits their marketable lifespan and the duration over which they can be stored and processed. This, in turn, impacts the ability to effectively balance supply and demand over time. Perishability also diminishes producers' bargaining

power with buyers, particularly those with alternative supply sources, and contributes to quality deterioration during transport and storage. As a result, there is a need for continuous quality grading at each stage of the AFSC, thereby increasing transaction costs. Furthermore, food products often exhibit variability in quality both within individual units and across different supply periods. Additionally, the quality and quantity of produce at the agri-food production stage are susceptible to fluctuations due to weather conditions (Gokarn & Kuthambalayan, 2017). These inherent characteristics of food items pose significant challenges to waste reduction efforts within the AFSC.

Supply chain uncertainty is influenced by various factors, including demand, supply, price, and process uncertainty. One of the challenges stems from the absence of a scientific approach to determining the optimal reordering quantity and batch size of produce. This is particularly crucial considering the diverse shelf lives of different products and the fluctuating patterns of supply and demand (Joshi et al., 2009). Additionally, uncertainties arise from natural events, such as crop damage caused by adverse weather conditions or pests, as well as from human behavior, such as stockpiling during shortages (Gokarn & Kuthambalayan, 2017). These factors contribute to supply and process uncertainty within the supply chain, making it difficult to predict and manage effectively.

Agri-food products often possess numerous quality attributes that are challenging to measure or observe accurately. Additionally, evaluating the value that consumers place on these attributes can be difficult. As a result, there is a challenge in providing informative grading and labeling of produce, particularly regarding aspects such as content and nutritional value (Van Rijswijk & Frewer, 2008).

The absence of coordination, trust, cooperation, and formal agreements reflects the lack of supply chain partnerships within the AFSC. This sector comprises numerous loosely connected entities, with many intermediaries separating producers from consumers. Wholesalers or commission agents serve as links between unorganized retailers and farmers, resulting in significant information asymmetry. Although supply chain contracts between different stages could mitigate the impact of supply and demand fluctuations, they are largely absent. In most areas, there are only a few buyers, leaving small, scattered producers vulnerable to monopolistic competition and lacking forward integration opportunities. Furthermore, a coordination challenge arises because the harvesting schedules of different suppliers do not align but instead

vary over time (Gokarn & Kuthambalayan, 2017). The deficiency in supply chain partnerships thus presents a barrier to reducing waste in the AFSC.

Agri-food production is geographically dispersed, making it challenging to gather crop intelligence due to the unpredictable production patterns of numerous small-scale farmers. Additionally, obtaining information on consumer preferences proves difficult. Consequently, inadequate harvesting planning occurs, leading to instances of oversupply or shortage of agrifood. These factors also contribute to suboptimal transportation planning and potentially escalate transportation costs. Furthermore, small-scale producers are discouraged from investing in storage facilities or standardized containers, which would otherwise reduce handling and quality inspection activities but entail additional transaction costs. (Gokarn & Kuthambalayan, 2017). Operational inefficiency thus presents a challenge to waste reduction in the AFSC

Consumers tend to have a lack of awareness regarding their consumption patterns and of the food they buy. Furthermore, their attitude, habits, and simply consumerism are all challenges, and they reflect the behavioral aspects of the consumer in AFSC. At the consumer end, food wastage occurs for a number of integrated reasons, which vary depending on the behavior of household consumers. These include, a lack of awareness, buying in excess of need, improper food storage, and lack of alternative use of leftovers (Parfitt et al., 2010).

Food policies and regulations play a crucial role in addressing the quality and safety of produce, providing financial support, and implementing awareness programs. However, in countries like India, the data pertaining to the quality of produce is often unavailable at any stage of the supply chain. There is a notable lack of awareness regarding quality control procedures and standards among stakeholders. Additionally, stringent health, safety, and quality standards mandated by foreign buyers, coupled with the price incentives they offer for high-quality produce, lead to the exportation of the finest-quality goods. This export-oriented focus may inadvertently impact domestic availability and quality control measures within the country (Shukla et al., 2014).

Inefficient supply chain networks pose a significant challenge for the reduction of waste in the food supply chain. This inefficiency can be attributed to three main factors: inefficient procurement channels, inadequate transportation networks, and ineffective distribution networks. Many countries face challenges such as complex and unpredictable procurement procedures, substandard transportation infrastructure (including ports, railroads, roads, and information technology), and poor road conditions in most regions. Given the geographical

dispersion of producers, the collection of produce becomes a costly endeavor. These inefficiencies hinder the smooth flow of goods from producers to consumers, resulting in increased food waste throughout the supply chain. Efforts to address these inefficiencies are crucial for effectively reducing waste in the food supply chain (Gokarn & Kuthambalayan, 2017).

IV. SPECIFIC FIELD OF THE FOOD INDUSTRY: PUBLIC SCHOOL FOOD PROVISIONS

In Hungary, public catering faces a negative social perception, often discussed by local media platforms (Munk, 2022a, 2022b), despite its high potential for sustainability (Vincze, 2022). Sustainability impacts encompass both environmental and socio-economic aspects, with environmental impacts evident in raw material choices, transport modes, processing, and water and energy use. Socio-economic impacts include short supply chains, economic support through supplier relationships, job creation, food culture, healthy eating promotion, and aid for disadvantaged individuals (Diófási-Kovács & Freund, 2022).

Environmental impacts stem from (1) the choice of ingredients, their seasonality, production location, agricultural practices, and food trading methods; (2) distribution strategies involving transportation and storage; (3) processing, which includes energy and water consumption, and waste production. These elements significantly influence the climate impact of school food systems and require careful consideration in planning. The socio-economic effects include short supply chains, indirect economic support via supplier relations, job creation, nurturing food culture, healthy eating habits, and aiding disadvantaged groups. Public procurement in school food systems plays a pivotal role in determining sustainability. It affects the supply chain's beginning stages (selection of suppliers and ingredients, and all associated sustainability factors) in food procurement. In catering procurement, it influences food production, including operations and services (sustainability impacts related to cooking, transportation, and even food waste management) (Diófási-Kovács & Freund, 2022).

Sustainable public food systems cover all activities, elements, and participants in food production, processing, distribution, preparation, serving, consumption, and waste management, including the spaces and environments where these occur (SchoolFood4Change project - EU Horizon 2020). They also encompass related educational activities. These systems aim to enhance the health of children and young adults profitably for all involved in the food chain, honoring social, cultural, and environmental aspects, and respecting the planet's boundaries. Sustainable school catering systems are democratically and participatively managed by all stakeholders, including farmers, buyers, chefs, teachers, students, parents, city and school officials, researchers, and policymakers (SchoolFood4Change project - EU Horizon 2020).

On Figure 4, it can be seen that within food supply chains, we generally observe a sequence of roles including producers, processors, and commercial agents who serve as intermediaries. Distribution tasks are usually handled by wholesalers and retailers, dealing with both processed and raw food items. Following the distributors are the catering entities, responsible for preparing ready-to-eat meals for educational institutions. This role can be filled by either a dedicated catering service or a restaurant. At the supply chain's conclusion, the consumer takes on various forms. The purchaser could be the school itself, the catering company, or even the municipal government or local authority, especially in cases involving public procurement. Beyond the educational setting, the ultimate beneficiaries are the students and their parents who finance these meal services.

