Social Supermarkets:

Assessing and Comparing Surplus Food Management Strategies in Sweden

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Social Supermarkets: Assessing and Comparing Surplus Food Management Strategies in Sweden

Social supermarkets: analisi e confronto tra strategie di gestione di surplus alimentare in Svezia

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Abstract

Food waste is a global issue with profound environmental, economic, and social consequences, as approximately one-third of all food produced for human consumption is either lost or wasted. Over the past decades, food waste (FW) management strategies have become more efficient, with landfilling gradually declining across Europe in favour of more sustainable options. European directives prioritize the prevention of surplus food production, as well as the reuse, recycling, and recovery of FW. In line with these principles, initiatives such as social supermarkets (SSMs) have emerged to divert surplus food from waste and redistribute it to financially vulnerable populations at affordable prices. This case study conducted a Life-Cycle Assessment (LCA) of a Swedish SSM. To provide a comprehensive evaluation of the environmental impact of SSM operations, system expansions like food substitution and the rebound effect were incorporated. The results were compared to the global warming potential (GWP) of more common FW management options in Sweden, such as anaerobic digestion and incineration with energy recovery. Additionally, the study offered insights into the social aspects of SSMs, emphasizing their potential to complement existing FW management strategies while addressing socio-economic challenges. The data collection employed questionnaires that were administrated to the SSM's customers. The results show that the SSM is more effective at reducing greenhouse gas emissions (-2.53 t CO_2e/FU) than anaerobic digestion and incineration (-0.23 and -0.11 t CO_2e/FU, respectively). However, the rebound effect offset 87% of this benefit, with -0.18 t CO_2e/FU as a net result. From a social perspective, customers are generally satisfied with the SSM, particularly appreciating the autonomy and dignity it offers in purchasing groceries compared to other forms of food assistance.

Keywords: Food Waste, Surplus food, Social Supermarkets, Life-Cycle Assessment (LCA), Rebound Effect

Abbreviations

AD	Anaerobic Digestion
CHP	Combined Heat Plant
CF	Carbon footprint
CO_2e	Carbon Dioxide Equivalent
EU	European Union
FL	Food Loss
FU	Functional Unit
FW	Food Waste
GHGE	Greenhouse Gas Emissions
GWP	Global Warming Potential
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MSW	Municipal Solid Waste
MFW	Metabolic Food Waste
SLU	Swedish University of Agricultural Sciences
SSM	Social Supermarket

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1. Introduction

Food waste and loss represent a critical global challenge with significant environmental, economic, and social implications. Annually, approximately one-third of all food produced for human consumption is either lost or wasted (Corrado et al., 2019; Skaf et al., 2021). The production of food destined to become waste results in the excessive and avoidable depletion of natural resources, including soil, water, and energy. Additionally, the disposal of food waste (FW) significantly contributes to environmental degradation, particularly through greenhouse gas emissions (GHGE). Moreover, FW causes substantial financial losses (UNEP, 2021). Simultaneously, millions of people suffer from hunger, lack guaranteed access to food, and are unable to consume balanced meals, leading to nutritional deficiencies and metabolic disorders. This paradox of surplus and scarcity underscores the urgent need for effective FW management.

In 2008, the European Union updated the waste framework directive (European Commission, 2008) with guidelines aimed at minimizing the environmental and health impacts generated by waste while enhancing resource efficiency. The waste hierarchy prioritizes waste prevention as the most preferred option, followed by waste management strategies such as reuse, recycling, recovery (e.g., energy recovery), and disposal (e.g., landfilling, incineration without energy recovery) as the least favoured option. In 2020, the European Commission published a brief on FW (European Commission, 2020) which applies food waste hierarchy principles to FW. According to this framework, the most effective practice for managing FW is to avoid surplus food production. The second-best option is to reuse surplus food for human consumption. Food banks and redistribution networks play a crucial role in this process. Composting and anaerobic digestion (AD) of FW for producing valuable products rank lower on the hierarchy, just above incineration with energy recovery, while landfilling remains the least preferred option. Surplus food redistribution involves collecting excess food from retailers, manufacturers, and producers, and distributing it to those in need before it becomes waste (Holweg et al., 2010).

Social supermarkets (SSMs) represent an innovative model within this framework. Although SSMs have been established in Europe since the 1980s, their history is relatively recent compared to traditional food banks. Unlike food banks, SSMs sell surplus food at significantly reduced prices to economically disadvantaged individuals, enabling them to purchase food with dignity and choice, rather than receiving it for free. SSMs not only address FW but also provide a more inclusive and dignified form of food assistance.

This study aims to assess the environmental benefits and impacts of a Swedish SSM and evaluate it as a potential alternative to more established FW management strategies. The research compares the environmental impact of the SSM, expressed as global warming potential (GWP), with the two most common FW management strategies in Sweden: AD and incineration with energy recovery. The methodology employed is a Life-Cycle Assessment (LCA) of the SSM's processes, including an analysis of system expansions such as food substitution and rebound effects. While a previous LCA of a Swedish SSM has been conducted (Bergström et al., 2020), this study seeks to fill a gap in the literature by providing an LCA that accounts for the rebound effect. The rebound effect is a phenomenon commonly associated with energy efficiency improvements (Sorrell et al., 2009). In this context, it describes a situation where the environmental benefits of reducing carbon emissions are partially or even completely offset by behavioural responses that lead to increased emissions. Other studies have considered the rebound effect when assessing the sustainability of food redistribution strategies (Sundin et al., 2022; Sundin et al., 2023), such as food bag centres and soup kitchens. Ultimately, this study provides insight into the social aspects that the SSM may influence, recognizing that sustainability encompasses both environmental and socio-economic dimensions.

2. Background

2.1 Food Loss and Waste definitions

About 1.3 billion tonens of edible food get wasted worldwide every year, representing approximately one-third of the total food production (Skaf et al., 2021). One of the earliest definitions for food loss comes from the Food and Agriculture Organization (FAO) of the United Nations which defines it as "any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people” (FAO 1981). In 2011, FAO requested further investigation into the topic of FW which led The Swedish Institute for Food and Biotechnology (SIK) to new definitions of “food loss" and “food waste”. “Food loss” may be described as the reduction in edible food mass at various stages of the food supply chain, especially during post-harvest and processing stages which directly leads to a decrease in the amount of food available for human consumption (Cederberg and Sonesson, 2011; Gustavsson et al., 2013). “Food waste”, on the other hand, denotes a reduction in the amount of food available for human consumption occurring at the retail and consumer stages of the FSC. (Parfitt, Barthel, and Macnaughton, 2010; Read et al., 2020). It is essential to remark that both "food waste" and "food loss" concern only those products that are edible and intended for human consumption, excluding non-edible parts. Food is wasted across all the stages of the FSC, from the initial agricultural production to the final household consumption. Past research showed that FW varies significantly along the FSC among high, medium, and low-income countries, due to consumption patterns, storage and distribution infrastructures, agricultural practices, and technological efficiency. Cederberg and Sonesson stated that in medium- and high-income countries, significant waste occurs at the final stages of the FSC, i.e., consumer and distribution levels (Cederberg and Sonesson, 2011). Conversely, in low-income countries, FW tends to be predominant during the early and middle stages of the FSC, mainly due to inefficient means of food production, transportation, and preservation (Parfitt, Barthel, and Macnaughton, 2010). On the other hand, recent research assesses that household FW was found to be similar across country income groups, suggesting waste is equally relevant in high, upper-middle, and lower-middle income countries. However, data is not considered sufficient to delineate a trend or comparison among country income groups (UNEP, 2021).

2.2 Food waste: an environmental, economic, and social issue

FW is an environmental, economic, and social issue of global significance. The next paragraphs will treat each aspect to provide a more detailed understanding.

2.2.1 The environmental aspect

The environmental impact of FW contributes to climate change, pollution, and waste of natural resources. It implies the unnecessary depletion of resources such as water, energy, and material inputs used in food production (Skaf et al., 2019), alongside the vain release of GHGE. Up to 10% of global GHGE come from food that is produced, but not eaten (UNEP, 2021). Surplus food contributes to overconsumption and FW. Abundance facilitates the purchase and consumption of bigger quantities of food, which can lead to health issues like obesity. However, food overconsumption is not only a threat to human health, but to the environment as well. Serafini and Toti (2016), introduce the concept of metabolic food waste (MFW) to describe the amount of food consumed beyond an individual's physiological needs. The authors consider this excess consumption as a proper waste that not only leads to health issues such as obesity but also has significant ecological impacts, producing GHGE that could be avoided, and unnecessarily depleting input resources. Moreover, the overconsumption of animal products is the main contributor to MFW. More research on the topic has been conducted in Sweden by Sundin et al. (2021). The study assessed MFW through different dietary scenarios. The results show that MFW exceeds Swedish avoidable household FW by up to 66%. Notably, animal-based food was the primary contributor to GHGE. The estimated GHGE from the MFW amounted up to 1.2 Mt carbon dioxide equivalent (CO_2e) a year, representing 2% of the total climate impact in Sweden (Sundin et al., 2021).

2.2.2 The economic aspect

FW also causes a significant economic loss which affects all the stakeholders of the FSC, from producers to consumers, costing the global economy close to $940 billion each year (UNEP, 2021). The costs include the monetary value of the unsold food, and the primary resources used throughout its production, transportation, and consumption.

2.2.3 The social aspect

Besides being an environmental and economic issue, FW represents a social issue too. The ethical dimension raises notable inconsistencies regarding social justice, equity, and responsibility toward future generations. It is estimated that in 2022 between 690 and 783 million people in the world faced hunger (FAO et al., 2023). The Food and Agriculture Organization (FAO), through the Food Insecurity Experience Scale (FIES), assessed that 2.4 billion people worldwide are either moderately or severely food insecure. According to FAO, the food wasted each year would be sufficient to feed the millions of people suffering from hunger (Gustavsson et al., 2013). Only 25% of the food currently wasted in the United States, the United Kingdom, and Europe could potentially solve the global malnourishment issue (Facchini et al., 2018). Malnourishment affects high-income countries as well as low-income ones. A large population suffers from deficiencies in essential nutrients and vitamins, also known as hidden hunger. About 85% of Americans fail to meet the recommended daily intakes of micronutrients and vitamins, e.g., iron, zinc, iodine, and vitamin A (Drake, 2019; Kiani et al., 2022).

Surplus food encourages overconsumption, and it might lead to obesity. In 2022, it was estimated that 37 million children under five years old were overweight (FAO et al., 2023), while 800 million individuals are currently obese. Obesity, hunger, and FW are all symptoms of a food system that prioritizes quantity and convenience over quality and sustainability. This suggests that actions must be taken to achieve an equal, healthy, and sustainable food system on a global scale. Therefore, the Sustainable Development Goals (SDGs) have recognised these issues as major challenges (United Nations, 2024). FW also causes a significant economic loss which affects all the stakeholders of the FSC, from producers to consumers, costing the global economy close to $940 billion each year (UNEP, 2021).

2.3 Food Waste Management in Europe

The European Commission relies on the waste hierarchy to rank the preferred strategies to manage FW (Figure 1). Preventive actions are the preferable option, while landfilling is the least preferable (European Commission, 2020). According to research, in the EU 20% of the food produced (about 129 Mt) was wasted in 2011. The consumption stage is responsible for 46% of the waste, while the primary production and manufacturing account for 25% and 24% respectively (European Commission, 2020). In 2021, 58 million tonnes of food were wasted in the EU (Eurostat, 2023). Households and food production processes are responsible for 72% of the FW generated in the EU (Ferdeș et al., 2022), while the rest is produced by catering and retailers.

In the EU, there is extreme variability in the approach to municipal solid waste

(MSW) management among different member states. In Finland, Sweden, Estonia, Belgium, Denmark, the Netherlands, and Luxembourg percentages of waste landfilled are constantly reducing. In these countries, incineration with energy recovery affects larger percentages of waste (from 41% in Luxembourg to 61% in Finland), according to 2021 data. On the other hand, several countries such as Malta, Romania, Cyprus, Croatia, Latvia, Spain, and Hungary dispose of more than 50% of MSW in landfills (ISPRA, 2023). In 2022, Italy generated approximately 29.1 million tonnes of MSW. 18% of it was sent to landfills, while only 3.3% was used for energy recovery. The organic fraction of MSW accounted for 34.7% (about 10.1 million tonnes). Of this fraction, 23% underwent biological treatment (ISPRA, 2023).

The United Kingdom produces around 115 million tonnes of waste each year. Most of it is sent to landfill. The UK government has stated the need to reduce the amount of organic waste sent to landfills and committed itself to stop sending biodegradable municipal waste to landfills by 2025. Landfills are a source of pollution and can represent a threat to the environment and human health, due to toxic substances released in soil and water. A considerable amount of materials that end up in landfills could be a potential input resource for circular economy, if used for recycling instead. Landfills are the primary source of methane emissions with a global warming potential (GWP) of 28-36 kg CO_2e. This means that over 100 years one tonne of methane impacts global warming as the equivalent of 28 to 36 tonnes of carbon dioxide (IEA, 2021). These are some of the reasons behind environmental policies tendency to promote more sustainable alternatives to landfilling.

The aim of the EU Directive 2018/850 of the European Parliament and of the Council is to establish an efficient system of waste management that reduces the amount of landfilled waste, biodegradable waste in particular. The Directive follows the waste hierarchy listing the most preferable options for surplus food management such as prevention, recycling, and reuse of waste, followed by energy recovery and biological treatments, such as AD and composting. According to art. 6, only pre-treated waste can be landfilled. The share of municipal waste landfilled must be limited to 10% by 2035 (European Commission, 2018). In addition, Sweden has set a voluntary goal, the 25/25, which aims to reduce by 2025 the production of food and residual waste by 25% compared to 2015 (Avfall Sverige, 2022a).

In Sweden, the most common strategies for managing surplus food align with good practices for FW management. Most of the food is still incinerated, while AD is constantly increasing. A small fraction of FW is redistributed for human consumption (i.e., SSMs and food banks), which among all of them is the most preferable option.

There is no evident conflict between AD and food redistribution, as they might even target different fractions of FW. However, according to Johansson (2021), Swedish politics addresses the issue as an environmental and economic matter more than a social one, hence the prioritization of renewable fuel production from food loss over redistribution.

