Master's Thesis

Food waste redistribution in Europe

A study on policy frameworks, and the socioeconomic and climate impacts of European Food Banks

Santeri Juho Kalle Lehtonen

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at

University of Natural Resources and Life Sciences, Vienna (BOKU)
Department of Water, Atmosphere and Environment (WAU)
Institute of Waste Management (ABF-BOKU)

&

University of Copenhagen (UCPH)
Department of Plant and Environmental Sciences

Supervisor: Stefan Petrus Salhofer, Ao.Univ.Prof. Dipl.-Ing. Dr.nat.techn. (ABF BOKU)
Co-Supervisor: Gudrun Obersteiner, Dipl.-Ing. (ABF BOKU)
Co-Supervisor: Christian Bugge Henriksen Associate Professor (UCPH)

Abstract

The issue of **Food Loss and Waste** (FLW) is currently deliberated on high **academic** and **political** levels. This pertains both to its large contribution to man-made **climate change**, and its moral dimensions regarding **food security** and **socioeconomics** at large. In the EU 88 million tonnes of FLW is generated annually, costing 143 billion € and emitting 170 million tCO_2eq... **Food redistribution** can significantly cut FLW, for example through **Food Banks** (FB). FBs redistribute surplus food from the food supply chain through charity organisations to those in need. In the EU Circular Economy Package FBs are defined as '**prevention**' and are considered a **Best Practise** in tackling FLW. Despite this, many legislative and economic hurdles **constrict** the functioning and capacity of FBs.

Concentrating on five '**Case Study Organisations**' (CSOs) in five EU countries (AT, DK, FI, HU & PL), this Thesis work describes the **policy frameworks**, their constraints, and suggests Best Practises. Furthermore, the **socioeconomic** and **climate impacts** of the CSOs are analysed. It is found that in 2017 the five CSOs saved over **195,000** tonnes of **carbon** emissions combined: 27 tonnes of CO_2eq. for each tonne their operations emit. A high **Return-On-Investment** of 10 € for every 1 € invested was found, with the combined economic saving of over **90 million €**, even without considering the **social cost of carbon** and significant **social capital** incurred by providing crucial social services.

Through increased **investment** in Food Banks, the EU and national governments can not only reduce FLW, but cost-effectively mitigate the **socioeconomic** and **climate struggles** yet a reality in Europe.

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[1] Institute of Waste Management / Institut für Abfallwirtschaft (ABF-BOKU)
[2] Department of Plant and Environmental Sciences, University of Copenhagen
[3] Institute of Waste Management / Institut für Abfallwirtschaft (ABF-BOKU)

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BAU	-	Business As Usual
CAP	-	Common Agricultural Policy
CF	-	Climate Footprint
CO	-	Charity Organisation
CSO	-	Case Study Organisation
DG	-	Directorate General
DO	-	Donor Organisation
EC	-	European Commission
EEA	-	European Environment Agency
EF	-	Emission Factor
EPR	-	Extended Producer Responsibility
EU	-	European Union
FAO	-	Food and Agriculture Organisation of the United Nations
FB	-	Food Bank
FEAD	-	Fund for European Aid to the Most Deprived
FEBA	-	European Food Banks Federation
FLW	-	Food Loss and Waste
FPFB	-	Federation of Polish Food Banks
FS	-	Food Surplus
FSC	-	Food Supply Chain
FSN	-	Food Security and Nutrition
GFL	-	General Food Law
GWP	-	Global Warming Potential
ICT	-	Information and Communications Technology
IPCC	-	Intergovernmental Panel on Climate Change
LCA	-	Life-Cycle Assessment
LCI	-	Life-Cycle Inventory
NWMP	-	National Waste Management Plan

PAYT	-	Pay-As-You-Throw
RO	-	Redistributive Organisation
SDG	-	Sustainable Development Goals
UN	-	United Nations
UNFCCC	-	United Nations Framework Convention on Climate Change
VA	-	Voluntary Agreement
VAT	-	Value Added Tax

1. Introduction

In recent years, Food Loss and Waste (FLW) has become an increasingly conspicuous topic. This is might pertain either to its large contribution to man-made climate change, its noncompliance with the popular principles of the circular economy & resource efficiency, its moral dimensions regarding food security or all of the above. As coined by the University of California's 'Climate Lab' in 2017, FLW has been often been described as:

"the World's dumbest problem"

This definition is apt, as FLW means discarding goods that could yet be further utilised by *inter alia* industry and agriculture, and goods that would be gravely needed by sections of society for sustenance and nutrition. Furthermore, discarding these goods comes often with a higher price than its circular options. For these reasons many large organisations, international bodies and national governments have taken the issue under scrutiny. FLW emerges as a focal issue in many United Nations and European Union roadmaps and is often at the forefront of global conversations about sustainability. The growing acknowledgement of the magnitude of the problem - and yet the concurrent capacity for change - has inspired many initiatives, targets and strategies. On the highest international level, the United Nations 2015 Sustainable Developments Goals (SDGs) address the issue of FLW through Target 12.3. of the SDG 12: "Responsible Consumption and Production":

"12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses"
- United Nations, 2015

However, despite the growing attention, concern and research (figure 1), the total global amount of FLW grows every year [4]. The absolute amount of FLW is estimated as 1.3 billion tonnes globally per year, or one third of all food produced for human consumption (Gustavsson *et al.,* 2011). The developed world is significantly more wasteful than the developing one, although due to better technology and infrastructure, post-harvest losses are smaller in developed countries. This is indicative of the fact that the majority of waste in developed countries occurs in the retail, food service and household consumption, while the food losses in the developing world occur upstream (Vittuari *et al.,* 2016).

[4] Tracking FLW quantities through time is a surprisingly under-researched area, largely due to the lack of monitoring and hence historical data. Claim here based on modeling by Hall *et al.* (2009) in the US, and the EEA (2007) projection for municipal waste generation in the OECD. According to Eurostat in the 2000s FLW (as Animal and vegetal wastes; subtotal, W091+W092+W093) is in overall decrease in the EU (Eurostat, 2018a).

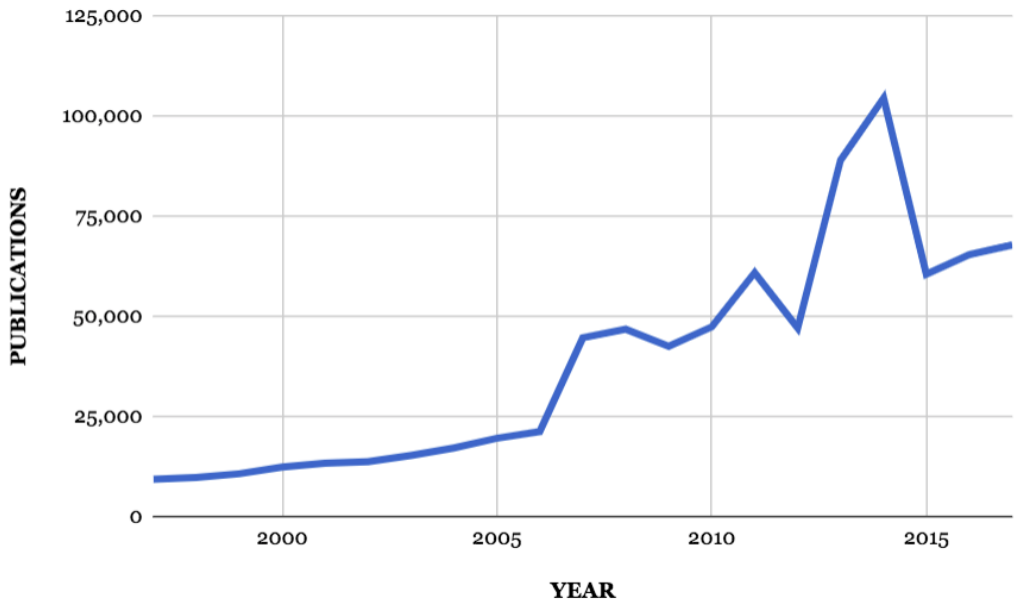

Figure 1. Academic attention of food waste since 1987. Number of publications with the keyword '*food waste'* from three decades: 1987 to 2017. Graph constructed by author; data from a tracking platform: dimensions.ai (2018).