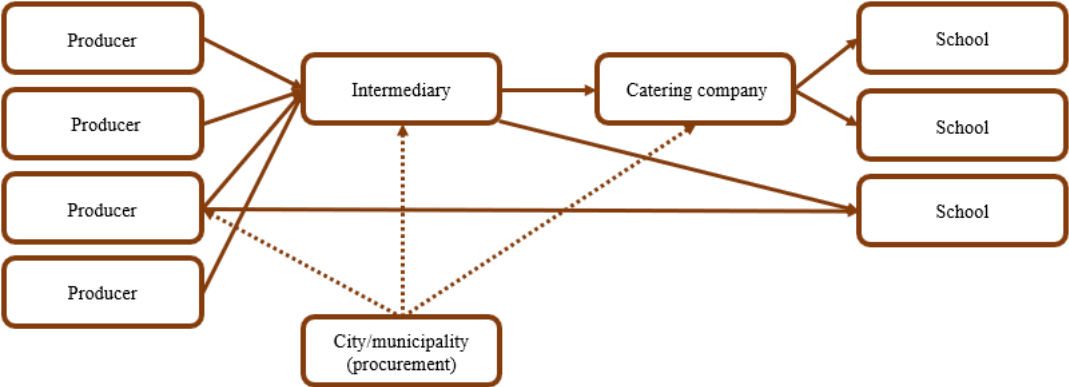


Figure 4
 Schematic diagram of the public catering network
 Adapted from: Diófási-Kovács & Freund, 2022

These systems are understood to encompass the entire range of actions, elements, and participants involved in food production, processing, distribution, preparation, service, consumption, and waste disposal, as well as the settings and environments where these activities occur (Franco and Fajó-Pascual, 2022; SchoolFood4Change project - EU Horizon, 2020). Additionally, school food systems or networks incorporate related educational practices.

From this analysis, it becomes possible to identify and characterize different public procurement models and their respective impacts on climate and sustainability. These models range from centralized to decentralized approaches (Tátrai and Vörösmarty, 2023).

In centralized school food systems (1), the municipality directly oversees the provision of meals to schools, conducting the public procurement process. This approach emphasizes efficiency, often involving multiple schools in a single tender. An interdisciplinary team, typically comprising legal experts, procurement managers, and food specialists, collaborates on setting

criteria for the public procurement (PP) of catering services. If the city adheres to a sustainability or food strategy, it may enforce mandatory sustainability criteria, fostering a policy-supported environment that sends clear signals to the market for sustainable services. The benefits of this system include the municipality's significant purchasing power and market influence due to large volume procurement, and better bargaining positions. This design is less resource intensive as kitchen maintenance, catering, cooking equipment, and staffing are outsourced. However, a drawback is the distance between the decision-makers and the end users (children and schools), potentially leading to misaligned needs. Additionally, the focus on catering processes in procurement criteria might overlook the upstream supply chain, such as ingredient sourcing and supply chain length, leaving the farm-to-caterer route less transparent (Diófási-Kovács & Freund, 2022).

In decentralized school food systems (2), schools independently manage food provision, including ingredient procurement, kitchen maintenance, and staff management. Typically, an individual at the school is responsible for food supply, with their expertise and motivation influencing sustainability in procurement. City or municipality-level sustainability and food policies may act as mere guidelines, offering considerable flexibility. Procuring in smaller volumes allows for partnerships with local farmers, shorter supply chains, and the purchase of regional and seasonal products. This system, while more adaptable and potentially more aligned with local needs, may lack the scale and influence of centralized systems (Diófási-Kovács & Freund, 2022).

Researchers found that in most schools hybrid models are used, some kind of combination of the described two models is in place.

School food systems are critical and possess immense potential for steering towards sustainability and minimizing climate impact. The success of sustainable school food systems centers on the collective effort of all stakeholders, aiming to create a healthier and more sustainable future from economic, social, and environmental perspectives. It's commonly acknowledged that without commitment at the policy level, significant changes in school food systems are unlikely. Practical implementation of sustainable public procurement in food can lead to more sustainable operations, provided there is strong motivation from decision-makers.

Given the extensive number of children, adolescents, and their parents involved, targeting school food systems for sustainability interventions appears to be a strategic move. Schools serve as an ideal platform for reaching a broad audience and are instrumental in initiating and

sustaining healthy eating habits that are in harmony with the planet's ecological boundaries. This approach not only addresses immediate health and environmental concerns but also sets a foundation for long-term sustainable practices within the community.

V. EU PROJECTS SUPPORTING FARM2FORK STRATEGY

V.1. Farm2Fork

The European Union's Farm2Fork Strategy, essential to the European Green Deal, is a determined plan aimed at transforming Europe's food system into one that prioritizes sustainability and waste reduction. This comprehensive strategy touches upon various aspects of the food supply chain, from production to consumption, underlining the EU's commitment to creating a fair, healthy, and environmentally friendly food system (Farm to Fork Strategy, 2023).

The strategy encompasses both regulatory and non-regulatory measures. It leverages the EU's Common Agricultural and Fisheries Policies as key tools in supporting this transition. A proposed legislative framework for sustainable food systems will support the implementation of this strategy and the development of sustainable food policies. It extends its influence beyond the EU by supporting the global transition to sustainable agri-food systems through its trade policies and international cooperation instruments. The strategy's objective is to create a food system with a neutral or positive environmental impact. This involves efforts to mitigate climate change, reverse biodiversity loss, ensure food security, and provide access to nutritious and sustainable food. The strategy also emphasizes the need to preserve the affordability of food while generating fair economic returns, fostering competitiveness, and promoting fair trade. The EU aims to make sure that everyone has access to sufficient, safe, nutritious, and sustainable food. This is particularly significant in the wake of challenges highlighted by the COVID-19 pandemic which has underscored the need for resilience. In response, the Commission plans to develop a contingency plan for ensuring food supply and food security, learning from the challenges and experiences brought forth by the pandemic (Farm to Fork Strategy, 2023).

The EU's role in the global food system is acknowledged, with a commitment to using its trade policies and international cooperation instruments to support sustainable agri-food systems worldwide (Farm to Fork Strategy, 2023).

V.2. SchoolFood4Change

SchoolFood4Change is an EU-funded project, headed by ICLEI – Local Governments for Sustainability and co-created by a consortium of 43 European partners, including environmental and non-governmental organizations, local governments, scientists and research institutes, schools, chefs, meal professionals and health experts (SchoolFood4Change, 2023). Besides this project, the Municipality of Budapest has also decided to join the Milan Urban Food Policy Pact (MUFPP), which provides a policy-level framework for the SF4C project. Budapest is also part of the FoodCLIC project, which aims, in line with the MUFPP, for the city to develop its own sustainable urban food policy and an integrated urban food strategy. This framework includes institutional catering, including school meals as well. Being the most significant among them, the research and analysis will be about SchoolFood4Change.

In Hungary, there are nine schools taking part in the program. The project aims to make school meals enjoyable and healthy for the children and the planet. This means developing sustainable public catering systems, providing delicious and healthy food, encouraging healthy eating skills, and giving access to knowledge about sustainability. The emphasis is on the farm to fork strategy, promoting domestic products and smaller producers with shorter supply chains and seasonal products. Therefore, green public procurement would be the upstream supply chain. The eight objectives of the program that should be achieved by all schools are listed in Table 2 (SchoolFood4Change, 2023).

1.	40% of food procured from organic agriculture
2.	25% of primary food products from regional sources
3.	25% GHG emissions reduction through more plant-based food content, food waste reduction and low-carbon food chain (from farm to fork)
4.	15% of schools offering free of charge breakfasts or healthy snacks
5.	15% of SF4C tenders including food education-related criteria
6.	15% increase of number of kitchens preparing less than 5000 meals/day
7.	12% of food procured from small farmers (below 10 ha) and/or social food-producing cooperatives or/and engagement with at least 3 SMEs in food procurement
8.	50% of coffee, tea and exotic fruits (if exotic!) come from fair trade

Table 2
Public procurement objectives
Adapted from: SchoolFood4Change, 2023

VI. PROBLEM DEFINITION

In the context of this research, the problem definition is about the sustainability and circularity of food supply chains in public schools in Budapest, with an emphasis on minimizing food waste. This issue is explored through two key companies: ÉSZGSZ, the public catering service provider entity overseeing food quality and supply chain management in Budapest's public schools. Secondly, the Hungarian Foodbank Association, responsible for managing food surplus and redistribution. The core of this research is summarized in the central question: Where does food waste occur at a public catering service provider (ÉSZGSZ) and how can it be reduced?

ÉSZGSZ, as the primary actor, plays a critical role in ensuring the quality of food provided to students and the effective management of the food supply chain. This organization's responsibilities encompass not just the provision of nutritious meals but also the adoption of sustainable practices in sourcing and distributing food. Furthermore, they redirect food surplus to places in need.