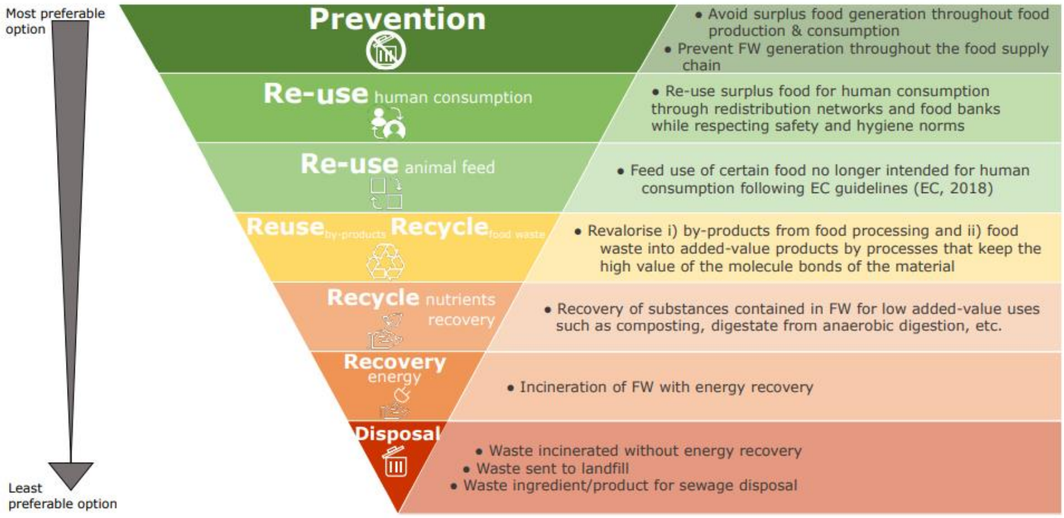

Figure 1. Hierarchy of food surplus, by-products and food waste (FW) prevention strategies in order of priority (European Commission, 2020).

2.4 Food Waste Management in Sweden

Sweden has built a strong waste management service and invested in campaigns and initiatives to raise consumers' awareness about FW. The development of an action plan to reduce food loss and waste by 2030 aims to reach a sustainable food system (Swedish Food Agency et al., 2018; Sundin et al., 2023). Sweden's waste system follows the waste hierarchy and a strict policy about landfilling. Therefore, as the least preferred organic waste management strategy, the amount of waste disposed in landfills corresponds to less than 1% of the total (Eriksson, Strid, and Hansson, 2015; Avfall Sverige, 2021; European Environment Agency, 2022). The landfill is used to treat waste that cannot be processed through other methods, such as contaminated materials (Avfall Sverige, 2022a). Incineration is the primary choice for waste management. Between 2016 and 2019, about 53% of MSW was incinerated. In 2023, over 1.5 million tonnes of residual waste were collected in Sweden. Food waste including home compost amounted to 465,000 tonnes (Avfall Sverige, 2023). There are several different systems for collecting and transporting organic waste. Collecting food and residual waste as a mixed fraction for energy recovery is becoming less common. Instead, FW can be collected as a separate fraction for energy recovery. Waste is often collected weekly from apartment buildings. Following the Government's decision, from July 2022, the garbage collecting system will be close to properties, rather than on recycling stations. The goal is to achieve higher levels of recycling. In 2021, 88.3% of Swedish municipalities had separate FW. Nonetheless, statistics show that 60% of waste is incorrectly sorted, mixing FW, packaging, paper, and even batteries and electrical waste for 0.5%. The most common MSW management strategies in Sweden are incineration with energy recovery, material recycling, and composting and digestion, respectively accounting for 49.7%, 31.0%, and 15.1% (Avfall Sverige 2021). Although surplus food redistribution is considered the second-best option according to the FW management hierarchy, it is still not a widely represented strategy. Nonetheless, it is rapidly increasing in Sweden, with remarkable results in alleviating environmental impacts as well as food insecurity (Bergström et al., 2020; Sundin et al., 2022). Matmissionen operates in Stockholm, Göteborg, Helsingborg, Malmö, and Linköping with SSM. The stores in Göteborg (under the name of MatRätt) handle over 40 tonnes of donated food every week. Matmissionen addresses ecological sustainability and contributes to the circular economy by significantly reducing FW. Since 2022, the Matmissionen has been collaborating with the Swedish trade organisations that represent the grocery industry and suppliers, respectively the Svensk Dagligvaruhandel and the Dagligvaruleverantörerna. Moreover, it works with all major food chains and about fifty suppliers.

In 2023, Matmissionen social grocery shops received donations for 4,180 tonnes of products that were meant to be discarded by other retailers. Matmissionen was able to sell most of the food, with a minor percentage FW. The redistribution of surplus food prevented CO_2 emissions that would have accounted for 6 million kronor (SEK) in carbon costs (Matmissionen 2024).

2.5 Anaerobic digestion, incineration, and social supermarkets

According to the purpose of the present study, the following sections will focus on the investigated FW management practices of AD, incineration and surplus food redistribution through SSMs.

2.5.1 Anaerobic digestion

In 2020, in the EU composting and AD rates increased from approximately 15 to 18.1% compared to the previous three-year period (European Environment Agency, 2022).

AD offers a cost-effective and sustainable alternative to the management of organic waste. AD helps mitigate environmental impact by reducing GHGE while producing renewable energy in the form of biogas. AD is a biological process that naturally happens to organic matter in the absence of oxygen. It works similarly to the food digestion in humans. During the AD process, the volatile components of organic matter are converted into biogas by four main groups of bacteria. The process's purpose is to break down complex molecules into simpler substances, which are then converted into fatty acids. The next reactions bring the methanogenic bacteria to the generation of methane and carbon dioxide, which are the main constituents of biogas. Biogas consists of about 60-70% methane and 30-40% carbon dioxide. Other by-products are hydrogen sulfide (H_2S), vapor water (H_2O), and ammonia (NH_3) (Yang, L. et al., 2015; Xu et al., 2018).

Besides biogas, AD has another output which is the digestate. The digestate is highly nutrient-concentrated, hence it can be utilised as a fertilizer in place of synthetic fertilizers. The AD process can take place at various temperatures, usually 35 -55 °C, but lower temperature reduces methane production (Khalid et al., 2011). AD could respond to the increasing demand for sustainable FW management and green farming.

AD is considered a valuable FW management strategy since it enhances the production of clean resources and contributes to circular economy. The methane included in biogas is a source of energy that, as it is, can provide electricity and heating. Moreover, if methane undergoes further processes it can be converted into biomethane and supply the gas grid or fuel public and private transportation. Uppsala is a virtuous example in Sweden of using biogas to fuel public transportation. From 2010 to 2019, the bus service provided by Gamla Uppsala Buss reduced fossil fuel consumption from about 3.2 million liters to zero. The buses are currently fueled by locally produced Hydrotreated Vegetable Oil biodiesel. Emissions avoided through this sustainable choice are about 8,300 tonnes each year (GUB, 2022). By using this green fuel, they are not only reducing their environmental impact but also avoiding any additional emissions that would have resulted from transporting fuel over long distances.

FW contains a high proportion of sugar and proteins (35.5–69% and 3.9–21.8% respectively). The high-energy content of this substrate makes it a valuable feedstock for the AD process, as it increases the efficiency and stability of the process (Millati et al., 2023). A study conducted by Zang et al. analysed the results of AD of FW collected by restaurants in San Fransisco, California. The biogas produced with the AD had a methane content of 73% (Zang et. al, 2007), confirming that FW is a highly suitable feedstock for AD.

Despite its benefits, AD poses challenges as well. These challenges include high operational and transportation costs, process instability due to pH oscillations, and the generation of toxic intermediates (Pramanik et al., 2019). In addition, biogas quantity and quality significantly vary due to the heterogeneity and complexity of the feedstocks (Ferdeș et al., 2022). According to research, nearly 40% of FW can be converted into biogas. However, it is important to consider the FW type. For instance, fruit and vegetable waste leads to a lower production of biogas, due to a high content of volatile solids and low content of total solids. In contrast, waste from the dairy industry requires specific pre-treatments to manage its high organic load and potential inhibitory effects on the AD process (Ferdeș et al., 2022). Moreover, a proper sorting of FW is essential to improve biogas production and the quality of the digestate. Poorly sorted FW can contain plastic, which will negatively affect the digestate. It can harm the quality of fertilizers and pose a hazard to human health, as well as to the environment. To address this issue, Sweden has declared organic waste sorting mandatory since January 2023 for households and businesses (Stockholm Vatten och Avfall, 2023). Furthermore, starting from January 2024, supermarkets and retailers are also obliged to separate packaging from FW to optimize the biological treatment of FW.

2.5.2 Incineration

From the late 19th century, waste-to-energy incineration technologies have remarkably evolved. Initially, the treatment had no purpose for energy recovery. To date, many facilities have combined heat and power plants which also have mechanisms to clean flue gas and utilize wastewater (Cewep, 2024).

Currently, over 450 waste-to-energy plants are active in Europe, with central and northern countries leading for energy recovery rates. Eastern and southern Europe still have lower values. In Romania, the waste-to-energy rate is only 5%, against 42% in the Netherlands (Dobrowolski, 2023). In Europe, energy recovered from incinerating 90 million tonnes of MSW supplies 18 million inhabitants with electricity and 15.2 million with heat. Considering that the waste is diverted from landfills and the energy and heat are not produced from fossil fuels, 24-49 million tonnes of CO_2 emissions can be avoided (Cewep, 2024). Hence, Waste-to-Energy contributes to reaching the targets set by the EU Landfill Directive, while replacing fossil fuels as feedstock.

Studies in Sweden found that, when separated from MSW, FW is an optimal fuel source that burns hotter, more uniformly, and generates fewer harmful emissions than regular garbage (Svensson Myrin et al., 2014). This remarks on the importance of correct sorting in the early stages of waste management, starting from the households. Moreover, processes such as hydrothermal pretreatment and air drying of FW significantly improve energy recovery (Tang et al., 2017). After 2010, the number of new plants constructed dramatically decreased. One of the factors behind this was the public opposition arising from pollution and health risks concerns (Makarichi, Jutidamrongphan and Techato, 2018). Movements like "Not In My Backyard" have profoundly affected political decisions on the matter of allowing new plant construction (Xu and Lin, 2020).

However, recent investigations are reassuring about the safety of incinerators. A study funded by Public Health England, UK universities, and public institutions analysed the potential effect on births of PM10 emissions from incinerators in the UK between 2003-2010 (Ghosh et al., 2019). Over a million births were assessed and no evidence was found for increased risk in alteration of considered birth parameters.

Over the past years, dioxin emissions from incineration plants have been reduced significantly, resulting in less than 0.2% of the total industrial dioxin pollution. In Sweden, the emissions dropped from 100g in 1985 to less than 1g in 2015, while doubling the amount of treated waste (Cewep, 2024).

The EU applies strict directives regulating incineration, comprehending continuous or periodic monitoring of emissions to minimize environmental pollution and health risks (Eur-Lex, 2011). Among the measures adopted to control the emissions, in 2003 an automatic sampling system was installed in the waste incinerator of Bozen, Italy. The results show there is not a significant source of fine and ultra-fine particles (Ragazzi et al., 2013). Similar results were found in Tarragona, Spain where the incineration plant was assessed not to produce additional health risks for the population living nearby (Vilavert et al., 2012).

2.5.3 Social Supermarkets

The European Commission used the waste hierarchy to rank the preferred strategies to avoid FW. While preventive actions are the preferable option, surplus food redistribution for human consumption is the second best (European Commission, 2020). Redistribution strategies might be online platforms or physical markets where regular customers can buy excess food for a lower price. Food banks and SSMs, however, involve a more specific target as recipients in economic hardship. Food banks and charities were already well established in Europe, Canada, and the States in the 1980s when the first SSMs appeared. However, Ranta et al., argue that SSMs could be used alongside food banks or as an alternative model for food support (Ranta et al., 2024). SSMs could be the answer to the global issues of growing FW and food insecurity.

There is no common definition of SSMs since there is a high variability of the concept in different countries and initiatives. Professor Christina Holweg, of the Institute for Retailing and Marketing in Vienna, is one of the leading exponents of SSMs research and the one who coined the name in 2010 (Holweg et al., 2010a). According to Professor Holweg, SSMs can be defined as retailers that sell mostly food, and whose clients are a restricted group of people living in financial distress or poverty (Holweg and Lienbacher 2011). The non-profit operation offers a limited assortment of products at low prices. The products are surplus and donated. By paying even a symbolic amount, customers can preserve their dignity and avoid the perception of receiving charity. At the same time, payments support SSMs' operational and management costs and guarantee the service's existence. Compared to the food bank, SSM allows choice, though limited, which is crucial for cultural and identity appropriation. (Berri and Toma, 2023; Ranta et al., 2024).

According to Holweg and Lienbacher (2016), SSMs were first established in France, Switzerland, and Belgium in the late 1980s and in Italy in 1998 with the

Last Minute Market (Segrè, 2004). The concept later spread in Austria with the first SSM opened in 1999 in Linz (Holweg et al., 2010a), thanks to a private initiative of four local families. The principles behind the choice to open the Linz shop are still applicable to the concept of SSM: sell surplus food; help people in financial vulnerability; and offer job opportunities. SSMs receive donations of food and primary needs from other supermarkets or retailers. Unlike other forms of charity that use saleable food, an SSM receives donations of surplus food that is consumable but meant to be wasted. The reasons behind the waste can be multiple: e.g. the products being past their expiration date, incorrectly labeled, not visually appealing (especially for fruit and vegetables which have high appearance standards), past the holiday season (for festive specialties), or due to a change of suppliers by the donating store. SSMs shelf prices are significantly reduced by 50-70% compared to regular supermarkets (Holweg et al., 2010a). The membership criteria are based on low income, and limit access to socially disadvantaged groups. Moreover, the workforce is usually volunteers, but also paid employees. One of the goals of SSMs is to provide job training and opportunities to people who have been long-term unemployed or need to do community service. The re-integration of these people into the job market is part of the social commitment that SSMs have as a guideline.

