Food redistribution in Stockholm

A comparative analysis of two scenarios – with and without a food bank

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Abstract

Food waste is a serious problem in today's society. Functional food waste is going to waste treatment while people are suffering from food insecurity. Food redistribution in form of a central food bank which collects food waste at food companies and delivers it to social organizations is a measure to deal with this issue. Stockholm City Mission plans to start up a central food bank in Stockholm and it is this implementation that is of focus in this report. The purpose of this study is to compare two scenarios, with and without a food bank, and evaluate this food bank regarding the possibilities for reduced climate impacts and the economic outcomes of the involving actors (food companies, the central food bank and social organizations).

The methods used are literature studies, interviews and a material flow analysis to be able to follow the flows of food through the redistribution system. The results found are that costs can be saved for the actors involved and whether the food bank will go with profit depends on the revenues that can be collected from the involved actors and external investors. Climate impacts are reduced as a result of the implementation, mainly in terms of that functional food waste avoids waste treatment and can be of use.

Key words: Food redistribution, Food waste prevention, Climate impacts, Costs

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Definitions and concepts

Carbon dioxide equivalents – A measure on greenhouse gas emissions and includes different gases ability to contribute to the greenhouse gas effect. The emissions are expressed as the amount of carbon dioxide that would needed to be released to get the same effect on the climate as the greenhouse gas of question.

Digestion – Anaerobic waste management process

Composting – Aerobic waste management process

Food waste – Biological compostable waste created in connection with treatment and management of food.

Household waste – Waste from households and thereby comparable waste from other businesses. Examples are food waste, bulky waste, garden waste, latrine, sludge grease and hazardous waste.

Comparable waste – Waste from businesses/industries/organizations comparable to household waste

Industrial waste – Waste created as a result of business activities

Functional food waste – Food waste that is eatable

Food redistribution – Food that is eatable is redistributed via a food bank to social organizations instead of going to waste

Social organization – A charity organization that brings food, shelter and support to people in need

Daily activity center – An activity center opened during daytime where people can gather and socialize, get food and support

Bar-code – Code of a series of vertical bars printed on packages of consumer products indicating the price

1. Introduction

Food production is a significant contributing factor to the environmental impact in Sweden. The aspects that are of most concern are the climate impacts, eco toxicity, acidification and biodiversity (Naturvårdsverket, 2014). The Swedish food production is causing 50 % of the total eutrophication and 20-25 % of the total climate impacts in Sweden (Naturvårdsverket, 2016c).

A third of all food that is produced ends up as waste and 15 % of the total greenhouse gas emissions are coming from the global food production. It costs the world 20 trillion SEK each year in form of socioeconomic and environmental damaging costs according to Food and Agriculture Organization of the United Nations (FAO, 2016). Within EU around 100 million tonnes of food is going to waste each year, in Sweden that amount is 1,5 million tonnes (of which 860 000 tonnes is avoidable) (Naturvårdsverket, 2015a).

Even if the waste management is shifting towards a more resource efficient treatment, trends are showing that the amount of waste will increase in the future. The amounts of food waste in Sweden could be doubled by 2030 (Naturvårdsverket, 2012). This implies that the treatment of every tonnes waste is improving, but that the amounts are increasing, which leads to increased costs and impacts in the whole food supply chain. To prevent food waste or to reduce the amounts are more beneficial for the society in terms of costs and environmental impacts than to utilize the energy and material in the waste through treatment processes (Naturvårdsverket, 2012).

Food waste is a global problem and a waste of resources from several perspectives, economically, environmentally and socially. It costs money for the society since the purchased food ends up as waste, it effects the climate negatively due to emissions and impacts during the production and whilst many people are in need and suffer from food insecurity functional food waste from food companies ends up at waste disposal plants (Naturvårdsverket, 2015a). Multiple negative effects can be seen from this. More food needs to be produced to feed the same amount of people. This leads to that more resources are spent and more greenhouse gas emissions are generated than necessary. Added to this, it also causes intensified farming, increased livestock, eutrophication and loss of biodiversity. Not only resources from farming are increased and wasted but also energy, water, packaging materials and transportation through the whole production chain (Loxbo, 2011).

The amount of food that is going to waste is equally big in industrialized countries as in developing countries. The difference is that in developing countries the food is not mainly wasted by the consumers and in the end of the food supply chain, but in previous steps further up in the chain. Due to bad storage possibilities, slow transportations, and defective packaging the food gets bad before it even ends up at the stores and consumers. In developing countries 40 % of the losses occur after harvesting and processing of the food and in industrialized countries 40 % of the losses occur in stores and in households instead. According to FAO food waste is more extensive in industrialized countries and stores and consumers are throwing fully eatable products (FAO, 2016).

Food waste is generated in every step of the food supply chain, in the production, at wholesalers, retailers, restaurants and households (Naturvårdsverket, 2014). The most negative impacts on the climate occur in the end of the food supply chain, since more resources, material, transportation and energy have been used for the product (Livsmedelsverket, u.d.). To be able to change this in a positive direction multiple measures need to be combined. To deal with the problem in a long term perspective a change in attitudes need to appear. Information and knowledge of these issues needs to be revealed and communicated to the common people in order to deal with the problem in a preventative manner (Loxbo, 2011). Awareness of the connection between food waste and environmental damaging needs to be strengthen within the food industry and also in households that are a significant contributing factor to the amount of food waste (Naturvårdsverket, 2016c). To deal with the problem in a more short term perspective when the waste already has appeared food redistribution is an efficient measure.

Food redistribution is a concept for reduction of food waste. All Nordic countries are working with this and it is becoming a more known and used measure to prevent food waste. Previously, food redistribution has mainly been a measure to provide food for low income people, but there is also another positive side to it. Instead of transporting food waste from food companies to waste management it can be redistributed via a central food bank to social organizations where the food is served to people in need. As a result, produced food is used and less functional food waste is going to waste treatment (Hanssen, et al., 2014). Food redistribution is a way to deal with the issues of food waste and to make sure that the societal resources are utilized in an effective way (Sobal & Nelson, 2003).

There are several ways to deal with food redistribution. It can both include a national redistribution center with several involving stakeholders, known as indirect redistribution, or more local alternatives which either includes a central food bank or delivers the food directly between food actors and social organizations, so called direct redistribution. Operating for the same purpose and goal but with different means (Hanssen, et al., 2014). Food banks should function as food redistribution centers, where producers, wholesalers, retailers or other organizations donate food to social organizations which can cook and serve this food to people in need (GFN, 2016).

Challenges and problems that are approached in this thesis are the abundance of food waste in our society today and the simultaneous food insecurity for some groups. To reduce the food waste and increase food security has been an initiative by Stockholm City Mission by starting up a central food bank in Stockholm and it is this implementation that is of focus in this study.

1.1 Aims and objectives

The aim is to evaluate the central food bank planned by Stockholm City Mission regarding the possibilities for reduced climate impacts and the economic outcomes of the involving actors (the food bank, social organizations and the food companies) as a result of this initiative. This is done by comparing two scenarios, with and without a food bank in Stockholm. The overall purpose is to investigate the role of food banks as a measure to prevent food waste and climate impacts, and to put this in relation to the costs involved.

The task involves analyzing and following the flows of food for both scenarios during the first year of establishment using a material flow analysis. Costs and climate impacts from the food waste, transports, store-keeping, cooling and waste treatment is analyzed for the involving actors. Also the climate impacts from the production of the food waste is studied and included in the analysis. First the two scenarios are accounted for with specific system boundaries and indata, and then a sensitivity analysis is made comparing different indata and the result of that.

The objectives are to reveal the costs of the two scenarios in order to get a picture of the possible gain or loss of financial means for the companies and organizations and also the possible gain or loss for the society in terms of climate impacts as a result of this measure.

1.2 Focus area

Food waste includes avoidable and unavoidable waste. Avoidable waste is waste that could have been prevented if treated differently and that is eatable but of different reasons (labelling, physical appearance etc.) is going to waste. Unavoidable food waste cannot be eaten (eggshells, bones, teabags etc.) (Naturvårdsverket, 2012).

All waste that is created at food companies, in the retail chain or at wholesalers, before it reaches the end consumer is seen as avoidable waste. The difference between food waste in the food industry or retail chain and at the end consumer is that even unavoidable waste is seen as ”wasted” food, since the whole food product would have been sold if treated properly (Jensen, et al., 2011). So hereafter, when referring to food waste before reaching the end consumer it is referred to as both avoidable and unavoidable food waste.

It is only the food that can be collected by the food bank that is part of the analysis. Food waste from primary production and households is not analyzed, only food that is ready for consumption from food companies before reaching grocery stores. Food that is returned to producers and fluent food waste that is poured down the drain is not discussed.

In this study, food redistribution only include food that is donated from food companies and which otherwise would have been wasted and treated at a waste management plant. The redistribution process includes donated food from food businesses via food banks, where the food is storaged and further distributed to social organizations and later donated and served to people in need. This implies that the redistribution goes via a food bank, so called indirect redistribution. Direct redistribution, where food is donated from the food stores directly to social organizations is not analyzed. See figure 1 that illustrates this.

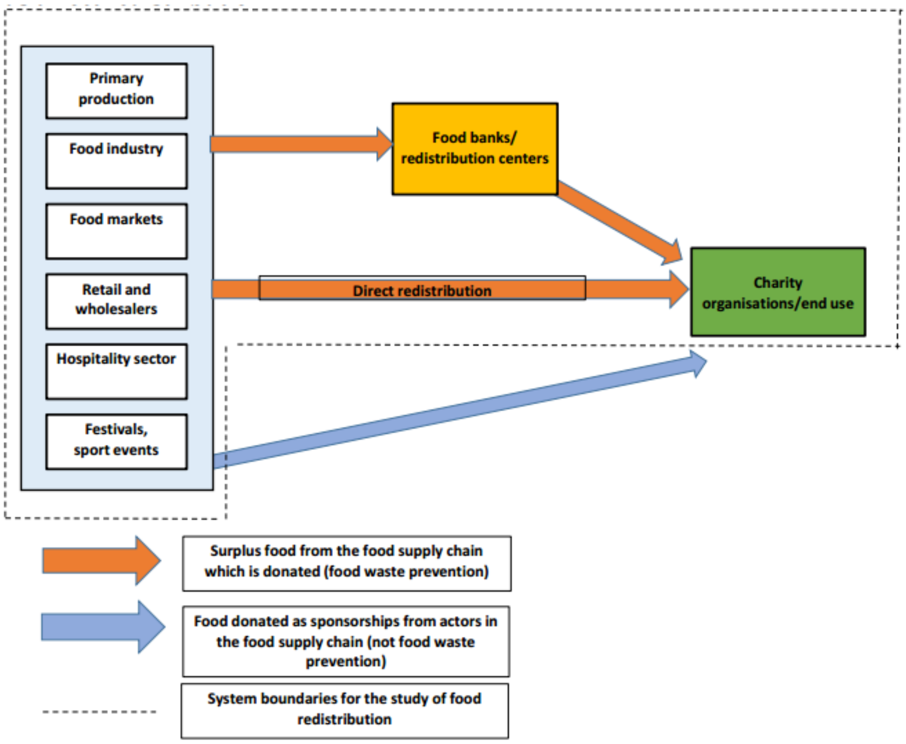

Figure 1. *Direct redistribution and indirect redistribution via a central food bank* (Hanssen, et al., 2014).

Two effects are calculated in this study, climate impact and costs. Climate impacts in this case are referred to as emissions in terms of carbon dioxide equivalents (CO_2 eq), including carbon dioxide, methane and nitrous oxide. This is most relevant since one of the goals put up by the Swedish government concerns the reduction of climate impacts (Naturvårdsverket, 2016a). Concerning costs both indirect and direct costs generated from the central food bank, food companies and social organizations are included.

There are some differences between the organizations that are dealing with food redistribution, regarding their structure and how they are financed. The European Federation of Food Banks (FEBA) has a strict definition of what a food bank is, but in this thesis all businesses that are dealing with redistribution in form of a redistribution center where food is transported and stored are called food banks, disregarding the organization. It is not of relevance to the report to differentiate between the various definitions, only the measure itself and its connection to climate impacts and economic costs.

The implementation of a food bank in Stockholm is yet on a planning basis. Therefore it is difficult making exact calculations of the system. Qualitative estimations of the climate impacts and costs are made according the information that could be found and compiled from literature, interviews and previous studies in the area. Exact calculations of the system cannot be made since the flow of food waste is not in place yet. Where no answers could be found data from reliable sources of the matter is used to make the calculations.

2. Methodology

Several methods have been used to gather information concerning the subject. General information has been collected through literature studies and is the basis of the background study. Literature studies have also been important for the result part, to be able to find information needed to make calculations of the different flows. Material flow analysis is a method used to follow and quantify the flows of food and to be able to calculate the costs and climate impacts. Interviews of the main actors have been performed to gather information and relevant data to visualize the flows and the system as a whole.

2.1 Literature studies

When performing the background study a thorough literature research was made. The main information collected was regarding food waste, waste management, climate impacts, costs and food banks. The main sources used for this information were from several Swedish authorities and from projects made in the subject area. Since food waste is a serious and recognized issue there are many efforts on a municipal, regional and national level to tackle the problem. Therefore there are many studies made in the area from reliable sources such as the Environmental Protection Agency, National Food Administration, Swedish Board of Agriculture, Nordic Council, Avfall Sverige, Stockholm Vatten, SMED and IVL (Swedish Environmental Research Institute).

2.2 Interviews

In this study semi-structured interviews have been performed when collecting information regarding the food bank, social organizations and the central warehouse. This method was suitable in these cases since the information needed was both in terms of facts concerning the flows of food, transports, costs and so forth but also concerning softer values and the driving forces behind this measure. An interview guide was created for each interviewed actor and can be seen in appendix I.

When gathering information concerning the waste management the questions were mainly regarding the treatment method, energy use and transportation. Information from the transportation company, from the pretreatment plant and the actual biogas plant was collected.

When possible the interviews were performed at the organization in question, otherwise they were performed via telephone. Both a qualitative and quantitative analysis were used. When analyzing the data a bottom-up approach was used meaning there was no theory or assumptions made before the interviewing.

2.3 Work shop

A workshop regarding the establishment of a central food bank in Stockholm was carried through in February 2016. This was an initiative by Stockholm City Mission to gather possible involving actors in the food redistribution process and included several food companies, social organizations and the planners behind the food bank. During this workshop several difficulties and possibilities were brought up and there was an open discussion how to organize this redistribution process properly, taking different aspects from the actors in mind.

By participating in this workshop information was collected which later could be used in the result regarding logistics, organization and distribution of food. The information was also used to identify interested food actors and social organizations.

2.4 Material Flow Analysis

Material Flow Analysis (MFA) is a quantitative measure for following flows of material and energy through a given system. It uses an input/output approach where inputs equal outputs according to the law of thermodynamics. The method helps analyzing the relationship between material and energy flows, human activities and environmental changes by using the principle of mass balancing (The sustainable scale project, 2003).

In this thesis a MFA has been performed to be able to follow the flows of food waste. The food waste is followed through a certain system between some specific main actors (food companies, social organizations, the central food bank and waste management companies).

The system boundary for the MFA performed is from that the food waste is created at the central warehouse, to the waste management in scenario 1, or to redistribution via the food bank to social organizations in scenario 2, see more information in section 2.7. The climate impact from the production of the food waste is also included in the study.

2.5 NTM Calc

NTM Calc is a tool used to calculate the emissions from transports of goods and from private transports. It helps evaluate the environmental performance of transports. It is a calculation method with up to date environmental data and includes emission levels, fuel consumption and energy use for the transport. It is specified by type of vehicle, size, transport distance and shipment weight (Network for transport measures, 2016). This method uses calculations including extraction, production, distribution of fuel and fuel use in the vehicle, called a Well-to-Wheel perspective and cover the entire life cycle (Network for transport measures, u.d.)

This tool is used in this report to calculate the emissions from the transports of waste from the food actors to the treatment plant, and also for the impacts from transports made by the food bank to collect food from the food actors and deliver it to social organizations. The version used was NTM Calc 3.0 Freight Basic (Network for transport measures, 2016).

2.6 Climate impacts from waste management

To calculate the climate impacts from waste management the emissions emitted from transportation and from the treatment of the food waste were brought out. The treatment method is generating greenhouse gas emissions due to transportation and by the energy used for the processes at the waste management plant, and it is these factors that were looked at when the calculations were made. Data on emissions and energy use from the whole production process is used, from the pre-treatment to the upgrading of the biogas.

Emissions from the transportation were calculated through information regarding the distance between the locations for the generated waste and the treatment plant, amount of transported waste, fuel consumption, fuel type and emissions generated for the combustion of the fuel.

To calculate the climate contribution from the treatment process data regarding energy sources used for the process, the emissions generated by the respective source, the amount of methane spill generated from the process and the emissions related to that were used to make the calculations. The energy consumption required per tonnes of treated food waste and the amount of methane spill were collected from a report which has calculated the climate impacts from treatment of food waste at Uppsala biogas plant (Gunnarsson, 2011).

The current biogas plant in this project, Syvab biogas plant, and Uppsala Vatten biogas plant are using the same digestion process, codigestion (Biogasportalen, 2016; Rosenkvist, u.d.). Therefore it is assumed that the data on the energy use per tonnes of food waste and the amount of methane spill from Uppsala biogas plant can be used in this case.

2.7 System boundaries and limitations

Actors that are part of the analysis are food businesses, social organizations, the central food bank and waste management companies and their different roles in the redistribution process can be seen in table 1. The food businesses involves central warehouses, food producers and wholesalers since it is these actors that the central food bank will focus on (Lunde Dinesen, 2016). System boundaries for food companies are set at central warehouses and information and data could only be compiled from one central warehouse. No specific data regarding amounts of food waste and costs could be collected from other food companies, therefore the calculations are based on the information that could be compiled from the central warehouse of concern. The time frame of the study is the first year of establishment of the food bank.

Table 1. *The involved actors and their role in the redistribution process.*

Actors	***Role***
The central food bank	Collects food waste from food companies and transport it to social organizations, function also as a storage unit
Food companies (Central warehouses, food producers and wholesalers)	Donates functional food waste to the food bank
Social organizations	Receives the functional food waste and serves it to people in need
Waste management companies	Transports and treats the functional food waste generated at the food companies

Specific information and calculations are done for one central warehouse and three social organizations, for the remaining food producers and wholesalers more general calculations are done based on the information collected from the central warehouse. The central warehouse of concerned is referred to as central warehouse 1. The three social organizations are Convictus, Ny Gemenskap and the Salvation Army and are all located in the Stockholm area. There are two waste management companies which are involved in the system, Ragnsells pretreatment plant in Högbytorp and Syvab biogas plant in Grödinge south of Stockholm.

It is only the costs and climate impacts that differ between scenario 1 and 2 that are focused on in the study since it is these that are of relevance for the comparison of the scenarios. The costs and climate impacts that are the same for scenario 1 and 2 do not provide anything for the result. For example the costs for warehousing at the food companies or social organizations, these factors will not change depending on the redistribution process and are therefore excluded from the study.

The costs that are analyzed from the food bank's perspective are personnel costs, warehouse charges and transportation costs, since these are most significant (Lunde Dinesen, 2016). The costs from the central warehouse of study are costs for waste management. For social organizations costs for purchasing food and transportation for food purchasing or collecting donations are analyzed.

The climate impacts of the two scenarios are also analyzed, in terms of impacts from food production, waste treatment, transportation between the actors, transportation made by social organizations and energy use for storing the food at the food bank. When the climate impacts from the waste treatment process are calculated it is the energy required for the digestion process and the emissions from the transportation that are of focus. These are the main factors that contribute to greenhouse gas emissions in the biogas production process (Dotzsky, 2016). The potential environmental benefit of replacing fossil fuels with biogas is not analyzed or calculated but is brought up in the discussion.

System boundary for climate impacts in scenario 1 is from the production of food, transportation and delivery to the food companies and impacts from transportation and treatment of the waste. The climate impacts from the production of purchased food that social organization must buy and the transportation to collect donated food or to buy food is also part of the system.

System boundary for costs in scenario 1 is from that the food is delivered at the food companies to waste management, and the costs generated at the social organizations. Including waste management costs and the costs for social organizations to buy food and their transportation costs. See figure 2 for the system boundaries in scenario 1.

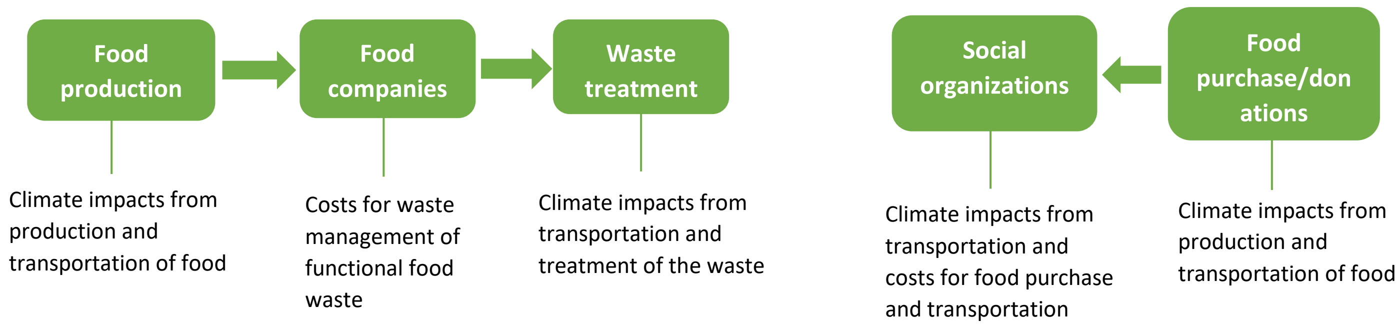

Figure 2. *System boundaries for scenario 1.*

System boundary for climate impacts in scenario 2 is from the transportation of functional food waste from food companies to social organizations via the central food bank. All impacts from transports and warehousing between the food companies and social organizations are accounted for. The climate impacts from the production of purchased food that social organizations must buy despite the redistribution from the food bank and the transportation due to this are also analyzed. The climate impacts from production of 500 tonnes food are not accounted for in this scenario. The amount of food waste that in scenario 1 goes to waste treatment is compared to scenario 2 where the waste goes to redistribution. Since food redistribution is seen as a climate impact reducing measure the climate impacts are reduced according the amount of waste that can be redistributed, in this case 500 tonnes (Eriksson & Strid, 2013).

System boundary for costs in scenario 2 is from that the food is delivered at the food companies to social organizations via the central food bank. Including costs for transportation, warehousing and personnel for the central food bank, costs for purchasing food and transportation for the social organizations. See figure 3 for the system boundaries in scenario 2.

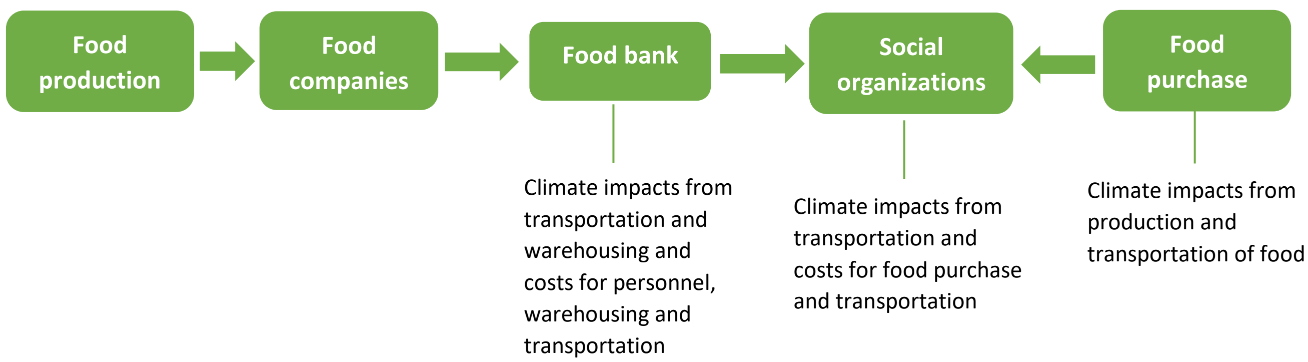

Figure 3. *System boundaries for scenario 2.*

2.8 Scenario description

Here follows a description of the two scenarios that are analyzed in this study. Interview material from the involved actors has mainly been the basis for this. More detailed information about the flows and scenarios can be found in section 4.6.

The estimated amount of food waste that can be handled by the central food bank during the first year is approximately 500 tonnes (Lunde Dinesen, 2016). This is assumed coming from central warehouses, wholesalers and food producers. Calculations are made for central warehouse 1 and the amount of functional food waste that could be collected from there. Remaining of the 500 tonnes of functional food waste assumes coming from other food actors, wholesalers and food producers.

It is assumed that the three social organizations that are analyzed, Convictus, Ny Gemenskap and the Salvation Army can all together receive 500 tonnes of food the first year. This assumption is based on the amount of food the organizations are handling currently per year, more information can be found in the section 4.2.

In scenario 2 it is assumed that the food bank is responsible for the transportation and collects 500 tonnes of food waste from the food actors during the first year. It has been assumed that the central food bank will be responsible for transportation of the functional food waste since it is unclear how the transportation routes will appear. It will probably vary on a daily basis and it is also uncertain whether the food companies can transport the food to the food bank. After the food has been collected at the food companies it is assumed that it is transported back to the central food bank for storage for every route and then is delivered to the social organizations.

All social organizations must purchase food and also receives food donations in scenario 1. In scenario 2 it is assumed that the donations can be reduced entirely. Transportations are used to purchase food or to collect donations by the organizations. The purchased food has generated a climate impact from the production and is calculated for both scenarios.

In figure 4 scenario 1 can be seen with the involving actors and flows of food. Food is produced and transported to the food companies, which turns in to functional food waste. The green arrows from the food companies to the waste disposal plant shows how the functional food waste is transported to waste management.

All three social organizations are receiving food donations and also needs to purchase food. Convictus and Ny Gemenskap uses their own transportation vehicles for collecting food donations and the Salvation Army gets the donations delivered by the donors (Åslund, 2016; Gerdin, 2016; Malmqvist, 2016). Convictus and Ny Gemenskap do not need to use transportation to purchase food since they have their grocery store’s located nearby. The Salvation Army uses own vehicles to purchase food. More information can be found in section 4.2.

Salvation Army has 10 social organizations in the Stockholm area that deals with food at the moment (Åslund, 2016). Addressed could be found for 8 of these since some are protected residences. The food redistribution from the central food bank assumes covering these 8 organizations. Currently all donations received by the Salvation Army are delivered at their internal food bank (Åslund, 2016). Therefore it is assumed that the donations made by the central food bank are also delivered there. The purchase of food made by the Salvation Army is transported directly to their different social organizations that deals with food. This can be visualized in figure 4 and 5.

