Food waste in Swedish households

Trends, challenges, and opportunities towards achieving the global reduction target

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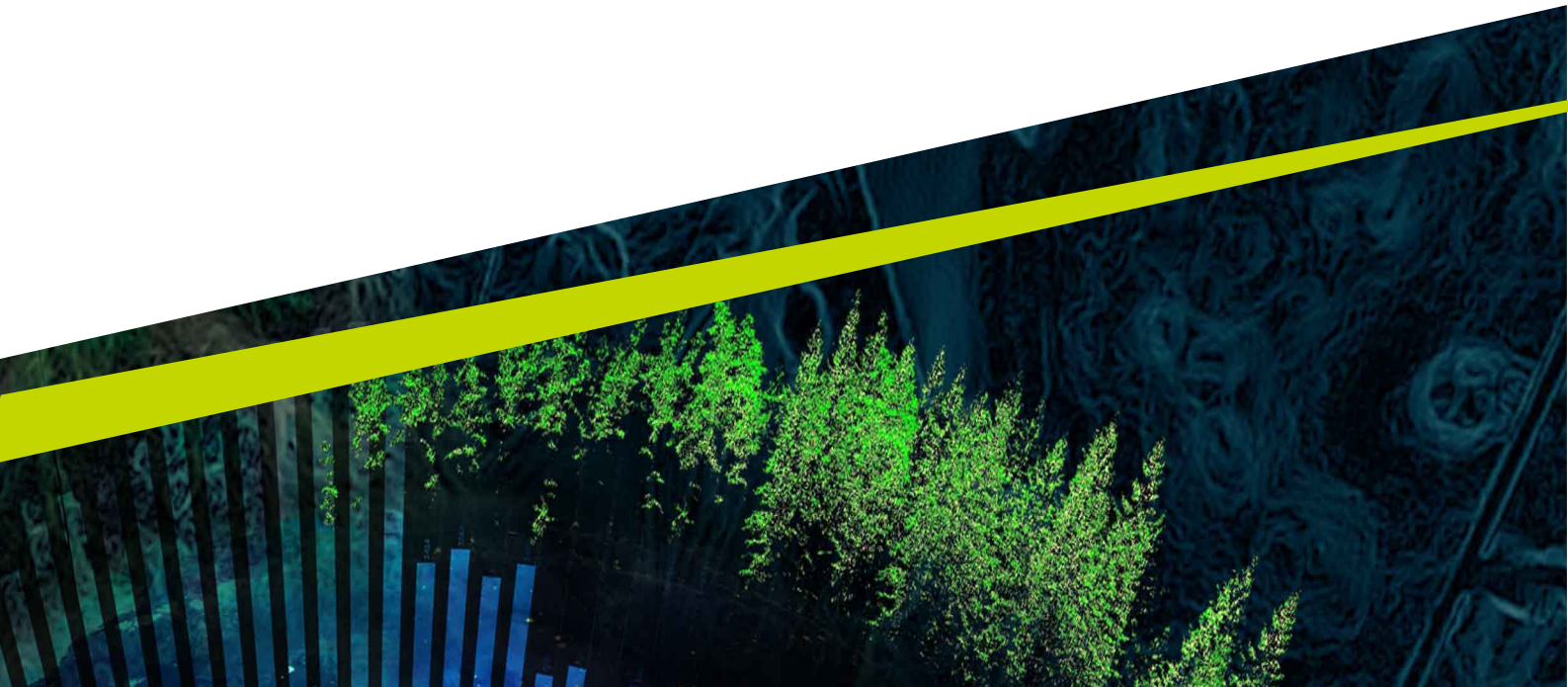

Food waste in Swedish households. Trends, challenges, and opportunities towards achieving the global reduction target.

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Abstract

Food systems are facing urgent environmental and social challenges in order to ensure a more sustainable future at a global scale. Considering that approximately one third of the food produced for human consumption is loss or wasted, reducing food waste is key issue to reduce the environmental impacts of food systems. The Sustainable Development Goals (SDG) include a specific target which aims to halve Food Loss and Waste (FLW) by 2030. Whether we are on the right path to achieving the SDGs is a question that has gained attention in the last years. This study focused on Swedish household food waste and aimed to examine potential trends in relation to the food waste reduction target of the SDGs, together with exploring challenges and opportunities for local governments to help accomplishing it. This study revealed a slight overall decrease of 4% in total food waste generation among Swedish households from 2018 to 2022, but this reduction is not on track to meet the 50% reduction target by 2030. The amount of avoidable sorted-food waste, which represents edible food, has increased by 17% during the same period. However, this figure includes only the sorted fraction, leaving the trend in the amount of avoidable non-sorted food waste unknown. Interestingly, the overall amount of sorted food waste has increased from 42% to 72%, which is in line with both EU regulations and municipal ambitions.

Challenges to reduce household food waste both within the municipalities and beyond the municipalities scope were identified through semi-structured interviews with municipal representatives. The unclear municipality role in ensuring systematic and concrete actions to reduce food waste in households, limited resources, and other priorities were identified as challenges within the municipality, whereas the underestimation of the own food waste generation of individuals and systemic enablers of food waste, such as low food prices and hectic lifestyles were some challenges beyond the municipality boundaries. Overall, helping households to reduce food waste was perceived as a hard task and the results reveals the multiple layers of this complex issue.

Collaborating with relevant stakeholders and clarifying the municipal role through top-down approaches are crucial opportunities to ensure more systematic and effective efforts towards reducing household food waste and achieving SDG Target 12.3. Future research exploring the effectiveness of potential interventions and providing local governments with actionable insights is urgently needed, to contribute developing more sustainable food systems.

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1. Introduction

Food systems are facing urgent environmental and social challenges in order to ensure a more sustainable future at a global scale. Food production accounts for around one quarter of the global greenhouse gas emissions (Poore & Nemecek 2018), while land-use change driven by agricultural expansion is currently the major driver of biodiversity loss (IPBES 2019). Furthermore, it is expected that by 2050, the environmental effects of the food system could increase between 50-90% if no measures are taken, reaching levels beyond the planetary boundaries safe operation space (Springmann et al. 2018). Strategies to improve sustainability within food production and consumption are therefore crucial to tackle climate change and environmental degradation and keep the planet within the planetary boundaries.

Considering that one third of the food produced for human consumption is loss or wasted (FAO 2011), reducing food waste might be a key issue to reduce the environmental impacts of food production, together with other strategies such as changing dietary preferences. Food loss and waste (FLW) is a complex topic, not only because of the multiple causes behind it throughout the food chain (Reynolds et al. 2020), but also because of the challenges in quantifying it (Xue et al. 2017). Differences in its definition has also been problematic, adding ambiguity to its quantification (Xue et al. 2017). In the literature, FLW along the food chain has been conceptualized into two parts. Firstly food loss, referring to decrease in food quantity or quality in the early stages of the food supply chain, i.e. before the retail and consumer level and secondly food waste, referring to the discarding of food products that are fit for consumption, occurring in the later stages of the food chain, i.e. retail and household level (Parfitt et al. 2010).

According to the UNEP (2021), the problem of FLW has been overlooked, as the true scale of its impacts is not fully understood, and due to the lack of relevant data. Nevertheless, this issue has emerged in recent years as a priority in the global agenda and has been addressed by setting food waste reduction targets at global scale. The UN Agenda 2030, through the Sustainable Development Goals (SDG), includes a specific target (12.3) which aims to “By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along

production and supply chains, including post-harvest losses." (UN 2015). On the other hand, even more ambitious reduction scenarios has been explored. Springmann et al. (2018) argues that FLW should be reduced between 50-75% in order to maintain the food systems within safe planetary boundaries. A scenario of 75% of food waste reduction is likely close to the maximum value that can theoretically be avoided (Parfitt et al. 2010). Overall, the SDG Target 12.3 has been seen as an *"historic window of opportunity opened to elevate the issue of food loss and waste reduction on the global agenda"* (Hoogeveen et al. 2023; 3).

As we get closer to the 2030, new studies have been tracking the progress on achieving the SDG targets, with the objective to find out the gaps and project future paths in the years to come (Moyer & Hedden 2020). In general, good data and clear metrics has been highlighted as critical points to track progress and devise pathways for achieving the SDG (Lafortune et al. 2020). When it comes to FLW, the target 12.3, is tracked through the Food Loss and Food Waste indexes (UNEP, 2021). The Food Waste Index was developed by the UN in 2021 in an attempt to standardize food waste metrics among different countries and provide guidance for them to produce better data.

When looking only at the food waste fraction, new findings shows that previous studies (FAO 2011) might have underestimated food waste generated at the consumer level by households and food services (UNEP, 2021). During 2022, 12% of the food waste generated globally came from retail, 28% from food service and around 60% from households (UNEP, 2024). This evidence shows that efforts reducing household food waste is urgently needed at a global scale, to improve the sustainability of food systems and reduce the pressures to the planetary system.

Household food waste data is therefore crucial to inform interventions and track progress towards the Target 12.3. On a global scale, household food waste generation data has improved, with more countries reporting data by 2022. Nevertheless, there are still many countries with limited data available (UNEP 2024).

Sweden is one of the countries that counts with reliable data, and therefore there is a good opportunity to effectively tracking their progress towards the Target 12.3. According to a recent report by the Environmental Protection Agency, Sweden generated an average of 135 kilograms of food waste per person in 2022, with approximately 74 kilograms coming from household, including both solid and liquid waste (SEPA 2024a). This indicates that households contribute to around half of the country's total food waste, which suggests a significant reduction potential within this sector.