My direct involvement in the SchoolFood4Change (SF4C) project helped me to observe and analyze these dynamics. The SF4C project, aimed at making the food supply chains of public schools in the European Union more sustainable, serves as a practical framework for this study. It highlights the challenges and opportunities in providing healthier and sustainable food options to pupils, thereby contributing to a broader understanding of the problem. The existing food supply system in Budapest's public schools faces several challenges. These range from ensuring consistent food quality, managing logistical complexities, to reducing food waste. The complexity of the supply chain with the need to meet diverse nutritional requirements adds to the difficulty of these challenges.

The main research question addresses the development of the public-school food system and supply chain. It seeks to identify strategies to enhance the sustainability and efficiency of these systems. This includes examining current practices, identifying inefficiencies, and exploring innovative solutions. A critical aspect of this investigation is understanding how circularity principles can be integrated into the supply chain to minimize waste and maximize resource utilization.

This problem definition sets the stage for a comprehensive analysis of the public-school food supply chain consisting of 101 schools in Budapest served by ÉSZGSZ. By focusing on the

roles of the two beforementioned key actors and their contributions to sustainability, the research aims to uncover practical solutions that can be applied not only in Budapest but potentially in other similar contexts. The ultimate goal is to formulate recommendations that can transform the food supply chain into a more sustainable, efficient, and resilient system, thereby contributing to the broader objective of sustainable development in the education sector.

VII. METHODOLOGY

The methodology of this research is designed to comprehensively explore circularity and sustainability in food supply chains, with a focus on waste reduction strategies. The research approach is built up a combination of theoretical and empirical methods to address the complicated nature of the subject.

The combination of theoretical and empirical methods was chosen to ensure a general understanding of the topic. While the theoretical part provides a conceptual basis, the empirical research adds practical relevance and depth to the study. The research methodology is a blend of qualitative and secondary research methods. The choice of qualitative research, particularly through conducting interviews, is driven by the need to gain in-depth insights into the practical aspects of circularity in food supply chains. Qualitative research is appropriate for exploring complex, context-dependent issues where the perspectives of individuals play a crucial role in understanding.

The research journey began with valuable guidance from my supervisor at the Corvinus University of Budapest. She provided not only critical insights, but also access to relevant academic resources regarding public school food provision. Subsequently, an extensive desk research was undertaken. This phase involved the collection and analysis of approximately forty scholarly articles, books, and journals related to circular food supply chains and waste reduction. These resources covered various disciplines, including environmental science, economics, and supply chain management, offering a wide perspective on the topic. The literature review conducted in this stage formed the foundation for the following empirical research.

From January, the study shifted to an empirical phase involving qualitative research. This meant conducting an in-depth interview with the managing director of ÉSZGSZ. The rationale behind selecting ÉSZGSZ for the case study stems from the fact that my supervisor was fortunately part of the SF4C project and could help me to gather vital information from the director of the organization. Moreover, a second interview was conducted with the founder and director of InDeRe Food Research and Innovation Institute, a food chain consulting firm that cooperates with ÉSZGSZ, and a third with a contact person at the Hungarian Foodbank Association.

The primary objective of these interviews was to gather firsthand information about the challenges and strategies associated with implementing circular practices in food supply chains.

This qualitative analysis helped to acquire a deeper understanding of the managerial decisions and policies in the real-world context.

The insights derived from the interviews were vital in creating the problem analysis section of the research, where the data collected from the interviews is analyzed and put against the theoretical framework established earlier. It demonstrates how the theoretical concepts of circularity and sustainability translate into practical actions, challenges, and opportunities.

VIII. PROBLEM ANALYSIS

VIII.1. Description of operations

To gain a better insight into the focal company of my analyzed supply chain, ÉSZGSZ, there are some significant numbers to be considered. The operator serves educational institutions, from which 95 kitchens are owned by them (15 cooking kitchens, 80 serving kitchens) and 6 are outsourced. These locations serve 16 228 children and 1822 adults annually (each of the 18 050 different individuals ordered at least one meal during the year). Last year, an astonishing 1 721 918 regular and 46 927 dietary food portions were served for lunch. (A. Tóth, personal communication, February 20, 2024).

There are three directors responsible for the management of the company: the managing director, the financial director, and the expert leader. They decide on every significant matter, including the sustainability objectives of the organization. According to the managing director, green aspects are taken into account in procurement and public procurement policies. This specifically means raw food materials and does not include their transportation system. As for now, there is no intention of investing in electric vehicles for the transportation of food, mainly because of budget issues. However, besides raw food material procurement, there is an urge from the municipality to be as energy efficient as possible and also consider using sustainable cleaning products. Given that the kitchens operated by them are part of the school premises, insulating cannot be done by them (e.g. replacing windows or doors) because that is the school district's responsibility. But energy-saving light bulbs and replacing oil radiators are still options and fortunately these steps have already been taken. The pressure from the municipality and the government regarding energy saving has been constant since 2022 when the Russian-Ukrainian war broke out. For this reason, everything is monitored, and data is requested from ÉSZGSZ, which is stored and analyzed in a database in order to develop the organization's sustainability and environmental friendliness (K. Simonné, personal communication, February 6, 2024).

VIII.1.1. Food system

The visualized food system is depicted by Figure 5. It captures the most relevant information about the public food system, offering a comprehensive overview for better

understanding. The schematic diagram is specifically designed to depict the process in which ÉSZGSZ operates. Key stakeholders in the system include farmers, suppliers, the catering service provider (in this scenario ÉSZGSZ), municipality, public education institutions (e.g. elementary and high schools), children, and parents. The symbols utilized in Figure 4 are subsequently explained, followed by a description of the relationships between these stakeholders within the food system.

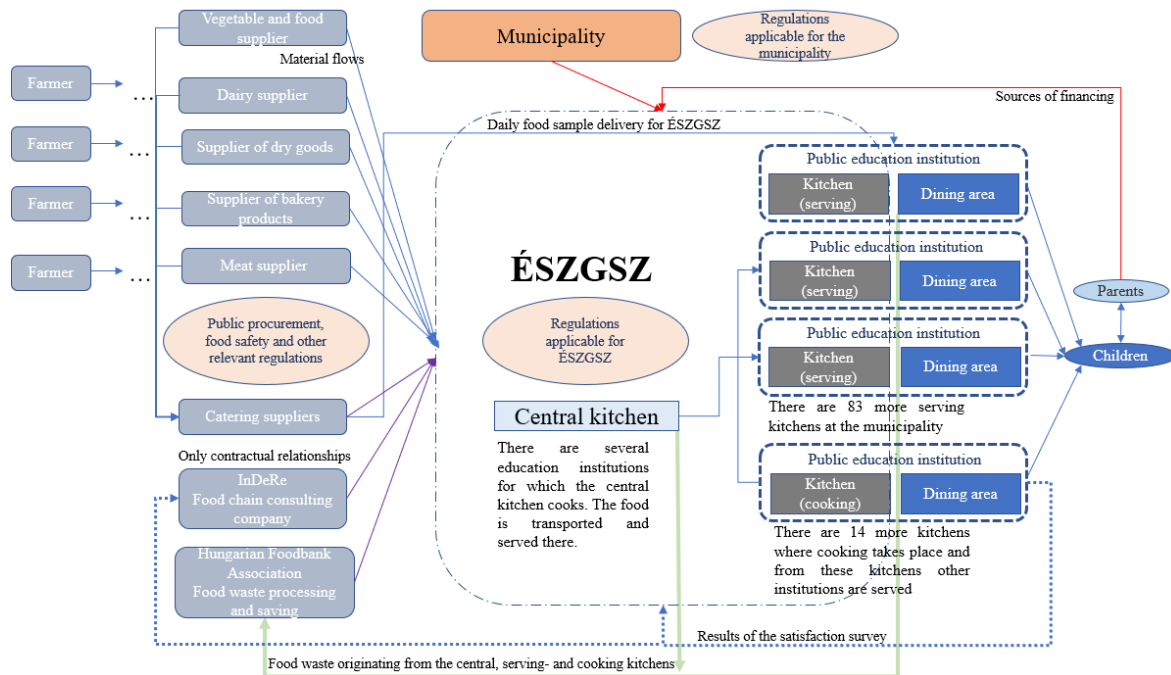


Figure 5
Visualized food system
Adapted from: Diófási-Kovács & Freund, 2022

In the visual representation, full lines in purple signify contractual relationships between parties. For instance, the Hungarian Foodbank Association has a contractual agreement with ÉSZGSZ, even though the physical collection of food occurs at various kitchens and sites. Full lines in blue denote both material flow and contractual relationships on the upstream side of the supply chain. An example is the meat supplier delivering goods to ÉSZGSZ with a corresponding contract. On the downstream side, full blue lines exclusively represent material flow, indicating that there is no contractual relationship between the central kitchen and other serving kitchens. The red lines show the financing arriving from different parties to the catering company for providing meals.