Since the economic crisis of 2008-2014, SSMs spread across Europe, to support the increasing financial instability and food insecurity (Knežević, Škrobot, and Žmuk, 2021; Maric and Knezevic, 2014).

In the UK, surplus food redistribution was carried out by Charity Shops in the 1990s (Holweg et al., 2010b), while the first SSM, addressed as a community shop, was opened in 2013 in South Yorkshire. In 2019, this shop was regularly serving around 750 households and helped them save on groceries an average of £212 a month (Rayner, 2019).

In 2010, about 60 SSMs were opened in Austria. Nowadays, the Austrian SSM chain SOMA supports 40,000 members, while in France, the ANDES network, helps about 140,000 members per year (Schneider et al., 2015; Saxena and Tornaghi, 2018).

In Sweden, Matmissionen is an initiative developed by Stockholms Stadsmission that combats food insecurity and FW, while providing job training and employment. Established in 2015, Matmissionen currently has 13 SSMs across the country. It provides hundreds of job training positions and reduces GHGE that would derive from FW. Moreover, in 2023, it handled 4,180 tonnes of surplus food and generated a social benefit of 180 million Swedish kronor (SEK) in savings for members of the stores (Matmissionen 2024).

The first SSM in Croatia was opened in 2009 in Split (Klindžić, Knežević and Marić, 2016). However, keeping track of the increasing number of similar stores is a challenging task, since there is no centralised registration of such initiatives.

A survey conducted in Lithuania, Serbia, and Poland (Knežević, Škrobot, and

Žmuk, 2021), showed that 59% of respondents in Lithuania are aware that there is an SSM in their city. In contrast, only 8% of the Serbian respondents do, but 86% recognised the need for this food support. In Poland, 65% of the interviewees consider reducing FW as the primary goal of an SSM. On the other hand, almost half the surveys indicate that in Serbia priority was given to helping people in need.

Additionally, SSMs not only offer valuable aid against food insecurity but also a dignified and inclusive shopping experience for people that are socially marginalised.

Nonetheless, SSMs present several limitations. In the beginning of their raising the concept encountered resistance from politicians who were concerned about the negative impact that a store for "poor people" might have on the neighborhoods (Holweg et al., 2010a). In addition, donations are not constant or predictable, which can lead to a limited quantity and variety of products available for sale. Some SSMs had to close due to a lack of regular donations that would allow them to properly stock their shelves. In addition, although SSM allows for some choice in purchasing, it remains limited and requires much flexibility from the customers.

According to Rayner (2019), in a letter published in The Guardian, 58 academics argued that the donation of surplus food only affects the reputations of big companies, without effectively solving social inequality.

2.5.4 Anaerobic digestion, incineration, and social supermarkets in Stockholm

According to the system's boundaries of the present study, this section provides an overview of the investigated FW management strategies in the municipality of Stockholm.

Stockholm municipality supports research projects aimed at improving FW management strategies such as reducing, reusing, and recycling. Moreover, it offers incentives (tax reductions, subsidies) for businesses that adopt FW sorting solutions and sustainability certifications. The city has been working to be fossil fuel independent by 2040, thanks to biofuel production.

About 35% of food leftovers go to waste unnecessarily. Only 25% percent of FW is correctly sorted in Stockholm. According to Stockholms stad, the reason behind this is that the collection of waste in Stockholm is poorly equipped for recycling (Stockholms stad, 2022). Starting January 1, 2023, it has become mandatory for Stockholm's households to separate their FW, and the municipality is responsible for the collection.

Stockholm has two AD plants located in Södertörn and Högbytorp (Fam, 2023). Högbytorp plant turns organic waste into biogas and digestate, using continuous dry AD. In the digester, microorganisms convert the feedstock at 55°C for two weeks. The biogas is then purified in biomethane, which can fuel vehicles or generate heat and electricity. The digestate, on the other hand, is separated into a solid fraction for compost and a liquid one for fertilizer. The plant can process 83,000 tonnes of organic and agricultural waste annually, generating approximately 6.8 million Nm^3 of biomethane. This amount of biomethane substitutes around 7 million liters of oil and diesel. The facility also produces 6,500 tonnes of compost and 50,000 tonnes of liquid fertilizer per year for local farms (Hitachi Zosen Inova, 2019). One metric tonne of organic waste can yield up to 1,000 kWh of energy and around 850 kg of high-quality natural fertilizer (Hitachi Zosen Inova, 2022). This massively reduces fossil fuels consumption, while providing a circular economy practice and a valuable organic waste management strategy. Another AD plant that serves Stockholm is Biokraft Södertörn AB. It receives both solid and liquid organic waste from households and businesses. A pre-treatment to separate unwanted waste is operated before the AD process. The feedstock is converted into biogas and then upgraded to meet quality standards for vehicle fuel (Södertörns brandförsvarsförbund, 2022). Södertörn Biogasanläggning's input capacity is 50,000 tonnes of FW, which produces 80 GWh of biogas and 14,000 tonnes of dry digestate as output (Arvidsson and Nordenram, 2022).

For residual waste, a sorting plant was built in Högdalen. In 2021, Sörab and Stockholm Exergi inaugurated Sweden's first automatic pre-treatment plant. The purpose is to remove recyclable material that might have ended in residual waste. That increases recycling rates and avoids plastic in incineration (Avfall Sverige, 2022b).

Energy recovery facilities work efficiently in Stockholm. Stockholm County treats the highest quantity of waste in Sweden with incineration, about 410,200 tonnes of household waste, in 2022 (Avfall Sverige, 2022a). Stockholm's Högdalenverket is a waste-to-energy plant located in Högdalen, a district in south Stockholm. Högdalenverket is a CHP (Fam, 2023), or combined heat and power plant that incinerates waste to produce electricity and heat. It has been working since the end of 2022 and is equipped with technologies to reduce pollutant emissions and environmental impact. Other CHP plants in Stockholm are located in Brista and Högbytorp. In 2022, Högdalenverket processed a total waste of 703,710 tonnes, of which 306,040 tonnes were Swedish household waste (Sweden imports high quantities of waste from other foreign countries). The output of the process was 1,868,710 MWh of heat and 322,880 MWh of electricity. Brista 1 is located in Sigtuna, while Brista 2 is in Sodermanland, Sweden. CHP Brista 2 has been working since 2013. In 2022, the plant processed 229,270 tonnes of waste, of which 104,160 tonnes were household waste from Sweden, producing 477,560 MWh of heating and 96,600 of electricity (Avfall Sverige, 2022b).

Stockholm’s City Mission has an entire department dedicated to social food stores, the Matmissionen. Matmissionen opened its first shop in 2015 in Hägersten, Stockholm. In March 2019, 1,300 members purchased in the store. In 2020, it counted around 3500 members. The store had five employees and offered job training to eight people (Bergström et al., 2020). Matmissionen currently has seven SSMs located throughout the municipality. The stores are named after the area where they are located and are Matmissionen Hallunda, Handen, Hägersten, Jakobsberg, Kista, Norrtälje, and Södertälje (Matmissionen, 2024).

3. Materials and methods

The analysis follows the standards ISO 14040, and ISO 14044 for an attributional Life Cycle Assessment (LCA). The purpose of the attributional LCA is to assess and quantify the environmental impact of the system. The SSM was the main system investigated, compared to two more FW treatment methods: AD and incineration with energy recovery. While the latter two are the most widely used strategies for FW treatment, SSMs represent an emerging approach. The integrated approach, combining LCA, literature review, and customer surveys, aims to provide a comprehensive understanding of the environmental and social benefits related to reducing FW through surplus food redistribution strategies, such as the SSM. Microsoft Excel (Microsoft Corporation, 2019) was utilised to process the data.

3.1 Data quality

The primary data about the SSMs were collected through interviews with the Manager of Strategic Partnerships, personal communication with other members of the staff, surveys to members, and field research at the SSM in Hallunda, Sweden. Secondary data for all three scenarios were extracted from previous scientific research in the field of GWP assessment and CF databases (RISE, 2023; Röös, 2014; Sieti et al., 2019; SLU, 2024). Tertiary data were calculated with calculations based on the functional unit (FU) and assumptions on probable scenarios.

3.2 Goal

The objective of the study is to assess the environmental impact of SSM as a strategy to manage food surplus and waste. The study aims to investigate this strategy as a possible alternative to other waste management strategies and to assess data on its environmental impacts, in terms of GHGE. The GWP is compared to results obtained from previous studies on AD and incineration. In addition, the aim is to highlight the potential social benefits of the SSM.

3.3 Scope

3.3.1 Social Supermarket Scenario

The system boundaries determine which processes are included in the study. The geographical boundaries concerned Stockholm County, in Sweden. The choice of Stockholm lies in the fact that it is the most populated county in Sweden, and it is the first to have opened SSMs in the country. Moreover, incineration with energy recovery is highly efficient in the County. The assessment refers to data collected in the year 2022. The temporal boundary of one year allows to take into consideration seasonal variations. The studied system is based on the SSMs of Stockholm open in 2022. The scenario is compared with the other two investigated pathways for FW management. The environmental impacts associated with substituted products and rebound effects were taken into consideration for the assessment. GWP contribution was scaled to the FU, to compare each system's process. The FU is 1 tonne of surplus food that from the retailer's outbound gate enters the studied system. Therefore, GHGEs for each process were divided by 1977 tonnes of surplus food, the total amount of food managed by the SSM in 2022. The store management and the consumer stage are responsible for a positive carbon footprint, while the substitution of food reduces carbon emissions as expressed in the schematic illustration of the system in Figure 2. The system structure and inputs are illustrated in Figure 2. The analysis will account for the entire life cycle of surplus food, from distribution to the SSM and management in-store to redistribution to customers and final disposal. Hence, the physical boundaries of the system are from gate (outbound retailer's gate) to grave. A system expansion was investigated with substitution and rebound effect. The same FU is applied. The system expansion will be further discussed in the following sections.

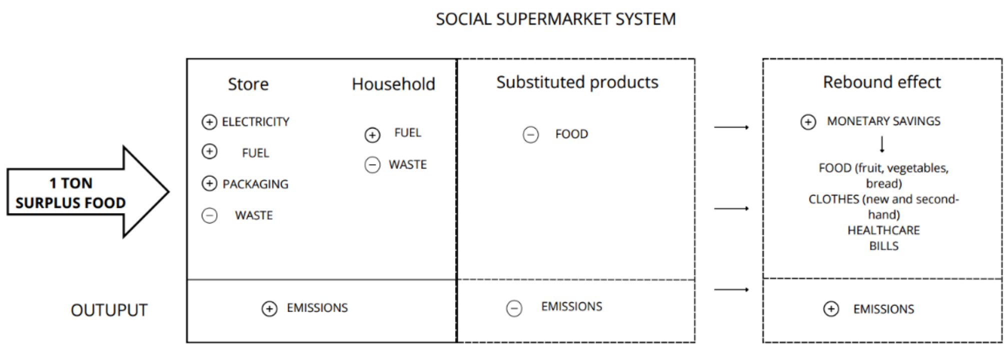

Figure 2. Schematic illustration of the processes assessed in the SSM system with system expansions.

3.3.2 Anaerobic digestion scenario

A study conducted in 2020, aimed to assess the carbon footprint (CF) of two different FW treatment scenarios in Uppsala, Sweden (Sundin et al., 2022). Surplus food redistribution through the “food bags” centre and “soup kitchen” was compared to AD treatment. To assess the environmental impact of AD with FW as feedstock, a biogas plant located in Uppsala was examined. The plant processes around 48,000 tonnes a year of FW and generates two main products: biogas and biofertilizer. The biogas produced replaces natural gas for city buses, resulting in environmental benefits. Biofertilizer substitutes for mineral fertilizers used in crop cultivation. For a complete LCA of the system, the study also accounts for the transportation of waste to the plant and the electricity used to power it. The rebound effect results in potential savings of approximately 30,000 SEK from the biogas sales profits. Comparing the value to the existing subscriber debt (21 million SEK) shows that the rebound effect has an insignificant influence on the result. The study suggests that using a biogas plant for FW management offers environmental benefits by replacing fossil fuels and mineral fertilizers. The CF associated with AD was -0.23 kg CO_2e/kg FW.

3.3.3 Incineration scenario

Secondary data on CF of incineration with energy recovery of FW were extracted from a study published in 2015 by Eriksson, Strid, and Hansson (2015). The study modeled the CF of FW management options according to the waste hierarchy. The study area was the city of Uppsala, Sweden where the incineration plant is located. The plant normally incinerates about 340,000 tonnes of waste per year. Using an LCA approach, the GWP of incineration was assessed. The FU was 1 kg of FW (including packaging) from the supermarket. The study focuses on common food items: bananas (grown in Costa Rica), iceberg lettuce, wheat bread, grilled chicken, and beef (all produced in Sweden). However, surveys revealed that the quantity of wasted meat in members' households was remarkably low. This might be attributed to the higher cost of meat and the SSM's policies restricting individual meat purchases. Consequently, the CF was recalculated by excluding the contribution of meat (Sundin et al. 2022). Environmental costs of FW transport, electric power of the plant, and water consumption accounted for the entire life cycle of the food, from production to retail. The FW was assumed to replace fossil peat as feedstock to produce heat and electricity. Since the findings on the limited savings potential of AD (Sundin et al., 2022) suggest that the rebound effect does not influence the final result, a similar scenario might be valid also for the incineration with energy recovery. Following this assumption, the rebound effect was not included in the CF calculation for the incineration. Final results provide a

CF for incineration with energy recovery of -0.11 kg CO_2e/kg of FW treated.

3.4 Life Cycle Inventory (LCI)

To assess the CF of the studied system, inputs, outputs and the rebound effect were investigated. In particular, the processes assessed were the energy that powers the supermarket operations (i.e. cooling, freezing, light, aeration vents etc.), the fuel consumed by the store to collect the food donations, the packaging used by the store to sell groceries (e.g. shopping bags), the fuel consumed by customers to travel back and forth to the store, the FW treatments needed both at the retailer and at the domestic stages. The rebound effect was included in the calculation. It has significant implications in the assessment of environmental impacts and is a widely investigated topic in the energy efficiency research field. The term describes a situation where the energy efficiency of a system leads to additional energy consumption. This effect could determine no net environmental benefits or even increased impacts. (Li et al., 2024; Gossart, 2015). In the context of surplus food redistribution, a rebound effect may be observed when the reduction in GHGE achieved through the system efficiency is counterbalanced by emissions from other operations. This occurs when customers, benefiting from financial savings accrued by purchasing from an SSM, allocate those savings to activities that result in producing additional emissions (Sundin et al., 2022). The inventory is shown in Table 2.

