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Climate benefits from saving food with Matsmart-Motatos

Commissioned by Matsmart in Scandinavia AB

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This report has been reviewed and approved in accordance with IVL's audited and approved management system.

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Summary

Food waste is a significant contributor to environmental degradation. The production and disposal of wasted food have significant environmental impacts, including releasing greenhouse gases and depleting natural resources such as water and land (Jaglo et al., 2021). Furthermore, food waste exacerbates hunger and poverty, as the resources used to produce the wasted food could have been used to feed people in need. Reducing food waste is critical in promoting environmental sustainability and addressing food insecurity. Strategies such as improving supply chain management, educating consumers on food storage and preparation, and diverting food waste to composting and recycling programs can help mitigate food waste's negative environmental and social impacts. On behalf of the Government, the Swedish Environmental Protection Agency (2020) proposes a milestone of 20% weight loss of food waste per capita by 2025. Likewise, the proportion of recyclable food packaging will increase by 25% by 2030 (Swedish Environmental Protection Agency, 2020).

Addressing food waste requires a multifaceted approach that includes new business models, consumer behaviour change, and pricing strategies. Many innovative business models are emerging to tackle the issue of food waste, such as grocery stores that sell surplus and imperfect produce at a discount and meal kit services that use only the exact amount of ingredients needed for a recipe. Low pricing strategies (such as bulk purchasing or offering discounts for items nearing their expiration date) can also encourage consumers to purchase products that might otherwise go to waste. However, consumer behaviour change is also critical, as individuals can reduce food waste by planning meals, storing food properly, and composting organic waste. Educating consumers on food waste's environmental and social impacts can also increase their motivation to reduce waste. Ultimately, a combination of these approaches is needed to reduce food waste's environmental and social impacts while ensuring access to affordable and nutritious food.

Matsmart in Scandinavia AB (hereafter Matsmart-Motatos) contacted IVL Swedish Environmental Research Institute with a request to make climate calculations for their range of products. Matsmart-Motatos sells products that would otherwise have been discarded. Groceries are bought in large quantities and sold online at a much lower price (up to 80 % discount). They are stored and sent with, e.g., Postnord, Budbee, Airmee or Best at the Swedish market and related services at the other markets. Matsmart-Motatos does not currently have any fresh products or in-house production. The project aims to communicate to Matsmart-Motatos customers how much climate impact (CO_2 eq) is "saved" by buying food from their service. The expected results are a better understanding of the environmental benefits of a service that redistributes food waste.

In the project, life-cycle data has been gathered and assembled to perform a simplified life-cycle assessment (climate impact) of about 20 products. A template of the climate footprint for the average shopping carts representing Matsmart-Motatos's five largest markets, Sweden, Denmark, Finland, Germany, and United Kingdome has been calculated. These standard values are rough estimates showing the order of magnitude and can be far from the product footprint calculated in Environmental Product Declarations (EPD). Therefore, these templates should only be used in their context, i.e., calculate the potential for recycling and not be published/communicated externally as a climate impact per product. The results show that the climate benefits, which are the climate impact minus possible energy recovery, were most prominent for the Swedish food cart, estimated to be 13,3 CO_2 eq/cart. The second largest savings were made in Finland at 10,7 CO_2 eq/cart, followed by Germany at 9,1 CO_2 eq/cart, the United Kingdom at 8,3 CO_2 eq/cart and Denmark at 6,1 CO_2 eq/cart. It is worth noting that a high climate impact is often associated with a high weight

of the product. Additionally, products that require resource-intensive production can also significantly contribute to climate impacts when combined with their weight.

1 Background on food waste

Reducing food waste is an essential step towards achieving resource efficiency and reducing environmental burden (Gentil et al., 2011, Oldfield et al., 2016). Every year, billions of tons of food are wasted, leading to the unnecessary depletion of natural resources, including water, land, and energy (World Bank, 2020, Schanes et al., 2018, Messner et al., 2020). By reducing food waste, we can conserve these valuable resources and minimise the environmental impact associated with food production and disposal. Furthermore, food waste in landfills contributes significantly to greenhouse gas emissions, which are a major contributor to climate change (Zhao et al., 2022, Chen et al., 2023). According to UNEP (2022), solid waste is the source of approximately 5 % of anthropogenic greenhouse gas emissions. By preventing food waste, we can reduce the amount of organic waste sent to landfills, reducing greenhouse gas emissions and mitigating climate change. Therefore, reducing food waste is not only an important strategy to conserve resources but also an effective way to reduce the environmental burden of food production and waste management.

