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From waste to value? Balancing climate and social outcomes in social supermarkets

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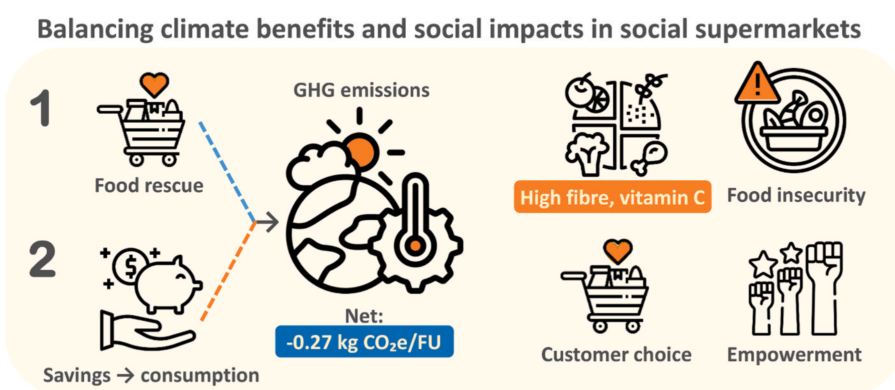
HIGHLIGHTS

- Assessed seven Swedish social supermarkets using full-year primary data.
- Integrated LCA, nutrition analysis, and customer survey methods.
- Redistribution reduced GHGEs, but 90 % was offset by rebound effects.
- Redistributed food was nutritionally balanced and low in added sugar.
- Customer autonomy may trade off with environmental performance.

GRAPHICAL ABSTRACT



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ABSTRACT

Surplus food redistribution (redirecting unsold but edible food to consumers) is promoted as a dual strategy to reduce food waste and alleviate food insecurity. Social supermarkets (retail-like outlets offering surplus food at reduced prices to low-income consumers) have emerged as a market-based model, offering surplus food at reduced prices to low-income consumers. However, their sustainability impacts remain under-examined, particularly regarding trade-offs between environmental and social outcomes. This study assessed seven social supermarkets in Stockholm, Sweden, using three methods: (1) life cycle assessment to estimate climate impacts, including substitution and rebound effects (emissions from re-spending savings); (2) nutrient calculations to evaluate the nutritional quality of redistributed food; and (3) customer surveys to explore experiences of food security, autonomy, and food waste behaviours. Based on full-year primary data, potential climate savings were 2.57 kg CO_2e/FU, of which 90 % was offset by rebound effects, reducing the net savings to 0.27 kg CO_2e/FU. The food was nutritionally balanced and high in dietary fibre (3 g/MJ), and vitamin C (13 mg/MJ), while low in added sugar. Customers valued autonomy and choice, suggesting a potential trade-off between consumer agency and environmental performance. While social supermarkets supported climate mitigation and food access, their distinguishing value lies in combining these functions with enhanced autonomy and nutritionally balanced food. To build on these strengths and address the identified trade-offs, policies should link food waste prevention with social welfare measures, ensuring realistic climate benefits while improving equitable food access.

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1. Introduction

Food waste is a critical global challenge with far-reaching environmental, economic, and social consequences. Approximately one-third of all food produced for human consumption, about 1.3 billion tonnes annually, is lost or wasted, despite international commitments to halve food waste by 2030 (UNEP, 2021). This wastage depletes essential natural resources such as soil, water, and energy, and accounts for roughly 10 % of global greenhouse gas emissions (GHGE) (WWF-UK, 2021). In parallel, the economic cost of food waste is estimated at $940 billion annually, while millions of people continue to face hunger and malnutrition, exposing a stark paradox of abundance amid scarcity (FAO; IFAD; UNICEF; WFP; WHO, 2024). These realities underscore the urgent need for effective food waste prevention and management strategies.

Surplus food redistribution originated as a humanitarian response to hunger in the 1960s, but has since been reframed as an environmental strategy aligned with food waste prevention (Schneider, 2013; Mourad, 2016). Surplus food is generally defined as safe and edible food that has left the conventional supply chain and is no longer saleable, for example due to approaching expiry dates, damaged packaging, or overstocking, but can still be consumed if redistributed (Damiani et al., 2021). In Europe, policies such as the EU Waste Framework Directive and the Food Waste Hierarchy position food redistribution, especially for human consumption, as preferable to energy recovery or disposal (European Commission, 2008). Various food aid models have emerged to redistribute surplus food while addressing food insecurity. These models are typically run by non-profit and non-governmental organizations, often relying at least partially on volunteer labour but differ in their operational structures, accessibility, and the level of choice afforded to recipients (Andriessen and van der Velde, 2024).

Social supermarkets have emerged as a distinct model within this space, blending market-based food aid with circular economy goals. Social supermarkets are typically supplied with unsold but edible foods from retailers, wholesalers, and food producers, often collected through partnerships with food aid organizations. Stores are usually run by non-profit organizations, often supported by volunteers, and operate with a membership system where eligible low-income customers can purchase food at reduced prices. Unlike food banks, which often offer pre-packed food parcels, social supermarkets enable low-income consumers to purchase surplus food at reduced prices in a retail-like environment to maintain customer autonomy and choice (Saxena and Tornaghi, 2018; Schneider, 2013). Previous research has highlighted that such autonomy and dignity are central to customer experiences and acceptance of social supermarkets (Berri and Toma, 2023; Ranta et al., 2024). Initially developed in Austria and Germany in the early 2000s, social supermarkets gained momentum after the 2008 financial crisis and have since expanded across Europe (Ranta et al., 2024; Berglund and Kristjansdottir, 2024). Their growth has been encouraged by national policies such as France's 2016 food donation law and Italy's Gadda Law, which incentivise structured redistribution systems (Condamine, 2020; Pacini Giuridica, 2024). This model is gaining traction in Nordic welfare states such as Sweden, where the expansion of social supermarkets reflects broader efforts to formalize food aid by integrating redistribution into structured, market-based models (Berglund and Kristjansdottir, 2024). However, scholars have also warned that formalising redistribution through retail-like models may unintentionally normalize surplus generation, creating a secondary market rather than addressing the root causes of overproduction (Mourad, 2016; Papargyropoulou et al., 2022).

Despite the growing prominence of social supermarkets, their sustainability impacts remain underexplored. Prior studies have primarily focused on food banks and traditional surplus food donation programs, often neglecting the unique role of social supermarkets as a market-based approach to surplus food redistribution (Albizzati et al., 2019; Sundin et al., 2022). Furthermore, while a few recent studies have begun to adopt integrated frameworks that include environmental and social outcomes, including nutrition (e.g., Sundin et al., 2023), the majority of research on surplus food redistribution still focuses on a single sustainability dimension, typically either environmental or social, thereby overlooking important interlinkages (Goossens et al., 2019). For instance, life cycle assessment (LCA) studies typically assume that redistributed food fully substitutes new production but neglect to account for rebound effects, where accrued monetary savings may be reallocated to other consumption, thereby offsetting intended environmental gains (Albizzati et al., 2022; Hegwood et al., 2023). Social outcomes such as autonomy, food security, food acceptance, and customer satisfaction are rarely integrated into environmental assessments, even though they shape the effectiveness and the environmental outcomes of food redistribution initiatives (Mulrooney et al., 2023; Sundin et al., 2022). At the same time, the nutritional quality of food provided by social supermarkets remains underexplored, with few studies assessing whether they offer nutritionally adequate options to their customers (Mulrooney et al., 2023). This gap is significant, especially considering concerns raised about food banks, where food aid often includes energy-dense, nutrient-poor items that fail to meet dietary needs (Fallaize et al., 2020; Simmet et al., 2017). Furthermore, as surplus food redistribution is increasingly advocated as a win-win solution to tackle both food waste and food insecurity, it is critical to examine potential trade-offs between environmental and social aspects.

Therefore, this study adopts a two-pillar sustainability framework, including environmental and social dimensions, to evaluate the performance of seven social supermarkets located in Stockholm, Sweden. Nutritional adequacy is treated as a core element of social sustainability, reflecting frameworks that link diet, equity, and health within food systems (Goossens et al., 2019; Neter et al., 2020). This integrated perspective is particularly relevant in the context of food redistribution, where access to nutritious food, user autonomy, and financial relief are inseparable from questions of justice and system sustainability. Building on this framing, three key gaps in the current literature are addressed. First, few empirical assessments combine life cycle assessment with a holistic evaluation of social impacts, including both nutritional quality and lived user experience. Second, the rebound effect, where cost savings from discounted food lead to additional emissions, is rarely quantified in food redistribution LCAs, despite its policy relevance (Albizzati et al., 2022; Hegwood et al., 2023). Third, the sustainability performance of social supermarkets remains under-examined relative to food banks, even as they expand across Europe.