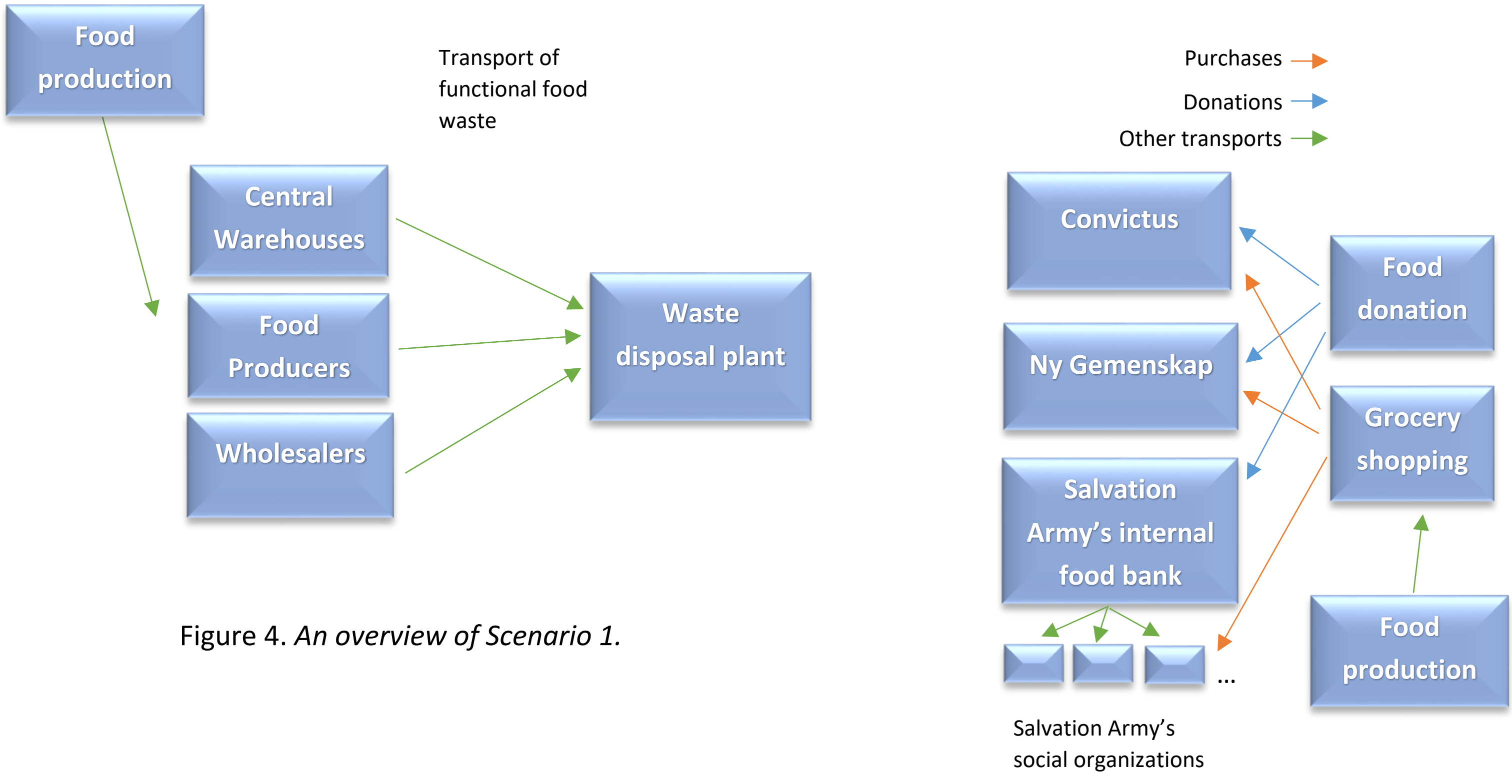

Figure 4. *An overview of Scenario 1.*

Scenario 2 and the involved actors and flows of food can be seen in figure 5. In this scenario the amount of 500 tonnes functional food waste is redistributed to the central food bank instead of being treated as waste. Therefore there is no waste management accounted for in this scenario. It is assumed that the food bank collects food at the food companies and transport it back to the food bank for storage for every route, and then delivers it to the social organizations in the order Salvation Army's internal food bank, Convictus, Ny Gemenskap and then back to the central food bank. This route was considered most probable due to the location of the central food bank and the social organizations and is assumed being done for every delivered tonnes of food waste. This route can be visualized in figure 5.

The arrows to the social organizations show that all organizations must purchase food despite the redistribution and only Salvation Army uses transportation for this as explained in scenario 1. It is assumed that donations can be reduced entirely in this scenario, while food purchases are reduced to some extent. This is further explained in section 4.2 and in appendix II.

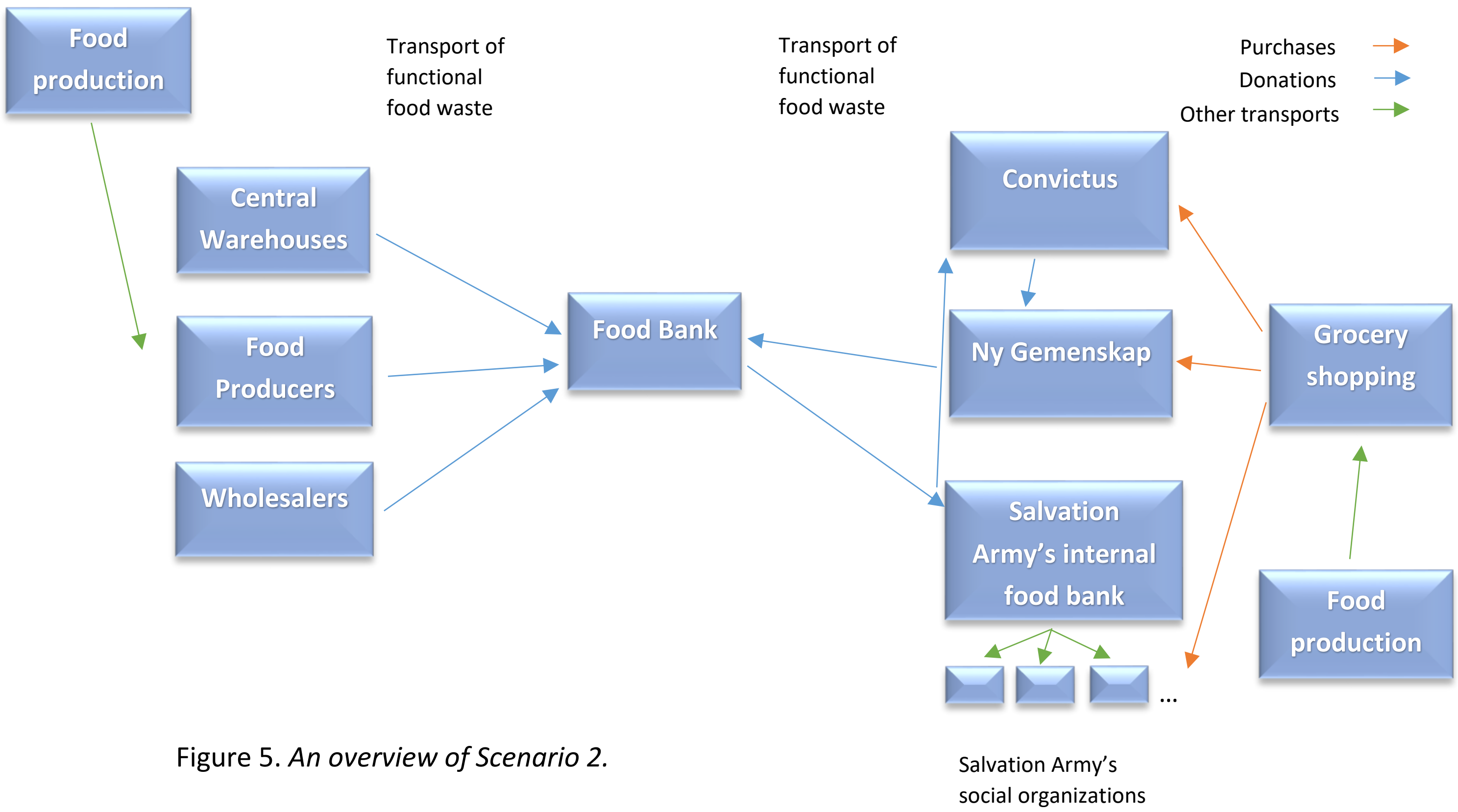

Figure 5. *An overview of Scenario 2.*

3. Background

This section cover the background of the study, providing information in the waste area, of food redistribution and food banks.

3.1 Laws, regulations, strategies and programs

The waste area is controlled on EU-, national-, regional- and local levels through laws, goals, plans and strategies. Directives and constitutions from EU should be implemented in national legislation by the member countries. The current directive is called the waste directive and constitutes a waste hierarchy which includes a set of priority levels from which waste should be managed properly (European Comission, 2016).

EU:s waste hierarchy is a measure to reach resource efficiency within the waste management area, where a preventative work is top priority. To only recycle materials and energy cannot compensate for the environmental impacts that production of new products leads to (Naturvårdsverket, 2012). These set of priorities should be implemented and followed by all countries in their legislation and politics concerning waste management and prevention of waste. Laws and measures should control the waste management according to this hierarchy (European Comission, 2016). These are the five levels with a declining priority: Prevention, Preparing for re-use, Recycling (Digestion or composting), other recovery (energy recycling from incineration) and Disposal (landfill) and can be visualized in figure 6.

Top priority

Prevention
Preparing for re-use
Recycling
Other recovery (energy recycling)
Disposal

Figure 6. *EU:s waste hierarchy.*

Different legal requirements based on EU directives control most part of the waste management. This is implemented in the Swedish legislation by laws and constitutions (Stockholms stad, 2013). According to the waste directive every member country should have waste management plans and programs operating in a preventative manner. In Sweden the Environmental Protection Agency has the responsibility for the national waste plan and program for preventing waste. They are also responsible for the waste legislation and the environmental quality goals connected to an effective resource use (Loxbo, 2011).

The County Government together with other regional authorities and actors are responsible for that the national environmental quality goals and stage goals are operated with in each county. In each county there are possibilities to develop and work with regional sub targets adjusted to that specific county (Stockholms stad, 2013).

The municipalities are responsible for management of household waste and comparable waste. In each municipality there should be a sanitation order where it is clear how household waste should be managed. This consists of a waste plan and directives regarding the waste management. For waste other than household waste, municipalities or regional authorities may regulate companies through supervision, but this is by enforcing national legislation and not covered by the sanitation order (Stockholms stad, 2013).

The environmental impacts that waste are generating concern several of the environmental quality goals set up by the Swedish parliament, specifically Limited climate impact and Toxic free environment (Naturvårdsverket, 2012).

3.1.1 Limited climate impact

According to the stage goal of this environmental goal the greenhouse gas emissions in Sweden should be reduced by 40 % by 2020 comparing to 1990 levels. In Sweden 8 % of the total greenhouse gas emissions come from waste management. This includes emissions from methane from landfilling, incineration of plastics, transportation and biological waste treatment. These emissions have on the other hand declined as a result of today´s waste management and that more waste is being recycled and reused (Naturvårdsverket, 2012).

The following stage goals concern the food waste management and climate impacts:

Increased resource management in the food supply chain
Actions should be taken so that by 2018 at the latest at least 50 % of the food waste is separated from other waste from households, grocery stores and restaurants. This waste should be treated biologically to be able to extract the nutrients and at least 40 % of the food waste should be treated to utilize the energy (Naturvårdsverket, 2016d).

Emissions of greenhouse gases reduced by 2020
The greenhouse gas emissions should be reduced by 40 % by 2020 comparing to 1990s levels. This implies that the emissions of carbon dioxide equivalents should be 20 billion tonnes lower by 2020 (Naturvårdsverket, 2016b).

3.1.2 Toxic free environment

Unfamiliar substances in the environment that have been created or extracted by the society should be minimized and not be damaging for human or environment. Waste containing toxic substances prohibit the management and treatment of the waste and reduce the recycling. The releasing of these substances can be in form of incineration of waste or through the spreading of leachate water in landfills. Emissions of cadmium, lead and mercury from waste management stands for approximately 20 % of the total emissions of these substances to air and water in Sweden (Naturvårdsverket, 2012).

3.2 The Swedish waste plan

The waste management in Sweden has shifted, from the main method landfilling to focus on recycling and reuse of materials and energy (Naturvårdsverket, 2012). This is an important step towards a sustainable waste management and reaching an effective economization of natural resources, which is a great challenge in today’s society with a continuous increasing consumption.

The national waste plan is brought out by the Environmental Protection Agency to make Swedish waste management more resource efficient. It is important that food waste is reduced to minimize the resource use through the entire food chain (Naturvårdsverket, 2012). The current waste plan embodies reaching a preventative approach to waste and economization of resources in line with the environmental quality goals and the waste hierarchy. The plan points out areas where actions are of significant importance and where food waste is one of them. Here also examples of actions to prevent food waste are brought up. Some of the actions that will be taken by the Environmental Protection Agency are spreading the knowledge of food waste, causes and consequences and how the waste amounts can be reduced. Also to bring out examples of how food actors can work preventative with food waste and to highlight what social economic benefits that can be found as a result of reduced food waste amounts (Naturvårdsverket, 2012).

To be able to reach these goals according to the national waste plan a cooperation between different actors is of importance such as municipalities, authorities, research institutes and the business sector (Naturvårdsverket, 2012).

3.3 Laws and regulations concerning food redistribution

There are several laws and regulations within EU and Sweden concerning food safety that affect food redistribution. EU:s food constitution is the foundation of how the food legislation for the countries within EU is defined (European Union, 2002). These regulations concerns traceability of food, food hygiene, registration, control and labeling and state the responsibilities that any food business actor have. The constitution is for example stating that any food that can be of risk for human health cannot be sold, otherwise it has to be withdrawn. Also the actors that sell food are obligated to make sure that the products are traceable through the whole production chain (Hanssen, et al., 2014).

These regulations should be applied in the whole production chain, processing and distribution of food. It applies to any food business, profitable or not, public or private, that is handling any activity related to production, processing or distribution of food. These regulations are not including private consumers and households. A food bank is concerned by these laws and regulations since it is an organization that receives food and redistributes it to other organizations and is thereby viewed as a food business operator (Hanssen, et al., 2014).

Sweden has a complementing law in excess of the laws and regulations from EU, called the Swedish Food Law (Riksdagen, 2006). It contains laws and provisions to be followed within the food business in Sweden, and also which authorities that are responsible for controlling the food business actors. The National Food Administration is responsible for developing regulations within the area (Hanssen, et al., 2014).

There are no specific regulations concerning food banks in Sweden. Food banks are therefore viewed as food businesses, as the EU:s food constitution stated (European Union, 2002). The responsibility for the safety of the food lies with the food business operator that donates the food to a food bank, charity organization or directly to the people (Hanssen, et al., 2014).

3.4 Waste management

There are different ways of treating and dealing with food waste which are generating varying impacts on the climate. These alternatives have a falling priority: Preventing food waste, separating the food waste and extract biogas, composting and incineration of the food waste to get district heating (Loxbo, 2011). Food waste can be treated either by material recycling or energy recovery. Digestion and composting are considered as material recycling (biological treatment) (Avfall Sverige, 2015).

In the composting process it is only the nutrients in the waste that are recycled and used as bio fertilizers in farming. The energy is released as heat and cannot be utilized and the greenhouse gas methane is also a byproduct from this process if anaerobic processes are present (Energy authority, 2010).

Digestion is the most common method when treating source sorted food waste (Avfall Sverige, 2015). In this method biogas can be produced which is a renewable energy source which consists of methane and carbon dioxide. The residuals can also be used as bio fertilizers in farming. Biogas can be used as transportation fuel, for heating or used in electricity production. The amount of waste that is treated through digestion has increased due to more food waste that is sorted out from household waste (Elander, et al., 2014). Methane is also created during the digestion process but it is only a very small amount (approx. 0,3 %) that is released to the atmosphere in terms of methane spill (Uppsala Vatten, 2015). Mostly it is the energy used to produce the biogas and the transportations that are causing the climate impacts of this process (Dotzsky, 2016). To treat the food waste through digestion instead of composting is more beneficial since both the nutrients and energy can be utilized from the waste (Livsmedelsverket, et al., u.d.).

It is more resource efficient and environmentally beneficial to work preventative with food waste than using it to produce biogas (Loxbo, 2011). To reduce the emissions from food production are generating more benefits for the society than dealing with the waste further down in the food supply chain. By reducing the food waste, the production of food can be reduced, and the resource use accordingly through the whole production chain. To recycle the food waste through digestion, where biogas and nutrition residuals can be utilized is only a small compensation for the resources used during the production of the food. Calculations show that only 10 % of the climate impacts that the food production has generated are compensated by this method (Loxbo, 2011). To minimize the waste by the source or to take care of the food before it end up as waste should be prioritized. Food waste that is created anyway, needs to be dealt with in the most resource efficient way i.e. produce biogas (Naturvårdsverket, 2012).

The amount of food waste that is treated biologically, where energy and residuals can be recycled, from retailers, restaurants, households and other food businesses reached 15 % in 2014 for whole Sweden. The goal is to increase this number to 50 % by 2018 (Stockholms stad, 2015). Since 2010 all source sorted food waste collected from households and food businesses in Stockholm is treated through digestion (Stockholms stad, 2015). Although, only 17 % of the food waste is source sorted, remaining amount is unsorted and treated trough other treatment methods such as incineration and landfill (Elander, et al., 2014).

3.4.1 Responsibilities

Municipalities are responsible for collecting and transporting household waste to a waste treatment plant for recycling, recovery or landfill. This applies to household waste but also similar waste from restaurants, retailers, offices etc. The municipalities are responsible for taking care of the waste and to inform the citizens how to deal with their waste, and how to recycle and reuse products in a correct manner (Loxbo, 2011; Sopor.nu, u.d.).

There are different types of waste created from businesses. Industrial waste is directly connected to the business activities. It can be production waste, discarded equipment and so forth. Household waste or comparable waste are created as a result of people located in a facility. This type of waste can be food waste, cleaning waste or all kind of waste that is created as a result of this. All companies are obligated to take care of the industrial waste according to the legislation. Companies that create household waste are obligated to hire the municipal collecting system for household waste (Upplands-bro kommun, u.d.). The business operator need to hire an external waste company that collects their food waste if it is viewed as industrial waste (Naturvårdsverket, 2012). Food waste from food companies such as producers, wholesalers and central warehouses is seen as industrial waste, since it is part of the business activities (Upplands-bro kommun, u.d.).

There are municipal regulations concerning whether it is obligatory to have municipal collection of food waste and regarding the treatment method. This is varying for each municipality. It is either mandatory or optional to have separate collection of food waste and the treatment method is either digestion or composting (Avfall Sverige, 2016).

Packed food waste, meat packages, fruit packages etc. has until recently not been collected separately, and has either been thrown together with household waste or with the sorted food waste, but then the package has to be removed first. The initiative of collecting packed food waste has started and currently it is the waste management company Ragnsells that collects this from food businesses in the Stockholm area (Dotzsky, 2016). The packed food waste is treated through digestion together with the other food waste (Hedenskog, 2016).

3.4.2 Waste fees

The costs connected to the collection of household waste are covered by a waste fee which is established by the city council within each municipality. This fee should cover the whole cost for the waste management and includes waste planning, customer service, billing, information and service at the recycling center where receiving of bulky waste and hazardous waste are included (Avfall Sverige, 2015). This fee can be used as a management control measure to benefit recycling and environmentally friendly waste management (Avfall Sverige, 2012).

All companies, enterprises and apartment blocks are obligated to have a subscription for collecting household waste. Included in this fee is collection, transportation and treatment of the waste. This fee is determined by the placement and design of the refuse chamber, volume, type of container and the number of pickups each week (Avfall Sverige, 2016). The municipal fee for collecting food waste is cheaper than collecting unsorted household waste, sorting out the food waste saves costs for the company since the household waste is reduced. The fee also rewards reduced amounts of waste and the customer is charged for the volume of the container or the amount of weight of the waste (Stockholm Vatten, 2016).

Food businesses are only sending a small amount of their total waste via the municipal collecting system. Deals are mainly made with external waste management companies for collecting the food waste that is generated at food companies. The taxes and charges for the collected waste are therefore negotiated between the food company and the waste management company and are separated from the municipal fee.

The waste fee that food businesses get to pay is mainly in form of a charge per tonnes of waste that is collected. The amount is varying depending on how the waste is sorted and packed, and in which form it arrives at the waste management plant (Hedenskog, 2016).

3.5 Reasons for food waste

Attitudes regarding the quality of food are a contributing factor to the amounts of food waste ending up in the end phase of the food supply chain. In the retailing business well exposed shelfs are a demand and required to make a good appearance to the consumers. It is more important that the shelfs are full and to have a large assortment than to make sure that the waste is minimized (Loxbo, 2011). Quality rules from EU or the retailers own rules regarding the food's quality and appearance leads to discard of flawless products. Spotted or brown fruits and vegetables are not sellable to the consumer, which the retailers are aware of, and therefore these products are wasted (Loxbo, 2011).

The reasons for the origin of food waste differ in the food supply chain. In the food industry it can be in form of damaged goods or defected production. At wholesalers, central warehouses and/or stores it is often passed best before dates, misjudgment in orders or irregular consumption patterns that are causing food waste. Other reasons for food waste are change of labelling and packages. It is also often due to the stores broad and continuous assortment and disadvantageous treatment of the food. The return systems for dairy and bread products are lowering the store´s incitement to reduce waste since they are compensated for this by returning the products instead of trying to sell them out (Naturvårdsverket, 2012).

3.6 Food redistribution and food banks

Food redistribution is an efficient way of dealing with surplus food from food businesses. Food actors have distribution deals with food banks that collects and store the food in a central warehouse. Thereafter the food is transported to social organizations which cook and serve the food to low income people. The food banks function as an intermediary between the food businesses and the social organizations and make the process more effective for the actors involved (Naturvårdsverket, 2012).

The organizations Global FoodBanking Network (GFN) and European Federation of Food Banks (FEBA) are promoting the food banking business. GFN is an international non-profit organization with the purpose of supporting and starting up food banks around the world. It is operating in over 30 countries and the main goal is to reduce the global hunger by developing food banks in societies where it is needed and by supporting already existing food banks (GFN, 2016). FEBA is another non-profit organization which brings together 265 food banks in 23 different member countries in Europe (FEBA, 2016).

There are some guidelines that a food bank needs to follow according to FEBA (European Federation of Food Banks): the distribution should be free of charge, the financing of the organization should be based on support from other organizations and volunteers, there should be a fair dividend of the food with no discrimination and so forth. In general, food banks are non-profit driven and are therefore dependent on other organizations and volunteers. The tasks involved in this type of distribution are: transportation, sorting and storing of the food, quality controls, keeping the redistribution chain cool and inventory work (FEBA, 2016).

Most of the Nordic redistribution organizations are not strictly following the guidelines from FEBA of how a food bank should be organized. The FEBA guidelines should be seen as an inspiration to practice the organization rather than an obligation (Hanssen, et al., 2014).

3.6.1 Examples of food banks

The first official food bank started up in the U.S and the first European initiative started in 1984 in France (Hanssen, et al., 2014). Food banking is a widespread concept and there are many examples of operations around the world. Currently there are mainly three examples of food banks that function as redistribution centers in the Nordic region, Matsentralen in Norway, FødevareBanken in Denmark and Allwin in Sweden. There are also several initiatives to food redistribution on a smaller scale in these countries.

The three Nordic food banks operate in different ways and have different methods of establishment. Matsentralen was established by a planning process including several authorities, charity organizations, research institutes and companies. The Danish and Swedish organizations were the result of private initiatives and developed in a continuous process. The food banks in Denmark and Norway collaborate with several local charity organizations and function as national redistribution centers for the region around them. Allwin in Sweden receive most of the donated food from retailers and the food industry and support mostly charity organizations in the Gothenburg region (Hanssen, et al., 2014). Matsentralen has been very successful due to the early involvement of different authorities and stakeholders in the planning process. This made it possible to establish collaboration between the food bank and local charity organizations early on in the process (Hanssen, et al., 2014).

Finland also has two examples of food banks operating in the country. In 2014 a food bank was established in the city of Vantaa as a result of collaboration with several churches, which was part of a food aid program. There is also an initiative in the Turku area called Operaatio Ruokakassi. Finland has been dealing with food redistribution for a long time and they have a large population in need for food security (Gram-Hanssen, et al., 2016).

3.6.2 Organizational structure of the Nordic food banks

This section describes the organizations of the Nordic food banks Matsentralen, FødevareBanken and Allwin, to get a picture of how food redistribution systems can be structured.

Matsentralen

Matsentralen in Norway was established in 2013 in a food industry area outside of Oslo. It was founded by five charity organizations together with authorities and food industry companies. The food bank is in business with 40 social organizations which are collecting food at the food bank in their own vehicles. In 2015 they redistributed 800 tonnes functional food waste. The model includes a central warehouse where the food waste can be stored (Lunde Dinesen, 2016). The redistribution model of Matsentralen can be seen in figure 7.

Matsentralen is charging a fee from the social organizations in form of long term deals (three years), which is a fixed sum per year. Several of the involving food actors are also financing the food bank in form of a yearly sum (Aubert, 2016).

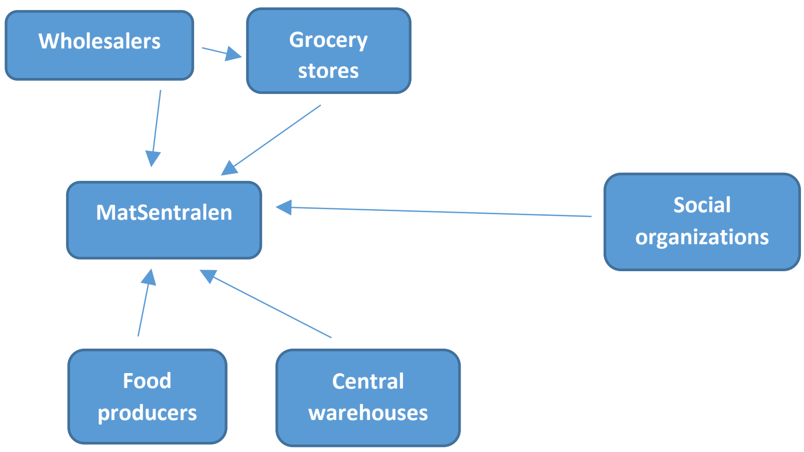

Figure 7. *The model of the Norwegian food bank, Matsentralen.*

FødevareBanken

FødevareBanken is a social organization and was established in 2009. The food bank delivers food to 84 social organizations in Copenhagen and Århus. The food is collected and delivered by volunteers and the organization also has 7-8 full time workers. It is funded by public and private donations and membership fees. In 2015 they redistributed 680 tonnes functional food waste.

The model includes a central warehouse where the food waste can be stored (Lunde Dinesen, 2016). The redistribution model can be seen in figure 8.

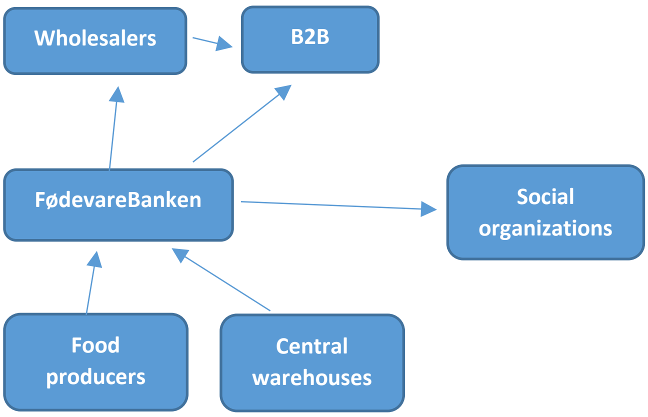

Figure 8. *The model of the Danish food bank, FødevareBanken.*

Allwin

Allwin started up as a project in 2004 by Simon Eisner in Gothenburg. In 2010 it became a profit-driven organization and a private corporation. In March 2006 the foundation Gemensamt Engagemang started and it is now this foundation that runs Allwin AB (Allwin, 2016). The company is daily picking up food from 26 different retail stores in exchange for a CSR fee (Corporate Social Responsibility) and delivers the food to social organizations which is served to low income people. This CSR fee should cover the costs for picking up and delivering the food. The main reason for charging a fee is not being dependent on financing and support from other organization and this way they can run their business more effectively. The business is currently operating in Gothenburg but is planning to expand to Stockholm and Malmö (Allwin, 2016).