Reducing food waste also has a significant impact on addressing issues of hunger and poverty. It is estimated that one-third of all food produced in the world is wasted, while millions of people suffer from hunger and malnutrition (Tóth and Zachár, 2021). By reducing food waste, we can potentially redirect surplus food to those who are food insecure, thereby promoting a more equitable distribution of resources. This can help to reduce hunger and malnutrition, particularly in low-income countries, where access to food is a major challenge. Food waste reduction initiatives can also create new job opportunities and support local economies, particularly in rural areas (Imbert, 2017). Therefore, reducing food waste is a crucial step towards promoting food security, reducing poverty, and achieving more equitable access to resources.

The latest initiatives and business models aim to tackle the issue of food waste by promoting its reuse or transformation into new products. Many businesses are exploring ways to monetise food waste by converting it into new food products, animal feed, or biofuels (Kizito et al., 2022, Rago et al., 2018). By doing so, they are reducing the amount of food waste that ends up in landfills and creating new revenue streams. Additionally, there is a growing trend towards circular business models in the food industry, where companies design products and services with the intention of reducing waste at every stage of the supply chain (Usmani et al., 2021). This can involve strategies such as reducing portion sizes, donating surplus food to charities, or composting food waste. These initiatives are essential in creating a more sustainable food system and reducing the environmental impact of food waste.

While selling food that would otherwise go to waste at a lower price may seem like a good solution to reduce food waste, it also has some shortcomings. Firstly, it can create an expectation among consumers that they will always be able to purchase food at a lower price, which can make it difficult for retailers and producers to sell products at their true value. This can lead to a reduction in the quality and variety of food products. But it could also cause so-called rebound effects where emissions stay the same due to overconsumption of cheaper products and unnecessary purchases (Sorrell and Dimitropoulos, 2008). Moreover, this strategy does not address the root causes of food waste, such as overproduction or inefficient supply chains. Additionally, selling food waste at a lower price may not be financially feasible for all businesses, particularly small-scale producers or retailers.

Consumer behaviour is also an important factor to consider. While many consumers are motivated to purchase food that is sold at a lower price, others may avoid buying products that are perceived as less fresh or of lower quality (Rohm et al., 2017, Young et al., 2018, Lazell, 2016). This can create a stigma around food waste products and make it difficult for businesses to sell them. Therefore, while selling food waste at a lower price can be a useful strategy to reduce food waste, it is important to also address the underlying causes of food waste and to consider the potential impacts on the overall food system and consumer behaviour.

2 Calculation model

According to the model by Wranne (2020), the environmental benefits of recycling can be calculated by comparing the impact of recycling versus purchasing new products. The impact of recycling is calculated as the difference between a product being either recycled or purchased new. If a product is reused, the production of a new product is avoided, and transport and waste management associated with the production of new products are reduced. However, reconditioning and delivery transport for reuse are added to the impact.

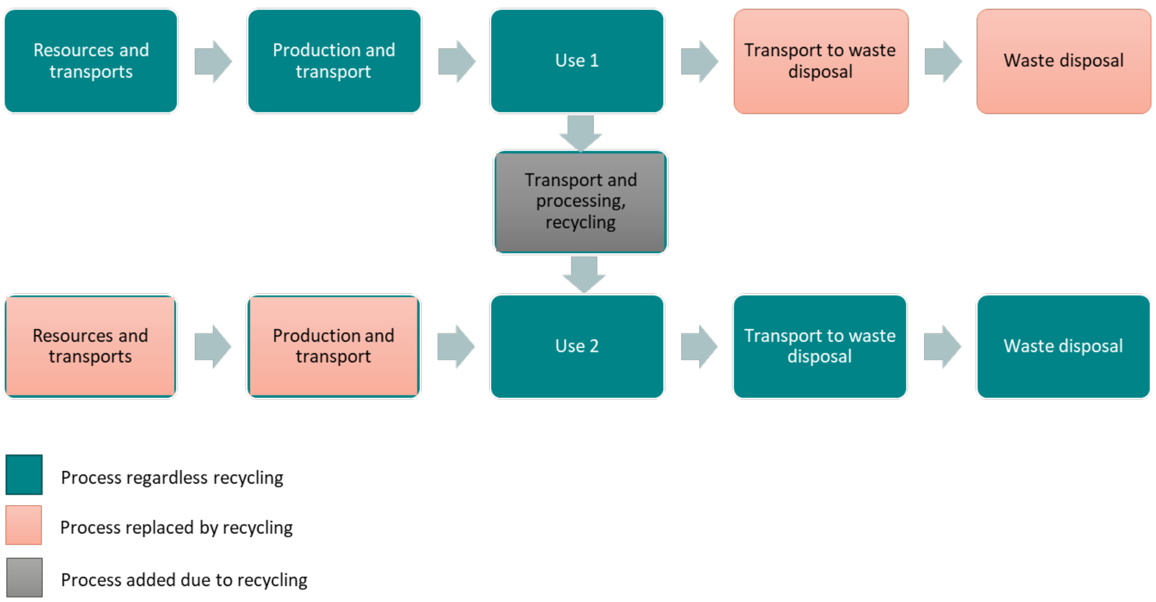

Figure 1: illustrates the calculation model for environmental benefits from recycling and is a translation of the original illustration and method description proposed by (Wranne, 2020).