However, even with a promising reduction potential and improved metrics, reducing food waste in Swedish households still requires effort from many actors. For instance, the 2023 Food Loss and Waste Progress Report underscores the central role of local governments in reducing food waste, exemplifying diverse initiatives undertaken by cities globally (Hoogeveen et al. 2023). Understanding the importance of local efforts and the challenges they face in reducing household food waste is therefore crucial for identifying future opportunities and guiding further interventions that will contribute to less food waste being generated.

1.1 Aim

The aim of this study is to analyse the food waste levels of Swedish households over time and examine potential trends in relation to the global ambitions to halve food waste by 2030. Moreover, the study discusses the challenges and opportunities to accomplish the global food waste reduction targets from the municipal perspective.

2. Background

This section offers an overview of the key concepts relevant to the current study. It begins by contextualizing the position of food waste within the sphere of sustainability and the Sustainable Development Goals (SDGs). In addition, it presents the current state of knowledge of household food waste and reasons behind it, and finally it shows different waste measurements, with a particular emphasis on waste composition analysis.

2.1 Food waste and Sustainable Development

It is undeniable that the idea of Sustainable Development has been expanding and taking over different spheres of society in the last decades. The concept of Sustainable Development was first adopted by the United Nations Brundtland Report in 1987 and was defined as the development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Since then, Sustainable Development has been a guide for the international agenda on development, with the aim of incorporating environmental and social issues as a central part of it. From a pragmatic perspective, Sustainable Development has been translated by the UN in an ambitious Agenda in 2015, the Agenda 2030.

The Sustainable Development Goal (SDG) 12 seeks to ensure responsible and sustainable consumption and production patterns, which has been portrayed as a key issue to sustain the livelihoods of current and future generations (UN nd). Food waste is a sign of both over production and consumption, therefore the Target 12.3 of the SDGs aims to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

Food is wasted throughout the food system chain, from agricultural production down to final household consumption (FAO 2011), leaving behind all the environmental and social impacts of the current food production system, and yet no benefits. From an environmental perspective an estimated 8-10 per cent of global greenhouse gas emissions are associated with food that is not consumed (FAO

2014). At the same time, global food system is a major driver of biodiversity loss (Newbold et al. 2015), depletion of freshwater reservoirs (Wada et al. 2010), and contamination of aquatic and terrestrial ecosystems from the application of fertilizers (Robertson & Vitousek 2009).

Food waste also entails significant economic and social impacts. According to estimates by FAO (2014), the economic toll of food loss and waste amounts to roughly 1 trillion USD annually. From a social perspective, there are also ethical implications behind food waste, since there is a huge paradox between waste and hunger. While between 691 and 783 million people in the world faced hunger in 2022 (FAO 2023), about one third of the food produced for human consumption never gets to be eaten.

In this context, food waste reduction can contribute to improve sustainability by tackling all three sustainability pillars: economic, social and environmental. Moreover, reducing food loss and waste does not only relate with the one of the SDG targets (12.3), but may also help solving sustainability issues related to other SDG, as there are synergies between them (UN 2023). For instance, reducing food waste might contribute to combat climate change and its impacts (SDG 13), halt and reverse land degradation (SDG 15), end hunger, achieve food security and improved nutrition and promote sustainable agriculture (SDG 2).

2.2 Household food waste

The evidence shows that household food waste represents a large fraction of FLW at a global scale, and even larger in Europe (FAO 2011). When it comes to food waste, i.e. food discarded in the consumption stage, households generated 60% of the food waste out of the 1.05 billion of tonnes generated in the later stages of food chain, including retail, and food service (UNEP 2024). Considering this, it is fundamental to reduce household food waste in order to achieve the SDG food waste reduction target.

Why does people waste food at home? Numerous drivers simultaneously influence the amount of food that households end up discarding. As outlined by Reynolds (2020) these are emotions, values, socio-demographic factors, economic factors, behavioural patterns, and systemic issues beyond the household boundaries. There is evidence showing that more food is wasted by higher income households (Szabó-Bódi et al. 2018), and by households that spend more money on food (Parizeau et al. 2015), both cases in the global North.

Concerning values, various intertwined factors operate at the individual level. For instance, over consumption and delivering excess of food to be a "good provider" has been identified as a food waste driver, whereas there is also a portion of population experiencing guilt when discarding food (Reynolds et al. 2020). Feelings of guilt might often stem from ethical rationales, including allusions to hunger (Parizeau et al. 2015) or economic concerns, often over environmental motivations (Stancu et al. 2016). In terms of behavioural factors, inadequate food storage and reluctance to eat leftovers could also contribute to food discarding.

It is also relevant to highlight systemics drivers that extend beyond individual decisions and contribute to household food waste. These include retail policies, packaging designs, imposition of aesthetics standards or misinterpretations regarding best before dates, to mention some (Williams et al. 2012; Aschemann-Witzel et al. 2015). Overall, household food waste should be seen as a systemic phenomenon that depends both on internal dynamics within the household and external factors, related to the societal structures.

2.2.1 Interventions: challenges, and opportunities in households

As mentioned in the previous section, household food waste generation is a multi-dimensional and complex issue, and therefore interventions to reduce it will require diverse approaches. Regulatory measures to prevent avoidable food waste, waste reduction models that discouraged surplus food at household level, together with facilitating household routines that allow the effective management of food and its waste in the home (Reynolds et al. 2020).

An essential aspect to consider is consumer behavior. van Geffen et al. (2020) have extensively discussed the relevance behavioral change interventions, arguing that they have a great potential to reduce overall food waste levels. Information campaigns, emotional appeal campaigns, social influences are some behavioral change strategies. There is though no clear consensus on the effectiveness of such interventions in literature. Two extensive systematic review on household food waste interventions reveals that there is a lack of studies evaluating its long-term effects (Hebrok & Boks, 2017; Stöckli et al. 2018). Overall, the importance of evaluating interventions in a systematic manner that allows accurate identification of short-term and long-term effects is highlighted (Stöckli et al. 2018).

The Swedish action plan for FLW reduction by 2030 incorporates a set of initiatives targeting households, such as: knowledge increase, behavioral change and attitudes, and motivational measures are three of the nine action areas of the plan (Livsmedelsverket 2018). Moreover, proposed measures include keeping the FLW issue alive in the public debate. Municipalities are tasked with actively

disseminating information to citizens citizens on how they as consumers can act to reduce their food waste.
To sum up, various interventions might hold promise for reducing household food waste. Nevertheless, further research needs to be done in this area. As argued by (Liu & Nguyen 2020), education in sustainable consumption and production together with data availability are some of the main challenges to both monitoring and ultimately achieving the SDG target 12.3.

2.3 Food waste measurement

Quantifying food waste is an essential first step in reducing food waste. Moreover, accurate food waste quantification is fundamental when designing and evaluating the implementation of waste-reducing measures (Lindbom et al. 2014) and tracking food waste reducing targets (CEC 2019). There are direct and indirect approaches to measure household food waste, each one with different strengths and limitations (Reynolds et al. 2020).

Surveys are a cost-effective indirect method to gather both quantitative and qualitative information about food waste (WRI 2016). Surveys can look at facts such as the number, size, and frequency of collection of food waste containers, which can therefore be used to estimate food waste generation. There are nevertheless disadvantages when using this method, one of them being the errors of estimation that might be introduced by the respondents when recalling food waste events and estimating food waste amounts (WRI 2016).

Direct observations require the food waste to be measured when it occurs. Food waste diaries, for instance, are direct observations often used to track household food waste, which consist in the self-report of daily waste generation rates by household or commercial kitchen members (WRI 2016). Real time recording is a main advantage of this method, nevertheless, research shows that diary estimates for household food waste usually tends to underestimate food waste generation (Quested et al. 2020). According to Quested et al. (2020) measurement bias, misreporting, or behavioural reactivity, i.e. people might tend to waste less than usual during the diary period, are some reasons for underestimation, that has shown to go from 7% to 40%.

Waste Composition Analysis (WCA) is a direct measure method, which yet more expensive, has shown to be effective in overcoming the under-reporting problems of the methods mentioned above (WRI 2016; Quested et al. 2020). The next section expands on the waste composition analysis methods in general, and in the Swedish context.

2.3.1 Waste Composition Analysis

WCA consists in physically separating food waste items from other waste streams, sorting them by category, and weighing them (WRI 2016). This method offers the possibility of choosing waste categories depending on the level of detail needed; for instance, food waste can be divided into avoidable and unavoidable food waste or even broken down into specific food item, such as meat or bread (WRI 2016). It is important to note that this method only allows to record solid food waste, which is one of its limitations (Quested et al. 2020).

Household WCA represent an opportunity for obtaining detailed data about food waste at local and regional levels, which has been increasingly used (Lebersorger & Schneider 2011). Moreover, in 2016 the launching of the Food Loss & Waste Protocol (FLW Protocol) by the World Research Institute has standardized the WCA method, which enables entities, companies, and countries to provide more accurate and comparable data. Many countries have launched their own WCA protocols to standardize these measurements at a national level, and Sweden is one of them. Moreover, the Commission Delegated Decision 2019/1597, stablishes a common methodology and minimum quality requirements for the measurements of food waste levels, which includes WCA as one of the methodologies to measure household food waste.