Food for 10 million SEK corresponding to 500 000 meals are being served every year. The company redistributes 2,6 tonnes surplus food per week. This food is mostly in form of bread, canned food, salads and sandwiches. Approximately 250 tonnes of surplus food is redistributed each year (Svensson, 2014). Unlike the previous two food banks this company is mainly dealing with small amounts of surplus food, in form of daily pick-ups and redistributes the food directly from the food actors to the social organizations. Therefore Allwin does not have a central warehouse to store the food which can be seen from figure 9 (Allwin, 2016).

Figure 9. *The model of the Swedish food bank, Allwin.*

3.6.3 Challenges in the food redistribution system

There are some important factors to make sure that a redistribution system is organized in an effective way. Safety and quality of the food needs to be ensured and routines regarding transports, traceability, storage and cooling needs to function correctly. It is important that systems for food tracing and quantification of food that is redistributed are developed, due to food regulations. In present, there is not any efficient way for tracing the food, and it is a challenge in order to develop an efficient redistribution system. The donor of the food has the same responsibility for the safety and quality of the food as when sold in stores. The food business is responsible for the safety of the food when donating food to a food bank. It is therefore important with quality controls and that it is clear where in the redistribution chain the controls need to be done and by whom (Hanssen, et al., 2014).

One problem that the social organizations usually face when receiving donations is that they do not receive a varied and continuous amount of food which creates problems in planning and organizing the distribution (Hanssen, et al., 2014). There is a need for more developed systems for food redistribution to make them more efficient and use the existing resources properly, in order to match the amount of surplus food and the need for food security for low income people.

Costs for transportation, storage, facilities and sorting the food are substantial. Efficient logistics are significant and more achievable in large scale food banking (Gram-Hanssen, et al., 2016). Also when having more large scale logistics, there are possibilities to reach out to more social organizations and to fully utilize the potential of this action (Hultén, 2016). It also has been shown that the Nordic national food banks that exist today are facing financial obstacles in terms of low incomes and low support from national authorities. The income or membership fee from food companies is not covering the entire part of the organization (Hanssen, et al., 2014).

The food banks are depending on financing support from other organizations and authorities which is a limited amount. The financing is often unpredictable and varying from time to time. Therefore the incomes are uncertain and do not always cover the actual cost during a period. The start-up phase is often covered with donations and financial support but there is a need for a continuous long term income to stabilize the organizations and to run it more efficiently (Gram-Hanssen, et al., 2016).

3.7 Food redistribution by Stockholm City Mission

Stockholm City Mission is a non-profit organization without association with state, municipality or church but cooperates with other non-profit organizations, municipalities and county councils. The main practice areas are social organizations, social business and school activities. This work includes organizations for people in need, second hand stores, cafés and different types of schools on upper secondary school level and university level. The organization is driven by employees and volunteers and is financed through private donors, businesses, funds, support from state, municipality and county councils and the profits from their different practices (Stockholms stadsmission, 2016b).

3.7.1 Pilot project

Between December 2015 and March 2016 there was a pilot project in form of small scale organization that was dealing with food redistribution in Stockholm. It was an initiative by Stockholm City Mission in collaboration with Axfood. It was in form of one car that collected surplus food from food companies and delivered it to a social supermarket called Matmissionen in Rågsved south of Stockholm. Unfortunately this store was burned to the ground in March 2016 of unknown reasons (Rindevall, 2016).

Currently there are plans on finding a new facility for the business. This store was directed to people with financial limitations which can buy food at the store at low prices. The food that Matmissionen couldn’t take care of due to lack of space was distributed to other charity organizations or handed out for free or at very low prices. The main idea and purpose with Matmissionen is to reduce food waste at food actors (Rindevall, 2016). According to Johan Rindevall, director of department at Matmissionen, the potential is large. During the three months that the store was in business they had reached 1200 members and the demand was high (Rindevall, 2016).

Matmissionen had a member model that aimed at people with low income and needs of economic support for different reasons. The members had to have an income that fall below 8 700 SEK per month. They could buy food for a third of the main price. People with an average income could buy food for the main price (Rindevall, 2016).

Matmissionen is part of a bigger project called Matcentralen. Included in this is Matmissionen, the planned central food bank and Matverket. Matverket is dealing with refining of functional food waste. The basic idea behind Matcentralen is to work with different models to reduce food waste from the food chain. Food that is wasted in different businesses should go to people in need and the organization should also benefit work integration (Rindevall, 2016). Matmissionen and Matverket are mainly directed to grocery stores and collects surplus food from there. The central food bank should mainly focus on central warehouses, wholesalers and food producers (Lunde Dinesen, 2016).

3.7.2 The planned central food bank

Stockholm City Mission has plans to start a large scale food redistribution center in Stockholm. This food bank plan to have a central warehouse where the food can be stored. It should function as a central food bank and be cost effective. This redistribution will cover larger quantities than the current pilot project mentioned above and be safer regarding food quality and traceability. This model will be inspired by the Norwegian and Danish food banks and should have a storage and cooling capacity (Stockholms Stadsmission, 2016a).

There should be a professional coach and administrators at place and the business will work continuously with work integration. It has been discussed that the social organization should be able to demand different products, sort of food and quantities. One problem today is that they can often receive large quantities of one specific product. Therefore there must be better communication in order to improve an even distribution (Stockholms Stadsmission, 2016a).

Key activities in this project are dealing with functional food waste, professional coaching and personal support. The customers are social organizations and food companies. The food bank should function as a platform where communication and information regarding the redistribution can be shared by the actors. The food actors involved should sign a long term commitment and help financing the food bank (Stockholms Stadsmission, 2016a). According to Anne Lunde Dinesen project leader of Matcentralen, the main obstacles in the establishment will be financial (Lunde Dinesen, 2016).

The purpose with the food bank in Stockholm is to reduce food waste and food costs for social organizations in Stockholm and also to increase the influence and employability for people standing outside the labor market. Social organizations receives food by a food deliverer or buys it at a grocery store and by receiving large quantities from food banks instead, they can save this cost (Stockholms Stadsmission, 2016a).

This project started in a small scale as a social supermarket, Matmissionen, described above, and is now developing to a larger scale. Stockholm City Mission has every third year developing plans and between the years 2015-2018 the establishment of a central food bank was included in this plan (Lunde Dinesen, 2016). The interest for this type of business is high. The food business wants to take social and environmental responsibility and to be a part of this organization is a concrete way to do so (Lunde Dinesen, 2016).

4. Result

4.1 The central food bank

To be able to get a picture of the redistribution process and the planned central food bank interviews with Anne Lunde Dinesen, project leader of Matcentralen, and Johan Rindevall, director of department of Matmissionen have been used as material. The information received from the interviews are ideas concerning the establishment of the central food bank and these ideas are continuously shifting and evolving as the project proceeds. In this thesis a model of the central food bank will be visualized and calculated for based on this information and qualified assumptions. Depending on the outcomes of the project planned by Stockholm City Mission this model can vary from the actual established food bank.

Early on in the process of establishing a central food bank there was a work shop by initiative from Stockholm City Mission, where several food actors got to participate and show there interest in the matter. There was an open discussion and several tasks worked on during this meeting, concerning the logistics, organization and distribution of food. Difficulties, obstacles and possibilities were discussed and brought up. It is still under discussion whether the participating companies will be involved in the food redistribution since this depends on how the process turns out concerning effective logistics and whether other main issues are solved. It is from the participation list that the assumed involved companies have been identified.

Inspiration from the Danish and Norwegian food bank model will be used as guidance for the Swedish initiative. The Swedish food bank will be aimed at food producers, wholesalers and central warehouses for grocery stores. They choose not to focus on grocery stores itself due to short expirations dates and small volumes. During the first year of establishment the food bank will cover four social organizations. The following years the idea is to reach out to more social organizations and cover the main part of Stockholm (Lunde Dinesen, 2016). The food actors that have showed a first interest in participating are companies distributing groceries as dairy products, bread, coffee, fruit-and vegetables, perishables and grocery products.

The food bank will have a central warehouse for treatment and managing of the food waste. Regarding who will be responsible for the transports from and to the food bank is still under discussion. There is no possibility for the social organizations to collect the food at the food bank, it is a question of food safety and it is also more efficient that the food bank delivers the food in refrigerator trucks to the organizations (Lunde Dinesen, 2016). The routes between the food actors via the food bank and to the social organizations will differ depending on the amount of food waste, availability, supply and demand. It is hard to estimate beforehand.

The food bank in Stockholm will be a social organization. There will be three employees, a work coach, instructor and a director of department. Remaining staff, who will deliver the food, will be people that stand outside the labor market which needs employment subsidies. They get paid from the employment office or similar authorities and these salaries are not paid by the food bank. No volunteers are planned to participate (Lunde Dinesen, 2016).

To finance the project the idea is to let the food actors participate with financial means in a long term perspective. This should cover the costs for the warehouse and treatment of the food and will be a yearly cost (Lunde Dinesen, 2016). Here they are planning to take inspiration from the Norwegian model, which is receiving several larger amounts of financial means from food actors they are cooperating with. On the other hand it is far from every actor that pays a yearly sum, this is varying (Aubert, 2016). No charging fee per amount of food waste that is collected or per time it is collected will be used. The food bank in Stockholm will receive no funding from the state, the idea is that the yearly charging fee from food actors and private funding will cover the costs. Another possibility is that they will take a logistics fee from the social organizations. This is still under discussion and whether it will be used and how much is unclear (Lunde Dinesen, 2016).

During the workshop where several food actors and social organization got to participate and discuss this project it was mentioned that the functional food waste should be possible to trace. The idea is that social organizations should be able to control the food they get delivered (amount and food type). It was discussed that the food waste that enters the food bank will be documented in a central database or such. The food will be traceable via their individual bar-code and a list of all food received will be available. By doing so, social organizations can get more control over the donations received. Also there is a matter of ensuring the safety of the products that are redistributed. This is important from all parts, both the deliverer and the receiver since the food actors do not want their products and brand being associated with lack of quality and the social organizations do not want to serve food that is not safe (Stockholms Stadsmission, 2016a). How to organize this efficiently needs to be further developed.

According to Anne Lunde Dinesen the main costs for the food bank will be warehouse charges, personnel costs and transportation costs (Lunde Dinesen, 2016). In table 2 the specific information concerning the food bank and the vehicle that will be used is seen.

Table 2. *Information about the food bank and vehicle.*

Food bank		**Transport vehicle**	
Location	Årsta[a]	*Model*	Mercedes Benz Sprinter[a]
Warehouse capacity	Approx. 700 m^2[a]	*Maximum shipment weight*	1000 kg[b]
Cooling capacity	2 large cooling rooms[a] 1 large cold chamber[a]	*Fuel*	Diesel[b]
Amount food waste	500 tonnes during the first year[a]	*Fuel consumption*	0,79 liter/mile[b]
Energy cost	Approx. 0,70 SEK/kWh[c]	*Fuel cost*	12 SEK/liter[d]

([a](Lunde Dinesen, 2016), [b](Clagine, 2015), [c](Rindevall, 2016), [d](Preem, 2016))

4.2 Social organizations

Information from the social organizations has been compiled through interviews with the responsible person for the corresponding organization. The organizations that are planned to be included in the redistribution during the first year are Convictus, Ny Gemenskap, Salvation Army and Musketörerna (Lunde Dinesen, 2016). These are of varying size, Salvation Army is by far the largest with several operations around Stockholm. Convictus and Ny Gemenskap are of similar size, dealing with similar amount of food every year, and have comparable activities and budget for their organizations. Musketörerna is a smaller café business.

Information has been collected from Convictus and Ny Gemenskap largest daily activity centers that are serving food. Ny Gemenskap also has three café businesses but these are not dealing with larger amount of food and have no capacity to store the food properly (Malmqvist, 2016). These businesses are therefore excluded from the study. Musketörerna is seen as a complement to Convictus and they are not dealing with larger amounts of food, they are also active in the same area as Convictus (Gerdin, 2016). Information regarding the business activities from Musketörerna was not available and was therefore also excluded from the study.

The Salvation Army has several different businesses in the Stockholm area that are dealing with food. The idea is that all these businesses will get deliveries of food from the central food bank (Åslund, 2016). Information and data regarding donations, grocery shopping and costs have been compiled for all businesses within Salvation Army together and an average result is taken from this. The transportation route from the central food bank to the Salvation Army is assumed going directly to their internal food bank in Hjorthagen.

An approximation of the amounts of food that can be received at the social organizations has been made with information from the interviews. For Convictus and Ny Gemenskap relatively certain calculations could be done due to the gathered information from the interviews. Where information was missing from Ny Gemenskap this was based on the organization of Convictus due to the similar size and type of organization and amount of costs. Concerning the Salvation Army the information was insufficient regarding the amounts of food, donations and food purchasing so in this case the calculations are more uncertain. A more general approximation is made based on the information gathered. The result is therefore reviewed critically and discussed in the analysis.

According to information from the Danish food banking model the food purchases could be reduced by approximately 50 % at some of the social organizations as a result of food redistribution (Lunde Dinesen, 2016). This is varying significantly among organizations and depends on the size of organization but this has been assumed for the social organizations in Stockholm.

4.2.1 Convictus

The basic idea with Convictus is to offer support to homeless people. The three catchwords are homelessness, addiction and health and are describing the purpose of the organization (Gerdin, 2016). They have several businesses around Stockholm which offers breakfast, lunch and they also have a health center which offers support to addicts who needs help to stabilize their health (Gerdin, 2016).

In this report only the business in Högdalen is analyzed since it is the largest one dealing with food. This organization has around 110-120 daily visitors and is opened Monday to Friday. Except offering breakfast and lunch they also some days have a doctor and lawyer at place. They have five employees and besides that also temporary employees and volunteers (Gerdin, 2016).

The organization in Högdalen receive donations from Coop Extra in Stuvsta. There they collect food four times a week and around 75 kg per time. The donations are free of charge and are mainly in forms of fruit, vegetables and bread. They use their own vehicle to collect the food, a Volkswagen Caddy without refrigerator plant. It is driven by biogas (Gerdin, 2016). Maximum shipment weight is 490 kg (Blocket, 2016).

Except this amount of donated food Convictus also purchase food for approximately 200 000 SEK/year according to estimations from Dino Gerdin, supervisor of Convictus. The amount of purchased food is mainly in form of dairy products and meat products, which they cannot receive from donations at the moment. It is revealed that the organization has an average meat consumption of approximately 10 kg a day since they want to be able to offer the visitors a balanced diet. They are purchasing food equal a full loaded shopping cart which holds 100 kg, five times a week, from a nearby shop in Högdalen center called Matdax. There they can purchase food for beneficial reasonable costs and they do not need a vehicle for this (Gerdin, 2016).

According to Gerdin the result of receiving donations from a central food bank would reduce the amount of purchased food for the organization (Gerdin, 2016). These costs could be almost completely avoided with a fully covered redistribution with varying products, assumed that the organization could control the type of food received. It could also reduce transportation costs and the related climate impact since they can get a significant share of their assortment covered by the central food bank. The saved costs would be used to strengthen the business, develop it and make sure that they can offer a higher value (Gerdin, 2016).

The organization is financed by taxes from Stockholm Stad and the associated municipality. The main costs to run the business are personnel costs and these are not considered changing as a result of a central food bank. Convictus has a relatively small economy and has no possibility to hire more personnel (Gerdin, 2016).

The business can meet the demand for food in the area. They have a strong assortment with varied food and it is seldom the food is not enough. The food they would receive from redistribution is therefore not about covering any insufficient supply, it would rather give the possibility to reduce costs for the organization which they can invest in developing the business (Gerdin, 2016).

4.2.2 Ny Gemenskap

Ny Gemenskap has several businesses around Stockholm. The mansion at Västberga gård is the largest and serve breakfast and lunch. They also have three smaller café businesses in the city which serve breakfast. Ny Gemenskap has 25 employees in total, spread around the different businesses. There are also some volunteers involved (Malmqvist, 2016).

The business at Västberga gård is a daily activity center for about 100 people per day. Approximately 50 portions of lunches and breakfasts are served daily. They also have lodging for about 12 people. They offer, except food, shower, used clothes and possibilities for laundry making (Malmqvist, 2016).

Västberga gård has no cooking possibilities so they are only receiving donations or purchase food that is cooked or does not need cooking. For example fruit, vegetables, bread, dairies, deli products, bakeries and so forth. They are purchasing food for approximately 300 000 SEK per year for the daily activity center (Malmqvist, 2016).

They both purchase food and receive donations. The donated food is free of charge. They are mainly receiving donations from Grimsta which are delivering fruit and vegetables. All donations are delivered to Västberga gård and no transportation needs to be done except when they drive to Ica Baronen once a week and collects four full black garbage bags of bread. The vehicle used for this is a Ford Mondeo driven on diesel without refrigerator plant. This is the only transportation made by the organization. The donations are only a small part of the total served food corresponding to around 10 % while the share of purchased food is approximately 90 %. Even if they receive food from the food bank they will probably need to purchase food that has a high consumption rate at the organization, for example coffee and dairy products. About 50 kg coffee per month is currently consumed. Food purchases are made from a nearby Coop store (Malmqvist, 2016).

Of all the facilities of Ny Gemenskap the one at Västberga gård has the best possibilities to store the food. They have a basement, storehouse, several freezers and refrigerators. Even though, currently they cannot receive more food than they do today. The café businesses have even less possibilities to storage the food since they are smaller and share their storages with other social organizations (Malmqvist, 2016).

The business at Västberga gård could not receive more food through redistribution but they could reduce the current received donations and purchase of food. If they could order and control the food they would receive from the food bank they could probably rely almost entirely on this, assumed that the redistribution is varying and continuous. Except possibly for coffee and dairy products which are consumed a lot. The business at Västberga gård does not have a high pressure and demand due to the location which is far from the city center and therefore there is no need to receive more food. It is seldom that the food served is insufficient (Malmqvist, 2016).

Ny Gemenskap does not plan to hire any more personnel as a result of a redistribution, since they already have their number of staff needed and since they cannot receive any larger amount of food than today's amount (Malmqvist, 2016).

Ny Gemenskap is financed by the municipal of Stockholm and that contribution stands for about half of the total yearly budget. Remaining financial means are coming from foundations, funds and private donations. The main costs for the organization are personnel costs, followed by facility costs and food cost (Malmqvist, 2016).

4.2.3 Salvation Army

The Salvation Army is a social organization and has about 100 businesses around Sweden. They have pre-schools, institutions, residents for drug abusers and homeless people and shelters for women in need. In the Stockholm area there are several institutions, community centers and hospices (Åslund, 2016). They also have their own internal food bank of a smaller size in Stockholm. It is located in Hjorthagen and has three facilities. They receive food from Linas matkasse among others. All donations delivered to Salvations Army in Stockholm are delivered via this food bank. Nothing is donated directly to the different organizations (Åslund, 2016). The different organizations in Stockholm have approximately 100 employees as well as some volunteers. Their internal food bank has two employees.

It is within the social organizations that food is being served and dealt with. There are around 10 organizations in Stockholm at the moment. The food that will be delivered by the central food bank is assumed to cover these social organizations dealing with food since several have shown interest for this (Åslund, 2016). No information regarding the amount of food that is being dealt with at the organizations and the internal food bank could be received. About 80 % is purchased food and remaining 20 % is donated according to estimations (Åslund, 2016). The food that is not covered by the donations are mainly dairy products. It appeared from the interview that mainly soup and similar food is served at the organizations. The consumption of meat appears not to be significant.

The food budget for all organizations connected to the Salvation Army in Stockholm that serve food is 2,8 million SEK per year. They also receive food donations directly to their internal food bank. All donations are free of charge and delivered by the donors. No transportation is done by Salvations Army's own vehicles for this purpose. The purchased food is from Martin & Servera. The vehicle used for this transport is a Volkswagen Caddy which run on diesel and has no refrigerator plant. The Salvation Army is financed by taxes, municipal contributions and operating grants but a large sum is also self-financed. The main costs are personnel followed by costs for the facilities and food (Åslund, 2016).

Salvation Army has seen an increased demand from people in need in the society, so if they could receive more food they would be able to help more people. If they receive food deliveries from the central food bank they could reduce their food costs and other donations. The food that probably would have to be purchased anyway is mainly dairy products if it is not provided in large quantities from the redistribution. The organization does not plan to hire any more personnel as a result of a redistribution (Åslund, 2016).

The Salvation Army is interested in being involved in the food redistribution process with a central food bank in Stockholm. However, it is still unclear how the distribution and logistics around this would appear. Either the central food bank would deliver the food directly to the social organizations via their internal food bank or it is possible that they will close down their food bank and only rely on food donations from the central food bank (Åslund, 2016).

4.3 Central warehouse 1

Central warehouses are dealing with large amounts of food which have been delivered by food producers. They in turn are delivering food to retailers based on an order made by the retailers themselves. The food is packed together on pallets and then transported to the retailer.

At central warehouse 1 there are product controllers at the logistics department that order products according to prognosis. The products are delivered to the terminal and are controlled that they are whole, clean and non-contaminated. Otherwise they are directly sent back with the deliverer. The best before dates are also controlled. They have a computerized system where all the products are available and where the related best before date is shown. The system warns if the products are nearing their best before date and then they usually can send the products back with the supplier or the prices are reduced at the retailers (Intervjuobjekt 1, 2016).

After the control the products are taken in to the warehouse and later packed together on pallets for preparation for delivery to the retailers. Irreparable products are being discarded and become waste. At central warehouse 1 they are trying as far possible to avoid that food ends up as waste. There are two people that daily control and repair products and packages that are broken but where the content is intact. They have some designated stores where they send some of the products where the packages are broken and the store can sell this for a reduced price. At the warehouse both food and non-food products are being dealt with. The food products are only dry goods, no refrigerated food is handled (Intervjuobjekt 1, 2016).

Around 7000 products are going to waste each year at the warehouse. This includes both food and non-food products. The products that are discarded are mainly where there have been leakages or when packages cannot be repaired. Therefore a relatively small amount of food waste is generated at the warehouse. This because it either goes in return with the suppliers or the packages gets repaired if they gets broken or is noticed broken at another time than at delivery (Intervjuobjekt 1, 2016).

The packages that are broken and unrepairable cannot be redistributed via the central food bank. According to the interviewee at the warehouse they could let more products go via the food bank instead of putting efforts on fixing the packages and selling them at reduced prices at stores, consequently some amount of functional food waste could be increased by this. It was estimated that around 5 % of the amount of food waste that is being generated at the central warehouse and currently goes to waste management could be collected by a central food bank. Remaining amounts cannot be redistributed (Intervjuobjekt 1, 2016).

The food waste generated is dealt with as followed; the person that broke or noticed the broken product puts it in discard boxes. These products are later controlled to see what can be repaired or what needs to go to waste treatment. The products that need to be discarded are thrown in a container in terms of a pendulum compressor which press the food waste together. This waste is collected once a week by the waste management company Ragnsells. Approximately 4-5 tonnes food waste a week is collected. The charging fee is 1265 SEK/tonnes and the yearly sum is approximately 350 000 SEK (Intervjuobjekt 1, 2016).

To let the functional food waste go to a central food bank instead of waste treatment would be a good idea and a beneficial alternative according to the interviewee. It is then avoided that this food is wasted and instead serves a good purpose. However, there are some difficulties concerning redistribution of goods from food companies. It is a matter of traceability and controlling that the brand and products are dealt with according to legislation. Central warehouse 1 does not want to risk that their own brand and products can be sold to actors without their control over the product. It is important that the products are not sold by someone not approved by the owner of the product or brand. This is a matter of ensuring quality of the product so that no products with lack of quality are sold or donated which can be associated with their brand (Intervjuobjekt 1, 2016).

Central warehouse 1 owns all the products in their warehouse, but not the brand itself (if it is not their own brand). Producers and suppliers have some rules that ought to be followed and their products maybe cannot be sold or donated to a third party. This is something that needs to be considered and controlled before any food is redistributed. Therefore it is important that an agreement is written concerning that the redistributed food cannot be sold by non-authorized actors. This is a demand from central warehouse 1 for being a part of the redistribution process. If the central food bank has a tracking system which controls the products according dates, quality and safety it would solve that problem considering the safety requirements for their own and their supplier's brands (Intervjuobjekt 1, 2016).

Central warehouse 1 could imagine paying a yearly sum for letting their functional food waste go to a food bank instead of waste treatment. However, it is unclear whether they could be responsible transporting the food to the food bank. They only book the transports absolutely needed. This is something that needs to be further discussed (Intervjuobjekt 1, 2016).

4.3.1 Waste management for central warehouse 1

The waste management company Ragnsells is responsible for collecting the packed food waste at central warehouse 1. Since there is only dry goods at the central warehouse there is not generated any unpacked food waste (Ragnsells, 2016).

Ragnsells collects the packed food waste in vehicles which weigh around 18-26 tonnes (Malm, 2016). The vehicle run on diesel and has an average fuel consumption around 2-4 liter/mile (Hedenskog, 2016). Ragnsells transports the food waste to a recycle center in Högbytorp where the waste is pretreated to a liquefied slurry. Then it is transported to Syvab biogas plant (Malm, 2016; Upplands-bro kommun, 2016). For the transport between Högbytorp and Syvab larger vehicles are used which weigh around 60 tonnes and run on diesel with a fuel consumption of 5 liter/mile. The trucks are normally loaded with approximately 33 tonnes before takeoff. A large amount of slurry is assembled to reduce transportation (Ragnsells, 2016).

4.4 Waste management

A certain amount of energy use and greenhouse gas emissions are generated in biogas production. Energy is needed for the digestion process since the digestion substrate needs to be heated and electricity is required for the pumps and to upgrade the biogas (Uppsala Vatten, 2015). The greenhouse gas emissions which are generated from waste management are related to the energy and fuel consumption required both for transportation and for the treatment process.

The climate impacts from transporting the waste from the pretreatment plant in Högbytorp to Syvab biogas plant, and also for the treatment of the waste are calculated. How these calculations are done is further explained in section 2.6. The climate impacts from transporting the waste from central warehouse 1 to pretreatment in Högbytorp are calculated by using the tool NTM Calc. The climate impacts from transportation between central warehouse 1 and the waste management plant are only accounted for the route from the central warehouse to the biogas plant via the pretreatment in Högbytorp, single route, where the vehicle is loaded with food waste. Not for when the transportation trucks are unloaded. Calculations can be seen in appendix II.

Syvab biogas plant is using energy in form of electricity from the grid (around 62 %) and the produced digester gas. The digester gas is produced in the biogas plant and is assumed not to generate any additional greenhouse gas emissions (Stark Fujii, 2015). According to the environmental report from Ragnsells all their facilities are driven by electricity, including the recycle center Högbytorp (Ragnsells, 2013). The calculations of the climate impacts from the treatment process are made based on the energy used in Syvab biogas plant which are electricity and digester gas.