Food waste is a major issue, and Matsmart-Motatos's service addresses this problem by selling waste from supermarkets and wholesale. The climate impact from food waste is calculated as the impact from all upstream processes, from manufacturing to sales and consumption. If the food waste had not been reused or resold as food, it would have been sent for digestion or incineration. Matsmart-Motatos mainly sells food that is suitable for energy recovery through composting or digestion. The environmental benefit of Matsmart-Motatos's service is thus calculated as the net climate impact, which is the difference between the climate impact from food production and the potential energy recovery during digestion.

The net climate impact is calculated using the formula: Production_Impact - Energy_Recovery = Net_Climate_Impact, where Production_Impact is the climate impact from the production stage, such as primary production, retail, packaging, and transportation, and Energy_Recovery represents the energy potentially recovered through digestion or incineration. The difference between climate impacts from production and the potential energy recovery is calculated as Net_Impact, which represents the final net climate impact of a product.

Reports such as "Climate impact from different waste fractions" (Miliute-Plepiene et al., 2019), provide estimates of the environmental benefits of waste treatment. The report estimates the climate impact of food waste for digestion at -0.1 CO_2 eq per kg of waste. Since products sold by Matsmart-Motatos are already manufactured, the alternative to their service would be to buy a new product, resulting in the production of two units. Therefore, the net climate impact of each product sold via Matsmart-Motatos's service is saved.

Life Cycle Assessment (LCA) is often used to analyse the entire life cycle of a product, from production to disposal, to assess the environmental impact of a product or service. However, conducting a full LCA can be time-consuming and costly. In this case, it was found sufficient to gather data on a representative basket of products and mirror the results to estimate the overall climate impact. This approach provides an indication of the environmental impact while avoiding the need for a full LCA. The results may not be as accurate as a full LCA, but they can still be useful in identifying areas of high environmental impact and making informed decisions about reducing that impact and providing valuable information for decision-making.

2.1 Alternative Sustainability Assessment Methods for Food Waste

Calculating greenhouse gas emissions from reused products can be a complex process that requires consideration of various factors. One common approach is to use a life cycle assessment (LCA), which considers the environmental impact of a product throughout its entire life cycle, from production to disposal. Applying LCA to sustainability assessments of alternative uses for food waste can be a complex process, especially when dealing with data from agriculture and primary production (Bartocci et al., 2020, Wang et al., 2021). Gathering large amounts of data from the different stages of the food waste management process is necessary for accurate analysis. For example, when considering alternative uses for agricultural waste, data on the crops' production, transportation, and processing needs to be collected. This includes factors such as the use of fertilisers, pesticides, and energy consumption during production.

Additionally, the environmental impacts of different waste management practices can be challenging to measure and compare, especially when considering the full life cycle of a product (Bernstad and la Cour Jansen, 2012). Despite these challenges, LCA is a valuable method that can provide insight into the environmental impacts of food waste management alternatives and guide decision-making towards more sustainable and circular food systems. By applying LCA, we can better understand the environmental trade-offs associated with food waste management practices and develop more effective solutions that promote sustainability.

Another approach is to use carbon accounting methodologies, which involve calculating the carbon footprint of a product based on the emissions associated with its production, transportation, and disposal. When conducting carbon accounting for food waste, it is important to consider the product's entire life cycle, from production to disposal (Brown, 2020). This includes factors such as the emissions associated with fertiliser and pesticide use during production, transportation of the product, and the emissions associated with different waste management practices. Using carbon accounting methodologies, we can better understand the environmental impact of different waste management practices, identify strategies to reduce emissions, and promote circularity and sustainability. A third approach is to use carbon offsets, where emissions from reused products are offset by reducing emissions elsewhere. This approach involves purchasing carbon credits that fund emissions reduction projects, such as renewable energy or reforestation, to compensate for the emissions associated with the reused products (Carlos Felipe et al., 2022). Carbon offsets provide a mechanism for balancing carbon emissions by supporting projects that reduce or remove greenhouse gases from the atmosphere (UNDP, 2022). In the context of food waste, carbon offsets can be used to compensate for the emissions associated with waste management practices that cannot be eliminated entirely. For example, suppose incineration is the only option available for certain types of waste. In that case, carbon offsets can be used to invest in projects that reduce greenhouse gas emissions elsewhere, such as renewable energy projects or reforestation efforts. While carbon offsets can be a useful tool in promoting sustainability, it is important to consider their limitations and potential risks. For example, some carbon offset projects may not deliver the promised emissions reductions or have unintended social and environmental impacts (Dumrose and Höck, 2023). Therefore, it is essential to carefully assess the credibility and effectiveness of carbon offset projects before using them to offset emissions from food waste management practices.