3.4.1 Surveys

Primary, secondary, and tertiary data were used for the study. To collect primary data, surveys to members were conducted in March 2024 in the Hallunda Centre SSM. Multiple-choice questionnaires were administered to members willing to participate (Berri and Toma, 2023; Ranta et al., 2024; Sundin et al., 2022). For the surveys to be inclusive and address potential linguistic barriers, they were available in Swedish, English, and Arabic. Participants were invited to sign an informed consent about the purpose of the study and data treatment. No sensitive personal data were requested, and the questionnaires were anonymous. The questionnaire is articulated in four parts that respectively collect data about the demographics and food security status; FW rates in members' households and food substitution patterns; rebound effect; social perceptions and impacts of the SSM. A copy of the questionnaire is presented in Appendix 1.

17 participants agreed to complete the survey. The participants' demographics showed a gender ratio of 59% women and 41% men, with age ranging from 27 to 73 years old. Participants were originally from Europe, the Middle East, South

America, and South Asia. The questions aimed to collect data on the environmental impact and social perception of the SSM. The environmental matters addressed through the survey were the household FW, the food substitution, the environmental impact of transportation used to reach the store, and the rebound effect. On the other hand, the aim of questions about the income per household of members, food security and hunger, and evaluation of shopping experience at the SSM was to assess the social aspects of SSM and its effects on members life quality. The data collected from the surveys were analyzed to identify trends and correlations.

3.4.2 Electricity

Average electricity consumption for the year 2022 was estimated from the consumption invoices of August 2023, provided by Matmissionen. Energy consumed in 2022 was calculated based on the actual number of stores open in 2022, assuming that no significant difference in electricity needs occurred between 2022 and 2023. The supplier provided detailed information about the electricity mix and its associated CF. The electricity mix consisted entirely of renewable energy sources. Specifically, 0.05% solar, 7.3% wind and 92.5% hydroelectric, with a climate impact of 9.12 g CO_2e/kWh.

3.4.3 Transport

Data regarding the quantity of fuel consumed by vans in 2022 for the collection of surplus food from other retailers was provided by Matmissionen and amounted to 34391 litres of diesel. The CF of diesel is 2.6 kg CO_2e/L as indicated by the manufacturer of the vans (Volvo Truck Corporation, 2018).

For the fuel consumed by retailers delivering food to SSM, an estimate was calculated based on weekly trips from Helsingborg to Stockholm (approximately 556 km). The trailer trucks involved in this transport deliver multiple goods, destined to different recipients in the capital city. Therefore, as this is a co-transport operation, the return trip was not included in the calculations. The environmental impact was modeled using the NTMCalc 4.0 (NTMCalc, 2021). Given the knowledge that vehicle is a truck with trailer, it was assumed that costs and emissions are optimized by transporting goods to full capacity (50-60 tonnes). However, the share of surplus food was estimated to be 15 tonnes (an average of 10 pallets at their maximum weight).

The percentage of members using their car to reach the SSM was assessed through interviews. Subsequently, the share of car users on the total number of members was estimated. Customers were assumed to drive petrol-fueled cars, rather than diesel, potentially due to the expectation of lower overall costs compared to diesel vehicles. The CF of petrol produced in Sweden is 2.92 kg CO_2e/L (Swedish Energy Agency, 2020) and the consumption of cars driven in the city was considered as an average of 5 L/100 Km. Since most members live in the neighborhood, it was assumed that the members traveling by car were those who lived the farthest in the area, at a distance of a 4-kilometer radius, and the trip being back and forth. The environmental impact derived from the use of public transport to travel to the SSM was assumed to be insignificant.

3.4.4 Packaging

The SSM provides only paper bags, not plastic, for members to transport their shopping. However, the policy is to strongly encourage members to bring their own reusable bags. Secondary and tertiary data were used for packaging, as no primary data were available. Sundin et al. (2022) studied a surplus redistribution system with a similar policy to the SSM's about prioritizing reusable bags. Therefore, it was assumed that the amount of paper bags sold at the SSM would be similar to the one found in their study. The number of paper bags sold was scaled for the actual number of members of the SSM and CF (0.03 kg CO_2e/ bag) was derived from the above-mentioned study.

3.4.5 Waste treatment

FW data for SSM was obtained by the organization. In 2022, 127 tonnes of FW (including packaging) were weighed at the store from the waste collection truck. Therefore, to estimate the environmental impact of SSM-generated FW treatment, it was assumed that all waste was incinerated. The CF for incineration (-0.11 kg CO_2e/kg FW) was derived from the study by Eriksson et al. (2015).

To assess the environmental impact of treatment for FW generated in customers' households, the survey requested respondents to estimate the amount of FW generated in their households from food bought in the SSM. As previously discussed in the background section, only 25% of FW is correctly sorted in Stockholm households. Consequently, it was assumed that 25% of FW was treated with AD, while the remaining 75% was incinerated. CF data for AD (-0.23 kg CO_2e/kg FW) was derived from the study by Sundin et al. (2022), which investigated the GWP impact of an AD plant in Uppsala (approximately 70 km north of Stockholm).

3.4.6 System Expansion

3.4.6.1 Substitution

Assuming that purchasing surplus food at the SSM entails that the same food is not bought in a regular store, all food sold was considered a substitution for conventional purchase. Avoided purchase is expected to reduce the production of the food itself and the associated environmental impact. The associated emissions avoided by substituted food were considered an environmental benefit and subtracted from the total environmental footprint of the SSM. A list of food products sold in the year 2022 was provided by the organization. A total of 1850.5 tonnes of surplus food was sold. The items sold were sorted into categories and subcategories (Table 1). To quantify the emissions avoided through substitution, it was calculated that the products substituted would produce if bought in regular shops. The CF of each product was multiplied by the volume sold per item. Specific CF values are derived from LCA literature, with emissions expressed as CO_2e (Scholz et al., 2015). Most CF was deducted from the Food-Climate List of the report of Röös (2014). The report’s updated version was commissioned by the Swedish University of Agricultural Sciences (SLU) by the Swedish Food Agency. The list comprehends GWP values for several food categories based on literature studies and the author's work with GHGE calculations, life cycle analysis, and food production. For the products that were not listed, a wider database was consulted. CF indicators were extracted from the Sustainability Assessment of Foods and Diets. This database elaborated by SLU assessed and presented the average environmental impact of foods generally available in Swedish food stores, considering the origin of different raw commodities, both domestic and imported. The CF is an average, weighed according to the production shares, accounting for waste occurring during production, retailer, and consumer levels (SLU, 2024). The CF for coffee and tea, and for baby food were respectively calculated from data provided by RISE (2023) and Sieti et al. (2019). In Figure 3, the studied system with the system expansions substituted products is illustrated.

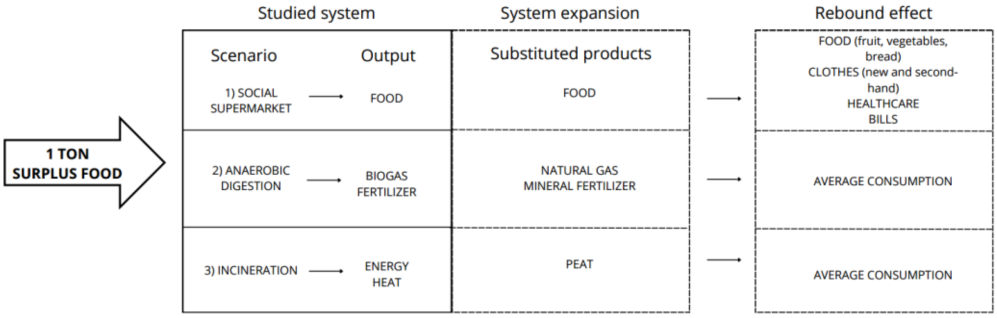

Figure 3. Schematic illustration of the SSM investigated system and system expansions substituted products.

Categories	Sub-categories	Amount (t)	CF (t CO_2e/t product)	CF reference
Cereals	rice	5.08	2	Röös, 2014
	pasta	8.12	0.8	Röös, 2014
	bread	174.70	0.8	Röös, 2014
	flour, sugar, grain	6.05	0.6	Röös, 2014
Roots	potatoes	22.29	0.1	Röös, 2014
Fruit, berries & vegetables		508.11	2.4	Röös, 2014
Legumes	beans	6.38	0.7	Röös, 2014
Eggs		9.96	2	Röös, 2014
Dairy	cheese	29.58	8	Röös, 2014
	milk and yoghurt	187.63	1	Röös, 2014
	butter	12.24	8	Röös, 2014
	cream	10.10	4	Röös, 2014
	ice cream	10.21	2	Röös, 2014
	dairy	90.32	2	Röös, 2014
Meat	beef	25.38	26	Röös, 2014
	pork	28.95	6	Röös, 2014
	chicken	53.60	3	Röös, 2014
	venison	0.10	0.2	SLU, 2024
	lamb	1.58	21	SLU, 2024
	charcuterie	36.09	19	Röös, 2014
	mixed minced meat	5.83	16	Röös, 2014
	other	16.28	12	Röös, 2014
Juices and jam		111.88	3	Röös, 2014
Oil		1.09	1.5	Röös, 2014
Fish		25.79	3	Röös, 2014
Composite meals	vegetarian	65.48	1.6	Röös, 2014
	meat	12.91	6	Röös, 2014
	baby food	11.02	3	Sieti et al., 2019
	other	7.72	2.4	Röös, 2014
Deep frozen products		5.47	4	SLU, 2024
Beverages	coffee and tea	1.19	0.5	RISE, 2023

	other	147.31	0.3	Röös, 2014
Sweets	candy	3.54	2	Röös, 2014
	pastries	35.69	2	Röös, 2014
Snacks		8.86	2	Röös, 2014
Spices, condiments		59.98	1	Röös, 2014
Other		104.04	4	SLU, 2024
Total		1850.54		

Table 1. Food sold by SSM in 2022 and associated carbon footprint (CF).

3.4.6.2 Rebound effect

The rebound effect may occur when SSM members accrue savings by purchasing affordable food at the store. Savings used to purchase other goods and services can result in additional environmental emissions, depending on the CF of the products bought. Previous studies demonstrate the importance of accounting for the rebound effect, as it can offset the positive environmental impact of surplus food redistribution (Sundin et al., 2022). The rebound effect was accounted for through SSM members' replies to the survey. To estimate the environmental impact of the rebound effect, the GHG intensity for spending on specific categories was calculated. Members were asked to allocate the potential accrued savings on a provided list of common items and services they might usually invest their savings on. The members' estimated monthly savings for each category were multiplied by the corresponding CF indicator and subsequently scaled to represent a year's worth of impact. The CF indicators were expressed as kg CO_2e/SEK spent on each category. GHG intensity was deducted for most categories by a previous study by Sundin et al. (2022). Conversely, for savings spent on second-hand clothes, a total substitution was assumed and the GHG intensity value was calculated based on previous studies on second-hand clothes market in Sweden and associated CF (Osterley and Williams, 2018; Persson and Hinton, 2023).

input	amount	unit
diesel (collection)	36,000	litres
electricity	130	MWh
waste (store)	-127	tonnes
packaging	5,000	paper bags
petrol (costumers)	120,000	litres
waste (households)	-160	tonnes
food (substitution)	-1,850	tonnes
rebound effect	930	SEK

Table 2. Life Cycle Inventory (LCI) of SSM processes, including system expansions.

3.5 Social aspects

An investigation of the social aspects of the SSM was conducted to provide a comprehensive overview of its benefits. The questionnaire included sections on demographic information, household composition, hunger and food insecurity status over the previous 30 days. Participants were invited to express their preference between the SSM and another form of surplus food redistribution, the "food bags." Specifically, they were asked about the significance of maintaining autonomy in shopping compared to receiving food chosen by someone else. The food bags system, which operates efficiently in Uppsala, Sweden (Sundin et al. 2022), is managed by Stadsmissionen, the main organization of which Matmissionen is a part. This system collects surplus food donations, sorts them into bags, and distributes them weekly to members against payment of a subscription fee. In addition to expressing their preference, SSM members were asked whether they believed the food bags system could lead to higher household FW than the SSM. The survey also assessed members' opinions on the accessibility of the supermarket, including its location and the ease of booking a time slot for shopping. Furthermore, it included questions on overall satisfaction with the quality and variety of products and their general shopping experience.

4. Results

4.1 Life Cycle Impact Assessment (LCIA)

LCIA quantifies environmental impacts caused by the studied system's processes. All processes were characterized by their factor (CF) for the chosen impact category, the GWP. The processes either generated emissions or environmental savings, resulting in a net value. The profiles of impacts will be presented in the following section.

4.1.2 Social Supermarket Scenario

The results from the studied system indicate a significant difference compared to the system's expansions. The inputs related to store management and consumer habits result in a negative environmental impact by generating carbon emissions, as does the rebound effect. In contrast, food substitution has a positive impact, reducing GHGE. Due to this disparity, the results will be presented individually for each compartment first. Then, the overall picture of results for the whole studied system will be provided.

4.1.2.1 Store and households

The average electricity consumption for the year 2022 was estimated to be 130 MWh. The input resulted in generating 1.19 t CO2e, which is a negligible contribution to the environmental impact of the process (Table 3).

MWh	**CF (gCO_2e/kWh)**	**CO_2e (t/year)**	**CO_2e (t/FU)**
130	9.12	1.19	1.0×10^{-3}

Table 3. SSM's electricity consumption and CF in 2022.

The total diesel consumption for collection and delivery of surplus food from other retailers was assumed to amount to approximately 36,000 litres. The diesel consumption for SSM logistics resulted in 0.06 t CO2e/FU.