The data which could not be found from Syvab biogas plant were the amount of methane spill to the atmosphere (approximately 0,3 % of incoming amount of methane) and the amount of energy required per amount of treated food waste (Uppsala Vatten, 2015). This data was collected from a report which has calculated the climate impacts from treatment of food waste at Uppsala biogas plant (Gunnarsson, 2011).

At the biogas plant in Uppsala all the treatment steps occur at the facility there, from pretreatment to upgrading of the biogas (Uppsala Vatten, 2015). The food waste from central warehouse 1 is on the other hand pretreated at Högbytorp before it is transported to Syvab for remaining treatment and upgrading (Syvab, 2016). The pretreatment step in this case is occurring on another location but this has no considerable impact on the result since it is the climate impact for the entire treatment process which is calculated, independent of the location. Therefore it is assumed that the data of the methane spill and energy use per tonnes of treated food waste from Uppsala biogas plant can be applied in this study.

4.5 Climate impacts from transportation and food production

This section describes how the climate impacts from transportation with a refrigerator plant and food production are determined.

4.5.1 Transportation

Climate impacts from the transportation made by the food bank are dependent on the vehicle, type of fuel, shipment weight, distance and whether it has a refrigerator system. Climate impacts from the refrigerator system depend on mainly two factors, the climate contribution from the refrigerating plant and leakage of refrigerants (Nilsson & Lindberg, 2011). The refrigerating plant run on diesel and the fuel consumption varies but a fuel consumption of approximately 3 liter diesel/hour is assumed (Winther, et al., 2009).

The climate contribution from a truck with 20 tonnes shipment weight is 0,4 g CO_2 eq/transported kg and hour of running of the refrigerator plant. The leakage of refrigerants is 0,025 g CO_2 eq/transported kg and hour of running of the refrigerator plant (Nilsson & Lindberg, 2011). According to this the climate contribution for the vehicle used in this study is 0,02125 g CO_2 eq/transported kg and hour of running of the refrigerator plant based on the size of the shipment weight. (Maximum shipment weight is 1000 kg for the vehicle used by the food bank. 20 000/1000 = 20. 0,4/20 = 0,02 g CO_2 eq/transported kg and hour of running of the refrigerator plant. Leakage of refrigerants: 0,025/20 = 0,00125 g CO_2 eq/transported kg and hour of running of the refrigerator plant.)

The climate impacts from refrigerator trucks depends on the shipment weight (Nilsson & Lindberg, 2011; Winther, et al., 2009). Therefore it is assumed that the climate contribution is reduced proportionally with the shipment weight.

4.5.2 Food production

A study made by Scholz (2013) has analyzed the greenhouse gas emissions (CO_2 eq, CH_4 and N_2O) from wasted food to reveal the climate impacts of food waste from the food chain. The wastage carbon footprint from all food waste from six different retail stores in Stockholm was calculated. The wastage carbon footprint included the carbon footprint value of the products, the emissions generated by the production, distribution and delivery to the stores. A farm to gate perspective has been used (Scholz, 2013).

The method used for determine the carbon footprint from a farm to gate perspective of the different products were literature reviews of LCA studies. Mainly the emissions from the production and transportation of the food were considered. The products analyzed were meat, deli, cheese, dairy, and fruit & vegetable (Scholz, 2013).

The average greenhouse gas emissions per tonnes of food waste were estimated to 1,6 tonnes CO_2 equivalents (Scholz, 2013). This emission factor is used in the report when calculating the climate impacts from production of the wasted food.

4.6 Food flow and calculations of the two scenarios

This section is describing the two scenarios, the assumptions and the starting point of the flow analysis. These assumptions and boundaries set are made through information gathered from the interviews and what has been learned during the study. The calculations made for the two scenarios are then compared to see the total outcomes of the redistribution process. How the calculations are made is further explained in appendix II.

From the analyzed central warehouse approximately 14 tonnes of functional food waste can be collected every year, see appendix II for calculations. The warehouse generates a total amount of 277 tonnes food waste per year but only around 5 % of this is seen as functional food waste and can be collected by a food bank (14 tonnes) (Intervjuobjekt 1, 2016). Remaining amount of the 277 tonnes needs to be waste treated (263 tonnes). Therefore it is assumed that the remaining amount of 486 tonnes food waste comes from the other food actors (other central warehouses, food producers and wholesalers) to sum up to the total amount of 500 tonnes.

It is assumed the same amount of workload by the staff at central warehouse 1 to let the food waste go to a food bank instead of waste treatment. Currently there is already an extensive treatment of the waste generated at the warehouse, the staff controls and repairs broken packages, put it in discard boxes, controls it again of what needs to be waste treated and put it in containers. This workload is not expected to be less demanding than redistributing the food instead. According to a survey made on several ICA-stores in the country that redistribute and donate food it does not require an extra workload in a majority of the cases (Pettersson, 2015).

In scenario 2 it is assumed that food is collected at the central warehouse of this study 14 times a year and collects 1 tonnes of food each time. During this transportation there is no need for refrigeration since it is dry goods. The remaining amount of food, 486 tonnes is collected 486 times a year and 1 tonnes each time, for these goods refrigeration is needed. The vehicle of use has a maximum shipment weight of 1 tonnes and it is assumed using a 100 % filling degree. The vehicle is assumed being unloaded on the way to the food actors.

In scenario 2 it is assumed that the refrigerator truck drives to the central warehouse and back to the food bank for every route. Then it is assumed that food is transported to the three social organizations in a given order per route, see figure 11 and table I in appendix II. These routes have been planned according to what seemed probable and efficient according to available maps (Hitta.se, 2016). How the actual routes will be is hard to estimate in this early stage. It depends on many different factors, such as amount of available food, capacity at the social organizations and so forth.

The transportation route used to collect the remaining 486 tonnes food waste is calculated for the same distance as between the food bank and central warehouse 1. This because it is not certain what food actors that will be part of the redistribution and therefore no other transportation routes have been brought out. Also, the costs and climate impacts for the remaining amount are calculated as coming from one unit and not specifically from each actor.

The expected transportation route that the refrigerator truck will drive is from the food bank in Årsta, to central warehouse 1 and back to the food bank for storage. Then it is assumed that food is delivered to the three social organizations in the order: Salvation Army´s internal food bank, Convictus, Ny Gemenskap and back to the food bank. See figure 11 to see this route and table I in appendix II. It is also assumed that the truck has a filling degree of 100 % and transports 1 tonnes food for every route and delivers 800 kg to Salvation Army and 100 kg each to Convictus and Ny Gemenskap (the vehicle has a maximum shipment weight of 1 tonnes). It is required that these routes are driven 500 times.

When the food bank is delivering the food to the social organizations it is assumed that Convictus and Ny Gemenskap can receive 50 tonnes of food each year. The Salvation Army is assumed to receive 400 tonnes each year. These assumptions are based on the amounts of food that the social organizations are handling currently, see appendix II for calculations. It is assumed that the central food bank delivers food to Salvations Army's internal food bank and that the organization itself is responsible for transporting this food to their different social organizations. Climate impacts and costs for transportation between their internal food bank and social organizations are not accounted for since this does not differ from scenario 1 and 2. It is not dependent of where the donations are coming from.

It could only be found addresses to 8 of the 10 social organizations from the Salvation Army. It is only these 8 organizations that are accounted for in the analysis, see appendix III for addresses. When the Salvation Army purchase food it is assumed that they need to purchase 400 tonnes food in scenario 1, see appendix II for further explanation. This amount need to be purchased 800 times since the vehicle used has a maximum shipment weight of approximately 500 kg. Therefore this transportation must be done 1600 times in total each year for the 8 organizations (back and forth). It is accounted for an average route from the 8 organizations to Martin & Servera at 10 km per route. All transportation routes from the 8 organizations were brought out and a mean value was taken from this since it is not clear how these transportation routes are made and how many times by each organization, see appendix III to see the transportation routes.

Figure 10 show scenario 1 and the flows of food through the analyzed system. 500 tonnes food is produced and transported to the food actors. This amount is becoming functional food waste and transported to a waste disposal plant for treatment. From central warehouse 1 14 tonnes of functional food waste is treated and remaining 486 tonnes comes from other food actors. The green arrows from and to the food actors show the flows of food, from production to waste treatment.

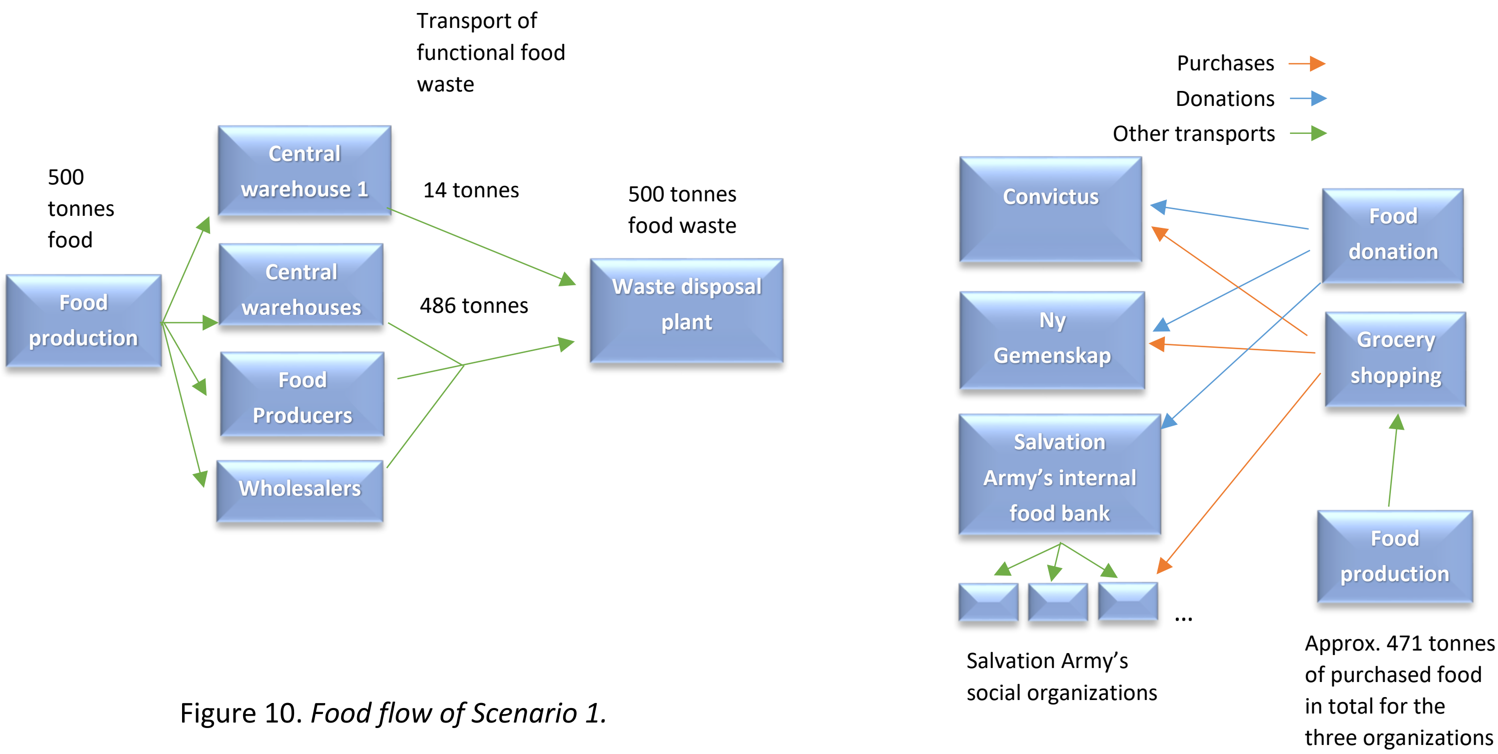

Figure 10. *Food flow of Scenario 1.*

The social organizations have a certain amount of food they purchase and get donated in this scenario. The three organizations purchase food of the total amount of approximately 471 tonnes which has been produced and transported to the grocery stores for this purpose. The blue and orange arrows in figure 10 connected to the social organizations show that they receive donations and purchase food in this scenario. Convictus and Ny Gemenskap uses transportation to collect food donations but not when they purchase food (Gerdin, 2016; Malmqvist, 2016). Salvation Army receives food donations which are transported to the organization but they need to use their own transportation to purchase food (Åslund, 2016). The donations are delivered at Salvation Army's internal food bank and the food purchases made by the organization are delivered directly at their different organizations which are handling food.

Calculations for scenario 1:

- Climate impacts for production of 500 tonnes food (thereby letting 500 tonnes functional food waste go to waste treatment instead of what was aimed for the production)
- Climate impacts for treatment and transport of 500 tonnes functional food waste
- Waste management costs for the total sum of 500 tonnes functional food waste
- Climate impacts for the total amount of food that the three social organizations must purchase, approx. 471 tonnes (Climate impacts for the production of this food)
- Climate impacts and costs for transportations that social organizations generate to purchase food or collect donations
- Costs to purchase food for social organizations

Figure 11 show scenario 2 and the flows of food through the system. The amount of 500 tonnes functional food waste is being redistributed via the central food bank to social organizations in this scenario instead of being waste treated. In this scenario the climate impacts from the production of 500 tonnes food are not accounted for, since in this case the functional food waste is redistributed instead of going to waste treatment. This food is transported to the three social organizations in an assumed route according to figure 11.

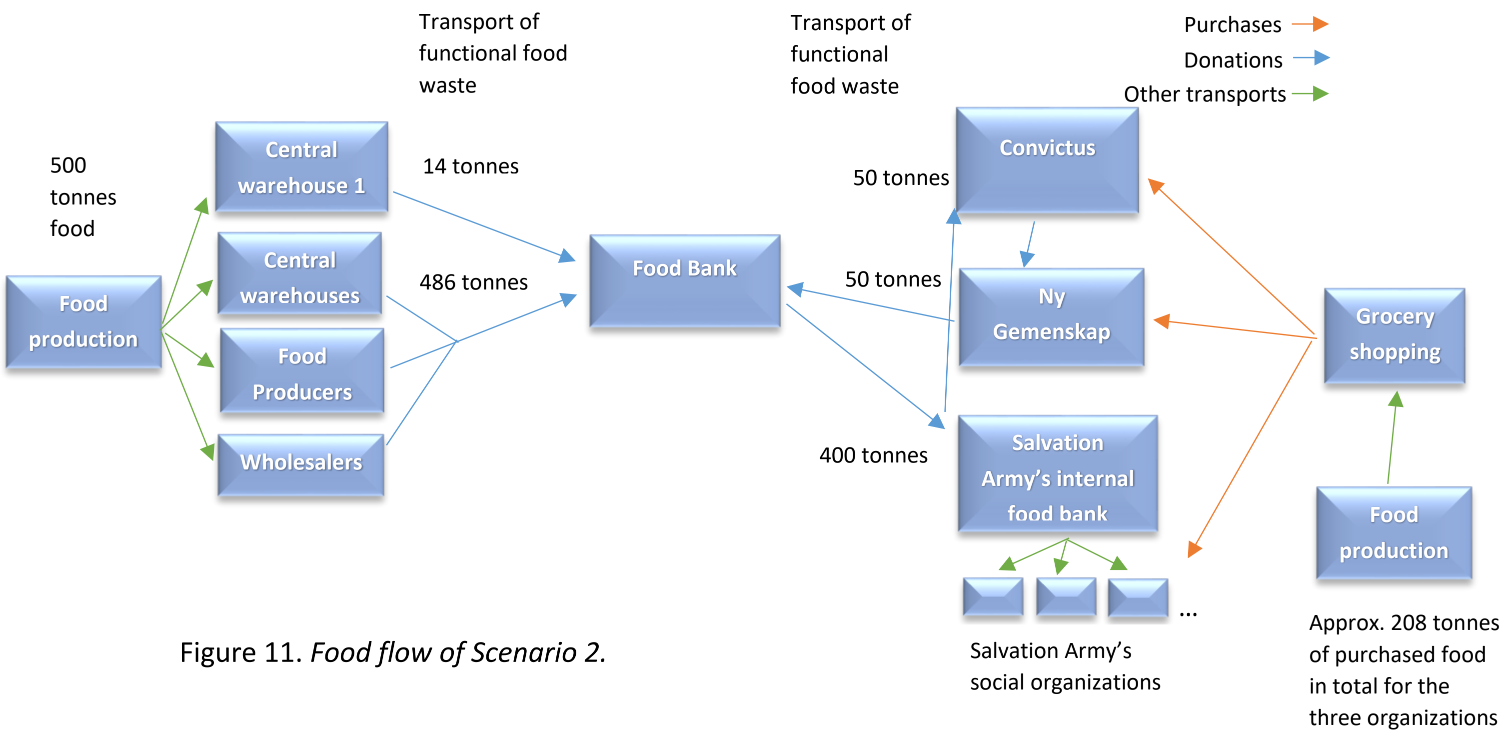

Figure 11. *Food flow of Scenario 2.*

It is assumed that the social organizations can reduce their food donations entirely in this scenario, and the purchased food can be reduced by 50-70 % based on examples in other Nordic food banking models and also based on interviews with the three social organizations (Lunde Dinesen, 2016; Åslund, 2016; Gerdin, 2016; Malmqvist, 2016). It is assumed that the central food bank will be able to deliver continuous and various food due to the planned IT-system for traceability and ordering of the food. It is assumed that the three organizations purchase food for a total amount of approximately 208 tonnes in this scenario. The orange arrows in figure 11 connected to the social organizations shows that all organizations must purchase food despite the redistribution. Only Salvation Army uses transportation for this.

Calculations for scenario 2:

- Climate impacts from transportations for the routes between food bank/food actors and food bank/social organizations
- Climate impacts from store-keeping at the central food bank
- Costs for transportation, warehouse and personnel for the food bank
- Climate impacts from the production of the total amount of food that needs to be purchased by the social organizations despite the redistribution, approx. 208 tonnes
- Climate impacts from the transportation from the social organizations to purchase food
- Costs for purchase food and transportation for the social organizations

4.7 Costs and climate impacts

This section summarize the costs and climate impacts for every actor in the food redistribution system, as a result of redistributing 500 tonnes of functional food waste. Tables 3-8 accounts for the costs and climate impacts generated in scenario 1 and 2 and also the total outcome of comparing this. See appendix II for calculations.

4.7.1 The central food bank

Costs and climate impacts calculated for the food bank for transportation, warehousing, personnel and food production and the total sum of this can be seen in table 3.

Table 3. *The costs and climate impacts generated by the activities of the food bank.*

Costs	***Personnel***	***Transport***	***Warehouse***	***Total***
Scenario 2	Approx. 1,37 million SEK/year	Approx. 77 400 SEK/year	1,12 million SEK/year	2,6 million SEK/year
Climate impacts	***Production of 500 tonnes food waste***	***Transport***	***Warehouse***	***Total***
Scenario 2	-800 tonnes CO_2 eq/year	Approx. 46 tonnes CO_2 eq/year	7 tonnes CO_2 eq/year	Approx. 53 tonnes CO_2 eq/year, -800 tonnes CO_2 eq/year

The food bank has costs of approx. 2,6 million SEK during the first year. Including personnel, transports and warehouse charges (rent and energy consumption). The climate impacts as a result of the food bank's activities reaches approx. 53 tonnes CO_2 eq the first year due to transportation and energy consumption in the warehouse. However, the savings in climate contribution as a result of redistributing 500 tonnes of functional food waste is 800 tonnes CO_2 eq. See appendix II for calculations.

4.7.2 Social organizations

Convictus

In table 4 the costs and climate impacts for food purchase and transportation made by Convictus are calculated. This is compared for the two scenarios.

Table 4. *The costs and climate impacts generated by the activities of Convictus.*

Costs	***Food purchase***	***Transport***	***Difference***
Scenario 1	200 000 SEK/year	1082 SEK/year	
Scenario 2	74 750 SEK/year		Approx. -126 000 SEK/year
Climate impacts	***Production of purchased food***	***Transport***	***Difference***
Scenario 1	41,6 tonnes CO_2 eq/year	0,1 tonnes CO_2 eq/year	

Scenario 2	5,5 tonnes CO_2 eq/year		Approx. -36 tonnes CO_2 eq/year

As a result of that Convictus replaces some of the food purchases and donations entirely by receiving food from the food bank, they can save approx. 126 000 SEK per year. The society saves approx. 36 tonnes CO_2 eq per year mainly in terms of reduced purchasing of newly-produced food and also from reduced transportation. See appendix II for calculations.

Ny Gemenskap

In table 5 the costs and climate impacts for food purchase and transportation made by Ny Gemenskap are calculated. This is compared for the two scenarios.

Table 5. *The costs and climate impacts generated by the activities of Ny Gemenskap.*

Costs	***Food purchase***	***Transport***	***Difference***
Scenario 1	300 000 SEK/year	510 SEK/year	
Scenario 2	73 925 SEK/year		Approx. -227 000 SEK/year
Climate impacts	***Production of purchased food***	***Transport***	***Difference***
Scenario 1	72 tonnes CO_2 eq/year	0,1 tonnes CO_2 eq/year	
Scenario 2	6,8 tonnes CO_2 eq/year		Approx. -65 tonnes CO_2 eq/year

As a result of that Ny Gemenskap replaces some of the food purchases and donations entirely by receiving food from the food bank, they can save approx. 227 000 SEK per year. The society saves approx. 65 tonnes CO_2 eq per year mainly in terms of reduced purchasing of newly-produced food and also from reduced transportation. See appendix II for calculations.

Salvation Army

In table 6 the costs and climate impacts for food purchase and transportation made by Salvation Army are calculated. This is compared for the two scenarios.

Table 6. *The costs and climate impacts generated by the activities of the Salvation Army.*

Costs	***Food purchase***	***Transport***	***Difference***
Scenario 1	2,8 million SEK/year	12 456 SEK/year	
Scenario 2	1,4 million SEK/year	6228 SEK/year	Approx. -1,4 million SEK/year
Climate impacts	***Production of purchased food***	***Transport***	***Difference***
Scenario 1	640 tonnes CO_2 eq/year	2,9 tonnes CO_2 eq/year	
Scenario 2	320 tonnes CO_2 eq/year	1,45 tonnes CO_2 eq/year	Approx. -320 tonnes CO_2 eq/year

As a result of that Salvation Army is assumed replacing the food purchases by half and donations entirely by receiving food from the food bank, they can save approx. 1,4 million SEK per year. The society saves approx. 320 tonnes CO_2 eq per year mainly in terms of reduced purchasing of newly-produced food and also from reduced transportation. See appendix II for calculations.

4.7.3 Central warehouse 1

Table 7 show the waste management costs for central warehouse 1 and the difference of comparing the scenarios. Also the climate impacts generated for producing 14 tonnes food and consequently the climate gain which can be done in scenario 2 when reducing the waste amounts.

Table 7. *The costs and climate impacts generated by the activities of central warehouse 1.*

Costs	***Waste management***	***Difference***
Scenario 1	350 000 SEK/year	
Scenario 2	332 500 SEK/year	-17 500 SEK/year
Climate impacts	***Production of food***	***Difference***
Scenario 1	443 tonnes CO_2 eq/year	
Scenario 2	421 tonnes CO_2 eq/year	Approx. -23 tonnes CO_2 eq/year

As a result of that central warehouse 1 can reduce their food waste with 14 tonnes (which is seen as functional food waste and redistributed to the central food bank) their total food waste amounts are reduced from the current yearly amount of 277 tonnes to 263 tonnes. These calculations are showing the waste management costs that can be saved for central warehouse 1 by reducing the amount by 14 tonnes and also the climate gain of reducing the functional food waste ending up at a waste treatment plant by calculating the climate impact that the production of that amount of food has generated. The waste management costs can therefore be reduced by 17 500 SEK and the society saves emissions of approx. 23 tonnes CO_2 eq per year. See appendix II for calculations.

Since the climate gain of the total amount of functional food waste being redistributed (500 tonnes) already has been accounted for in table 3 (a reduction of 800 tonnes CO_2 equivalents) the amount of 23 tonnes CO_2 equivalents from central warehouse 1 is included in 800 tonnes CO_2 equivalents and not added to this. The calculations were also made separately for central warehouse 1 to get a number of the reduction of climate impacts that this central warehouse contributes to the society.

4.7.4 Waste management

The climate contribution of transporting and treating 500 tonnes waste can be seen in table 8, and consequently the climate gain of reducing the waste amounts with the same amount. The costs for treating the total amount of 500 tonnes food waste are also seen in the table.

Table 8. *The costs and climate impacts generated by transporting and treating 500 tonnes of food waste.*

Climate impacts	***Transport***	***Treatment***	***Total***
Scenario 1	2.3 tonnes CO_2 eq/year	4,7 tonnes CO_2 eq/year	7 tonnes CO_2 eq/year
Costs		***Treatment***	
Scenario 1		632 500 SEK/year	632 500 SEK/year

These calculations are made for 500 tonnes food waste. The calculations are based on the data and waste treatment scenario that is the case for central warehouse 1 and have been applied for the total amount of 500 tonnes. To transport and treat this amount of food waste generated emissions of approximately 7 tonnes CO_2 eq. By redistributing this amount of food waste instead this climate impact can be saved in scenario 2. See appendix II for calculations.

Waste management costs that can be saved by the food actors in total for reducing treatment of 500 tonnes food waste is 632 500 SEK.

4.7.5 Concluding result

The concluding results for comparing the calculations made for scenario 1 and 2 are:

- The society save approximately 1177 tonnes CO_2 eq each year as a result of this implementation
- The social organizations save approximately 1,8 million SEK each year in total by reducing food purchases and transportation
- Central warehouse 1 saves 17 500 SEK on reduced waste management costs for 14 tonnes food waste
- Total saved waste management costs is 632 500 SEK for 500 tonnes food waste
- The central food bank has yearly costs of 2,6 million SEK in terms of personnel, warehouse and transportation.

5. Analysis

In this section a sensitivity analysis is made, where important factors in the redistribution process are analyzed, followed by an analysis of the result and the two scenarios concerning climate impacts and costs.

5.1 Sensitivity analysis

In this report climate impacts and costs have been calculated for a specific case where qualified assumptions are made, setting the boundaries for the system. A result has been achieved based on these assumptions and limitations. Therefore it can also be important to discuss some factors that can have relevance for the costs and climate impacts generated. The significant factors are: filling degree in the vehicle, amount of times the transportation is made, transportation routes, number of involved actors, what type of food that can be redistributed and the amount of redistributed food.

Several factors depend on and affect each other. In this section an analysis is made of three categories, *filling degree*, *type of food* and *varying food amounts,* since these are important aspects to have in mind when planning the redistribution activity. Some important variables have been varied and compared with each other. From this conclusions are made about what is important to consider when dealing with indirect food redistribution involving a food bank. It can also reveal what is most effective from a climate- and cost perspective to focus on.

Filling degree
This analysis compares two different filling degrees in the vehicle driven by the food bank. A filling degree of 100 % with a total shipment weight of 1 tonnes and a filling degree of 20 % with a total shipment weight of 200 kg. With a filling degree of 100 % 1 tonnes food waste is collected from the central warehouse at 10 occasions and the food is transported to the social organizations 10 times, 1 tonnes is being delivered each time. In the other case it is calculated that 200 kg food is collected at the central warehouse 10 times and the food is transported to the social organizations at 2 occasions, 1 tonnes is delivered each time. This gives a total amount of food waste of 10 tonnes in the first case and 2 tonnes in the second.