In addition to LCA, carbon accounting methodologies, and carbon offsets, waste hierarchy and emission intensity models can also be used to calculate greenhouse gas emissions from reused products. The waste hierarchy model prioritises waste management strategies based on their environmental impact, with waste prevention and reduction being the most preferred options, followed by reuse, recycling, and energy recovery (Kowalski et al., 2021, Teigiserova et al., 2020). By using this model, food waste management practices can be evaluated based on their potential to reduce greenhouse gas emissions, promoting sustainability and circularity. On the other hand, emission intensity models estimate the greenhouse gas emissions associated with a specific activity or product based on data such as energy consumption and emission factors (Avetisyan et al., 2014, Mrówczyńska-Kamińska et al., 2021). This model can be useful in estimating the emissions associated with food waste management practices and identifying opportunities to reduce emissions. By considering all these different approaches and models, we can better understand the environmental impact of food waste management practices and develop more effective strategies to promote sustainability and reduce greenhouse gas emissions. Overall, the most effective approach to calculating greenhouse gas emissions from food waste may depend on the specific product and context. It is important to consider factors such as the product's life cycle, the emissions associated with the redistribution process, and the potential for carbon offsets to reduce emissions.

2.2 Excluded in report

2.2.1 Emissions from transports

In the food system, transportation is one of the many processes that contribute to greenhouse gas emissions. To fully understand the environmental impact of transportation, it is necessary to consider its emissions in the context of the entire food system from a life cycle perspective. Life cycle assessment (LCA) can be used to estimate the emissions associated with each stage of the food system, including production, processing, packaging, transportation, and disposal. Transportation emissions have been shown to have little impact on the entire life cycle of food. According to various studies, transportation accounts for only a small portion of food's overall carbon footprint somewhere between 1-6 % (Virtanen et al., 2011, Notarnicola et al., 2017). However, Pradhan (2022) and Li et al. (2022) advocate the opposite, that Food Miles and emissions from transport are of significance and account for approximately 20 % of the greenhouse gas emissions related to the food system. Hence, transport should not be dismissed when aiming to achieve food security as well as reducing emissions from the food system. No aspect should be neglected as climate targets must be met. While reducing transportation emissions is important for mitigating climate change, it is clear that addressing other parts of the food system, such as food waste and production practices, is crucial for achieving significant reductions in greenhouse gas emissions.

Transport is one of many processes in the food supply that contributes to climate impacts. Reducing transportation emissions is important for mitigating climate change. However, addressing other parts of the food system, such as food waste and production practices, is crucial for significantly reducing greenhouse gas emissions. Hence, transportation emissions were excluded from this study. Nevertheless, should emissions from transport not be dismissed, but rather all aspects of the food system should be considered to meet climate targets.

2.2.2 Rebound effects

Rebound effects are unintended consequences that may arise when implementing strategies or policies aimed at reducing negative impacts (Sorrell and Dimitropoulos, 2008). In the context of low prices and food waste, rebound effects can occur when consumers are incentivised to buy more food due to lower prices, increasing food waste.

When food prices are low, consumers may be more likely to buy more food than they need or can consume, as it appears to be a good deal. This behaviour can result in food waste when consumers end up throwing away unused or spoiled food. According to research, low prices may encourage overconsumption, leading to higher food waste in households and food retailing (Rosenlund et al., 2020). Moreover, when prices are lower, consumers may be less concerned about wasting food since they perceive it to be less valuable. This behaviour could lead to consumers being less careful when storing or preparing food, resulting in higher amounts of food waste.

Rebound effects can also occur in the food industry when food manufacturers and retailers offer price discounts on their products, similar to studies on energy see, e.g. Andersen et al. (2020). Consumers may purchase more food than they need, leading to an increase in food waste. Food retailers and manufacturers may also increase the amount of food they produce and stock, leading to more waste when unsold products expire.

While low prices on certain food products may result in some rebound effects that lead to increased food waste, it is also true that reducing food prices can potentially help reduce food waste in certain contexts. For example, suppose food products that are nearing their expiration dates are sold at discounted prices. In that case, it could incentivise consumers to purchase and consume those products before they expire, thereby reducing food waste. In addition, low prices on certain food products can also help make those products more accessible to low-income households who may otherwise struggle.

Therefore, it is crucial to consider the potential rebound effects when implementing strategies aimed at reducing food waste. Pricing strategies to reduce food waste should be carefully designed to avoid incentivising overconsumption or waste, and consumers should be educated about the importance of reducing food waste regardless of the price. In summary, rebound effects should be considered when designing policies and strategies related to food pricing and food waste reduction to ensure that the intended outcomes are achieved without negative consequences.