This study aims to address these gaps by:

1. Assessing the climate impact of social supermarkets using a system-expansion attributional LCA approach that accounts for both substitution and the rebound effects;
2. Quantifying nutrient savings from surplus food redistribution, providing new insights into the nutritional quality of redistributed food through social supermarkets;
3. Examining customer perspectives on food security, autonomy, and food waste behaviours to gain insight into the broader social implications of social supermarkets.

By integrating environmental and social dimensions, with a specific focus on social supermarkets, the study contributes new insights into the role of surplus food redistribution in sustainable food systems. Recognising the ethical and practical constraints of engaging vulnerable and multilingual populations, the study combines a robust, full-year quantitative dataset with an exploratory qualitative component to contextualise behavioural and social aspects. It highlights both the potential and the trade-offs of social supermarkets in addressing environmental and social challenges. The findings offer practical insights for policymakers and organizations aiming to implement or scale up social supermarkets, and can inform strategies to ensure that food redistribution not only reduces waste and emissions but also promotes equitable access to nutritious food. While based in Sweden, the findings have broader relevance for countries developing social supermarket models within circular economy strategies.

2. Materials and methods

The present case study commenced in March 2024, in Stockholm County, Sweden, where the Matmissionen social supermarkets were used as the case. Matmissionen is a social supermarket initiative byStockholm City Mission, aimed at reducing food waste and supporting people facing economic hardship. Stockholm was chosen as the study location because it is the most populated county in Sweden and was the first to introduce social supermarkets in the country in 2015. Currently, there are seven Matmissionen social supermarkets in Stockholm County, located in the suburbs and nearby municipalities of Stockholm. These stores allow their members to purchase food at approximately one-third of regular retail prices, helping to both alleviate food insecurity and reduce food waste by selling products that would otherwise go to waste.

To address the three aims of the present study, assessing climate impact, evaluating nutritional quality, and examining customer perspectives, three types of methods were combined: LCA, nutrition calculations, and a member survey. The survey included questions on food security and autonomy and, together with nutrition calculations, contributed to the assessment of social impacts associated with the social supermarket model. The survey also provided primary input data for the LCA, such as information on food waste behaviour and economic savings, to complement the environmental assessment. The study assessed incineration and anaerobic digestion as alternative treatment options for the surplus food, as these are the most common ways to treat food waste from supermarkets in Sweden.

2.1. Assessing climate impact

To assess the climate impact of the social supermarket model, the standards ISO 14040–14044 for an attributional LCA were used. The model was compared to the two most prominent food waste treatment pathways in Sweden, including anaerobic digestion and incineration with energy recovery, in the same geographical location as the social supermarket model. A functional unit (FU) of 1 kg *surplus food at the supplier gate* was used, and modelling was conducted from gate to grave. System expansion was used to include substitution and rebound effect as illustrated in Fig. 1. Microsoft Excel was used to model the system and calculate the climate impact of each subsystem as well as the net climate impact of the social supermarket in terms of global warming potential (GWP). The GWP values were sourced from multiple databases and literature. Food product values came primarily from the RISE Climate Database (Rise, 2022), Röös (2014), and SAFAD (SLU, 2024); transport and fuel from NTMCalc 4.0 (2022), Volvo Truck Corporation (2018), and the Swedish Energy Agency (2020); and background data were cross-checked against Statistics Sweden (2024). Further details are provided in the following subsections for each scenario and calculation.

2.1.1. Social supermarket scenario

Primary data covering the full calendar year of 2022 was collected from all seven social supermarkets, including quantities and types of redistributed food, food waste statistics, fuel consumption during transport, packaging, and electricity consumption across seven social supermarkets. Data were gathered through interviews and contact with social supermarket staff. This comprehensive, multi-site dataset underpins the quantitative life cycle and nutrient analyses, minimising seasonal and site-specific bias and providing a robust basis for the environmental and nutritional assessments. Additionally, a survey was conducted at one of the stores in Hallunda Centrum to assess customer satisfaction, food security, financial savings, shopping and transport habits, as well as household food waste. This qualitative and exploratory component, conducted with a small and diverse group of members, aimed to capture experiential and behavioural insights that complement the quantitative data, while acknowledging the practical and ethical constraints of engaging a vulnerable, multilingual population.

In 2022, Matmissionen received 1980 tonnes of surplus food, of which 127 tonnes became waste. Since food was not separated from packaging where applicable, all waste was assumed to be incinerated. Household food waste generated from social supermarket purchases was estimated by survey respondents at 9 % (±9). This waste was assumed to be managed through anaerobic digestion (25 %) and incineration (75

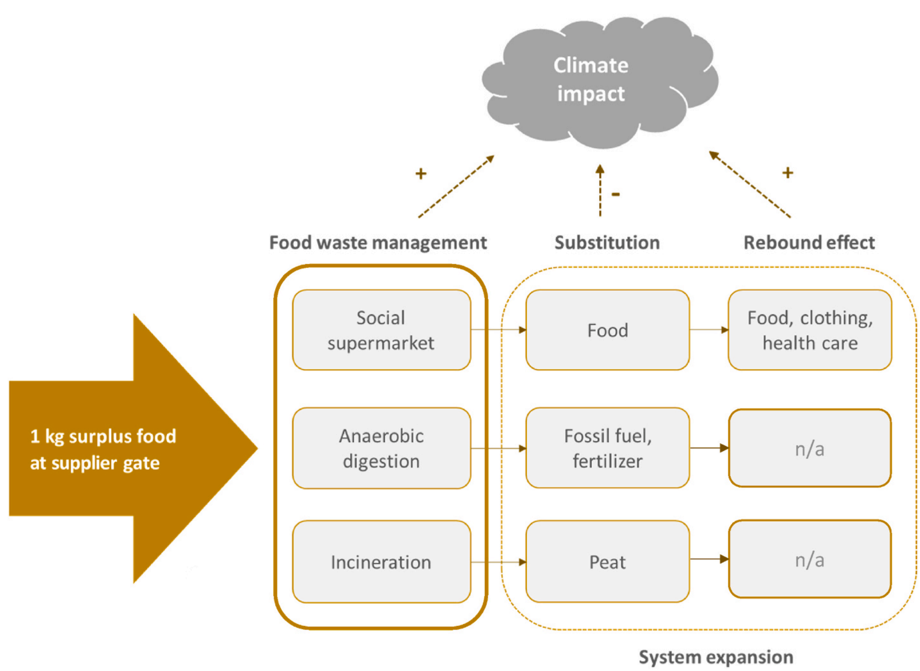

Fig. 1. System boundary diagram illustrating the three different food waste management options assessed including substituted products and rebound effect where applicable. The positive (+) or negative (−) signs indicate whether each sub-system contributes positively or negatively to the overall climate impact of each assessed option.

%), reflecting the national averages for household food waste treatment in Sweden. As household-level separation data were unavailable, this assumption provides a realistic approximation of prevailing practices.

Fuel consumption for surplus food recovery totalled 34 391 L of diesel with the carbon footprint of 2.6 kg CO_2e/L (Volvo Truck Corporation, 2018). For other retailer deliveries, emissions were modelled for co-transport operations based on weekly trips between Helsingborg and Stockholm (556 km), using NTMCalc 4.0 (2022). Weekly loads of 15 tonnes with no dead freight were assumed.

Customer transport emissions were estimated based on interviews, assuming car users drove petrol-fuelled vehicles at an average consumption of 5 L/100 km, with trips spanning a 4 km radius. The carbon footprint of petrol was 2.92 kg CO_2e/L (Swedish Energy Agency, 2020). Public transport emissions were considered negligible.

The social supermarkets provide only paper bags and encourages reusable bags. The estimated carbon footprint of paper bags was 0.031 kg CO_2e/bag (Bisinella et al., 2018). The emissions from electricity consumption were estimated using invoices from 2023, adjusted for the number of stores in 2022, and based on a renewable energy mix with a carbon footprint of 9.12 g CO_2e/kWh.

2.1.2. Anaerobic digestion and incineration scenarios

The carbon footprint associated with anaerobic digestion was −0.23 kg CO_2e/kg food waste (Sundin et al., 2022). Biogas and bio fertilizer produced from food waste were assumed to substitute for fossil fuel and mineral fertilizer, respectively. The rebound effect was found to be negligible and therefore excluded in this scenario (Sundin et al., 2022). Further, the carbon footprint associated with incineration with energy recovery was −0.11 kg CO_2e/kg food waste (Eriksson et al., 2015). The heat and electricity produced from food waste were assumed to substitute for fossil peat as feedstock. Based on the anaerobic digestion scenario, the rebound effect was assumed to be negligible and therefore excluded.