These calculations have been based on the same calculations as for central warehouse 1 in the result but with replaced variables to suit the two cases, see appendix II for calculations. It is assumed that every transport contains refrigerated products and that the refrigerator plant is switched on. This analysis only compare the costs and climate impacts generated by the food bank, since it is in this case it becomes a relevant difference. It seems most interesting comparing the outcomes it provides from the food bank's perspective since it is the food bank that can affect the filling degree and thereby plan the business according the most effective alternative. Costs and climate impacts have also been calculated per tonnes of food waste that is being redistributed.

All costs and climate impacts generated by the food bank's activities have been accounted for, even when it is not affected by the filling degree. Costs for warehouse, personnel and transportation, and climate impacts from warehousing, transportation and production of food that is collected have been accounted for.

Figure 12 show that the costs by having 100 % filling degree is approx. 250 000 SEK/tonnes food waste and the costs by having 20 % filling degree is approx. 1 250 000 SEK/tonnes food waste. See appendix II for calculations. The costs per tonnes of redistributed food waste differ significantly between having a filling degree of 100 % and 20 % differing with approx. 1 million SEK/tonnes food waste.

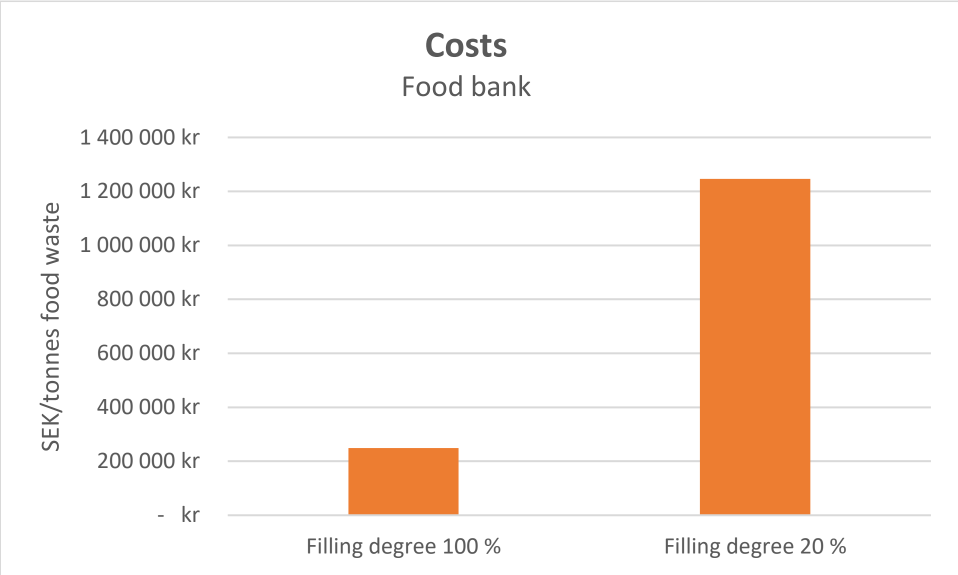

Figure 12. *Illustrates how the costs per tonnes of food waste varies for the food bank when the filling degree is 100 % and 20 % respectively.*

In figure 13 it is shown that the climate contribution is reduced by approx. 0,8 tonnes CO_2 eq/tonnes food waste by having a 100 % filling degree. This is mainly due to that the climate contribution from the production of food is reduced relatively to the amount of food that is being redistributed. So by a larger amount of food redistributed, the more reduced emissions. The reduction of climate impacts exceeds the climate contribution from energy consumption for the warehouse and transportation in this case.

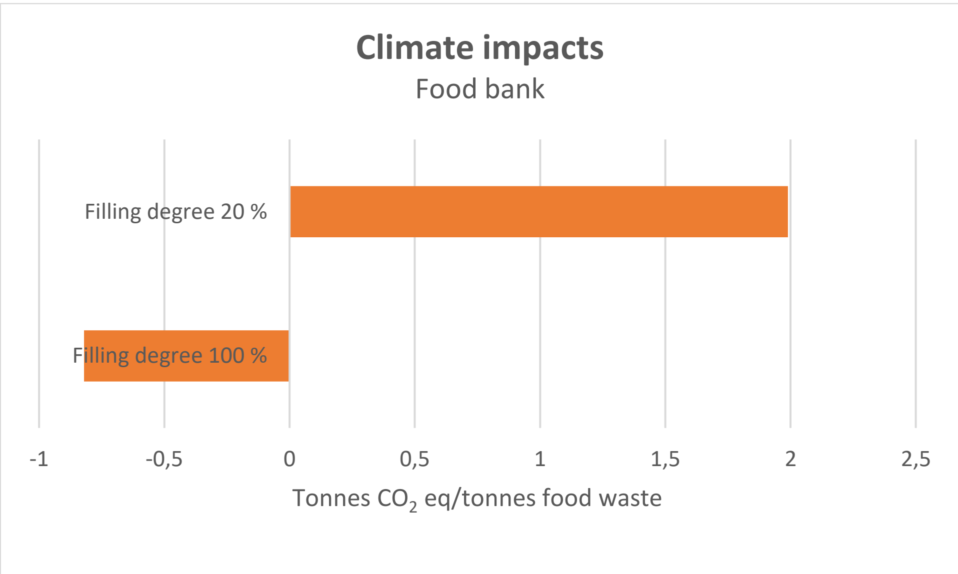

Figure 13. *Illustrates how the climate impact per tonnes of food waste varies for the food bank when the filling degree is 100 % and 20 % respectively.*

When having a filling degree of 20 % emissions of approximately 2 tonnes CO_2 eq/tonnes food waste are generated. This is mainly due to that the emissions from transportation and warehouse are exceeding the reduction of emissions it gives by redistributing 2 tonnes of food. See appendix II for calculations. A 20 % filling degree is generating an increased climate impact of 2,8 tonnes CO_2 eq/tonnes food waste comparing to the case with 100 % filling degree.

Conclusion

In both comparisons of costs and climate impacts it is more beneficial to use a filling degree of 100 %. The costs vary between approx. 250 000 SEK/tonnes food waste and 1 250 000 SEK/tonnes food waste and the climate impacts between approx. -0,8 tonnes CO_2 eq/tonnes food waste and 2 tonnes CO_2 eq/tonnes food waste for a 100 % filling degree and a 20 % filling degree.

To be able to see the total benefit of having a 100 % filling degree rather than 20 % the climate impact can be translated into an environmental cost. This is done to appreciate the socioeconomic benefits by reducing the greenhouse gas emissions in monetary values by avoiding environmental damaging. If the climate impact of 2,8 tonnes CO_2 eq would be translated to an environmental cost it can be done by using compiled model values presented in a study from the Environmental Protection Agency, which are varying between 0,1031 to 5,8085 SEK/kg CO_2 eq (Naturvårdsverket, 2015a; Noring, 2014). This gives a cost of approximately 289 to 16 264 SEK. These costs saved are negligible comparing to the economic costs of 1 million SEK saved.

Food types

In this analysis different food types that have varied impacts on the climate from the production are compared. It is compared redistributing 1 tonnes meat (pork, beef and ground beef) with 1 tonnes of a food category which has a lower climatic impact (bread, vegetables and fruit).

It is compared transporting 1 tonnes of each food category from the central warehouse to the social organizations via the central food bank. The costs that can be saved by reducing purchase of 1 tonnes of each food category are also calculated for the social organizations. This is done to get a picture of the difference in climate impacts that different food types generate and the price difference of the products. Consequently, it can reveal whether it is more beneficial redistributing food that has generated a high climatic impact or low climatic impact and put this in relation to the cost savings involved.

The climate impacts for the food categories have been collected from a report from the Swedish University of Agricultural Science which has stated the climate contribution from different food types. This includes emissions from primary production, production, refinery, packaging and transport to Sweden. Emissions from pork, beef and ground beef are calculated by a mean value for the three products and generate 16 kg CO_2 eq/kg product. Emissions from bread, vegetables and fruit are also calculated for a mean value from a selection of products and generate 0,74 kg CO_2 eq/kg product (Röös, 2014).

Costs for the different categories have been collected from a report from Swedish Board of Agriculture where it is revealed that the selected meat products are all together generating a cost of 80,4 SEK/kg. A mean value was calculated from the three products. The costs for bread and a selection of vegetables and fruit generates a cost of 16,25 SEK/kg (Jordbruksverket, 2011).

Food bank

Figure 14 show that the costs for the food bank do not differ depending on what type of food that is redistributed. Warehouse and personnel costs are the same and the transportation costs do not change depending on the food type since it is the same amount and transportation distance in both cases.

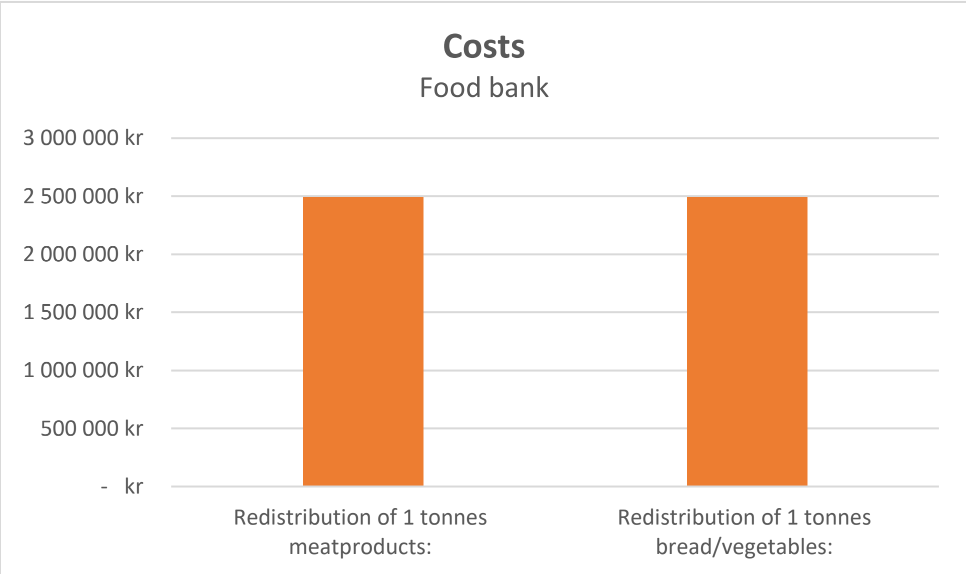

Figure 14. *The costs for the food bank when redistribution different food types.*

Figure 15 show that redistribution of meat products is more beneficial for the climate than redistributing bread/vegetables. This depends on the climate gain that is generated by reducing the amount of meat that goes to waste treatment. The meat products in this case generates emissions of 16 kg CO_2 eq/kg product and bread/vegetables 0,74 kg CO_2 eq/kg product. This climate contribution is thereby reduced by redistributing the food instead and gives therefore a significant difference between the two food categories.

Redistributing 1 tonnes meat gives a climate gain of approx. 8,9 tonnes CO_2 eq and redistributing 1 tonnes bread/vegetables gives a climate gain of approx. 0,6 tonnes CO_2 eq.

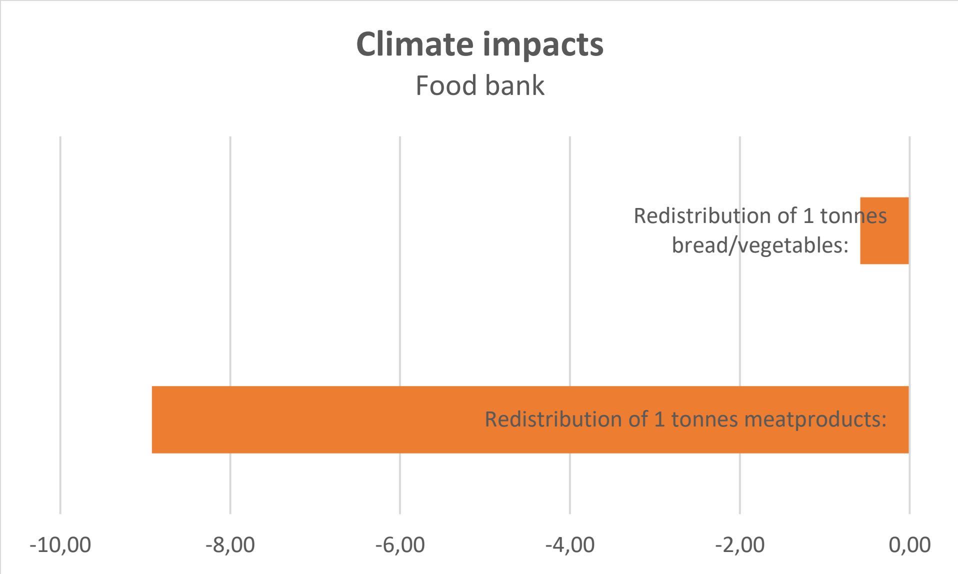

Figure 15. *Climate impacts for the food bank when redistribution different food types.*

The climate contribution from energy consumption in the warehouse and from transportation is the same for the two food types. It is the same amount being transported, the same distance and both categories need refrigeration. However, the emissions from the refrigerator plant (approximately 0,00029 tonnes CO_2 eq) are negligible in this case since it is such a short time and route. See appendix II for calculations.

Social organizations

For social organizations it is only the cost difference of purchasing 1 tonnes meat products and 1 tonnes bread/vegetables that is accounted for. There is no difference in emissions or costs for transportation since it is the same amount of food purchased and the same distance.

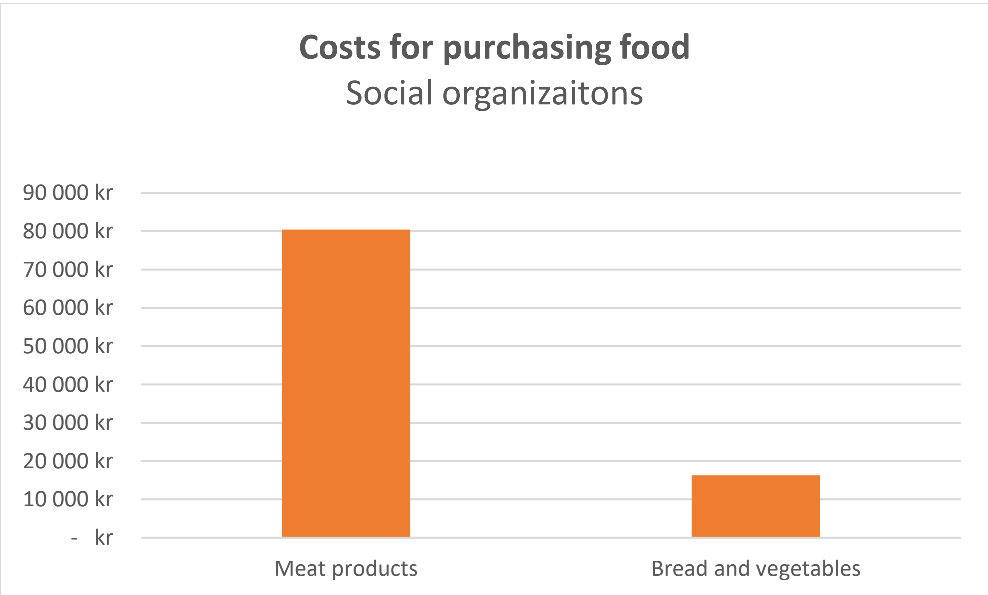

Figure 16. *Shows the cost for purchasing 1 tonnes of meat products and 1 tonnes of bread/vegetables.*

In figure 16 the costs that social organizations can save are shown, by either receiving 1 tonnes meat or 1 tonnes bread/vegetables. By receiving 1 tonnes meat and thereby reducing purchase of the same amount and product had reduced costs by 80 400 SEK and by receiving 1 tonnes bread/vegetables had reduced costs by 16 250 SEK.

Calculating climate impacts and costs for the central warehouse and waste management are not relevant in this case, since it is not affected by what type of food product it is.

Conclusion

By redistributing 1 tonnes of meat products compared to bread/vegetables generates no difference in costs for the food bank. Warehouse and personnel costs are the same and transportation costs are also the same for the both cases since they have the same conditions. However, it might require a larger cooling area if a larger amount of meat is redistributed since it needs more space and is more sensitive for temperature than fruit and vegetables. In the amount of 1 tonnes of the category bread/vegetables is also bread accounted for which does not need cooling. This has not been accounted for in the calculations but can affect the outcomes.

The reduction of climate impacts by redistributing meat products are 8,9 tonnes CO_2 eq and 0,6 tonnes CO_2 eq for bread/vegetables. This gives a reduction of 8,3 tonnes CO_2 eq by redistributing meat products instead of bread/vegetables. This can be translated into an environmental cost by using the previous source which has brought out model values varying between 0,1031 to 5,8085 SEK/kg CO_2 eq (Naturvårdsverket, 2015a). Which gives a cost reduction between 918 to 56 923 SEK for 1 tonnes meat products and between 60 to 3 369 SEK for 1 tonnes bread/vegetables.

The cost savings for social organizations are 80 400 SEK and 16 250 SEK for reducing purchase of 1 tonnes meat products and bread/vegetables respectively. This gives a total socioeconomic cost saving between 81 318 to 137 323 SEK for meat products and 16 310 to 19 619 SEK for bread/vegetables. Which means that by redistributing meat products instead of bread/vegetables approx. 65 000 to 120 000 SEK can be saved in total in terms of socioeconomic costs. This makes it clear that it is more beneficial to redistribute 1 tonnes meat product from a socioeconomic aspect.

It is also important to emphasize that it is more beneficial to reduce the production of meat than bread/vegetables. It is always better to reduce the amount of food waste early in the production chain, since more resources, costs and emissions have been generated further down in the chain (Livsmedelsverket, u.d.). However, if these products already have been produced and transported to the food companies for consumption it is more beneficial to reduce the amount of meat products going to waste than products that have caused less climate impacts during the production.

Varying food amounts

In this study a food waste amount of 500 tonnes has been used. This can be compared to redistributing a food waste amount of 100 tonnes or 1000 tonnes to see the outcomes of this change and to see whether it is more beneficial to redistribute more food waste or not.

The same calculations have been used as for the result but the amounts of 100 tonnes and 1000 tonnes were inserted instead of 500 tonnes. The cost difference did not vary significantly but the reduction of greenhouse gas emissions was more significant, which can be visualized in table 9.

Table 9. *Comparing costs and climate impacts generated for the food bank when redistributing different food waste amounts.*

Food bank	***100 tonnes***	***500 tonnes***	***1000 tonnes***
Total costs	2 507 513 SEK	2 569 464 SEK	2 646 903 SEK
Total climate impacts saved	Approx. - 145 tonnes CO_2 eq	Approx. - 747 tonnes CO_2 eq	Approx. - 1485 tonnes CO_2 eq
Difference in costs (compared to 500 tonnes)	Approx. - 62 000 SEK		Approx. + 77 500 SEK
Difference in climate impacts (compared to 500 tonnes)	Approx. + 602 tonnes CO_2 eq		Approx. - 738 tonnes CO_2 eq

Redistributing 100 tonnes is only reducing the costs with approx. 62 000 SEK and the increasing costs for redistributing 1000 tonnes were approx. 77 500 SEK seen from the reference point of 500 tonnes. So the cost difference of increasing or reducing the amount of redistributed food waste does not differ significantly. Comparing this with the reduction of greenhouse gas emissions more noteworthy results can be seen. Redistributing 500 tonnes food waste can reduce approx. 602 tonnes more emissions than redistributing 100 tonnes food waste. Redistributing 1000 tonnes food waste can reduce approx. 738 tonnes more emissions than redistributing 500 tonnes food waste.

To be able to compare the difference in greenhouse gas emissions with the cost difference the emissions can be translated into an environmental cost by using the previous source which has brought out model values varying between 0,1031 to 5,8085 SEK/kg CO_2 eq (Naturvårdsverket, 2015a).

The difference of emissions for the amounts 100 tonnes and 500 tonnes were approx. 602 tonnes CO_2 equivalents, and the cost difference was approx. 62 000 SEK. Emissions of 602 tonnes CO_2 equivalents gives an environmental cost varying between approx. 62 066 to 3 496 717 SEK. So by redistributing 500 tonnes instead of 100 tonnes is more beneficial from this perspective since the increased economic costs are 62 000 SEK and the environmental costs that can be saved by redistributing a larger amount are between 62 066 to 3 496 717 SEK. Even for the lower interval these costs that can be saved to reduce the emissions are equal the increasing costs for the food bank.

The difference of emissions for the amounts 500 tonnes and 1000 tonnes were approx. 738 tonnes CO_2 equivalents, and the cost difference was approx. 77 500 SEK. 738 tonnes CO_2 equivalents gives an environmental cost varying between approx. 76 088 to 4 286 673 SEK. So by redistributing 1000 tonnes instead of 500 tonnes the society can save an environmental cost equal the interval brought out and the food bank will have increased costs by 77 500 SEK. The increased costs exceeds the lower interval of the saved environmental costs, but this should be weighed against the potential environmental benefit that can be reached in the higher interval and the insignificant cost difference between the increased costs and the saved costs in the lower interval.

To redistribute a larger amount of food waste should be prioritized since the costs for the food bank are lower or equal to the socioeconomic benefits that can be reached. Seen from a socioeconomic perspective the potential benefits outweigh the costs.

It is mainly the fixed costs for the warehouse and personnel that controls the costs for the food bank. It has been assumed that the food bank does not need to have a larger warehouse, or more personnel. When redistributing higher volumes of food waste this need to be considered. Redistributing 1000 tonnes of food waste assumes not be needing more personnel or warehouse capacity, assumption based on the food bank in Norway which have a warehouse of 700 m^2 and have redistributed 800 tonnes food waste in 2015, and plans on increasing this by 1000 tonnes (Stockholms Stadsmission, 2016a).

It is assumed that the three social organizations in the study cannot receive more food than 500 tonnes (based on their current capacity and food amounts), but this means that more organizations can be involved in the redistribution process if redistributing a larger amount. The amount of costs saved for the social organizations are relative to the amount of food being redistributed and by redistributing the double amount of 500 tonnes should mean that the total cost savings for social organizations would be doubled also, and vice versa. Although, this vary between different organizations and is also dependent on a varying, covered and continuous redistribution from the food bank.

The waste management costs and climate impacts that can be reduced are also dependent on the amount of food being redistributed and can be visualized in table 10.

Table 10. *Difference in reduction of costs and climate impacts of avoiding waste management of different food waste amounts.*

Waste management	***100 tonnes***	***500 tonnes***	***1000 Tonnes***
Costs saved	126 500 SEK	632 500 SEK	1 265 000 SEK
Climate impacts saved	Approx. 1,4 tonnes CO_2 eq	Approx. 7 tonnes CO_2 eq	Approx. 14 tonnes CO_2 eq

Conclusion
It is more beneficial redistributing 1000 tonnes than 500 tonnes and 100 tonnes since the costs for the food bank does not increase significantly and the climate gain that can be reached outweighs the increased cost. The social organizations can also save more costs relative to the increased food amounts and the food companies can save more costs and reduce climate impacts relative to an increased amount of redistributed food waste. So the only cost and climate impact increased by having a larger amount of redistributed food is the transportation costs for the food bank and the climate impacts accordingly.

However, the climate gain of redistributing a larger amount of food and the saved costs for the involved actors are more beneficial seen from a socioeconomic perspective since the increased costs and greenhouse gas emissions generated by the food bank in terms of increased transportation are not considered significant compared to that.

5.2 Climate impacts

Food redistribution reduces greenhouse gas emissions and climate impacts in terms of less functional food waste going to waste management, reduced impacts from treatment and transportation of the food waste and reduced transportation and purchased newly-produced food for social organizations. The main contributing factor to the total reduction of climate impacts is the fact that 500 tonnes of produced food is being utilized as the purpose of the production, and that social organizations can reduce their purchased food. The climate impacts from waste management and transportation are not significant in comparison to this.

However, if only the transportations are compared from scenario 1 and 2 these are increased as a result of an implementation of a food bank. The transports for social organizations and waste treatment are reduced by approximately 4 tonnes CO_2 eq per year. The climate impact generated from the transportations by the food bank is approximately 46 tonnes CO_2 eq per year. Consequently the climate impacts from transportation are increased with 42 tonnes CO_2 eq in scenario 2.

Although, this should be viewed in a wider perspective and be compared to the amount of reduced purchase of newly-produced food social organizations can make and the amount of functional food waste that can be utilized for a good purpose. Production of food generate heavy emissions and to produce food which goes to waste treatment is seen as a waste of natural and societal resources which are required for the production. To utilize this food is seen as a climate improving measure and outweighs the emissions that are generated as a result of the food banks activities.

The total climate gain of redistributing functional food waste from food companies depends on what type of food that is redistributed and consequently what type of food that social organizations can purchase less of since different food types generates varying emissions. To reduce purchase of meat provides a larger climate gain than reducing purchase of for example dairy products (Scholz, 2013).

The social organizations that in scenario 1 do not have a significant consumption of meat perhaps normally purchase mainly vegetables, beans, bread, dairy products etc. If they in scenario 2 can receive a significant amount of meat they are perhaps replacing the previous purchase of food types (beans, vegetables etc.) with this donated meat. Just because social organizations can receive large amounts of meat it doesn't mean that they are reducing purchase of meat with an equal amount. This means that they are replacing consumption of beans and vegetables with meat. This is an example of when food redistribution is not beneficial and profitable from a socioeconomic perspective. It had been more beneficial to reduce the production of meat to avoid that it ended up as food waste, rather than redistributing it, seen from a waste preventative and climatic perspective.

In the calculations made in this study a mean value of the climate impacts generated from food production was used and not the climate impact for every food product itself. This should be studied more thorough to get an exact number of the potential climate gain.

The amount of carbon dioxide equivalents being reduced as a result of the implementation are approximately 1 177 tonnes per year. This can be compared to the amount of CO_2 equivalents that Sweden's total external flight transport is generating, which are 2 298 000 tonnes CO_2 eq and the internal railway transports of 47 000 tonnes CO_2 eq (Naturvårdsverket, 2015b). An average person in Sweden is generating 5,5 tonnes CO_2 eq per year (The world bank, 2016).

The main contributing factor for the reduction of climate impacts is the fact that functional food waste which is going to waste treatment in scenario 1 can be reduced and redistributed instead in scenario 2. This is giving a climate gain of 800 tonnes CO_2 eq for 500 tonnes food waste. The reduction of emissions that the implementation of a food bank generates are relatively small in relation to the impacts from flight and railway transports but it is important to realize that this is only a single measure with a limited amount of actors. The potential is large to reduce the emissions from the food chain by implement the concept of a central food bank in a larger scale and to combine this with other measures to reduce the food waste.

5.3 Costs

Food redistribution is profitable from an economic point of view for social organizations and food companies since it is reducing costs. If the food bank should be profitable there is a need for yearly revenues from food companies, social organizations and other investments from private and public actors.

The costs that could be saved as a result of this measure were varying between the actors. Social organizations could together save costs of approximately 1,8 million SEK. The food actors could all together save 632 500 SEK in reduced waste management costs, measured for the waste management costs for central warehouse 1 and on the total amount of 500 tonnes food waste. Although the saved costs for social organizations are uncertain due to the insufficient data from the Salvation Army and since this may vary significantly among organizations. These saved costs were calculated for a varied redistribution that covers the main purchased food for Convictus and Ny Gemenskap and half of the purchased food for Salvation Army. This amount is probably overestimated but is still significantly larger than the costs saved for the food actors.