It is essential to note that rebound effects are not always straightforward to predict, as their occurrence can vary depending on the specific circumstances and the implementation of policies or strategies. In the case of food waste reduction, it is crucial to consider the potential rebound effects that may arise when designing pricing strategies, as low prices can both help reduce food waste and incentivise overconsumption and waste. Furthermore, the effects of pricing strategies may differ depending on the target population and the food products being sold. For instance, a pricing strategy aimed at reducing waste in high-income households may have different outcomes than one targeted towards low-income households. Therefore, it is essential to carefully analyse and evaluate potential rebound effects when designing policies and strategies related to food pricing and waste reduction. This was found outside the scope of this study but is recommended area for future research.

2.2.3 Packaging

While reducing packaging waste and minimising plastic use is important, it's crucial to keep in mind that adequate packaging plays a critical role in preserving food quality and extending shelf life. Certain types of food require specific types of packaging, such as vacuum-sealed bags for meat or airtight containers for fresh produce, to maintain their freshness and nutritional value (Lindh et al., 2016, Verghese et al., 2015, Minami et al., 2010). Inadequate packaging can lead to food spoilage, resulting in significant food waste. For example, produce that is not packaged or stored properly can quickly spoil, leading to reduced shelf life and increased waste. Similarly, products that are not packaged securely are at risk of being damaged during transport, leading to further waste.

Therefore, it's important to strike a balance between reducing packaging waste and ensuring that food is adequately packaged to maintain its quality and shelf life (Wikström and Williams, 2010). This requires careful consideration of the specific needs of different types of food products and the development of packaging solutions that are both effective and sustainable. By developing effective, sustainable packaging solutions that preserve food quality and extend shelf life, we can reduce waste while ensuring that consumers have access to high-quality, fresh food products.

It is important to note that while packaging plays a critical role in preserving food quality and extending shelf life, it was excluded from the study due to limitations in the scope and availability of data (Williams et al., 2012). The study focused primarily on the impacts of food waste and did not include a comprehensive analysis of the environmental impacts of packaging. However, it is important to consider the environmental impacts of packaging, including the resources required for its production, transportation, and disposal. Sustainable packaging solutions, such as compostable or reusable packaging, can help reduce the environmental impact of packaging waste. Further research is needed to understand the impacts of packaging waste better and to develop sustainable solutions that balance the need for adequate packaging with the need to reduce waste.

2.2.4 Energy recovery

It is important to acknowledge that the calculations of food waste and the potential climate benefits of selling food waste have limitations. This study assumes that all products are digestible and have an energy recovery from digestion. However, in reality, not all food waste is suitable for digestion, some might still be packaged or non-food. Other waste treatment methods, such as incineration, could be used instead. Therefore, in further studies, it could be useful to consider the specific waste treatment methods available and the actual digestibility of the waste when evaluating the climate benefits of selling food waste.

3 Results

Gathering available LCA (Life Cycle Assessment) data is a simplified way to learn about the environmental impacts of products and services. In this study, data for the calculations were taken from existing EPD (Environmental Product Declarations) calculations, RISE available list for food, scientific literature, and the database Ecoinvent 3.5. To ensure representative results, the shopping carts used in the study consisted of a basket of representative products from each market based on average purchases. The study primarily focused on composite products, and data were chosen for equivalent products or the main ingredients. The result of the study provides an indication of the environmental benefits of Matsmart-Motatos's service in reducing food waste.

Figure 1 illustrates the net benefits of using Matsmart-Motatos's services in terms of reducing CO_2 emissions. The net benefits are the result of subtracting the potential energy recovery from digestion from the climate impact of production. The Swedish shopping cart had the highest climate impact (13.3 CO_2 eq/chart) and therefore resulted in the greatest benefit in terms of saved emissions. The second-greatest savings were found in Finland, followed by Germany, the United Kingdom, and Denmark, respectively. It is worth noting that a high climate impact is often associated with a high weight of the product. Additionally, products that require resource-intensive production can also significantly contribute to climate impacts when combined with their weight.

Figure 2: The climate benefits of Matsmart-Motatos's service are depicted by the calculation of net CO_2 emissions, which takes into account the amount of energy recovered from digestion.

In Figure 3, the climate impact is measured without considering the potential energy recovery from digestion. As a result, the values shown in this figure are higher than those in Figure 2. In this case, Sweden still has the largest climate impact with 14.8 CO_2 eq/cart, followed by Finland, Germany, the United Kingdom, and Denmark. These findings suggest that these countries have a greater potential for reducing carbon emissions by further developing of the assortment of products in Matsmart-Motatos's selection.