The formalized flow of information is depicted by blue dotted lines in the figure. This signifies that schools provide feedback on their satisfaction with the service within a quality assurance system administered by the InDeRe food chain consulting company. In instances where a

contractual relationship exists, it is assumed that there is a certain level of interaction and information exchange between the involved parties. Due to the nature of these "natural" information flows in contractual relationships, they are not explicitly represented in the figure. Notably, based on interviews and market dialogues, it's observed that consultations with suppliers are not formally managed and organized by the catering company, suggesting potential opportunities for further development in this aspect.

Green lines represent the reverse flow of material (food waste) from the place of origin to the food waste processors.

ÉSZGSZ has been allocated as the "central" actor or focal company in the public food system. This choice is driven by its substantial impact on customer satisfaction, particularly among children and their parents. Additionally, it plays a key role in influencing sustainability impacts, such as supporting domestic producers, utilizing healthy and seasonal ingredients, and minimizing energy use.

However, it's crucial to recognize that ÉSZGSZ operates within a limited decision-making position in several aspects. The broader market actors and environment, procurement processes, food legislation, financing considerations, and control over the service area collectively influence the quality-of-service provision and the provider's range of actions. These elements are appropriately incorporated into Figure 4 to offer a comprehensive understanding.

The food service provider is funded both by the municipality, as per legal obligations, and by parents. The funding structure is subject to public procurement regulations, encompassing the procurement of goods and services. The catering service prepares meals in its own cooking kitchens, utilizing the raw materials and ready-to-cook products received from suppliers.

Within the figure, three points between farmers and suppliers symbolize the unexplored segment of the network. The SF4C consortium encourages cooperation between these farmers, suppliers, schools, and caterers in providing sustainable and healthy school meals (SchoolFood4Change, 2023). For this reason, the traceability of raw materials and the identification of producers emerge as key priorities. These measures are essential to reduce negative environmental impacts and amplify positive social and economic contributions. The exact number of companies supplying to ÉSZGSZ are specified in the next section.

On the supplier side, the food system involves various actors:

Suppliers of Food Raw Materials (Farmers and Suppliers): These entities provide ÉSZGSZ the essential raw materials and ready-to-cook products, forming a critical link in the procurement process. The traceability of raw materials and the identification of producers are emphasized for environmental and socio-economic impact.

Catering suppliers (Ready Meal Suppliers): Another category of suppliers comprises catering service providers delivering ready meals directly to public education institutions. As part of quality control, these providers are obligated to furnish a daily food sample to ÉSZGSZ. Quality assurance is further enhanced through partnerships with food service consultancy partners.

InDeRe food chain consulting company: This company specialized in food service consultancy, contributing to quality assurance by conducting activities such as satisfaction surveys in public education establishments. It plays a crucial role in ensuring the overall satisfaction and quality of food services. With the contribution of the company, I was able to identify the underlying reasons of waste generations in the dining area.

Hungarian Foodbank Association: They maintain a contractual relationship with ÉSZGSZ and engage in reverse logistics activities. They manage the disposal of food waste generated in public education institutions, transporting it for further recovery. This aligns with sustainability efforts to reduce waste and enhance resource recovery.

ÉSZGSZ operates a central cooking kitchen and additional kitchens on the premises of public schools. Food preparation occurs in these spaces, and the prepared meals are delivered to serving kitchens using specialized containers and vehicles. While they retain control over the canteen's infrastructure and staff, responsibility for the dining area now rests with the respective educational establishments.

The customers, or end-users, in the system are primarily the children and their parents. These stakeholders, beyond the school, have influence as they are partially responsible for funding the meals. The satisfaction and preferences of these end-users act as key drivers shaping the system. (Diófási-Kovács & Freund, 2022).

VIII.2. Waste streams

Based on the interviews I conducted, there are four main points where waste occurs in the supply chain of ÉSZGSZ. These are highlighted on Figure 6 using Figure 5 as a base. In the following these points will be analysed and described.

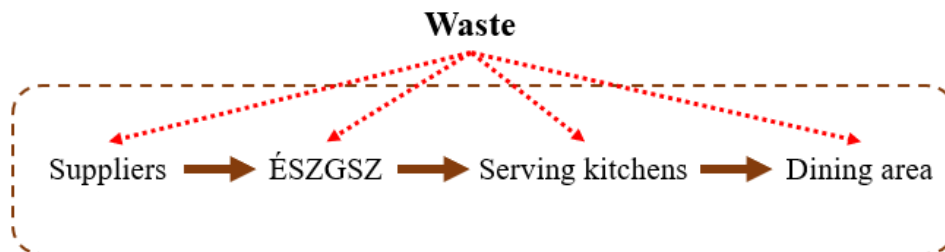


Figure 6
Points of waste occurrence
Own editing, 2024

As for ÉSZGSZ's food waste management, a company called Biotrans handles its transportation, while the municipality manages municipal waste. Special waste like refrigerators and cooking oil is under the management of the Hungarian oil company, MOL. In all schools, selective waste collection is now operational, allowing for the collection of kitchen waste alongside school waste. While there is a separate contract between the cooking kitchens and the schools, serving kitchens lack individual waste management contracts, leading to their waste being combined with school waste. Regarding packaging waste, ÉSZGSZ has no influence on manufacturers' packaging decisions. Efforts are made to procure items in bulk, which proves to be more cost-effective. For instance, frozen foods are delivered in 25 kg bags. As for the packaging materials, suppliers competitively bid, and the best price is selected. Typically, they ask three separate companies every quarter of a year to provide an offer. However, storage capacity for packaging is lacking, with no available space. Currently, besides serving schools, ÉSZGSZ also provides daily meals in 500 plastic containers for refugees, utilizing all available capacity they used to have. Additionally, they deliver meals on weekends for schools, sometimes handling 200-300 containers (K. Simonné, personal communication, February 6, 2024).

VIII.2.1. Subcontractors

Each subcontractor is a market player, necessitating regular negotiations to keep prices relatively low, with any agreements strictly documented in writing as verbal agreements are not

permissible. In 2013, the ÉSZGSZ system had only 57 suppliers, but by 2017, 56 new suppliers had been added (K. Simonné, personal communication, February 6, 2024).

For bakery products, fruits, and vegetables, ÉSZGSZ has several suppliers. For vegetables, 4-5 companies supply, for bakery, one company covers 90% of the schools and the remaining 3% is shared between three companies. These are difficult to reach schools, typically located on hilltops. Eggs are supplied by one company, which also guarantees the eggs are domestic. Unfortunately, during the COVID period, many small suppliers went out of business, and since then it has been necessary to contract out the best of the few. Delivery time, quality, susceptibility to back-pricing (due to quality problems), seasonality, and supplying domestic products where possible, which is particularly difficult in winter, are all taken into account when selecting a subcontractor. Products that are grown in greenhouses during winter are too expensive, so it is sometimes necessary to rely on imports. The requirement that products should be organic, or bio is impossible to meet, and the municipality cannot finance it in terms of price. The meat suppliers initially insisted on imports, but agreements were reached with two major companies that only supply domestic products, covering all schools. They offer a unique price to ÉSZGSZ because their standard prices are too high, requiring pressure to be put on them. The main questions for them were whether they could supply multiple kitchens, be flexible in delivery times, and send processed and not frozen meat (K. Simonné, personal communication, February 6, 2024).

