Master's Thesis Internship - master Sustainable Business and Innovation

Food ≠ waste

A sustainability assessment of circular strategies managing food waste in the food-service sector of Amsterdam

By Jonah Link
J.N.H.Link@gmail.com

Supervisor City of Amsterdam

Froukje Anne Karsten
F.Karsten@Amsterdam.nl

Supervisor Utrecht University

Dr. ir. Jesús Rosales Carreón
J.RosalesCarreon@uu.nl

City of Amsterdam

Utrecht University

"A society that allows itself to admit and articulate its nonmaterial human needs, and to find nonmaterial ways to satisfy them, would require much lower material and energy throughputs and would provide much higher levels of human fulfillment" – Donella Meadows

Abstract

Our current food system is one of the main drivers of global climate change. While, still many communities remain without adequate supply of food, roughly a third of all food is wasted before it reaches the final consumer. The food-service sector is responsible for a significant share of this waste. There are many options to manage this waste through circular strategies. However, the sustainability implications of circular strategies remain unclear. The aim of this research is to identify the sustainability implications of circular strategies through a comparative case study analysis in the food-service sector. First a material flow analysis was conducted at two food-service sector organizations located in Amsterdam. Thereafter, the material flows of both cases were reviewed within four group interviews with 39 food-service sector practitioners and stakeholders ranking their most preferred circular strategy using Q-methodology. Subsequently, the implications of these preferred strategies were analyzed using Sustainable Development Goal indicators. Finally, the implications of the current situation were compared with the circular strategies to reveal the sustainability implications. It was found that between 29% and 46% of the weight of food never reaches the final consumer. The most preferred circular strategy was *stimulating behavioral change for circularity* among managers and employees. The results indicate that circular food waste management strategies improve decent work and economic growth (SDG 8) by reducing costs, sustainable cities and communities (SDG 11) through less traffic for waste management, sustainable consumption and production (SDG 12) by reducing food waste and climate action (SDG 13) through prevention of CO_2-eq emissions. More research is needed to identify the current possible barriers to behavioral change towards more circular practices. If these barriers are to overcome, addressing food waste through circular strategies can be a significant contribution in reaching multiple Sustainable Development Goals.

Executive summary

Food waste has one of the highest priorities in the European Commissions' Circular Economy Action Plan because it has a large potential for resource conservation and reduces environmental impact. Valorization of organic waste streams can be an attractive source of revenue for the city of Amsterdam. CO_2-eq emissions can be reduced by 600.000 metric tons on an annual basis which can generate 150 million Euro in revenues. The food-service sector of Amsterdam wastes between 5.100 and 34.580 metric tons of edible foods each year. The sector is expected to grow in the city, hence, there is a need to address the potential of circular strategies in valorizing food waste for the food-service sector of Amsterdam. Therefore, the following question is addressed: *What are the sustainability implications of a circular economy in managing food waste in the food-service sector of Amsterdam on an organizational level?*

First, a material flow analysis (MFA) was conducted among two hotel restaurants in the city of Amsterdam. The MFA reveals where in the system food waste occurs. From the MFA a baseline was presented for both cases operating over the year 2017. After the MFA a literature analysis was conducted to identify circular waste management options for food waste. Using these waste management options, the most preferred circular strategies were synthesized through four focus groups in which thirty-nine managers, employees and other food-service sector practitioners were consulted. After establishing the circular strategies, their impact was calculated through indicators that measure progress towards the Sustainable Development Goals to review the implications for sustainability.

The MFA showed that between 29% and 46% of the weight of purchased food is lost during storage, preparation, cooking, consumption and after buffet events. However, not all parts of food could be consumed. In terms of net food waste for case A, 23% of edible food was wasted. For case B 16% of edible food was wasted. The rest of the organic materials was either lost during evaporation or was not edible such as fruit peels, bones and coffee grounds. The largest shares of food waste occurred during the consumption phase which consisted of plate waste or buffet waste. During the preparation phase significant amounts of food were wasted as well to make the food appear more attractive by removing relatively ugly parts. Of this waste case A recycled 43% of all organic waste for case B this was 32%.

During the group interviews the material flows were discussed including twenty-one circular solutions to manage food waste. From the top rated solutions three strategies were synthesized. The most preferred strategy was '*stimulating behavioral change towards circularity'*. Changing the menu, tracking and monitoring food waste, stimulating zero-waste management and training employees were the most preferred solutions in this strategy. The second strategy found was '*smart waste management systems'*. By improving waste separation, training employees, using food waste rescue apps and through collaboration with suppliers to set up reversed logistics systems this strategy aimed to improve food waste management. This strategy was most preferred by the two executive chefs of the cases. The third strategy found was '*minimizing waste through luxury'*. In this strategy the aim was that guests would only notice improvements to the actual scenario by serving a la carte breakfast instead of buffets and allowing more flexibility in portion sizes, handing out doggy bags and improving waste separation.

Indicators to measure progress towards the Sustainable Development Goals (SDGs) were coupled with policy targets of the city of Amsterdam. Four SDGs were found most relevant to the city and the food-service sector namely SDG 8 (decent work and economic growth), SDG 11 (sustainable cities and communities), SDG 12 (responsible production and consumption) and SDG 13 (climate

action). Table 1 shows the indicators for the current scenario (BAU) and the most optimal circular scenario (circular) over the year 2017. Circular strategies to manage food waste can substantially reduce food waste costs (SDG 8). In addition, the reduction in waste and volume through decentralized waste treatment technologies reduces the amount of vehicles needed for waste transportation, 80% for case A and 86% for case B, thus contributing to more sustainable cities and communities (SDG 11). Furthermore, reducing the amount of avoidable food waste through circular strategies do not only reduce the actual waste level, it prevents the need to purchase more food than necessary. Less food purchased means costs of food can be saved and the embodied CO_2-eq impact of products is prevented thereby contributing to SDG 8, 12 and 13. Thus using circular strategies in managing food waste overall reduces costs, CO_2-eq emissions and traffic thereby contributing to sustainable development.

Several practical recommendations can be made to policymakers and management of food-service sector organizations. It was found that the disposal fees for recycling organic waste were higher than none recycled waste. If the city wants to become more circular, there is a need for an improved price mechanism that financially incentivizes waste recycling in the food-service sector. The advantage of waste improved recycling is not only that materials are saved, mixed wastes are an attraction to pests and cause unwanted smells. Moreover, reducing food waste directly reduces food costs, through the communication channels of the municipality the advantages of food waste prevention can be promoted. This can be further stimulated by rewarding best practices or through collaboration with existing certification schemes such as Green Globe to stimulate food waste reduction strategies.

Management can substantially reduce costs of food waste and contribute to an improvement in their neighborhood by adopting circular strategies for food waste management. First by starting with tracking and analyzing food waste they can measure their current impact, following this measurement they can train their employees. In this way they can advance their organizational culture towards more circular practices. Reducing food waste has direct financial benefits to businesses. Current menus are frequently designed from scratch. If chefs wish to design circular, it requires them to design with what they have while using as much material as possible from each product. Some parts of food that are now seen as unavoidable food waste, can be consumed. Including food waste in menu design can significantly reduce costs.

			Case A		Case B	
			BAU	Circular	BAU	Circular
Sustainable development goal indicators	SDG 8	Full Time Equivalent (FTE)	28	28	43	43
		Couverts (guests)	59269	59269	132120	132120
		Food waste costs	€ 86.591,26	€ 26.171,60	€ 102.802,23	€ 39.929,71
		Food waste costs per couverts	€ 1,46	€ 0,44	€ 0,78	€ 0,30
		Food waste per FTE (Kg)	334	111	363	150
	SDG 11	Theoretical SWILL vehicles	114	23	100	14
		SWILL Vehicles	104	23	104	104
		Noise/Smell/Pests complaints	No data	No data	No data	No data
	SDG 12	Raw Material Consumption (RMC)	59352	53026	104380	95138
		RMC/couvert	1,00	0,89	0,79	0,72
		Net food waste (%)	23%	8%	16%	7%
		Recycle (%)	43%	90%	32%	90%
	SDG 13	CO2-eq/RMC	379457	339013	626855	571352
		CO2-eq/couvert	6,40	5,72	4,74	4,32
		CO2-eq intensity (Kg)	6,39	6,39	6,01	6,01
		CO2-eq of food waste (Kg)	174529	115778	144528	67003

Table 1: Comparison Current situation (BAU) and Circular strategy

Acknowledgements

To me food is one of the most amazing things that grows on our living planet. Not only do we need it for its nutrients to support us through everything in life, such as writing a master's thesis, it is one of the only things that can still surprise us three times a day by its wonderful and exotic flavors. During the past months I have experienced that food was not the only thing that could surprise me on a daily basis. The process of writing this thesis surprised me all the time. Although food kept me going for most parts, it was not my only source of energy. I could not have done it without the people who supported me during this journey.

I would like to thank my supervisors from Utrecht University. Life is full of chaos, complexities, uncertainties and trade-offs. Jesús Rosales Carreón thank you for teaching me these principles in a way that I could accept, embrace and use them to move forward in no way another supervisor could have done it for me. During several phases of the thesis you gave me the right directions which have led me to the results presented in this thesis. In addition, I would like to thank Ernst Worrell for reviewing my research proposal and providing me with valuable comments. Nicolas, thank you for giving me feedback on one of the last versions of the final thesis.

Living in Amsterdam has been one of the best experiences I have had in life so far. It could therefore not have been better than conducting my internship at the institution that represents it herself, the Gemeente Amsterdam. Froukje Anne Karsten I am very grateful that you have given me the opportunity to study this research topic, the various moments of feedback you gave and letting me contribute to the 'Koplopersgroep Circulaire Hotels'. Also I would like to thank Nula van Rijn for supporting me along the process, excel sheets and focus group workshops.

I would like to thank the hotel managers, executive chefs and all other employees that contributed to the food waste audit in both hotels. When I was measuring waste, the chefs frequently asked me if I wanted to taste the food they cook. An offer very hard to resist. You made me feel welcome from the second I entered the door which overall made it an easier (and tastier) task to conduct. Furthermore, I would like to thank all the thirty-nine participants that contributed to the focus group workshops. Your enthusiasm showed me that there is great momentum to tackle this challenge during the coming decade.

Last, I would like to thank the people with whom I shared most of my food, my family. Food is not merely a necessity it is one of the cores of our culture and brings us together on the moments when it is needed most. Thank you for teaching me to value food and supporting me all the way every day. Nino, thank you for all the creative feedback sessions on FaceTime. You are a true inspiration to me.

Table of contents

1. Introduction

1.1 Food waste

The global population is expected to grow thereby increasing the demand for land, water and energy while overexploiting our oceans and exhausting our soils using our current system of food production and consumption (Godfray et al., 2010). The same agricultural system is seen as one of the main drivers of deforestation, global biodiversity loss and phosphorus depletion (WWF, 2016). Although large revenues are made in the food industry, the market is highly inefficient as one third of the food produced is wasted globally. This amounts up to 1.3 billion metric tons of food which equals 802 billion Euro annually (FAO, 2011a; Gustavsson et al., 2011). Food waste can be related to 4.4 $GtCO_2$-eq which is 8% of global annual anthropogenic greenhouse gas emissions with a potential damage of 333 billion Euro (FAO, 2011b). In addition, 815 million people of which 155 million children are currently undernourished which overall makes food waste an environmental, social and economic issue of global scale (FAO et al., 2017). To tackle this challenge, the UN (2018) has developed the Sustainable Development Goals (SDGs) with target 12.3 stating global food waste to be halved by 2030.

1.2 Circular food waste management

The European Commission (EC) has set food waste as a high priority as it has a large potential of resource conservation and a reduction in environmental impact. Therefore, the EC has prioritized food waste in the CE Action Plan (EC, 2015; EC, 2018). Circular Economy (CE) advocates claim that valorization of food waste can be an attractive source of revenue through the use of CE principles (EMF, 2017). High value utilization of organic waste streams can generate 150 million Euro and reduce CO_2-eq emissions with 600.000 metric tons on an annual basis in Amsterdam (Circle Economy, TNO & Fabric, 2016). Composting, anaerobic digestion and vermicomposting have proven to be effective in valorizing organic waste streams into organic fertilizer, proteins and renewable energy (Khalid et al., 2011; Lalander et al., 2015; Zhang et al., 2014). However, reducing the amount of food waste is the leading target as it is environmentally, socially and economically most preferable (Cristobal Garcia et al., 2016; Papargyropoulou et al., 2014).

Although the benefits of valorization of food waste seems to be evident it still remains unclear how these methods compare in terms of their circularity and their sustainability implications to large food wasters such as food-service sector organizations. In the European Union (EU) approximately 14% of food waste can be attributed to the food-service sector (Caldeira et al., 2017). In Switzerland food losses between 20% and 45% occur within restaurants, typical operators of this sector (Beretta et al., 2013). Approximately 70% of these losses can be avoided as products are still edible (Soethoudt & van der Burgh, 2017). While the sector is growing in Amsterdam (ABN AMRO, 2017), there are no indications that the food-service sector will move towards more sustainable operations (Pirani & Arafat, 2016; Refsgaard & Magnussen, 2009). Thus there is a great need to address the circular economy and the sustainability implications for food waste and its valorization in the food-service sector.

In the food-service sector of the Netherlands it is estimated that 51.000 metric tons of edible foods are being wasted (Luitjes, 2007). A conservative estimate considering that approximately 14% of food waste can be allocated to this sector, while in the Netherlands between 1,78 and 2,47 million metric tons of edible foods are being wasted overall (Bos-Brouwers et al., 2015; Caldeira et al., 2017; Soethoudt & Vollebrecht, 2018). With 10% of the food-service sector located in Amsterdam it can be expected that between 5.100 and 34.580 metric tons of edible food is being wasted annually[1]. The food waste is mainly incinerated among municipal solid wastes (AEB, 2016), although being an improvement compared to landfilling this is still not an effective solution considering the high water content of food waste (Bernstad & la Cour Jansen, 2012). Only 3% of organic waste materials are being source separated in Amsterdam of which 70% is composted and 30% is processed into bio-energy (AEB, 2016).

Many studies address different waste management systems from a lifecycle perspective in order to prioritize waste management strategies through environmental impact indicators (Bernstad & la Cour Jansen, 2011; Bernstad & la Cour Jansen, 2012; Cristobal Garcia et al., 2016; Eriksson et al., 2015; Lundie & Peters, 2005; Salemdeeb et al., 2017). Furthermore, prevention of food waste as a food waste management option is often excluded from research while being the most preferable waste management option (Bernstad & la Cour Jansen, 2012; Eriksson et al., 2015). The aforementioned studies mainly focus on comparing food waste management alternatives as if the solution would be in one management option, this however does not represent the reality of food waste related activities in the food-service sector.

Some authors conclude that there is room for improvement when it comes to harmonizing current life-cycle assessment approaches to food waste management (Cristobal Garcia et al., 2016), while others call for more indicator values of which strategic decisions can be made towards more sustainable food waste management practices (Eriksson et al., 2015). Managers are usually constrained with time to undertake detailed sustainability assessments such as LCAs. Therefore, different methods of assessment can be valid when determining effective strategies towards more sustainable food waste management practices such as operationalizing the circular economy and mapping its sustainability implications to the food-service sector on an organizational level through more streamlined assessments. Practitioners such as hotel managers want to increase their performance towards a CE, while the implications of such a transition are still unclear. Simultaneously proper tools and indicators towards a CE on a micro-scale are currently lacking and being non existent to the food-service sector. This while these indicators may have a significant impact on addressing these global challenges (Lonca et al., 2018).

1.3 Aim and research questions

The aim of this research is to review the sustainability implications of a circular economy of food waste management for food-service sector organizations in Amsterdam. The aim purposes the development of circular strategies towards sustainable development. It does so by addressing the following main research question:

What are the sustainability implications of circular strategies in managing food waste for food-service sector organizations in Amsterdam?

To indicate how the food-service sector can increase their food waste management performance towards a circular economy, there is a need for indicators applicable to businesses. However, current micro-level circular economy indicators are under development and have not been related to food waste (Pauliuk, 2018). In addition, sustainability indicators are complex and therefore mainly used by policymakers and academia. Thus more simplified indicators applicable to food-service sector

[1] Minimum of food waste is 10% of 51.000 tons, maximum is 1,4% of 2,47 million tons.

managers are necessary and need to be developed to review the state of circularity and its sustainability implications. The following sub-question will be answered through a literature review of existing micro-level indicators for circularity.

1. What indicators can be applied to review the current and future state of a circular economy and its sustainability implications within businesses operating in the food-service sector?

Addressing the sustainability implications of a circular economy requires a review of the scale of the current challenge of managing food waste within a food-service sector organization in terms of their economic, social and environmental challenges. To review the implications of a desired future state, such as the circular economy, a base line is needed. Therefore, the following sub-question will be answered.

2*. What is the current state of food waste management within food-service sector organizations in Amsterdam?*

After the baseline is developed, the implications of a desired state can be assessed using the same indicators as the baseline. However, current circular strategies for food-service sector organizations need to be developed first.

3. What circular waste management strategies can be assessed and which are the most preferred by food-service sector organizations?

Thereafter it is important to determine the sustainability implications of the preferred circular waste management strategies. Using the developed indicators, the sustainability implications of these circular strategies will be reviewed which answers the main research question what the sustainability implications are of managing food waste in the food-service sector of Amsterdam.

1.4 Social and scientific relevance

Most scientific literature addresses certain types of waste management strategies and compare their performance using solely environmental indicators and excludes methods of waste prevention (Bernstad & la Cour Jansen, 2011; Bernstad & la Cour Jansen, 2012; Cristobal Garcia et al., 2016; Eriksson et al., 2015; Lundie & Peters, 2005; Salemdeeb et al., 2017). For the food-service sector more practical knowledge of these waste management strategies is currently lacking, more practical knowledge development enhances the exchange of experiences between academia, practitioners and policymakers. Thereby contributing to more comprehensive decisions in terms of food waste management by including methods of waste prevention which overall fits the EU and Amsterdam their objectives towards a CE (Circle Economy, TNO & Fabric, 2016; EC, 2018).

The food-service sector is expected to grow in the coming years in Amsterdam (ABN AMRO, 2017), there is a great need to decouple economic growth from the use of resources and production of waste in this sector. Furthermore, environmental practices in the sector have been linked to increased performance levels (Molina-Azorín et al., 2009). Thus, the outcomes of this report will be relevant for various firms that work with food such as restaurants, hotels, caterers, canteens but also for other actors within the food supply chain such as retailers, waste handlers and food processors.

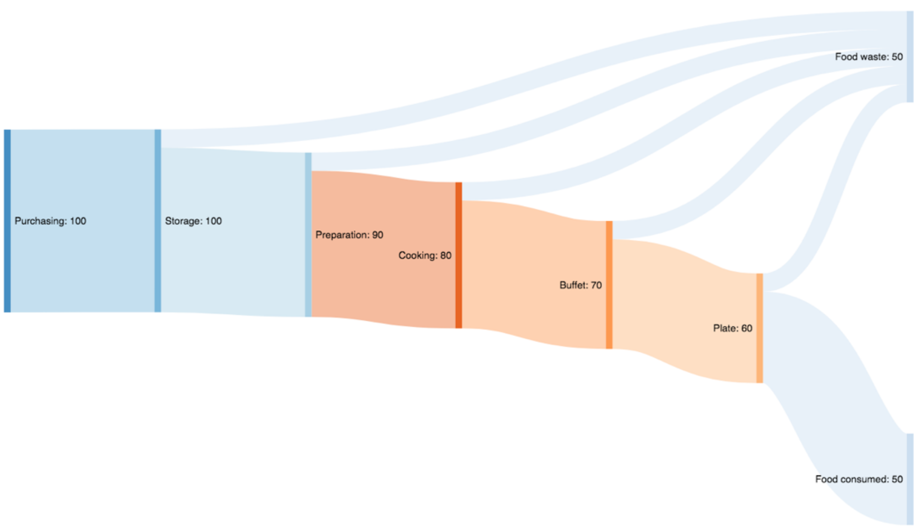
There have been, to my knowledge, no attempts yet to operationalize the circular economy of food and its waste products. In addition, it is not yet determined if the circular economy is an actual improvement in terms of sustainable development. This research attempts to overcome these gaps by putting forward an operationalization of a circular economy for food and its sustainability implications.

2. Theoretical Framework

2.1 Food Waste

The FAO (2013 p. 9) uses the following definitions for food waste and losses: "*Food loss refers to a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption. ... Food waste refers to food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. … Food wastage refers to any food lost by deterioration or waste. Thus, the term "wastage" encompasses both food loss and food waste."*. Food waste that originates from the consumption stage can be divided in two types of waste namely edible or avoidable waste and non-edible or unavoidable food waste. An example of unavoidable wastes are bones and fruit peels which have a significant mass but are not directly edible (Halloran et al., 2014; Papargyropoulou et al., 2014; Papargyropoulou et al., 2016). The FAO (2013) refers to this type of waste as food loss, for the edible waste the term food waste is applicable. Throughout this thesis the definitions avoidable and unavoidable food waste are used.