Several interrelated factors drive the generation of FLW, inter alia, supply chain inefficiency, consumer preferences, unpredictable markets & food prices and inept legislation. As previously mentioned, regional and country differences of drivers are vast, as are the impacts. The negative economic impact of FLW is estimated globally as USD 1 trillion (FAO, 2016) and as 143 billion € in the EU alone (Stenmarck *et al.,* 2016).

Beyond the direct economic costs, the environmental impacts and costs of FLW have also been increasingly highlighted in recent years. Those trying to raise awareness on the issue are often found quoting the now famous statistic from the Food and Agriculture Organisation of the UN (FAO, 2013):

"If food waste were a country, it would be the third largest emitter of GreenHouse Gases in the World."

Food produced for human consumption, but ultimately lost or wasted, generates ~ 8 % of the global GHG emissions annually, but also installs unnecessary burden on finite natural resources, water, land and the environment (FAO, 2015; European Commission [EC], 2017).

While food waste puts strain on the economy and the environment, close to one-tenth of the population of the EU, 42.5 million people, are not able to afford a quality meal every second

day (EC, 2017). Given the fact that Food Surplus - the section of FLW that could be made effectively available for human consumption - could ensure Food Security and Nutrition (FSN) to all citizens in all EU Member States (EC, 2017), the question remains: what can be done close this gap between 'supply' and demand?

The **redistribution of surplus food** has a long history in the EU, and an immense diversity of charity initiatives exists to help those less fortunate (Schneider, 2013). In the Waste Hierarchy of the EU [5], redistribution of FLW for human consumption ranks high; as the 'second-best' option just behind preventing FLW generation at the source first-hand (figure 2). The hierarchy concept recognises that redistribution methods are able to capture a large proportion of the original calorific, nutritional, and economic value of the waste (O'Connor *et al.,* 2014). One of the most widespread and standardised concepts of food redistribution are the **Food Banks (FB**). Principally, Food Banks facilitate the logistics between donors (e.g. supermarkets, farmers, wholesalers) and charities who prepare the meal for the end-users (EC, 2017). A large number of European FBs are members of the European Food Banks Federation (FEBA), who provides information sharing, resources and funding for its members. The added value of Food Security and Nutrition (FSN) and the social capital incurred through projects surrounding food banks further increases their preferability (Schneider, 2013; Riches & Silvasti, 2014). Despite the evidence of social, economic and environmental benefits of food redistribution, food redistribution is commonly underfunded and under-utilised (Vittuari *et al.,* 2016; EC, 2017). A testament of this is the fact that even though in the year 2017 FEBA members distributed an extraordinary 501,000 tonnes of food to 6.6 million people in the EU (FEBA, 2017), this only represents a fraction of the European Food Surplus (~1%) and materially deprived people (~10%) respectively [6].

[5] EU Waste Framework Directive 2008/98/EC (EU, 2008) - currently under review of the European Parliament and Council (2018) to be included in the Circular Economy Package

[6] EU FLW 88 million tonnes (Stenmarck *et al.,* 2016), assumed 84% edible (Corrado & Sala, 2018) and 80% avoidable and rescuable fraction for Food Surplus and 12.6% of 506.9 million Europeans materially deprived in 2014 (Eurostat, 2018b).