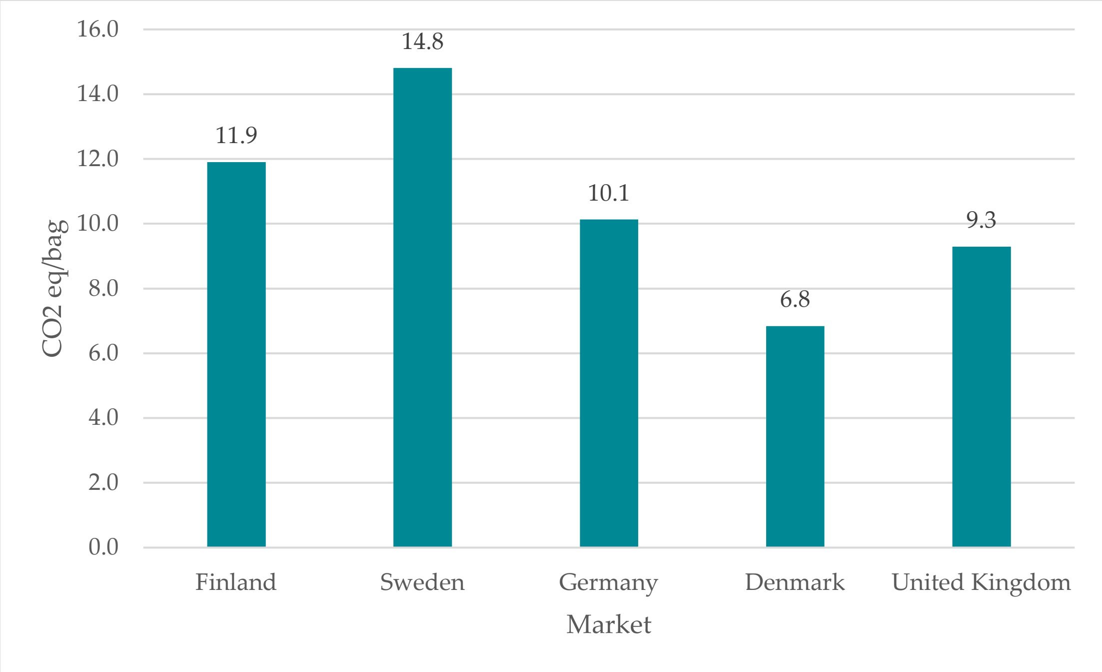

Figure 3. Depicts climate impact per grocery bag and market, total CO_2 emissions.

Figure 4 displays the climate impact per kilogram of products in each market. The results differ from those in Figures 2 and 3. In this case, Finland has the largest climate impact per kilogram of products, with 1.2 CO_2 eq/kg. Sweden follows closely with 1.1 CO_2 eq/kg, while the United Kingdom has a climate impact of 1.0 CO_2 eq/kg. Germany and Denmark have the lowest climate impacts per kilogram of products, with 0.9 CO_2 eq/kg and 0.8 CO_2 eq/kg, respectively. These findings suggest that there are significant differences in the environmental impact of products across markets and that more sustainable practices should be adopted to reduce carbon emissions in each market, focusing on the products available to consumers and Matsmart-Motatos's offer.

Figure 4. shows the climate impacts of CO_2 eq/kg in the representative grocery bags from each market

3.1 Shopping cart Sweden

The Swedish shopping cart consists of crackers, biscuits, candy, crisps, spices, ketchup, crushed tomatoes, spaghetti, lemonade, soft drinks, chocolate pudding, shower gel and bin bags. The total weight is 13.5 kg, and the climate impact is calculated at 14.8 kg CO_2 eq, see Table 1. The gain from Matsmart-Motatos's service will be 13.3 kg CO_2 eq, representing the difference between total emissions and energy recovery. The products that account for the greatest climate impact in the Swedish shopping cart are pasta, soft drinks and cookies. The soft drink and the pasta contribute significantly, and the cookies have a more resource-intensive production process. Looking at the climate impact per kg of product, the cookies have a significantly larger impact per kg than the other products, followed by bin bags and pasta.

Table 1 shows calculations of climate gain from the Swedish cart at Matsmart-Motatos

Sweden	
13.5	**Sum weight [kg]**
14.8	**Sum climate impact [kg CO_2-eq]**
1.5	**Climate benefits from digestion [kg CO_2-eq]**
13.3	**The net benefit of Matsmart-Motatos's services [kg CO_2-eq]**

3.2 Shopping cart Denmark

The Danish shopping cart consists of nuts, crackers, ketchup, bars, candy, crushed tomatoes, juice, soft drinks, pancakes and toys. The total weight is 8.7 kg, and the climate impact is estimated at 6.8

kg CO_2eq, see Table 2. The gain from Matsmart-Motatos's service will be 6.1 kg CO_2-eq, representing the difference between total emissions and energy recovery. In the Danish shopping cart, crushed tomatoes had the greatest environmental impact, followed by nut mix and biscuits. Seen per kg, the nuts had a significantly higher impact than the rest of the products, followed by crushed tomatoes and a chocolate almond cookie. The nuts had a higher environmental burden per kg, but the crushed tomatoes were bought at a larger weight, contributing to the largest impact.