When it comes to Swedish waste management, the Swedish Environmental Code (1Miljöbalk (1998:808), 15 kap 10§) establishes that every municipality has the responsibility for municipality waste management, i.e. transporting and recycling. Municipality waste management includes the waste generated in restaurants, boutiques, and households. These last have the responsibility of sorting and delivering their waste to the collection system available. Municipalities have also been responsible for implementing WCA and gathering household food waste data (Avfall Sverige, 2024a). In this sense, WCA have become an important tool for Swedish municipalities to follow up that the quality of the waste meets the requirements of each waste treatment system, evaluate and compare different collection systems, and monitor goals in waste management plans (Avfall Sverige 2024a).

Waste Sweden (*Avfall Sverige*) is a trade organization for Swedish municipal waste management that supports and represents all Swedish municipalities (Avfall Sverige, 2024b). Waste Sweden has delivered manuals, checklists, and guides to support the conduction of WCA. In 2005, Waste Sweden launched the first national manual for WCA, which has been updated and expanded several times up until 2020. The manual provides instructions for carrying out WCAs: sample and sorting instructions, examples, and templates. This tool also helps municipalities and

performers of WCA to gain a better understanding of the importance of following standardized methods to obtain the most reliable WCA results possible. (Avfall Sverige, 2024a). The data collected by WCA, which follows to the guidelines of the manual, is then compiled by Waste Sweden and serves as a fundamental input for national yearly waste statistics, including food waste.

In this context, Sweden has a significant amount of food waste data in the form of WCA, accumulated over the years at a municipal level and aggregated through the efforts of Waste Sweden. Overall, these analyses might contain rich information about societal behavior and may enable tracking of historical changes.

2.3 Household food waste in Sweden

Household food waste is context specific (FAO 2011). In Sweden, household food waste represents a substantial portion of the country's food waste. Nevertheless, the last report from the Swedish Environmental Protection Agency (SEPA) suggests that household food waste signifies a smaller portion of food waste compared with the previous studies from 2020 and 2021 (SEPA 2024a). In 2022, approximately half of the Swedish food waste was discarded at a household level, which translates to 56 kg per person in 2022 excluding what has been wasted down the drain. According to the same report household food waste has declined, while other sectors have increased.

Regarding the methods and assumptions behind that figure, it is important to note that it is built on the statistics from Waste Sweden. The amount of sorted food waste is based in food waste collected by the municipality, which also includes quantities from business, nursing homes, restaurants, and others. The proportion of household food waste was assumed to be 75%, based on data from six municipalities for the years 2013-2014 that have implemented weight-based fees for households. Regarding the not sorted food waste discarded as residual waste, it is based on WCA. The total amount of household food waste was calculated by adding those two fractions.

A recent study shows that household food waste composition has also changed. The amount of leftovers discarded has decreased, meaning that, vegetables represents now the larger category of what is discarded (36%), followed by bread and bakery products (19%) and meat (12%) (Swedish Food Agency 2023).

3. Material and methods

As stated previously, the aim fo the study is to analyse the food waste levels of Swedish households over time and examine potential trends in relation to the global ambitions to halve food waste by 2030, together with identifying the challenges and opportunities to accomplish the global food waste reduction targets from the municipal perspective. To achieve this aim, a mixed methods approach was employed. Mixed methods research, which combines elements from both qualitative and quantitative paradigms, is especially useful when researching complex issues such as environmental questions (Kanazawa 2018).

A quantitative methodology was used to analyze the levels of food waste generation over time. Subsequently, to discuss the challenges and opportunities associated with achieving global food waste reduction targets from the municipal perspective, a qualitative approach, in form of interviews, was adopted. This section will expand on the details of the methods implemented.

3.1 Household food waste: changes over time

3.1.1 Data collection

WCA reports were used to gather food waste data at a municipal level in order to analyse potential trends in household food waste. To collect WCA reports, Swedish municipalities were contacted via email, and asked for waste composition reports from their municipalities. Municipalities or waste treatment organization sent either PDF reports with the food waste generation data and/or excel files with the compiled quantities of waste generation.

The reports quantified food waste generation either sorted as food waste, disposed in the residual waste or both, hence the level of detail of the information varied depending on the aim of each WCA. All of them had followed the guidelines of the most updated version of the Manual for Waste Composition Analysis provided by Waste Sweden. As indicated in the Manual, the WCA were performed separately between Apartment buildings (*Flerbostadshus*) and Houses (*Villahus*).

Food waste generation rates were extracted from the reports/files and organized in an Excel file per each year, for both apartment buildings and houses, according to the categories shown in the Figure 1.

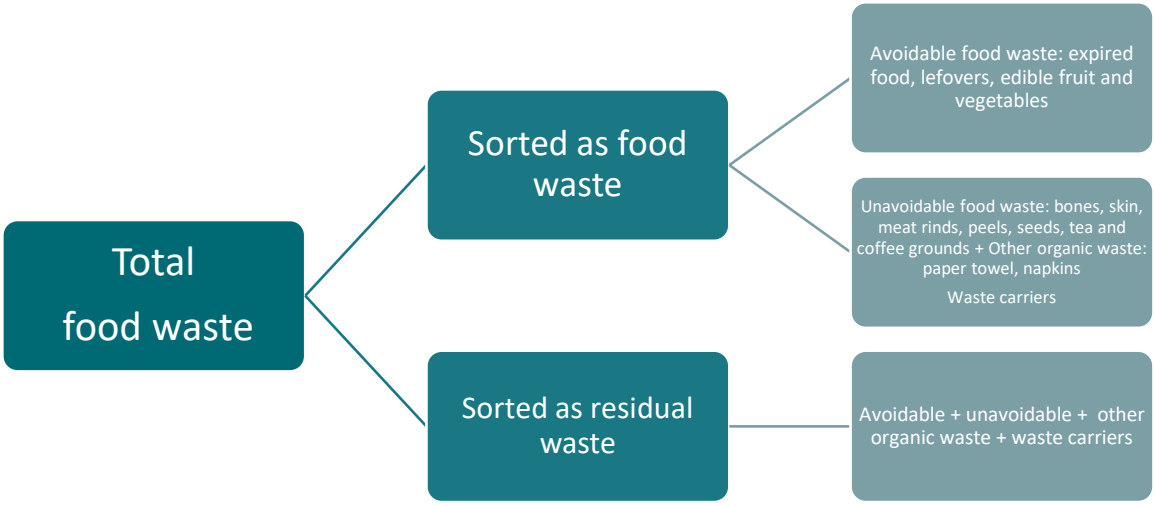

Figure 1 Categories of food waste data gathered from the WCA reports.

3.1.2 Data processing

The unit of food waste generation rate chosen for the analysis was kilograms of food waste per year per person (kg/pp/yr), nevertheless in most of the WCA reports the food waste was reported in kilograms per household per week (kg/h/w). In those cases, the data was converted to kg/pp/year through the following steps:

- From kilograms per household to kilograms per person:
  - Official statistics on the average number of inhabitants per household were collected from The National Statistical Agency (SCB nd*a*), including both apartments and houses, for each municipality and year of analysis.
  - To obtain the number of kilograms per person, the number of kilograms per household was divided by the average number of inhabitants per household, for each municipality and year of analysis.

- From kilograms per week to kilograms per year:
  - The weekly food waste rate was multiplied by 52 weeks.

In total, WCA reports from 100 municipalities were collected, which corresponds to 30% of the Swedish municipalities, and approximately 60% of the Swedish population. However, reports from 14 municipalities were excluded since food waste generation was reported in as a percentage of food waste in relation to total waste, or total kilograms per WCA sample and hence they would not serve the purpose of doing further comparisons which also considered the population.

Thus, reports from 86 municipalities were included in the analysis, each providing WCA data for at least one year and one category of data. Among these, 66 municipalities contributed data on total food waste, i.e both sorted food waste and food waste discarded as residual waste. Consequently, 20 municipalities were excluded from this aspect of the analysis because their reports lacked data on both sorted and unsorted food waste.

Regarding the number of years that each municipality contributed with, 26 municipalities provided data for one year, 26 municipalities for two years, 10 municipalities for three years, one municipality for four years, and three municipalities for five years.

3.1.3 Changes over time

As a first step, descriptive statistic was used to summarize and illustrate the collected data. Descriptive statistics consists of methods for organizing, displaying, and describing data by using tables, graphs, and summary measures (Mann 2013). The measures used to describe the collected data were average, maximum, minimum, and standard deviation.

Changes over time were explored through linear regressions and percentages of variation per year. A linear regression is a statistical method that models the relationship between an independent and a dependent variable. In this case the independent variable is the years and the dependent variable the amount of food waste generated. In general, linear regressions can help identify trends over time, predict values of the dependent variable or assess relationships between variables (Mann 2013). The linear regression analysis was conducted using Excel's regression function, only in years where data from more than 10 municipalities was available. Regarding the data, it is relevant to note that the sample for each year combined different municipalities.

Changes over time were explored for the following indicators:

- Average of total food waste:
    - The total food waste was determined by combining both sorted and unsorted food waste data. However, in cases where information was available for only one of these categories the data point was

excluded. Calculations were carried out separately for houses and apartments.

- Average of sorted and not sorted food waste:
  - Calculated as a percentage.

- Average of sorted food waste avoidable and unavoidable over time:
  - Calculated as percentage.

- Yearly variation:
  - Percentage of variation in total food waste and avoidable sorted-food waste, distinctively for both apartments and houses. Additionally, a weighted average was calculated for both apartment dwellers and homeowners, utilizing data from The National Statistical Agency (SCB nd*b*), which accounted for the proportion of the population residing in apartments and houses as of 2022.