The cost savings for the social organizations are relative to the food amounts being redistributed since they can reduce their purchased food accordingly. The reduced costs for food companies are also relative to the food amounts, so this relation between costs saved for social organizations and food companies will always be the same, as long as the food redistributed is varied, continuous and of large amounts. Therefore it is reasonable that social organizations are paying a yearly sum to finance the food bank and should be prioritized, since they are the "winners" in this redistribution process.

The studied central warehouse had only a smaller amount of functional food waste that could be collected by a food bank, and can therefore only save a smaller cost from waste treatment. It can be seen as less motivated from their point of view to donate this amount of food to the food bank instead of waste treatment since they also will need to pay a yearly sum to the food bank. This yearly sum plus the waste management fee can exceed their current waste management costs depending on how large the fee paid to the food bank will be. Seen from a cost effective perspective the level of initiative from the food actors should be related to the amount of functional food waste that can be redistributed.

The food companies can however increase their immaterial resources by creating a good reputation, strengthen their brand and increase the range of customers by donating their food waste. Then it can be economically beneficial for a company with a smaller amount of functional food waste to donate it to a food bank. The benefits the act creates from a social, ethical and environmental perspective can be incentive enough for the food companies to be involved in the redistribution system.

If the food bank should go with profit the revenues needs to cover the calculated costs for personnel, transports and warehouse. These revenues need to be received from the actors and organizations involved and other funders to support the organization. The amount of revenues that can be received from food actors will probably not exceed 632 500 SEK since that were the charges they had for waste management, if they do not find it beneficial in terms of goodwill and can imagine paying a larger sum. Therefore it is extra important that external financiers are also involved. It is important that the food bank received continuous capital to cover unforeseen costs and to be able to reach the full potential of the business. It is known that the financing is the main obstacle in these types of businesses.

6. Discussion

Here follows a discussion of the results and analysis. Food redistribution is discussed in a broader perspective and important factors concerning incentives, financing and traceability are highlighted. The uncertainties in the methods used and suggestions for further studies are also presented.

6.1 Food redistribution as a measure

Food redistribution via a central food bank is a waste reducing measure which does not deal with the actual basic problem with large amount of food waste and the reason for why it is created. This is a measure that deals with waste in an efficient way when it already has been created. To reduce the total food waste in our society, measures also need to be taken earlier in the food chain. To get to the root of the problem one needs to consider trying changing behavior patterns of consumers, improve knowledge and routines of food actors and producers and implement management control measures on a governmental level which counteracts the origins of food waste.

Food waste needs to be considered from an overall perspective where the whole chain is considered and not every step separately. Effects and reasons of food waste needs to be analyzed from a life cycle perspective where it's considered where in the chain it is most beneficial to reduce waste. Taking measures in early steps of the life cycle should be prioritized since more resources are spent in later steps of the chain (Loxbo, 2011). It is more climatic and economically beneficial for the society since then it is avoided that unnecessary resources are spent on food products that ends up as waste. Although it is important that measures are taken in every step of the way where waste is created to minimize the amount.

The climatic benefits from food redistribution depends on the type of food that is being redistributed and consequently what type of purchased food social organizations can reduce. It is more beneficial to redistribute meat than for example bread and vegetables since the production of meat is generating more greenhouse gas emissions and it should therefore be more prioritized to avoid that these products are going to waste over products which are generating less emissions.

As mentioned it is important to realize that it is more socioeconomic beneficial for the society to reduce unnecessary food production in earlier stages of the food chain that is generating high values of climate impacts. Redistributing meat cannot compensate for the climate contribution generated during the whole food chain. Certainly not if the social organization did not have a noteworthy meat consumption before the redistribution and this donation becomes just a "bonus".

When food is produced without serving its purpose, the emissions and climate impacts from the production are generated for nothing. It is important to use the resources in our society in the most efficient way. To prevent food waste or redistribute the food via food banks are more resource efficient for the society than producing biogas. It provides food security, the social organizations and food actors are reducing their costs and functional food waste is not going to waste treatment. Although, when waste treatment is unavoidable it is preferable to treat it through digestion and produce biogas since it is the most resource efficient alternative after prevention and reuse according the EU:s waste hierarchy.

Producing biogas out of food waste generates a certain amount of energy use and releases emissions as a result of the digestion process. To be able to see the total benefits of the method this should however be weighed against the benefits created by producing biogas, which replaces fossil fuels and reduces the amount of greenhouse gas emissions in the atmosphere. Producing biogas from food waste is a step lower on the waste hierarchy than reducing and preventing the waste. Therefore should food redistribution as a measure be prioritized over biogas production regardless of the benefits it can generate considering the replacement of fossil fuels. Taking also the social and ethical aspects in mind, letting fully eatable functional food waste be redistributed to social organizations rather than producing biofuels should be seen as more sustainable and defendable alternative.

6.2 Financing and incentives

It seems to be a low engagement from social security authorities and other relevant authorities in supporting the establishment of food banks. A closer involvement and cooperation between food banks and authorities is necessary since the food banks established today are under-financed and lack the necessary support to be able to develop the business properly (Hanssen, et al., 2014). By an early cooperation among involved actors, authorities and potential financers a more strong organization can be built from the ground and opens up for more possibilities for development. This example could be seen for the food bank in Norway which through a long planning process and cooperation with social organizations created a stable foundation and market for food redistribution where they could redistribute a large amount of food early on in the process (Hanssen, et al., 2014). This should be considered for the central food bank in Stockholm in order to be able to build a strong organization from start and to secure continuous financial funding.

In this study it was revealed that social organizations could save a significant amount of money in reduced food purchase and should therefore help finance the central food bank. To require financial means from social organizations can seem unethical since these organizations are based of charity, volunteering and serve an important role in the society increasing food security. Although, receiving financing from social organizations can be crucial to make sure that the central food bank can exist. Therefore it should be considered in a realistic perspective, overweighing the beneficial aspects from this financing, since without a central food bank there will be no cost savings at all for social organizations.

To increase the level of initiative from food actors to be involved in this implementation a certification system could be developed, where it is clear which actors who are involved in food redistribution. This can create incentives to be part of the process since it improves the reputation and image of the food company and brings more competitive advantages. In the end this could also increase the turnover for the company. Simultaneously it strengthens the financing of the food bank if it leads to more food companies being involved. According to a study made on donations of food from retailers, goodwill is seen as an important incentive from retailers to donate their food (Pettersson, 2015). This can be seen as a long term investment in the company with a more satisfied personnel and customers which in the long run gives a strengthened brand.

Looking at it from a socioeconomic perspective it should be beneficial for every involved actor if social organizations and food companies are financing the food bank with a sum equal the saved costs. Also that private or public stakeholders are financing the business. Then the food bank can invest in the business and develop efficient logistics and IT-systems which are improving the redistribution system.

The more developed and effective the food banking business is the more actors want to be involved and more revenues can be received. It should be on the common agenda to help finance these kinds of waste preventing initiatives since it involves the whole society, in terms of food security, waste prevention and reduced climate impacts. Climate impacts are not only affecting the actor behind the emissions, it is a societal problem which includes everyone.

6.3 Traceability

An important factor that will increase the incentives of being part of the redistribution system is whether there is a tracking system for the food and possibilities to order the type of food that will be delivered. This helps reaching the full potential of the measure and is important for every actor involved, food actors, the food bank and social organizations. Food companies want to make sure that their brand or their suppliers brand is not receiving bad publicity and associated with goods of bad quality. Social organizations want to be able to control the type of food they receive and then they also can plan their business more efficiently and reduce food purchases accordingly.

A covered redistribution with varying products where there is an ordering and traceability system is a condition if this business should function optimally. More money being put into the business opens up the possibilities for efficient logistics and a functioning IT-system and the more beneficial the measure gets from a socioeconomic perspective.

6.4 Uncertainties in the methods used

Uncertainties in the result are mainly due to the insufficient data that could be compiled. Data could only be collected from one central warehouse and the outcomes and calculations would have been more certain if this could be covered with several food actors. Some numbers and assumptions in the result have been based on the interviews and other on previous methods from literature. The information and data from the social organizations regarding their costs, transports, donations and food purchase are mainly estimations from their side. There are also some uncertainties in the result due to the assumptions that had to be made since the food bank is yet on a planning basis. Qualified assumptions were made based on the compiled information and data and therefore the results of this model are realistic calculations rather than measurements.

The transportation routes that have been calculated to and from the food bank can be overestimated. It can be expected that these routes vary from time to time depending on supply and demand from the actors involved. Also that the routes are more efficiently planned than assumed in this report, and that the food is not transported to the food bank for storage after every collected tonnes of food. This will probably also vary depending on different factors and conditions. As a result of this the costs and climate impacts calculated for the transports made by the food bank can be overrated.

The transportation route calculated for the Salvations Army's facilities to Martin & Servera has been estimated as a mean value of the routes for the 8 organizations of 10 km per route. This can also be either over or under-estimated since the routes for every organization vary greatly from this distance. It was not revealed by the interview how these transports were made and how often, neither how large amounts of food that are handled at the organizations. The amount of purchased food was therefore based on the size of Convictus and Ny Gemenskap and their amount of purchased food per year. The amount of reduced purchased food for Salvation Army in scenario 2 is also a rough estimation and can vary greatly from the reality. However all the assumptions have been based on the interviews and have been made on a reasonable basis.

The amount of reduced purchased food and cost savings calculated for the three social organizations can be overestimated, this may vary significantly among different organizations and depends on a varying and continuous redistribution from the central food bank.

The tool NTM Calc which has been used to calculate the emissions from transportation from the food bank and from waste management is using preselected values on the fuel consumption according the selected vehicle. This can vary from different vehicles and give varying results. However the fuel consumption was similar to the fuel consumed by the vehicles used in this study. The vehicle from the food bank has a fuel consumption of 0,79 liter/mil and in NTM Calc a consumption of 0,85 liter/mile was preselected for diesel. The vehicle used by Ragnsells from central warehouse 1 to the pretreatment plant was also similar in fuel consumption and weight on the vehicle (2 liter/mile and 14-20 tonnes for NTM Calc and information based from Ragnsells there is a fuel consumption between 2-4 liter/mile and the vehicle weighs around 18-26 tonnes).

Calculations of the climate contribution from the refrigerator plant were based on literature studies, which calculated this for a vehicle of 20 tonnes and it was assumed in this report that the impacts were reduced relatively the weight of the vehicle. There can be some uncertainties in this assumption whether it is applicable for the vehicle used in this study.

When calculating the climate impact from waste treatment and transportation some data was collected from Uppsala biogas plant where information was insufficient at the current biogas plant used in this report. The data used and which not has been updated for the current biogas plant is the methane spill and the amount of energy required to treat 1 tonnes food waste used for Uppsala biogas plant. These numbers can differ between the biogas plants and therefore can the result of this be misleading. However it is assumed that these numbers could be applicable for the current situation since it is the same treatment method, codigestion and the same type of processes occurs. The energy consumption for Syvab biogas plant included the whole disposal plant, not only the biogas plant, and therefore these numbers could not be used. No information regarding exact data on the energy use from the biogas production could be found from the pretreatment plant in Högbytorp or Syvab. Therefore the energy use per tonnes of food waste calculated for Uppsala biogas plant was used in this study.

The used model values of environmental costs need to be considered with care, since evaluating environmental costs in monetary terms is uncertain. The model values are also calculated independent on the location and specific type of climate pressure (Naturvårdsverket, 2015a). This should be seen as material for discussion rather than actual results.

6.5 Future studies

The study in this report is made on a limited system with a certain amount of actors and conditions. Therefore it can be interesting analyzing this measure from a wider perspective to see the outcomes of costs and climate impacts.

To get a picture of the actual climate gain from redistribution a more extensive study of what type of food that is redistributed, what type of food that is purchased by the social organizations, what type of food that reduces in purchase and what climate contribution every food type generates. This can vary significantly among organizations and it also differ greatly in climate contribution from different food types. Doing a more detailed study of this can reveal the full potential food redistribution has as a waste reducing measure.

It would also be interesting to investigate whether it is more beneficial from a cost and climate perspective with a few larger central food banks that reach out to a wider area, or with several smaller food banks which reach out to fewer social organizations within a more narrow area. By only having the redistribution in the local area fewer food actors can be reached. It can be interesting to evaluate whether it is more effective to have longer transportations distances, larger warehouses and more personnel in relation to the extra amount of food that can be redistributed. Whether if this extra cost and climate impact generated compensate for the extra amount of food that can be redistributed.

7. Conclusion

The establishment of a central food bank in Stockholm will reduce the total climate impacts mainly in terms of that functional food waste is being utilized and the climate impacts from the production of this food are not seen as a waste of resources. The fact that social organizations can reduce purchases of newly-produced food is also a significant contributing factor. Although, the climate impacts from the transportation generated as a result of the food bank are exceeding the reduction of transports from social organizations and transportation from waste management and are thereby more extensive in scenario 2. Nevertheless, the benefits of reducing purchases of newly-produced food and avoid unnecessary waste treatment outweighs the increased emissions from transportation.

The economic outcome of this measure is varying. The amount of costs that can be saved for social organizations depends on the amount of food purchase that can be reduced. A continuous redistribution with varying goods is increasing the saved costs. Food companies can save costs in terms of reduced waste management costs and this depends on the amount of functional food waste that can be redistributed from the companies. In this case social organizations could save a significant amount of financial means and central warehouse 1 could save a smaller part of their total waste management costs due to the minor amount of functional food waste. Seen for the food actors combined a larger cost could be saved but not as nearly as the costs saved for social organizations or the costs generated from the activities of the food bank.

Whether the business will be profitable for the food bank depends on the revenues that can be collected from involving actors and external investors. It is reasonable that food companies and social organizations should both pay a yearly sum to finance the food bank due to the costs they can save. Since the social organizations are the "winners" in this redistribution system and can save most costs it is defendable that they should pay an important amount of money to the central food bank.

Food redistribution in form of a central food bank is a good measure to prevent and deal with functional food waste and simultaneously providing food security for people in need. It is important to emphasize that multiple measure need to be taken to deal with food waste in a more long term perspective and getting to the root of the problem with food waste and the resulting climate impacts. Food banks are an important and valuable measure when food waste already has been created.

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Appendices

Appendix I

This section is listing the interview questions asked to the organizations, such as the central food bank, the organization Matmissionen, the social organizations and the central warehouse.

Interview guide

The central food bank

Introduktion
Berätta lite om din roll på Stockholm Stadsmission?
Berätta kort om Matcentralen, matmissionen, och den pilotprojektet med den nuvarande matbanken
Berätta lite om det pågående projektet med en storskalig matbank i Stockholm
- Hur startade det?
- Vilka drivkrafter ligger bakom?
- Vad är syftet med matbanken?

Organisation
Hur är matbanken tänkt att vara organiserad?
Hur ser modellen ut för denna matbank?
- Ska ni ta inspiration från svenska, norska eller danska modellen?
Ska matbanken hämta och leverera maten?
Hur kommer flödena av mat ut? (Transporter samt när maten hamnar hos matbanken)
Hur är det tänkt att maten ska hanteras när den kommer till matbanken?

Involvering/samarbetspartners
Vilka samarbetspartners är involverade?
- Vilka sociala organisationer ska ni dela ut maten till?
- Vilka mataktörer tänker ni arbeta med?
- Vilka organisationer är bestämda hittills?

Lokalisering
Vart är matbanken tänkt vara lokaliserad?

Transporter
Vad är det för typ av transportmedel ni har tänkt använda?
- Hur stora matvolymer ryms i fordonet?
Hur många bilar? Vad tänkte ni starta med? Hur många bilar är idealt?

Lagerhållning
Om du utgår från de erfarenheter som finns idag, och tänker hur det skulle kunna se ut i en snar framtid,

Hur stort ska lagret vara i matbanken?
Hur många kylar/frysar är tänkt att rymmas?
Vilka energikostnader? Energikälla?
Vilka kostnader kommer detta generera uppskattningsvis? (I kWh)

Matvolymer
Om du utgår från de erfarenheter som finns idag, och tänker hur det skulle kunna se ut i en snar framtid,
Hur stora matvolymer kommer matbanken att kunna hantera?
- Vad är målet? Hur mycket mat är tanken att ni ska kunna leverera till sociala organisationer? (kg/vecka)

Är tanken att denna redistribution ska kunna ersätta matinköp för de sociala organisationerna?
- Att all mat de ger ut till behövande kan komma från redistribution?
- Eller hur tror ni att fördelningen kommer att se ut?

Tror ni att det kommer uppstå något matsvinn på matbanken?
- Hur mycket uppskattningsvis?
- Hur kommer detta matsvinn att hanteras?

Anställda
Vilka ska arbeta med matbanken?
- Ska de få lön? Hur mycket?

Finansiering/kostnader
Hur ska finansieringen se ut?
- Ska ni få bidrag från stat?

Ska det vara en ideell eller kommersiell organisation?
Ska ni ta ut en avgift av livsmedelsaktörerna för att hämta överskottsmaten?
- Hur mycket i såna fall?

Ska ni ta en avgift av sociala organisationer för att leverera maten?
- Hur mycket i såna fall?

Vilka kostnader är det som uppstår i samband med denna organisation?
- Personal, administration, lagerhållning, kyl-transporter?
- Vart ligger de främsta kostnaderna tror ni?

Svårigheter/Potential
Hur påverkar lagstiftningen er verksamhet?
- Vilka rutiner för livsmedelssäkerhet ska finnas? Spårbarhet?

Vilka svårigheter kan ni stöta på i detta projekt?
Vilken potential finns för denna åtgärd?
- Hur ser intresset ut bland livsmedelsaktörer för den här typen av organisation?

Matmissionen

Introduktion
Berätta lite om detta projekt/organisation
Berätta lite om din roll och vad du har för ansvarsuppgifter?

Hur startade denna idé?

Organisation
Kan du berätta lite om hur det går till när ni hämtar/tar emot maten?
Vart kör bilen? Vart hämtas maten och vart levereras den?
Finns det något centralt lager för maten som hämtas upp av bilen? Eller körs maten direkt ut till Matmissionen efter att det hämtats upp hos donatorerna?

Transporter
Vilket transportfordon används? Vilken modell?
- Vilka kostnader finns det för denna bil? (I form av bensin/mil, kylanordning)
- Vilken bränslesort har bilen, diesel, fordonsgas, bensin, E85?
- Vilken bränsleförbrukning har kylbilen? (När kylanordningen är igång)
- Hur mycket ryms i denna bil? (kg)

Matvolymer
Hur stora mängder mat får ni in varje dag/vecka/år i snitt?
- Vart kommer maten ifrån?
- Är det enbart matsvinn/överskottsmat som ni får in? Eller kan butiker skänka produkter till er som inte klassas som matsvinn?
- Har ni någon uppfattning om hur stor andel av maten som skänks som utgörs av svinn dvs. som hade kastats om ni inte tagit tillvara på den?
Vilka typer av mat får ni från givarna?
- Vad får ni mest av? Saknar ni något?
- Vad är det som ni inte får tillgodoräknat från donationer? Från överskottsmaten? Som ni alltså alltid måste köpa in?
- Är det endast produkter, alltså inte färdiglagad mat ni får in till butiken?

Anställda:
Hur många är ni som arbetar med den här typen av verksamhet?
- Hur stor del av arbetet utförs ideellt?
- Hur många är anställda?

Involvering/Samarbetspartners
Vilka livsmedelsföretag/samarbetspartners?
Kan du berätta lite om hur ert samarbete ser ut med olika aktörer som donerar mat?
Hur många donatorer har ni?

Finansiering/kostnader
Hur ser det ut med avgifter?
- Betalar Matmissionen för att ta emot maten? Hur mycket?
- Tar Matmissionen betalt för att ta emot maten? Hur mycket?
Är denna verksamhet lönsam?
Hur mycket kostar den här delen av er verksamhet? Vart ligger de främsta kostnaderna? (transport, personal, lager)

Svårigheter
Vilka svårigheter har stötts på?

Potential
Hur ser behovet ut? Är det mer överskottsmat som behöver hämtas upp?
Vad har ni lyckats åstadkomma hittills?

Social organizations

Organisation
Vad är organisationens huvudsyfte?
Beskriv organisationen, flödena in och ut med mat. Hur går det till mer praktiskt?
Hur många organisationer har ni runtom i sthlm som tar emot mat?
Hur många personer är anställda, volontärer respektive i arbetsträning hos er?

Matvolymer
Hur mycket mat (måltider, kg) serverar/hanterar ni per år?
Hur ser behovet ut, hur mycket mer hade ni behövt?
Hur får ni tag på den mesta av maten (köpa, hämta överskottmat från butik, sponsrad ”vanlig” mat)?
Vad är andelen köpt och andelen donerad mat av det ni distribuerar till behövande?
Varför köper ni mat?
Hur mycket kg mat köper ni in per månad?
Hur mkt kg mat får ni donerat per månad?
Vad är era matkostnader för denna mängd inköpta mat per månad?
Hur många butiker/företag får ni matdonationer ifrån?

Om ni köper in maten själva:
- Vart köps maten in ifrån? Vilken typ av mat?
Hur fungerar detta?
Vilka transportmedel använder ni?
- Vilket drivmedel? E85? Bensin? Diesel? Fordonsgas?
- Hur mycket rymmer transportfordonet? (kg)
Har ni någon uppskattning om hur mycket det kostar för er organisation att köpa in mat per vecka/månad/år?

Om ni får maten från överskottsmat/donationer:
- Hur fungerar detta?
- Hämtar ni upp maten?
Om ja,
Varifrån?
Vilka transportmedel använder ni?
Kommer ni bestämda tidpunkter eller blir ni kontaktade när det finns någonting att hämta?
Kan du berätta lite om hur det går till när ni hämtar/tar emot maten?
Vilken typ av mat doneras främst?
Får ni betalt för detta/betalar ni för detta?
Vilka kostnader finns i samband med donationer för er organisation?
Tror ni att ni enbart kan förlita er på att få mat via matbanken?
- Eller är det något ni måste komplettera med?
- Hur stor andel mat tror ni att ni alltid kommer att behöva köpa in? Oavsett om det sker redistribution och donationer?

- Vad är det som ni inte får tillgodoräknat från donationer? Från överskottsmaten? Som ni alltså alltid måste köpa in?
Låt oss säga att ni får in 100-200 ton mat från matbanken på ett år, hur mkt måste ni komplettera med?
Hade ni behövt extra personal för att hantera mat från redistribution?
Hur många av era verksamheter har hand om matleveranser/inköp av mat? Vart kommer maten levereras, om ni får mat från matbanken?

Lagerhållning
Har ni möjlighet att förvara maten och tillaga den?
Hur ser kapaciteten ut?
Hur mycket mat kan ni få in och ta hand om maximalt?

Distribution
Hur går det till när ni distribuerar den till behövande?
Vilka serverar ni mat till? Kommer människor till er eller ni till dem?

Finansiering/Kostnader
Hur finansieras organisationen?
Får ni någon finansiering från kommunen/stat?
Vilka kostnader finns det med i organisationen? (Personal, transporter, inköp av mat)
Vart ligger de främsta kostnaderna?

Svårigheter/Potential
Är behovet av mat större än det ni kan leverera till behövande idag?
Hade ni behövt få in mer mat från donationer/matbank?
Vilka svårigheter/hinder finns det för er organisation?

Central warehouse 1

Organisation
Hur går verksamheten till?
Hur går det till när ni får leveranser?
Vilka butiker levererar ni till?

Matfraktioner och avfallshantering
Vilken typ av mat hanterar ni på centrallagret? Torra varor? Paketerade livsmedel? Frukt och grönt? Kött- kylvaror?
Vilken typ av matavfall uppstår på centrallagret? Förpackade livsmedel? Oförpackat matavfall?
Vilka matfraktioner rör det sig om? (Som blir till avfall)
Varför uppstår det matsvinn på centrallagret? Vad är orsakerna?
Hur mycket matavfall har ni per månad/år?
Hur hanteras det matavfall som uppkommer på centrallagret?
Slängs matavfallet separat och går till biogasproduktion? Eller slängs matavfallet tillsammans med det brännbara avfallet?
Hur ser fördelning av detta ut? Ungefär?

Vilket företag är det som hämtar upp matavfallet?

Kostnader
Vad betalar ni i avfallstaxa för behandlingsmetoden?
Vad är kostnaderna totalt för den mängd matavfall som ni har?

Övrigt
Skulle ni vilja donera ert matsvinn till en matbank istället för att låta det gå till avfallshantering? Varför i sådana fall?
Skulle ni kunna tänka er att betala en årlig avgift för att distribuera matsvinn till matbanken?
Skulle ni kunna tänka er att stå för transporten av matsvinnet till den centrala matbanken? (Tanken är att den centrala matbanken ska vara lokaliserat i Årsta, Stockholm)

Appendix II

Calculations

How the calculations are done

When costs and climate impacts from the transportation from the food bank to the food actors are calculated in scenario 2 it is done specifically for central warehouse 1 and the amount of 14 tonnes functional food waste. Transportation route, vehicle specifications, amount of food that can be collected per year and type of food have been considered. From central warehouse 1 only dry goods can be collected, therefore there is no need for the refrigerator plant to be switched on for this transportation.

Remaining food amounts of 486 tonnes are assumed being refrigerated products and other products, such as dairy products, fruit, vegetables, meat, coffee, bread etc. For these goods the refrigerator plant need to be switched on since it is assumed that refrigerated and dry goods are collected on the same delivery. The total amount of 500 tonnes functional food waste is calculated based on the information collected from central warehouse 1 but with consideration of the type of food and the whether it is refrigerated or non-refrigerated food that is collected.

The costs and climate impacts from transportation made by the food bank are first calculated for central warehouse 1 and the amount of functional food waste that can be collected from there, and remaining amount is calculated for the same transportation distance but with consideration of the food type and how much that can be collected in total per year.

For central warehouse 1, differences in costs and climate impacts for 277 tonnes food waste in scenario 1 and 263 tonnes in scenario 2 are calculated (a difference of 14 tonnes). This includes costs for waste treatment and the reduction of climate impacts they contribute to the society by reducing the amount of waste with 14 tonnes. This is done by calculating what it has generated in climate impacts to produce this amount of food waste and that in scenario 2 is seen as a reduction of impacts. This is calculated from the perspective of central warehouse 1 to see how much that specific company can save in costs and climate contribution. Although, this is included in the calculations of the climate impacts for production of the total amount of 500 tonnes food, and not added to this.

Climate impacts from production of total 500 tonnes are calculated, also climate impacts for waste management of 500 tonnes food. This is done for scenario 1, and in scenario 2 these impacts can be saved since redistribution of food is seen as a climate improving measure and since the food is not waste treated.

The climate contribution from waste management is calculated for the total amount of 500 tonnes, also the production of 500 tonnes food in scenario 1. The total waste management costs to treat 500 tonnes functional food waste are also accounted for, to get a picture of the total costs that can be saved by the food companies in scenario 2. Calculations made specifically for central warehouse 1 and for the total amount of 500 tonnes are not added, what is calculated for central warehouse 1 is included in the total amount.

Calculations for costs and climate impacts for waste management are based on the information collected from central warehouse 1, even the amounts of food waste that are not coming from there. The costs for waste management are calculated for the total amount of 500 tonnes based on the waste charges for central warehouse 1. This fee is assumed being similar for food actors.