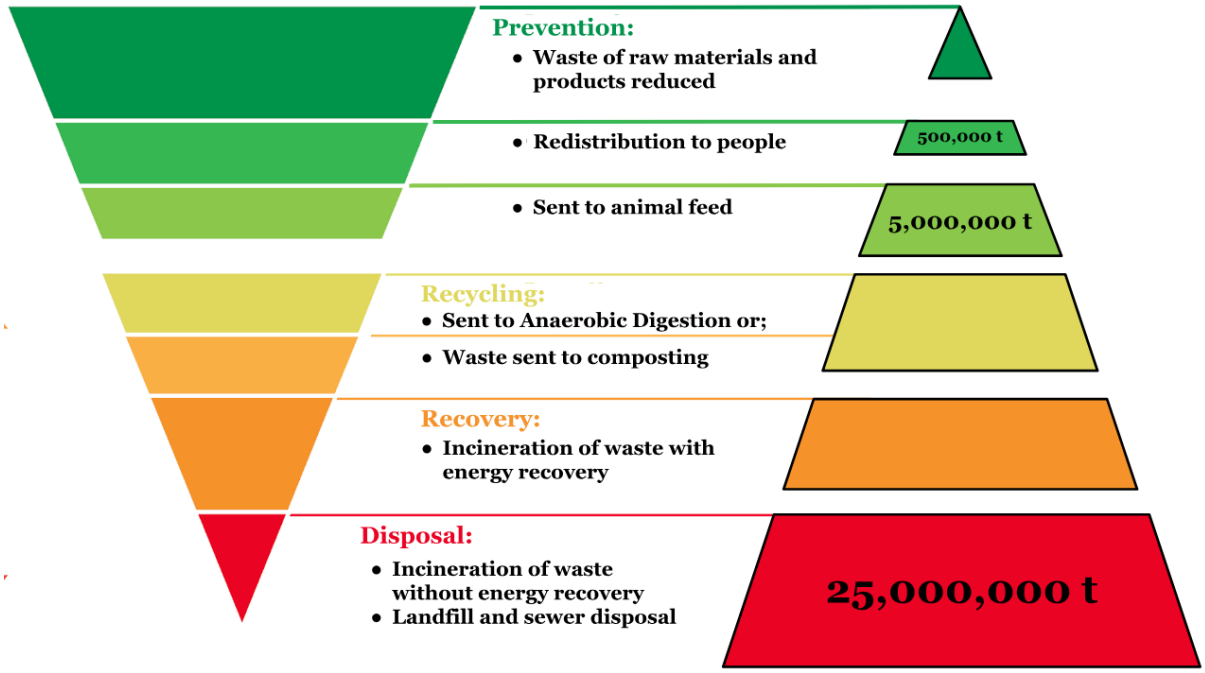

Figure 2. The EU Food Waste Hierarchy. The desired [left] versus reality [right] view. Original 'desired' figure modified from WRAP UK, 2013; idea from Cseh (2018); data for 'reality' food waste treatment from: Stenmarck et al., 2016; FEBA, 2017; Eurostat, 2018a. Disposal: total EU-28 food waste generation adjusted to edible fraction only with household fraction excluded.

1.1. Aims and objectives

The **aim** of this Thesis work is to investigate the socioeconomic and climate impacts of Food Banks as they operate in variable policy frameworks, using five Case Study Organisations (CSOs) as example and proxy.

The **objectives** of this Thesis work are, concentrating on five Target Countries and their central Food Banks or 'CSOs':

- Describe the policy frameworks European food redistribution operates in, and how the capacities of the Food Banks are constrained and enabled by them;
- Describe the current and potential positive impacts of Food Banks on society through the social, economic and environmental dimensions.

1.2. Research Questions

RQ1: How are the capacities of Food Banks constrained or enabled by current policy frameworks in the EU?

RQ2: What are the current and potential socioeconomic and climate impacts of Food Banks?

1.3. Literature Review

The following literature review will first briefly explain the status quo of European politics and policies addressing the issue of FLW and food redistribution as a solution. Secondly, the impact of FLW on socioeconomics, the environment and the climate is explored with reference to how food redistribution can solve some of these challenges.

1.3.1 European status quo

The EU Action Plan for the Circular Economy of 2015 states that in the light of UN's Sustainable Development Goal 12, the development of a common EU methodology to measure food waste, and the development of relevant indicators are needed (European Commission, 2015). However, the recent European Commission Communication *"monitoring framework for the circular economy"*, addressing the 2018 Circular Economy Package, notes that specific Food Waste and Loss the indicators are yet *"under development"* (European Commission, 2018a). This underlines the challenge for Member States, who are required to transpose the new Circular Economy targets into national law by 5th of July 2020, including measures based in the Food Waste Hierarchy (figure 2) achieving at minimum a 30% reduction in FLW. The Package, once in force, will amend many directives on waste including the Waste Framework Directive (WFD) (EPRS[7], 2018). For now however the WFD is the main guiding document for Member States to develop the tremendously multi-complex task of monitoring the amount of FLW generated at all levels of the Food Supply Chain. The most recent revision of the WFD calls for the Member States to establish multi-sectoral monitoring systems for the quantities of FLW, based on a catalogue of methodologies described by the FUSIONS (Food Use for Social Innovation by Optimising Waste Prevention Strategies) 'Food Waste Quantification Manual' (Tostvint *et al.,* 2016).