Finally, to assess potential trends in relation to the SDG Target 12.3, the yearly average reduction of total food waste, needed to achieve a 50% reduction by 2030 was calculated, using 2020 as the baseline year.

3.2 Opportunities and challenges for food waste reduction

3.2.1 Data collection: Semi-structured interviews

A qualitative approach was used to study the current efforts done by local governments regarding household food waste reduction an ultimately investigate what are the potential challenges and opportunities to reach the food waste reduction goals for households. The method used was semi-structured interviews.

Semi-structured interviews allow to have a natural conversation and give the opportunity for extensive and complete responses, follow-up questions and the pursuit of unexpected themes and paths (Kanazawa 2018). The guide with the set of questions is presented in Appendix 1.

The interview sample was composed by local government representants, as they were considered to be key actors in household food waste reduction. Specifically, waste management departments of Swedish municipalities were targeted. 19 Municipalities were contacted via email to participate in this study. The interviews were conducted via Zoom in English, and in order to facilitate the analysis, they were recorded with the consent of the respondents.

A total of 7 municipal workers agreed to participate in the interviews; however, only 5 interviews were deemed relevant for inclusion in the analysis. This decision was made as the remaining two interviews were conducted with individuals exclusively involved in public catering, thus deviating from the focus of the study. The name of the municipality and the person were to be kept anonymously. The role and the department in which they work in the municipality is presented in Table 1.

Table 1 List of interviewees and their role at the municipality

Municipality	Role
Municipality 1	Respondent 1: Project manager at the waste department. Has worked with waste management for 25 years. Respondent 2: Quality manager at the waste department. Has been working in that role 7 years.
Municipality 2	Respondent 3: Project manager at the waste and water department. Has been working in that role for 5 years.
Municipality 3	Respondent 4: Waste planner at the waste department. Has been working in that role for three years.
Municipality 4	Respondent 5: Waste management responsible at the waste department. Has been working there for 5 years in that role.
Municipality 5	Respondent 6: Research and planning engineer at the municipal waste management agency. Working in waste management since 2001 and in the municipality for 5 years.

3.2.2 Interview analysis

A systematic analysis of the data collected through the interviews was done based in the methodological steps presented by (Ose 2016). As a first step the audio files of the interviews were transcribed by the automatic transcription service https://goodtape.io/. Thereafter, the text was transferred to an Excel document, where the information was coded. Coding is a crucial stage of the qualitative analysis, which consists of labelling segments of data in a way that they are simultaneously categorized and summarized (Charmaz 2006). In this sense, each code can be interpreted as a "unit of meaning" (Kanazawa 2018).

The interviews were coded on first hand in three primary themes: current actions or strategies, challenges, and opportunities. Subsequenlty, the information within these three themes was further coded in subthemes. A final validation process was

done by reviewing all the subthemes, ensuring the coherence of each "unit of meaning," and re-coding when necessary.

5. Results

5.1 Changes over time

The results describing changes in household food waste generation over time within the sample of analysis are presented in the current section.

5.1.1 Overall percentage changes: total food waste and avoidable sorted-food waste

Total household food waste showed an average decrease of 4% between 2018 and 2022 for both apartments and houses combined (Table 2). However, this decrease was not constant over the years, since there was an increase in food waste generated for both types of households, which peaks in 2020. Starting from 2020, there was an average reduction in total food waste of 16% between 2020 and 2021, followed by a further 14% decrease between 2021 and 2022. These reductions contributed to the slight negative trend observed in Figure 2.

Regarding the changes in the avoidable fraction of sorted food waste, there was an increase of avoidable food waste between 2018 and 2020, followed by a decrease between 2020 and 2021 of 23% and of 26% between 2021 and 2022. Over the period of study (2018 – 2020) avoidable sorted food waste had an increase of 17% (Table 2 Yearly variation of total food waste generation and avoidable food waste generation of the sorted fraction, between 2018 and 2022 for houses and apartments and as a weighted average.

Table 2 Yearly variation of total food waste generation and avoidable food waste generation of the sorted fraction, between 2018 and 2022 for houses and apartments and as a weighted average.

Years	Apartments		Houses		Weighted average	
	Total food waste	Avoidable, sorted food waste	Total food waste	Avoidable, sorted food waste	Total food waste	Avoidable, sorted food waste
2018 - 2019	38%	114%	14%	66%	27%	92%
2019 - 2020	8%	13%	2%	-1%	5%	7%
2020 - 2021	-22%	-30%	-10%	-14%	-16%	-23%

2021 - 2022	-10%	-21%	-18%	-30%	-14%	-26%
2018-2022	**5%**	**33%**	**-14%**	**-2%**	**-4%**	**17%**

5.1.2 Total food waste

Figure 2 *Average food waste generated by houses and apartments from 2018-2022 and its linear trends.*shows the yearly average of total food waste generation for apartments and houses from 2018 to 2022, and illustrates its linear trends projected until 2030.Both trends show a negative slope, which indicates a slight decrease in food waste generation over the years. For houses, the trend is slightly steeper. Meanwhile, for apartments, the trend also demonstrates a decrease, though with a gentler slope.

Additionally, Figure 2 shows the theoretical reduction needed to achieve a 50% decrease in food waste rates by 2030, using 2020 as the base year. For both apartments and houses, an average annual reduction of at least 7% would be necessary, which means to reduce the kilograms per person per year from 84 and 82 to 41 and 42 for houses and apartments respectively. However, as seen in Figure 2, the projected trends based on observed data from 2018 to 2020 do not align with the theoretical reduction needed to halve food waste by 2030. By following the current trend, the projected food waste generation is 61 (kg/pp/yr) for apartments and 52 (kg/pp/yr) for houses.

Regarding the differences between houses and apartments, a slightly higher number of kilograms of food waste per person were generated by houses, which was a common pattern for each year of analysis (Figure 2).

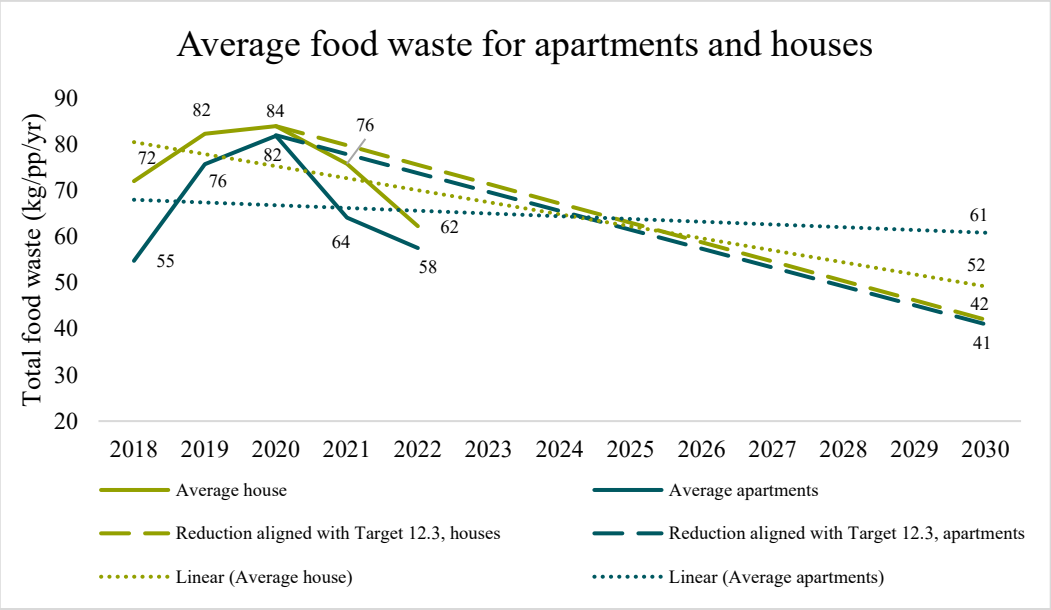

Figure 2 Average food waste generated by houses and apartments from 2018-2022 and its linear trends.

There was a variation in the average of food waste generated by the different municipalities that contributed with data over the years, which can be seen in the range of maximum and minimum food waste per year (Figure 3 and Figure 4 *Average food waste generated per year by persons living in houses, in kilograms per person per year. The "n" shows the size of the sample, i.e. the number of municipalities contributing with data for each year.*). In the case of the apartments (Figure 3 Average food waste generated per year by persons living in apartments, in kilograms per person per year. The "n" shows the size of the sample, i.e. the number of municipalities contributing with data for each year.), the maximum amount of total food waste generated, ranges from 90 (kg/pp/yr) in 2018 to 159 (kg/pp/yr) in 2022, while the minimum goes from 16 (kg/pp/yr) in 2018 to 21 (kg/pp/yr) in 2022.