Food waste and losses occur from 'field to fork'. Half the food produced never reaches the final consumer (Lundqvist et al., 2008). Generally, in industrial developed economies food waste can be attributed for its largest share to the final stage, the consumption stage which is the focus of this thesis (Gustavsson et al., 2011). During the consumption stage five main sources of food waste can be differentiated. Food waste occurs during storage which can be addressed to qualitative storage failure, or by improper purchasing. Next, losses occur during the preparation of food such as seeds, peels and loafs from fruits and vegetables. After preparation food may be stored again and then lost for not being consumed, or it occurs during the serving stage as food may be left on serving dishes and finally plate waste may occur (Engström & Carlsson-Kanyama, 2004). Sankey 1 shows an example of where food waste occurs.



Sankey 1: Consumption phase food waste

2.1.1 Food waste in the food-service sector

Pirani and Arafat (2016) distinguish several factors that cause the generation of food waste in the hospitality sector. First, the type of service is a large determinant of the amount of food wasted. A la carte service usually causes less plate waste and leftovers as consumers directly pay for their consumption and portion sizes are relatively well prepared. Buffet style service is more wasteful as it is hard to indicate how much food will be consumed during a buffet. Furthermore, buffets need to be refilled and especially in luxurious restaurants and hotels have to look abundant. Other determinants are the type of food served. Carbohydrates are more commonly wasted in terms of mass than meat.

The expected number versus the actual number of customers are a factor for food waste. Restaurants want to continuously provide their guests with food and therefore keep their stocks high as they are afraid some guests will not have the same options. Seasonal differences may cause varying waste products and the type of food-service organization could be of influence (Ibid., 2016). At last food waste may be caused by cultural beliefs or values towards food consumption, in some cultures food must always be plentiful and therefore gets wasted by the consumers (Papargyropoulou et al., 2016).

2.2 Food waste management

After food waste occurs its method of separation influences the further streams of waste. In some cases, such as the waste of used oils, waste separation is quite common in the Netherlands and its waste is used in the production of biodiesel (Zhang et al., 2003). In Amsterdam it is not common in the food-service sector that biodegradable wastes, such as food waste, are source-separated with the exception of used oils (Stimular, 2016). Source-separation is generally seen as the most environmental preferred method as resources are kept within bio-cycles as long as possible although post-separation is the most used option within urban areas due to the economic efficiency of incineration (van Velzen et al., 2013). These centralized methods of waste management such as incineration have been reviewed as a black box to its users and therefore knowledge and motivations of the value of different waste streams are lacking among system users (Refsgaard & Magnussen, 2009).

Scientists and institutions have been developing frameworks for food waste management to support decision makers in prioritizing activities to use the value that has been put into food on its highest possible level as can be seen in figure 1 and 2 (Papargyropoulou et al., 2014; Rood et al., 2017; EC, 2018). A well known framework in the Netherlands is Moerman's ladder (figure 2). The hierarchy demonstrates different steps of waste management according to its highest use value. Moerman's ladder shows the necessary steps to be taken with at its highest level food waste prevention and at its lowest level incineration of food waste (or landfilling).

When reviewing the sustainability implications of the hierarchies, strictly following the hierarchies does not necessarily cause better results in terms of environmental impact. In addition, the highest value from a social perspective does not always make the best business case (Eriksson et al., 2015). This is illustrated by the example in which the use of edible portions of food waste for bio-medical purposes have a high economic value, however its social impact would have been higher when consumed as food by humans thereby leaving trade-offs to the decision maker (Rood et al., 2017). The hierarchy by Papargyropoulou et al. (2014) (figure 1) proposes several steps to take to maintain value of food waste at its highest level. They claim that avoidable food waste must be prevented or recycled as animal feed. Most authors state that it is important to use the hierarchies as an indicative rule of thumb when managing food waste and that deviations can occur for local differences with respect to environmental, economic or social performance. Although these hierarchies are indicative they currently do not reveal actual sustainability trade-offs and therefore they lack in providing options for synergies. Thus, sustainable food waste management requires a more holistic assessment of value retention options (EPA, 2015; Garcia et al., 2005; Papargyropoulou et al., 2014; Rood et al., 2017).

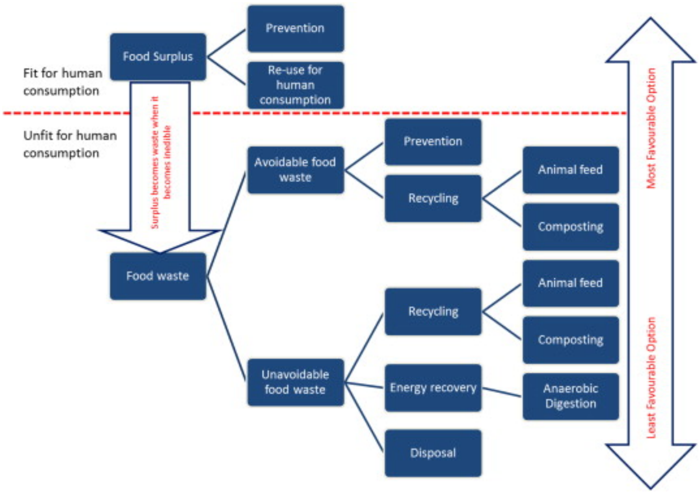


Figure 1: Food waste hierarchy (Papargyropoulou et al., 2014).

Figure 2: Moerman's ladder (Rood et al., 2017).

2.2.1 Food waste management in the circular economy

Rood et al. (2017) uses the concept of the circular economy to prioritize in the actions to be taken within food waste management quite similar to the food waste management hierarchies. Within a CE, the resources such as nutrients must be used and managed effectively. This means reducing the need for raw materials, waste disposal and closing material cycles (Elia et al., 2017). Unnecessary waste of food is a waste of resources and must be prevented while residue streams must be used at their highest optimum to prevent the loss of biomass (Rood et al., 2017). Thus, a CE is not only dependent on effective waste management. The CE is an economic system which is dependent on innovative business models and responsible producers and consumers which reduces the use of materials and alternatively reuses or recycles them on all scales of society with the purpose of sustainable development (Kirchherr et al., 2017). The CE does not only have a primary focus in waste management, but must be included over various stages within businesses while being enabled by cross sector collaborations (Elia et al., 2017).

Jurgilevich et al., (2016 p. 2) defines a circular economy for food as "*reducing the amount of waste generated in the food system, re-use of food, utilization of by-products and food waste, nutrient recycling, and changes in diet toward more diverse and more efficient food patterns. Avoidance of food waste and surplus is also a consumption issue related to consumer food competences and skills. The loop of nutrients related to the food system can, principally, be closed. The loop of matter can be partly closed relating to the reuse of food, and the utilization of byproducts and waste. Minimization of food surplus and waste reduces the overall matter consumption in the economy, thus decreasing the flow of matter related to the linear economy. The measures must be implemented both at the producer and consumer levels and, finally, in waste management.*". Thus circular food waste management is embedded in a larger food system of sustainable production, distribution and consumption practices.

However, a circular economy in itself should not be the aim, the aim should be sustainable development (Jurgilevich et al., 2016). A circular food system therefore should be a sustainable food system guided by the principles of sustainable development. Meaning that a circular food system should embed these principles where environmental, social and economic implications are integrated and contributing to long term social, economic and ecological stability for now and future generations.

2.2.2 Circular food waste management in a sustainable food system

At the EAT Stockholm Food Forum Röckstrom and Sukhdev from the Stockholm resilience center argue that food and our agricultural system is interconnected with all the Sustainable Development Goals (Röckstrom & Sukhdev, 2016). *"Because agricultural systems are the principal interface between human and environmental interactions, they are arguably our single most important solution space for addressing both environmental sustainability and food security challenges as articulated in the Sustainable Development Goals (SDGs). An ecosystem service-based approach guides this transition towards and agriculture that contributes to sustainability by emphasizing the multifunctional contributions that agriculture can make to multiple dimensions of human well-being."* (DeClerck et al., 2016 p. 93). Our food system can either directly or indirectly be linked to many of the SDGs. In short, our food system should contribute to ending hunger, poverty, inequality, fight climate change, enhance biodiversity and contribute to livable sustainable cities with healthy inhabitants. However, these goals are very high level and therefore not directly applicable on an organizational level. In a way, environmental, social and economic issues are interconnected and can be seen as 'wicked' or complex (Brown et al., 2010).

Due to the high level complexity of the circular economy and sustainable development, sustainable decision making requires certain simplifications. Indicators are found useful tools for simplifying complexity which can be the basis of informed and effective choices towards sustainable development (van Dooren et al., 2018). Therefore, it is important that when an indicator for the circular economy is being developed, environmental, social and economic criteria are reviewed simultaneously.

2.3 Indicators for a sustainable and circular food system for the food-service sector

More often measuring sustainability has been referred to as measuring the immeasurable (Böhringer & Jochem, 2007; Bell & Morse, 2012). The same might apply to measuring circularity. One can simply define a concept and then observe and measure their relationship to other phenomena (Heijungs et al., 2010). Appropriate indicators can be beneficial to decision-makers with regards to complex issues as indicators make the information more manageable (Olsthoorn et al., 2001). Indicators in general *"should be objective, understandable, significant (covering all relevant aspects), consistent with the objectives, responsive to stakeholder expectations, and allow for meaningful comparisons at a reasonable cost. They should also be "workable", in the sense that the data required to implement them are really available in practice."* (Olsthoorn et al., 2001). Thus sustainability and circular economy indicators are measurements (qualitative or quantitative) that indicate the state of sustainable development on an economic, environmental and social level and the level of circularity (Hallstedt, 2017).

2.3.1 CE-indicators

Currently, within the field of the CE, indicators are being developed for the macro, meso and micro-level (Linder et al., 2017). On a macro-level indicators are developed to review the effectiveness of policy interventions on a national or supra-national scale. Meso-level indicators are developed for industrial sites for instance in industrial heat exchange. While micro-level indicators are more relevant to review processes and products on certain quality aspects. Currently most indicators for circularity are developed for the meso and macro level, in which material flows are measured through MFA largely based on economic input-output data (Wiedmann et al., 2015). An example can be found in the Economy-Wide Material Flow Accounting Framework (EM-MFA) which is part of a UN program to combine environmental and economic indicators in one system (UN, 2014). Indicators for circularity on a micro-level, as for instance with product circularity, are not standardized yet (Geng et al., 2012). However, recent literature shows that development of indicators at micro-level is currently growing (Cayzer et al., 2017; Elia et al., 2017; Lonca et al., 2018; Walker et al., 2018).

The development of indicators towards a CE does not necessarily lead to sustainable development. Processes may become more efficient in terms of material usage, while direct material loops are being closed energy use from unsustainable sources may increase (Lonca et al., 2018). Furthermore, economic growth through applying the circular economy is frequently used as an argument to stimulate more circular behavior although critical assessments of undesirable rebound effects of more pollutive expenses are currently lacking (Scheepens et al., 2016). Metrics devoted to the CE must be systemic enough that the perceived value increases due to circularity without shifting the gains towards more environmentally polluting or socially damaging activities through these rebound effects (Ibid., 2016). Therefore, a circularity metric must function through examining the relationship between product circularity and other variables with the main purpose to increase not necessarily monetary exchange value, although it can be a motivator for businesses to participate, but also more intrinsic use value to overcome these trade-offs (Lonca et al., 2018). Indicators on micro-level should *"link the micro levers and the consequences at the macro-level. A CE assessment tool should account for both scales to drive the transition toward an authentic circularity."* (Ibid., 2018). A CE indicator needs to be applied to a broader context of sustainable development in order for it to be effective (Lonca et al., 2018; Potting et al., 2018). Thus, social, environmental and economic impact must be accounted for when using metrics for the circular economy.

2.3.2 CE-indicator assessment

In general, three types of circularity indicators can be differentiated namely material, value and activity based indicators. Most circularity metrics therefore account for different qualities to be measured. Some researchers make use of product or material value to define the circularity by determining the economic value of cascaded cycles (Coronado et al., 2015; Linder et al., 2017; Park & Chertow, 2014; Verbeek, 2016). Others indicators, usually the more qualitative ones, focus on business practices, guidelines and operations and are therefore based upon business activities (Di Maio et al., 2017; Sandoval Martinez, 2016; Togård, 2016). Use of these qualitative indicators for comparative purposes does not make sense unless specific precautions are taken by reviewing the subjective criteria in a more objective way by including objective social, environmental or economic performance criteria. Some of the indicators are based upon ROs and material cycles (EMF, 2017; Figge et al., 2018; Veleva, 2017), these indicators are frequently applied in combination with material flow analysis. The value based and material based indicators overlap as value can be assigned to a certain material and chemical or technical material properties may be assigned to a certain value.

According to Potting et al., (2018) indicators must be established by input (materials, value), throughput (activities, efficiency), output and outcome (resource use, environmental pressure, socio-economic developments). Most circularity indicators mainly focus on either input or output of value and materials. Some authors working on circularity indicators try to develop the indicator as a single-score indicator. Single-score indicator however do not have meaning. For example, an increase of the durability of a product might cause a decrease in recyclability. When combining these criteria in a single-score circularity indicator, the sustainability implications are overlooked (Lonca et al., 2018; Potting et al., 2018). Thus, putting the indicator in a broader context helps in identifying the implications of a circular economy on a micro-level. Moreover, the CE concept comprises of different layers of strategies (throughput) that ultimately have different implications (input, output and outcomes). Therefore, the next sections provide a broader perspective of a circular economy by first discussing circular strategies for addressing food waste. Thereafter Material Flow Analysis (MFA) is discussed as the circular strategies have impact on the material flows.

2.4 Circular economy strategies for addressing food waste

Reike et al. (2018) describe ten Recourse Retention Options (ROs) as a hierarchy of different CE strategies. Their framework focusses on technical flows thereby leaving out services and biological flows. According to their conceptualization biological flows can be addressed through refuse (R0), reduce (R1), re-use/resell (R2) and recover (R8) of materials. Potting et al. (2018) demonstrate that more circular strategies can be applied to biomass and food. Using the frameworks by Potting et al. (2018), Reike et al. (2018), Papargyropoulou et al. (2014) and Moerman's ladder, a circularity performance ladder for food and its waste products was created. The circularity performance ladder differentiates in three main levels namely short loop cycling (food remains its function), medium long loop cycling (producers are involved and materials are upcycled) and long loop cycling (materials lose their original functionality) (Reike et al., 2018). An overview of the circular flows can be found in figure 3. The yellow flows are monetary flows spend to purchase food and fees for waste management.

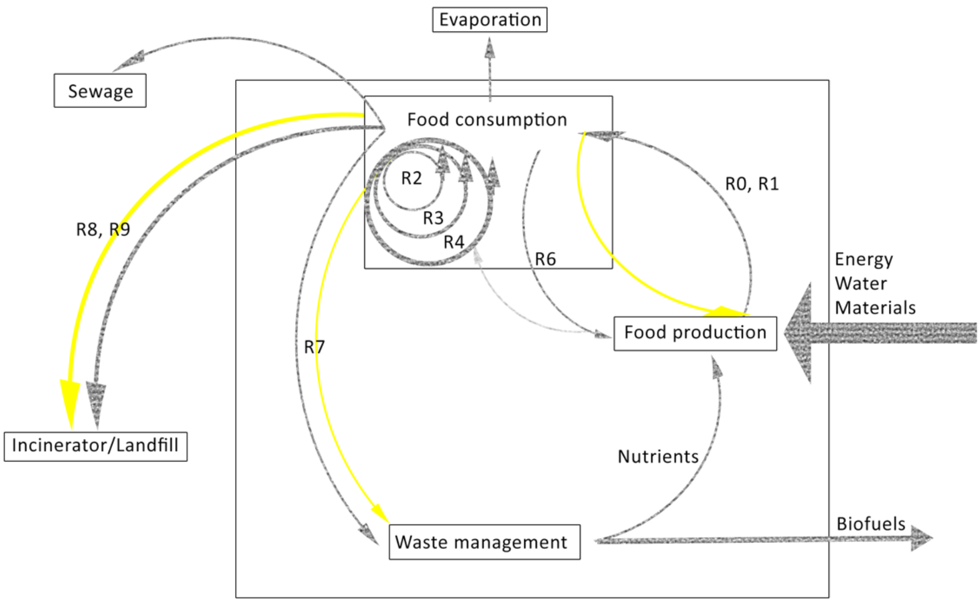


Figure 3: Circular strategies

2.4.1 Short loops: Refuse, Reduce, Reuse, Resell, Repair, Refurbish & Remanufacture

Potting et al. (2018) explains different examples of circular strategies for food and biomass. Refuse (R0) as a circular strategy can be described as avoiding hazardous materials or designing products to avoid waste (Reike et al., 2018). This can be done by shifting diets from animal based protein to plant based protein, or by for instance, refusing the consumption of snacks thereby completely eliminating a certain type of product from a diet (Potting et al., 2018). Thus, the circular strategy R0 can be seen as a dietary shift. Potting et al. (2018) describe Reduce (R1) as eating more efficient products, such as industrial prepared foods or choosing food products with higher nutritional value over other types of products. The circular strategy R1 can thus be described as using less material per unit of production

(Reike et al., 2018), or consuming more efficient. Potting et al. (2018) also mentions Rethink as a circular strategy. As rethinking a system is a necessary strategy, it does not work well as a categorization in the food waste circularity ladder because both R0 as well as R1 requires businesses to rethink their current strategy. Nevertheless, either refuse, rethink or reduce implies buying and using different materials and designing different products. Refuse can better be described as entirely eliminating certain types of products to be used. While reduce as a strategy would be aiming for products with a higher nutrient density or products from a more efficient production value chain.

Next, within the short loop cycle, products can be reused or resold (R2). Both concepts are interchangeable as reselling food automatically means it will be reused. Examples of this can be found in food donations of products that have not been sold, or the reuse of edible foods in sauces, soups or by selling them on alternative markets to avoid food wastage. Lastly products can be Repaired. Potting et al. (2018) does not give any example within this circular strategy. Food products can actually be repaired (R3), for instance a broth can become 'cloudy' which is an undesirable quality, it can become clear again using special cooking techniques. In the end, all strategies can be used. They however only serve one purpose which is finally reducing the total amount of waste and increasing the efficiency of consumption. Looking at Moerman's ladder all fall within the categories where food products end up as human food.

At last, there are the strategies to Refurbish (R4) and Remanufacture (R5). In technical cycles these are described as medium long cycles, however, for the food-service sector these activities will probably remain within the companies own activities. Potting et al. (2018) gives the example of refurbishing vegetables in water in a way that the quality of the product improves. Remanufacturing is not mentioned by Potting et al. (2018). However, a quick google search shows that food products can be remanufactured, for instance, old bread can be turned back into new bread through the use of sourdough (Williams, 2017). Which is in line with the description provided by Reike et al. (2018), new materials are added to old materials to upcycle the overall value of a product.

2.4.2 Medium long loop: Repurpose

Refurbish (R4), remanufacture (R5) and repurpose (R6) are described as the medium long loops (Reike et al., 2018). In the case of food only repurposing food is a medium long loop circular strategy. Potting et al. (2018) use the example of repurposing food or unavoidable food waste as animal feed. Through this strategy the materials are added to a new lifecycle of either animals or insects. Repurposing food therefore resembles the category of Moerman's ladder which describes animal feed as second highest priority.

2.4.3 Long loop: Recycle & Recover

At last there are the so-called long loops namely recycle (R7) and recover (R8). Potting et al. (2018) categorizes food and biomass recycling as using the materials in pharmaceutical products or by using unavoidable waste as material for packaging. Other recycling methods are composting and anaerobic digestion. According to Reike et al. (2018) recovery is more often connected to incineration of waste with energy recovery.

Overall it can be stated that for food in the food-service sector there are three possible circular options. Food or avoidable food waste can either be consumed by humans (R0, R1, R2, R3, R4, R5) trough the use of various short-loop strategies, it can be repurposed (R6) within medium long loops to be consumed by animals and food can either be recycled (R7) or recovered (R8). When looking at unavoidable food waste the same hierarchy applies. However, unavoidable food waste can only end up in the short loop through a cultural change by perceiving unavoidable waste of food as edible.

2.5 Material flow analysis

According to Brunner and Rechberger (2016) the material flow analysis (MFA) offers helpful tools in identifying indicators for target setting and eventual reduction of food waste for the food-service sector. MFA is a systematic method in which an overview of used materials can be presented and analyzed to set up a base line for an evaluation while providing a tool for forecasting future developments of waste reduction strategies (Brunner & Rechberger, 2016). With the MFA the materials that flow through a company in terms of inputs and outputs can be measured and therefore is frequently applied in food waste studies (Beretta et al., 2013; Betz et al., 2015; Papargyropoulou et al., 2014). The MFA helps in understanding where in the system food waste is occurring and why. It involves the analysis of process steps and visualizing quantities of waste materials through Sankey diagrams. Although the MFA is a useful tool in identifying material cycles, its main limitation is that it solely provides quantitative information on material flows and therefore neglects other areas of sustainability implications such as environmental or social impact (Brunner & Rechberger, 2016). However, the MFA can be used for the development of the indicators that represent input, throughput and output of food products and waste materials. This still leaves a gap in indicators that represent the outcomes of the material flows, such as environmental impacts, associated costs or other social burdens. For the review of environmental, social and economic indicators it is necessary to conduct a sustainability assessment and for that appropriate indicators that represent the sustainability of a system are needed.