The calculations for the emissions generated by the transportation and treatment of food waste are based on the transportation distance from central warehouse 1 to the concerning treatment plants. It is the transport from the food actors to the waste management when the vehicles are loaded with food waste that the climate impacts from transportation are calculated. The transportation route, waste management plant and vehicle used for waste treatment specifically for central warehouse 1 have been calculated and applied on the total amount of 500 tonnes. The emissions generated are calculated per tonnes of food waste and assumes being similar disregarded of the location.

When the climate impacts generated from the production of 500 tonnes food waste are calculated, the amount of food waste that in scenario 1 goes to waste treatment is compared to scenario 2 where the waste goes to redistribution. Since food redistribution is seen as a climate impact reducing measure the climate impacts are reduced according the amount of waste that can be redistributed, in this case 500 tonnes (Eriksson & Strid, 2013). Therefore, the climate contribution from production of 500 tonnes food is saved by having redistribution via a central food bank.

When calculating the climate impact from the production of food that the social organizations purchase it is only accounted for the amount of purchased newly-produced food and not for the donations received for the two scenarios. Donations of food waste are seen as a waste reducing measure and beneficial for the climate (Eriksson & Strid, 2013). That social organizations can reduce their purchased food as a result of redistribution from a central food bank is in this case most relevant and therefore this is compared between the two scenarios.

Food bank

Revenues

The food bank expects receiving a yearly sum of revenues from food actors which includes handling and storing the food waste. It is still unclear how much the revenues will end up to since it is still uncertain which actors that will be involved and how large the fees will be.

Personnel

The three employees at the food bank are assumed being full time employed during the first year. The salaries for an instructor, a work coach and director of department have been brought out.

Average salary instructor Stockholm: approx. 24 000 SEK/month = 288 000 SEK/year
Average salary director of department Stockholm: approx. 36 500 SEK/month = 438 000 SEK/year
Average salary work coach Stockholm: approx. 26 500 SEK/month = 318 000 SEK/year
Total: 288 000+438 000+318 000 = approx. 1 044 000 SEK/year
(Lönestatistik, u.d.)

Employment taxes required by the employer are 31,42 % of the total sum of the gross wages paid out per year (Skatteverket, 2016).

Total personnel costs: **1 372 025 SEK/year ~ 1,37 million SEK/year**

Transports

The vehicle that will be used by the food bank is a refrigerator truck. The model is a Mercedes Benz Sprinter (Lunde Dinesen, 2016). The fuel consumption is 0,79 liter/mile and fuel cost is 12 SEK/liter. Maximum shipment weight is 1000 kg (Clagine, 2015; Preem, 2016). Every extra 100 kg in shipment weight corresponds to 5 % extra fuel consumption (Gröna bilister, u.d.).

The climate contribution from the refrigerator plant:
0,02 g CO_2 eq/transported kg and hour the plant is running.
The climate contribution from leakage of refrigerants:
0,00125 g CO_2 eq/transported kg and hour the plant is running.
Which gives a total climate contribution of: 0,02125 g CO_2 eq/transported kg and hour the plant is running (Nilsson & Lindberg, 2011).

The climate impacts from the driving the vehicle without shipment weight are calculated from its CO_2 eq WTW (well-to-wheel). The tool used to calculate the climate impact does it in similar way as the tool NTM Calc, using a life cycle perspective with similar system boundaries (Miljöfordon, 2016c; Network for transport measures, u.d.). The net emissions of greenhouse gases are calculated, so called life cycle emissions. Consideration is taken for emissions of the whole life cycle of the vehicle, for the whole production chain from cultivation of raw materials to combustion of the fuel in the vehicle (Miljöfordon, 2016b; Miljöfordon, 2016c). A value of the amount of CO_2 equivalents generated is brought out when the total amount of fuel consumption used for the calculated transportation route is inserted in the table (Miljöfordon, 2016a).

The reason for using both the source Miljöfordon and NTM Calc is since the above described source is calculating the CO_2 eq WTW for the vehicle when it is unloaded and NTM Calc is calulcating the CO_2 eq WTW when the vehicle is loaded with food. By adding these together with the climate contribution from the refrigerator plant the total amount of CO_2 eq for transportation is calculated.

In table I the transportation routes driven by the food bank are visualized, the distance, the estimated travel time, how much the truck is loaded for the different routes and whether the refrigerator plant is switched on or not. The distance and travel time can be seen in appendix III.

Table I. *An overview of the routes driven by the food bank.*

Routes	**Distance (km)**	**Time (min)**	**Shipment weight (tonnes)**	**Refrigerator plant**
1. Food bank – Central warehouse 1	42,9	32	0	No
2. Central warehouse 1 – Food bank	42,9	32	1	Yes/No
3. Food bank – Salvation Army's internal food bank	13,4	19	1	Yes/No
4. Salvation Army's internal food bank – Convictus	18,6	21	0,2	Yes/No
5. Convictus – Ny Gemenskap	5,4	10	0,1	Yes/No
6. Ny Gemenskap – Food bank	2,59	7	0	No

Table I show the total routes that are assumed being driven by the food bank when collecting food at central warehouse 1 and being delivered at the three social organizations. See figure 11 to visualize the routes. All these stops are made every time food is collected at the central warehouse. It is assumed that 1 tonnes food is collected each time and that 800 kg is delivered at Salvation Army's internal food bank and 100 kg each for Convictus and Ny Gemenskap. The amount of food that is loaded on the truck between these routes can be seen in the fourth column in table I.

This means that 1 tonnes is delivered at the three social organizations for every time and it is required that these routes are driven 500 times to come up in the total sum of 500 tonnes food. Salvation Army expects can receive 400 tonnes and Convictus and Ny Gemenskap 50 tonnes each. It is assumed that the food is transported to the central food bank for storage before reaching the social organizations.

Only 14 tonnes could be collected at central warehouse 1 and this food were dry goods and require no refrigerating when transporting it. It is therefore assumed that at 14 of the total 500 times when food is collected is the refrigerator plant switched off. By the remaining 486 times is the refrigerator plant switched on when food is collected at the other food actors. These routes are calculated for the same transportation route as for central warehouse 1, it is calculated for the same distance.

The food that Salvation Army receives is assumed being delivered at their internal food bank in Hjorthagen. Transportation from there and to their social organizations is made by their own vehicles (Åslund, 2016). This transportation is not being considered in the calculations since this does not differ from scenario 1 and 2. This transportation is made regardless of if the food comes from the central food bank or from previous donors.

Transportation costs

These are the calculations of the routes driven with and without shipment weight. See table I to see shipment weight of the vehicle for each route 1-6. The vehicle is loaded without shipment weight, with 1000 kg, 200 kg and 100 kg between the different routes between food companies and social organizations. Since every route should deliver 800 kg to Salvation Army, and 100 kg each to Convictus and Ny Gemenskap for each time food is delivered at the organizations.

Route 1 and 6. Transportation route without shipment weight: 42,9+2,59 km = 45,49 km = 4,549 mile. 4,549 mile*0,79 liter/mile*12 SEK/liter = 43,12452 SEK.
Route 2 and 3. Transportation route with 1000 kg shipment weight: 42,9+13,4 km = 56,3 km. $1{,}05^{10}$*0,79 liter/mile = 1,2868 liter/mile. 5,63 mile*1,2868 liter/mile*12 SEK/liter = 86,93816 SEK.
Route 4. Transportation route with 200 kg shipment weight: 18,6 km. $1{,}05^{2}$*0,79 liter/mile = 0,870975 liter/mile. 1,86 mile*0,870975 liter/mile*12 SEK/liter = 19,44 SEK.
Route 5. Transportation route with 100 kg shipment weight: 5,4 km. $1{,}05^{1}$*0,79 liter/mile = 0,8295 liter/mile. 0,54 mile*0,8295 liter/mile*12 SEK liter = 5,37516 SEK.

Total costs: 154,877696 SEK.
Total costs for transporting 500 tonnes: **77 438,848 SEK/year ~ 77 400 SEK/year**

Climate impacts from transportation

For the routes without shipment weight the climate impacts are calculated using the tool from Miljöfordon that has been described above (Miljöfordon, 2016b). The total distance for route number 1 and 6 is (42,9+2,59 = 45,49 km) 4,549 mile. This gives a total fuel consumption of (4,549 mile*0,79 liter/mile = 3,59 liter). The fuel consumption is inserted in the fuel calculation and gives emissions of 0,01 tonnes CO_2 eq (Miljöfordon, 2016a).

The climate impact for the routes with shipment weight is calculated using NTM Calc. This is calculated separate for route 2, 3, 4 and 5 and gives emissions of 34,77 kg, 30,72 kg, 3,015 kg and 0,4377 kg CO_2 eq. In total it gives approx. 68,9427 kg CO_2 eq = 0,0689427 tonnes CO_2 eq for the routes driven and for the respective shipment weight. (The specifications used in the tool were vehicle type van, diesel consumption of 0,85 liter/mile, the distance and shipment weight) (Network for transport measures, 2016).

The total climate impact for transportation with and without shipment weight is 0,0789427 tonnes CO_2 eq. This is multiplied with 500 tonnes to get the total climate impact for the routes driven the first year and gives emissions of 39,47135 tonnes CO_2 eq.

The climate contribution from the refrigerator plant and refrigerants:
0,02125 g CO_2 eq/transported kg and hour running of the plant.
The total transported shipment weight between the actors needing refrigeration is: 486 tonnes.
The total time that the shipment is transported during the first year is:
(32 min+19 min+21 min+10 min*486 times/year) = 39 852 min = 664,2 hours.
The total climate contribution from the refrigerator plant:
0,02125*486 000 kg*664,2 hours = 6 859 526 g CO_2 eq = 6,859526 tonnes CO_2 eq/year.

The total climate impact from transportation: **46,33088 tonnes CO_2 eq/year ~ 46 tonnes CO_2 eq/year**

Warehousing

Costs

All facilities within Stockholm City Mission have a fixed cost for electricity use and is approx. 0,70 SEK/kWh using electricity as a source of energy (Rindevall, 2016). The warehouse will be approx. 700 m^2 and include two large cooling rooms and one large cold chamber (Lunde Dinesen, 2016).

To be able to dimension the energy use in the warehouse data from a literature study was used which has brought out key numbers of the energy use for storing food in a warehouse (Ekman & Svärdsjö, 2012). It is revealed that the total energy use for a warehouse storing food is approx. 500 kWh/m^2 and year. This includes electricity heating, comfort cooling, pumps, fans, facility electricity, food cooling, lighting and electricity used for the business activities.

Based on this data the total usage of kWh for the warehouse of 700 m^2 is 350 000 kWh/year. This is an assumption and the calculations used in the study are based on key figures. This can vary greatly from different situations but it gives an estimation of the total energy usage for the warehouse of study.

Costs for warehousing:
350 000 kWh*0,70 SEK/kWh = 245 000 SEK.

Also fixed costs for rent needs to be added. The rent will be between 1200-1300 SEK/m^2 for the food bank (Rindevall, 2016). For the warehouse of 700 m^2 the costs will be between 840 000-910 000 SEK.

The total costs for warehousing: 1 085 000-1 155 000 SEK/year. Mean value is **1 120 000 SEK/year ~ 1,12 million SEK/year**

Climate impacts

The climate contribution per kg kWh for Swedish electricity mix is 0,02 kg CO_2 eq/kWh. Swedish electricity mix is calculated as an average of the electricity produced in the country (Klimatkompassen, u.d.).

350 000 kWh/year * 0,02 kg CO_2 eq/kWh = 7 000 kg CO_2 eq/year. Which gives **7 tonnes CO_2 eq/year**

Food production

The climate impact of letting 500 tonnes produced food end up at waste treatment instead of being eaten is 1,6 tonnes CO_2 eq/tonnes food waste*500 tonnes food waste = 800 tonnes CO_2 equivalents (Scholz, 2013). In scenario 1 this climate contribution is 800 tonnes CO_2 equivalents since the food is transported to waste treatment but in scenario 2 this impact can be saved since the food is redistributed and fulfilling the purpose of the production.

Scenario 1: **800 tonnes CO_2 eq**
Scenario 2: **0 tonnes CO_2 eq**

Results

Costs

Personnel: approx. 1,37 million SEK/year
Transport: approx. 77 400 SEK/year
Warehousing: 1,12 million SEK/year

Total costs for the food bank during the first year: **approx. 2,6 million SEK**

Climate impacts

Production of 500 tonnes food waste: The society saves emissions of 800 tonnes CO_2 equivalents by redistributing 500 tonnes food waste.
Transport: approx. 46 tonnes CO_2 eq/year
Warehousing: 7 tonnes CO_2 eq/year

Total climate impact as a result of the activities of the food bank during the first year: **approx. 53 tonnes CO_2 eq.** On the other hand does the society save emissions of **800 tonnes CO_2 eq**.

Social organizations

Convictus

Transportation distance for collecting donations: 3 km (See appendix III).
The route is driven 4 times/week back and forth. 2*4*52 = 416 times/year (Gerdin, 2016).

Scenario 1

Food amounts
Donations: 75 kg*4 days/week*52 = 15 600 kg/year (Gerdin, 2016).

Purchased food: 100 kg*5 days/week*52 = 26 000 kg/year (Gerdin, 2016).
(A full loaded shopping cart holds 100 kg) (Butiksprofil AB, 2015). Total food amounts being handled: 15 600+26 000 = 41 600 kg = 41,6 tonnes.

Costs
Donations: Free

Purchased food: **approx. 200 000 SEK/year** (Gerdin, 2016)**.**

Transport donations: The vehicle used run on biogas and has a fuel consumption of 6 liter/100km for that model. The fuel price is 14,45 SEK/liter (Bilsvar, 2016). Which gives a fuel consumption of: 0,06 liter/km*3 km = 0,18 liter. 14,45 SEK/liter*0,18 liter = 2,601 SEK. 2,601 SEK*416 = **1082 SEK/year.**

Climate impacts
Donations: The climate impacts from transportation are calculated the same way as described above for the food bank without shipment weight using the tool Miljöfordon (Miljöfordon, 2016c). The total route driven is 416*3 = 1248 km and gives a total fuel consumption of 74,88 liter. This is inserted in the tool and gives emissions of **0,123 tonnes CO_2 eq ~ 0,1 tonnes CO_2 eq** (Miljöfordon, 2016a).

Production of purchased food: Emissions from the production of food are 1,6 tonnes CO_2 equivalents/tonnes food (Scholz, 2013). Total amount of purchased food: 26 tonnes. 1,6 tonnes CO_2 equivalents/tonnes food waste*26 tonnes = **41,6 tonnes CO_2 eq.**

Scenario 2

Personnel costs: Do not differ from scenario 1. The personnel costs are assumed being unchanged in the both scenarios since the organization did not plan having more or fewer peronnel as a result of receiving food from the central food bank (Gerdin, 2016).

Purchased food: The organization does not need to purchase larger amounts of food since this assumes being covered by the redistribution. Eventual support purchasing occasionally may be needed for products that are consumed significantly on a daily basis (Gerdin, 2016). For example dairy products and meat for Convictus. Consumption of dairy products is calculated by information from Dino Gerdin, supervisor at Convictus, of their daily consumption of food (Gerdin, 2016). Consumption of butter is approx. 3 packages/day, approx. 15 packages of dairy products/day and the meat consumption is approx. 10 kg/day. These amounts are on the other hand assumed being covered by the redistribution to some extent, since several food producers and wholesales are distributing these food types. It is estimated that this amount can be reduced by 50 % since that has been the case for social organizations in the Danish food banking model and that number has been assumed here as well. The prices are collected from Matdax (Matdax, 2016).

Donations: The donated food is assumed being reduced entirely for Convictus. They mainly receive donated fruit, vegetables and bread and this can probably be covered by the redistribution from a central food bank, also that the donations were only a smaller part of the total food amount handled by the organization. Consequently, they do not need to drive to Coop in Stuvsta to collect the donations.

Costs

Donations: No donations are assumed.

Purchased food: 3 packages of butter*25 SEK*5*52 = 19 500 SEK. Reduced by half = 9 750 SEK. 15 packages of dairy products*10 SEK*5*52 = 39 000 SEK. Reduced by half = 19 500 SEK. 10 kg meat*35 SEK/kg*5*52= 91 000 SEK. Reduced by half = 45 500 SEK. Total: 9 750+19 500+45 500 = **74 750 SEK/year** (Matdax, 2016)**.**

Transport donations: No transport is needed.

Climate impacts

Donations: No donations are assumed.

Production of purchased food: 0,75 kg butter*5*52 days = 195 kg. 7,5 kg dairy products*5*52 = 1950 kg. 5 kg meat*5*52 = 1300 kg. Total amount of purchased food: approx. 3445 kg. 1,6 tonnes CO_2 eq/tonnes food waste*3,445 tonnes = **5,512 tonnes CO_2 eq ~ 5,5 tonnes CO_2 eq**

Transport donations: No transport is needed.

Results

Costs

Scenario 1: 200 000 SEK+1082 SEK = 201 082 SEK/year. (Food purchase and transportation)
Scenario 2: 74 750 SEK/year (Food purchase)
201 082-74 750 = 126 332 SEK/year.

By a redistribution from a central food bank Convictus would save **approx. 126 332 SEK/year ~ 126 000 SEK/year**

Climate impacts

Scenario 1: 0,123 tonnes+41,6 tonnes = 41,723 tonnes CO_2 eq/year
Scenario 2: 5,512 tonnes CO_2 eq/year
41,723-5,512 = 36,211 tonnes CO_2 eq/year

By a redistribution from a central food bank the society would save **approx. 36,21 tonnes CO_2 eq/year ~ 36 tonnes CO_2 eq/year**

Ny Gemenskap

Transportation distance for collecting donations: 9,5 km (See appendix III).
The route is driven 1 times/week back and forth. 2*52*1 = 104 times/year (Malmqvist, 2016).

Scenario 1

Food amounts

No information regarding the amount of food handled per year could be collected from the interview. This amount is assumed being similar to Convictus, since they have the same size of organization, same amount of visitors, are the same type of organization (daily activity center which serves breakfast and lunch) and has similar food costs per year. The amount of food that Ny Gemenskap is handling is therefore assumed being **approx. 50 tonnes/year.** The share of purchased food is approx. 90 % of the total amount of food that is handled by the organization according to Anna Malmqvist. Remaining amount is donated (Malmqvist, 2016). The purchased food is 50*0,9 = approx. 45 tonnes per year and remaining 5 tonnes is donated.

Costs

Donations: Free

Purchased food: **approx. 300 000 SEK/year** (Malmqvist, 2016)**.**

Transport donations: The vehicle used is a Ford Mondeo (Malmqvist, 2016), run on diesel and has a fuel consumption of 4,3 liter/100 km for that model (Bilweb, 2016a). The fuel price is approx. 12 SEK/liter (Preem, 2016). Which gives 0,043 l/km*9,5 km = 0,4085 liter per route. 12 SEK/liter*0,4085 liter = 4,9 SEK. 4,9 SEK*104 = **509,8 SEK/year ~ 510 SEK/year**

Climate impacts

Donations: The climate impacts from transportation are calculated the same way as described above for the food bank without shipment weight (Miljöfordon, 2016c). The total distance is 104*9,5 km = 988 km and gives a total fuel consumption of 42,484 liter diesel. This is inserted in the tool and gives emissions of **0,119 ton CO_2 eq ~ 0,1 tonnes CO_2 eq** (Miljöfordon, 2016a)**.**

Production of purchased food: Emissions from the production of food are 1,6 tonnes CO_2 equivalents/tonnes food (Scholz, 2013). Total amount of purchased food: approx. 45 tonnes. 1,6 tonnes CO_2 eq/tonnes food waste*45 tonnes = **72 tonnes CO_2 eq.**

Scenario 2

Personnel costs: Do not differ from scenario 1. The personnel costs are assumed being unchanged in the both scenarios since the organization did not plan having more or fewer peronnel as a result of receiving food from the central food bank (Malmqvist, 2016).

Purchased food: The organization does not need to purchase larger amounts of food since this assumes being covered by the redistribution. Eventual support purchasing occasionally may be needed for products that are consumed significantly on a daily basis. For example dairy products and coffee for Ny Gemenskap. The consumption of coffee is approx. 50 kg/month, which gives 100 packages/month and the costs are approx. 35 SEK/package. Consumption of dairy products is calculated according the consumption at Convictus and assumes being similar at Ny Gemenskap. Consumption of butter is approx. 3 packages/day. Consumption of dairy products is assumed being 20 packages/day. It appeared from the interview that some sour milk was also consumed at Ny Gemenskap (Malmqvist, 2016). These amounts are on the other hand assumed being covered by the redistribution to some extent, since several food producers and wholesales are distributing these food types. It is estimated that this amount can be reduced by 50 %. The prices are collected from Coop (Coop, 2016).

Donations: The donated food is assumed being reduced entirely for Ny Gemenskap. They mainly receive donated fruit, vegetables and bread and this can probably be covered by the redistribution from a central food bank. Consequently, they do not need to drive to collect bread at Ica Baronen once a week.

Costs

Donations: No donations are assumed.

Purchased food: 100 packages of coffee*35 SEK*12 months = 42 000 SEK. Reduced by half = 21 000 SEK. 3 packages of butter*30 SEK*365 days = 32 850 SEK. Reduced by half = 16 425 SEK. 20 dairy packages*10 SEK*365 days = 73 000 SEK. Reduced by half = 36 500 SEK. Total: 21 000+16 425+36 500 = **73 925 SEK/year** (Coop, 2016).

Transport donations: No transport is needed.

Climate impacts

Donations: No donations are assumed.

Production of purchased food: 25 kg coffee*12 months= 300 kg. 10 kg dairy products*365 days = 3650 kg. 0,75 kg butter*365 days = 273,75 kg. Total: approx. 4223,75 kg. 1,6 tonnes CO_2 eq/tonnes food waste*4,22375 tonnes = **6,758 tonnes CO_2 eq ~ 6,8 tonnes CO_2 eq**

Transport donations: No transport is needed.

Results

Costs
Scenario 1: 300 000 SEK+510 SEK = 300 510 SEK/year. (Food purchase and transport)
Scenario 2: 73 925 SEK/year (Food purchase)
300 510-73 925 = 226 585 SEK/year.

By a redistribution from a central food bank Ny Gemenskap would save **approx. 226 585 SEK/year ~ 227 000 SEK/year**

Climate impacts
Scenario 1: 0,119 tonnes+72 tonnes = 72,119 tonnes CO_2 eq/year
Scenario 2: 6,758 tonnes CO_2 eq/year
72,119-6,758 = 65,359 tonnes CO_2 eq/year

By a redistribution from a central food bank the society would save **approx. 65,36 tonnes CO_2 eq/year ~ 65 tonnes CO_2 eq/year**

Salvation Army

Transportation distance for food purchase: approx. 10 km (See appendix III for the routes).

This route is assumed being driven 800 times/year for the 8 different organizations. Back and forth this is 1600 times/year. Half of the times the vehicle is unloaded and remaining times loaded with 100 % filling degree.

Addresses to all 10 organizations could not be found since some are protected residences. It is also unclear how the transportation routes are driven between the organizations to purchase food. This information could not be collected from the interview. Addresses to 8 organizations were found that handles food within the Salvation Army and all of these are assumed to receive food from the food bank. The remaining two organizations are Kurön, which is located at Adelsön, an island in Stockholm archipelago and a protected residence for women which were both excluded from the study.

Scenario 1

Food amounts
No information regarding the amount of food handled per year could be collected from the interview. This amount is estimated by comparing the size of Convictus and Ny Gemenskap with Salvation Army. The food budget of Salvation Army is approx. 10 times the size of the other two organizations. By a rough estimation it can be assumed that they handle approx. 500 tonnes food/year for all the internal organizations combined. The share of purchased food is approx. 80 % of the total amount of food that is handled by the organization according to Per-Uno Åslund. Remaining amount is donated (Åslund, 2016). The purchased food is 500*0,8 = approx. 400 tonnes per year and remaining 100 tonnes is donated.

Costs
Donations: Free

Purchased food: **approx. 2,8 million SEK/year** (Åslund, 2016)**.**

Transport food purchase: All the organizations are accounted for as one unit and not separately for the 8 organizations. An average transportation route is calculated by a mean value of the distance for the 8 organizations to purchase food. This is approx. 10 km one way, see appendix III. It is assumed that these purchases occurs approx. 800 times/year for the different organizations in total and that it is purchased food for approx. 500 kg/time (maximum filling degree in the vehicle). The route is driven 1600 times/year in total back and forth to cover the amount of food of 400 tonnes. The vehicle used is a Volkswagen caddy with maximum shipment weight of approx. 500 kg (Åslund, 2016). 800 times/year*500 kg= 400 tonnes food. This route is roughly estimated since it were significantly longer and shorter distances for the 8 organizations driving to Martin & Servera. This is assumed being evened out by taking an average value. This is further discussed in the analysis.

Without shipment weight:
The vehicle run on diesel, with a fuel consumption of 0,57 liter/mile for that model (Bilweb, 2016b). The fuel price is approx. 12 SEK/liter (Preem, 2016). 0,057 l/km*10 km = 0,57 liter per route. 12 SEK/liter* 0,57 liter = 6,84 SEK. 6,84 SEK*800 times = 5472 SEK/year

With shipment weight:
Extra fuel consumption for 500 kg shipment weight (Gröna bilister, u.d.): $1{,}05^5$*0,57 liter/mile = 0,72748 liter/mile. 10 km (1 mile) is driven per route. 12 SEK/liter*0,72748 liter*800 times = 6983,8 SEK/year.

Total transportation costs: **12 455,8 SEK/year ~ 12 456 SEK/year**

Climate impacts
Transport food purchase: The climate impacts from transportation are calculated the same way as described above for the food bank without shipment weight (Miljöfordon, 2016c). The total distance is 10 km*1600 = 16 000 km and gives a total fuel consumption of 1037,6 liter diesel (with extra fuel consumption calculated for half of the distance). This is inserted in the tool and gives emissions of **2,9 tonnes CO_2 eq/year** (Miljöfordon, 2016a)**.**

Production of purchased food: Emissions from the production of food are 1,6 tonnes CO_2 equivalents/tonnes food (Scholz, 2013). Total amount of purchased food: approx. 400 tonnes. 1,6 tonnes CO_2 eq/tonnes food waste*400 tonnes = **640 tonnes CO_2 eq/year**

Scenario 2

Personnel costs: Do not differ from scenario 1. The personnel costs are assumed being unchanged in the both scenarios since the organization did not plan having more or fewer peronnel as a result of receiving food from the central food bank (Åslund, 2016).

Food purchase: It is assumed that this amount can be reduced by half. Since no information could be collected regarding their food purchase it is assumed that the costs are reduced by half of their total current costs of 2,8 million SEK and that the transportations are reduced accordingly. No precise amounts are calculated since the insufficient data.

Donations: The donated food is assumed being reduced entirely for Salvation Army. This amount is assumed being covered by the central food bank.

Costs

Donations: No donations are assumed.

Food purchase: Half of 2,8 millions = **1,4 million SEK.**

Transport food purchase: It is assumed that the transportations are reduced by half. 12 455,8/2 **= 6227,9 SEK ~ 6228 SEK/year**

Climate impacts

Donations: No donations are assumed.

Transport food purchase: Climate impact from transportations assumes being reduced according the same reasoning above. 2,9 tonnes/2 = 1,45 tonnes. **1,45 tonnes CO_2 eq/year.**

Production of purchased food: 400 tonnes/2 = 200 tonnes. 1,6 tonnes CO_2 eq/tonnes food waste*200 tonnes = **320 tonnes CO_2 eq.**

Results

Costs

Scenario 1: 2 800 000 SEK+12 456 SEK = 2 812 456 SEK/year. (Food purchase and transport)
Scenario 2: 1 400 000 SEK + 6228 SEK = 1 406 228 SEK/year. (Food purchase and transport)
2 812 456-1 406 228 = 1 406 228 SEK/year.