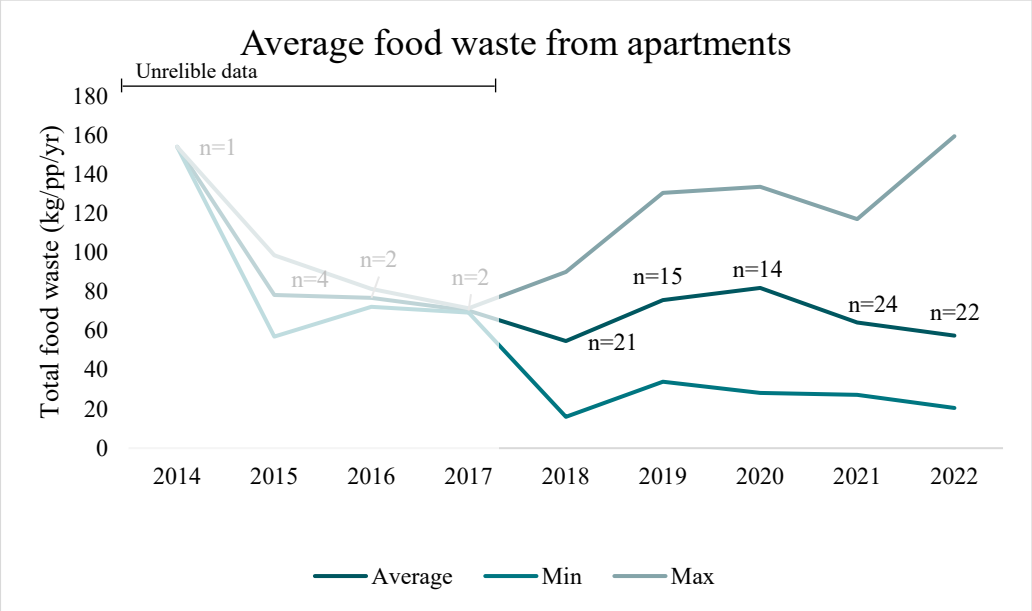

Figure 3 Average food waste generated per year by persons living in apartments, in kilograms per person per year. The "n" shows the size of the sample, i.e. the number of municipalities contributing with data for each year.

In the case of the houses (Figure 4), the variation of maximum and minimum has a slight lower variation than for the apartments. Maximum food waste values range from 123 (kg/pp/yr) in 2018 (kg/pp/yr) to 92 (kg/pp/yr) in 2022, while the minimum goes from 21 (kg/pp/yr) in 2018 to 37 (kg/pp/yr) in 2022.

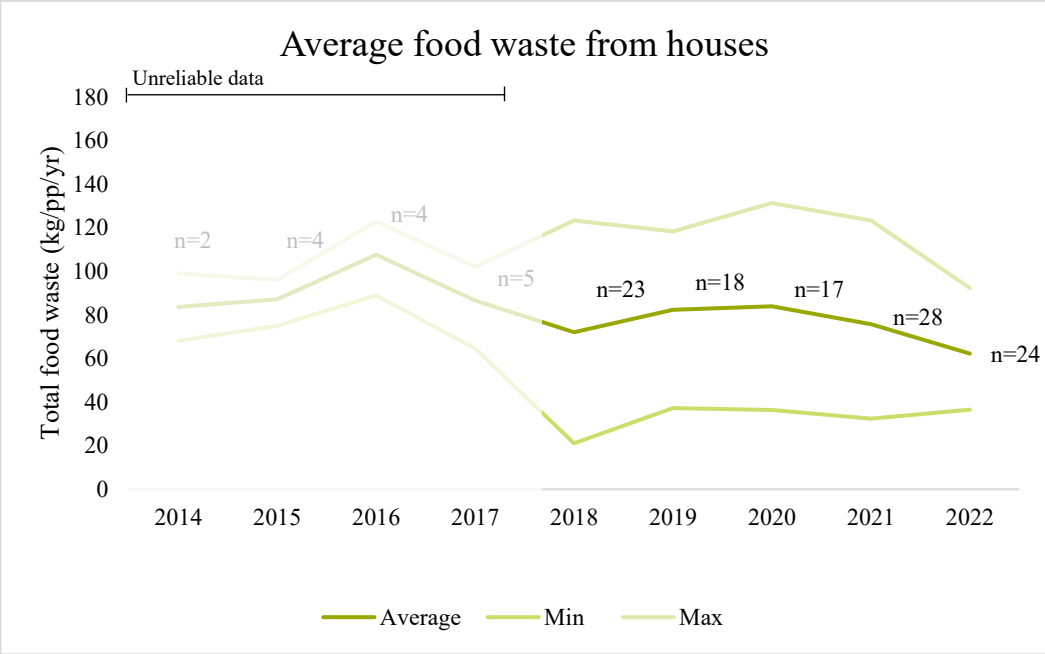

Figure 4 Average food waste generated per year by persons living in houses, in kilograms per person per year. The "n" shows the size of the sample, i.e. the number of municipalities contributing with data for each year.

It is relevant to note that, as shown in Figure 3 and Figure 4 *Average food waste generated per year by persons living in houses, in kilograms per person per year. The "n" shows the size of the sample, i.e. the number of municipalities contributing with data for each year.*, the sample size was very limited for the years 2014, 2015, 2016 and 2017, with data from less than 10 municipalities. Hence, those years were considered as unreliable, and excluded from the trend analysis.

5.1.2 Sorted food waste: avoidable and unavoidable

The percentage of unavoidable and avoidable food waste, from the sorted fraction is shown in Figure 5. It is relevant to note that, as mentioned in the Methods section, the unavoidable figures include other organic waste and non-food waste. The results show similar magnitudes throughout the years with ranges from 11% to 15% of avoidable food waste discarded in the apartments and 12% to 15% in the houses, and no apparent trend was observed.

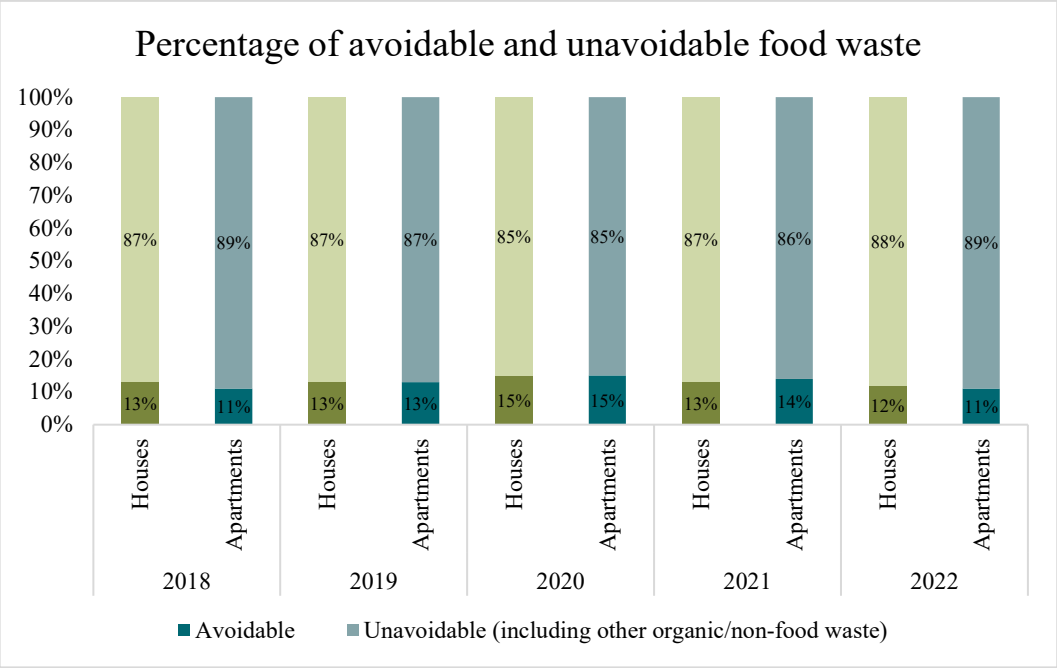

Figure 5 Percentage of avoidable and unavoidable food waste in the waste sorted as food waste in apartments and houses, between 2018 – 2022.

5.1.3 Sorted and not sorted food waste

The percentage of sorted and not sorted food waste over time is shown in Figure 6. The proportion of sorted food waste has increased from 49% in 2018 to 72% in 2022. In this case the results are shown combined for apartments and houses, based on a weighted average.

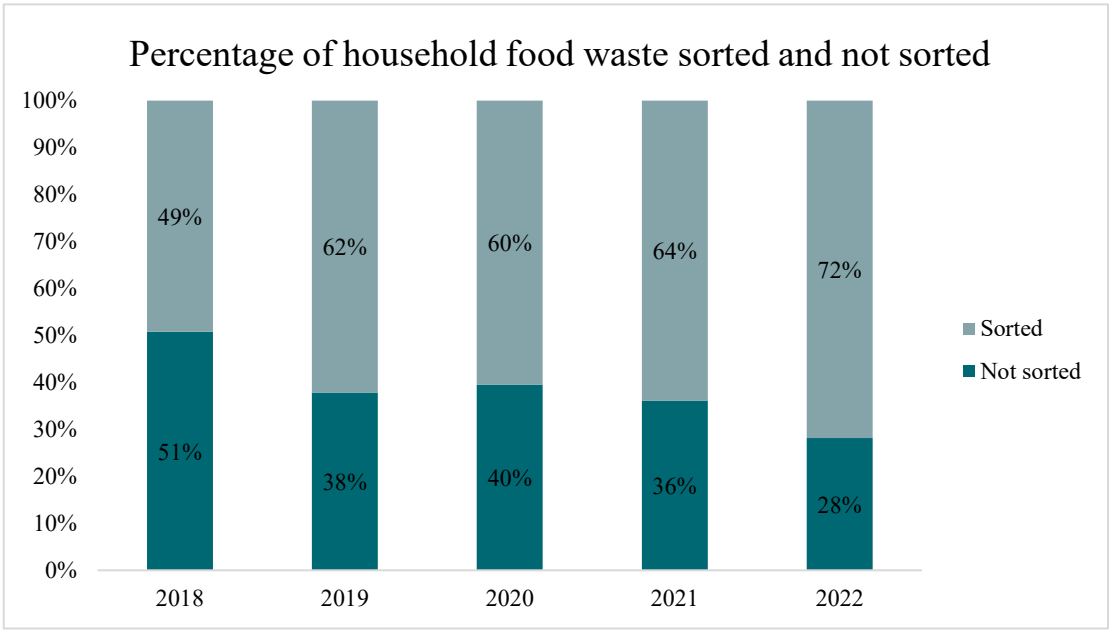

Figure 6 Percentage of household food waste sorted and not sorted, based on a weighted average for apartments and houses between 2018 and 2022.