Dry goods are also supplied by two companies to the schools (such as pasta, spices, etc.), but in one case, problems have arisen because they have started invoicing delivery costs, which were not previously discussed. If this is not suspended, the ÉSZGSZ will look for a new supplier (K. Simonné, personal communication, February 6, 2024).

There are also two suppliers for dairy products. One supplies short-shelf-life products at a very favorable price, while the other supplies longer-shelf-life products. The former delivers the same products that the latter could also supply, but since these products expire soon, they are much cheaper to obtain. Additionally, this supplier is very flexible and cooperative. In contrast, the other supplier has also started invoicing delivery costs, and negotiations are currently underway regarding this matter (K. Simonné, personal communication, February 6, 2024).

All suppliers are required to use the Quadrobite food service software, where they can upload their offerings, and every school's food service manager can then compile weekly menus from there, taking into account food sensitivities as well. Orders are made based on inventory and

needs, considering the school's refrigeration capacity. Some schools have refrigerators, while others need to order each day ('they cook from the truck'). The database contains fixed recipes for quicker ordering, but there is also the possibility of creating new ones. To access these and the discounted prices provided to ÉSZGSZ, they simply need to log in to the system with their user account. Once a school places an order, it is signed at the ÉSZGSZ headquarters and then forwarded to the supplier. Upon receipt, it is the school's responsibility to ensure that all ordered items have arrived (K. Simonné, personal communication, February 6, 2024).

VIII.2.2. Measurement of food waste in schools

As described earlier, with the help of the food consulting company, InDeRe, the measurement of food waste has become possible for ÉSZGSZ since the cooperation has begun in 2015. InDeRe is a nonprofit company, sustaining itself through grants, therefore, it is much cheaper than other food consulting firms, which is one of the main reasons for ÉSZGSZ choosing them. Since the SF4C has not yet come into effect, the company has not implemented any interventions. Currently, their mandatory tasks include: the HACCP (Hazard Analysis & Critical Control Point) systems, self-monitoring systems and dietary supervision. Besides, they have been doing a lot of individually undertaken tasks providing a lot of help for ÉSZGSZ, including internal food safety advisory supervision, surface microbiological examinations, microbiological examination of prepared foods, training of food handlers, food service management academy, measurement of food waste, and measurement of consumer satisfaction (A. Tóth, personal communication, February 20, 2024).

Table 3 provides a comprehensive overview of school waste data spanning from 2017 to 2022, highlighting various metrics such as the number of surveys conducted, ordered portions, portions actually served, total measured quantity in kilograms, quantity not served, quantity returned, percentage of food left on plates, number of portions not served, and the percentage of food not served.

Basic data	2017	2018	2019	2020	2021	2022
Number of surveys	98	98	98	99	95	95
Number of ordered portions (portion)	8800	9342	8866	9006	7915	9590
Number of portions actually served	7782	8283	7783	7227	6023	7552

Total measured quantity (kg)	6670	6934	8135	6501	5769	6274
Quantity not served (kg)	1394	1226	1638	1955	1871	1633
Quantity returned (kg)	1421	1440	1750	1476	1234	1370
Percentage of food left on plates	27%	25%	27%	32%	32%	30%
Number of portions not served	1018	1059	1083	1779	1892	2038
Percentage of food not served	12%	11%	12%	20%	24%	21%

Table 3
Measured food waste from 2017-2022
Adapted from: A. Tóth, personal communication, February 20, 2024

The table reveals a consistent number of surveys conducted annually, with 98 to 99 surveys recorded each year. Over the years, the number of ordered portions varies, ranging from 8,800 to 9,590. Similarly, the actual number of portions served fluctuates, with values ranging from 6,023 to 8,283. It is important to note that the percentage of food left on plates increase from 27% to 32% between 2019 and 2020 and remained on that level in 2021. Analyzing the number of portions not served and the corresponding percentage provides additional insights. For example, the number of portions not served ranges from 1,018 to 2,038 portions, with corresponding percentages ranging from 11% to 24% with the highest number similarly in 2020 and 2021. According to Tóth during our interview, the quantity of food waste due to COVID in the past few years is not indicative. The main concern was to prevent people from getting infected, so there was a lot of waste, and environmental protection and waste reduction were not considered. Classes went in and out of schools haphazardly due to quarantine regulations, resulting in a lot of ordered food being thrown away. However, analyzing the quantity returned it can be seen that the amounts have not changed during the pandemic, so the reason must be different. Based on the conducted surveys, the following three-three explanations in Figure 7 give the answers (A. Tóth, personal communication, February 20, 2024).

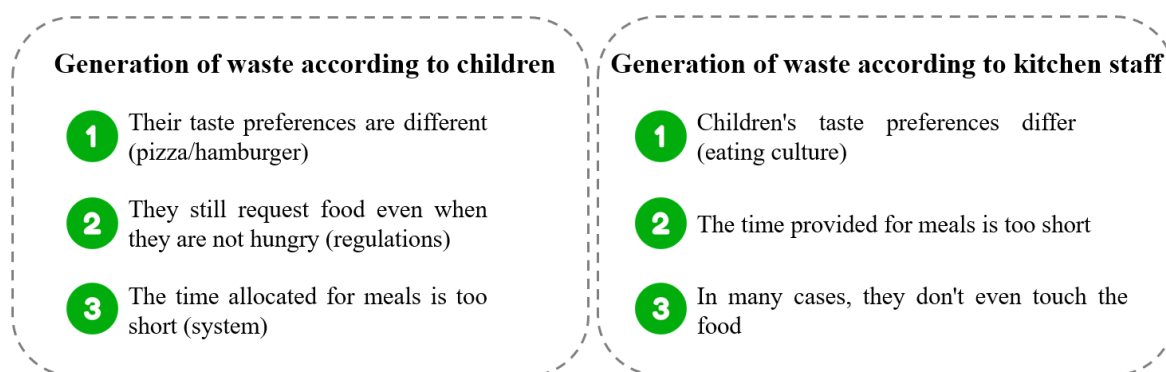


Figure 7
Reasons for waste generation according to children and staff
Adapted from: A. Tóth, personal communication, February 20, 2024

As a matter of fact, both the children and the kitchen staff think similarly regarding the reasons behind waste generation. The most significant issue is that children have different taste preferences in contrast to what is served to them in the school kitchens. Most of them prefer chicken breast over stews and if the latter is served to them, they tend to not eat it. Furthermore, there is a pressure that the food must be requested, even if they would not consume it. This is a regulation issue which should be rethought, because served food cannot be saved. As a third point, children emphasized the lack of time provided for meals. In many cases, it is impossible to completely finish their lunch because they have to rush to the next class. If lunch breaks are 20-30 minutes long, and by the time a student goes through the waiting line and receives the food remains only 5-10 minutes making the whole experience unenjoyable and hectic. It is also highlighted by the kitchen staff that lunch breaks must be reconsidered in order to avoid waste generation. Lastly, the staff also mentioned that there are cases when students do not even touch the food. This point is closely connected to the first that taste preferences significantly differ (A. Tóth, personal communication, February 20, 2024).

All in all, the amount of waste in school dining worldwide ranges between 42-50% (A. Tóth, personal communication, February 20, 2024). This quantity comprises both the food served but not consumed and the food not served. It's not necessarily the case that there's more waste in places where there is breakfast, lunch, and dinner compared to those serving only lunch. A good example is a student living in a dormitory who consumes all three meals at school. In more affluent areas, where there are restaurants or fast-food outlets near schools, there may be more waste in terms of volume, even though there's only one meal served. Overall, the 80-20 rule applies, the more children there are, the more waste, in direct proportion. Served food is also called contaminated and unserved is uncontaminated food. The former refers to food that has

come into contact with consumers, for example the previously described children who only request their meals because it is a regulation. These foods are considered hazardous waste and even to animals it cannot be given after heat treatment. Uncontaminated food could potentially be used for feeding purposes, but the primary aim is to distribute it to people. If there was no waste from unserved food, approximately half of the ordered quantity could be saved, thus instead of a linear food supply chain where the end result is the waste, a circular supply chain would be functioning, and the uncontaminated food would be consumed (A. Tóth, personal communication, February 20, 2024).