2.1.3. Substitution calculations of avoided production

The substitution of avoided production refers to the environmental benefit assumed when redistributed surplus food replaces the need for new food production, avoiding associated GHGE (Caldeira et al., 2019). In this study, all food sold by social supermarkets was assumed to substitute conventional purchases, and thus, replacing new food production with the avoided emissions was treated as an environmental benefit subtracted from the social supermarket's net carbon footprint emissions.

Matmissionen provided a list of products sold in 2022, including their net weights, totalling 1850.5 tonnes of surplus food (Table S1). Based on the customer survey results on respondents' typical shopping patterns, it was determined that food items purchased from social supermarkets would likely replace similar items they would have otherwise bought elsewhere. To estimate avoided emissions, the carbon footprint of each product was multiplied by its sales volume.

Carbon footprint values (kg CO_2e/kg food), were primarily sourced from the Food-Climate List (Röös, 2014), to align data vintage (≈2010–2015) with the consumption-based intensities used for rebound effect calculations (Grabs, 2015), ensuring internal methodological consistency. For product categories not covered by Röös, such as venison, lamb, and certain deep-frozen products, values were supplemented from the SAFAD database, which provides average carbon footprint values for foods sold in Sweden, accounting for production shares and waste across the supply chain (SLU, 2024). Using data sources of similar vintage minimizes bias between substitution and rebound estimates, while SAFAD improves completeness for categories missing from earlier inventories. The carbon footprint for coffee, tea, and baby food was calculated using data from (Rise, 2022; Sieti et al., 2019).

2.1.4. Rebound effect calculation

The rebound effect, initially studied in energy efficiency, occurs when resource savings lead to additional consumption, partially offsetting environmental benefits (Baudino et al., 2024). This can be direct (increased use of the same resource) or indirect (savings spent on other activities with environmental impacts). While traditionally linked to energy, it is highly relevant in food waste reduction (Hegwood et al., 2023). In surplus food redistribution, financial savings from discounted or free food may fund activities generating additional GHGE (Albizzati et al., 2022), potentially offsetting some of the climate benefits.

The rebound effect is defined as the proportion of potential carbon footprint reductions (ΔH) offset by environmental impacts of re-spending savings (ΔG), followed the framework established by Chitnis et al. (2014) (Eqn (1)):

$$\textit{Rebound effect}\ (\%) = \frac{\Delta G}{\Delta H} \times 100 \tag{1}$$

Survey data from social supermarket members were used to estimate ΔG. Members allocated their savings across predefined categories (e.g., food, clothing, healthcare), which were converted into carbon footprint impacts using category-specific GHGE intensities (Grabs, 2015). For second-hand clothing, carbon footprint impacts were adjusted for substitution effects, based on Swedish second-hand market studies (Osterley and Williams, 2019; Persson and Hinton, 2023).

On average, members saved 930 SEK per month, primarily reallocating these savings to complementary food and personal care (Table S2). Following established rebound methodologies (Chitnis et al., 2014; Albizzati et al., 2022), we attributed all re-spending of savings from surplus food purchases to the intervention, reflecting that these savings may enable households to consume slightly more in categories they would otherwise cut back on. Annual savings were calculated as 11 times the monthly savings per member assuming that members may occasionally miss a visit. While no specific frequency data was available for our case, survey evidence from the UK indicated that not all members visited their social market every week (Moore et al., 2025). The total annualized carbon footprint impact of these expenditures (ΔG) was then calculated and added to the social supermarkets' net carbon footprint emissions. Furthermore, by comparing avoided food waste carbon footprint savings (ΔH) with re-spending impacts (ΔG), the rebound effect of the social supermarket was quantified (Eqn (1)).

A sensitivity analysis was also conducted on rebound parameters previously identified as highly sensitive in surplus food redistribution LCAs (Sundin et al., 2022, 2023). The analysis tested variations in the amount of monthly savings (300 SEK and 1500 SEK) and the proportion of savings spent on food (0 % and 100 %), in order to assess their effect on the magnitude of the rebound effect and the net results.

2.2. Customer survey

In March 2024, an exploratory survey was conducted at the Hallunda Centre to help assess the environmental and social impacts of the social supermarket model. The survey, designed as a multiple-choice questionnaire, aimed to complement the quantitative assessments by capturing qualitative insights into members' experiences, behaviours, and perceptions. Because the target group included linguistically diverse and socio-economically vulnerable customers, participation was subject to practical and ethical constraints. The survey was therefore conceived from the outset as an exploratory, contextual component intended to provide qualitative understanding rather than statistical representation. It was developed based on established frameworks from previous studies. Food insecurity was assessed using the validated USDA Six-Item Short Form (USDA, 2012), while questions on re-spending and household food waste were adapted from Sundin et al. (2022). Autonomy and choice were explored through self-developed items, informed by previous literature on food aid dignity and customer perspectives (Saxena and Tornaghi, 2018; Andriessen and van der Velde, 2024). The survey consisted of four sections covering demographics and food security, household food waste rates and food substitution patterns, saved money and spending thereof, and customer perceptions of the social supermarkets (S3). To ensure inclusivity, the survey was available in Swedish, English, and Arabic, allowing participants to respond comfortably in their preferred language. Convenience sampling was used, involving participants who were readily accessible and available at the store location.

The survey was completed by 17 members, with a gender ratio of 59 % women and 41 % men, and with participants ranging from 27 to 73 years old, representing diverse backgrounds, including origins in Europe, the Middle East, South America, and South Asia. 35 % of the households included children aged 0–17, a factor that can significantly influence the quantity and type of food required due to specific dietary needs based on age. While the sample was purposively selected to include variation in age, gender, and background, the small number of participants (n = 17) limits the generalizability of the results and may not fully capture the diversity of experiences within the wider social supermarket customer population. Given the small and purposive sample, results are interpreted qualitatively and are intended to identify indicative patterns rather than statistically representative findings.

Informed consent was obtained from all participants, with assurances of anonymity, and no sensitive personal data were collected. Environmental aspects explored through the survey included household food waste, food substitution, transportation, and rebound effects, while social questions focused on income, food security, and shopping experience at the social supermarket. The data collected were then analysed to assess social supermarkets' impact on both environmental outcomes and members' quality of life.

2.3. Social impact assessment

2.3.1. Calculations of nutrient savings

Nutrient savings embedded in the food sold by Matmissionen in 2022 were calculated using net weights and the Nutrition Data (2022) software. The total energy, macronutrient, micronutrient, and dietary fibre contents of the sold food were determined for the entire data collection period. Macronutrient content was further expressed as energy percentage (E%) values to evaluate whether the food sold was overall balanced in terms of macronutrient content. The total nutrient values were averaged per kilogram of sold food and adjusted to energy per mega joule (MJ) to express nutrient densities. These nutrient density values were then compared to the recommended nutrient density values to evaluate the overall nutritional quality of the sold food. Additionally, the number of Wasted Nutrient Days was calculated for the total sold food. This metric represents the number of days during which the sold food could meet the daily recommended intake values for assessed nutrients for adults. The Wasted Nutrient Days calculation involved dividing the mean energy and nutrient values of the food by the recommended intake values for males and females aged 25–50 years with average physical activity levels, as defined in the Nordic Nutrition Recommendations 2023; Nordic Council of Ministers (2023). When recommended intake values differed between genders, the average of the aforementioned two was used. By dividing the Wasted Nutrient Days value by the total members in 2022, 14 231, an indicator per member could be retrieved. By comparing the Wasted Nutrient Days values of nutrients with the Wasted Nutrient Days value for energy, possible large deviations from recommended nutrient intakes could be evaluated to assess the overall nutritional quality of the redistributed food.

2.3.2. Assessment of customer perspectives

To explore customer perceptions regarding the social supermarket model, a survey (S3) was conducted among a sample of social supermarket members. The survey aimed to provide qualitative insights into customers' experiences and preferences, addressing several key aspects of the social supermarket model. The questionnaire included sections covering food insecurity status within the preceding 30 days. The survey further explored members' perceptions of the supermarket's accessibility, including its physical location and the convenience of scheduling shopping times. Additionally, questions were included to gauge overall satisfaction with the quality and variety of available products and to assess their general shopping experience at the social supermarkets. Participants were also asked to compare the social supermarket with an alternative surplus food redistribution system: donated food bags. They rated the importance of maintaining shopping autonomy at the social supermarket versus receiving pre-selected food items. The food bag system, used effectively for example in Uppsala, Sweden, involves weekly distribution of sorted surplus food to members via subscription (Sundin et al., 2023). Participants also assessed whether the food bag system might lead to higher household food waste compared to the social supermarkets.