The spearhead of the current EU efforts to share knowledge, define measures and monitor progress in the field of FLW prevention is the 'EU Platform on Food Losses and Food Waste'. The Platform is currently 37 members strong, comprising of NGOs; trade and business associations; academia, research institutes and think tanks; social enterprise and cities. EU Member States, EU Committee of Regions (CoR), European Economic and Social Committee (EESC), Food and Agriculture Organisation (FAO), Organisation for Economic Co-operation and Development (OECD) and the United Nations Environment Programme (UNEP) are always invited for the meetings and conferences of the Panel (DG SANTE, 2018). Following the October 2017 symposium of the Platform, a sub-group of experts was

[7] European Parliamentary Research Service

deployed to study food redistribution as a particularly impactful area of FLW prevention (DG SANTE, 2018). The sub-group consists of 14 Member States and 11 private and public sector organisations (e.g. EuroCommerce, European Federation of Food Banks (FEBA), FoodDrinkEurope (FDE) and FoodServiceEurope). The main objectives of the group are to continuously review and update the 'EU guidelines on food donation' (2017/C 361/01), information sharing between the participants, and development of the 'Pilot Project' [8] (DG SANTE, 2017a).

The 'EU guidelines on food donation' (2017) serve as the primary information and instruction on the many different pieces of legislation with relevance food donation and redistribution; for Donor Organisations (DOs), Food Banks, other Redistribution Organisations (ROs) and Charity Organisations (COs) in all Member States. Table 1 below summarises the legal provisions of the European Union with relevance for food donation.

Table 1. Summary table of EU legal provisions with relevance to ROs [and DOs & COs] (modified from: Annex 1 of the 'EU guidelines on food donation', 2017 and Lexology, 2018. Specific text from regulations, directives and communications detailed under column 'Relevance')

Legislation name and number	**Relevance**
General Food Law Regulation (EC) No 178/2002	ROs are classified as 'food business operators' placing food on the market and have to thusly satisfy all requirements of the General Food Law. ROs must therefore comply with Articles concerning food safety, food hygiene, traceability, cold chain monitoring and reporting, proper date labelling, and food information for consumers. In the case of a food safety issue, e.g. food poisoning, the primary responsibility will be determined by public health authority and liability based on cause of problem and the operation or activity.
Food Hygiene Package Regulation (EC) No 852/2004 Regulation (EC) No 853/2004	ROs need to ensure food safety and the integrity of the cold chain through all activities. Special attention should be paid to freezing temperatures. All practises and procedures should adhere to the principles of HACCP (Hazard Analysis and Critical Control Points).

[8] SANTE/2017/E1/051; the pilot project aims to collect information from the EU Member States on regulatory, policy and operational frameworks relevant for food redistribution (DG SANTE, 2017b)

Food labelling and durability Regulation (EU) No 1169/2011	As food business operators ROs are required to indicate a 'best before' or a 'use by' date. Redistribution beyond 'best before' dates is allowed, although some Member States restrict or prohibit this. Products over the 'use by' date are considered unsafe and thus prohibited. Food information to consumers by ROs is required to match the level found in-store: *"name of the food, ...list of ingredients, the date of minimum durability (i.e. 'best before' or... 'use by')...; any special storage conditions and/or conditions of use; and a nutrition declaration"*. Special labelling required for food of animal origin. In instances where food is donated to RO due to mislabelling or similar erros, additional clarification must be included to ensure complete food information to end-beneficiary. Food information is required to *"appear in a language easily understood by the consumers of the Member States where a food is marketed"*.
VAT rules Directive 2006/112/EC	Value Added Tax (VAT) has to be paid for donated food if *"VAT paid by donor upon purchase has been deducted."* The amount taxable is the purchase price at the time of donation adjusted to condition of product. In case of surplus food this value is to be *"fairly low, even close to zero"* where food has almost no value. Although VAT is commonly perceived as being one of the major obstacles for food redistribution, most Member States facilitate food donation with VAT exceptions or other fiscal incentives as per to the recommendation of the EU VAT Committee and the European Commission.
Official Controls Regulation (EU) 2017/625; (effective from 14th December 2019 replacing inter alia Regulation (EC) No 854/2004 & Regulation (EC) No 882/2004)	Official Controls endow the Commission and national authorities with powers to ensure effective enforcement of regulations concerning: *"food and feed law, rules on animal health and welfare, plant health and plant protection products."* Additionally, the Official Controls Regulation (OCR) gives the Commission audit and control powers in Member States and Third countries to take action at EU level.
Waste Framework Directive (WFD) Directive 2008/98/EC Amended by:	Determines food donation for human consumption high in the Waste Hierarchy; as 'waste prevention'. Calls on Member States to prevent Food Loss and Waste at all stages of supply chain. Requires Member States to create sustainable waste