Table 2 shows calculations of climate gain from the Danish cart at Matsmart-Motatos

Denmark	
8.7	**Sum weight [kg]**
6.8	**Sum climate impact [kg CO_2-eq]**
0.7	**Climate benefits from digestion [kg CO_2-eq]**
6.1	**The net benefit of Matsmart-Motatos's services [kg CO_2-eq]**

3.3 Shopping cart Finland

The Finnish shopping cart consists of cookies, bars, candy, tortilla crisps, pizza dough, curry sauce, corn, spaghetti, juice, cotton pads, shower gel and bin bags. The total weight is 9.6 kg, and the climate impact is calculated at 9.8 kg CO_2-eq, see Table 3. The gain from Matsmart-Motatos's service will be 8.8 kg CO_2-eq, representing the difference between total emissions and energy recovery. Sweet corn in the Finnish shopping cart contributed the largest climate impact, followed by spaghetti and juice. The largest climate impact per kg came from the cotton pads, sweet corn, and shower gel. The top three climate-impact products (sweet corn, spaghetti and juice) were also bought at the largest weight in this shopping cart.

Table 3 shows calculations of climate gain from the Finish cart at Matsmart-Motatos

Finland	
10.2	**Sum weight [kg]**
11.9	**Sum climate impact [kg CO_2-eq]**
1.2	**Climate benefits from digestion [kg CO_2-eq]**
10.7	**The net benefit of Matsmart-Motatos's services [kg CO_2-eq]**

3.4 Shopping cart Germany

The German shopping cart consists of crackers, crisps, candy, cookies, soft drinks, coffee, chicken stock, tomato sauce and noodles. The total weight is 11.6 kg, and the climate impact is estimated at 10.1 kg CO_2-eq, see Table 4. The gain from Matsmart-Motatos's service will be 9.1 kg CO_2-eq, representing the difference between total emissions and energy recovery. The soft drink is responsible for the greatest climate impact in the German shopping cart, followed by rice and tomato sauce. The soft drink had the single largest weight with 6 kg, more than six times the second largest. All other products were bought in quantities weighing less than 1 kg. The biggest climate impact per kg of the product was found in the rice, followed by different types of cookies.

Table 4 shows calculations of climate gain from the German cart at Matsmart-Motatos

Germany	
11.6	**Sum weight [kg]**
10.1	**Sum climate impact [kg CO_2-eq]**
1.0	**Climate benefits from digestion [kg CO_2-eq]**
9.1	**The net benefit of Matsmart-Motatos's services [kg CO_2-eq]**

3.5 Shopping cart The United Kingdom (UK)

The UK shopping cart consists of crackers, cookies, crisps, teriyaki sauce, ketchup, red pepper, rice, soft drinks, shower gel, bin liners and body scrub. The total weight is 9.2 kg, and the climate impact is estimated at 9.3 kg CO_2-eq, see Table 5. The gain from Matsmart-Motatos's service will be 8.3 kg CO_2-eq, representing the difference between total emissions and energy recovery. The most significant climate impact came from rice, followed by roasted red peppers in oil and ketchup. The biggest climate impact per kg of the product was in bin bags, rice and milk cholate cookies. In this cart, rice was not the heaviest product, but in the middle, the climate impact per kg made it contribute most to climate impacts. Bin bags were bought at a low weight of 0,3 kg and thereby had a small contribution to the overall emissions.

Table 5 shows calculations of climate gain from the German cart at Matsmart-Motatos

UK	
9.2	**Sum weight [kg]**
9.3	**Sum climate impact [kg CO_2-eq]**
0.9	**Climate benefits from digestion [kg CO_2-eq]**
8.3	**The net benefit of Matsmart-Motatos's services [kg CO_2-eq]**

4 Discussion

The results from the 2022 calculations show some differences from the previous calculations made in 2021. The main difference between the years is the composition of the representative baskest from each market that now contain other products than it did the previous year. The order of magnitude is similar, however, ranking of the countries has changed between 2021 and 2022, with Sweden still having the largest climate impact but with a slightly lower value of 13.3 CO_2 eq/cart in 2022 compared to 13.7 CO_2 eq/cart in 2021. Denmark's climate impact has decreased from 10.3 CO_2 eq/cart in 2021 to 6.2 CO_2 eq/kg in 2022. In contrast, Finland's climate impact has increased from 9.8 CO_2 eq/cart in 2021 to 10.7 CO_2 eq/kg in 2022. Germany's climate impact has also increased from 7.9 CO_2 eq/cart in 2021 to 9.1 CO_2 eq/kg in 2022. It's worth noting that the United Kingdom is a new market for Matsmart-Motatos, and there was no data available for 2021. The rankings suggest that changes in consumption patterns and production processes can significantly impact a country's carbon emissions, highlighting the need for continued monitoring and analysis.