By a redistribution from a central food bank Salvation Army would save **approx. 1 406 228 SEK/year ~ 1,4 million SEK/year**

Climate impacts

Scenario 1: 2,9 tonnes+640 tonnes = 642,9 tonnes CO_2 eq/year
Scenario 2: 1,45 tonnes+320 tonnes = 321,45 CO_2 eq/year
642,9-321,45 = 321,45 tonnes CO_2 eq/year

By a redistribution from a central food bank the society would save **approx. 321,45 tonnes CO_2 eq/year ~ 320 tonnes CO_2 eq/year**

Central warehouse 1

Scenario 1

Food amounts
Waste management costs are approx. 350 000 SEK/year and the waste fee 1265 SEK/tonnes. This gives a food waste amount of approx. 277 tonnes/year. Approx. 5 % of this amount could be redistributed (Intervjuobjekt 1, 2016). The functional food waste which can be collected by the central food bank is therefore approx. 14 tonnes.

Costs
Waste management: **350 000 SEK/year**

Climate impacts
Production of the amount of food waste: 1,6 tonnes CO_2 eq/tonnes food waste (Scholz, 2013)*277 tonnes food waste = **443,2 tonnes CO_2 eq ~ 443 tonnes CO_2 eq**

Scenario 2

Food amounts
277-14 = 263 tonnes food waste is going to waste treatment in scenario 2 after redistributing 14 tonnes.

Costs
Waste management: Costs for waste management are 95 % of 350 000 SEK. Which gives 332 500 SEK.

Climate impacts
Production of the amount of food waste: 1,6 tonnes CO_2 eq/tonnes food waste*263 tonnes food waste = **420,55 tonnes CO_2 eq ~ 421 tonnes CO_2 eq**

Results

Costs
Waste management cost of approx. **17 500 SEK** can be saved by reducing the food waste amounts by 5 % or 14 tonnes.

Climate impacts
Central warehouse 1 has saved the society emission of **approx. 23 tonnes CO_2 eq/year** by redistributing the functional food waste instead of letting it go to waste treatment.

Waste management

Climate impacts

Transportation

NTM Calc is used to calculate the climate impacts from transportation between central warehouse 1 and pretreatment at Högbytorp. The transportation distance, vehicle (rigid truck 14-20 tonnes) and shipment weight were inserted in the tool. The type of fuel and fuel consumption were preselected for the vehicle and was approx. 2 liter/mile and diesel. This was similar to the information received from Ragnsells regarding their vehicles which uses vehicles of 18-26 tonnes, run on diesel and has an average fuel consumption of 2-4 liter/mile (Malm, 2016).

When the climate impact for transportation between Högbytorp and Syvab biogas plant is calculated information and data regarding the transports have been received from the product manager at Högbytorp (Ragnsells, 2016). Table II show the transportation distance between central warehouse 1 to Högbytorp and Syvab biogas plant.

Table II. *Transportation routes and distance for transporting the waste.*

Transportation route	Distance
Central warehouse 1 – Högbytorp	10,1 km[a]
Högbytorp – Syvab biogas plant	73 km[b]

To calculate the climate impacts from transportation of the waste NTM Calc is used. Pre-chosen data of fuel consumption of approx. 2 liter/mile and the vehicle used is rigid truck 14-20 tonnes. It was selected that 1 tonnes was transported per time and the distance of 10,1 km between central warehouse 1 and Högbytorp was inserted. Emissions of **1,295 kg CO_2 eq/tonnes food waste** were accounted for that route (Network for transport measures, 2016).

For the transportation route between Högbytorp and Syvab the following calculations were done. Tank cars of 60 tonnes are used for this transportation. These are loaded with approx. 33 tonnes slurry before being transported to Syvab. The trucks run on diesel with a fuel consumption of 5 liter/mile (Ragnsells, 2016).

7,3 mile*5 liter/mile = 36,5 liter. 36,5 liter/33 tonnes = 1,106 liter/tonnes food waste.
Combustion of 1 liter diesel gives emissions of 3 kg carbon dioxide (Miljöfordon, 2016).
Which gives emissions of 1,106 liter/tonnes waste*3 kg CO_2 eq/liter = **3,318 kg CO_2 eq/tonnes food waste** for that route.

Total emissions from transportation: 1,295+3,318 = **4,613 kg CO_2 eq/tonnes food waste.**

Transporting 500 tonnes food waste gives emissions of: **2,3065 tonnes CO_2 eq ~ 2,3 tonnes CO_2**

[a] (Hitta.se, 2016)
[b] (Hitta.se, 2016)

eq

Treatment

Syvabs biogas plant

The energy use for treating 1 tonnes food waste is 0,30934 MWh at Uppsala biogas plant (Gunnarsson, 2011). This data was collected from an environmental report from 2013 at Uppsala biogas plant. In this study the energy at Syvab biogas plant is from 62 % electricity and remaining energy is from the digester gas from the production and generates no added greenhouse gas emissions.

0,30934*0.62 = 0,19179 MWh/tonnes from electricity. Swedish electricity mix generates emissions of 0,02 kg CO_2 eq/kWh (Klimatkompassen, u.d.). 191,79 kWh/tonnes waste*0,02 kg CO_2 eq/kWh = 3,8358 kg CO_2 eq/tonnes food waste.

There can also be emissions of methane gas from the digestion process. At Uppsala biogas plant there is a methane slip of approx. 0,3 % of the gas flow. For every tonnes food waste that is treated 180 m^3 biogas is produced, which contains 66 % methane gas and 33 % carbon dioxide (Gunnarsson, 2011).

180 m^3 biogas/tonnes food waste*0,66 = 118,8 m^3 biogas. 118,8*0,003 = 0,3564 m^3/tonnes. This gives methane emissions of 0,3564 Nm^3/tonnes. The density for methane gas is 0,75 kg/Nm^3 which gives emissions of methane of 0,2673 kg/tonnes (Gunnarsson, 2011). Methane has a greenhouse gas index of 21 kg CO_2 eq/kg (Airclim, u.d.). 0,2673*21 = 5,6133 kg CO_2 eq/tonnes food waste.

Total emissions from treatment: 3,8358+5,6133 = **9,4491 kg CO_2 eq/tonnes food waste.**

Treating 500 tonnes food waste generates emissions of **4,72455 tonnes CO_2 eq ~ 4,7 tonnes CO_2 eq.**

Results

Transportation

For the amount from central warehouse 1: 4,613 kg CO_2 eq/tonnes food waste*14 tonnes = 64,582 = **approx. 0,065 tonnes CO_2 eq** are saved each year by redistributing this amount instead.

Remaining amount of food waste from other food actors: 4,613 kg CO_2 eq/tonnes food waste*486 tonnes = 2241,918 = **approx. 2,24 tonnes CO_2 eq** are saved each year by redistributing this amount instead.

Treatment

For the amount from central warehouse 1: 9,4491 kg CO_2 eq/tonnes food waste*14 tonnes = 132,2874 = **approx. 0,13 tonnes CO_2 eq** are saved each year by redistributing this amount instead.

Remaining amount of food waste from other food actors: 9,4491 kg CO_2 eq/tonnes food waste*486 tonnes = 4592,2626 = **approx. 4,6 tonnes CO_2 eq** are saved each year by redistributing this amount instead.

Total emissions saved: **approx. 7 tonnes CO_2 eq** by reducing the treatment and transport of 500 tonnes food waste.

The total costs saved for the food actors combined can be calculated by the waste management costs per tonnes food waste that central warehouse 1 has. The waste fee can vary slightly among food actors but this gives an estimation of what costs can be saved: 1265 SEK/tonnes food waste*500 tonnes = **632 500 SEK** that can be saved in total.

Sensitivity analysis

Filling degree

These calculations have been based on those described for the food bank. The calculations accounted for in this section are those which have been updated with new data, remaining calculations for the food bank are the same as before.

100 % filling degree

It is assumed that 1 tonnes food is collected 10 times at the central warehouse and that this is transported back to the food bank for storage and then delivered at the three social organizations according the same route described earlier, and that is described in table III. This route is driven 10 times to transport 10 tonnes food to the social organizations.

Table III. *Show the indata used when using a filling degree of 100 % in the vehicle.*

Routes	**Distance (km)**	**Time (min)**	**Shipment weight (tonnes)**	**Refrigerator plant**	**Amount of times:**
1. Food bank – Central warehouse 1	42,9	32	0	No	10
2. Central warehouse 1 – Food bank	42,9	32	1	Yes	10
3. Food bank – Salvation Army's internal food bank	13,4	19	1	Yes	10
4. Salvation Army's internal food	18,6	21	0,2	Yes	10

bank – Convictus					
5. Convictus – Ny Gemenskap	5,4	10	0,1	Yes	10
6. Ny Gemenskap – Food bank	2,59	7	0	No	10

Transportation costs to transport 10 tonnes food are calculated the same way as before for the food bank but are multiplied by 10 times instead of 500. Same goes for calculating the climate impacts.

The climate contribution from the refrigerator plant is calculated as before but for the amount of time for this analysis, 14 hours.

Costs

Route 1 and 6. Transportation route without shipment weight: 42,9+2,59 km = 45,49 km = 4,549 mile. 4,549 mile*0,79 liter/mile*12 SEK/liter = 43,12452 SEK.
Route 2 and 3. Transportation route with 1000 kg shipment weight: 42,9+13,4 km = 56,3 km. $1,05^{10}$*0,79 liter/mile = 1,2868 liter/mile. 5,63 mile*1,2868 liter/mile*12 SEK/liter = 86,93816 SEK.
Route 4. Transportation route with 200 kg shipment weight: 18,6 km. $1,05^{2}$*0,79 liter/mile = 0,870975 liter/mile. 1,86 mile*0,870975 liter/mile*12 SEK/liter = 19,44 SEK.
Route 5. Transportation route with 100 kg shipment weight: 5,4 km. $1,05^{1}$*0,79 liter/mile = 0,8295 liter/mile. 0,54 mile*0,8295 liter/mile*12 SEK liter = 5,37516 SEK.

Total costs: 154,877696 SEK.
Total costs for transporting 10 tonnes: **1548,7786 SEK/year ~ 1550 SEK/year**

Climate impacts

For the routes without shipment weight the climate impacts are calculated using the tool Miljöfordon (Miljöfordon, 2016). The total distance for route number 1 and 6 is (42,9+2,59 = 45,49 km) 4,549 mile. This gives a total fuel consumption of (4,549 mile*0,79 liter/mile = 3,59 liter). The fuel consumption is inserted in the fuel calculation and gives emissions of 0,01 tonnes CO_2 eq (Miljöfordon, 2016).

The climate impacts for the routes with shipment weight are calculated using NTM Calc. This is calculated separate for route 2, 3, 4 and 5 and gives emissions of 34,77 kg, 30,72 kg, 3,015 kg and 0,4377 kg CO_2 eq. In total it gives approx. 68,9427 kg CO_2 eq = 0,0689427 tonnes CO_2 eq. (The specifications used in the tool were vehicle type van, diesel consumption of 0,85 liter/mile, the distance and shipment weight) (Network for transport measures, 2016).

The total climate impact for transportation with and without shipment weight is 0,0789427 tonnes CO_2 eq. This is multiplied with 10 tonnes to get the total climate impact for the routes driven the first year and gives emissions of 0,78942 tonnes CO_2 eq.

The transports which needs refrigerating are route **2-5.**
The climate contribution from the refrigerator plant and refrigerants:
0,02125 g CO_2 eq/transported kg and hour running of the plant (Nilsson & Lindberg, 2011).
The total transported shipment weight between the actors needing refrigeration is: 10 tonnes.
The total time that the shipment is transported during the first year is:
(32 min+19 min+21 min+10 min*10 times/year) = 820 min = 14 hours.
The total climate contribution from the refrigerator plant:
0,02125*10 000 kg*14 hours = 2975 g CO_2 eq = 0,002975 ton CO_2 eq/year.

The total climate impact from transportation: **0,79292402 tonnes CO_2 eq/year ~ 0,79 tonnes CO_2 eq/year.**

Food production

The climate impact of letting 10 tonnes produced food end up at waste treatment instead of being eaten is 1,6 tonnes CO_2 eq/tonnes food waste*10 tonnes food waste = 16 tonnes CO_2 equivalents (Scholz, 2013). In scenario 1 this climate contribution is 16 tonnes CO_2 equivalents since the food is transported to waste treatment but in scenario 2 this impact can be saved since the food is redistributed and resources are not wasted.

Scenario 2: **- 16 tonnes CO_2 eq**

Personnel costs: 1 372 025 SEK (from previous calculations)
Warehouse costs: 1 120 000 SEK (from previous calculations)
Warehousing: 7 tonnes CO_2 eq (from previous calculations)

20 % filling degree

It is assumed that 200 kg food is collected 10 times at the central warehouse and that this is transported back to the food bank for storage and then delivered at the three social organizations according the same route described earlier, and that is described in table IV. This route is driven 2 times to transport 2 tonnes food to the social organizations.

Table IV. *Show the indata used when using a filling degree of 20 % in the vehicle.*

Routes	Distance (km)	Time (min)	Shipment weight (tonnes)	Refrigerator plant	Amount of times:
1. Food bank – Central warehouse 1	42,9	32	0	No	10
2. Central warehouse 1 – Food bank	42,9	32	0,2	Yes	10
3. Food bank – Salvation Army's	13,4	19	1	Yes	2

internal food bank					
4. Salvation Army's internal food bank – Convictus	18,6	21	0,2	Yes	2
5. Convictus – Ny Gemenskap	5,4	10	0,1	Yes	2
6. Ny Gemenskap – Food bank	2,59	7	0	No	2

Transportation costs to transport 2 tonnes food are calculated the same way as before for the food bank but with consideration that this was only collected at the central warehouse 10 times and delivered to the social organizations 2 times with 1 tonnes shipment weight instead of 500. Consideration is also taken that only 200 kg is collected at the central warehouse each time. Same goes for calculating the climate impact.

The climate contribution from the refrigerator plant is calculated as before but for the amount of time for this analysis which is 7 hours.

Costs
Transportation route without shipment weight:
Route 1 and 6. 42,9 km = 4,29 mile. 4,29 mile*0,79 SEK/liter*12 SEK/liter*10 times = 406,692 SEK
2,59 km = 0,259 mile. 0,259 mile*0,79 SEK/liter*12 SEK/liter*2 times = 4,91064 SEK
Route 3. Transportation route with 1000 kg shipment weight:
13,4 km = 1,34 mile. 1,34 mile*$1,05^{10}$*0,79 liter/mile = 1,2868 liter/mile. 1,34 mile*1,2868 liter/mile*12 SEK/liter*2 times = 41,383488 SEK.
Route 2 and 4. Transportation route with 200 kg shipment weight:
18,6 km. $1,05^{2}$*0,79 liter/mile = 0,870975 liter/mile. 1,86 mile*0,870975 liter/mile*12 SEK/liter*2 times = 38,880324 SEK.
42,9 km. $1,05^{2}$*0,79 liter/mile = 0,870975 liter/mile. 4,29 mile*0,870975 liter/mile*12 SEK/liter*10 times = 448,37793 SEK.
Route 5. Transportation route with 100 kg shipment weight:
5,4 km. $1,05^{1}$*0,79 liter/mile = 0,8295 liter/mile. 0,54 mile*0,8295 liter/mile*12 SEK/liter*2 times = 10,75032 SEK.

Total costs for transporting 2 tonnes: **950,99556 SEK/year ~ 951 SEK/year**

Climate impacts
For the routes without shipment weight the climate impacts are calculated using the tool Miljöfordon (Miljöfordon, 2016). The total distance for route number 1 and 6 is 42,9 km and 2,59 km. Route 1 is driven 10 times and route 2 is driven 2 times. This gives a fuel consumption of (4,29 mil*0,79 liter/mile*10 times = 33,891 liter) and (0,259 mile*0,79 SEK/liter*2 = 0,20461

liter).This gives a total fuel consumption of 34,3 liter. The fuel consumption is inserted in the fuel calculation and gives emissions of 0,097 tonnes CO_2 eq (Miljöfordon, 2016).

The climate impacts for the routes with shipment weight are calculated using NTM Calc. This is calculated separate for route 2, 3, 4 and 5 and gives emissions of 6,954 kg, 30,72 kg, 3,015 kg respective 0,4377 kg CO_2 eq. In total it gives approx. 41,13 kg CO_2 eq = 0,04113 tonnes CO_2 eq. These routes are driven 2 times which gives emissions of 0,08226 tonnes CO_2 eq. (The specifications used in the tool were vehicle type van, diesel consumption of 0,85 liter/mile, the distance and shipment weight) (Network for transport measures, 2016).

The total climate impact for transportation with and without shipment weight is 0,17926 tonnes CO_2 eq to transport 2 tonnes food.

The transports which needs refrigerating are route **2-5.**
The climate contribution from the refrigerator plant and refrigerants:
0,02125 g CO_2 eq/transported kg and hour running of the plant (Nilsson & Lindberg, 2011).
The total transported shipment weight between the actors needing refrigeration is: 2 tonnes.
The total time that the shipment is transported during the first year is:
(32 min+19 min+21 min+10 min*2 times/year) = 420 min = 7 hours.
The total climate contribution from the refrigerator plant:
0,02125*2 000 kg*7 hours = 296,8 g CO_2 eq = 0,0002968 tonnes CO_2 eq/year.

The total climate impact from transportation: **0,1795575 tonnes CO_2 eq/year ~ 0,18 tonnes CO_2 eq/year**

Food production
The climate impact of letting 2 tonnes produced food end up at waste treatment instead of being eaten is 1,6 tonnes CO_2 eq/tonnes food waste*2 tonnes food waste = 3,2 tonnes CO_2 equivalents (Scholz, 2013). In scenario 1 this climate contribution is 3,2 tonnes CO_2 equivalents since the food is transported to waste treatment but in scenario 2 this impact can be saved since the food is redistributed and fulfilling the purpose of the production.

Scenario 2: **- 3,2 tonnes CO_2 eq**

Personnel costs: 1 372 025 SEK (from previous calculations)
Warehouse costs: 1 120 000 SEK (from previous calculations)
Warehousing: 7 tonnes CO_2 eq (from previous calculations)

Results
Costs 100 % filling degree: approx. 2 493 574 SEK/10 tonnes food waste
Costs 20 % filling degree: 2 492 976 SEK/2 tonnes food waste

Costs 100 % filling degree per tonnes food waste: approx. 250 000 SEK
Costs 20 % filling degree per tonnes food waste: approx. 1 250 000 SEK

Climate contribution 100 % filling degree: approx. - 8,2 tonnes/10 tonnes food waste
Climate contribution 20 % filling degree: approx. 4 tonnes/2 tonnes food waste

Climate contribution 100 % filling degree per tonnes food waste: approx. – 0,8 tonnes
Climate contribution 100 % filling degree per tonnes food waste: approx. 2 tonnes

Food types

Food bank

These calculations have been based on those described for the food bank. The calculations accounted for in this section are those which have been updated with new data, remaining calculations for the food bank are the same as before. These calculations are personnel costs, warehouse costs and climate impact from the warehousing.

Costs

See table III for the routes calculated for. These are only calculated for 1 tonnes of transported food waste.
Route 1 and 6. Transportation route without shipment weight: 42,9+2,59 km = 45,49 km = 4,549 mile. 4,549 mile*0,79 liter/mile*12 SEK/liter = 43,12452 SEK.
Route 2 and 3. Transportation route with 1000 kg shipment weight: 42,9+13,4 km = 56,3 km. $1{,}05^{10}$*0,79 liter/mile = 1,2868 liter/mile. 5,63 mile*1,2868 liter/mile*12 SEK/liter = 86,93816 SEK.
Route 4. Transportation route with 200 kg shipment weight: 18,6 km. $1{,}05^{2}$*0,79 liter/mile = 0,870975 liter/mile. 1,86 mile*0,870975 liter/mile*12 SEK/liter = 19,44 SEK.
Route 5. Transportation route with 100 kg shipment weight: 5,4 km. $1{,}05^{1}$*0,79 liter/mile = 0,8295 liter/mile. 0,54 mile*0,8295 liter/mile*12 SEK liter = 5,37516 SEK.

Total costs transporting 1 tonnes food: **154,877696 SEK ~ 155 SEK.** This cost does not differ depending on the food type and is the same for meat and bread/vegetables.

Personnel costs: 1 372 025 SEK (from previous calculations)
Warehouse costs: 1 120 000 SEK (from previous calculations)

Climate impacts

For the routes without shipment weight the climate impacts are calculated using the tool Miljöfordon (Miljöfordon, 2016). The total distance for route number 1 and 6 is (42,9+2,59 = 45,49 km) 4,549 mile. This gives a total fuel consumption of (4,549 mile*0,79 liter/mile = 3,59 liter). The fuel consumption is inserted in the fuel calculation and gives emissions of 0,01 tonnes CO_2 eq (Miljöfordon, 2016).

The climate impacts for the routes with shipment weight are calculated using NTM Calc. This is calculated separate for route 2, 3, 4 and 5 (see table III) and gives emissions of 34,77 kg, 30,72 kg, 3,015 kg and 0,4377 kg CO_2 eq. In total it generates emissions of approx. 68,9427 kg CO_2 eq = 0,0689427 tonnes CO_2 eq for driving these routes. (The specifications used in the tool were vehicle type van, diesel consumption of 0,85 liter/mile, the distance and shipment weight) (Network for transport measures, 2016).

The total climate impact for transportation with and without shipment weight is 0,0789427 tonnes CO_2 eq. This is the climate contribution regardless of what food type that is transported, and is same for meat and bread/vegetables.

The transports which needs refrigerating are **route 2-5.**
The climate contribution from the refrigerator plant and refrigerants:
0,02125 g CO_2 eq/transported kg and hour running of the plant (Nilsson & Lindberg, 2011).
The total transported shipment weight between the actors needing refrigeration is: 1 tonnes.
The total time that the shipment is transported during the first year is:
(32 min+19 min+21 min+10 min*1 times/year) = 82 min = 1,3667 hours.
The total climate contribution from the refrigerator plant:
0,02125*1 000 kg*1,3667 hours = 29,942 g CO_2 eq = 0,00029042 tonnes CO_2 eq/year. This contribution is negligible in this case.
The total climate impact from transportation: **0,07897 tonnes CO_2 eq/year ~ 0,08 tonnes CO_2 eq/year.** This contribution is the same for transporting meat and bread/vegetables since it is the same distance and shipment weight.

Warehousing: 7 tonnes CO_2 eq (from previous calculations)

Food production of meat

The climate impact of letting 1 tonnes produced meat products end up at waste treatment instead of being eaten is 16 kg CO_2 eq/kg product*1000 kg = 16 tonnes CO_2 equivalents (Scholz, 2013). In scenario 1 this climate contribution is 16 tonnes CO_2 equivalents since the food is transported to waste treatment but in scenario 2 this impact can be saved since the food is redistributed and resources are not wasted.

Scenario 2: **- 16 tonnes CO_2 eq**

Food production of bread/vegetables

The climate impact of letting 1 tonnes produced bread/vegetables end up at waste treatment instead of being eaten is 0,74 kg CO_2 eq/kg product*1000 kg = 0,74 tonnes CO_2 equivalents (Scholz, 2013). In scenario 1 this climate contribution is 0,74 tonnes CO_2 equivalents since the food is transported to waste treatment but in scenario 2 this impact can be saved since the food is redistributed and fulfilling the purpose of the production.

Scenario 2: **- 0,74 tonnes CO_2 eq**

Results

Food bank

Costs

Redistribution of 1 tonnes meat products: 2 492 180 SEK
Redistribution of 1 tonnes bread/vegetables: 2 492 180 SEK

Differens: 0 SEK.

Climate impacts
Redistribution of 1 tonnes meat products: - 8,92 tonnes CO_2 eq ~ -8,9 tonnes CO_2 eq
Redistribution of 1 tonnes bread/vegetables: - 0,58 tonnes CO_2 eq ~ -0,6 tonnes CO_2 eq

Differens: -8,34 tonnes CO_2 eq ~ -8,3 tonnes CO_2 eq are saved by redistributing 1 tonnes meat products compared to 1 tonnes of bread/vegetables.

Social organizations

Meat products: 80,4 SEK/kg product
Bread/vegetables: 16,25 SEK/kg product
(Jordbruksverket, 2011)

Purchase 1 tonnes meat products: 80,4 SEK/kg*1000 kg = 84 000 SEK
Purchase 1 tonnes bread/vegetables: 16,25 SEK/kg*1000 kg = 16 250 SEK

Appendix III

This section is listing the locations of the actors involved in the redistribution system and also the transportation routes and distances that are relevant for this study.

Locations of different actors

Food bank – Årsta
Convictus – Skebokvarnsvägen 341, Högdalen
Ny Gemenskap – Västberga Gårdsväg 30, Hägersten
Salvation Army's internal food bank – Hjorthagen
Martin & Servera – Grosshandlarvägen 7, Årsta
Coop Extra Stuvsta – Ågestavägen 1, Huddinge
Ica Baronen – Odengatan 40, Stockholm
Ragnsell pretreatment plant – Högbytorp, Bro
Syvab biogas plant – Himmerfjärdsverket, Grödinge

(Lunde Dinesen, 2016; Gerdin, 2016; Åslund, 2016; Malmqvist, 2016; Hitta.se, 2016)

Transportation routes

These are the routes assumed being driven by the central food bank to collect and deliver functional food waste between central warehouse 1 and the social organizations. These routes can also be visualized in figure 11 and table I in appendix II. It also shows the distance between central warehouse 1 and the waste disposal plant which the food waste is transported in scenario 1 and the distance social organizations must drive to either collect donations or purchase food.

Food bank – Central warehouse 1 = 42,9 km (32 min)
Central warehouse 1 – Food bank = 42,9 km (32 min)
Food bank – Salvation Army internal food bank = 13,4 km (19 min)
Salvation Army's internal food bank – Convictus = 18,6 km (21 min)
Convictus – Ny Gemenskap = 5,4 km (10 min)
Ny Gemenskap – Food bank = 2,59 km (7 min)

Central warehouse 1 – Waste management = 10,1 km + 73 km

Convictus – Transport for food donations = 3 km
Ny gemenskap – Transport for food donations = 9,5 km
Frälsningsarmén – Food purchase = approx. 10 km

(Hitta.se, 2016)

Transportation routes for the Salvation Army to purchase food

These are the 8 addresses for Salvation Army's organizations which handles food and make food purchases at Martin & Servera. All these 8 organizations located at these addresses are purchasing food at Martin & Servera and this list below shows the transportation distance for every organization.

Sundbyberg – Martin & Servera = 10,8 km
Östermalm – Martin & Servera = 8,86 km
Wättinge Gårdsväg 1 – Martin & Servera = 15,8 km
Grev turegatan 66 – Martin & Servera = 9,46 km
Midsommarslingan 1 – Martin & Servera = 1,75 km
Långholmsgatan 32 – Martin & Servera = 3,37 km
Hjorthagen – Martin & Servera = 12,7 km
Sibeliusgången 6 – Martin & Servera = 19,7 km

Mean value = approx. 10 km

(Hitta.se, 2016)