Directive (EU) 2018/851	management, improve resource use efficiency, and value waste as a resource. Frames minimum requirements for Extended Producer Responsibility. Incentives for waste hierarchy and pay-as-you-throw schemes.
Information society services Directive 2000/31/EC	Ensures free movement of information between Member States, contributing to functioning of the EU internal market and transborder food donation.
Common organisation of the markets in agricultural products Regulation (EU) No 1308/2013	Art. 34(4) on Charity withdrawals. Withdrawn fruits and vegetables are determined as an organised form of donation and are 'free' for end-beneficiaries. 'Charity withdrawals' have a higher priority and support than other destinations.
Common organisation of the markets in fishery and aquaculture products Regulation (EU) No 1379/2013	Art. 34(2) in compliance with common marketing standards. Contrasting with the above, fishery products not complying with common marketing standards are not to be provided for direct human consumption.
Fund for European Aid to the Most Deprived (FEAD) Regulation (EU) No 223/2014	FEAD programmes may oversee financing of donations, when food is donated to a partner organisation free of charge. The cost for the collection, transport, storage and redistribution of donated food may be covered by FEAD funds. FEAD may also support awareness-raising activities for potential food donors.

The legal frameworks in the target countries that the Case Study partner Organisations (CSOs) operate in, are found in a greater detail in the Methodology section under 'Target Countries and Case Study Organisations'.

Current literature, especially when addressing social innovation and the sustainable transformation of food systems, lists food donation and redistribution as a key tool in fighting the issue of Food Loss and Waste (Schneider, 2013; Caraher & Cavicchi, 2014; Scherhaufer *et al.,* 2015; Vittuari *et al.,* 2016; Hebinck *et al*., 2018). Although food redistribution [9] serves as an essential aid for those most in need and as a significant lever to reduce FLW; the EU and national laws, regulations and data collection methodologies are non-standardised or interpreted in various ways (Vittuari *et al.,* 2016). Despite the new 'EU guidelines on food

[9] Often also referred to as 'food aid' or 'food assistance'

donation' (European Commission [EC], 2017) and the support of FEBA (European Food Banks Federation), large gaps in knowledge, its dissemination and implementation remain.

The following two chapters consist of information collated from literature on the impacts of Food Loss and Waste on socioeconomics, the environment and the climate. Furthermore, the chapters explore the effectiveness of food redistribution as a solution to mitigate those impacts.

1.3.2. Socioeconomics

As previously outlined, Food Loss and Waste represents a tremendous economic loss, amounting to 143 billion euros annually in the EU alone (Stenmarck *et al.,* 2016). FLW incurs further costs at every step of the Food Supply Chain (FSC), including the value of the hundreds of thousands of wasted man-hours. Improving the efficiency and fairness within the FSC has the potential of mitigating the negative impacts on the food producers, but also end-consumers by reduced costs and increased access (FAO, 2015). The direct waste management of FLW is also costly for municipalities, and the companies, especially where landfilling is the only option and gate fees very high. The total global economic cost of FLW is estimated as 2.6 trillion USD with 1 trillion direct economic cost, 700 billion in social cost and 900 billion in environmental costs (IAI, 2017).