VIII.3. Food saving

The Hungarian Foodbank Association assists ÉSZGSZ in reducing food waste by rescuing surplus food. This organization has been operating for 19 years, and in 2023 alone, they managed to save 10,000 tons of food in Hungary. Their main focus is collaborating with major food retailers, from which they rescue surplus, damaged packaging, or soon-to-expire food items and distribute them to those in need. They collect food from a total of 700 stores daily and distribute it from their warehouse in the 17th district. However, this branch is showing a decreasing trend as stores also strive to minimize their generated waste, prompting the organization to explore new opportunities. Thus, in the spring of 2023, they began rescuing prepared meals from schools and events (J. Bajdik, personal communication, February 26, 2024).

In transportation and logistics, they receive assistance from 500 partners. These are all charitable organizations or foundations, typically family support centers, day care centers, and homeless shelters, which distribute the food to those in need. The food rescue operation currently operates in seven schools, five of which are under ÉSZGSZ, with the other two also being in Budapest. Among the five schools, the distribution in three is handled by the same large organization, while in the other two, it's done by smaller ones. The former delivers food to the homeless, one smaller one does the same and the second smaller serves families in transitional housing. Deliveries always take place on the day after the meal service, when the partner organizations visit the schools in the morning and distribute the food for lunch or dinner. The Hungarian Foodbank Association coordinates the process and also provides the boxes needed for packaging and the shock freezers for freezing (J. Bajdik, personal communication, February 26, 2024).

These shock freezers are high-performance units capable of cooling food from 60 degrees Celsius to below 5 degrees Celsius within one and a half hours, with a power of 3-3.5 kW. The food is shocked after it has cooled down in the afternoon and is delivered within 24 hours. Due to their high-power requirements, they need a stable power supply circuit to operate, and unfortunately, it sometimes happens that the school lacks the necessary infrastructure. Additionally, there is a need for a three-phase power system, which is a more common issue than the strength of the network itself. Among the schools under ÉSZGSZ all of them have adequate systems. In Budapest, the municipality renovates the infrastructure for all schools, but in rural areas, this may not always be the case. There are two sizes of shock freezers available: a smaller one (50+ boxes, costing 2 million HUF) and a larger one (100+ boxes, costing 5 million HUF). Most schools do not require the larger units, as the capacity of the smaller ones is sufficient. In several cases, the large freezer does not even fit into the kitchen due to its dimensions (2.1 meters tall and 190 kg), making the smaller freezers the only viable solution (J. Bajdik, personal communication, February 26, 2024).

Although the collaboration between ÉSZGSZ and the Hungarian Foodbank Association started in the spring of 2023, the fifth school joined the program in November 2023, allowing for proper measurement of the quantity of saved food since then. In the last recorded month, January 2024, more than 3000 boxes of food were delivered to those in need within a month from the five schools. It is certain that in the coming months, larger quantities will be available because January did not produce as much salvageable food due to school breaks. These 3000 boxes of food correspond to the same number of portions, each portion being individually packaged in 750 ml boxes. On days dominated by soup, such as cauliflower soup days, this is typically what remains and is delivered, while on days dominated by main courses, where stew is the main dish, stew is mostly delivered to those in need (J. Bajdik, personal communication, February 26, 2024).

VIII.4. Challenges of waste reduction

In the food supply chain of ÉSZGSZ, one challenge I could identify during the research is related to the suppliers. It is really difficult to find those that are willing to transport Hungarian products for a low price and be flexible as well. The continuous negotiations with suppliers are therefore focused on keeping the prices low, making it challenging for ÉSZGSZ to also enforce sustainability-related expectations on them. Breaking it down on a monthly basis, which

roughly equates to about twenty school days, the average daily raw material cost should be around 480 HUF per person (K. Simonné, personal communication, February 6, 2024). Although batch ordering helps in both keeping prices low and reducing waste, there is still a significant amount of waste generated from packaging materials, which suppliers often do not remove, leaving ÉSZGSZ to manage it. Another challenge is that it's not always possible to order domestic products due to the seasonality of fruits and vegetables, sometimes forcing the use of imported goods. According to Simonné (2024), 80% of their annual procurement must be domestic, meaning that sometimes even tomatoes may not come from domestic producers at all.

The other main source of waste is generated from the previously defined served and unserved meals. On the one hand, there is insufficient time for meals, mostly the responsibility of the schools. On the other hand, the main issue lies in the fact that students do not consume the prepared meals. In many cases, they don't even request them, and if they do, they leave them on the plate, resulting in over a ton of food waste annually. The aforementioned price pressure also plays a significant role here. According to public opinion surveys conducted among children, they would much prefer peaches with breaded meat instead of pickles, but due to the excessive price difference, they are unable to order them, leaving them with pickles, most of which go to waste. Furthermore, given that ÉSZGSZ is owned and supervised by the municipality of Budapest, there are long and exhaustive processes if they want to implement something new or just make some changes in the recent system (K. Simonné, personal communication, February 6, 2024).

Comparing the challenges detailed in the literature faced by an agri-food supplier and the above-mentioned challenges faced by a public catering service provider in Table 4 below, it is visible that they have similar barriers to tackle.

	Agri-food supplier	Public catering service provider
1.	Food characteristics	Price pressure
2.	Supply chain uncertainty	Lack of suppliers in the public catering industry
3.	Information technology	Relatively short time for seasonal products
4.	Supply chain partnerships	Difficult and long processes (only five schools from ÉSZGSZ joined to the Hungarian Foodbank Association)
5.	Operational capability	Insufficient amount of time for children for eating (regulation)

6.	Consumer behavior	Different taste preferences
7.	Food policy and regulation	Controlled and financed by the municipality
8.	Supply chain networks	

Table 4
Challenges for a manufacturer and public catering service provider reducing waste
Own editing, 2024

These challenges demand solutions for both suppliers and public catering service providers. There is no doubt that the recent system of ÉSZGSZ could be developed in order to reduce waste. For the procurement, the SF4C project could provide guidance with the eight objectives set by the consortium. Currently, two are already functioning in ÉSZGSZ: 15% of schools are offering free of charge breakfasts or healthy snacks and there has been a 15% increase of number of kitchens preparing less than 5000 meals/day. Theoretically, 25% of primary food products come from regional sources, but this cannot be controlled properly yet and suppliers may not keep their promises. 25% GHG emissions reduction through more plant-based food content is becoming more viable, just like 15% of SF4C tenders including food education-related criteria. For that suppliers should pay visits or hold events at their factories or logistics centers regarding their products. Moreover, the goal that 50% of coffee, tea and exotic fruits should come from fair trade is also under discussion. The only two goals that seem impossible in Hungary (as of now) are that 40% of food should be procured from organic agriculture and 12% of from small farmers. On the long run, when the other six are achieved, hopefully these will be possible too.

IX. CONCLUSIONS

The ÉSZSGZ has already taken several steps to make its supply chain more circular and sustainable, but as we have seen in the analysis, waste still occurs at several points, so further solutions are needed.

It's evident that children's consumption is primarily related to the quality and variety of foods. Several ideas have already been proposed on how to improve the quality of food, thereby reducing the considerable waste left on students' plates.

One initiative from the InDeRe company is to organize training sessions for kitchen staff to enhance their skills. From here came the idea of collaborating with other schools or even universities to learn from each other. In 2023, several school cooks had the opportunity to visit the Pollenzo Foodlab at the University of Gastronomic Sciences in Italy. Participants from 12 countries attended, learning from 22 chefs and nutrition experts over five days, sharing best practices with each other.