The customers' fuel consumption assessment was based on car users. 18% of survey respondents used their cars to reach the SSM. On average, members shopped at the SSM 2.3 ± 0.6 times per week. Over one year, private transport was estimated to produce carbon emissions for approximately 350 t CO_2e. The LCA result was 0.18 t CO_2e/FU. Private transport of members was the second-highest contributor to emissions, significantly exceeding the SSM's logistics emissions due to the substantially higher number of car trips transporting smaller quantities of food compared to the SSM's trucks.

Regarding packaging, about 5,000 paper bags were estimated to be sold in the SSM per year. Carbon dioxide emissions were calculated for a total of 0.2 t CO_2e, which indicates that the impact of packaging is negligible (1.0×10^{-4} t CO2e/FU).

The survey results indicate that 9% of the food sold was wasted in members' households resulting in approximately 170 t of FW. The environmental impact of FW treatment for the households resulted in -0.01 t CO_2e/FU. According to the results of the survey, the most wasted food types in the members' households were fruit (28%), vegetables (28%), bread (16%), cheese (16%), meat (8%), and canned products (4%). The reasons behind the waste were that products were perishable (53%), had passed their expiration date (26%), were considered to be of poor quality (16%), and were purchased in excessive quantities (5%).

The results for the characterization of each process of the SSM system are shown in Table 4.

Categories	**CO_2e (t)**	**CO_2e/FU (t)**
diesel (store)	120	0.06
petrol (customers)	350	0.18
electricity	1.2	negligible (1.0×10^{-3})
packaging	0.2	negligible (1.0×10^{-4})
waste treatment (households)	-23	-0.01
waste treatment (store)	-14	-0.01
total CO_2e (t)	444	0.22

Table 4. LCIA for SSM's processes associated to the store management and household waste treatment.

Analyzing the SSM impacts, the results show a carbon-positive value. The only minor carbon-negative contribution derives from waste treatment through AD and incineration, virtuous processes that save carbon emissions.

4.1.2.2 Substitution

The participants in the survey were asked which foods they usually bought in regular supermarkets. Based on the answers, it was deemed consistent that the food sold by the SSM could completely substitute purchases from other supermarkets. Each food type sold was characterized by its CF (Table 5). Total GHGE avoided through food substitution was assessed as 5451 t CO_2e. Therefore, the impact on the system is carbon-negative and accounts for -2.76 t CO_2e/FU. This value is derived from Table 5, where the total and per FU carbon emissions related to the production of the sold food were calculated. However, since the complete substitution of that food is assumed, the final value is translated into a negative figure.

Categories	Sub-categories	Amount (t)	CF (tCO_2e/t product)	CO_2e (t)	CF reference
Cereals	rice	5.08	2	10	Röös, 2014
	pasta	8.12	0.8	6.5	Röös, 2014
	bread	174.7	0.8	139.8	Röös, 2014
	flour, sugar, grain	6.05	0.6	3.6	Röös, 2014
Roots	potatoes	22.29	0.1	2.2	Röös, 2014
Fruit, berries, vegetables		508.11	2.4	1219.5	Röös, 2014
Legumes	beans	6.38	0.7	4.5	Röös, 2014
Eggs		9.96	2	20	Röös, 2014
Dairy	cheese	29.58	8	237	Röös, 2014
	milk and yoghurt	187.63	1	188	Röös, 2014
	butter	12.24	8	98	Röös, 2014
	cream	10.1	4	40	Röös, 2014
	ice cream	10.21	2	20	Röös, 2014
	dairy	90.32	2	181	Röös, 2014
Meat	beef	25.38	26	660	Röös, 2014
	pork	28.95	6	174	Röös, 2014
	chicken	53.6	3	161	Röös, 2014
	venison	0.1	0.2	0.02	SLU, 2024
	lamb	1.58	21	33	SLU, 2024
	charcuterie	36.09	19	686	Röös, 2014
	mixed minced meat	5.83	16	93	Röös, 2014
	other	16.28	12	194	Röös, 2014
Juices, jam		111.88	3	336	Röös, 2014
Oil		1.09	1.5	1.6	Röös, 2014

Fish		25.79	3	77	Röös, 2014
Composite meals	vegetarian	65.48	1.6	102.3	Röös, 2014
	meat	12.91	6.3	80.7	Röös, 2014
	baby food	11.02	3	33	Sieti et al., 2019
	other	7.72	2.4	18.3	Röös, 2014
Deep frozen		5.47	4.4	23.8	SLU, 2024
Beverages	coffee and tea	1.19	0.5	0.6	RISE, 2023
	other	147.31	0.3	44.2	Röös, 2014
Sweets	candy	3.54	2	7	Röös, 2014
	pastries	35.69	2	71	Röös, 2014
Snacks		8.86	2	18	Röös, 2014
Spices, condiments		59.98	1	60	Röös, 2014
Other		104.04	3.9	406.2	SLU, 2024
Total		1850.54		5450.6	
CO_2e (t/FU)				2.76	

Table 5. LCIA for food substituted by purchase at the SSM.

Figures 4 and 5 graphically show the most representative categories of food sold in terms of quantity and in terms of GWP impact, respectively.

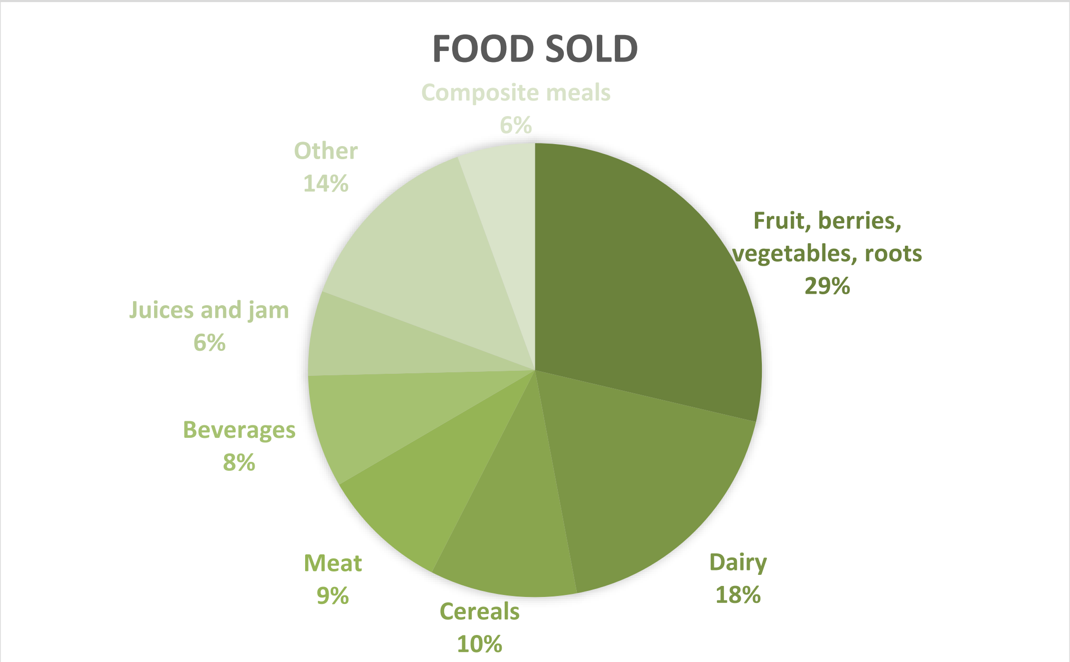

Figure 4. Most representative categories of food sold by the SSM in terms of quantity.

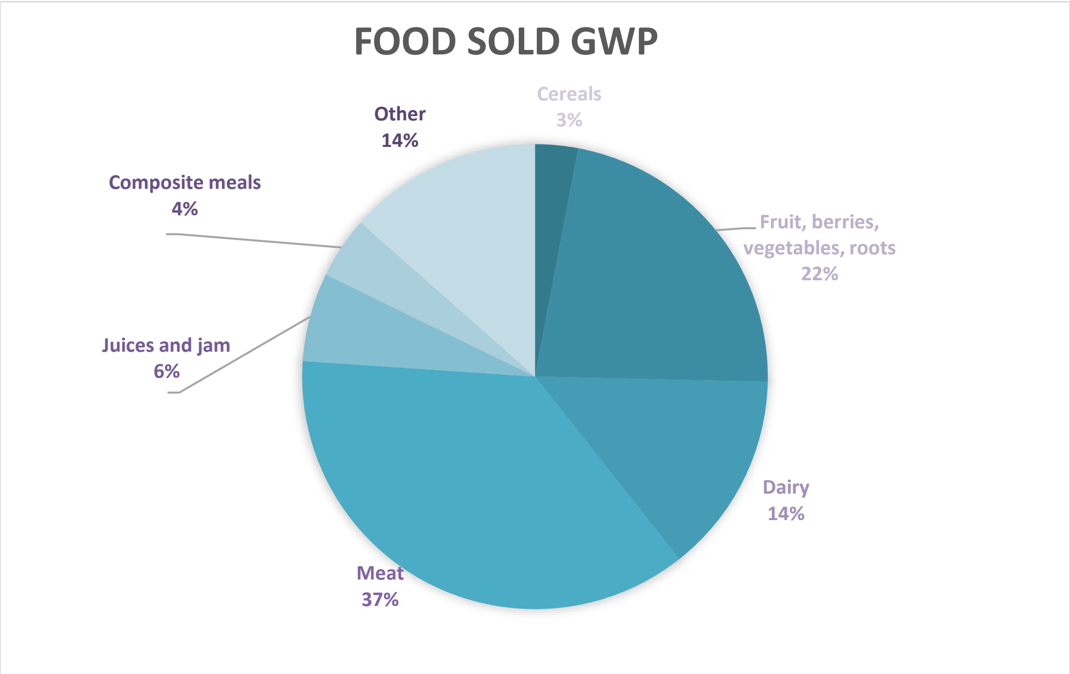

Figure 5. Most representative categories of food sold by the SSM in terms of GWP.

Participants' responses regarding how they spent the savings accrued from shopping at the SSM were converted into expenditure percentages, scaled for one year, and characterized by each CF (Table 6). On average, SSM members saved 990 ± 630 SEK/month through their purchases. Of those interviewed, 94% reported spending all their savings. The remaining 6% had not yet spent their savings and their contribution to the average savings was subtracted from the total considered for the rebound effect. Consequently, it was estimated that approximately 930 SEK/month were spent on other goods and services. Most of these funds (29%) were used to purchase additional food from other stores. The results indicate that the rebound effect has a significant impact on the system, resulting in about 4,600 tonnes of CO_2e and 2.76 t CO_2e per FU, marking the most substantial impact on the studied system.

Expenditure category	Expen diture (%)	Expenditure (SEK/month/ subscriber)	Expenditure (SEK/year/su bscriber)	GHG intensity* (kgCO_2e/ SEK)	CO_2e (t/total subscribers)	CO_2e (t/FU)
Clothes, shoes (new)	12	113	1361	0.03	523	
Clothes, shoes (second hand)	15	136	1633	-0.10	-2324	
Consumables	7	68	817	0.03	349	
Food	29	272	3266	0.082	3812	
Healthcare	10	91	1089	0.018	279	
Housing (rent, bills)	17	159	1905	0.044	1193	
Leisure	5	45	544	0.027	209	
Transportation	5	45	544	0.078	604	
Total		930			4644	2.35

Table 6. LCIA for alternative allocation of savings from substitutions.
**Sundin et al. (2022)*

In conclusion, in the SSM scenario, the net carbon result was carbon-negative, being -0.18 t CO_2e/FU. The environmental savings primarily resulted from the substituted food (-2.76 t CO_2e/FU). However, the rebound effect (2.38 t CO_2e/FU) offset 87% of the positive contribution offered by the food substitution. FW treatment offered minor benefits in reducing emissions (-0.01 t CO_2e/FU and -0.01 t CO_2e/FU for treatment of the store FW and households' FW respectively) as well as sustainable packaging and electricity mix. Figure 6 graphically shows that the two processes that have the most significant impact are the rebound effect and the food substitution. The other processes have a minimal impact on the final net result.

The SSM GWP was assessed to be -0.18 t CO_2e/FU when considering the rebound effect. On the other hand, when the rebound effect was excluded from the analysis, the net result of the SSM system's GWP was -2.53 t CO_2e/FU.

GWP figures for the AD and for the incineration scenarios were derived from previous studies and both are carbon-negative, -0.23 (Sundin et al., 2022) and

-0.11 (Eriksson et al., 2015) CO_2e/FU respectively. The comparison of the scenarios results is shown in a graphic representation provided in Figure 7.

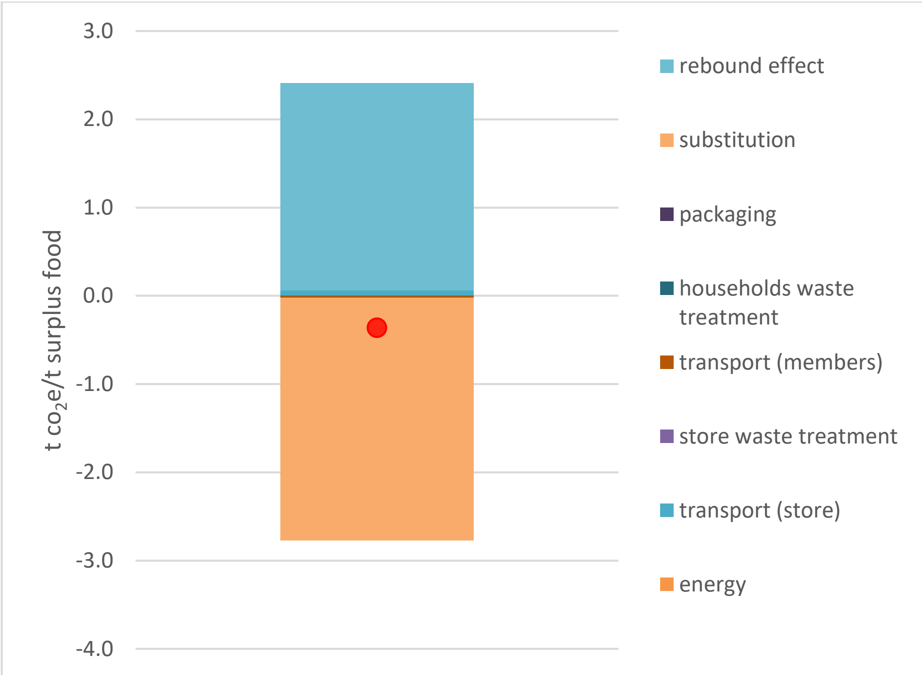

Figure 6. Net global warming potential (GWP) impact contribution of the system's processes. The red spot indicates the net result.