Food redistribution saves significant investment in food purchases for the charities that serve the materially deprived (ØUG, 2016). Moreover, engaging in food donation can be directly beneficial for the donor company or organisation. In most cases donating food is cheaper than the waste management costs. Furthermore, although fiscal incentives for donation are still few in Europe, a move towards VAT deductions and other tax credits has been observed e.g. in Portugal, with spreading interest (Vittuari *et al.,* 2016). The increasing adoption of the principles of Corporate Social Responsibility (CSR) and Extended Producer Responsibility (EPR) has followed the recognition of the reputation of the donor, customer fidelity and increased profits (Giuseppe *et al.,* 2014).

The concepts of CSR and EPR become increasingly relevant when discussing the moral dimension of FLW, and the fact that while edible food is discarded by truck-loads, many Europeans are experiencing chronic hunger. Although the large majority of people in the EU are considered food secure, meaning that *"people have sufficient money to purchase the food they want to eat, to meet social as well as health and nutritional norms"* (Dowler & O'Connor, 2012), many socio-economic groups, including the 'new poor' of the 2008

economic crisis and immigrants, find themselves in poverty, which regularly manifests as unhealthy and nutrient-poor diets (Heibnick *et al.,* 2018). As it stands, complete Food Security and Nutrition (FSN) is not a given and food assistance is necessary in many sections of European societies. As seen in Figure 3, the share of people facing severe material deprivation in Hungary and Poland has decreased dramatically towards the mid 2010s but still remain high at 14.5% and 6.7% respectively. In Austria, Finland and Denmark this figure has oscillated around 3 percent of the population in the past years. The indicator measures: *"the share of severely materially deprived persons who have living conditions severely constrained by a lack of resources."* - who are experiencing a minimum of 4 out of 9 deprivations items; related to *"economic strain, durables, housing and environment of the dwelling"* (Eurostat, 2018b). This describes a situation where there are significant sections of European societies who cannot afford basic necessities on the state's social welfare alone. Food assistance in all of its forms, including Food Banks, has become integral and expected in modern societies to alleviate these symptoms (Heibnick *et al.,* 2018).

Without raising the debate of whether the institutionalisation of food assistance is an extension or a failure of welfare states, it is clear that there are tremendous positive socioeconomic impacts resulting from food redistribution (Schneider, 2013; Heibnick *et al.,* 2018). Besides the immediate benefits of bettering European FSN, food assistance takes off pressure from other expenditures and increases the purchasing power of the users, while the social engagement, volunteering and job opportunities increase the sense of self-worth, meaning and social cohesion. Additionally, in the example of Austria, Schneider (2013) describes several uses for monetary savings; from joining seniors' clubs to attending sports and cultural activities. Nevertheless, the money saved due to food assistance is still overwhelmingly spent on rent and running costs and is essentially preventing homelessness. The increased social capital around food assistance projects reflects linearly to economic capital and the wellbeing of society through covering basic needs, increasing of purchasing power, bettering household management (Vittuari *et al.,* 2017) and saving costs in healthcare, education and social services (Perryman, 2014; De Pieri, 2017). Scherhaufer *et al.,* (2015) add that food banks naturally better food security / food safety, but also critically increase trust, groups and networks; collective action and cooperation; information and communication; and social cohesion and inclusion. Furthermore, saving the carbon emitted by FLW in the absence of food redistribution embodies an economic saving in the form of social cost of carbon. With runaway climate change, the costs borne of increased risk of conflict, loss of livelihoods, health etc. could become insurmountable (FAO, 2014).