In addition, they organize training sessions for kitchen staff here at home as well, where they can also share experiences. During these occasions, there is a strong emphasis on increasing the sustainability of school catering and reducing food waste. Furthermore, education has begun on the prioritization of plant-based ingredients and the consideration of seasonality, exploring alternatives for substituting non-seasonal fruits or vegetables.

There are already several best practices on the types of healthy foods that children enjoy. Examples include beetroot ketchup, celery ice cream, or Hokkaido pumpkin, which can be used to make desserts similar to brownies or chips. Experience shows that if we give food a different name, some kind of invented fantasy name, it becomes much more popular. In trial runs at ÉSZGSZ schools, they looked at whether the unpopular broccoli cream soup would be consumed by more students if it were named after the beloved strong and green superhero, Hulk soup. Consumption increased by more than 60%. What is important in such introductions is gradual communication with both kitchen staff, the school, and the students. Healthy changes like these need to be introduced gradually, so to speak, "with plenty of sweets" (A. Tóth, personal communication, February 20, 2024).

Another important aspect is changing the surroundings. The dining area should be made a more attractive and better place in almost every school. This can be achieved with appealing

decorations or notices displaying information about healthy foods, motivating students to eat healthily and consume their meals. Extending the previously mentioned often twenty-minute lunch breaks would give students more time to eat and avoid rushing. This requires rearranging the schedule and allocating potentially twice as much time for lunch, similar to many Western countries. If possible, it is also worth increasing the size of the cafeteria and kitchen or designing them to be larger from the start, as more spacious areas provide better conditions. Additionally, tables could be spaced out more freely, and dining would not be in cramped spaces.

To motivate other schools, informational posters could be placed in all kitchens, stating that the ÉSZGSZ is participating in the SF4C project and welcomes participation from others. It could also indicate how many schools are already participating, in the hope that more would join.

When ordering fruits and vegetables, a lot of waste is generated in the kitchens. These could be sent to compost bins for disposal.

Alongside changing our diets, we need to transform agricultural production methods and our food environment. Like in the developed regions of the world, we should consume much less meat, especially red meat, and much more plant-based food, including proteins. Meat-free days could also be implemented once a week in schools for health reasons. Animal protein is legally mandated, so meat-free days would be feasible as it could be substituted by other sources.

In recent times, there is increasing talk about the self-service solution, which seems to be a promising option based on trial periods. The initiator in Hungary is the Hungast catering provider. They did a self-service project with the Hungarian company KÖZSZÖV after they gathered experiences from providers in Sweden during their visit to the country. Based on what they saw abroad, they concluded that the self-service system can also be well-operated in schools, and the initial experiences confirmed that such an experiment can be justified domestically as well (Előd, 2024).

KÖZSZÖV tested it from March to June 2023 in 18 service areas and 24 institutions (10 primary schools, 14 secondary schools). The target age groups were 7-10, 11-14, 15-18, and 19-69, encompassing approximately 5,000 consumers. The solution offered both quantitative and qualitative choices (multiple menu options), including soup, two main courses, and a selection from the cold counter each time. Consumer satisfaction significantly increased. The youth were educated to respect food by taking only what they could eat. Every meal found a taker. There was less environmental burden from waste transportation and disposal (Előd, 2024).

The questions raised by such a self-service system are related to hygiene. If children, especially the youngest ones, forget to wash their hands or even pick out certain foods by hand, diseases can easily spread, which is definitely not hygienic. To address this, I would suggest the idea of having a plexiglass barrier in front of the buffet table, with kitchen staff still serving the food. Children would simply point at what they want and indicate how much, and the staff would serve them.

IX.1. Limitations and further research possibilities

The study encountered several limitations that offer opportunities for further research. Firstly, due to constraints, interviews with suppliers, particularly those where waste occurs, were not conducted. Exploring their processes and strategies for waste reduction would provide valuable insights into potential interventions. Secondly, the research focused solely on Budapest, and within it only on ÉSZGSZ, which presents a unique case with one catering provider serving multiple schools. However, this may not be representative of other cities and rural areas, where catering arrangements may differ significantly. Investigating similar setups in other regions could offer comparative insights into waste management practices. Lastly, the SF4C project is in its initial stages, and the study did not capture its full impact. Continued monitoring of the project's progress over an extended period would expose its effectiveness in waste reduction over time, providing valuable data for future research and policy development.

X. SUMMARY

The core of this research is summarized in the central question: Where does food waste occur at a public catering service provider and how can it be reduced? The issue is explored through ÉSZGSZ, the entity overseeing food quality and supply chain management in Budapest's public schools.

The methodology of this research is designed to comprehensively explore circularity and sustainability in food supply chains, with a focus on waste reduction strategies. The research approach is built up a combination of theoretical and empirical methods to address the complicated nature of the subject. While the theoretical part provides a conceptual basis, the empirical research adds practical relevance and depth to the study. The research methodology is a blend of qualitative and secondary research methods. The choice of qualitative research, particularly through conducting interviews, is driven by the need to gain in-depth insights into the practical aspects of circularity in food supply chains. Qualitative research is appropriate for exploring complex, context-dependent issues where the perspectives of individuals play a crucial role in understanding.

The literature review highlights the alarming global issue of food waste, shedding light on the significant amount of food wasted worldwide. The research explores the differences between linear and circular supply chains and delves into the principles of the 3R concept: reduce, reuse, and recycle. Challenges faced by food suppliers in transitioning to circularity are identified, offering insight into the barriers hindering progress in this area.

Further analysis focuses on public school food provisions, examining relevant literature and EU directives such as the Farm to Fork strategy, particularly the SF4C project. The problem analysis specifically targets the public catering provider in Budapest, ÉSZGSZ, detailing the organization's structure and revealing four main points of waste occurrence: suppliers, organizational processes, kitchen operations, and dining areas.

The recent improvements toward sustainability are discussed, including the adoption of low-energy kitchen appliances and the involvement of five schools in the Hungarian Foodbank Association, which saves leftover food. The analysis compares the challenges faced by food suppliers and a public catering service provider. Furthermore, the goals set by the EU's SF4C project are highlighted concerning ÉSZGSZ.

The recommendations include expanding participation in the Hungarian Foodbank initiatives. Besides the five schools under ÉSZGSZ others should start to cooperate. The regulations must be revised, including more time for children to eat, and providing larger dining areas with decorations and posters about healthy eating habits. In order to improve the food quality, further education and training is needed for kitchen staff. There must be more attention put into the introduction of healthier and plant-based meal options, and lastly, implementing self-service serving, where children decide what type of meal and how much they want to consume in order to minimize both the served and unserved food waste.