Matsmart-Motatos is a company that sells food products that are no longer possible to sell at the regular market. Food waste could occur due to a surplus, wrong packaging, mislabelled barcodes, products bound to a season or festivity, short date or poor inventory management. The products are still safe for consumption and have, for some reason, been discarded. Despite the relatively low risk to food and health safety, there are still some possible concerns with Matsmart-Motatos approach. For example, their low prices do not provide sufficient economic incentives to encourage supermarkets and wholesalers to reduce waste at the source. Additionally, a stigma is attached to buying "expired" or "damaged" food, which may prevent some people from purchasing these products.

According to the waste hierarchy, preventive measurements have the highest priority based on their large environmental benefits (Tonini et al., 2018, Gentil et al., 2011, Oldfield et al., 2016). Hence, the largest effort and resources to reduce climate impacts from the food system should be directed towards preventive measures. Nevertheless, alternative and more comprehensive solutions to food waste could include donating excess food to food banks and other charitable organisations, improving inventory management and reducing overproduction, investing in technologies that can extend the shelf life of food, and educating consumers on how to reduce food waste at home.

4.1 Future improvements

While Matsmart-Motatos's service aims to promote more sustainable consumption by saving food otherwise wasted, this study shows that the greatest savings arise from the shopping cart with the largest emissions (seen in relation to Matsmart-Motatos's own product assortment). Hence, buying products that generate greenhouse gas emissions results in greater savings. It could be argued that buying a shopping cart containing these products may contradict the overall purpose of reducing emissions. By purchasing products with a high carbon footprint, consumers may be inadvertently contributing to the problem of climate change rather than mitigating it, even if we here account for it as savings. While identifying products with a high carbon footprint can be useful in making more informed decisions, it is important to remember that the ultimate goal is to reduce emissions and promote sustainability. The focus should therefore be directed towards providing a further sustainable product assortment. This will, however, result in lesser saves.

Furthermore, focusing solely on products with a significant climate impact may overlook other important aspects of sustainability, such as the social and economic impacts of production and consumption. For example, products that have a low carbon footprint but are produced through unsustainable labour practices may not be considered as part of this service, even though they contribute to unsustainable consumption patterns.

Overall, while Matsmart-Motatos's service has the potential to promote more sustainable consumption, it is important to consider in what direction the service should develop to save greater amounts of carbon emissions or develop a product assortment that is more sustainable. Moreover, the broader context of sustainability should be incorporated, not solely focusing on the carbon footprint of products.

4.1.1 A classification system based on risk

Food waste is a pervasive issue that carries both economic and environmental consequences. Different types of food products present varying risks when wasted, depending on factors such as their best-before-date, freshness, and specific product characteristics. To mitigate food waste risks, it is crucial to understand these factors and develop strategies for reducing waste.

One of the most significant risks associated with wasting fresh produce is the loss of nutrients. Fresh fruits and vegetables are essential sources of vitamins, minerals, and fibre, and their waste results in the loss of vital nutrients. In addition, the disposal of fresh produce can also lead to environmental problems, such as the release of methane gas during decomposition in landfills, contributing to climate change.

In addition to the environmental risks, food waste also has significant economic implications. Food waste results in a loss of resources, including e.g., labour, water and energy used for transporting and producing packaging materials. This loss of resources can lead to increased costs for consumers and businesses, ultimately affecting the economy.

Based on the different risks for food waste in product groups, there are suggestions for developing a classification system at Matsmart-Motatos. To evaluate the risks of wasted food products, a classification system could be developed based on factors such as their best-before-date, freshness, specific product characteristics, environmental impacts and economic value. A classification system for food waste could help identify which products are at higher risk of spoilage and prioritise efforts to reduce waste for these products. It could also assist businesses and individuals in implementing better storage and inventory management practices as it is presented to the public with high transparency.

4.2 Nutritional value

When evaluating the sustainability of food, it is important to take into account not only the environmental impact of production and transportation but also the nutritional value of the food. The nutritional content of food plays a significant role in human health and well-being and should therefore be considered alongside environmental factors.

Food waste is a major concern in the sustainability of food. When food is wasted, the environmental impact of its production and transportation is wasted, and so is its nutritional value. In the United States, for example, approximately 30-40% of food is wasted each year, meaning a significant amount of nutrients is also lost. Incorporating the nutritional content of food products into the evaluation of their sustainability could help to further communicate the value, which in term leads to less waste.

Incorporating the nutritional value of food into the evaluation of its sustainability can also help to promote a more sustainable diet overall. A more sustainable diet can be achieved by encouraging the consumption of nutrient-dense foods, such as fruits and vegetables, while reducing the consumption of less nutrient-dense foods, e.g., processed snacks.

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