5.2 Opportunities and challenges for food waste reduction from the municipality perspective

The results of the interviews with five municipalities representatives are presented in this section. They contributed with insights on which is the current state of work and efforts in helping reducing household food waste, while at the same time sharing their perceptions on main challenges and potential opportunities to reduce household food waste.

Figure 7 summarizes the main challenges and opportunities identified through the interviews.

Figure 7 Summary of the challenges and opportunities for reducing food waste in households according to the perspective of the interviewees.

5.2.1 Current municipality actions and strategies to reduce household food waste.

Communication through the municipality website or social media, information campaigns, pilot projects, and public events or activities are, in general, current actions used by the municipality in helping to reduce household food waste.

Three of the five interviewed municipalities mentioned that no specific interventions other than sharing general information in the webpage on how to reduce food waste was done by their municipalities "*We are trying to reduce the food waste, but to achieve it, I don't really know what the municipality can do other than to inform" (Municipality 5).*

Two municipalities named further interventions and campaigns targeting household food waste. Moreover, the waste management department of Municipality 1 had food waste as the theme of the year, meaning that communication efforts will be put in that subject to raise awareness and knowledge about it among the citizens:

> *"We are going to have a cook along with a famous chef, where the households can join us to cook a dinner. We will talk about reducing food waste and how you can save your food scraps on a tasty way. We have a communication campaign about reducing food waste, in every letter we send out there is a small text about how you can take care of your food (...) on our vehicles there is adds about food waste and also in the garbage trucks. It is a priority this year" (Municipality 1)*

Municipality 2 mentioned both a communication campaign and a pilot project undertaken last year focusing on increasing knowledge about proper food handling at home:

> *"We had a campaign last year All in mot matsvinn, we had that on advertisement boards in the city and in arenas, and some in Facebook, and social media of the municipal platform (...) We had a pilot project, we were trying to get the landlords of apartment buildings to initiate activities to reduce waste in general. And there we had the theme of reducing food waste. We had staff going and knocking on doors in the buildings, and informing households about small activities that would reduce quite a lot of food waste. And then we handed out thermometers for the fridge, and some easy information material" (Municipality 2)*

The information in which this pilot was based was based on recommendations from Livismedelsverket, which expands on practical tips about how to reduce household food waste by, for instance, improve the food storage in the fridge.

It is relevant to note that the respondents mentioned their current efforts to reduce waste in general and specially focusing on improving the waste quality, which means to improve the household waste sorting. In this sense, food waste sorting was a common theme among the respondents, in particular concerning the implementation of the Article 22 of the Waste Framework Directive (2008/98/EC). This Article requires all EU Member States to ensure that biowaste is managed separately and not mixed with other types of waste. This requirement is applicable from January 2024.

Overall, all the respondents mention that the food waste reduction goals are part of their waste management plan. Beyond household food waste, they highlighted their active work to reduce food waste in schools and elderly care; since it is part of their operations it is seen as an easier path to implement food waste reduction actions "*In schools and elder care, they have had special projects (...) they have done a lot and seen that it has been reducing a lot."*

5.2.2 Challenges at household level

The interviewees named challenges and barriers faced by municipalities in targeting household food waste reduction, which were classified into two levels: challenges within the municipality and structural challenges beyond the municipality.

Challenges within the municipality

Regarding challenges within the municipality, one key aspect highlighted by two respondents is the actual role of the municipality in ensuring systematic efforts to reduce household food waste, and determining where within the municipality this responsibility should lie. Municipality 2 provides a clear example of this issue:

> "*One of the challenges for the municipality when it comes to the information part, about reducing food waste is that most municipalities don't have a clear assignment for a specific department to continue to pump out these campaigns or informational material (...) in the Swedish Environmental Code it says the municipality has the right to use the tariffs of waste to inform households or do activities that would reduce waste, but it doesn't say anything about the ambition. Because information about reducing waste could be on a web page (...).*

Together with this, there is a lack of clear mandates on what actions to be implement, how often, and how ambitions potential interventions towards households should be. Moreover, three responded see the lack of knowledge as a barrier; what are the intervention strategies having a better impact in households? in the words of Municipality 3:

> "*(...) towards the households it is harder to know what we can do and what will have effects and where is our place in it (...) we know that only communication maybe doesn't always lead to change your behaviour. We try to work with that it should be easy to do the right thing (...) and it shouldn't be hard to understand but towards reduce food waste it is a challenge".*

The limited resources available in the municipalities was also directly mentioned as a challenge by two respondents, including time, money, and personal. Regarding the pilot campaign developed by Municipality 2 -mentioned in the previous section, the respondent shared:

> "*When we were sitting with our campaign, we had a lot of ideas, but not necessarily the resources for it* (…) a*ll of these with knocking on apartment doors and the organization in the fridge, the information about the temperature, and the best before date and so on does have an effect. But it's quiet resource intensive. You would have to have staff or hire someone go out there to the households and do it. And the municipality probably would be able to do it, but perhaps lacks the resources. Or doesn't prioritize the resources".*

In this sense the availability of resources would also shape the ambition of the interventions and actions that might be done by the municipalities. Overall, the respondents coincide in that there is a constant need of prioritizing the tasks within their departments.

Regarding priorities, it was clear throughout all the interviews that the current priority within household food waste was the implementation of the Waste Framework Directive (2008/98/EC), i.e. to ensure the proper sorting of the food waste. For instance, as mentioned by the respondent of the Municipality 4., their main challenge is to increase sorting:

> *"We want, of course, we want to reduce (food waste), but it's hard to do it. We still have the problem that we have too much food waste in the ordinary waste (...) We are trying to collect the food waste".*

This idea is also expanded by Municipality 2 as follows:

"(...) we want to increase the amount of food waste that we have separate from other waste, and we have a lot of material and information about that, because that is a challenge in itself. And then adding this other perspective on top of that is almost too much for people to take in".

Systemic challenges beyond the municipality

The respondents also focused on structural challenges, or issues that goes beyond the boundaries of the municipality, which might work as a barrier to reduce household food waste. The difficulty of behavioural change was mentioned by all the respondents. As portraited by Municipality 5:

"I think that everyone has a problem with this (reducing food waste). It's not an easy question. We can tell the inhabitants not to throw waste, but it's a mindset of people that needs to change".

Peoples owns preconceptions and beliefs regarding the topic might is also a barrier to reducing their food waste according to the respondents. One of them is that people tend to underestimate the amount of food waste they generate: "*Livsmedelsverket has also identified some of the key challenges. And I mean, they are, of course, the same to us that people underestimate the amount of unnecessary food waste they generate" (Municipality 2).* In relation to this this point, Municipality 5 exemplifies the issue by sharing the conversations they have had with some households, *"And they don't have (food waste) they say they don't have any. They say we don't throw any food away. We eat everything that we have".* Moreover Municipality 5 mentioned the behavioural challenges they currently have even when it comes to sorting food waste. In the words of the respondent "(*...) they (households) think brown bin is very ugly. It doesn't end up very well in their yard, it doesn't look good at all, so they kind of don't want to have it there".*

Another systemic challenge expressed by the respondents arises from the combination of food prices and our current lifestyles, both of which facilitate discarding food. This is shown in the following quote:

"*So other challenges, of course, are the price of food. Food is cheap, so you can throw it away. The living conditions that we have in our society, we work a lot, we are stressed (...) So we have too many variables that make it easier for the population to just get rid of it instead of taking the extra step. And those are things that the municipality has little or no control over (Municipality 2).*

From a more technical perspective, other challenges that lie beyond the scope of the municipality are packaging concerns. This was highlighted by Municipality 3

as a challenge: *"The packaging also affects; you buy big things, and you don't use a lot of it and then it is left and then of course you can use it for something else but that is when you might forget" (Municipality 3).*

Another issue named by one of the respondents was the lack of clear discourses in society regarding the importance of achieving environmental goals, specifically from the government. In the words of the respondent:

> *"The government in Sweden has been discussing if we should try to reach these goals or not (...) I mean it is even harder for us to communicate and say that we should work towards this because it's very important and at the same time the government says like oh but no we don't we don't stand behind this, I understand if it's get confusing for people (...)* (Municipality 3).

Overall, reducing household food waste was also interpreted as a complex environmental issue. As one of the respondents from Municipality 2 mentioned, it is a challenge itself to make people understand the environmental and/or social consequences of food waste, in the respondents' words: "*the consequence of it is not visible to them, right? It's like with any other complex environmental challenge. You don't feel the direct consequence, so there's no need to change."*

5.2.3 Opportunities

Communication and sharing knowledge about food waste was named as an opportunity by all the municipalities. Moreover, the importance of having multiple approaches when both designing interventions and sharing information was also highlighted throughout the interviews. People might act driven by diverse reasons; hence different communication strategies might allow the municipality to target a broader variety of society groups "*some people are very motivated by the economy aspect of things and others really are interested in like what my neighbour is doing this (...) some people they listen what politician says" Municipality 1*. For instance, one opportunity named was to visualize the economical savings that reducing food waste might bring to the households.