2.6 Sustainability assessment

Using sustainability assessment, the material flows and their current and future impact can be reviewed based upon environmental, economic and social criteria. Sustainability assessment is increasingly used in decision making as it offers new perspectives to produce holistic solutions and highlight trade-offs. In order to use a sustainability assessment framework, the sustainable food waste management practices should be identified first, thereafter the impacts in terms of environmental, social and economic criteria can be reviewed (Iacovidou & Voulvoulis, 2018). According to Waas et al. (2014), conducting a sustainability assessment has four possible advantages to decision makers. First, SA ensures that a decision is taken in a holistic matter as all sustainability impacts are reviewed. Second, SA operationalizes sustainability by assigning certain criteria to it, which encourages debate about what is important within a socio-environmental context. Third, SA is a learning process which can change the views of decision-makers and therefore might create opportunities for change. Fourth, SA is a tool which structures complex information and allows decision-makers to deal with different criteria in a structured manner. A holistic framework for identifying targets and indicators for sustainability are the Sustainable Development Goals.

2.6.1 Sustainable Development Goals and targets

The Sustainable Development Goals have several targets which are relevant for the development of the city of Amsterdam. In total there are seventeen different SDGs and according to Röckstrom & Sukhdev (2016) all seventeen are directly or indirectly related to the supply chain of food products (figure 4). For the city and food waste in the food-service sector four goals were identified as most relevant for its development. Therefore, they are highlighted in more detail in the next paragraphs.

Figure 4: The seventeen Sustainable Development Goals (UN, 2018)

Although the SDGs are not directly taken up by the city in its official policy documents, there is movement towards implementation of the goals from several organizations (Impact Hub Amsterdam, 2018; Fennema, 2018; Iorga, 2018). Current policy and vision reports show that for many of the SDG targets existing policy already seems to align with the SDG's. Amsterdam has the ambitions to increase employment and stimulate economic growth through the circular economy (Circle Economy et al., 2016), this is in line with the targets of SDG 8 for decent work and economic growth. Moreover, through sustainable use of materials Amsterdam wants to become 50% circular by 2030 and 100% circular in 2050, an ambition in line with SDG 12 for responsible production and consumption (Ibid., 2016). The city wants to stimulate smart transportation systems to increase the quality of air (van Bergen, 2015), in line with SDG 11 for sustainable cities and communities. Furthermore, Amsterdam is member of the Climate Leadership Group (C40) and wants to comply its policy goals to the Paris Agreement by reducing impact to global warming (Van den Bosch, 2018). Reducing emissions of direct and indirect CO_2-equivalent is directly in line with SDG 13 for climate action.

2.6.2 SDG 8 decent work and economic growth

SDG 8 aims to *"promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all"* (GRI & UNGC, 2018). The food-service sector in Amsterdam can be related to three targets of this goal. Target 8.2 for instance aims to achieve higher levels of economic productivity in labor-intensive sectors while fostering productive local employment. Target 8.4 is described as improving *"progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programs on sustainable consumption and production, with developed countries taking the lead".* At last target 8.9 states that "*by 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products".* Hotels and their restaurant, the objects of study in this thesis, are inherently connected to the tourism sector in Amsterdam.

2.6.3 SDG 11 Sustainable cities and communities

SDG 11 aims to "*make cities and human settlements inclusive, safe, resilient and sustainable*" (GRI & UNGC, 2018). Possible relevant business actions that can contribute to this goal is understanding the impact of business activities on its local community. In terms of food waste, a significant amount of traffic is caused by transportation of waste. Target 11.2 aims to provide sustainable transport including transportation of materials and products. Currently in Amsterdam quality of air is high on the agenda as the current quality is exceeding the standards that are demanded by the EU (Milieudefensie, 2018). Target 11.6 aims to "*reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management*.".

2.6.4 SDG 12 Responsible consumption and production

The goal of SDG 12 aims to "*ensure sustainable consumption and production patterns*". This SDG touches upon many of the other SDG's because it directly aims to address material and energy efficiency of businesses. In total there are five targets that can directly be related to food waste management. Target 12.2 aims to *"achieve the sustainable management and efficient use of natural resources"*. Target 12.3, maybe the most relevant target to this thesis, is set 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".* In addition, target 12.4 aims to achieve environmentally sound management of all wastes with target 12.5 aiming to reduce the generation of waste trough circular strategies such as the prevention, reduction, reuse and recycling of waste materials. At last target 12.6 can be related to food waste, although it is more focused on communicating with stakeholders to ensure adequate sustainable performance.

2.6.5 SDG 13 Climate action

The last goal is SDG 13 which objective is to *"take urgent action to combat climate change and its impacts"*. As food products require a significant amount of energy, land and resources to be produced and finally consumed indicators related to food waste and climate change performance can be highly relevant to disclose. Target 13.1 supports businesses to set science based targets in line with the Paris agreement by disclosing data on CO2-eq emissions. Target 13.2 for instance encourages businesses to integrate climate change measures in its strategies and policies.

3. Methodology

3.1 Research design & data sample

The aim of this study is to understand the sustainability implications of a circular economy for food waste in the food-service sector. To address this question, a comparative case study design was used (Bryman, 2008). The comparison among cases gives the opportunity to understand phenomena in different contexts (Goodrick, 2014). The implications of food waste management are highly context specific and therefore the generalizability of findings is low as can be seen in prior food waste related studies (Eriksson et al., 2012; Eriksson et al., 2015). Thus the design of this research was explorative as the aim was not to depict a generalizable outcome but to get a more comprehensive understanding of the implications involved.

Following a comparative case study design it was necessary that the sample of case studies were comparable (Bryman, 2008). The selected sample consisted of two hotel-restaurants. Two cases were selected because this allowed a cross comparison of different situations and an understanding of similarities and differences among the cases to the benefit of theory building (Gustafsson, 2017). The two selected cases were part of a city wide government program in Amsterdam called 'Koplopersgroep circulaire hotels' meaning 'First movers towards circular hotels'. Therefore, interest in conducting this research was at hand among the cases. Mapping food waste flows was a timely exercise, conducting a comparative case study analysis using two cases was therefore the right balance between research quality, costs (in time) and validity for the given time of this thesis. The study was divided into four phases (Figure 5).

Phase 1: Food waste audit

Research question: What is the current state of food waste management within food service sector organizations in Amsterdam?

Methods: Material flow analysis & observations

Phase 2: Food waste management options

Research question: What food waste management strategies can be assessed and which strategies are the most preferred by food-service sector organizations?

Methods: Literature review

Phase 3: Circular strategy development

Research question: What food waste management strategies can be assessed and which strategies are the most preferred by food-service sector organizations?

Methods: Group interviews (n=39) & Q-methodology

Phase 4: Sustainability Assessment

Research question: What are the sustainability implications of circular strategies in managing food waste for food-service sector organizations in Amsterdam?

Methods: Calculations Sustainable Development Goal indicators

Figure 5: Phases, research questions and methods

In the first phase, section 3.2.1, a food waste audit was executed. In the second phase, section 3.2.2, a literature review of food waste management options was conducted. Following Iacovidou and Voulvoulis (2018), these options were qualitatively reviewed on their sustainability. In the third phase, section 3.2.3, the food waste management options were discussed through four group interviews with 39 hotel and restaurant stakeholders to synthesize the most preferred circular strategies. The fourth phase, section 3.2.4, consists of a revision of the material flows from the food waste audit using the circular strategies from the third phase. After the revision of the material flows, the flows are assessed on their sustainability using Sustainable Development Goal indicators. This is followed by a triangulation of the results with the hotel management.

This thesis uses both quantitative as well as qualitative data, the methods of data collection can therefore be described as mixed. The quantitative data is mainly provided by the mass balance and the derived indicators, while the qualitative data consists of in field observations, informal interviews and group interviews. This section describes the tools and materials of data collection that were used during this thesis.

3.2 Methods of data collection

3.2.1 Phase 1: Food waste audit

The food waste audit consists of three methods of data collection. During the first step in setting the base line and building the context and cases for the next phases, ethnographic research was conducted in the form of participant observation. In ethnographic research the researcher immerses itself in a given context, listens to and engages in conversations for an extended period of time (Bryman, 2008). For both case studies the researcher has immersed himself for a week in the restaurants. The participant observation was part of the waste audit. Furthermore, the employees are a sufficient resource of providing context when large amounts of food waste were found. During the observations notes and pictures were taken to get as much detail on the organization and processes involved.

The food waste audit (step 2) was conducted to collect data on flows of avoidable and unavoidable food waste. The waste was measured using a weighing scale and three types of waste bins to separate the avoidable and unavoidable food waste from other general waste flows. The waste was collected from the storage, during preparation, cooking, consumption and after buffet events (Sankey 2). Quantities were established for breakfast, lunch, dinner and the staff cafeteria. Waste audits are used to measure quantities and to determine compositions of waste streams, the waste audit is conducted by means of small samples to represent larger amounts of waste produced over a year (Eriksson et al., 2018; FLW, 2016). To extrapolate the data, the average of food waste per worked hour was multiplied with the total amount of worked hours over the year 2017.

In the third step, using a mass balance, incoming flows of food and outgoing flows of organic waste were calculated. The mass balance can then be presented in a Sankey diagram (Sankey 2). After the conducted mass balance, sustainability and circularity indicators for the baseline were derived from the material flow analysis for both cases. The protocol of this food waste audit can be found in Annex A.

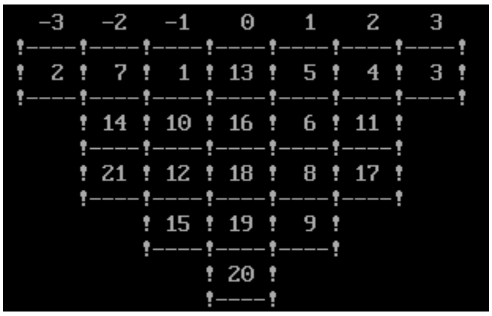
3.2.2 Phase 2: Literature review food waste management options

In the second phase a literature review of food waste management options was conducted. First reports on food waste management in the food-service sector were collected from institutions such as the Food and Agricultural Organization (FAO), Waste and Resources Action Programme (WRAP), Environmental Protection Agency (EPA), Rethink Food waste through economics and data (ReFED), European Commission (EC) and the World Wildlife Fund (WWF). Using their food waste reports, the possible waste management options for the food-service sector were gathered. After determining the possible options, they were qualitatively reviewed on their circularity using the R-framework and on the sustainability criteria costs, CO_2-eq emissions, traffic, use of space, practicality, sounds and smells using a five-point red-green scale. Thereafter, using case studies from scientific reports and grey literature their possible impact on the material flows was determined.

3.2.3 Phase 3: Circular strategy development through Q-methodology

In this third phase the results of the material flow analysis, the observations and the literature review of waste management options was discussed during four group interview sessions conducted with fifteen staff members of the given cases and twenty-four other food-service sector related stakeholders. The group interviews were set to verify the data collected and to seek clarification in what the most preferred strategies are in tackling food waste in the food-service sector. The aim of this group interview is to spark discussions among the participants to discover the best strategy for solving the given problem. In group interviews participants respond to each other thereby tending to provide checks and balances to their answers (Flick, 2014).

To gather the best strategy from an in-field perspective the Q-methodology was used as an inspiration to the group interview protocol. Q-methodology was originally developed as a psychological method for revealing human subjectivity (Brown, 1980; Stephenson, 1953). Currently the method is spreading towards other disciplines and sustainability oriented research topics such as stakeholder perspectives of wind farms and environmental decision-making highlighting consensus and conflicts within policy (Webler, Danielson & Tuler, 2009; Späth, 2018; Wolsink & Breukers, 2010; Qu et al., 2015). With Q-methodology participants individually rank statements written down on cards in a quasi-normal distribution scaled from disagreement to agreement thereby revealing their subjective perspective (figure 6) (Brouwer, 1999). After the card sort the sort can be analyzed with the PQmethod software by Schmolck using a principal component analysis (McKeown & Thomas, 1988)[2]. In this analysis not the respondents, but their given set of statements are the unit of analysis. This highlights similarities between respondents. These similarities are simplified to a reduced number of factors (Späth, 2018). The factors, that represent a simplified shared perspective of these individuals, can then be placed into a narrative using quotes and insights from the interviews during the process of card sorting.



-3	-2	-1	0	1	2	3
2	7	1	13	5	4	3
	14	10	16	6	11	
	21	12	18	8	17	
		15	19	9		
			20			

Figure 6: Quasi-normal distribution in PQmethod software including coded waste management options.

During the four group interviews one of the two cases was presented to the participants. The participants received data related to the food waste flows of the given case. In addition, context for the given cases was provided such as the amount of space, employees and service style. Throughout the workshop the participants reviewed the goal to improve the food waste management of the given case. The participants were then divided in teams of three, table 1 shows the division of teams and the case the team was assigned to. Using their personal experience in the sector they were asked to scale twenty-one proposed circular solutions into the quasi-normal distribution according to their perspective for the given cases. The solutions were presented on cards together with the sustainability criteria (Picture 1). Green indicates an improvement, yellow for no change and orange and red for a decrease. The complete card sort can be found in appendix A.

Picture 1: Example solution card for Q-method.

[2] http://schmolck.userweb.mwn.de/qmethod/downpqmac.htm

Focus group	Qmethod team	Participant nr.	Function	Organization
1 – case A	1	1	Executive chef	Restaurant
		2	Intern food services	Hotel
		3	Assistant professor	University
	2	4	Account manager	Waste consulting
		5	Operations director	Hotel
		6	Advisor	Governmental organization
	3	7	Regional manager	KHN
		8	F&B manager	Hotel
		9	Manager foodservice	Caterer
	4	10	Operations manager	Hotel
		11	Hotel manager	Hotel
		12	Data analyst	Consulting company
2 – case B	5	13	Hotel manager	Hotel
		14	F&B manager	Hotel
		15	Executive board member	Amusement park
	6	16	Policy advisor	Municipality
		17	Hotel manager	Hotel
		18	Business analyst	Bank
	7	19	General manager	Hotel
		20	Hotel manager	Hotel
		21	Hotel manager	Hotel
	8	22	Hotel director	Hotel
		23	Marketing manager	Restaurant
		24	Farmer	
3 – Case A	9	25	Executive chef	Hotel
		26	Chef	Hotel
		27	Director	Hotel
	10	28	Reception	Hotel
		29	Bar	Hotel
		30	Hotel manager	Hotel
	11	31	Chef	Hotel
		32	Sous-chef	Hotel
		33	Chef	Hotel
4 – Case B	12	34	Executive chef	Hotel
		35	Financial controller	Hotel
		36	Chef	Hotel
	13	37	Waiter	Hotel
		38	Chef	Hotel
		39	F&B manager	Hotel

Table 2: Focus group participants, Q-method team division and case assignment

3.2.4 Phase 4: Sustainability assessment

GRI and UNGC (2018) recommend several key performance indicators that were used to measure and track progress over time for the four Sustainable Development Goals discussed in section 2.6. Table 2 shows the method of measurement for the indicators and its data sources.

To measure progress of SDG 8 five indicators were selected. The first indicator is the the total amount of Full-time equivalents (FTE). Tracking the amount of FTE is a strong indicator of a business its contribution to employment rates. If the amount of FTE increases, a business its employment increases. To then review if an increase or decrease in total amount of FTE is fit with a decoupling of material impact it was coupled to the total amount of (avoidable) food waste. That being a food waste-FTE performance indicator. Next, economic value was used as an indicator to track progress over time. Current food waste practices are associated with costs of purchasing food products. These costs can be diverted if for instance, food waste is prevented and material costs of products are decreasing while profits are increasing. To track food waste performance, food waste costs (FW-costs) was measured as a value indicator for food waste. The FW-cost comprises of the total amount of cost spend to purchase raw material never being consumed, including the fees for waste hauling. As these costs can be much higher for bigger companies the costs were linked to the amount of couverts. A couvert in restaurants is a common unit of measurement to indicate the amount of people served.

Significant amounts of traffic are caused by waste hauling. This heavy weight transportation is a large emitter of NOx thereby being a contributor to local air pollution. Therefore, keeping track of the total amount of waste vehicles related to food waste is a key performance indicator for businesses to their performance towards sustainable cities and communities (SDG 11). In addition, a theoretical optimum of the amount of vehicles was added to review the efficiency and if improvements can be made. Furthermore, organic waste is associated with noise, pests and smell. Another KPI that was measured is the amount of complaints related to sound, pests such as rats or smells.

For SDG 12 the total amount of consumed products was measured in Raw Material Consumption (RMC). To add context to the total amount of consumed product it was set off to a production unit namely the amount of couverts. To measure progress in food waste reduction the total amount of net consumption was related to the amount of avoidable food waste which gives the total food waste expressed in percentages. Growth or decline in sales is included in the figure, thereby presenting the overall increase or decrease of food consumption efficiency over time. In terms of waste recycling the percentages of wasted food to composting and anaerobic digestion was monitored.

To measure SDG 13 four indicators were found. The CO_2-eq emissions of all raw (food) materials consumed was calculated and expressed in ton. Divided by the amount of couverts, every guest has an average CO_2-eq footprint. The CO_2-eq intensity is the amount of emitted emissions per Kilogram of food purchased. Less consumption of high energy intensive food products results in a lower amount of CO_2-eq intensity. This is a rate that can be used for comparison. At last food waste was expressed in CO_2-eq emissions. An overview of calculations can be found in table 2, more details can be found in Annex C.

Indicator	*Formula*	Source
Food waste cost (€)	*(average food price (€) * Avoidable waste (Kg)) + waste fees (€)*	
	Average food price (€) = Food costs (€) / Food purchased (Kg)	Price level de Kweker (2018) & Invoice
	*Waste fees = (separated waste (Kg) * €0,22) + (non-serparated waste (Kg) * €0,14)*	Invoice
SWILL vehicles	*Invoiced pick up moments*	Invoice
Theoretical SWILL vehicles	*Total waste volume (l) / Waste storage capacity*	Food waste audit
	*Total waste (Kg) * waste density*	Food waste audit
Raw material consumption	*Raw material consumption (- avoided food waste)*	Invoice
Net food waste (%)	*Avoidable food waste / (Raw material consumption - Unavoidable food waste - evaporation)*	Food waste audit
Recycle (%)	*Total collected organic waste / Total organic waste*	Invoice
CO2-eq of RMC	*(CO2-eq product 1 * total consumption product 1) + … (CO2-eq product n * total consumption product n)*	RIVM (2016); RIVM, in press
CO2-eq intensity	*CO2-eq / RMC*	
CO2-eq FW	*CO2-eq intensity * Food waste*	

Table 3: Indicators, calculations and sources

3.3 Data analysis

The objective of this thesis was to assess the sustainability implications of circular strategies in managing food waste. The material flows for both cases were used during the group interviews in phase 3, therefore the data was visualized using the open source Sankey tool 'SankeyMatic' by Steve Bogart. To analyze the results of the group interviews, the solution cards (phase 2) were numerically coded in a random order. Thereafter, the quasi-normal distribution was inserted into the Pqmethod software. Subsequently, the codes of the card sorts from the thirteen teams were entered into the software. The sorts were then analyzed through a principal component analysis (PCA). In PCA the data is reduced to a few factors which is done through two steps. First the factors are extracted. With the factor extraction all responses were summarized into three factors. These three factors represent similar views of teams. Three factors were chosen to optimize the representativeness of the results, more factors would have resulted in qualitatively similar factors and therefore not of added value as a circular strategy. After the PCA a factor rotation was applied. Through factor rotation a clearer and more interpretable structure is created for the results where the significant loadings of some teams were rotated from in between two factors to one factor. After factor rotation there are two important sets of data that describe a factor. The factor loadings indicate the relation between each team and circular strategy in a correlation coefficient. In addition, the z-scores are calculated through a weighted average of significant loaded card sorts. These z-scores determine how strong a strategy is related to a waste management option. More details of the software can be found in the pqmethod manual[3].

Finally, each factor represents a certain amount of waste management options that were either positively or negatively loaded. Thus these factors can be associated with a positive or negative preference over a solution. The circular strategies were synthesized from the four waste management options with the highest z-scores. These strategies were then interpreted using quotes and anecdotes from the group interviews of the teams with the highest correlation coefficient to the factor. The strategy was then described in a narrative style to clarify their meaning (Watts & Stenner, 2012).

[3] http://schmolck.org/qmethod/pqmanual.htm#view

After establishing the narratives for the circular strategies the Sustainable Development Goal indicators are calculated for the current situation as well as for each circular strategy. In this way a quantitative value was given to a strategy which represents a realistic outcome of the most preferred strategy among practitioners in the food-service sector. The resulted change in value for the given indicators are then used to analyze the implications of the circular strategies to sustainability.