XI. REFERENCES

- Ada, N., Kazancoglu, Y., Sezer, M. D., Ede-Senturk, C., Ozer, I., & Ram, M. (2021). Analyzing barriers of circular food supply chains and proposing industry 4.0 solutions. In *Sustainability (Switzerland)* (Vol. 13, Issue 12). MDPI AG. <https://doi.org/10.3390/su13126812>
- Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S., & Cembalo, L. (2017). Consumers' perspective on circular economy strategy for reducing food waste. *Sustainability (Switzerland)*, 9(1). <https://doi.org/10.3390/su9010141>
- Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: Moving toward new theory. In *International Journal of Physical Distribution and Logistics Management* (Vol. 38, Issue 5, pp. 360–387). <https://doi.org/10.1108/09600030810882816>
- Castellani, V., Sala, S., & Mirabella, N. (2015). Beyond the throwaway society: A life cycle-based assessment of the environmental benefit of reuse. *Integrated Environmental Assessment and Management*, 11(3), 373–382. <https://doi.org/10.1002/ieam.1614>
- Cheng, H., Dong, S., Li, F., Yang, Y., Li, Y., & Li, Z. (2019). A circular economy system for breaking the development dilemma of 'ecological Fragility–Economic poverty' vicious circle: A CEEPS-SD analysis. *Journal of Cleaner Production*, 212, 381–392. <https://doi.org/10.1016/j.jclepro.2018.12.014>
- Chiaraluce, G., Bentivoglio, D., & Finco, A. (2021). Circular economy for a sustainable agri-food supply chain: A review for current trends and future pathways. In *Sustainability (Switzerland)* (Vol. 13, Issue 16). MDPI. <https://doi.org/10.3390/su13169294>
- Despoudi & Dora. (2020). Circular food supply chains. *Food Science and Technology*, 34(1), 48–51. https://doi.org/10.1002/fsat.3401_13.x
- Diófási-Kovács, O., & Freund, A. (2022). 22nd international scientific conference *Business Logistics in Modern Management*.
- Dou, Z., & Toth, J. D. (2021). Global primary data on consumer food waste: Rate and characteristics – A review. In *Resources, Conservation and Recycling* (Vol. 168). Elsevier B.V. <https://doi.org/10.1016/j.resconrec.2020.105332>
- Előd Fruzsina. (2024, February). Svédasztalos menzák jöhetnek több tízezer diáknak. Telex; *Telex*. <https://telex.hu/belfold/2024/02/01/menza-svedasztal-kiserlet-hungast-altalanossa-tennek>
- Esposito, B., Sessa, M. R., Sica, D., & Malandrino, O. (2020). Towards circular economy in the agri-food sector. A systematic literature review. In *Sustainability (Switzerland)* (Vol. 12, Issue 18). MDPI. <https://doi.org/10.3390/SU12187401>
- FAO. (2011). *Global food losses and food waste : extent, causes and prevention : study conducted for the International Congress "Save Food!" at Interpack 2011 Düsseldorf, Germany*.
- FAO. (2019). *The state of food and agriculture. 2019, Moving forward on food loss and waste reduction*.
- FAO. (2020). The State of Food and Agriculture 2020. In *The State of Food and Agriculture 2020*. FAO. <https://doi.org/10.4060/cb1447en>
- FAO. (2021). The State of Food and Agriculture 2021. In *The State of Food and Agriculture 2021*. FAO. <https://doi.org/10.4060/cb4476en>

- Farm to Fork Strategy. (2023). Food Safety. https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
- Food Marketing Technology. (2021, November 24). What is Global Food Supply Chain - *FMT Magazine*. *Food Marketing Technology*. <https://fmtmagazine.in/what-is-global-food-supply-chain/>
- Fogarassy, C., Nagy-Pércsi, K., Ajibade, S., Gyuricza, C., & Ymeri, P. (2020). Relations between circular economic “principles” and organic food purchasing behavior in Hungary. *Agronomy*, 10(5). <https://doi.org/10.3390/agronomy10050616>
- Franco, M. and Fajó-Pascual, M. (2022) ‘School food systems’, *Reference Module in Food Science*, pp. 1–9. doi: 10.1016/b978-0-12-821848-8.00146-3.
- Geng, Y., & Doberstein, B. (2008). Developing the circular economy in China: Challenges and opportunities for achieving “leapfrog development.” In *International Journal of Sustainable Development and World Ecology* (Vol. 15, Issue 3, pp. 231–239). <https://doi.org/10.3843/SusDev.15.3:6>
- Gokarn, S., & Kuthambalayan, T. S. (2017). Analysis of challenges inhibiting the reduction of waste in food supply chain. *Journal of Cleaner Production*, 168, 595–604. <https://doi.org/10.1016/j.jclepro.2017.09.028>
- Govindan, K., & Hasanagic, M. (2018). A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective. *International Journal of Production Research*, 56(1–2), 278–311. <https://doi.org/10.1080/00207543.2017.1402141>
- Gustavsson, Jenny., Food and Agriculture Organization of the United Nations., & ASME/Pacific Rim Technical Conference and Exhibition on Integration and Packaging of MEMS, N. (2011). *Global food losses and food waste : extent, causes and prevention : study conducted for the International Congress “Save Food!” at Interpack 2011 Düsseldorf, Germany*.
- Helm, S., Serido, J., Ahn, S. Y., Ligon, V., & Shim, S. (2019). Materialist values, financial and pro-environmental behaviors, and well-being. *Young Consumers*, 20(4), 264–284. <https://doi.org/10.1108/YC-10-2018-0867>
- Henshaw, Han, & Owens. (1996). *henshaw1996*.
- Joshi, R., Banwet, D. K., & Shankar, R. (2009). Indian cold chain: Modeling the inhibitors. *British Food Journal*, 111(11), 1260–1283. <https://doi.org/10.1108/00070700911001077>
- Kumar, M., Sharma, M., Raut, R. D., Mangla, S. K., & Choubey, V. K. (2022). Performance assessment of circular driven sustainable agri-food supply chain towards achieving sustainable consumption and production. *Journal of Cleaner Production*, 372. <https://doi.org/10.1016/j.jclepro.2022.133698>
- Munk, V. (2022a, January 19). Truttyfőzelék, éhes gyerekek: miért ilyen rossz az iskolai menza? Telex; *Telex*. <https://telex.hu/belfold/2022/01/19/truttyfozelek-ehes-gyerekek-miert-nem-jobb-az-iskolai-menza>
- Munk, V. (2022b, January 27). Volt, aki fekete műkörömre harapott a nudliban, máshol viszont imádják az iskolai menzát. Telex; *Telex*. <https://telex.hu/belfold/2022/01/27/fekete-mukoromre-harapott-a-nudliban>

- Pannila, N., Jayalath, M. M., Thibbotuwawa, A., Nielsen, I., & Uthpala, T. G. G. (2022). Challenges in Applying Circular Economy Concepts to Food Supply Chains. *Sustainability (Switzerland)*, 14(24). <https://doi.org/10.3390/su142416536>
- Parfitt, J., Barthel, M., & MacNaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. In *Philosophical Transactions of the Royal Society B: Biological Sciences* (Vol. 365, Issue 1554, pp. 3065–3081). Royal Society. <https://doi.org/10.1098/rstb.2010.0126>
- Prendeville, S. (2014). *Circular Economy. Is it Enough?* <https://doi.org/10.13140/RG.2.1.1473.1128>
- SchoolFood4Change. (2023). *Fenntartható közbeszerzés és fenntartható közétkeztetés*. <https://foodclic.eu/>
- SchoolFood4Change project - *EU Horizont*. (2020). Grant number: 101036763.
- Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, 16(15), 1699–1710. <https://doi.org/10.1016/j.jclepro.2008.04.020>
- Shukla, S., Shankar, R., & Singh, S. P. (2014). Food safety regulatory model in India. *Food Control*, 37(1), 401–413. <https://doi.org/10.1016/j.foodcont.2013.08.015>
- Siemens, S. (2023, June 22). The Circular Supply Chain Is Driving Corporate Decarbonization. Supplychainbrain.com; *SupplyChainBrain*. <https://www.supplychainbrain.com/articles/37525-the-circular-supply-chain-is-driving-corporate-decarbonization>
- Tátrai, T. and Vörösmarty, G. (2023) ‘Comparative Analysis of the European Centralised Public Procurement’, *Central European Journal of Public Policy*, 17(1), pp. 1–15. doi: 10.2478/cejpp-2023-0007.
- United Nations Environment Programme (2021). Food Waste Index Report 2021. Nairobi.
- Van Rijswijk, W., & Frewer, L. J. (2008). Consumer perceptions of food quality and safety and their relation to traceability. *British Food Journal*, 110(10), 1034–1046. <https://doi.org/10.1108/00070700810906642>
- Vincze, B. (2022, February 4). A szomszédban már az ingyenes menzát is megpróbálták, máshol szinte ismeretlen a klasszikus iskolai menza fogalma. Telex; *Telex*. <https://telex.hu/kulfold/2022/02/04/iskolai-menzak-europaban-korkep-az-iskolai-etkezesrol>
- Ying, J., & Li-jun, Z. (2012). Study on Green Supply Chain Management Based on Circular Economy. *Physics Procedia*, 25, 1682–1688. <https://doi.org/10.1016/j.phpro.2012.03.295>