Working to reduce food waste in the schools was also named as an opportunity by three interviewees, as it is seen as a way for students to transference knowledge and habits from schools to households: *"Working with schools so that kids learn it and they take it home I believe that's really good and have an effect" (Municipality 3),* and,

> *"If maybe the schools would get an assignment and the corresponding resources. They would become a great information channel in each municipality. And it would become more homogenous as well. And not every municipality trying to figure out the best way, so I think that would be one way forward" (Municipality 2).*

Moreover, as mentioned by the respondent of municipality 1, not only schools but other operations runed by the municipality can have the same role: *"the municipality cook a lot of food in schools and in elderly care homes and so we can be role models because we have a lot of people employed and then they have friends to talk with and they have families to talk with so we can start a movement" (Municipality 1)*

Two municipalities, that have already been implementing campaigns and pilot projects regarding food waste saw an opportunity to continue with that work, but in a more systematic way or even to get more guidelines and directives. One of them mentioned that "(…) *it would be beneficial then like a top-down approach; you have to do this, and maybe even centralized. You have to do it this way. So that it becomes more homogenous among municipalities" (Municipality 2).*

As mentioned earlier, there has been significant emphasis by all municipalities on spreading information about food waste sorting. Regarding this last, improving sorting was considered to be a one potential opportunity to reduce household food waste, because it might be a way for households to actually see how much food waste they generate, *"So when you start to have the little bag in your kitchen, then you really, you realize how much you throw. So that's one way to visualize it" (Municipality 5).*

Finally, collaborating with other actors beyond the municipality, such as landlords, non-profit organization or even universities, were also named as an opportunity to help households reducing their food waste, *"So, in municipalities where there are universities. That there could be collaborations with those, or that the universities maybe themselves have initiatives (...)"*

6. Discussion

In this section, the results are interpreted and discussed within a broader context, while also addressing limitations of the study and suggesting areas for further research.

6.1 Changes over time

Overall, a decrease of 4% of total household food waste was detected between 2018 and 2022. When comparing these results with the data recently published by the SEPA some similarities and differences arise. According this last, household food waste has decreased 18% between 2018 and 2022, going from 68 to 56 kilograms per person per year (SEPA 2024a), which is substantially more than the 4% obtained through this study. SEPA (2024a) also shows a persistent decrease over the years, which differs from the 27% increase obtained in the present study between 2018.
and 2020.

Certainly, there are methodological differences between these studies that might help to understand the different outcomes. One of them relates to the data used to estimate the amount of sorted food waste. Whereas the SEPA report used data from food waste collected by municipalities, including business, nursing homes, restaurants and assumes that 75% of it corresponds to households, the present study used data exclusively from households WCA.

A second and noteworthy difference relates with the size of the sample. The SEPA report includes the data from all the municipalities that are members of Waste Sweden, nevertheless the data used in this study was limited to the number of municipalities that shared the WCA reports, culminating in a sample of 66 municipalities for total food waste analysis. Further implications and limitations related to the sample size are discussed below in the section “Limitations and future research”. It is yet, interesting to note that despite these methodological distinctions, this study, taking a slightly different approach, aligns with official data trends, indicating an overall reduction in household food waste for Sweden in the last few years.

However, the findings present a less optimistic view than what is indicated by the statistics of the SEPA. In the context of the SDG target 12.3 and considering the year 2020 as a baseline, a 4% decrease between in the four years of analysis would not be enough to reach a 50% decrease by 2030, when it comes to household food waste (Figure 2). In fact, the reduction should be no less than 7% on average per year. The baseline year is a key element when talking about reductions throughout the years and accomplishing targets. In this study 2020 was considered a theoretical baseline, since Sweden has committed to reduce 20% of its food waste between 2020 and 2025 (SEPA 2024b). Therefore, this year might also be a coherent baseline for the SDG Target 12.3. Nevertheless, there is still not a clear baseline year for the SDG Target 12.3, and the absolute numbers of food waste reduction might look different if choosing another baseline year.

It is also worth noting that the observed trends presented in this study are based on average food waste values per year per. Nevertheless, this figure should be interpreted taking into account the variability of the sample; when looking at the maximum and minimum values, wide variations arise in the case of apartments (Figure 3) and slightly narrower in the cases of the houses (Figure 4). This shows a variety of food waste generated by the different municipalities assessed. This variability is interesting from the point of view of potential interventions. As argued by (Eriksson et al. 2019) in the context of food waste in the hospitality sector, focusing on catering units with the highest food waste volumes could be an efficient and cost-effective strategy for reducing overall food waste. Hence, a similar approach could be applied to managing food waste across different municipalities.

When it comes to reducing household food waste, a significant reduction in the avoidable fraction needs to be ensured, since a large portion is unavoidable or inedible. In this line, it is worth noting that, as shown in Table 2, the avoidable fraction from the sorted waste has increased 17% (from 2.6 to 3.4 kilograms per person per year) between 2018 and 2022, as a weighted average for houses and apartments. This figure is far to what has been reported by the SEPA, which is approximately a 21% decrease in the avoidable fractions of households under the same period (SEPA 2024a). However, considering that the figure for avoidable food waste obtained in this study refers only to the sorted food waste fraction, the portion of avoidable food waste discarded as residual waste is hidden.

From a global perspective, data on the avoidable fraction of household food waste remains very limited, since very few countries have accurate data on avoidable; for those who have, it ranges from 31% to 77% of the total food waste (UNEP, 2024). Considering those figures, the reduction of avoidable food waste is urgently needed

at a global scale to achieving the global goal. When it comes to Sweden, the results indicate that the avoidable fraction ranges from 11% to 15% (Figure 5), which corresponds to approximately 3 to 9 kg per person per year during the years of analysis. According to the data from the SEPA report, 15 kg of avoidable food waste were discarded per capita in 2022, which corresponds to 27% of the food waste. In both cases, Swedish figures of avoidable food waste lies under the world average.

The difference between these two studies may be explained by this analysis only including avoidable food waste in the sorted fraction, while the SEPA report also includes avoidable food waste in residual waste. Additionally, it might be explained due to wrong categorization of avoidable food waste as unavoidable Since the current study uses WCA, this might be a risk especially when a significant amount of time has passed since the food was discarded or when weather conditions have accelerated the degradation process (WRI 2016). In this regard, when analyzing avoidable food waste, it is crucial to highlight that the boundary between what is deemed as "edible" or "inedible" is often ambiguous. What is considered inedible and edible food can vary between countries, regions, and consumer preferences. Hence what should be included in each category can vary between studies (Caldeira et al. 2020).

6.2 Challenges and opportunities

6.2.1 Challenges

Challenges within the municipality

According to the results, the current initiatives and actions implemented by the municipalities to reduce household food waste differ among those interviewed. Even though all the municipalities that participated in the interviews have a waste plan that includes the national targets for food waste reduction – which is in line with the SDG target 12.3 – only two of the five interviewees mentioned interventions or actions targeting households, other than sharing general information on how to reduce food waste in their webpage or social media.

This result could be interpreted in the light of the non-legally binding procedures that forces municipalities to reduce food waste, hence there might be vague guidelines when it comes to the implementation of systematic actions. This situation might lead to the non-homogenous reality for Swedish municipality food waste management, as seen in this study. In fact, the lack of clarity regarding the

municipality's role in determining what actions to implement, how often and the ambition of the actions were mentioned as a challenge by two interviewees, referring to the lack of top-down guidelines, such as a specific law.

Additionally, a second challenge identified through the interviews was the limited resources available in the municipalities to implement more ambitious interventions towards households, which together with other priorities in the waste management departments, might difficult a systematic work towards reducing household food waste. In fact, all the municipalities shared their efforts in complying with the Article 22 of the Waste Framework Directive (2008/98/EC), which declares as mandatory for households and business to sort their biological waste and to all local authorities to provide a separate collection system and came into effect in January 2024 (European Commission 2018). It is interesting to note that a systematic increase of the sorted food waste fraction in relation with the food waste discarded as residual waste was seen in this study; from 49% in 2018 to 72% in 2022 (Figure 5). This is therefore consistent with the results of the interviews, as all the respondents highlighted the efforts currently made by their municipalities to increase the amount of sorted food waste.

In this sense, legally binding targets might help to set new standards in the work of the municipality towards reducing household food waste and to prioritize this topic within the waste departments. A relevant fact is that the European Commission has proposed in July 2023 setting legally binding targets requiring European Union (EU) member states to reduce food waste by 30 percent (per capita) at retail and consumption stages, including (restaurants, food service establishments, and households) by 2030 (European Commission 2023).

It is still important to note the efforts of two municipalities that had been implementing interventions in the current or previous years. The guidelines on how to reduce waste in households, provided by Swedish Food Agency (*Livsmedelsverket*) were mentioned as useful material to promote campaigns.