3. Results

3.1. Environmental impact of the social supermarket scenario

This section quantifies the climate impact of the social supermarket model using life cycle assessment, including substitution and rebound effects. Life cycle assessment of the social supermarket scenario resulted in a carbon negative result of −0.27 kg CO_2e/FU (Fig. 2). This carbon negative result was largely due to the substitution effect of −2.76 kg CO_2e/FU, which, however, was offset to a large degree by the rebound effect of 2.30 kg CO_2e/FU corresponding to 90 % of the potential climate impact savings amounting to 2.57 kg CO_2e/FU. Emissions from inbound and outbound transports as well as food waste treatment were only minor, with 0.06, 0.1 kg and −0.02 kg CO_2e/FU, respectively, and emissions associated with electricity and packaging were negligible, with 0.001 kg and 0.0001 kg CO_2e/FU, respectively. Despite the large rebound effect, the social supermarket net result (−0.27 kg CO_2e/FU) was similar to the result of anaerobic digestion scenario (−0.23 kg CO_2e/FU) and more than two-fold carbon negative in comparison to incineration (−0.11 kg CO_2e/FU) scenario.

The sensitivity analysis related to rebound parameters confirmed high sensitivity to the amount of savings accrued and the proportion of savings spent on food. Assuming minimum monthly savings (300 SEK) improved the net climate impact to −1.73 kg CO_2e/FU, whereas maximum savings (1500 SEK) led to a backfire effect, resulting in a net impact of 1.57 kg CO_2e/FU. Similarly, allocating 0 % of the savings to food improved the net climate impact to −1.39 kg CO_2e/FU, while allocating 100 % of the savings to food resulted in a more pronounced backfire effect, with a net impact of 3.47 kg CO_2e/FU. Since these climate outcomes depend on the types of foods redistributed, the following section examines their nutritional composition to highlight the social value of redistribution.

3.2. Nutrient quality and savings

The types of foods redistributed determined both the substitution effects in the climate assessment and the nutritional, hence social value delivered to customers. The social supermarket model yielded significant nutrient savings, notably from the sale of perishable foods such as fruit, vegetables, and roots (29 %), dairy (18 %), and meat, fish and eggs (11 %) (Fig. 3.). Overall, the social supermarket scenario in 2022 resulted in approximately 13.8 million MJ of energy, 124 tonnes of protein, 104 tonnes of fat, and 439 tonnes of carbohydrates (Table 1.). These savings corresponded up to 1.49 million Wasted Nutrient Days, with the energy sufficient to meet the needs of all 14 231 members for 103 days.

The macronutrient profile was well-balanced, with an average composition of 15 % energy (E%) from protein, 28 E% from fat, and 57 E % from carbohydrates (Table 1.). Micronutrient savings were also substantial, including dietary fiber (3 g/MJ), vitamin A (80 RE/MJ), vitamin C (13 mg/MJ), and iron (1.3 mg/MJ). However, some nutrients fell below recommended intake levels, corresponding to typical intake

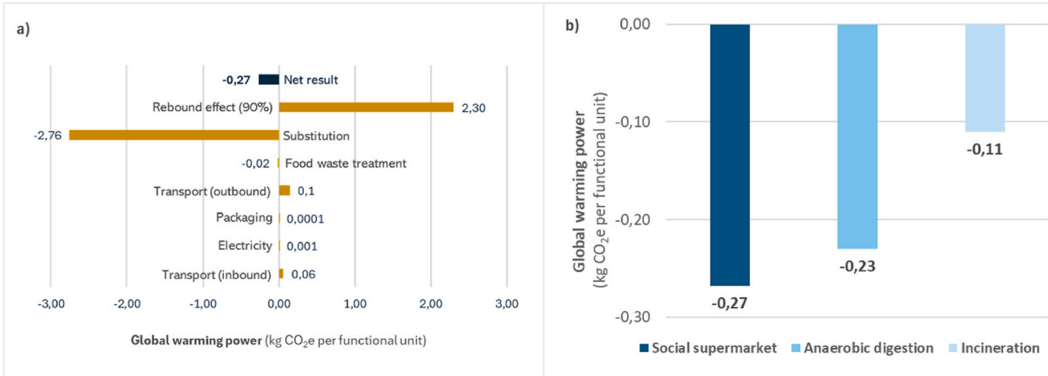

Fig. 2. a) Climate impact associated with social supermarket scenario with a net result of −0.27 kg CO_2e per functional unit. The rebound effect (90 %) substantially offset the potential carbon footprint savings, which originated mainly from substitution, while other subsystems (transport, electricity, packaging, and food waste treatment) contributed only marginally; b) Comparison of the net global warming power (GWP) value of social supermarket to the net GWP values of anaerobic digestion and incineration showed that despite the substantial rebound effect, the social supermarket performed the best out of the three scenarios.

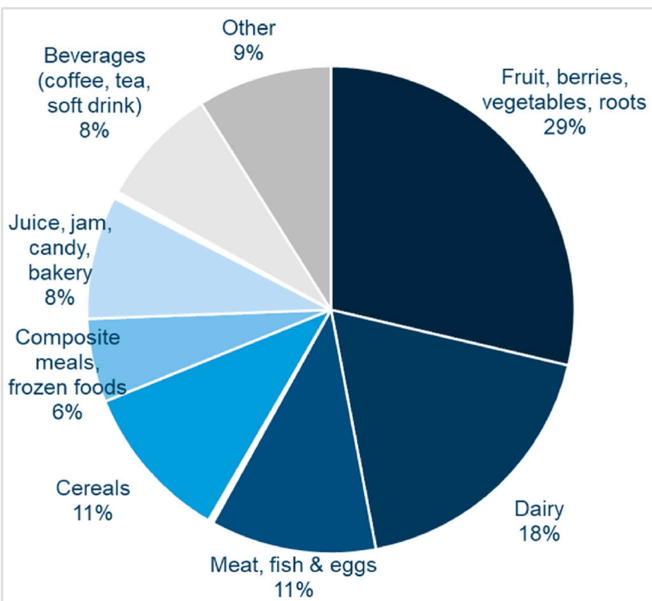

Fig. 3. The sold food by Matmissionen in 2022, divided into diverse food categories. Approximately 60 % of the sold food consisted of fresh, perishable food items such as fruits and vegetables, dairy, and meat.

levels in the Swedish population (Amcoff et al., 2012), such as vitamin D (1 μg/MJ) and selenium (3 μg/MJ). Additionally, the salt content exceeded the recommended maximum daily intake, with a Wasted Nutrient Days for salt of 4.1 million, compared to the 1.46 million Wasted Nutrient Days for energy. However, the Wasted Nutrient Days for added sugar was 0.8 million, indicating that the content did not surpass the recommended maximum daily level. The nutritional results, together with the types of foods redistributed, provide context for understanding members' experiences of food access, autonomy, and consumption behaviours presented in the next section.

3.3. Customer perceptions

To further explore the social aspects of the social supermarket model, this section presents survey-based insights into food insecurity, autonomy, and customer satisfaction among social supermarket members. Given the small and purposive sample, the results should be interpreted as indicative patterns rather than statistically representative outcomes. Among respondents, 18 % reported that the food they purchased in the previous 30 days was always insufficient to feed themselves or their household members. For 47 %, this was often true, while only 6 % indicated it was never true. Additionally, 23 % of respondents stated that they had never had a balanced meal during the same period. A balanced meal was defined as one including carbohydrates, proteins, and fruits or vegetables.

Accessibility to the social supermarket was rated positively, with an average score of 4.1 (±0.9) out of 5. Approximately 35 % of respondents walked to the social supermarket, reflecting its inclusivity and accessibility for those without private vehicles. The overall experience with the social supermarket was rated at an average score of 3.9 (±1.0) out of 5. The variety and quality of products received average scores of 3.4 (±0.8) and 3.3 (±1.1) out of 5, respectively. Autonomy in shopping was consistently rated as highly important by respondents with an average score of 4.7 (±0.5). Specifically, 71 % of respondents stated that maintaining autonomy was very important, while the remaining 29 % considered it quite important.

Food bag centers represented an alternative surplus food redistribution model in the survey. These centers distribute pre-packed food bags to members in exchange for a small membership fee, typically allowing members to receive one bag per week (Sundin et al., 2022). However, when social supermarket members were asked whether they preferred this system over purchasing food at the social supermarket, only 7 % expressed a preference for food bags or an equal preference for both systems.