3.4 Methodological limitations

3.4.1 Limitations phase 1

There are several limitations concerning the undertaken methods. For instance, the mass balance was conducted by extrapolating direct measurements to indicate the amount of waste over a year. As through seasons different types of food products are consumed. However, the method is very effective and through verification by the chef and by a comparison of yearly bought food the largest remarks in data were found and explained when they occurred.

During the waste audit the researcher immersed himself in the analyzed organizations. The disadvantage of this method of direct observations and measurements is that participants of the research feel studied and might want to show 'the best side of itself' which may have influenced the data collected. To prevent this, the role of '*participant as observer'* was taken by the researcher, this means that members of the organization were aware of the researcher's status as a researcher but offers the opportunity of getting close to the people which gains trust and therefore minimizes the risk of behavioral change or active deceptions of data (Bryman, 2008). During the waste audit and observations, the researcher wore the same professional clothing and assisted in food preparations without implicating the results of this study.

3.4.2 Limitations phase 2 and 3

Instead of applying Q-method in the traditional sense using semi-structured interviews, this thesis applied the method in group interviews. In addition, the card sort was not performed individually but in teams of three individuals. There are several risks to group interviews. For instance, there is a chance of group thinking that might arise during the sessions (Flick, 2014). This may occur when one participant is influencing the thought process of the other participants. However, the card sort was performed in smaller teams. Every team had their own quasi-normal distribution to divide the cards. It is therefore unlikely that one participant would influence the overall thought processes of the sort of other teams as they were given the opportunity to discuss the cards amongst themselves. Within the teams there is still a probability of group think where the decision of one of the participants would outweigh the decision of another during the card sorting process. Still, the intention of the card sort was not to collect all possible perspectives but to arrive at preferred strategies. The researcher of this thesis, who was also the moderator of the focus groups, would observe if conflicts would emerge within the teams during this process.

The choice of waste management options for the card sort has a significant impact on this research and to Qmethod in general because it limits the choices of the participants (Zabala, Sandbrook & Mukherjee, 2018). The way that the participants perceive a certain solution may influence the results. To overcome this, the selected options came from reliable institutions and an extra handout was given to the participants where they could review the meaning of a waste management option. In addition, the overcome bias of the researcher in selecting the options a variety of short to long loop circular options were chosen. During the group interviews the participants were stimulated to suggest other alternatives.

3.4.3 Limitations phase 4

The same for other methods of sustainability assessment such as life cycle assessment some difficulties may arise with selecting impact categories (Reap et al., 2008). For instance, other SDGs could have been identified as being relevant to the city of Amsterdam and the food-service sector. Different SDGs would have resulted in other indicators to measure the sustainability implications. However, for the food-service sector in Amsterdam there have not been any analyses like this thesis before. The author therefore relied on feedback from food-service sector practitioners as well as civil servants in setting boundaries in terms of impact categories. In addition, the aim of this thesis is to provide a tool not only available to an expert audience, simplifications were therefore necessary.

In sustainability assessments there are multiple complexities involved to objectively determine which targets are more important than others. Decision makers are often faced with trade-offs and have multiple objectives to choose from. To remain objective during this process the Q-method was used to identify the most preferred strategies and to then objectively determine the implications of these preferred strategies.

At last, some remarks can be made in terms of data quality. The projected impact on the circular material flows was derived from earlier case studies. Therefore, it can not be guaranteed that this will have the same effects if implemented because of the contextual difference between the sources and case studies involved. To overcome this limitation, the sources for the impact was documented in this thesis to remain transparent.

4. Results

4.1 Case A

4.1.1 Context case A

Case A is a restaurant that operates in the center of Amsterdam within a four-star hotel. The hotel has 56 hotel rooms. On maximum capacity 112 people can overnight. The hotel lobby has a bar including public and private meeting rooms. The hotel is green globe certified, meaning that they have achieved over 50% of the green globe standard criteria related to sustainable management, cultural heritage and environment. The restaurant can be described as classic French style, using seasonal products, artisanal and local food. Breakfast starts at 07:00 and ends at 11:00, lunch is between 12:00 and 15:00 and dinner is served between 18:00 and 22:30.

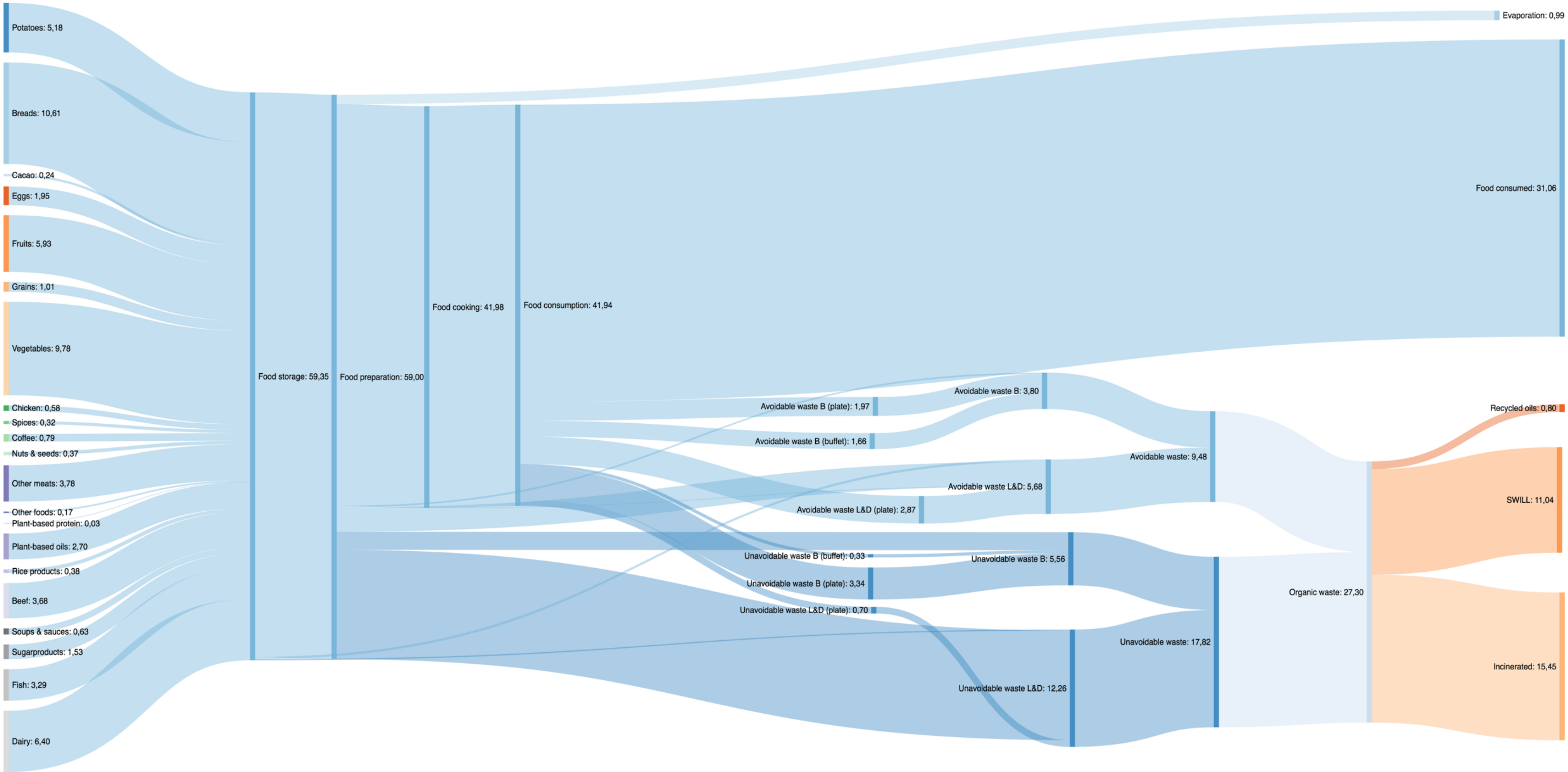
The breakfast is classic Dutch. The concept is a buffet style breakfast but is a 'hybrid' as warm dishes such as poached eggs, French toast and pancakes can be ordered on the side from a menu but is included in the buffet price. Various cheeses, meats, drinks and different types of breads are stored on the buffet which is unlimited and does not include a fee for not finishing the plate. The buffet is continuously refilled so that products remain fresh and food safety can be guaranteed. The breakfast is primarily served to hotel guests, however, as an outsider it is possible to visit the restaurant for non hotel guests. The average amount of customers served during breakfast is 54 every day which is 55% of the guests that overnight. The cost of a breakfast is €22,50.

Lunch includes a variety of different meals. Customers can for instance choose late breakfast types of dishes such as yoghurt and omelets but can also order different types of sandwiches, soups and salads that include a variety of meats, fish, cheeses and vegetables. A lot of the products that are used for the lunch are also used for the dinner. This is done to safe the amount of storage space and to reduce the amount of labor needed for the preparation of the food. The dinner has various starters in which options for vegetarian and vegan are available. Typical French dishes are served such as snails, oysters and foie de canard. For the main course with the meat dishes French fries and green salad is included. A three course dinner costs €42,50 and a five course meal €52,50.

The restaurant also has some necessary logistics to provide the guests with the same menu every day. The food is delivered by seventeen different suppliers of which some, such as the bakery, deliver every day. Other suppliers with specialty foods such as the snails do not arrive every day but once every week or once every two weeks. For the hotel and the restaurant general waste is picked up every day (excluding Sunday) and includes two 700 liter containers. SWILL, or food waste, is picked up using two special 240 liter containers and is picked up every three to four days except on Sunday.

4.1.2 Material flows case A

The next paragraphs present the material flows for food and its waste products that are being produced, consumed and finally wasted. Sankey 3 is presented on the next page and differentiates between five stages namely food purchasing, food storage, food preparation, food consumption and food waste handling. Following the RIVM (in press.) 21 different categories of food products are presented within the purchasing stage. The amounts are measured in metric tons per year for the year 2017.



Sankey 2: Food material and waste flows Case A

4.1.2.1 Purchased products

Figure 7 shows the total amount of purchased products differentiated over 21 categories. In total in case A 59,35 tons of products are purchased. The categories potatoes, breads, fruits, vegetables, other meats, beef, fish and dairy represent 77% of the total amount of food. The largest amount of food being consumed by weight are the breads which are followed by vegetables. The total amount of products that are consumed in 2017 and includes breakfast, lunch, dinner and staff food. After the products are being purchased some are directly used in food preparation and never reach storage or are shortly stored after preparation before finally serving them. Over all purchased products 0,99 tons of weight is lost due to evaporation of cooking processes. From the total amount of purchased foods 31,06 tons are finally consumed. Thus meaning that 46% of all purchased products by weight is not consumed. Figure 7 shows the different product categories purchased by case A expressed in Kg.

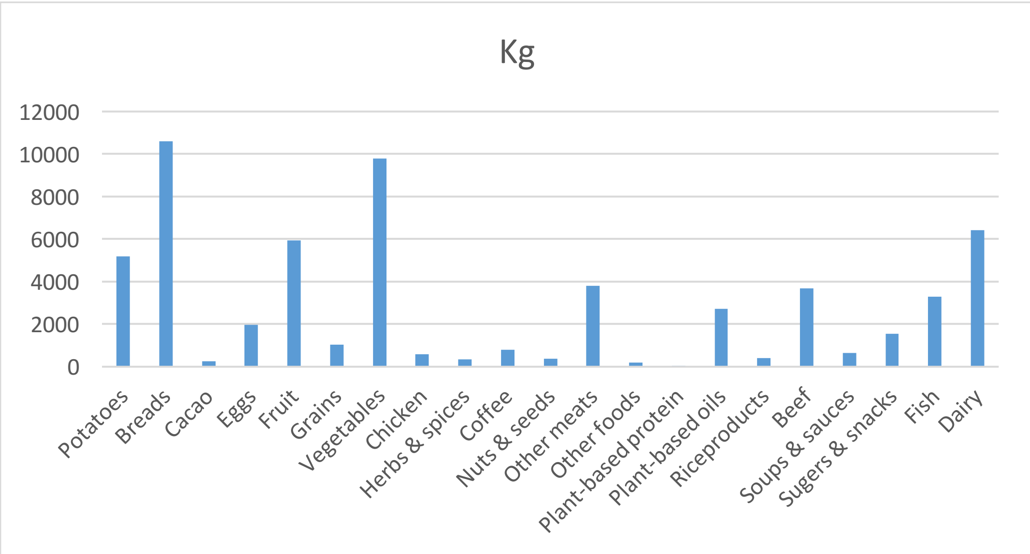


Figure 7: Purchased products Case A

4.1.2.2 Food storage waste

In this case the food that went out of date was relatively low, only a minor fraction 0,3% of food was lost during storage. Two things affected this avoidable loss of food storage. A portion of edible prepared food was dropped and therefore not useable anymore for human consumption. The second origin was fish as it is a product that deteriorates faster than other products in general.

4.1.2.3 Food preparation waste

The largest share of unavoidable food waste occurred during the preparation stage. Of the raw materials coming in the food preparation stage 16,03 tons was lost before it could be consumed. As the Sankey indicates the largest share of preparation food waste is unavoidable waste 11,44 tons for the lunch and dinner. A very large part of unavoidable waste originates from bones which were used to make stock but also vegetables that were used in the stock. Another source of unavoidable waste were leftovers of fish and fish scales that were used for a bouillabaisse. According to the chef using stocks, soups, sauces and bouillabaisse is in general the most common way to reuse food products. For a bell pepper we measured the amount of unavoidable waste being the seeds and stem. The waste of the bell pepper was 50 grams for every whole pepper (200 gram including unavoidable waste). Another unavoidable preparation waste stream 1,88 tons, but significantly smaller, was meant for the breakfast buffet. Large share of this waste consisted of fruit skins from melon, pineapple and grapefruits. Furthermore, unavoidable waste consisted of eggshells. In addition, coffee grounds contributed to a large share of unavoidable food waste. Every gram of coffee consumed takes up four times it weights due to the added water content.

In addition, avoidable food waste was found during the preparation stage. The amount of avoidable food waste during preparation of breakfast is negligible (0,17 tons). For the preparation of lunch and dinner 2,54 Tons of edible food was lost. The largest share of this waste can be pointed to the style of cooking and plate presentation such as the tournée cut. Using this style all vegetables are cut in exactly even parts. In this way the food cooks evenly over the whole product, however, to do so many edible parts of food are left unused. Another source is the use of biscuit cutters to make even circles within beetroots for presentational purposes. From a day to day basis these types of food waste look negligible but add up to a significant amount of the total waste flows. These were the largest flows of waste within this case.

Phase	Kg/y	T/y
Total avoidable storage waste Breakfast	0,0	0,0
Total avoidable preparation waste B	167,9	0,17
Total avoidable kitchen waste B	0,0	0,00
Total avoidable plate waste B	1970,4	1,97
Total avoidable buffet waste B	1663,9	1,66
Total avoidable breakfast FW	**3802,2**	**3,80**
Total avoidable storage Lunch & Dinner	229,0	0,23
Total avoidable preparation L&D	2542,3	2,54
Total avoidable kitchen L&D	41,1	0,04
Total avoidable plate waste L&D	2865,2	2,87
Total avoidable buffet waste L&D	0,0	0,00
Total avoidable L&D FW	**5677,6**	**5,68**
Total avoidable FW	**9479,8**	**9,48**
Total unavoidable storage waste B	0,0	0,00
Total unavoidable preparation waste B	1878,5	1,88
Total unavoidable kitchen waste B	0,0	0,00
Total unavoidable plate waste B	3341,9	3,34
Total unavoidable buffet waste B	334,9	0,33
Total unavoidable breakfast FW	**5555,3**	**5,56**
Total unavoidable storage L&D	120,7	0,12
Total unavoidable preparation L&D	11441,7	11,44
Total unavoidable kitchen L&D	0,0	0,00
Total unavoidable plate waste L&D	701,1	0,70
Total unavoidable buffet waste L&D	0,0	0,00
Total unavoidable L&D FW	**12263,5**	**12,26**
Total unavoidable FW	**17818,7**	**17,82**
Total breakfast	**9357,5**	**9,36**
Total lunch and diner	**17941,1**	**17,94**
Total FW	**27298,6**	**27,30**

Table 4: Avoidable and unavoidable food waste per phase Case A

4.1.2.4 Food consumption waste
The largest share of total avoidable food waste occurred during consumption stage (10,88 tons). The largest share of avoidable waste originated from lunch and dinner plates (2,87 tons). From visible observations this mainly were supplements added to main courses during the dinner. Furthermore, this hotel usually has a lot of guests from the United States who frequently do not eat their vegetables. According to one of the chefs there is a reason that restaurants serve and throw away these supplements. This is, according to the chef, because guests want to be provided with enough food. The restaurant tried to sell the main courses without the supplements but the revenue of the supplements was missed on a daily basis so they shifted back to the system where supplements are standard included.

The other share of avoidable waste from food consumption is actually larger than the lunch and dinner plate waste, namely 3,63 Tons avoidable breakfast food waste, however is divided over plate waste (1,97 Tons) and buffet waste (1,66 Tons). Plate waste was frequently accompanied by cheeses, meats, eggs and bread. Buffet waste mainly consisted of breads, although a large share of breads is distributed to the staff canteen. According to the staff the amount of plate waste was usually caused by guests, frequently families, who make a buffet of their own on the table. During some occasions bread and butter cake is made out of bread leftovers.

4.1.2.5 Organic waste separation
In total 27,30 tons of organic waste was found. The waste can be divided in 9,36 Tons of avoidable waste and 17,94 tons of unavoidable waste. No matter what part the waste originates from, they can both be described as organic waste streams. Of the organic waste approximately 11,04 tons was collected as SWILL and 0,7 tons was collected as used cooking oils. This leaves 15,45 tons of waste with the general waste streams and therefore is assumed to be incinerated among other municipal solid wastes.

4.2 Case B
4.2.1 Context case B
Case B is a restaurant that operates in an area which is currently under large scale development in Amsterdam within a four-star hotel, the hotel has 288 rooms. The hotel has opened quite recently and is located within a new building. The restaurant has two kitchens, one for the initial preparation of all foods and the 'show' kitchen which is used to finish the ordered dishes for the guests. The style is described as Dutch cuisine. The style is therefore mainly focused on vegetables that are grown within the Netherlands therefore using seasonal and local products. The restaurant is open from 06:30 until 23:00. There is no break between breakfast, lunch and dinner. Breakfast starts at 06:30 and ends when lunch starts at 11:30 with lunch and dinner starting from then.

The breakfast is served a la carte, which is not common for hotels this size. However, guests can order as much breakfast as they pay one fee to be admitted to the breakfast which includes (most) drinks and dishes. The dishes include a variety of yoghurts, eggs and sandwiches. The guests can order in as much rounds as they want although the restaurant prefers the guests to order in one round as they need to make space for the next guests to arrive. The average amount of guests served is 200 each day. The costs of a breakfast are €29,50 however, prices vary as more often the breakfast is included within the hotel payments.

Within this restaurant not only lunch and dinner use the same ingredients, the same dishes are served. Guests can choose a variety of different meals all varying in size and price including vegan and vegetarian options. The prices of the meals vary between €8,50 and €37,5.

The restaurant has 20 different suppliers with varying moments of delivery. Because of the size of the hotel a special purchasing team accepts and plans the deliveries. In terms of waste management, a waste compactor is used for the general waste which is emptied when full. For the SWILL 240 liter containers are used and emptied once every three to four days except on Sunday.

4.2.2 Material flows case B

Because of the size of the hotel the restaurant has two kitchens. One for preparation and one for cooking in the restaurant. During the cooking stage food and products are also wasted sometimes because too much is prepared or a product is cooked in a wrong way and therefore wasted. In addition, the cafeteria food waste was added to the Sankey on the next page as the waste flows were significant part of the total amount of food waste expresses in tons over the year 2018.

4.2.2.1 Purchased products

Figure 8 shows the purchased food. In total 104,62 tons of food are expected to be consumed within 1 year of operation. The largest category of food being purchased are the vegetables (36,05 tons) which represent roughly a third of all products. The category is followed by fruits, beef, dairy, eggs and potatoes which together are good for 75% of all purchased food products including products that are used in the staff canteen. From the total amount of purchased food 76,43 tons are consumed. Thus 29% of all purchased food is not consumed. The material flows of case B can be assessed in Sankey 3.