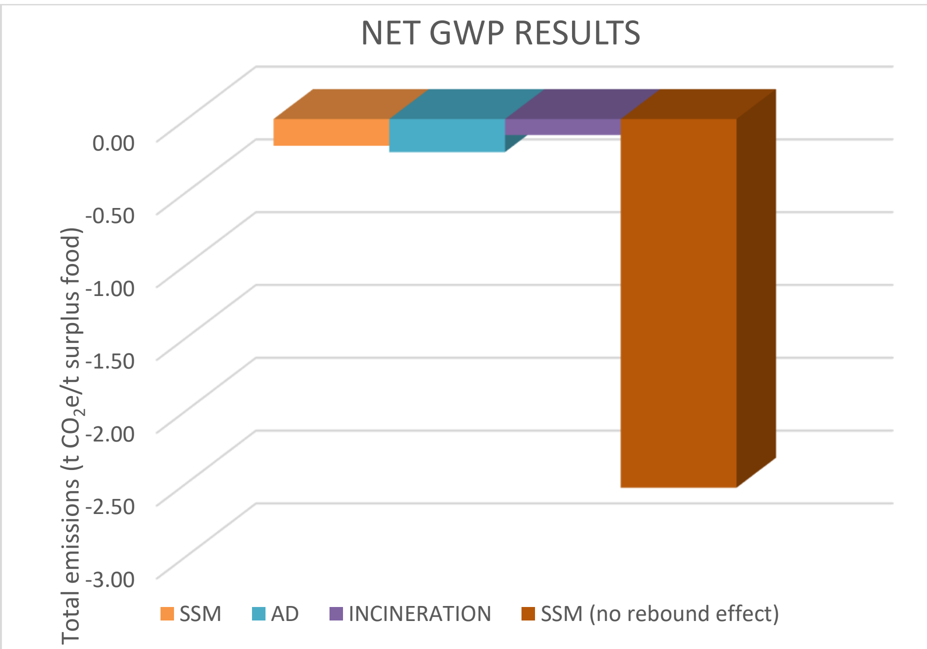

Figure 6. Graphic representation of GWP results for FW management scenarios: SSM system (including rebound effect), SSM system (excluding rebound effect), AD, and incineration.

4.2 Social aspects

Respondents to the survey were 59% women and 41% men aged 27-73. 35% of their households have children (0-17 years old). The presence of children in a family can significantly influence the quantity and type of food needed, because of specific dietary needs depending on their age. This can increase the vulnerability of the households' food security and may affect purchasing and consumption choices. Regarding food insecurity, 18% of respondents reported that the food they bought was always insufficient to feed themselves or their household members in the previous 30 days. For 47% of respondents, this was often true, while only 6% said it was never true. Additionally, 23% never had a balanced meal in the previous 30 days. A balanced meal is defined as one that includes carbohydrates, proteins, and fruit or vegetables.

35% of respondents walk to the SSM. This is an indicator of inclusivity. It shows that the SSM is accessible for those who do not have a private vehicle and enables them to save on public transportation, besides being beneficial for the environment.

Members rated their overall experience with the SSM with an average score of 4 out of 5, where 1 indicated a very negative experience and 5 very positive. Conversely, regarding the variety and quality of products available in the store, both aspects received a rating of 3 out of 5, where 3 corresponded to adequate.

Food bag centres are another form of surplus food redistribution: they receive food donations and prepare food bags which are later collected by members (Sundin et al., 2022). Members pay a small membership fee which entitles them to receive a pre-packed food bag per week. When SSM members were asked whether they would prefer receiving a food bag instead of buying food at the SSM, only 7% of respondents expressed a preference for the food bags or both systems equally. The remaining respondents favoured the SSM for several reasons. The primary reason, cited by 52% of respondents preferring the SSM, was the freedom of choice it provides. Additionally, 22% emphasized the importance of being able to provide for themselves by purchasing their own food. Another 22% highlighted their specific dietary requirements, such as allergies or cultural food habits, which are not easy to take into consideration for all food bag subscribers. Lastly, 4% of respondents appreciated that shopping at the SSM helped them to go out and socialize. Additionally, respondents were asked to compare the food bag system and the SSM in terms of FW. 64% indicated that they would likely waste more food if they had received it from a pre-packed food bag due to their food preferences. 21% assumed they would not know how to cook some food, further remarking on the importance of being able to select it themselves. Conversely, 14% of respondents believed that they would not waste more food, as they eat all kinds of food.

All members of the SSM agreed on the importance of autonomy in their shopping experience. Specifically, 71% of respondents stated that maintaining autonomy in their shopping was very important, while the remaining 29% considered it quite important.

5. Discussion

The case study highlights the environmental impact and the social aspects of an SSM in Stockholm, Sweden. Moreover, it aims to assess the SSM as an alternative FW management strategy and compare its potential with well-established technologies like AD and incineration. The most significant findings regarding the SSM impact are the food substitution and the rebound effect. Logistics also played a considerable role in generating GHGE. Petrol assumed to be consumed by customers driving to the SSM, had a greater impact than the diesel used by the organization to collect food donations, consistently with Bergström et al. (2020). Other factors, such as energy consumption, waste treatment through AD, incineration, and the SSM's packaging, have negligible impacts on the system.

From an environmental perspective, the SSM demonstrates notable potential for reducing GHGE through substituting regular supermarket purchases. However, the rebound effect offset some of these benefits.

In the latest Matmissionen report on SSM trends in 2023 (Matmissionen, 2024), the results concerning the largest categories of food sold by weight suggest minimal variation between 2022 and 2023. The proportions of sales by weight for major categories, such as fruit and vegetables (29%), dairy (18%), and bread/cereals (10%), are consistent across both studies. However, the present study includes meat (9%), which Matmissionen does not specify, and lists beverages at 8% compared to Matmissionen’s 9.9%. Meat is the product with the highest CF and the most significant impact on substitution (2000.8 t CO_2e). The other two food categories that contribute the most are fruit and vegetables, sold in quantities approximately five times greater than meat, and dairy products, which are universally recognized for their high environmental impact due to being animal-derived products.

Matmissionen has implemented policies to enhance the sustainability of its commercial operations. The organization’s electricity provider exclusively uses renewable energy sources. Additionally, the store does not sell plastic bags, opting instead for paper bags and actively encouraging customers to use reusable bags. However, these measures have a minimal benefit on the overall environmental footprint of the store's operations. As a matter of fact, the GWP of paper bags and electricity is comparable to the values reported by Sundin et al. (2022), which assessed the sale of both plastic and paper bags, as well as the Nordic electric mix as the electricity provider.

The substitution effect was the most crucial among all SSM LCA processes (Bergström et al., 2020; Eriksson et al., 2015; Eriksson and Spångberg, 2017; Sundin et al., 2022), as it measures the effectiveness of SSMs in lowering carbon emissions (-2.76 t CO_2e/FU). The net result of the GWP of the SSM's operations including the food substitution system expansion is -2.35 t CO_2e/FU.

5.1 Rebound effect

This study aimed to conduct a holistic analysis of the system, considering system expansions that have indirect environmental impacts, such as the rebound effect. Although the rebound effect is often excluded from LCA studies, the present study includes this phenomenon to provide a comprehensive picture of the social, economic, and environmental implications of the system. As a matter of fact, the rebound effect is influenced by social behaviour, which in turn affects the environmental outcome. As sustainability regards equally environment, economy, and society, it is reasonable, when assessing the sustainability of interventions aimed at reducing carbon emissions, to include social factors as well. However, it is worth noting, that several factors could contribute to the uncertainty surrounding the rebound effect data. These factors include variability in consumer behaviour such as fluctuations in the type and frequency of purchases over time; insufficient detailed data on how consumers utilize their savings; assumptions and simplifications made to manage the complexity of the analyzed systems. In the light of these assumptions, it is reasonable to suppose that the rebound effect may have been either underestimated or overestimated and, therefore, to illustrate the results of the system's GWP independently of the rebound effect.

Bergström et al. (2020) conducted an LCA on several food redistribution initiatives in Sweden. The study assessed the environmental and social impact of Matmissionen SSM in Hägersten, Stockholm. The GWP result was promising with the SSM generating a carbon-negative impact of -1 kg CO_2e per 1 kg of redistributed surplus food. However, this assessment did not account for the rebound effect. This result emphasizes the importance of considering indirect effects when assessing the sustainability of food assistance programs. It suggests that the overall effectiveness of the SSM in reducing GHGE depends on numerous variables such as consumer behaviour and spending patterns.

Studies concerning the rebound effect on energy efficiency have shown that it can lead to an increased consumption of the same good (Sorrell et al., 2009) or other types of goods and services in the case of the indirect rebound effect (Maxwell et al., 2011), negating some benefits. The most significant component of the rebound effect in the present study was the direct one, as most funds (29%) were invested in buying more food.

In the context of food systems, Druckman et al. (2011) found that savings from reduced household FW in the UK often resulted in increased spending on other goods and services, thus offsetting some environmental benefits. Chitnis et al. (2013) highlighted the importance of considering indirect effects when assessing the environmental impact of consumption patterns, as these can significantly alter the overall outcome.

The rebound effect offsets 87% of the benefits generated by the substitution effect. This finding turns the net result from -2.35 to -0.18 t CO_2e/FU. By contrast, previous research on surplus food donation involving the rebound effect reported a 51% offset of emissions (Sundin et al., 2022). Given this discrepancy, it is of interest to investigate the differences between the two studies which might have led to such results.

Sundin et al. (2022) assessed, through self-estimated questionnaires filled by the food bag centre recipients, that the average accrued savings per capita were 176 (± 131) SEK/week. In a month, this would be approximately 700 SEK. Conversely, in the present study, SSM's customers declared spending a higher amount of savings - 930 SEK/month - which led to a significantly larger rebound effect. On one hand, customers of the SSM may have overestimated their savings, since the rebound effect figure is very distant from the findings of Sundin et al. (2022). On the other hand, the report published by Matmissionen (2024) shows that 180 million SEK were saved by customers in 2023 due to purchases at the SSM, with an average monthly saving of approximately 1,000 SEK, which is consistent with the present study. Further differences may lie in the expenditure categories chosen by the authors. In this study, second-hand clothes were considered as a category for customers to spend their savings on (15%). Expenditure on second-hand clothes produces a carbon-negative outcome due to their environmental benefits. In contrast, Sundin et al. (2022) did not include second-hand clothes, and most savings (29%) were spent on new clothes, which led to a higher rebound effect. Conversely, Sundin et al. (2022) included services that have the lowest carbon emissions rate among all considered categories, while this study did not account for them. Services could have contributed to mitigating the rebound effect's impact, as 7% of the savings were invested in them. Overall, the difference between the two studies lies in the methodology of assessment, as well as in different target recipients.

The interviewed clients reported spending most of the savings accrued thanks to the SSM (29%) on food, which has the highest GHGE intensity among the categories considered. However, they were not asked whether part of the extra food bought with savings was purchased at the SSM rather than at regular supermarkets, which is a plausible scenario. If this were the case, a share of those savings could contribute to food substitution and lead to a smaller rebound effect. Investigating these implications in future studies could lead to a more accurate outcome.

The rebound effect extends beyond its environmental impacts. On one hand, the rebound effect shows an increase in the overall consumption of goods. On the other hand, it serves as an indicator of the social benefit created by the SSM. The social benefit arises from the fact that financially vulnerable individuals can accrue savings and allocate them toward other essential needs, thereby improving their overall quality of life. This financial flexibility helps to alleviate economic insecurity and fosters greater social inclusion.

5.2 Comparing SSM with Anaerobic Digestion and Incineration with energy recovery

Comparing the GWP results of the SSM with two other FW management options – AD and incineration – leads to insightful outcomes. While Eriksson et al. (2015) did not account for the rebound effect in the net results of incineration GWP, Sundin et al. (2022) assessed its impact on AD, which is negligible (2%). Excluding the rebound effect from the three-way comparison reveals that the SSM generates -2.53 t CO_2e/FU, while AD and incineration result in GWPs of -0.23 t CO_2e/FU and -0.11 t CO_2e/FU, respectively. This indicates that, in the absence of the rebound effect, the SSM has valuable potential as an alternative FW management strategy, drastically reducing GHGE. Specifically, the SSM reduces GHGE by approximately 11 times more than AD. Notably, AD exhibits a lower GWP compared to incineration. This is partly because incineration efficiency is compromised by the presence of FW with high water content, especially in fruits and vegetables, which requires additional heating to be effectively incinerated, consequently increasing GHGE (Eriksson et al., 2015; Eriksson and Spångberg, 2017). Nonetheless, both AD and incineration, as included in the waste hierarchy, are valuable FW management strategies.

Considering the net results of the three studies, the SSM contribution to carbon emission (-0.18 t CO_2e/FU) is consistent with the GWP of AD and incineration with energy recovery. This result shows that the SSM can be considered a valuable alternative to well-established FW management strategies.

5.3 Social Aspects of SSM

Regarding social aspects, the SSM plays a crucial role. Besides enhancing food security, it addresses the mental well-being of customers. The ability to afford sufficient, nutritious food is a basic need that, when unmet, can lead to psychological distress. Food insecurity is associated with higher rates of depression and anxiety among adults (Gundersen and Ziliak, 2015). Furthermore, the inability to perform simple tasks, such as buying groceries, can reduce one's self-esteem and lead to feelings of embarrassment and inadequacy.

The SSM acts as a social safety net, providing customers with food access while also creating a sense of community and offering autonomy of choice and self-determination. This autonomy positively impacts members' dignity and self-esteem (Fischler, 1988) by allowing them to feel independent and capable of managing their needs, which is essential for their psychological and social well-being. As expected, 71% of respondents to the survey valued autonomy in their shopping as very important, while the remaining 29% as quite important. Food choice not only exercises personal autonomy but also expresses both individual and group identity (Ranta et al., 2024). Food reflects cultural heritage and traditions, as well as personal preferences. Therefore, autonomy and freedom of choice in food support programs are crucial.