Respondents who favored the social supermarket, cited the following main reasons:

- 52 % valued the freedom of choice the social supermarket offers.
- 22 % appreciated the ability to provide for themselves by purchasing their own food.
- 22 % highlighted specific dietary needs, such as allergies or cultural preferences, which are difficult to accommodate with pre-packed food bags.
- 4 % appreciated that shopping at the social supermarket provided an opportunity to socialize and go out.

Respondents were also asked to compare the food bag system with the social supermarket in terms of food waste. A significant 64 % believed they would likely waste more food with pre-packed food bags due to mismatched food preferences. Additionally, 21 % indicated they might not know how to cook some items included in the food bags, further indicating that choice may help reduce food waste by better aligning with individual preferences. Conversely, 14 % believed they would not waste more food, as they consume a wide variety of items.

Table 1
A breakdown of the total energy, macro- and micronutrients salvaged by the social supermarkets of Matmissionen in 2022, presented as total amounts, per kg sold food, per mega joule (MJ), and in relation to recommended intake (RI).

Energy and macronutrients		total	per kg sold food	per MJ	E%	RI	WND
energy	kcal	3 287 530 771	1777				1 461 125
energy	MJ	13 758 963	7				
Protein	g	124 254 967	67	9	15	15–20	1 461 823
Fat	g	103 624 263	56	8	28	25–40	1 279 312
Carbohydrate	g	438 651 013	237	32	57	45–60	1 486 953

Micronutrients		total	per kg sold food	per MJ	RI per MJ	RI	WND
Fiber	g	44 188 097	24	3	3	35	1 262 517
Salt	g	24 578 467	13	2		<6	4 096 411
Vitamin A	RE	1 106 779 942	598	80	80	800	1 383 475
Vitamin D	μg	6 997 387	4	1	1.4	10	699 739
Vitamin E	mg	14 811 218	8	1	0.9	11	1 346 474
Vitamin K	μg	92 827 687	50	7		75	1 237 702
Vitamin B1	mg	2 449 260	1	0.2	0.1	1.1	2 226 600
Vitamin B2	mg	2 387 355	1	0.2		1.6	1 492 097
Niacin	NE	69 876 188	38	5	1.6	18	3 882 010
Vitamin B6	mg	13 561 632	7	1	0.13	1.8	7 534 240
Folate	μg	430 316 068	233	31	45	330	1 303 988
Vitamin B12	μg	4 455 679	2	0.3	0.2	4	1 113 920
Vitamin C	mg	180 661 989	98	13	8	110	1 642 382
Calcium	mg	1 211 629 752	655	88	100	950	1 275 400
Phosphorus	mg	2 303 207 454	1245	167	80	520	4 429 245
Iron	mg	17 459 768	9	1.3	1.6	15	1 163 985
Zinc	mg	17 036 073	9	1.2	1.2	12.7	1 341 423
Selenium	μg	38 419 490	21	3	5.7	90	426 883
Added sugar	g	46 692 132	25	3		<56	833 788

Acronyms: kcal = kilocalories, MJ = mega joule, g = grams, μg = micrograms, mg = milligrams, RE = retinol equivalents, NE = niacin equivalents, E% = percentage of total energy, RI = recommended intake, WND = wasted nutrient days. Wasted nutrient days (WND) indicate a number of days a nutrient met the recommended daily intake value for adults.

4. Discussion

This study assessed the environmental and social impacts of social supermarkets in Stockholm, demonstrating their potential to mitigate GHGEs, redistribute surplus food with significant nutrient savings, serve as an accessible food source for economically vulnerable populations, and highlight the critical importance of autonomy in food assistance models. By integrating environmental, social, and nutritional assessments, this study expands on prior research that primarily focused on food banks and donation-based models (Albizzati et al., 2019; Sundin et al., 2023), providing a more comprehensive evaluation of market-based surplus food redistribution.

The results highlighted the dual climate impact of social supermarkets. The substitution effect, where redistributed food offsets the need for new production, emerged as the most significant contributor to reducing GHGE, resulting in a potential net climate impact of −2.57 kg CO_2e/FU. However, this climate benefit was largely offset by a substantial rebound effect, which accounted for 90 % of the potential savings, reducing the net result to −0.27 kg CO_2e/FU. In line with established rebound methodologies (Chitnis et al., 2014; Albizzati et al., 2022), all re-spending of savings was attributed to the intervention. This reflects that surplus food savings may enable households to spend slightly more on goods and services they often cut back on, such as healthcare, clothing, or fresh foods, with food insecurity in high-income countries frequently manifesting as reliance on cheaper, less nutritious foods (Loopstra, 2018). While previous studies have reported rebound effects of up to 71 % associated with food waste reduction (Hegwood et al., 2023), this study identified an even higher rebound effect. In studies on food bag donations, rebound effects of 31 % and 52 % were reported, with sensitivity analyses showing that increased savings and their re-spending on food increased the rebound effect (Sundin et al., 2022, 2023), similar to the present study. These sensitivities may at least partially explain the higher rebound effect observed in the present study, where accrued savings were approximately 30 % greater, and 9 % more of the total savings were re-spent on food in comparison to the previous studies. The higher rebound effect here may reflect differences in surplus food composition, with larger proportions of meat, eggs, and dairy in the present study amplifying savings from costlier items. This, in turn, may suggest a trade-off. While social supermarkets provide more consumer choice, this flexibility may enable customers to reallocate monetary savings toward additional food purchases, particularly of high-emission products, thereby increasing the rebound effect and offsetting some of the environmental gains. However, interestingly, the sensitivity analysis suggests that the more effectively social supermarkets meet customer needs with redistributed food, the lower the rebound effect and the greater the potential for environmental mitigation. If social supermarkets offer a sufficient variety and quantity of food to meet customer needs, it could reduce the necessity for customers to purchase additional food from conventional supermarkets. As a result, the overall environmental benefit of social supermarkets could be higher, as less of the accrued savings would be spent on high-carbon foods. Although challenging, this underscores the importance of designing social supermarkets that provide a comprehensive range of foods, enabling customers to rely more on redistributed items and less on higher-emission supermarket purchases.

The quantified rebound effects in this study represented income-driven rebounds, where savings from discounted food were re-spent on other consumption (Albizzati et al., 2022). Beyond this household-level mechanism, redistribution systems may also generate system-level feedbacks: as social supermarkets expand, they can stabilise demand for surplus food and thus risk normalising its generation (Mourad, 2016; Papargyropoulou et al., 2022). These dynamics, sometimes termed systemic food waste or structural rebounds, highlight that interventions reducing waste locally may sustain it systemically. Recognising these broader feedbacks is also important when interpreting the overall sustainability of surplus food redistribution.

Although social supermarkets reduced emissions compared to incineration (−0.11 kg CO_2e/FU), their net climate benefit (−0.27 kg CO_2e/FU) was similar to anaerobic digestion (−0.23 kg CO_2e/FU), highlighting that redistribution is not a clearly superior mitigation strategy in Sweden's context of efficient waste management. However, unlike prevailing waste management systems, social supermarkets offered additional benefits beyond climate mitigation, particularly in terms of social value. By redistributing surplus food, social supermarkets addressed food access to vulnerable customers, improved their financial flexibility through accrued monetary savings in addition to providing significant nutrient savings of high quality. These findings underline that environmental and social benefits of food redistribution are interconnected with nutritional outcomes, as access to affordable but also nutritionally adequate foods is crucial for addressing food insecurity sustainably (Caraher and Furey, 2017; Loopstra, 2018).

The nutritional analysis revealed that the redistributed food from social supermarkets was generally well balanced, with appropriate macronutrient distribution and substantial micronutrient content. Elevated salt levels and lower amounts of vitamin D and selenium aligned with typical Swedish dietary patterns (Amcoff et al., 2012)(, indicating that social supermarkets reflect existing nutritional trends rather than exacerbating deficiencies. While concerns about redistributed food often focus on potential high levels of added sugars and poor nutritional quality (Simmet et al., 2017), the findings showed that added sugar content was low and the overall nutritional profile balanced. This challenges the notion that surplus food is inherently of poor nutritional quality. Supporting this perspective, a previous study on food bag donations inSweden found balanced macro- and micronutrient content, attributed to the high proportion of perishable foods included in redistributed food (Sundin et al., 2023). However, contrary evidence exists, such as a study on food bank parcels in Oxfordshire, the United Kingdom, which found that these parcels exceeded energy requirements, provided disproportionately high levels of sugar and carbohydrates, and lacked sufficient vitamin A and vitamin D compared to the United Kingdom guidelines (Fallaize et al., 2020). Additionally, a systematic review highlighted inconsistencies in the ability of food parcels from food banks to meet nutritional requirements, often failing to address individual cultural and health preferences. Nevertheless, the review found that food bank use improved food security and dietary quality, enabling access to food that might otherwise have been unattainable (Oldroyd et al., 2022). These differences may stem from the types of surplus food available for redistribution, which depend heavily on what is donated and, in turn, reflect broader patterns of surplus generation in retail.