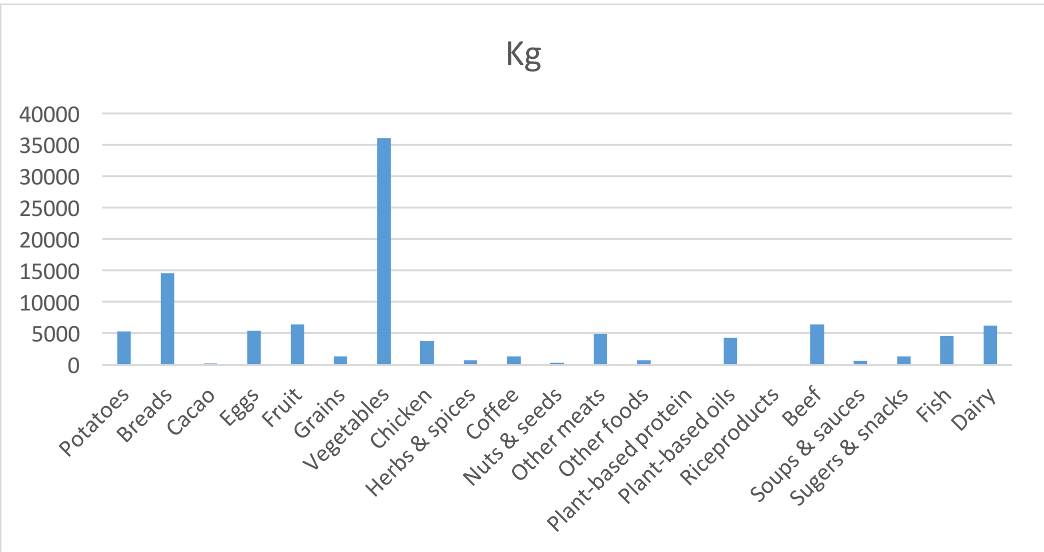
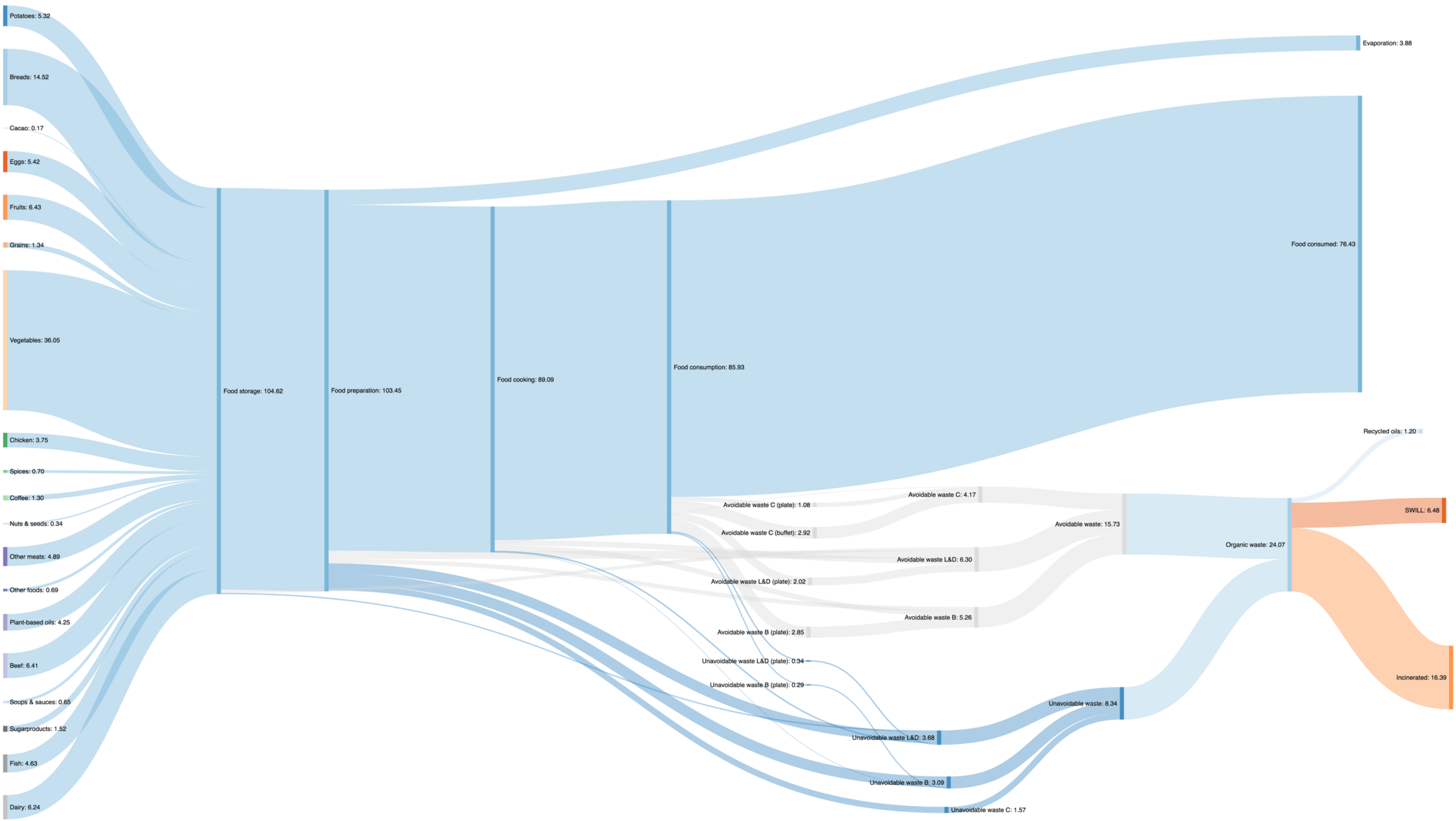


Figure 8: Purchased products Case B

4.2.2.2 Food storage waste

For case B a negligible amount of food (0,21 tons) is being wasted from storage waste. The restaurant has a very large area for storage with many different storage units and different temperatures of storage too cool meats, dairy, fruits and vegetables according to their needs in separate cooling units.



Sankey 3: Food and food waste material flows Case B

4.2.2.3 Food preparation waste

During the initial preparation stage 14,36 tons of raw materials are wasted. Of this waste 2,01 tons originates from preparation for lunch and dinner and is avoidable food waste. This mainly originated from vegetables being cut to improve their visual qualities. Some parts were edible but one of the chefs mentioned that this would be eaten in for instance Japan, but not in the Netherlands. Another 1,10 tons of avoidable food waste is preparation for breakfast. The main source for this was spillage due to overcooking during preparation of steamed fruits and burned bread. For the canteen preparation 0,17 tons of avoidable waste was found. In terms of unavoidable waste during lunch and dinner 2,64 tons was measured. This mainly came from parts from inedible parts of vegetables such as the stems and leaves of cauliflowers and fish scales from for instance the smoked salmon. For breakfast unavoidable preparation waste was 2,75 tons of which a large share came from egg shells. For the canteen 1,57 tons of unavoidable waste was found which was mainly coffee grounds.

4.2.2.4 Food cooking waste

According to the chefs a lot of cooking waste occured because the waiters are not trained enough yet. During busy hours the waiters make mistakes pushing through wrong tickets and therefore not the right dish is made. Frequently this dish was used as staff food or sold to somebody else, but this was not always possible. For breakfast 1,31 tons of avoidable waste was found. During lunch and dinner 1,42 Tons of edible food was wasted. This waste could mainly be allocated to over production of vegetables but also leftover sauces. Unavoidable waste was found 0,05 tons for breakfast, mainly being egg shells. For lunch and dinner, the unavoidable waste (0,38 tons) originated from the vegetables.

4.2.2.5 Food consumption waste

The food waste occurring during the consumption stage was mainly caused by leftover plate waste. During breakfast this waste was 2,85 tons for the avoidable flows. In the breakfast a lot of cheeses, meats, eggs and breads were wasted. Although the motivation to not have a buffet for this hotel was to reduce the amount of food waste, their current approach for breakfast a la carte still includes a system where the guests can order as much food as they want without feeling the consequences of not finishing their plates. According to the waiters it frequently occurred that guests form the UAE would order all the dishes on the menu only being able to finish a third of what they would have ordered. In addition, food waste was found in small sauce containers which were mainly used for butter and jam, by estimate more than a third of all prepared butter and jam containers returned to the kitchen and was wasted.

For the lunch and dinner, the waste was measured as 2,02 tons marked avoidable. One of the waiters, mentioned that the guests didn't eat their vegetables "but they had a good time and that's what we're going for". Again mainly supplements and vegetables were wasted by guests, even though they would have ordered it themselves. About 1,08 tons of avoidable plate waste came from the canteen, sometimes the staff scooped up a lot from the buffet but found out it just wasn't to their taste. In the canteen about 2,92 tons was thrown away as buffet waste. For case B this is the largest food waste flow. This was mainly due to over preparation of for instance potatoes but also filling salads such as pasta salads and a significant amount of edible bread.

The amount of unavoidable consumer plate waste was very low, during breakfast this mainly was found in tea, eggshells or fruit (0,29 tons). During lunch and dinner 0,34 tons of unavoidable waste was found which was frequently caused by oyster shells and inedible parts of vegetables.

Phase	Kg/y	T/y
Total avoidable storage waste B	0,0	0,00
Total avoidable preparation waste B	1101,7	1,10
Total avoidable kitchen waste B	1307,7	1,31
Total avoidable plate waste B	2848,3	2,85
Total avoidable buffet waste B	0,0	0,00
Total avoidable breakfast FW	**5257,7**	**5,26**
Total avoidable storage L&D	853,6	0,85
Total avoidable preparation L&D	2005,3	2,01
Total avoidable kitchen L&D	1422,7	1,42
Total avoidable plate waste L&D	2018,8	2,02
Total avoidable buffet waste L&D	0,0	0,00
Total avoidable L&D FW	**6300,4**	**6,30**
Total avoidable storage C	0,0	0,00
Total avoidable preparation C	171,3	0,17
Total avoidable kitchen C	0,0	0,00
Total avoidable plate waste C	1076,5	1,08
Total avoidable buffet waste C	2923,8	2,92
Total avoidable C	**4172,2**	**4,17**
Total avoidable FW	**15730,3**	**15,73**
Total unavoidable storage waste B	0,0	0,00
Total unavoidable preparation waste B	2753,9	2,75
Total unavoidable kitchen waste B	53,8	0,05
Total unavoidable plate waste B	287,1	0,29
Total unavoidable buffet waste B	0,0	0,00
Total unavoidable breakfast FW	**3094,8**	**3,09**
Total unavoidable storage L&D	315,8	0,32
Total unavoidable preparation L&D	2639,8	2,64
Total unavoidable kitchen L&D	378,9	0,38
Total unavoidable plate waste L&D	341,0	0,34
Total unavoidable buffet waste L&D	0,0	0,00
Total unavoidable L&D FW	**3675,5**	**3,68**
Total unavoidable storage C	0,0	0,00
Total unavoidable preparation C	1565,9	1,57
Total unavoidable kitchen C	0,0	0,00
Total unavoidable plate waste C	0,0	0,00
Total unavoidable buffet waste C	0,0	0,00
Total unavoidable C	**1565,2**	**1,57**
Total unavoidable FW	**8335,6**	**8,34**
Total breakfast	8352,4	8,35
Total lunch and diner	9976,0	9,98
Total cafetaria	5737,4	5,74
Total FW	**24065,8**	**24,07**

Table 5: Avoidable and unavoidable food waste Case B.

4.2.2.6 Organic waste separation

For the total of 24,07 tons of organic waste, 16,39 tons ended up as general waste, 6,48 tons as SWILL and 1,20 tons of oil was recycled. The restaurant had only opened very recently therefore the core focus was on preparing the food well. Although there was a team for purchasing and contact with waste handlers, no special system was put in place through the entire restaurant to manage and separate organic waste streams. The organic waste was therefore only source separated in the production kitchen and at the dishwasher.

4.3 Food waste management options

Table 6 shows 21 food waste management options scaled along the circularity ladder. A non exhaustive list of waste management options were reviewed on their possible impact on food waste. The options came from several sources such as WRAP (2018), NEA (2016), Jensen and Teuber (2017), Filimonau and De Coteau (2019) and Martin-Rios et al. (2018). A description of these options can be found in Annex B. The options are possible interventions to increase the circularity of food consumption within the food-service sector. These options were used and discussed during the focus group to identify the most preferred strategies. The results of the focus group can be found in the next sections.

Circularity	Solutions	impact	Waste stream	Source
R0	Menucard adaptation	17%	Avoidable FW	ReFED, 2018
	Waste tracking & analytics	15%	Avoidable FW	EPA, 2015
R1	Smaller plates	20%	Buffet plate waste	ReFED, 2018
	ugly vegetables			Instock, 2018
	Stafffood per plate	20%	L&D avoidable preparation waste	ReFED, 2018; WRAP, 2018
	Educating guests	20%	Avoidable plate waste	Kallbekken & Sælen, 2013
	A la carte breakfast	20%	Avoidable breakfast plate	ReFED, 2018; WRAP, 2018
	Training employees	32%	Avoidable preparation waste	WRAP, 2018
	Improved reservation system	no data	Breakfast buffet waste	Tuppen, 2014.; WRAP, 2018
	Flexible portion sizes	no data	Plate waste	Berkowitz et al., 2016
	Zero waste chef	10%	Avoidable FW	Restaurant Nolla, 2018
R2	Food waste rescue app	17%	Breakfast buffet waste	Wang et al., 2017
	Doggy bag	10%	Plate waste	
R6	Vermicomposter	5%	Unavoidable waste	Le Compostier, 2018; Munroe, n.d.
R7	Composter	50%	Reduces waste volume	Bortolotti et al., 2018
	Dehydrator	70%	Reduces waste volume	Bortolotti et al., 2018
	Improved waste separation	90%	Increases waste separation	
	FW grinder + vaccuummachine	15%	Reduces waste volume	Bortolotti et al., 2018
	GRO/SOOP		Reduces waste of coffee (Kg)	
	Reversed logistics	no data	Reduces logistics	Govindan & Soleimani, 2017
	Anaerobic digester	30%	Reduces waste volume	Bortolotti et al., 2018

Table 6: Food waste management options

4.4 Focus group results

Overall most teams agreed that training employees was the best circular strategy of managing food waste. From the focus groups the main line of reasoning for this was that whatever waste management option or circular strategy a company chooses, the most important thing for its success is the participation of employees using these solutions. When employees understand why a certain strategy is necessary and how they can commit themselves to that strategy the effectiveness will increase. One of the participants mentioned that "*a waste management option can work really well in theory, but will never work out on the floor if the employees do not understand why it is necessary and what the impact will be*".

The Q-varimax rotation revealed in total three factors with an explained variance of 55%. This means that more than halve the perspectives are represented by the strategies presented in the following paragraphs. Table 7 shows the correlation coefficient of the teams for each factor. The flagged results, green in table 7, were used to create the factors. Factor 1 has an explained variance of

25%, factor 2 with 17% and factor 3 with an explained variance of 13%. Only team 11 did not correlate enough with the results of the other teams to be included in one of the factors. Four out of the seven teams that were subjected to case A have their scores in factor 1, meaning this was the most preferred strategy for case A. For Case B two out of six Qsorts were used for factor 2 and two out of six Qsorts were used for factor 3 thereby not having a significant indication of which strategy is most preferred. In the next paragraphs these three factors are explained and represent three possible circular strategies for managing food waste in the food-service sector.

	Factors		
	1	2	3
Team			
1	0.8385	-0.0143	-0.0563
2	0.3850	0.1554	0.5365
3	0.6754	0.0556	0.1670
4	0.8230	0.1310	0.3575
5	0.0309	0.4194	0.5878
6	0.5436	-0.3543	0.2396
7	0.6411	0.1983	-0.1944
8	0.1911	0.3235	0.0566
9	-0.1855	0.7548	0.2958
10	0.6656	0.4711	-0.1382
11	0.0324	-0.0015	-0.4252
12	0.1872	0.9114	-0.0559
13	0.1024	0.2976	0.7142
% expl.Var.	25	17	13

Table 7: Correlation coefficient per team and factor.

4.4.1 Circular strategy 1. Stimulating behavioral change for circularity

Table 8 shows the Z-scores for all the given strategies. The four best strategies are changing the menu card (3), waste tracking and analytics (5), assigning a zero-waste chef (20) and training the employees (17). These options all fall within short-loop circularity. According to the factor the worst options were flexible portion sizes (19), the dehydrator (2), the anaerobic digester (21) and the use of a food grinder in combination with a vacuum machine (10). Most of these options except for the flexible portion sizes can be described as long-loop circularity. The very most distinguishing solutions for circular strategy 1 with $P < 0.01$ was changing the menu card and the zero-waste chef. Most of the participants that were within one of the teams of factor 1 had a function related to management or were indirectly related to the food-service sector.

According to the teams that contributed to this factor, managing food waste begins with cultural and behavioral change of the team and the guests. Methods of waste prevention however, are most important, thereafter options such as recycling should be looked at. They see the challenges of communicating these measures of food waste prevention to the team and operationalizing these solutions. A way of communicating measurements to the team is by using waste tracking and analytics to keep track of progress. Weekly assigning a different waste manager in the team can stimulate behavioral change and encourage better performance in relation to food waste management. An interesting addition of adapting the menu is that you can directly also lower your impact by choosing more seasonal products which overall increases the value as these products are frequently cheaper than other products, while at the same time maximizing the output of these products by using as much as possible.

Remarkably flexible portion sizes, although suggested by many of the used resources, was seen as one of the worst options for food waste management. Multiple teams stated that this waste management option might have an opposite impact to food waste. Using flexible portion sizes makes it even more difficult to estimate the total amount that will be consumed and requires a very high level of flexibility which is forced by the consumer instead of by the producer. The producers, in this case the chefs, usually know by experience how much food is a right portion size. If somebody is less hungry they are more likely to choose the lighter options on the menu instead of ordering a small sized portion of a heavy meal. Using flexible portion sizes was associated with fast-food companies. In hospitality being flexible is key in delivering good service, if somebody asks for a smaller or a bit larger size, it is never a problem.

Code	Circular strategy	Z-scores
3	Menucard adaptation	1.531
5	Waste tracking and analytics	1.472
20	Zero waste manager	1.440
17	Training employees	1.377
12	A la carte breakfast	0.832
8	'Ugly' Vegetables	0.410
6	Improved waste separation	0.369
4	Smaller plates	0.367
18	Improved reservation system	0.353
11	Nudging guests	0.082
16	Reversed logistics	0.066
9	Staff food per plate	0.004
7	Food waste rescue app	-0.006
14	Vermicomposter	-0.394
13	Doggy bag	-0.396
1	Composter	-0.738
15	GRO/SOOP	-0.947
19	Flexible portion sizes	-1.331
2	Dehydrator	-1.478
21	Anaerobic digester	-1.497
10	Food grinder and vacuum machine	-1.516

Table 8: Card sort Z-scores for Factor 1.

4.4.2 Circular strategy 2. Smart waste management systems

Table 9 shows the Z-scores for factor 2. The most preferred food waste management options in this factor are improved waste separation (6), training the employees (17), Food waste rescue app (7) and reversed logistics (16). In terms of circularity these options are part of short-loop circular strategies, medium-loop and long-loop circularity. The worst waste management options are improving the reservation system (18), the food waste crusher and vacuum machine (10), plating staff food (9) and the use of the dehydrator (2). The most distinguishing solutions for this factor are Food waste rescue app, reversed logistics. Most of the participants in the teams of this factor were directly related to hotels and restaurants in the food-service sector. Both executive chefs of the actual cases being reviewed participated in two teams in this factor.

During the focus groups teams related to this factor were more frequently mentioning logistics and waste management than other teams. There will always be a certain fraction of waste, better organizing the waste management by collaborating locally is the way to go forward according to the teams. For instance, collaborating with an app such as Too good to go[4] seems an ideal solution to increase flexibility of the breakfast buffet or a good way to sell leftover cakes while simultaneously attracting more local guests to the restaurant. One of the participants had experience using the app and stated that the use of the app stimulates a certain behavioral change because it requires the employees to improve their planning to reduce food waste. This factor also focusses on increased recycling of waste, increasing recycling is the easiest and most practical strategy in becoming more circular in food consumption if it is assumed that incineration is the non-circular option. All teams were very interested in reversed logistics as a strategy to reduce unavoidable waste, for instance returning wasted coffee grounds with the coffee supplier or sending back unavoidable waste of vegetables to the supplier who can distribute it to a local composter. Internally stimulating the discussion to re-review the whole cycle of suppliers and waste managers collecting the waste is essential in making this system more optimal. However, a challenge herein lies within the responsibility, who should be responsible for reviewing this cycle and stimulating change. In addition, every change should be facilitated and be made as easy as possible to employees.

Code	Circular strategy	Z-scores
6	Improved waste separation	2.054
17	Training employees	1.347
7	Food waste rescue app	1.312
16	Reversed logistics	1.278
5	Waste tracking and analytics	0.776
15	GRO/SOOP	0.741
21	GRO/SOOP	0.508
8	Ugly' Vegetables	0.410
4	Smaller plates	0.166
11	Nudging guests	-0.234
12	A la carte breakfast	-0.297
14	Vermicomposter	-0.365
13	Doggy bag	-0.410
20	Zero waste manager	-0.463
19	Flexible portion sizes	-0.474
1	Composter	-0.508
3	Menucard adaptation	-0.542
2	Dehydrator	-1.015

[4] Too good to go is an online app that can be used to distribute unsold products to app users to prevent food being wasted. Their website can be found in the reference list.