Ranta et al. (2024) remarked the importance of the ability to pay for food among members of an SSM in the UK. The study assessed the social impact of a pay-as-you-feel model. Interviewed members expressed their satisfaction with this approach, as it allowed them to preserve their dignity by paying for their food rather than receiving it for free, as is common in other food assistance initiatives, without the concern of spending beyond their means.

93% of Hallunda SSM interviewed customers declared they would prefer shopping at the SSM rather than receiving pre-packed food bags. Of them, 52% said this is because of the freedom of choice in selecting the groceries. Additionally, from an environmental perspective, the freedom of choice at the SSM significantly contributes to reducing FW. Members can choose items according to their preferences and dietary needs, leading to more efficient use of the food they receive. Survey results from SSM customers indicate that 86% of respondents believe they would waste more food if they received a pre-packed food bag without deciding on its content. However, the comparison between household FW rates of SSM members and food bag recipients, based on interviewed members' estimates, showed no significant difference. SSM members declared to waste about 9% (± 9%) of the food they buy, while food bag recipients 9% (± 13%) (Sundin et al., 2022).

A 27-year-old woman who participated in the survey expressed her satisfaction with the SSM, stating: "I am satisfied with the SSM because it helps my family to save. Since I have a 1-year-old son, and I have no one to leave him with and go to work. Thank you!" This emphasizes that the SSM value extends beyond reducing FW. It provides tangible support to families, addressing real-life challenges faced by participants and supporting them through times of hardship. The overall positive experience reported by members, despite some dissatisfaction with product variety and quality, underscores the importance of this initiative.

5.4 Criticism of Surplus Food Redistribution

While appreciated by many, SSMs have also faced criticism. In 2019, 58 experts signed a letter to The Guardian, arguing that food aid provided through charity is a temporary and superficial solution to the more serious and deep problem of systemic socioeconomic inequality (Rayner, 2019; The Guardian, 2019).

The SSM reduces FW. In 2022, Stockholm's SSM redistributed 1850.5 t of surplus food. Only 9% of food bought at the SSM was wasted at the consumers' stage and the FW rate in the store is about 6%. The initiative has also the potential to reduce carbon emissions (Bergström et al., 2020). However, the rebound effect negatively affected the environmental benefits. This is because the production system is oriented towards limitless variability and availability of consumer goods, overproduction, and waste. Thus, while SSM customers' savings are spent on essential goods, the production system that generates these goods maximizes the exploitation of natural resources and environmental carrying capacity, making their investments a source of GHGE. To mitigate the rebound effect, both consumption and production trends need to be downsized and more efficient (Sorrell, 2010; Vivanco, 2016).

Despite the SSM initiatives effectively mitigating FW and alleviating food poverty in the short term, they do not address the root causes of these issues. It is important to highlight that SSMs must not be seen as a final solution but as an instrument to support the most vulnerable during a shift towards a sustainable food system. Systemic change includes reducing overproduction and improving resource allocation (Gustavsson et al., 2013). However, while focusing on long-term solutions is necessary, it must be remembered that surplus food redistribution is still far from being abandoned. Poverty is increasing and FW shows no signs of decreasing. The number of people receiving food aid reached almost 7 million in France in 2020, and this figure has been steadily increasing for over ten years. According to l'Atelier Paysan (2021), the redistribution of surplus food to the most disadvantaged is no longer a temporary emergency: redistribution has become a structural mechanism that serves the economic function of disposing of surplus agricultural production, acting like an integral part of the economic efficiency of the food system. In 2016, France enacted the Garot Law, which allows large retailers to donate excess products and, in exchange, to avoid disposal costs for unsold products and benefit from tax breaks (l'Atelier Paysan, 2021). Similarly, for many years, Italian legislation has exempted food banks and charities from value-added tax (VAT) payments (Bech-Larsen et al., 2019).

The paradox is that to support this system and the growing poverty, there will be a need for more production, more unsold food, and eventually, more waste. This scenario is unsustainable in the long run and harmful to the environment, as well as exacerbating social distress. A profound change in the agri-food system is needed to create a society that respects ecological limits and promotes equitable life quality and collective well-being. The happy degrowth theory (Latouche, 2007) describes the principles of this alternative system. Long-term solutions, therefore, must aim to make food production sustainable at its origin, both environmentally and socially.

Similarly to food production, all productive sectors and, more generally, the economic system and people's lifestyles are oriented towards overproduction and consumerism. The ever-increasing energy demand greatly benefits from using FW as a feedstock for waste-to-energy plants and AD, instead of fossil substrates. On the contrary, a system that produces what is necessary, distributes resources equitably, and minimizes waste, requires less energy inputs to be sustained. Therefore, long-term solutions should focus on reducing energy demand, rather than using FW for energy production. Yet, FW can still be a sustainable choice to support energy production if the food is inedible (Tamasiga, 2022) or the waste is unavoidable, as approximately 12% of it is (Slorach et al.,2019).

A report by the International Food Policy Research Institute (IFPRI, 2021) discusses the need for coordinated action among all the stakeholders of the food system, including farmers, producers, distributors, retailers, consumers, and policymakers. The intervention of governments through policies, investments, and regulations is essential to ensure the sustainability of production and to provide food access for all, particularly for the most vulnerable populations while minimizing reliance on waste.

5.5 Strengths

One of the strengths of this study is the main use of primary input data, provided by Matmissionen and collected on the field through customer interviews. Furthermore, this study adopts a comprehensive approach by analyzing the rebound effect, which many LCA studies typically exclude. By doing so, it offers a more holistic view of the environmental impacts associated with the system. A thorough review of major scientific databases revealed no other LCA research on SSMs except for Bergström et al. (2020), which, however, does not account for the rebound effect. Although a few studies have analyzed the environmental benefits of surplus food redistribution initiatives, this study represents the first instance in the literature of an LCA of the GWP of an SSM that includes the rebound effect.

While not conducting a social LCA, this study still aims to provide an overview of the social aspects involved in the initiative, based on how the customers perceive and rate this service. The rebound effect offsets some of the environmental benefits achieved by the SSM. However, the allocation of customers' savings not only has an environmental relevance but also indicates a social benefit for financially vulnerable individuals. A detailed analysis of consumer behaviour, including private transport and spending patterns, offers a broader understanding of the implications involved in food redistribution systems. The inclusion of social aspects, such as the customers' autonomy of choice, integrates the social dimension into the analysis, as choice has been demonstrated to significantly impact FW habits. This perspective underscores the strong correlation between environmental and socio-economic levels of sustainability.

5.6 Limitations

There are several limitations to this study. Firstly, primary data were not available for all inputs and processes of the studied system. Secondary data and assumptions were utilized when primary data were unavailable (e.g., average household FW amount, number of paper bags sold by the SSM, etc.). Additionally, simplifications were necessary to manage the system's complexity, which can introduce uncertainties. For instance, assuming complete food substitution, although plausible, might not reflect real-world scenarios. SSM customers might have bought food that they would have not purchased in other stores. In addition, the data collected through the survey in 2024 were assumed to apply to the investigated temporal boundary (2022). Similarly, in the absence of primary data on inputs and processes for AD and incineration plants in Stockholm, secondary data were sourced from the literature regarding plants in Uppsala (70 km north).

Although the selection of the participants involved in the study was not randomized, the cluster showed representative demographics, with a balanced gender ratio and wide age range.

Moreover, this study assessed only one impact category, GWP, which limits its perspective. Conversely, the food redistribution operations in Uppsala mitigated impacts for 19 out of 20 midpoint and endpoint indicators (Sundin et al., 2023), including GWP. Based on this positive outcome, future research on SSMs' environmental impact could investigate whether similar benefits might be found for other impact categories.

5.7 Generalizability

This study is primarily focused on Swedish conditions; however, the methodologies used, and the environmental impacts assessed can serve as a model for future similar analyses in different countries. It is important to recognize that Sweden benefits from advanced and efficient waste management infrastructures and policies that prioritize resource recovery and minimize landfill use. In contrast, in countries where landfilling remains prevalent and waste treatment facilities are less developed, diverted FW could lead to results of significantly different magnitude. Future research should consider these differences and explore the adaptability of the results presented.

6. Conclusion

This study demonstrates that the surplus food redistribution operated by the SSM is an effective method for reducing FW while offering environmental, economic, and social benefits, particularly for vulnerable groups of the population. SSMs demonstrate great potential in reducing GHGE. However, a large part of the environmental benefits is offset by the rebound effect. Nonetheless, the final net result is consistent with GWP of well-established FW management options like AD and incineration. Hence, SSMs are a valuable alternative for FW management.

The study offered an overview of the social aspects concerning SSMs, emphasizing their ability to simultaneously manage both FW prevention and socio-economic challenges. SSMs are well-received by customers, particularly for the autonomy they provide in grocery shopping, making them a valuable tool in addressing food insecurity. However, although effective in mitigating FW, reducing emissions, providing access to basic needs, and providing food access to its members, SSM must be viewed as a short-term solution. As stated in the waste management hierarchy adopted by the European Commission, the best option for managing FW is to prevent the production of surplus food in the first place. Surplus food redistribution initiatives, while crucial for the support of socially and economically vulnerable populations, are not the solution to the growing poverty issue and the waste of billions of tonnes of food, but temporary support. In the long term, a systemic change is essential. Focusing on reducing overproduction and improving resource distribution is what is needed to create a truly sustainable and equitable food system.

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Popular Science Summary

Food waste is a global issue with profound environmental, economic, and social consequences. About one-third of all food produced for human consumption is lost along the food supply chain or wasted. In recent decades, waste management strategies for organic materials in Europe have become more efficient, with a progressive reduction in landfilling in favor of more sustainable options. European directives prioritize the prevention of food overproduction, as well as reuse, recycling, and recovery. In line with these principles, initiatives such as social supermarkets (SSM) were created to avoid food waste at the retail stage. SSMs are generally run by non-profit organizations and accept donations of surplus food from other retailers that would otherwise waste it. Surplus food is then sold at below-market prices to economically vulnerable people, addressing both food waste and food insecurity.

This study conducted a life cycle assessment (LCA) of an SSM in Stockholm, Sweden. LCA is a methodology for calculating the environmental impact, in this case in terms of greenhouse gas emissions, or global warming potential (GWP), of the processes involved in a system producing a good or service. The results were compared with those of anaerobic digestion and incineration with energy recovery, which are the most common options for FW management in Sweden. Anaerobic digestion produces compost and biogas by degrading organic waste, while incineration with energy recovery burns waste to generate heat and electricity. In addition, the study provides an overview of the social aspects concerning SSMs, emphasising their ability to deal with socio-economic challenges. Anonymous questionnaires were administered to SSM supermarket members, revealing the importance of dignity and self-determination in purchasing food, as opposed to other forms of food assistance, and members' appreciation and gratitude for this initiative.

The results of the study show that SSMs have a significant potential to reduce greenhouse gas emissions by -2.53 tonnes for every tonne of food managed by the SSM. However, this benefit is largely offset by the rebound effect. The rebound effect occurs when the savings accrued by purchasing at the SSM are used to buy

other goods or services, which are responsible for the production of emissions. The emissions attributed to the goods or services purchased with members’ savings partly or fully offset the environmental benefits provided by SSM. Hence, the final net result of the SSM impact is -0.18 tonnes of emissions per tonne of surplus food, which is completely in line with results found in the literature for anaerobic digestion and incineration with energy recovery. Therefore, SSM proved to be a viable alternative to the most common food surplus management strategies.

However, although effective in mitigating food waste, reducing emissions, providing access to basic necessities and alleviating food insecurity of its members, SSMs must be considered as a short-term solution. As stated in the waste management hierarchy adopted by the European Commission, the best option for managing food waste is to prevent the production of surplus food. While fundamental for supporting socially and economically vulnerable people, redistribution strategies do not solve the problem of growing poverty. Indeed, the causes of the issue are deeply rooted in the current system of production and consumption. In the long term, a systemic change that focuses on reducing consumption and overproduction, while ensuring sustainable exploitation and a more equitable distribution of resources, is essential. SSMs should be seen as a temporary support to the most vulnerable members of society during the transition to a sustainable and equitable food system.

Riassunto per la divulgazione scientifica

Lo spreco alimentare è una problematica di dimensioni globali con profonde conseguenze ambientali, economiche e sociali. Circa un terzo di tutto il cibo prodotto per il consumo umano viene perso lungo la filiera alimentare o sprecato. Negli ultimi decenni, in Europa, le strategie di gestione dei rifiuti organici sono diventate più efficienti, con una progressiva diminuzione del conferimento in discarica a favore di opzioni più sostenibili. Le direttive europee danno priorità alla prevenzione della produzione di cibo in eccesso, nonché al riutilizzo, al riciclo e al recupero. In linea con questi principi, sono emerse iniziative come i social supermarket (SSM) finalizzate ad evitare che il cibo venduto dai supermercati venga sprecato. Gli SSM sono generalmente gestiti da organizzazioni no-profit e accettano donazioni di eccedenze alimentari da altre attività commerciali che altrimenti le sprecherebbero. Questi alimenti vengono poi venduti, a prezzi inferiori di quelli di mercato, a persone economicamente vulnerabili, affrontando così sia il problema dello spreco che quello dell'insicurezza alimentare.