Systemic challenges beyond the municipality

People underestimating the amount of food waste they generate was perceived as a challenge by the interviewees in their municipalities. This is, in fact, a documented issue. The evidence shows that in general, people underestimate the amount of food they waste themselves, which also affects how much they waste (Abeliotis et al. 2014). Furthermore, research indicates a prevalent underestimation among EU citizens of the scope and the consequences of global food waste levels on the environment (Secondi et al. 2015). The interviewees are also aware of the systemic

causes of food waste, which have been argued in the literature, such as low food prices, lifestyles and packaging issues (Hebrok & Boks 2017). This perception can be interpreted as a positive sign, as the respondents acknowledge this topic as complex environmental issue, which has challenges beyond the municipality boundaries.

In order to reduce household food waste, changing consumer food practices is crucial. Nevertheless, as Hebrok & Boks (2017) discuss it is arguable if the change should come through individualistic/agentic approach, i.e. targeting citizens with awareness and informative campaigns or a systemic approach address for instance by policy. This is indeed a multilayers issue, and as stated by the authors both approaches might be needed. Overall, all the challenges discussed above may explain the perception of all the interviewees: reducing household food waste as a hard task.

6.2.2 Opportunities

On a local scale, representatives of the municipalities expressed some opportunities that might help reduce household food waste. When it comes to raising awareness campaigns, having multiple approaches that allows to target a wide range of citizens was pointed out. This is a relevant input since there is a variety of food waste reduction motivators. As named by Van Der Werf et al. (2021) strongest potential food waste reduction motivators appear to be saving money, and moral values. While more weaker motivators are concern with environmental motivation. Moreover, one opportunity mentioned was to highlight potential economic savings of food waste reductions. Overall, there is a synergy when tackling food waste reduction from different approaches (Hebrok & Boks 2017).

Improving sorting was also perceived as an opportunity to reduce food waste; it was seen as a way to create awareness on the amount of food waste generated. Researchers have suggested that seeing the amount of food collected in the separate bag within the household may influence food waste related attitudes and behaviors (Miliute-Plepiene & Plepys 2015). Hence, it could be expected that the increase of sorted food waste might have as a consequence, the reduction of avoidable food waste in the households.

Clearer mandates with top-down approaches and details on what interventions should be implemented and how often, also arose as an opportunity. This connects to one of the challenges mentioned above. As previously discussed, this might be overcome by the potential implementation of a new regulation which would set legally binding reduction targets in the European Union (EU). The need of more detailed guidance on the ambition of interventions towards households could also

be taken into account by the central government or other institutions in charge of supporting towards food waste reduction, such as the Swedish Food Agency (*Livsmedelsverket*), and the SEPA (*Naturvårdsverket*).

Another interesting opportunity is the collaboration between municipalities and other stakeholders, such as landlords, non-profit organization and universities. In fact, Hebrok & Boks (2017) points out the lack of diversity in food waste interventions suggested in literature, and the lack of studies on its long-term effects. Hence, collaboration between local governments and universities could provide a great opportunity to develop and implement effective interventions towards household food waste reduction.

6.2 Limitations and future research

As previously noted, a significant limitation of the quantitative section of this study was the sample size, specifically the number of municipalities and years for which data was collected. While a substantial number of municipalities contributed with WCA reports (100), data from 66 municipalities was ultimately used to estimate the total food waste per capita per year. Additionally, the sample size varied across different years of analysis, making it challenging to employ further statistical analyses. Consequently, the analysis was constrained to a descriptive statistics approach, given both the limited sample size and the variability in sample sizes across years.

A limitation arises from the variability of the sample across years, coupled with differences in food waste generation among municipalities. As the municipalities providing data vary from year to year, drawing an overall conclusion on the direction of food waste generation becomes difficult. At a global level, it is also likely that data from different countries might come from different places from year to year, facing the same uncertainties.

A notable constraint concerns the access to WCA data from municipalities. Despite it being compiled within the *Avfall Web* platform, it remains unavailable for the public access. The access to this platform might have facilitated and improved the results of the current study.

Another limitation is that specific data on avoidable and unavoidable food waste disposed of as residual waste was not registered, which hindered a more precise analysis of the avoidable waste fraction. Additionally, the total food waste figure in this study included other organic waste types, such as paper, or improperly sorted

waste. Thus, the total food waste figure might be overrepresented. Since the aim of the study was to compare the trends between years it is assumed that the levels of other waste have remained stable. Further quantitative research should focus with more detail on the trends in the avoidable fraction of food waste, to inform the potential of waste reduction.
A final limitation of the quantitative aspect of this study is that the primary data was not under the control of this research, as it was collected by WCA companies hired by the municipalities following Waste Sweden's manual.

Regarding the qualitative part of this analysis, this study has focused on the perception of local governments and specifically the departments of the municipalities working directly with waste management, as key actors for this topic at a local level. However, a broader perspective on the challenges and opportunities towards reducing food waste can be taken by adding the perspectives from other actors at a national level, such as Waste Sweden (*Avfall Sverige*), the Swedish Food Agency (*Livsmedelsverket*), and the SEPA (*Naturvårdsverket*).

Two of the studied municipalities have actively been implementing actions towards households, such as campaigns, activities with citizens, visiting households and sharing information, to mention some. However, the impact of these actions has not yet been measured. Future research could focus on the impacts of such interventions, whether they lead to short and long-term behavioral changes and hence inform future actions towards reducing food waste.

Conclusion

Whether we are on the right path to achieving the SDGs is a question that has gained attention in recent years, as there are now only six years left to meet these goals. This study has provided relevant insights into the current state and trends of household food waste in Sweden revealing a slight overall decrease of 4% in total food waste generation among Swedish households from 2018 to 2022, which is not on track to meet the 50% reduction target by 2030. The amount of avoidable sorted-food waste, which represents edible food, has increased by 17% during the same period. However, this figure includes only the sorted fraction, leaving the trend in the amount of avoidable non-sorted food waste unknown. Interestingly, the overall amount of sorted food waste has increased from 42% to 72%, which coincides with the current efforts and ambitions described by municipalities.

This study also reveals that despite Sweden having some of the most reliable data globally, it is not exempt of difficulties when tracking food waste generation. One limitation encountered was the variation in the municipalities included in the analysis from year to year, which complicates consistent tracking. Additionally, the high variability in food waste levels between different municipalities, as found in this study, must be considered when monitoring trends and prioritizing the implementation of interventions.

Several challenges for the municipalities were identified. Overall, helping households to reduce food waste was perceived as a hard task. In this context, challenges both within the municipalities and beyond the municipalities scope were identified, showing the multiple layers of this complex environmental issue. Collaboration with other relevant stakeholders and clarifying the municipal role on which interventions towards households needs to be implemented, were some of the opportunities to ensure a more systematic and effective work towards reducing household food waste and achieving the Target 12.3 of the SGDs, and overall, to contributing to the advancement of more sustainable food systems.

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Popular science summary

The way we produce and consume food have serious environmental and social impacts. Considering that one third of all the food we produce for people ends up being lost or wasted, cutting down on food waste is crucial if we want to reduce the environmental impact of food production and consumption. The Sustainable Development Goals (SDGs) have set a specific target to cut Food Loss and Waste (FLW) in half by 2030. With only six years to go, this study research the current trends in food waste generation in Swedish households and potential challenges and opportunities according to municipalities. The results show that there has been a slight decrease of 4% in total food waste from both apartments and houses in Swedish municipalities between 2018 and 2022. Yet, this trend won't be enough to reach the 50% reduction goal by 2030, considering as 2020 a baseline year. When it comes to avoidable sorted-food waste, which is the fraction of edible food that ends up discarded, it increased by 17% over the same period. Nevertheless, this increase only represents the edible food waste in the sorted fraction, so the edible food waste discarded as residual waste is still unknown. An interesting result was that Sweden has improved in separating organic waste, as sorted food waste has increased from 42% to 72%.

Challenges to cutting household food waste, both within and outside the municipalities were also researched. According to representatives from municipalities, unclear roles for local governments, limited resources, and other priorities makes helping households reducing food waste a difficult task. They even highlight barriers such as people underestimating how much food they are generating themselves and low food prices as drivers of food waste beyond their own control. Overall, the results highlight the many layers of this complex environmental issue. Working together with other key actors, such as universities social organizations and getting better insights from the central government on what municipalities can do to help households cut waste are some of the ways to move forward in the task of reducing food waste. Future research can investigate which strategies work best in households, so local governments can implement them, contributing to achieving global goals, and most importantly improving sustainability of food systems.

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Appendix 1 – Interview guide

Presentation

My name is María Silva, and I am a master student of the Master program in sustainable development from Uppsala university/ SLU. This interview is part of my master's thesis, which aims to analyse the food waste levels of Swedish households in relation to the food waste reduction target of the Agenda 2030, and to discuss challenges and opportunities to accomplish the global food waste reduction target at a household level.

Thanks for taking the time to being part of this interview. The name of the municipality will be anonymous, and the information will only be use for the purposes of this thesis.

Do you agree with me recording this conversation?

Questions

1. What is your role within the municipality and how long have you been working in it?

2. Does the municipality keep track of the household food waste levels, and do you have a food waste reduction goal at a municipal level?

3. Regarding the SDGs, and specifically the target 12.3 that aims to *"By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses."*

   Is the municipality actively working towards SDG target 12.3 aiming to halve food waste by 2030 or the national target? If so, could you elaborate on the strategies and initiatives? Can you provide examples of specific actions?

4. From your perspective, what are the primary challenges faced by the municipality when addressing SDG targets related to reducing food waste, at the household level?

5. In your opinion, what are the main opportunities for the municipality in helping to achieve SDG targets or reduce household food waste.

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