9	Staff food per plate	-1.113
10	Food grinder and vacuum	-1.215
18	Improved reservation system	-1.956

Table 9: Card sort Z-scores for factor 2.

4.4.3 Circular strategy 3. Minimizing waste through luxury

Table 10 shows the Z-scores for factor 3. On the contrary to the first two factors, the best strategy in this factor is having flexible portion sizes (19), followed by a la carte breakfast (12), improved waste separation (6) and using doggy bags (13). The first two options are short loop circular and aim to reduce the total amount of waste, the use of a doggy bag was medium loop circularity while improving waste separation contributes to a long loop circular food system. The worst waste management options were long loop circular options namely vermicomposting (14), anaerobic digester (21), composter (1) and one short loop strategy of food waste prevention by nudging guests (11). The participants in this factor were most diverse in terms of functions and organizations.

Flexible portion size was according to the teams in this factor the best waste management option. Although the motivations behind this seem to suggest that it is not necessarily the portion sizes but more being flexible in the operations which is effective in reducing food waste. For instance, being flexible in the amount that is presented on a buffet and using different types of plates to present the buffet at the end of the event can reduce the amount of leftovers. Or being flexible in giving the guest the opportunity to order more food during their dinner can reduce the amount of plate waste. One of the participants with the context of case B mentioned that the difference of an a la carte breakfast was very much visible in the waste scores of the staff food buffet, in terms of waste per couvert, more food is wasted for the canteen than for the restaurant. When buffets are used, the basic needs should be there, but more special foods should be asked upon request. In addition, a buffet needs the right incentives to encourage people to walk more often instead of making a small buffet around the table. Encouraging improved waste separation seemed like a logical step to take in order to improve the overall food waste management system. Separating waste is not that difficult as an option, most mistakes were made because there is a large share of the employees who do not naturally want to improve their own waste management, but if appropriately facilitated it is not that difficult. One of the chefs in this factor mentioned that guests come to enjoy the restaurant, these are the moments people want to enjoy and relax without being nudged to change their behavior therefore, the guests should not notice any difference.

Code	Circular strategy	Z-scores
19	Flexible portion sizes	1.803
12	A la carte breakfast	1.356
6	Improved waste separation	1.298
13	Doggy bag	1.024
4	Smaller plates	0.642
17	Training employees	0.533
18	Improved reservation system	0.476
20	Zero waste manager	0.447
3	Menucard adaptation	0.390
7	Food waste rescue app	0.224

5	Waste tracking and analytics	0.181
2	Dehydrator	0.100
15	GRO/SOOP	-0.100
16	Reversed logistics	-0.281
9	Staff ffood per plate	-0.556
10	Food grinder and vacuum	-0.614
8	Ugly' vegetables	-0.951
11	Nudging guests	-1.298
14	Vermicomposter	-1.370
21	Anaerobic digester	-1.413
1	Composter	-1.889

Table 10: Card sort Z-scores factor 3.

4.5 Sustainability implications of circular strategies case A

The following results show the SDG indicators for the baseline and three most preferred circular scenarios. One scenario was added to the table namely the scenario where all options with a possible impact were included, this is the most optimal circular scenario.

4.5.1 SDG Baseline indicators case A

Table 11 shows the performance indicators for case A in the year 2017. The current situation (BAU) employed 28,4 FTE over the year 2017. It's avoidable food waste was measured at 9,48 tons. The FW-FTE indicator can thus be measured as 334 Kg avoidable FW/FTE. The FW-cost for case A is €86.591,26. Serving 59269 couverts the costs of food waste per couvert are €1,46.

The indicator directly related to food waste transportation is 104 vehicles per year (SDG 11). The theoretical amount of vehicles that would be needed to recycle all waste is 114. This shows that the current waste management and collection system is not viable for 100% waste recycling. For the other social indicators, no quantitative data was available. But it was mentioned that smell complaints came from the general waste bins. General waste bins do not get cleaned often whereas SWILL waste bins are replaced after being emptied.

For SDG 12 the following indicators we calculated. The RMC is 59,35 tons. Per couvert this amount is approximately 1,0 Kg meaning that for every guest and staff member entering the restaurant 1,0 Kg of food is purchased or indirectly consumed. The net food waste is calculated 23%. Of the total of organic waste material 43% is separately recycled as SWILL or recycled oils. The other 57% is assumed to be incinerated among general waste streams.

For SDG 13 the total CO_2-eq of all products consumed is 379 tons. Per couvert 6,40 Kg of CO_2-eq is emitted during the production, distribution, cooling, consuming and waste of food products. For every Kg of food consumed 6,39 Kg CO_2-eq is emitted. For the total amount of food wastage 174,53 tons of CO_2-eq were emitted.

Sustainable development goal indicators		BAU	C1	C2	C3	C4
SDG 8	FTE	28	28	28	28	28
	Couverts	59269	59269	59269	59269	59269
	FW-cost	€ 86.591,26	€ 46.197,66	€ 74.946,44	€ 77.807,81	€ 26.171,60
	€/couverts	€ 1,46	€ 0,78	€ 1,26	€ 1,31	€ 0,44
	FW/FTE (Kg)	334	172	293	305	111
SDG 11	Theoretical SWILL vehicles p/y	114	95	109	109	23
	SWILL Vehicles/year	104	104	104	104	104
	Noise/Smell/Pests complaints/y	No data	No data	No data	No data	No data
SDG 12	RMC (tons)	59,35	54,48	58,20	58,57	53,03
	RMC/couvert (Kg)	1,00	0,92	0,98	0,99	0,89
	Net food waste (%)	23%	13%	21%	21%	8%
	Recycle (%)	43%	52%	86%	85%	90%
SDG 13	CO2-eq/RMC (Tons)	379,46	350,00	372,10	374,24	339,01
	CO2-eq/couvert (Kg)	6,40	5,88	6,28	6,31	5,72
	CO2-eq intensity (Kg)	6,39	6,39	6,39	6,39	6,39
	CO2-eq of FW (Tons)	174,53	145,07	167,18	169,31	134,09

Table 11: SDG indicators for current situation and after circular strategies Case A.

4.5.2 SDG indicators Circular strategy 1 case A

Circular strategy 1 (C1, stimulating behavioral change for circularity) was most preferred by the professionals during the group interviews. This circular strategy can potentially avoid 4,87 tons of organic waste. Because of the reduced amount of avoidable waste, it was assumed that less products are consumed in this scenario. To start with SDG 8, the current amount of FTE remains the same, this can be explained as the amount of extra required labor was not included, in addition the total amount of couverts remains the same as well. Compared to the BAU-scenario the total amount of food waste costs falls significantly with €40.393,60. Per couvert the costs are therefore €0,78 compared to the €1,46 in the BAU-scenario. Meaning the costs for food waste can almost be halved by stimulating behavioral change for circularity. The total amount of avoidable food waste per FTE drops from 334 to 172 Kg, meaning that the employees are producing significantly less waste over a year.

For SDG 11 the total amount of vehicles remains similar. However, in theory the amount of vehicles that need to be used to collect the SWILL can be 19 less each year because the total amount of waste was reduced. No data was found for noise, smell and pest complaints.

For SDG 12 the RMC is 4,87 Tons lower, meaning that per couvert 80 gram less food needs to be purchased. The net food waste falls from 23% to 13%. Meaning that if target 12.3 would be addressed to businesses their current food waste management system, this target can almost be achieved using this strategy. The recycling increases to 52% because it was assumed that the same amount of waste was recycled, while the total amount of waste decreased.

For SDG 13 the following indicators were measured. The total amount of CO_2-eq decreased with 29,45 Tons due to the reduction in purchased products. Thus, per couvert 520 grams of CO_2-eq was emitted less than the BAU-scenario. The intensity of CO_2-eq remains unchanged as the exact same products are purchased. The CO_2-eq of total food waste was 29,45 Tons less than the baseline.

4.5.3 SDG indicators Circular strategy 2 case A

The second strategy overall has less improvements than the first strategy except for the total amount of recycled waste which increased to 86% due to the facilitation of waste separation. The materials streams are affected with 1,15 tons of organic waste avoided. The impact of the materials streams on the SDG indicators are the following: For SDG 8 the total amount of food waste costs can be reduced by €11.644,82. For the waste management of recycled waste the price for waste increased. However, this increase in price is offset due to the overall reduction of avoidable food waste. Per couvert now on average €1,26 is spend on food waste which is caused by 293 Kg of avoidable food waste per FTE.

In theory, to collect the total amount of SWILL the traffic could increase with 5 vehicles per year due to extra collected SWILL which is caused by the increase in recycling. The RMC is reduced with 1,15 tons per year. The RMC/couvert therefore now 20 grams of less raw material is purchased per couvert. The net food waste reduces 2%. The total amount of CO_2-eq emissions 7,35 tons which is a reduction of 120 grams of CO_2-eq per couvert.

4.5.4 SDG indicators Circular strategy 3 case A

The third strategy scores lowest on all impact categories except for the baseline. The total amount of waste recycling increases to 85%. But the overall avoidable waste was reduced with 1,15 tons. Nevertheless, the costs for food waste are in this scenario €8783,45 lower than the baseline. Meaning that per couvert the food waste costs can be reduced by €0,15 due to a decrease in FW/FTE by 29 Kg.

For the amount of vehicles required to transport the waste, the same amount is needed as for strategy 2 because of the increased waste recycling. Raw material consumption declines by 0,87 tons. Which affect the indicator for the RMC by 10 grams per couvert. The total amount of CO_2-eq for the RMC and food waste reduced by 5,22 tons. This means a reduction of 90 grams per couvert.

4.5.5 SDG indicators Circular strategy 4 case A

Lastly, a fourth strategy was added to this section. In this strategy all the reviewed strategies are implemented to review the maximum possible impact. The total amount of organic waste was reduced by 9,19 tons using these waste management options of which 6,33 tons' avoidable food waste. The total amount of food waste costs is reduced by €60.419,66. This is a reduction of €1,01 per couvert compared to the baseline.

The avoidable food waste per FTE is reduced by 223 Kg. Because in this scenario a dehydrator was used to reduce the total volume of waste the theoretical amount of vehicles needed to transport the waste can be reduced by 81 vehicles per year. The RMC can be reduced by 6,33 tons of purchased materials which is a reduction of approximately 11%. Per couvert this is a reduction of 110 grams of purchased products. Through this difference a net food waste of 8% can be achieved. This reduction is more than half the food currently wasted. The total amount of waste recycling is estimated at 90%.

Due to the lower amount of RMC 40,44 tons of CO_2-eq emissions can be avoided that being a reduction of 680 grams of CO_2-eq emissions per couvert. The total amount of food waste, including the unavoidable amount of food waste thus contribute to 134,09 tons CO_2-eq emissions.

4.6 Sustainability implications of circular strategies case B

Table 11 shows the estimated impact over the four circular strategies for case B. The impacts are described in more detail in the following sections.

4.6.1 SDG 8 indicators case B

For case B the total amount of FTE operating in the restaurant was 43,4 per year. It's avoidable food waste was measured 15,7 tons over a whole year operating. Thus the food waste FTE indicator is calculated at 363 Kg per FTE. The table shows the total amount of couverts being 132.120 persons for the year 2017. The food waste-cost indicator for case B is measured at €102.802,23. These costs on average are €0,78 per customer served.

For case B, currently 104 vehicles are used each year to collect the amount of SWILL. With 100% waste recycling 100 vehicles would be necessary in theory to collect all waste. As roughly 30% of waste is currently separated more waste could be collected with the same amount of vehicles. The hotel is located in a new building, therefore there have not been smell complaints yet. However, for the general waste of the hotel a press container is used. Collecting food waste in one of these containers can increase smells and attracts pests such as rats.

For case B the indicators are shown in table 12 over the year 2017. In total 104,38 tons of raw materials are consumed. For the total amount of guests served, including the staff, 0,8 Kg of raw materials are consumed for each guest. The net food waste is 16% meaning, that of all edible products 16% directly ends up as waste. Of the total organic waste streams 32% is recycled, the other 68% is incinerated.

For the production, distribution, cooling and storing, consumption and waste management of the RMC for case B 627 tons CO_2-eq is emitted. Per couvert the intensity is 4,74 Kg CO_2-eq. Per Kg of purchased food the intensity is 6,01 Kg CO_2-eq. For the total amount of food wastage 144,53 tons of CO_2-eq was emitted for materials that are never consumed as food.

			BAU	C1	C2	C3	C4
Sustainable development goal indicators	SDG 8	FTE	43	43	43	43	43
		Couverts	132120	132120	132120	132120	132120
		FW-cost	€ 102.802,23	€ 57.572,44	€ 97.674,72	€ 94.617,17	€ 39.929,71
		€/couverts	€ 0,78	€ 0,44	€ 0,74	€ 0,72	€ 0,30
		FW/FTE (Kg)	363	197	340	328	150
	SDG 11	Theoretical SWILL vehicles p/y	100	70	96	92	14
		SWILL Vehicles/year	104	104	104	104	104
		Noise/Smell/Pests complaints/y	No data	No data	No data	No data	No data
	SDG 12	RMC (tons)	104,38	97,18	103,39	102,90	95,14
		RMC/couvert (Kg)	0,79	0,74	0,78	0,78	0,72
		Net food waste (%)	16%	10%	16%	15%	7%
		Recycle (%)	32%	46%	90%	90%	90%
	SDG 13	CO2-eq/RMC (tons)	626,86	583,68	620,89	617,96	571,35
		CO2-eq/couvert (Kg)	4,74	4,42	4,70	4,68	4,32
		CO2-eq intensity (Kg)	6,01	6,01	6,01	6,01	6,01
		CO2-eq of FW (tons)	144,53	101,29	138,56	135,63	89,02

Table 12: SDG indicators for current situation and after circular strategies Case B.

4.6.2 Sustainability implications Circular strategy 1

The total avoidable food waste avoided in this strategy is 7,20 tons. The costs for food waste can be reduced by €45.229,79 for strategy C1. Per couvert the costs of food waste for this strategy is reduced to €0,44. Per FTE this means 197 Kg of food is wasted. This can potentially reduce the amount of vehicles required for the collection of SWILL by 30 vehicles per year. The RMC can be reduced from

104,38 tons to 97,18 tons which is a reduction of 50 grams per couvert. The net food waste can be reduced from 16 to 10% with the % of waste recycling increasing to 46% due to the reduced amount of organic waste overall. The CO_2-eq emissions that can be avoided using this strategy is 43,24 Kg. The CO_2-eq impact per couvert can become 4,42 Kg. The CO_2-eq impact of food waste is therefore reduced to 101,29 tons per year.

4.6.3 Sustainability implications Circular strategy 2

The second strategy is less impactful than the first on all SDGs except for the % of waste recycling due to the facilitation of waste separation. In total 0,99 tons of food waste was avoided. The costs of food waste can be reduced by €5127,51. This is a reduction of €0,04 per couvert. The total amount avoidable waste is then reduced by 23 Kg per FTE. The amount of vehicles needed can be reduced from the baseline with 8 vehicles per year, meaning that increased recycling does not affect the transportation streams of organic waste for this case. The RMC is reduced by 0,99 tons per year. Per couvert a reduction of 10 grams which overall not affects the % of net food waste. The avoided CO_2-eq impact can thus be 5,97 tons. Per couvert this is an average reduction of 40 grams CO_2-eq.

4.6.4 Sustainability implications Circular strategy 3

The third circular strategy is a slight improvement compared to the second as 2,07 tons of food waste was avoided. The cost of food waste is reduced by €8185,06, a reduction of €0,06 per couvert. Per FTE 35 Kg of food is wasted less than the baseline. The amount of vehicles can further be brought down to 92 per year. The net food waste is reduced by 1% for this strategy with 90% waste recycling. The RMC per couvert is 0,78 Kg a reduction of 10 grams compared to the baseline. The CO_2-eq emissions that can be avoided due to less purchased raw materials are 8,89 tons, per couvert now 4,68 Kg of CO_2-eq is indirectly consumed.

4.6.5 Sustainability implications Circular strategy 4

Also for case B, a strategy was added wherein most circular strategies are implemented. In total 12,91 tons of organic waste was avoided. Of the organic waste 9,24 tons was avoidable food waste and 3,67 tons was unavoidable. For this strategy the costs of food waste can be brought down to €39.929,71. Per couvert the costs for food waste can thus become €0,30 less than halve the amount of the baseline (€0,78). The amount of food waste per FTE is reduced to 150 Kg. The amount of vehicles can be reduced to 14 vehicles per year for the collection of SWILL. For this case the RMC in total can be reduced to 95,14 tons per year which gives an average of 0,72 Kg of raw material consumed per couvert. The net food waste is reduced to 7%. Percentage of waste recycling can increase to 90%. In terms of CO_2-eq emissions 57,50 tons can be avoided by purchasing less raw materials. Per couvert 4,32 Kg of CO_2-eq emissions are emitted. For food waste 89,02 tons of CO_2-eq emissions are emitted.

4.7 Comparing the implications

For case A and B the relative distance between the baseline and the C4 strategy were compared as they had most impact for both cases. Figure 9 shows the difference in percentage for each indicator in possible avoided impact, every line represents 10% impact. Overall both cases show an improvement on the measured indicators for all four sustainable development goals. The impact for case A is higher for the SDG 8 indicators. This indicates that when more food is wasted per couvert in the current situation, the relative impact of avoidable food waste prevention on SDG 8 is higher for the chosen strategies than when less food is wasted. For the other SDGs the amount of unavoidable waste plays a more significant role in the final impact. The amount of unavoidable waste is an important factor for both the amount of transportation needed for the waste as well as the relative impact an organization can have using food prevention strategies on its waste. When an organization has a relatively high amount of unavoidable waste, the reduction of avoidable waste has a smaller impact on SDG 11, 12 and 13.

The costs of food waste decrease faster than the carbon footprint of food waste, in terms of costs unavoidable food waste does not (strongly) influence the price of food waste whereas the CO_2-eq emissions were divided over both unavoidable and avoidable food waste. Overall the indicators for SDG 8 and 11 reveal the largest change from the current situation. This indicates that the social and economic impact of food waste management may be even greater than the environmental impact to food-service sector organizations.

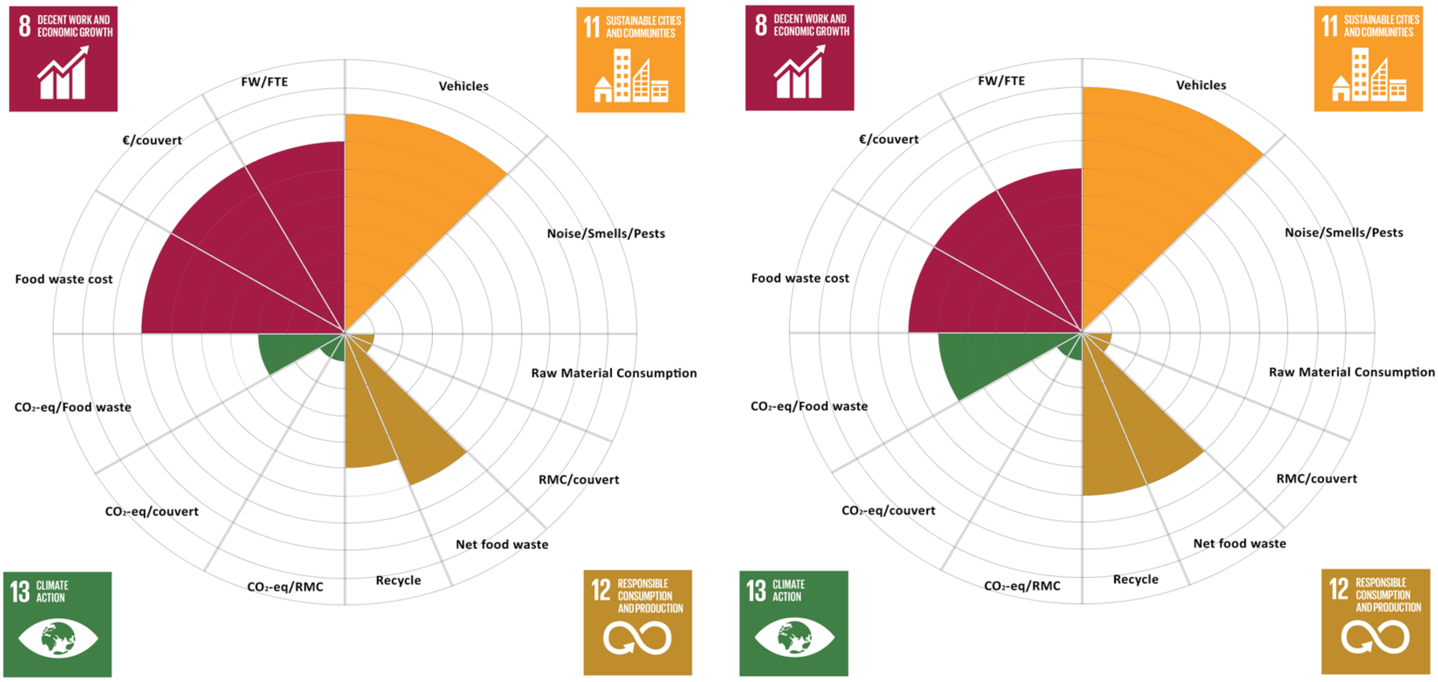


Figure 9: Change in % between current situation and most optimal circular strategy. Left: Case A. Right: Case B

Per FTE more food was wasted for case B, however, case B shows a higher productivity if the amount of couverts is compared with the amount of FTE. Thus, that the employees waste more food per year does not indicate its food waste performance is worse as productivity may be higher per employee.