Surplus food reflects systemic inefficiencies across the food supply chain, from overproduction and strict quality standards to logistical mismatches and consumer purchasing patterns. In Sweden, limited evidence suggests that retail-level surpluses include fresh produce, including bread, vegetables, fruits, dairy, and meat; items that remain nutritionally valuable when redistributed (Bartek et al., 2025; Sundin et al., 2023). The Swedish food system reflects a system where strict European Union-regulated safety and quality protocols (e.g. EC 178/2002) ensure surplus food remains safe and suitable for redistribution. Furthermore, Sweden consistently ranks highly in the Global Food Security Index, particularly strong in food availability, quality, and safety (Economist Impact, 2025). This favourable food system may help explain the comparatively balanced nutrient profile of redistributed foods found in the present study. However, more research is needed to explore how these dynamics vary across different national and redistribution contexts, but also in the rapidly changing redistribution landscape in Sweden (Berglund and Kristjansdottir, 2024). Ensuring that redistributed foods are not only sufficient in quantity but also adequate in nutritional quality is critical, particularly because food insecurity and poor diet are mutually reinforcing. Food insecurity can lead to poor diet choices due to limited access to nutritious food, while a poor diet can exacerbate health problems, thereby increasing vulnerability to food insecurity creating a vicious cycle (Loopstra, 2018; Caraher and Furey, 2017).

Findings suggested that food insecurity may persist among social supermarket members despite access to affordable and nutritious food, underscoring the complex relationship between food assistance and underlying economic conditions. In our survey, 65 % of respondents reported that food had often or always been insufficient in the past 30 days, and 23 % had never eaten a balanced meal, despite access to surplus food. This aligns with Sundin et al. (2023), who also reported persistent food insecurity among recipients of donated food bags, suggesting that surplus food redistribution provides short-term relief but does not resolve food insecurity in the long term. Annual nutrient savings in terms of energy provided enough for 103 days per member - less than one third of annual energy needs - helping to explain the persistence of food insecurity. Moreover, food insecurity is deeply intertwined with poverty; providing food alone does not address the root causes of economic hardship (Drewnowski, 2022). Research indicates that malnutrition and poverty create a vicious cycle, where poverty leads to inadequate food access, and malnutrition reduces economic potential, perpetuating poverty (Siddiqui et al., 2020). Thus, the findings support broader discussions in food justice literature: access to surplus food alone does not address structural inequalities driving food insecurity (Caraher and Furey, 2017; Evans et al., 2017). Therefore, while social supermarkets alleviate immediate food needs, comprehensive strategies addressing income inequality and social protection are essential for long-term food security (Loopstra, 2018). These findings align with the European Commission's Farm to Fork Strategy and the European Pillar of Social Rights, both of which emphasize that tackling food insecurity requires structural solutions beyond redistribution, including improved income support and social safety nets (European Commission, 2020; European Commission, 2017).

Nevertheless, the social supermarkets played an important role in supporting customers' psychological and social well-being. Customer feedback underscored the importance of autonomy and choice in food assistance models. The preference for social supermarkets over pre-packed food bags was attributed to the freedom to select preferred items, the dignity associated with purchasing food, and the ability to cater to specific dietary requirements. This aligns with findings from other studies, where recipients of food aid expressed a desire for choice and control over their food selections, which contributes to a sense of dignity and reduces food waste due to unwanted items (Andriessen and van der Velde, 2024). The expressed concern that pre-packed food bags may lead to increased food waste due to mismatched preferences or unfamiliar items further emphasizes the value of choice in food assistance programs. By allowing individuals to select foods they are more likely to consume, social supermarkets can reduce waste and environmental impacts while improving satisfaction among users (Stluka et al., 2018). However, it is worth noting that food in social supermarkets may be more expensive than pre-packed food bags, which could influence preferences and accessibility for certain customer groups. Further investigation is needed to understand whether customers still prefer social supermarkets when cost differences are explicitly considered, as this factor may introduce additional trade-offs. Exploring customer preferences in scenarios where food prices differ could provide deeper insights into how choice and cost interact in shaping the effectiveness and equity of food assistance models.

While the present study provided robust insights, it acknowledges some limitations. The environmental assessment focused exclusively on greenhouse gas emissions, reflecting both the study's aim to balance climate outcomes with social outcomes and the policy relevance of climate change in food waste prevention debates. Future research could address these gaps by expanding to a multi-impact framework, including categories such as water use, land use, and eutrophication.

Another limitation relates to the estimation of annual savings, where we applied an 11-month factor to account for occasional missed visits. While this was a conservative assumption, actual visit frequency may vary. Furthermore, our sensitivity analysis confirmed that the results are highly dependent on assumptions regarding the amount of savings accrued and their allocation, which should therefore be interpreted with caution. While the scenarios tested (e.g., minimum vs. maximum savings, 0–100 % allocation to food) may not fully reflect the complexity of real-world spending behaviour, they illustrate the potential range of outcomes and highlight the importance of this parameter for future research.

The life cycle inventory relied primarily on carbon footprint data from Röös (2014) to maintain alignment in data vintage (≈2010–2015) with the consumption-based intensities used in the rebound effect calculations (Grabs, 2015). This choice ensured internal methodological consistency between substitution and rebound estimates. For product categories not covered by Röös, more recent data from SAFAD (2024) were used to improve completeness and category specificity (e.g., venison, lamb, and deep-frozen products). Although these datasets differ in temporal coverage, the inclusion of SAFAD affects only a small share of total mass and does not alter the study's overall conclusions.

Moreover, the survey had a small sample size (17 participants), which limits the ability to draw statistically representative conclusions. Despite this, the qualitative data provided valuable, context-specific insights into members' lived experiences and behaviours, dimensions that are difficult to capture through quantitative data alone. The survey was an exploratory component of the study, designed to complement the quantitative LCA and nutritional assessment, offering qualitative insights into customer experiences. Respondents were purposefully selected to reflect a diverse range of age groups and backgrounds, providing varied perspectives on key aspects such as food security, shopping behaviour, and food waste. While these findings are not generalizable, they offer valuable contextual insights that can inform future studies with larger or more targeted samples.

Finally, as the study was conducted in Stockholm, Sweden, future research could assess the applicability of these findings in other contexts, considering differences in local policies, socio-economic conditions, and food systems. Prevailing conditions in Sweden, including stringent safety protocols, retail surplus profiles favouring perishable and nutrient-rich items, and high baseline standards for food availability, may not be generalizable to contexts with weaker food safety oversight or lower dietary diversity. Therefore, while the findings offer valuable insights, their applicability should be evaluated in light of national redistribution infrastructure, welfare policy, and surplus food characteristics. Furthermore, a deeper understanding of social supermarket customers' purchasing behaviour affecting the rebound effect could refine the evaluation of environmental outcomes. A further limitation is that rebound effects were calculated using data from Grabs (2015), as more recent sector-specific data were unavailable. This may have led to an overestimation of rebound effects due to increased food prices, and as emissions have generally decreased over the past decade in Sweden (Statistics Sweden, 2024). Nevertheless, the study had notable strengths, including the use of primary data and comprehensive data collection spanning an entire calendar year, effectively capturing seasonal variations in redistributed food.

Furthermore, the findings underscore the critical need to account for rebound effects in LCA studies to ensure comprehensive evaluations. Including behavioural aspects and rebound effects in LCA interpretations is essential for providing a more realistic assessment of environmental impacts and supporting effective policy-making (Nita et al., 2017). In the context of surplus food redistribution, incorporating rebound effects allows for a more accurate calculation of achievable GHGE savings, avoiding overestimation of climate benefits and ensuring alignment with reduction targets. However, it is equally important to recognize that rebound effects may arise from lifting individuals out of poverty, an outcome that reflects the success of such initiatives in improving lives. While this additional consumption generates emissions, addressing systemic poverty is a social imperative. By transparently accounting for rebound effects, policymakers can balance these priorities, designing complementary strategies to offset emissions elsewhere while achieving both environmental and social sustainability.