Questo studio ha condotto un'analisi del ciclo di vita (LCA) di un SSM di Stoccolma, in Svezia. L'LCA è una metodologia che permette di calcolare l'impatto ambientale, in questo caso in termini di emission di gas serra, o potenziale di riscaldamento globale (GWP), dei processi coinvolti in un sistema di produzione di un bene o di un servizio. I risultati sono stati confrontati con quelli della digestione anaerobica, processo che produce compost e biogas a partire dalla degradazione dei rifiuti organici, e dell'incenerimento con recupero di energia, ovvero le opzioni di gestione di rifiuti alimentari più comuni in Svezia. Inoltre, lo studio offre una panoramica sugli aspetti sociali riguardanti gli SSM, sottolineando la loro capacità di affrontare sfide di natura socio-economica. A questo scopo, sono stati somministrati questionari anonimi ai membri del supermercato, da cui è emersa l'importanza che rivestono la dignità e l'autodeterminazione nell'acquistare il cibo, rispetto ad altre forme di assistenza alimentare, e la gratitudine e l'apprezzamento dei membri nei confronti di questa iniziativa. I risultati dello studio mostrano che l'SSM ha un potenziale significativo nel ridurre le emissioni di gas serra di -2.53

tonnellate per ogni tonnellata di cibo gestita dall'SSM. Tuttavia, questo beneficio è in gran parte annullato dal rebound effect. Il rebound effect si verifica quando il risparmio ottenuto grazie all'acquisto dei prodotti economici dell'SSM viene utilizzato per comprare altri beni o servizi, che a loro volta, sono responsabili della produzione di emissioni. Le emissioni imputate ai beni o servizi acquistati grazie ai suddetti risparmi controbilancia, in parte o del tutto, i benefici apportati dall'SSM. Pertanto, il risultato netto finale è di -0.18 tonnellate di emissioni evitate per ogni tonnellata di cibo. I risultati ottenuti dall'analisi dell'SSM sono stati messi a confronto con quelli di digestione anaerobica ed incinerimento con recupero energetico, risultando completamente in linea.

L'SSM si è dunque dimostrato una valida alternativa alle più comuni strategie di gestione del surplus alimentare. Tuttavia, sebbene efficace nel mitigare lo spreco alimentare, ridurre le emissioni, fornire accesso a beni di prima necessità ed alleviare la condizione di insicurezza alimentare dei propri membri, l'SSM deve essere considerato come una soluzione a breve termine. Infatti, come indicato nella gerarchia di gestione dei rifiuti adottata dalla Commissione Europea, la migliore opzione per la gestione dello spreco alimentare consiste nel prevenire la produzione di cibo in eccesso. Al contempo, le strategie di redistribuzione del surplus alimentare, pur essendo fondamentali per il sostegno di persone socialmente ed economicamente vulnerabili, non risolvono il problema della povertà crescente. Le cause del problema, infatti, sono profondamente radicate nel sistema attuale di produzione e consumo. Gli SSM dovrebbero essere considerati come un supporto temporaneo ai membri più vulnerabili della società durante la transizione verso un sistema alimentare sostenibile ed equo. Nel lungo termine, è essenziale un cambiamento sistemico che si concentri sulla riduzione del consumo e della sovrapproduzione, e garantisca allo stesso tempo uno sfruttamento sostenibile ed una più equa distribuzione delle risorse.

Populärvetenskaplig sammanfattning

Matsvinn är en global fråga med djupgående miljömässiga, ekonomiska och sociala konsekvenser. Ungefär en tredjedel av all mat som produceras för mänsklig konsumtion går förlorad i livsmedelskedjan eller slängs. Under de senaste decennierna har strategierna för avfallshantering av organiskt material i Europa blivit mer effektiva, med en gradvis minskning av deponering till förmån för mer hållbara alternativ. I EU-direktiven prioriteras förebyggande av överproduktion av livsmedel samt återanvändning, återvinning och återvinning. I linje med dessa principer har initiativ som social matbutik (SSM) skapats för att undvika matsvinn i detaljhandelsledet. SSM drivs i allmänhet av ideella organisationer och tar emot donationer av överskottsmat från andra detaljhandlare som annars skulle slänga den. Överskottsmaten säljs sedan till under marknadspris till ekonomiskt utsatta personer, vilket motverkar både matsvinn och osäker livsmedelsförsörjning.

I denna studie genomfördes en livscykelanalys (LCA) av en SSM i Stockholm, Sverige. LCA är en metod för att beräkna miljöpåverkan, i det här fallet i form av utsläpp av växthusgaser eller global uppvärmningspotential (GWP), av de processer som ingår i ett system som producerar en vara eller tjänst. Resultaten jämfördes med rötning och förbränning med energiåtervinning, som är de vanligaste alternativen för hantering av FW i Sverige. Rötning producerar kompost och biogas genom nedbrytning av organiskt avfall, medan förbränning med energiåtervinning förbränner avfall för att generera värme och elektricitet. Dessutom ger studien en översikt över de sociala aspekterna av SSM, med betoning på deras förmåga att hantera socioekonomiska utmaningar. Anonyma frågeformulär delades ut till medlemmarna i social matbutik och visade hur viktigt det är med värdighet och självbestämmande vid inköp av livsmedel, i motsats till andra former av livsmedelsbistånd, och hur uppskattade och tacksamma medlemmarna är för detta initiativ.

Resultaten av studien visar att SSM har en betydande potential att minska utsläppen av växthusgaser med -2.53 ton för varje ton livsmedel som SSM hanterar. Denna fördel uppvägs dock till stor del av rebound-effekten. Rebound-effekten uppstår när de besparingar som uppstår genom inköp hos SSM används för att köpa andra varor eller tjänster, som är ansvariga för produktionen av utsläpp. De utsläpp som hänförs till de varor eller tjänster som köps med medlemmarnas besparingar uppväger helt eller delvis de miljöfördelar som SSM ger. Det slutliga nettoresultatet av SSM:s påverkan är därför -0,184 ton utsläpp per ton överskottsmat, vilket är helt i linje med de resultat som finns i litteraturen för rötning och förbränning med energiåtervinning. SSM visade sig därför vara ett genomförbart alternativ till de vanligaste strategierna för hantering av livsmedelsöverskott.

Men även om SSM är effektiva när det gäller att minska matsvinnet, minska utsläppen, ge tillgång till grundläggande förnödenheter och lindra den osäkra livsmedelsförsörjningen för medlemmarna, måste SSM betraktas som en kortsiktig lösning. I enlighet med den avfallshierarki som antagits av Europeiska kommissionen är det bästa alternativet för att hantera matavfall att förhindra produktion av överskottsmat. Omfördelningsstrategier är visserligen grundläggande för att stödja socialt och ekonomiskt utsatta människor, men de löser inte problemet med den växande fattigdomen. Orsakerna till problemet är djupt rotade i det nuvarande produktions- och konsumtionssystemet. På lång sikt är det nödvändigt med en systemförändring som fokuserar på att minska konsumtionen och överproduktionen, samtidigt som man säkerställer en hållbar exploatering och en mer rättvis fördelning av resurserna. SSM bör ses som ett tillfälligt stöd till de mest utsatta samhällsmedlemmarna under övergången till ett hållbart och rättvist livsmedelssystem.

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Appendix 1

This is the English version of the questionnaire distributed to customers at the Hallunda Social Supermarket (SSM). Participation in the study was voluntary, and respondents were assured of anonymity. No sensitive information was requested during the survey.

Survey: Sustainability assessment of Social Supermarkets

Part I – Food security assessment

1. Nationality

2. Age:

3. Gender

☐ Female
☐ Male
☐ Other

4. How often do you shop at the social supermarket?

☐ Three times a week
☐ twice a week
☐ once a week
☐ once in two weeks
☐ once a month
☐ less than once a month

5. Household composition:

how many adults live in your household (over 18 years old)? ……..…
how many children (< 18 years old)? …………

6. Is the next statement often, sometimes, or never true for your household in the past 30 days? “The food that I/we bought just didn’t last, and I/we didn’t have money to get more.”

☐ Always true
☐ Often true
☐ Sometimes true
☐ Rarely true
☐ Never true

7. Is the next statement often, sometimes, or never true for your household in the past 30 days? “I/we couldn’t afford to eat balanced meals.” (A balanced meal consists of a meal that includes food items such as potatoes/rice/pasta/bread AND meat/fish/tofu/beans/lentils AND vegetables/fruit.)

☐ Always true
☐ Often true
☐ Sometimes true
☐ Rarely true
☐ Never true

8. In the last 30 days, did you ever cut the size of your meals or skip meals because there wasn't enough money for food?

☐ Yes → Go to question 9
☐ No → Go to question 10

9. In the last 30 days, how many days did this happen?

☐ Everyday
☐ 8 days
☐ 4 days
☐ 2 days
☐ 1 day

10. In the last 30 days, were you ever hungry but didn't eat because there wasn't enough money for food?

☐ Yes
☐ No

11. If you buy food in other supermarkets, what do you usually buy? (choose all applicable options).
    - ☐ Fruit
    - ☐ Vegetables
    - ☐ Bread
    - ☐ Milk
    - ☐ Cheese
    - ☐ Canned products
    - ☐ Grains (pasta, rice, oat, flour etc.)
    - ☐ Eggs
    - ☐ Meat
    - ☐ Other; specify: …………………………………………….…
    - ☐ I never buy in other supermarkets

Part II – Food Waste Assessment

12. What types of food you buy in the social supermarket are the ones that are usually disposed of from your grocery shopping (perhaps because it gets spoiled or rotten)? You can choose several alternatives:

- ☐ Fruit
- ☐ Vegetables
- ☐ Bread
- ☐ Milk
- ☐ Cheese
- ☐ Canned products
- ☐ Grains (pasta, rice, oat, flour etc.)
- ☐ Eggs
- ☐ Meat
- ☐ other; specify: ……………………………………
- ☐ none, I always manage to consume everything before it spoils

13. How much of the food you buy is usually disposed? Please write a percentage between 0% and 100%
    Examples:
    "Half of the food shopping (=50%) ";
    "1 item out of 4 (= 25%)";
    "1 item out of 5 (=20%);
    "1 item out of 10 (= 10%);

“1 item out of 20 (=5%)”;
“Nothing (=0%)

Write the percentage here ………. %

14. What are the main reasons of food waste in your household? (Select all applicable options)

☐ Bought too much food
☐ Perishable products
☐ Short expiration date of products
☐ Poor quality of the product
☐ Lack of ideas on how to use certain products
☐ Family’s food preferences
☐ Other reasons (please specify): ___________________________________

Part III – Rebound effect assessment

15. Do you think that you saved money by buying at the social supermarket?

☐ Yes
☐ No

16. How much money do you estimate you/your household has saved per month?

____________SEK/month

17. Have you/your household already spent the money that you have saved on something?

☐ Yes
☐ No

18. What have you/your household spent the money you saved on? How much of the money you saved thanks to the social supermarket have you spent on each category?

☐ To buy more food in other supermarkets …………….........SEK/month
☐ To buy clothes ……………………………………….…………….SEK/month
☐ Second hand clothes………………………………………………..SEK/month
☐ Healthcare (dentist, glasses, medicine etc.) …………………..SEK/month

- ☐ Toys/activities/sports for children………..…………………..SEK/month
- ☐ Mobile phone/phone bills……………………......................SEK/month
- ☐ To pay for rent/household bills…………….…………….…...SEK/month
- ☐ To pay for transportation expenses…………..………..............SEK/month
- ☐ To pay for recreative activities (sport, cinema, restaurant etc.) ……………………………………………………………SEK/month
- ☐ Other: ………………………………………………………..SEK/month

Part IV – Social sustainability assessment

19. How easy is it for you to arrive to the social supermarket (is it close to your household, are there transport connections etc.)?
    - ☐ Very easy
    - ☐ Fairly easy
    - ☐ Neither easy nor difficult
    - ☐ Fairly difficult
    - ☐ Very difficult

20. How easy is for you to access to the social supermarket (is it easy to book a time slot)?
    - ☐ Very easy
    - ☐ Fairly easy
    - ☐ Neither easy nor difficult
    - ☐ Fairly difficult
    - ☐ Very difficult

21. What means of transportation do you use to arrive to the social supermarket?
    - ☐ None, I walk
    - ☐ Train/subway
    - ☐ Bus
    - ☐ Bike
    - ☐ Car

22. Compared to your expectations, how do you rate the quality of the products available?
    - ☐ Excellent
    - ☐ Good
    - ☐ Adequate

- ☐ Poor
- ☐ Inadequate

23. Compared to your expectations, how do you rate the variety of the products available?
    - ☐ Excellent
    - ☐ Good
    - ☐ Adequate
    - ☐ Poor
    - ☐ Inadequate

24. How do you rate your overall shopping experience at the social supermarket?
    - ☐ Very positive
    - ☐ Positive
    - ☐ Neutral
    - ☐ Negative
    - ☐ Very negative

25. Choose the option that you prefer.
    - ☐ To buy discounted food at the social supermarket where I choose what I need ---- go to question 26
    - ☐ Receive a free bag of food every week (paying a small yearly fee) without choosing its content ---- go to question 27
    - ☐ I would like both options ---- go to both questions 26 and 27

26. I prefer the social supermarket because (choose all applicable options):
    - ☐ I want to choose myself what to buy
    - ☐ I want to be able to provide for myself
    - ☐ I have specific food necessities, and I know what to buy for myself
    - ☐ I have always bought food in the supermarkets/shops and I want to keep the habit
    - ☐ To buy food in the supermarket allows me to go out and socialize with people
    - ☐ To buy food myself is a routine and it gives me a sense of stability
    - ☐ other reasons: ______________________________

27. I prefer the food bags because (choose all applicable options):
    - ☐ It is better to have food almost for free
    - ☐ I don't have to choose and buy the groceries myself
    - ☐ It takes less time to collect a food bag than to actually do the shopping
    - ☐ I can try some new food I have never bought before
    - ☐ It is nice that someone cares for me and chooses the products for me
    - ☐ To pick up the food bag allows me to go out and socialize with people
    - ☐ other reasons: ____

28. In terms of food access, how important is the sense of autonomy to you? (for example, the ability to choose or purchase your food)"
    - ☐ Very important
    - ☐ Quite important
    - ☐ Not very important
    - ☐ Not important at all

29. If you could receive food through donations or food bags, do you think MORE food would be wasted in your household? (Choose all applicable options)
    - ☐ Yes, I might not like some of the food
    - ☐ Yes, I might not know how to cook some food
    - ☐ Yes, other reason:____
    - ☐ No, I like every food
    - ☐ No, I eat/cook even the food I don't like/don't know how to cook
    - ☐ No, other reason: ____

30. Is there any other consideration or thought you would like to share?

____
____
____
____
____
____
____

That is the end of the survey. Thank you!

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