For case A, the RMC remains higher than for case B per couvert. A significant amount of unavoidable waste is purchased by case A. Although more than halve of the food waste is reduced, the CO_2-eq emissions related to food waste is not halved for both cases. The amount of unavoidable waste remains relatively unchanged. Despite the relative differences between the cases, for both cases the results indicate that reducing the amount of food waste and adopting circular food waste management strategies have positive impact on all four chosen sustainable development goals and indicates that circular food waste management for the food-service sector may contribute to the sustainable development goals for decent work and economic growth (SDG 8), sustainable cities and communities (SDG 11), sustainable consumption and production (SDG 12) and climate action (SDG 13).

5. Discussion

The aim of this research was to review the sustainability implications of a circular economy in managing food-waste in the food-service sector of Amsterdam from an organizational perspective. The results of this thesis indicate that applying circular strategies to food waste and food waste management, can be effective in reducing the overall amount of food waste whilst improving current waste management practices (sections 4.5, 4.6). The impacts on food waste material flows may contribute to decent work and economic growth (SDG 8), more sustainable cities and communities (SDG 11), sustainable consumption and production (SDG 12) and fighting climate change impact (SDG 13). The following sections discuss the overall findings of the thesis.

5.1 Sustainability implications of circular waste management strategies

The current system for the consumption and production of food is not sustainable (Godfray et al., 2010). Roughly a third of all food never reaches the final consumer (Gustavsson et al., 2011). Thus, reducing food waste is leading in waste management policy targets because of its social, economic and environmental benefits (Cristobal Garcia et al., 2016; Papargyropoulou et al., 2014). The results of this study show that in the two analyzed cases more products are purchased than actually necessary (sections 4.1, 4.2). It was found that short loop circular strategies such as food waste prevention for food-service sector organizations have social, economic and environmental benefits (section 4.7). Therefore, food waste prevention should not only be top priority to policymakers but also to food-service sector organizations.

Alternative waste management strategies such as improved waste separation and using decentralized waste treatment technologies have benefits as well to food-service sector organizations. The amount of traffic necessary for waste hauling could potentially be reduced thereby contributing to more sustainable cities and communities (SDG 11). In the center of Amsterdam waste haulers move slowly through an urban dense environment where no space is left for other forms of traffic. With over thousand food-service sector organizations a reduction of 80% as indicated in section 4.7, can have significant impact on traffic flows. Although no accurate data was found on noise, sound and smells of current waste management practices, several restaurant managers mentioned that most of the smells arise from the general waste bin due to a lack of organic waste separation. Most studies only address the environmental implications (Bernstad & la Cour Jansen, 2011; Bernstad & la Cour Jansen, 2012; Cristobal Garcia et al., 2016; Eriksson et al., 2015; Lundie & Peters, 2005; Salemdeeb et al., 2017). This thesis demonstrates that more holistic methods of assessments can identify other important social and economic benefits that can support policy and decision makers towards more sustainable waste management systems.

The most preferred strategy overall was stimulating behavioral change for circularity (section 4.4.1). Compared to the other strategies, this strategy had the most impact on the SDG indicators (section 4.7). These results strengthen the findings by Principato et al. (2018) that behavior and attitudes towards food waste directly affect material flows within food-service sector organizations. These social considerations are often overlooked by scientists and practitioners engaged with the circular economy who mainly focus on aspects of design, material flows and technologically-based innovation (Ghissellini et al., 2015; Hobson & Lynch, 2016). However, these social and behavioral considerations play a vital role in how aspects of design and technology will affect material flows. Thus, including socio-cultural aspects in research and practice is essential in systemic change towards a sustainable and circular economy.

5.2 Measuring food waste

The definition of avoidable and unavoidable food waste is a highly subjective exercise which is influenced by cultural identities and therefore may change over time (Halloran et al., 2014; Papargyropoulou et al., 2014; Papargyropoulou et al., 2016). The observations of the staff during the food waste audit was frequently accomplished by intensive discussions on what was actually edible and what was not. Betz et al. (2015) identified that the fraction of unavoidable food waste was 22%. The fraction unavoidable waste was measured as 65% for case A and 33% for case B. But as both Papargyropoulou et al. (2016) and Betz et al. (2015) point out, the variations in these numbers also originate from the fact that the type of product that is chosen to be consumed causes a higher or lower amount of unavoidable waste. However, the exact definition of unavoidable waste is decisive in determining the actual avoidable food waste. As cultural differences towards food products hold true, there is a need for different typologies and one objective standard of what can be categorized as avoidable or edible waste. Therefore, more research is needed in the cultural differences of what parts of products are seen as avoidable or unavoidable waste in different social groups and cultures. From this research global standards should be developed so that food waste practitioners can describe the guidelines they followed in their waste audit based on a cultural perspective or on the objective one. This will allow for an improved comparison among different studies and finally in determining the most effective strategies to reduce waste.

The food waste audit is not the most viable possible method as the collection of purchased food data can be a timely exercise. The invoices that were used to establish the material flows in section 4.1 and 4.2 did not always show the exact amount of products by weight but use measurement units such as 'a dozen eggs' or 'ten bunches of mint'. Although these categories are perhaps good for chefs in finding the actual amount of eggs or mint necessary, an extra column of data on the weight of products would be beneficial to map how much organic products are actually consumed. The most effective method of measuring restaurant food waste would be if suppliers of food products would include a database which already indicates the amount of unavoidable waste when products are purchased and the actual weight of what can be consumed. In this case the total amount of food waste within a period of time can easily be estimated if the organic waste streams are almost entirely separated.

Moreover, chefs write recipes and calculate the total amount of products that are required for a certain dish. If these recipes are connected to the software where the dishes are ordered, the same system can calculate the amount of products that should have been consumed. Connecting these databases would give highly detailed data of how much is supposedly purchased, consumed and finally wasted. Large gaps in data can then be identified more efficiently. In addition, other parameters can be checked such as theft. If then food waste seems to be a problem, it should still be monitored where the amounts of food waste occur. This can be done using automated food waste audit technology or by using the waste audit conducted in this thesis.

5.3 Limitations

There are several limitations to the validity, reliability and generalizability of the results in this thesis. First, a selective sample was chosen and therefore the data is not representative for the whole food-service sector of Amsterdam. This study was conducted at two hotel locations both rated as four star hotels. So they do indicate the sustainability impact food waste reduction potentially has to their segment. Future research is recommended to study the differences in food waste generation per food-service sector segment thereby identifying where food waste mainly occurs. From that research more specific solutions can be found to reduce the amount of avoidable waste for each segment.

The results indicate that circular measures can be effective in achieving the SDGs. The SDGs mainly consist of macro-level targets. It can thus be questioned if food waste within the supply chain overall reduces if food-service sector organizations adopt the circular strategies provided in this thesis. However, using the provided indicators does help food-service sector organizations in addressing a share of their responsibility in achieving these macro-level targets. Achieving these targets initially starts with tracking progress over time, therefore indicators are necessary from micro to macro level and over the whole supply chain to identify what needs to be done.

The data collected during the food waste audit is extrapolated to indicate food waste over a period of one year. If the data was collected on another moment this might have influenced the indicators. To overcome this limitation, the data was triangulated with the executive chef for both cases. Chefs design their recipes typically in a way that the amount of ingredients needed in weight does not fluctuate. In addition, the food costs are almost always kept at 30% of their selling price. In professional kitchens there is an informal rule which states that employees should always be productive when working. If there is no work, somebody is send home early. In this thesis, the average amount of waste per worked hour was used to extrapolate the data over all worked hours in 2017 as it is a more constant factor than average waste per meal. Nonetheless, it is recommended for future researchers to verify the assumption that average food waste per worked hour is more constant factor than average food waste per meal sold over a larger time frame.

Only the costs for food purchasing are accounted for. Tracking the change in FTE is recommended to businesses in order to review the cost effectiveness of a circular strategy. In the results, the FTE remained the same for each strategy because there was no data to measure the change in FTE. Moreover, the hours spend in overhead were excluded in the FTE indicator. However, it might just be that an increase in the overhead hours spend could potentially reduce food waste in terms of improved menu planning or better management. Christ and Burritt (2017) allocate the costs of labor, electricity and storage space as well to the waste. However, allocating these costs to food waste is a subjective exercise, the implications of food waste and reduction of food waste to labor and energy requirements and its costs has not been studied. More research is needed to study the energy, management and labor requirements of circular food waste management strategies to objectively review these implications and to improve the economic indicators.

5.4 Recommendations for future research

Combining the material flow analysis with indicators towards the SDGs can be a useful tool in establishing a baseline and suggesting circular strategies towards more sustainable systems. However, even if a strategy may look good on paper, it is not a guarantee for its implementation. Frequently Q-methodology is used in discourse analysis and conflict studies. Combining methodologies that can identify multi-stakeholder preferred strategies, such as Q-methodology, while simultaneously determining the impact of these strategies through a material flow analysis can support in identifying strategies that are both impactful as well as avoiding overall conflicts in the implementation phase. This study has been performed within the food-service sector, although contexts are different the same methodology can be used among other industries.

The concept of the circular economy suggests certain pathways to create more value over less materials. Changes towards more efficient food patterns by choosing products with a higher nutrient density or food from a more efficient supply chain may be an effective strategy to reduce the environmental, economic and social impacts of products. In the case studies, the overall CO_2-eq intensity of the food did not reduce using the circular strategies that were identified in this thesis. However, changing diets can have a significant effect in reducing the environmental impacts of food waste. Through the concept of the circular economy and by mapping its sustainability implications food waste can be diminished while overall reducing its environmental impact by shifting to a more efficient diet. Although the impact of different diets was not included in this study, the circular economy does suggest we should rethink the way we consume materials. Therefore, the concept is a useful addition to Moerman's ladder as it questions what food humans should consume.

The focus of this thesis was measuring the amount of food waste and indicating the impact of circular strategies to this system within two food-service organizations. In many urban environments not only food waste is a major challenge towards sustainable development. From a circular economy perspective, food intake which exceeds individual requirements of food in nutrients and energy may be as inefficient as food waste. With obesity rates still growing in metropolitan areas research is needed to identify this double inefficiency of our current food system. Overconsumption of food was not monitored during this thesis, however, it can be as significant as food waste. Future research should identify practices of overconsumption and their connection towards the SDGs in combination with research into food waste to identify the current inefficiencies of our food system.

The suggested waste management strategies in this thesis should be studied in the food-service sector to measure the effectiveness of the strategies in reducing food waste and its contribution to sustainable development. A testing bed for this would be to have multiple similar operating restaurants to use for a comparative analysis testing different waste management options. In addition, the impacts on energy consumption have been excluded from this research. Both extra energy or labor requirements may have a significant impact on the sustainability of strategies. More research is needed to identify if trade-offs or rebound effects occur during the implementation of circular strategies

6. Conclusion

Currently, in the food-service sector significant amounts of food are being wasted. In Amsterdam food-service sector organizations want to become more circular. Reducing food waste is thereby one of the leading targets in the CE package of the European Commission. However, food waste remains an issue for the sector as organizations do not know how much food is actually wasted within their organizations and what the sustainability implications would be if managed more circular. This thesis was guided by the following research question: *What are the sustainability implications of a circular economy in managing food waste in the food-service sector of Amsterdam on an organizational level?* The research question was divided in three sub-questions, the conclusions to these questions are provided below thereby following the overall structure of this thesis.

The current state of food waste in two hotel restaurants was addressed using a material flow analysis. After the MFA four focus group sessions were organized with 39 food-service sector practitioners, both management and employees, and other relevant stakeholders to review the most preferred strategies towards a circular economy using Q-methodology. Thereafter, the sustainability implications were calculated through indicators addressing four of the Sustainable Development Goals for the actual situation, the preferred circular strategies derived from the Q-method and the most optimal circular strategy.

The MFA of the two case studies revealed that food waste in its current situation occurs over every phase from storage until final plate and buffet waste. It was found that between 29 and 46% of the weight of all purchased products never reach a final consumer due to evaporation, unavoidable food waste and avoidable food waste. As avoidable food waste occurs it can be prevented through the use of different circular strategies.

Three circular strategies were found to improve food waste management. The most preferred option in managing food waste by management, employees and other food-service sector related stakeholders was *stimulating behavioral change towards circularity*. This strategy was synthesized from the waste management options that include changing the menu card, tracking and monitoring food waste, training employees and stimulating zero-waste management. Through these waste management options, a culture of waste prevention is encouraged among the management and employees which stimulates overall measures to prevent avoidable food waste. The second most preferred strategy was by setting up *smart waste management systems*. This through improving waste separation, training the staff, using food waste rescue apps and by collaborating with suppliers to encourage reversed logistics. This strategy is not much aimed at preventing food waste, but encourages collaboration with the supply chain to improve overall waste management. The last strategy found was *minimizing waste through luxury*. In this strategy guests would only notice difference if it were an improvement to the actual scenario by serving a la carte breakfast and allowing more flexibility in portion sizes.

It was found that *stimulating behavioral change for circularity* had most impact on the chosen indicators. Moreover, all found strategies positively affected the SDG indicators. It can be concluded that food-service sector organizations in Amsterdam can contribute to the Sustainable Development Goals by creating decent work and economic growth (SDG 8), more sustainable cities and communities (SDG 11), improving sustainable consumption and production (SDG 12) and addressing climate action (SDG 13) through adoption of circular food waste management strategies. For the targets of SDG 8 and 11 substantial figures were found if circular strategies are adopted by food-service sector organizations. Thus addressing the SDGs potentially holds many benefits to food-service sector organizations.

Reducing the amount of avoidable food waste does not only reduce the actual waste level. It reduces the need to purchase more food than necessary. Less food purchased means costs of food can be saved and the embodied CO_2-eq impact of products is prevented thereby contributing to SDG 8, 12 and 13. The reduction in waste reduces the need for waste hauling thus contributing to more sustainable cities and communities. The use of composters, dehydrators and other tools to reduce waste were not preferred. However, the optimal circular strategy shows that their impact does not lie in the fact that costs are saved or large environmental benefits are made if compared to waste prevention strategies. These systems may improve overall waste management and reduces the need for waste hauling of organic wastes between 80 and 86% and therefore may contribute to more sustainable cities and communities.

Some trade-offs were identified. Improved waste recycling may increase the demand for waste transport and increases overall waste management costs for food-service sector organizations. If applied in combination with overall food waste reduction strategies, these trade-offs can potentially be offset. These examples show that the circular economy requires a systemic monitoring of different social, economic and environmental targets in order to overall contribute to more sustainable development. This thesis demonstrates that to contribute to sustainable development, the food-service sector should stimulate practices that encourage behavioral change towards a circular economy.

7. Literature

ABNAMRO (2017). Circulaire economie in de hotellerie. *Retrieved from:* http://45930bh9th529s3dibaz4nhs.wpengine.netdna-cdn.com/files/2017/09/Stef-Driessen-Circulaire-Economie-in-de-Hotellerie.pdf

AEB Amsterdam (2016). Jaarverslag 2016. *Retrieved from: https://www.aebamsterdam.nl/media/1720/aeb170821_jaarverslag2016.pdf at 13-11-2018.*

Bell, S., & Morse, S. (2012). Sustainability indicators: measuring the immeasurable? *Routledge*.

Beretta, C., Stoessel, F., Baier, U., & Hellweg, S. (2013). Quantifying food losses and the potential for reduction in Switzerland. *Waste management*, *33*(3), 764-773.

Berkowitz, S., Marquart, L., Mykerezi, E., Degeneffe, D., & Reicks, M. (2016). Reduced-portion entrées in a worksite and restaurant setting: impact on food consumption and waste. *Public health nutrition*, *19*(16), 3048-3054.

Bernstad, A., & la Cour Jansen, J. (2011). A life cycle approach to the management of household food waste–a Swedish full-scale case study. *Waste management*, *31*(8), 1879-1896.

Bernstad, A., & la Cour Jansen, J. (2012). Review of comparative LCAs of food waste management systems–current status and potential improvements. *Waste management*, *32*(12), 2439-2455.

Bizikova, L., Roy, D., Swanson, D., Venema, H. D., & McCandless, M. (2013). The water-energy-food security nexus: Towards a practical planning and decision-support framework for landscape investment and risk management. Winnipeg, Manitoba: International Institute for Sustainable Development.

Böhringer, C., & Jochem, P. E. (2007). Measuring the immeasurable—A survey of sustainability indices. *Ecological economics*, *63*(1), 1-8.

Bortolotti, A., Kampelmann, S., & De Muynck, S. (2018). Decentralised Organic Resource Treatments–Classification and comparison through Extended Material Flow Analysis. *Journal of Cleaner Production*, *183*, 515-526.

Bos-Brouwers, H. E. J., Soethoudt, J. M., Vollebregt, H. M., & van der Burgh, M. (2015). *Monitor voedselverspilling: update Monitor voedselverspilling 2009-2013 & mogelijkheden tot (zelf) monitoring van voedselverspilling door de keten heen* (No. 1541). Wageningen UR-Food & Biobased Research.

Bratanova, B., Loughnan, S., Klein, O., Claassen, A., & Wood, R. (2016). Poverty, inequality, and increased consumption of high calorie food: Experimental evidence for a causal link. Appetite, 100, 162-171.

Brouwer, M. (1999). Q is accounting for tastes. *Journal of Advertising Research*, *39*(2), 35-35.

Brown, S. R. (1980). Political subjectivity: Applications of Q methodology in political science. *Yale University Press.*

Brown, V. A., Harris, J. A., & Russell, J. Y. (Eds.). (2010). Tackling wicked problems through the transdisciplinary imagination. *Earthscan.*

Brunner, P. H., & Rechberger, H. (2016). *Handbook of material flow analysis: For environmental, resource, and waste engineers*. CRC press.

Bryman, A. (2008). Social research methods. *Oxford university press.*

Caldeira, C., Corrado, S. Sala, S. (2017). Food waste accounting - Methodologies, challenges and opportunities. *Publications office of the European Union. Retrieved from: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC109202/jrc_technical_report__food_waste_rev_2_online_final.pdf at 24-04-2018.*

Cayzer, S., Griffiths, P., & Beghetto, V. (2017). Design of indicators for measuring product performance in the circular economy. *International Journal of Sustainable Engineering*, *10*(4-5), 289-298.

Chowdhury, R. B., Moore, G. A., Weatherley, A. J., & Arora, M. (2017). Key sustainability challenges for the global phosphorus resource, their implications for global food security, and options for mitigation. *Journal of Cleaner Production*, *140*, 945-963.

Christ, K. L., & Burritt, R. (2017). Material flow cost accounting for food waste in the restaurant industry. *British Food Journal*, *119*(3), 600-612.

Circle Economy, TNO & FABRIC. (2016). Circular Amsterdam: A vision and action agenda for the city and metropolitan area, http://www.circle-economy.com/wpcontent/uploads/2016/04/CircularAmsterdam-EN-small-210316.pdf

Coronado, M., Iacovidou, E., Busch, J., Purnell, P., & Velis, K. (2015). Complex Value Optimization for Resource Recovery (CVORR): A tool for an evidence-based pathway to circular economy. In *WASCON 2015–Resource Efficiency in Construction*. Leeds.

Cristobal Garcia J; Vila M; Giavini M; Torres De Matos C & Manfredi S. (2016). Prevention of Waste in the Circular Economy: Analysis of Strategies and Identification of Sustainable Targets - The food waste example. Publications Office of the European Union. *Retrieved from: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC105415/kj-na-28422-en-n.pdf at 20-02-18.*

DeClerck, F. A., Jones, S. K., Attwood, S., Bossio, D., Girvetz, E., Chaplin-Kramer, B., ... & Noriega, I. L. (2016). Agricultural ecosystems and their services: the vanguard of sustainability?. *Current opinion in environmental sustainability*, *23*, 92-99.

Di Maio, F., & Rem, P. C. (2015). A robust indicator for promoting circular economy through recycling. *Journal of Environmental Protection*, *6*(10), 1095.

Elia, V., Gnoni, M. G., & Tornese, F. (2017). Measuring circular economy strategies through index methods: A critical analysis. *Journal of Cleaner Production*, *142*, 2741-2751.