While surplus food redistribution is prioritized within the European Union's food waste prevention strategies, particularly under the Waste Framework Directive and the Farm to Fork Strategy, its alignment with broader policies addressing the systemic causes of food insecurity and food waste remains limited (European Commission, 2020). The Farm to Fork Strategy aims to reduce food loss and waste and ensure access to nutritious food, promoting sustainability across the food system. However, although European Union guidelines recommend that redistributed food should contribute to a balanced diet, this remains non-binding, and in practice, nutritional quality is not systematically ensured (European Commission, 2017). Moreover, the strategy primarily focuses on environmental and economic aspects, with less emphasis on integrating social policies that tackle the root causes of food insecurity, such as poverty and inequality. This siloed approach may inadvertently normalize surplus generation and reinforce reliance on charitable food redistribution, rather than fostering systemic changes that prevent food waste and address food insecurity at its core (Spring et al., 2024). To achieve a truly sustainable food system, it is essential to integrate food waste prevention policies with social welfare and poverty alleviation strategies, ensuring that efforts to reduce food waste also contribute to reducing food insecurity and promoting social equity.

5. Conclusions

The present study highlighted the multifaceted benefits of social supermarkets in Stockholm, Sweden, including environmental advantages through GHGE mitigation and the provision of nutritious food to those experiencing food insecurity. However, it also revealed the limitations of such initiatives in addressing the root causes of food insecurity, which are fundamentally linked to poverty. Additionally, while prioritizing customer autonomy and choice can improve the dignity and effectiveness of food assistance programs, this flexibility may contribute to environmental trade-offs through increased rebound effect, partially offsetting climate benefits. Despite these trade-offs, the environmental impact mitigation achieved through social supermarkets was still more favourable compared to alternative waste management practices. Importantly, it is the added social value, particularly autonomy, food access, and nutritional adequacy, that makes the social supermarket model stand out. Given that surplus food redistribution is often promoted as a win-win strategy, simultaneously addressing food waste and food insecurity, it is crucial to pay attention not only to environmental but also to social outcomes, including nutritional adequacy, recognising that nutrition is intrinsically linked to food insecurity. While based on a small, exploratory survey sample, the study demonstrated how combining robust quantitative data with qualitative insights can provide a richer understanding of both environmental and social outcomes. Future social supermarket models could be improved by focusing on the redistribution of nutritionally adequate surplus foods, using choice architecture to promote healthier selections without restricting autonomy, and embedding complementary social services such as financial support and nutrition education within the stores. Additionally, systematically monitoring multiple outcomes, including nutritional quality, environmental impact, and customer satisfaction, would help optimize the effectiveness and equity of surplus food redistribution initiatives. To enhance the effectiveness of social supermarkets, it is crucial to integrate them into broader social policies that tackle income inequality and provide robust social protection. Furthermore, rebound effects should be accounted for in food waste prevention strategies and climate policies to avoid overestimating the climate benefits of surplus food redistribution in national and international climate targets. By situating social supermarkets within a comprehensive strategy that addresses both immediate nutritional needs and the underlying socio-economic factors contributing to food insecurity, while ensuring realistic climate impact assessments, policymakers can develop more sustainable and equitable solutions to these pressing challenges.

CRediT authorship contribution statement

Niina Sundin: Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis, Conceptualization. **Emma Citro:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Mattias Eriksson:** Writing – review & editing, Funding acquisition.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT 4o, an AI-powered tool developed by OpenAI, to refine the text for clarity, readability, and grammatical accuracy. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2025.146950.

Data availability

Data will be made available on request.

References

Albizzati, P.F., Tonini, D., Chammard, C.B., Astrup, T.F., 2019. Valorisation of surplus food in the French retail sector: environmental and economic impacts. Waste Manag. 90, 141–151. https://doi.org/10.1016/j.wasman.2019.04.034.
Albizzati, P.F., Rocchi, P., Cai, M., Tonini, D., Astrup, T.F., 2022. Rebound effects of food waste prevention: environmental impacts. Waste Manag. 153, 138–146. https://doi.org/10.1016/j.wasman.2022.08.020.
Amcoff, E., Edberg, A., Enghardt Barbieri, H., Lindroos, A.K., Nälsén, C., Pearson, M., Warensjö Lemming, E., 2012. Riksmaten – vuxna 2010-11: Livsmedels- och näringsintag bland vuxna i Sverige. Livsmedelsverket, Uppsala. Retrieved from. https://www.livsmedelsverket.se/globalassets/publikationsdatabas/rapporter/2011/riksmaten_2010_20111.pdf.
Andriessen, T., van der Velde, L.A., 2024. How the social dignity of recipients is violated and protected across various forms of food aid in high-income countries: a scoping review. Agric. Hum. Val. 41, 363–379. https://doi.org/10.1007/s10460-023-10476-w.
Bartek, L., Eriksson, M., Sturén, F., Christensen, J., Cicatiello, C., Giordano, C., Malefors, C., Pasanen, S., Sjölund, A., Strid, I.V., Sundin, N., Brancoli, P., 2025. From surplus to sustainability: the role of legislation in reducing climate impact from Swedish bread waste. https://doi.org/10.2139/ssrn.5087054.
Baudino, M., Krafft, J., Quatraro, F., 2024. Exploring the direct rebound effects for residential electricity demand in urban environments: evidence from nice. Ann. Reg. Sci. 72, 757–795. https://doi.org/10.1007/s00168-023-01219-0.
Berglund, J., Kristjansdottir, L., 2024. The Food Bank Report #1-By Whom and How Is Surplus Food Redistributed in Sweden?.
Berri, A., Toma, L., 2023. Factors influencing consumer use of social supermarkets in the UK: a redistribution model providing low-cost surplus food. Clean. Responsible Consum 10 (100133). https://doi.org/10.1016/j.clrc.2023.100133.
Bisinella, V., Albizzati, P.F., Astrup, T.F., Damgaard, A., 2018. Life Cycle Assessment of Grocery Carrier Bags 144.
Caldeira, C., De Laurentiis, V., Sala, S., 2019. Assessment of food waste prevention actions, EUR 29901 EN. Publications Office of the European Union, Luxembourg. ISBN 978-92-76-12388-0, doi:10.2760/9773.
Caraher, M., Furey, S., 2017. Is it Appropriate to Use Surplus Food to Feed People in Hunger? Short-term Band-Aid to More Deep Rooted Problems of Poverty.
Chitnis, M., Sorrell, S., Druckman, A., Firth, S.K., Jackson, T., 2014. Who rebounds most? Estimating direct and indirect rebound effects for different UK socioeconomic groups. Ecol. Econ. 106, 12–32. https://doi.org/10.1016/j.ecolecon.2014.07.003.
Condamine, P., 2020. France's law for fighting food waste Food Waste Prevention Legislation. https://zerowasteeurope.eu/wp-content/uploads/2020/11/zwe_11_2020_factsheet_france_en.pdf.
Damiani, M., Pastorello, T., Carlesso, A., Tesser, S., Semenzin, E., 2021. Quantifying environmental implications of surplus food redistribution to reduce food waste. J. Clean. Prod. 289 (125813). https://doi.org/10.1016/j.jclepro.2021.125813.
Drewnowski, A., 2022. Food insecurity has economic root causes. Nat. Food 3, 555–556. https://doi.org/10.1038/s43016-022-00577-w.
Eriksson, M., Strid, I., Hansson, P.-A., 2015. Carbon footprint of food waste management options in the waste hierarchy – a Swedish case study. J. Clean. Prod. 93, 115–125. https://doi.org/10.1016/j.jclepro.2015.01.026.
European Commission, 2017. Commission notice — EU guidelines on food donation. Off. J. Eur. Union C 361, 1–29, 25.10.2017. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017XC1025%2801%29.
European Commission, 2020. Brief on food waste in the European Union. https://ec.europa.eu/jrc/sites/default/files/kcb-food_waste_brief_print_hq.pdf.
European Commission, 2008. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives (Text with EEA Relevance), OJ L.
Evans, D., Welch, D., Swaffield, J., 2017. Constructing and mobilizing 'the consumer': responsibility, consumption and the politics of sustainability. Environ. Plann. 49, 1396–1412. https://doi.org/10.1177/0308518X17694030.
Fallaize, R., Newlove, J., White, A., Lovegrove, J.A., 2020. Nutritional adequacy and content of food bank parcels in Oxfordshire, UK: a comparative analysis of independent and organisational provision. J. Hum. Nutr. Diet. 33, 477–486. https://doi.org/10.1111/jhn.12740.
FAO, IFAD, UNICEF, WFP, WHO, 2024. The State of Food Security and Nutrition in the World 2024 – Financing to end hunger, food insecurity and malnutrition in all its forms. Rome. https://doi.org/10.4060/cd1254en.
Giuridica, Pacini, 2024. Food donations and tax on waste: a way to encourage circular economy and to prevent pollution. Rivista Diritto Tributario - pacini Giuridica. https://www.rivistadirittotributario.it/2024/07/16/food-donations-and-tax-on-waste-a-way-to-encourage-circular-economy-and-to-prevent-pollution/.
Goossens, Y., Wegner, A., Schmidt, T., 2019. Sustainability assessment of food waste prevention measures: review of existing evaluation practices. Front. Sustain. Food Syst. 3 (90). https://doi.org/10.3389/fsufs.2019.00090.
Grabs, J., 2015. The rebound effects of switching to vegetarianism. A microeconomic analysis of Swedish consumption behavior. Ecol. Econ. 116, 270–279. https://doi.org/10.1016/j.ecolecon.2015.04.030.
Hegwood, M., Burgess, M.G., Costigliolo, E.M., Smith, P., Bajželj, B., Saunders, H., Davis, S.J., 2023. Rebound effects could offset more than half of avoided food loss and waste. Nat. Food 4, 585–595. https://doi.org/10.1038/s43016-023-00792-z.
Impact, Economist, 2025. Global Food Security Index 2022. https://impact.economist.com/sustainability/project/food-security-index.
Loopstra, R., 2018. Interventions to address household food insecurity in high-income countries. Proc. Nutr. Soc. 77, 270–281. https://doi.org/10.1017/S002966511800006X.
Moore, A., Heard, H., Murray, L., Shillitoe, R., Clifford, R., Mensah, D.D., Jenkins, M., 2025. Food and you 2: wave 9. Food standards agency. https://doi.org/10.46756/sci.fsa.tlg343.
Mourad, M., 2016. Recycling, recovering and preventing "food waste": competing solutions for food systems sustainability in the United States and France. J. Clean. Prod. 126, 461–477. https://doi.org/10.1016/j.jclepro.2016.03.084.
Mulrooney, H.M., Ranta, R., Nancheva, N., Bhakta, D., Lake, S., 2023. Social supermarkets, nutritional implications and healthy eating: exploration of members and their views. J. Hum. Nutr. Diet. 36, 2108–2120. https://doi.org/10.1111/jhn.13226.
Neter, J.E., Dijkstra, S.C., Twisk, J.W.R., Visser, M., Brouwer, I.A., 2020. Improving the dietary quality of food parcels leads to improved dietary intake in Dutch food bank recipients—effects of a randomized controlled trial. Eur. J. Nutr. 59, 3491–3501. https://doi.org/10.1007/s00394-020-02182-8.
Nita, V., Castellani, V., Sala, S., Commission, European (Eds.), 2017. Consumer's Behaviour in Assessing Environmental Impact of Consumption: State of the Art and Challenges for Modelling Consumer's Behaviour in Life Cycle Based Indicators. Publications Office, Luxembourg. https://doi.org/10.2760/931669.
Nordic Council of Ministers, 2023. Nordic Nutrition Recommendations 2023. https://doi.org/10.6027/nord2023-003.
NTMCalc 4.0, 2022. https://www.transportmeasures.org/ntmcalc/v4/advanced/index.html?sig=undefined#/Si.
Nutrition Data, 2022. Om oss. Nutrition Data. https://nutritiondata.se/om-oss/.
Oldroyd, L., Eskandari, F., Pratt, C., Lake, A., 2022. The nutritional quality of food parcels provided by foodbanks and the effectiveness of foodbanks at reducing food