Ellen MacArthur Foundation (2018). Cities and the circular economy for food. *Retrieved from: https://www.ellenmacarthurfoundation.org/assets/downloads/Cities-and-the-circular-economy-for-food-1.pdf at 29-06-2018.*

Ellen MacArthur Foundation (EMF), (2017). Urban Biocycles. *Retrieved from:* https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Urban-Biocycles_EllenMacArthurFoundation_21-06-2017.pdf

Engström, R., & Carlsson-Kanyama, A. (2004). Food losses in food service institutions Examples from Sweden. *Food policy*, *29*(3), 203-213.

Eriksson, M. (2012). *Retail food wastage* (Vol. 45).

Eriksson, M., Osowski, C. P., Björkman, J., Hansson, E., Malefors, C., Eriksson, E., & Ghosh, R. (2018). The tree structure—A general framework for food waste quantification in food services. *Resources, Conservation and Recycling*, *130*, 140-151.

Eriksson, M., Strid, I., & Hansson, P. A. (2015). Carbon footprint of food waste management options in the waste hierarchy–a Swedish case study. *Journal of Cleaner Production*, *93*, 115-125.

European Commission. (2015). Towards a circular economy: A zero waste programme for Europe. *Retrieved from: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0398 at 25-04-2018.*

European Commission. (2018). On a monitoring framework for the circular economy. *Retrieved from: http://ec.europa.eu/environment/circular-economy/pdf/monitoring-framework.pdf at 25-04-2018.*

FAO, (2011a) http://www.fao.org/docrep/014/mb060e/mb060e.pdf

FAO, (2011b). http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/FWF_and_climate_change.pdf

FAO, IFAD, UNICEF, WFP and WHO. 2017. The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security. Rome, FAO.

Fennema, J. (2018). Gezocht: Probleemoplossers voor SDG-uitdaging Amsterdam. *Retrieved from: http://www.sdgnederland.nl/nieuws/gezocht-probleemoplossers-voor-sdg-uitdaging-amsterdam/ at 12-11-2018.*

Figge, F., Thorpe, A. S., Givry, P., Canning, L., & Franklin-Johnson, E. (2018). Longevity and Circularity as Indicators of Eco-Efficient Resource Use in the Circular Economy. *Ecological Economics*, *150*, 297-306.

Filimonau, V., & Delysia, A. (2019). Food waste management in hospitality operations: A critical review. *Tourism Management*, *71*, 234-245.

Flick, U. (2014). *An introduction to qualitative research*. Sage.

Food and Agriculture Organization of the United Nations. (2013). *Food Wastage Footprint: Impacts on Natural Resources: Summary Report*. FAO.*Retrieved from http://www.fao.org/docrep/018/i3347e/i3347e.pdf*

Food loss and waste protocol. (2016). Guidance on FLW quantification methods. *Retrieved from: http://flwprotocol.org/wp-content/uploads/2016/05/FLW_Protocol_Guidance_on_FLW_Quantification_Methods.pdf at 20-04-2018.*

Garcıa, A. J., Esteban, M. B., Marquez, M. C., & Ramos, P. (2005). Biodegradable municipal solid waste: Characterization and potential use as animal feedstuffs. *Waste Management*, *25*(8), 780-787.

Geng, Y., Fu, J., Sarkis, J., & Xue, B. (2012). Towards a national circular economy indicator system in China: an evaluation and critical analysis. *Journal of Cleaner Production*, *23*(1), 216-224.

Global Reporting Initiative & United Nations Global Compact (2018). Business reporting on the SDGs. An analysis of the goals and targets. *Retrieved from: https://www.globalreporting.org/resourcelibrary/GRI_UNGC_Business-Reporting-on-SDGs_Analysis-of-Goals-and-Targets.pdf at 01-11-2018.*

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., ... & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *science*, *327*(5967), 812-818.

Goodrick, D. (2014). Comparative Case Studies, Methodological Briefs: Impact Evaluation 9, UNICEF Office of Research, Florence.

Govindan, K., & Soleimani, H. (2017). A review of reverse logistics and closed-loop supply chains: a Journal of Cleaner Production focus. *Journal of Cleaner Production*, *142*, 371-384.

Guèye, E. F. (2000). The role of family poultry in poverty alleviation, food security and the promotion of gender equality in rural Africa. Outlook on agriculture, 29(2), 129-136.

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). *Global food losses and food waste* (pp. 1-38). Rome: FAO.

Halloran, A., Clement, J., Kornum, N., Bucatariu, C., & Magid, J. (2014). Addressing food waste reduction in Denmark. *Food Policy*, *49*, 294-301.

Hallstedt, S. I. (2017). Sustainability criteria and sustainability compliance index for decision support in product development. *Journal of Cleaner production*, *140*, 251-266.

Heijungs, R., Huppes, G., & Guinée, J. B. (2010). Life cycle assessment and sustainability analysis of products, materials and technologies. Toward a scientific framework for sustainability life cycle analysis. *Polymer degradation and stability*, *95*(3), 422-428.

Hill, R. V., Smith, L. C., Wiesmann, D. M., Frankenberger, T., Gulati, K., Quabili, W., & Yohannes, Y. (2007). The world's most deprived: Characteristics and causes of extreme poverty and hunger (Vol. 43). Intl Food Policy Res Inst.

Hobbs, P. R. (2007). Conservation agriculture: what is it and why is it important for future sustainable food production?. The Journal of Agricultural Science, 145(2), 127.

Iacovidou, E., & Voulvoulis, N. (2018). A multi-criteria sustainability assessment framework: development and application in comparing two food waste management options using a UK region as a case study. *Environmental Science and Pollution Research*, 1-14.

Iacovidou, E., Velis, C. A., Purnell, P., Zwirner, O., Brown, A., Hahladakis, J., ... & Williams, P. T. (2017). Metrics for optimising the multi-dimensional value of resources recovered from waste in a circular economy: A critical review. *Journal of Cleaner Production*, *166*, 910-938.

Impact Hub Amsterdam (2018). Sustainable Development Goals meetup Amsterdam. *Retrieved from: https://www.meetup.com/nl-NL/Sustainable-Development-Goals-Meetup-Amsterdam/ at 12-11-2018.*

Instock (2018) *Retrieved from:* http://www.instock.nl/ *at 24-04-2018.*

Iorga, C. (2018). The SDGs in Amsterdam Challenge Lab. *Retrieved from: https://amsterdamsmartcity.com/events/the-sd-gs-in-amsterdam-challenge-lab at 12-11-2018.*

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., & Schösler, H. (2016). Transition towards circular economy in the food system. *Sustainability*, *8*(1), 69.

Kallbekken, S., & Sælen, H. (2013). 'Nudging'hotel guests to reduce food waste as a win–win environmental measure. *Economics Letters*, *119*(3), 325-327.

Khalid, A., Arshad, M., Anjum, M., Mahmood, T., & Dawson, L. (2011). The anaerobic digestion of solid organic waste. *Waste management*, *31*(8), 1737-1744.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221-232.

Lal, R. (2015). The soil–peace nexus: our common future. Soil science and plant nutrition, 61(4), 566-578.

Lalander, C. H., Fidjeland, J., Diener, S., Eriksson, S., & Vinnerås, B. (2015). High waste-to-biomass conversion and efficient Salmonella spp. reduction using black soldier fly for waste recycling. *Agronomy for Sustainable Development*, *35*(1), 261-271.

Linder, M., Sarasini, S., & Loon, P. (2017). A Metric for Quantifying Product-Level Circularity. *Journal of Industrial Ecology*, *21*(3), 545-558.

Lonca, G., Muggéo, R., Imbeault-Tétreault, H., Bernard, S., & Margni, M. (2018). Does material circularity rhyme with environmental efficiency? Case studies on used tires. *Journal of Cleaner Production*, *183*, 424-435.

Luitjes, H. (2007). *Voedselverspilling in de horeca*. Agrotechnology and Food Sciences Group.

Lundie, S., & Peters, G. M. (2005). Life cycle assessment of food waste management options. *Journal of Cleaner Production*, *13*(3), 275-286.

Lundqvist, J., de Fraiture, C., & Molden, D. (2008). Saving water: from field to fork: curbing losses and wastage in the food chain. *Stockholm: Stockholm International Water Institute.*

MacArthur, E. (2015). Circularity indicators: An Approach to Measuring Circularity. *Methodology*.

Martin-Rios, C., Demen-Meier, C., Gössling, S., & Cornuz, C. (2018). Food waste management innovations in the foodservice industry. *Waste Management*, *79*, 196-206.

Martínez, D. S. (2016). Towards an inclusive circular Amsterdam: A framework for evaluating local circular initiatives.

McKeown, B., and D. Thomas. 1988. Q Methodology. *Sage University Paper Series on Quantitative Applications in the Social Sciences 07-066. Sage, Beverly Hills, California.*

Milieudefensie (2018). Hoe vervuild is de lucht in mijn straat. *Retrieved from: https://milieudefensie.nl/recht-op-gezonde-lucht/hoe-vervuild-is-de-lucht-in-mijn-straat at 01-10-2018.*

Molina-Azorín, J. F., Claver-Cortés, E., Pereira-Moliner, J., & Tarí, J. J. (2009). Environmental practices and firm performance: an empirical analysis in the Spanish hotel industry. *Journal of Cleaner Production*, *17*(5), 516-524.

Møller, H., Hanssen, O. J., Gustavsson, J., Östergren, K., Stenmarck, Å., & Dekhtyar, P. (2014). Report on review of (food) waste reporting methodology and practice. *Ostfold Research, Norway*.

National Environment Agency (2018). Food waste minimization guidebook for food retail establishments. *Retrieved from: https://form.sg/#!/forms/nea/5a93692b86434f006f9f9b60 at 10-10-2018.*

Oldeman, L. R., Hakkeling, R. T. A., & Sombroek, W. G. (2017). World map of the status of human-induced soil degradation: an explanatory note.

Olsthoorn, X., Tyteca, D., Wehrmeyer, W., & Wagner, M. (2001). Environmental indicators for business: a review of the literature and standardisation methods. *Journal of Cleaner Production*, *9*(5), 453-463.

Papargyropoulou, E., Wright, N., Lozano, R., Steinberger, J., Padfield, R., & Ujang, Z. (2016). Conceptual framework for the study of food waste generation and prevention in the hospitality sector. *Waste management*, *49*, 326-336.

Papargyropoulou, E.; Lozano, R.; Steinberger, J.K.; Wright, N.; Bin Ujang, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *J. Clean. Prod.* 2014, *76*, 106–115.

Park, J. Y., & Chertow, M. R. (2014). Establishing and testing the “reuse potential” indicator for managing wastes as resources. *Journal of environmental management*, *137*, 45-53.

Pauliuk, S. (2018). Critical appraisal of the circular economy standard BS 8001: 2017 and a dashboard of quantitative system indicators for its implementation in organizations. *Resources, Conservation and Recycling*, *129*, 81-92.

Pirani, S. I., & Arafat, H. A. (2014). Solid waste management in the hospitality industry: A review. *Journal of environmental management*, *146*, 320-336.

Pirani, S. I., & Arafat, H. A. (2016). Reduction of food waste generation in the hospitality industry. *Journal of cleaner production*, *132*, 129-145.

Potting, J., Hanemaaijer, A., Delahaye, R., Hoekstra, R., Ganzevles, J., & Lijzen, J. (2018). Circulaire economie: wat we willen weten en kunnen meten: Systeem en nulmeting voor monitoring van de voortgang van de circulaire economie in Nederland.

Potting, J., M. Hekkert, E. Worrell & A. Hanemaaijer (2016): Circulaire economie: Innovatie meten in de keten, Den Haag: PBL.

Qu, Y., Li, M., Jia, H., & Guo, L. (2015). Developing more insights on sustainable consumption in China based on Q methodology. *Sustainability*, *7*(10), 14211-14229.

Reap, J., Roman, F., Duncan, S., & Bras, B. (2008). A survey of unresolved problems in life cycle assessment. *The international journal of life cycle assessment*, *13*(5), 374.

Refsgaard, K., & Magnussen, K. (2009). Household behaviour and attitudes with respect to recycling food waste–experiences from focus groups. *Journal of Environmental management*, *90*(2), 760-771.

Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0?—Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, *135*, 246-264.

Restaurant Nolla (2018). https://www.restaurantnolla.com/eng

Rethink Food waste through economics and data (2018). Food waste solutions. *Retrieved from:* https://www.refed.com/solutions/?sort=economic-value-per-ton *at 10-10-2018.*

Rijksinstituut voor Volksgezondheid en Milieu (RIVM). (in press.). Milieubelasting van de voedselconsumptie in Nederland. *Retrieved from: personal contact. At 20-08-2018.*

Rockström, J., & Sukhdev, P. (2016). How food connects all the SDGs. *Stockholm Resilience Centre*.

Rood, T., Muilwijk, H. & Westhoek, H. (2017). Food for the circular economy. *Retrieved from: http://www.pbl.nl/sites/default/files/cms/publicaties/PBL-2017-Food-for-the-circular-economy-2878.pdf at 10-03-2018.*

Salemdeeb, R., zu Ermgassen, E. K., Kim, M. H., Balmford, A., & Al-Tabbaa, A. (2017). Environmental and health impacts of using food waste as animal feed: a comparative analysis of food waste management options. *Journal of cleaner production*, *140*, 871-880.

Scheepens, A. E., Vogtländer, J. G., & Brezet, J. C. (2016). Two life cycle assessment (LCA) based methods to analyse and design complex (regional) circular economy systems. Case: Making water tourism more sustainable. *Journal of Cleaner Production*, *114*, 257-268.

Soethoudt, H. & M. Vollebregt (2018), Monitor voedselverspilling. Update Monitor 2009-2016. Wageningen: Wageningen UR Food & Biobased Research. *Retrieved from:* https://www.wur.nl/upload_mm/8/2/a/762faac4-2efa-42de-8a91-a4a3896dfb85_Monitor%20Voedselverspilling%20Update%202009-2016.pdf *at 13-11-2018.*

Soethoudt, H., & van der Burgh, M. (2017). *Monitor Voedselverspilling: update 2009-2015* (No. 1747). Wageningen Food & Biobased Research.

Späth, L. (2018). Large-scale photovoltaics? Yes please, but not like this! Insights on different perspectives underlying the trade-off between land use and renewable electricity development. *Energy Policy*, *122*, 429-437.

Springmann, M., Godfray, H. C. J., Rayner, M., & Scarborough, P. (2016). Analysis and valuation of the health and climate change cobenefits of dietary change. Proceedings of the National Academy of Sciences, 113(15), 4146-4151.

Stephenson, W. (1953). The study of behavior; Q-technique and its methodology.

Stimular (2016). Kansen voor minder restafval bij 9 KWD sectoren. Onderzoek in het kader van VANG-buitenshuis. *Retrieved from: https://www.afvalcirculair.nl/publish/pages/124520/onderzoek_kwd-sector_1_overkoepelend_rapport_-_stimular_okt2016.pdf at 24-04-2018.*

The waste and Resources Action Programme (2018). Supporting Resources for the hospitality and food service sector. *Retrieved from: http://www.wrap.org.uk/content/supporting-resources-hospitality-and-food-service-sector-3 at 01-10-2018.*

Togård, C. (2016). Measuring Circularity and Customer Satisfaction of Product-Service Systems at IKEA.

Food waste rescue app (2018). *Retrieved from: https://toogoodtogo.nl/*

Tuppen, H. (2014). Reducing and managing food waste in hotels. *Green Hoteliers. Retrieved from: http://www.greenhotelier.org/know-how-guides/reducing-and-managing-food-waste-in-hotels/ at 20-09-2018.*

United Nations (2014). System of Environmental-Economic Accounting 2012. *Retrieved from: https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf at 11-11-2018.*

United Nations (2018). The Sustainable Development Goals. *Retrieved from: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ at 13-11-2018.*

United Nations (2018). WFP calls for investments in school meals by West African governments. *Retrieved from: http://www.wfp.org/news/news-release/wfp-calls-more-investment-school-meals-west-african-governments at 29-06-2018.*

United States Environmental Protection Agency (2015). Reducing Wasted Food & Packaging: A Guide for Food Services and Restaurants. *Retrieved from: https://www.epa.gov/sites/production/files/2015-08/documents/reducing_wasted_food_pkg_tool.pdf at 11-10-2018.*

Van Bergen, H. (2015). Maatregelenpakket schone lucht voor Amsterdam. *Retrieved from: https://assets.amsterdam.nl/publish/pages/775589/notitie_schone_lucht_voor_amsterdam_-_februari_2016.pdf at 12-11-2018.*

Van den Bosch, H. (2018). The meaning of the Paris Agreement for cities like Amsterdam. *Retrieved from: https://amsterdamsmartcity.com/posts/the-meaning-of-the-paris-agreement-for-cities-like at 12-11-2018.*

van Dooren, C., Aiking, H., & Vellinga, P. (2018). In search of indicators to assess the environmental impact of diets. *The International Journal of Life Cycle Assessment*, *23*(6), 1297-1314.

de Valk, E., Hollander, A., & Zijp, M. (2016). Milieubelasting van de voedselconsumptie in Nederland. *Rijksinstituut voor volksgezondheid en milieu (RIVM). Retrieved from: https://www.rivm.nl/bibliotheek/rapporten/2016-0074.pdf at 20-06-2018.*

van Velzen, U. T., Bos-Brouwers, H., Groot, J., Bing, X., Jansen, M., & Luijsterburg, B. (2013). Insights into the complex issue of recycling plastic packaging waste. *Retrieved from* http://www.ddleco.nl/fileadmin/Rapporten/Verbetermogelijkheden_in_de_kunststofhergebruiksketen_mei_2013.pdf *at 13-04-2018.*

Veleva, V., Bodkin, G., & Todorova, S. (2017). The need for better measurement and employee engagement to advance a circular economy: Lessons from Biogen's "zero waste" journey. *Journal of Cleaner Production*, *154*, 517-529.

Verbeek, L. H. (2016). *A Circular Economy Index for the consumer goods sector* (Master's thesis).

Waas, T., Hugé, J., Block, T., Wright, T., Benitez-Capistros, F., & Verbruggen, A. (2014). Sustainability assessment and indicators: Tools in a decision-making strategy for sustainable development. *Sustainability*, *6*(9), 5512-5534.

Waldron, A., Garrity, D., Malhi, Y., Girardin, C., Miller, D. C., & Seddon, N. (2017). Agroforestry can enhance food security while meeting other Sustainable Development Goals. Tropical Conservation Science, 10, 1940082917720667.

Walker, S., Coleman, N., Hodgson, P., Collins, N., & Brimacombe, L. (2018). Evaluating the Environmental Dimension of Material Efficiency Strategies Relating to the Circular Economy. *Sustainability*, *10*(3), 666.

Wang, L. E., Liu, G., Liu, X., Liu, Y., Gao, J., Zhou, B., ... & Cheng, S. (2017). The weight of unfinished plate: A survey based characterization of restaurant food waste in Chinese cities. *Waste Management*, *66*, 3-12.

Watts, S., & Stenner, P. (2012). *Doing Q methodological research: Theory, method & interpretation*. Sage.

Weber, C. F. (2016). Nutrient content of cabbage and lettuce microgreens grown on vermicompost and hydroponic growing pads. *Journal of Horticulture*, *3*(4), 1-5.

Webler, T., Danielson, S., & Tuler, S. (2009). Using Q method to reveal social perspectives in environmental research. *Greenfield MA: Social and Environmental Research Institute*, *54*, 1-45.

Wiedmann, T. O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., & Kanemoto, K. (2015). The material footprint of nations. *Proceedings of the National Academy of Sciences*, *112*(20), 6271-6276.

Williams, S. (2017). How to make sourdough bread. *Retrieved from: https://www.thatsusanwilliams.com/2013/05/how-to-make-sourdough-bread/ at 11-10-2018.*

Wiskerke, J. S. (2009). On places lost and places regained: Reflections on the alternative food geography and sustainable regional development. International planning studies, 14(4), 369-387.

Wolsink, M., & Breukers, S. (2010). Contrasting the core beliefs regarding the effective implementation of wind power. An international study of stakeholder perspectives. *Journal of Environmental Planning and Management*, *53*(5), 535-558.

World Wide Fund. (2016). Living planet report 2016. *Retrieved from: http://awsassets.panda.org/downloads/lpr_living_planet_report_2016.pdf at 24-04-2018.*

Zabala, A., Sandbrook, C., & Mukherjee, N. (2018). When and how to use Q methodology to understand perspectives in conservation research. *Conservation Biology*.

Zhang, C., Su, H., Baeyens, J., & Tan, T. (2014). Reviewing the anaerobic digestion of food waste for biogas production. *Renewable and Sustainable Energy Reviews*, *38*, 383-392.

Zhang, Y., Dube, M. A., McLean, D. D. L., & Kates, M. (2003). Biodiesel production from waste cooking oil: 1. Process design and technological assessment. *Bioresource technology*, *89*(1), 1-16.

8. Annex and appendix

For further access to the annex and/or appendix please contact the author j.n.h.link@gmail.com.

Annex A: Step-by-step guide to the food waste audit

Annex B: Literature review food waste management options

Annex C: Data template material flows and indicators

Appendix A: Group interview guide, raw data q-methodology and card game

Appendix B: Food waste data case A & B, Sankey codes case A & B