insecurity in developed countries: a mixed-method systematic review. J. Hum. Nutr. Diet. 35, 1202–1229. https://doi.org/10.1111/jhn.12994.

Osterley, R., Williams, I.D., 2019. THE SOCIAL, ENVIRONMENTAL AND ECONOMIC BENEFITS OF REUSE BY CHARITY SHOPS. Detritus. https://doi.org/10.31025/2611-4135/2019.13849.

Papargyropoulou, E., Fearnyough, K., Spring, C., Antal, L., 2022. The future of surplus food redistribution in the UK: reimagining a 'win-win' scenario. Food Policy 108 (102230). https://doi.org/10.1016/j.foodpol.2022.102230.

Persson, O., Hinton, J.B., 2023. Second-hand clothing markets and a just circular economy? Exploring the role of business forms and profit. J. Clean. Prod. 390 (136139). https://doi.org/10.1016/j.jclepro.2023.136139.

Ranta, R., Nancheva, N., Mulrooney, H., Bhakta, D., Lake, S., 2024. Access, dignity, and choice: social supermarkets and the end of the food bank model in the UK? Food. Culture & Society 27, 1216–1233. https://doi.org/10.1080/15528014.2024.2321409.

Rise, 2022. Öppna Listan – Ett Utdrag Från RISE Klimatdatabas För Livsmedel V. 2.1, 2022.

Röös, E., 2014. Mat-klimat-listan. URL https://pub.epsilon.slu.se/11671/7/roos_e_141125.pdf, Version 1.1.

Saxena, L., Tornaghi, C., 2018. The Emergence of Social Supermarkets in Britain: food poverty, food waste and Austerity Retail. (Research report). Centre for agroecology. Water and Resilience. Coventry University, Coventry.

Schneider, F., 2013. The evolution of food donation with respect to waste prevention. Waste Management, Special Thematic Issue: Urban Mining 33, 755–763. https://doi.org/10.1016/j.wasman.2012.10.025.

Siddiqui, F., Salam, R.A., Lassi, Z.S., Das, J.K., 2020. The intertwined relationship between malnutrition and poverty. Front. Public health 8. https://doi.org/10.3389/fpubh.2020.00453.

Sieti, N., Rivera, X.C.S., Stamford, L., Azapagic, A., 2019. Environmental impacts of baby food: Ready-made porridge products. J. Clean. Prod. 212, 1554–1567. https://doi.org/10.1016/j.jclepro.2018.12.009.

Simmet, A., Depa, J., Tinnemann, P., Stroebele-Benschop, N., 2017. The nutritional quality of food provided from food pantries: a systematic review of existing literature. J. Acad. Nutr. Diet. 117, 577–588. https://doi.org/10.1016/j.jand.2016.08.015.

SLU, 2024. SAFAD sustainability assessment of foods and diets. https://safad.se/.

Spring, C., Souza, R. de, Garthwaite, K., 2024. Surplus food and the rise of charitable food provision. In: Oxford Research Encyclopedia of Food Studies. https://doi.org/10.1093/acrefore/9780197762530.013.97.

Stluka, S., Moore, L., Eicher-Miller, H.A., Franzen-Castle, L., Henne, B., Mehrle, D., Remley, D., McCormack, L., 2018. Voices for food: methodologies for implementing a multi-state community-based intervention in rural, high poverty communities. BMC Public Health 18 (1055). https://doi.org/10.1186/s12889-018-5957-9.

Sundin, N., Persson Osowski, C., Strid, I., Eriksson, M., 2022. Surplus food donation: effectiveness, carbon footprint, and rebound effect. Resources. Conserv. Recycl. 181 (106271). https://doi.org/10.1016/j.resconrec.2022.106271.

Sundin, N., Bartek, L., Persson Osowski, C., Strid, I., Eriksson, M., 2023. Sustainability assessment of surplus food donation: a transfer system generating environmental, economic, and social values. Sustain. Prod. Consum. 38, 41–54. https://doi.org/10.1016/j.spc.2023.03.022.

Sweden, Statistics, 2024. Greenhouse gas emissions from the Swedish economy decrease in 2023. Statistikmyndigheten SCB. https://www.scb.se/en/finding-statistics/statistics-by-subject-area/environment/environmental-accounts-and-sustainable-development/system-of-environmental-and-economic-accounts/pong/statistical-news/emissions-to-air-fourth-quarter-2023/.

Swedish Energy Agency, 2020. http://www.energimyndigheten.se/fornybart/hallbarhetskriterier/drivmedelslagen/vaxthusgasutslapp/.

UNEP, 2021. Food Waste Index Report 2021. Nairobi. http://www.unep.org/resources/report/unep-food-waste-index-report-2021.

USDA, 2012. U.S. Household Food Security Survey Module: Six-Item Short Form Economic Research Service, USDA [WWW Document]. URL. https://www.ers.usda.gov/media/8282/short2012.pdf.

Volvo Truck Corporation, 2018. Emissions from Volvo's trucks. https://www.volvotrucks.com/content/dam/volvotrucks/markets/global/ourvalues/environmental-care/our-trucks/Emis_eng_10110_14001.pdf.

WWF-UK, 2021. Driven to Waste Global Food Loss on Farms.