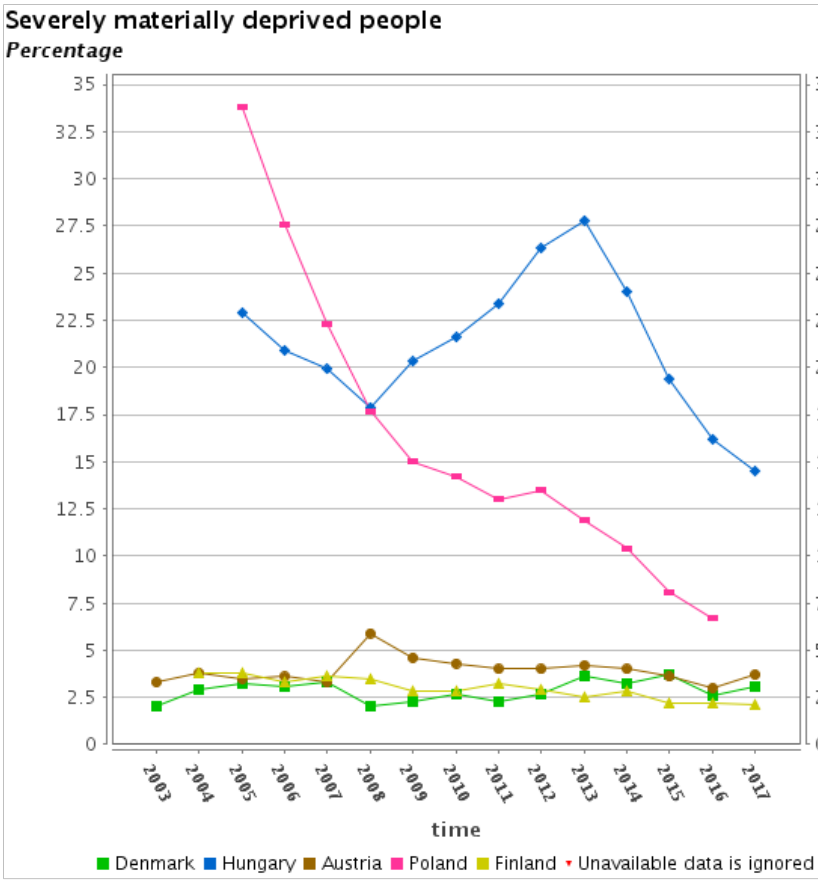

Figure 3. Percentage of severely materially deprived people in the EU. Vertical axis shows material deprivation rate indicator: percentage of population with an enforced lack of at least three out of nine material deprivation items in the 'economic strain and durables' dimension - Code: t2020_53. Disclaimer: This graph has been created automatically by Eurostat software according to external user specifications for which Eurostat is not responsible. Graphic included General Disclaimer of EC website: http://ec.europa.eu/geninfo/legal_notices_en.htm [Eurostat, 2018b].

1.3.3. Environment and Climate

The environmental footprint of FLW is significant. Therefore, reducing the amount of Food Loss and Waste could not only enhance Food Security and Nutrition, but environmental sustainability as well. FLW contributes to environmental damage and climate change in four major ways: 1) through decomposition of FLW in landfills; 2) embedded carbon from FSC activities; 3) natural resource depletion (e.g. land, water, nutrients); and 4) pollution potential (e.g. fertiliser use, waste disposal) (Papargyropoulou *et al.,* 2014; Aschemann-Witzel, 2016; Brancoli *et al.,* 2017).

Decomposition of food waste in the landfill produces methane and carbon dioxide, both very potent greenhouse gases in the short and in the long term. Other end-of-life methods for FLW

like: use as animal feed; anaerobic digestion; composting; or incineration, in a decreasing order of efficiency, can capture some of the original energetic value of the agri-products (Tonini *et al.,* 2018). These methods should always be prioritised over landfilling (figure 2). Importantly however in the case redistributing Food Surplus - the avoidable and edible fraction of FLW - to human consumption results in a net-zero climate footprint in comparison (Papargyropoulou *et al.,* 2014).

Embedded carbon refers to all of the CO_2eq. (including high Global Warming Potential [GWP] gases such as CH_4 and N_2O) emitted throughout the life-cycle of a food item (Porter *et al.* 2016a). This includes everything from production, distribution and packaging to fertiliser use. Here, depending on the length of the supply chain; energy mix and fuel used; level of processing, location and season; foods can have very different levels of embedded carbon per kilogram, kilocalorie, gram-protein etc., even within the same product category. Differences become extreme between product categories when comparing beef and lentils for example. This is also why sustainable diets play a significant role in the future of global food systems, and why the trend of global transition from cereals towards animal products, and especially the associated FLW is a reason for concern (Hiç *et al.*, 2016) (figure 4).

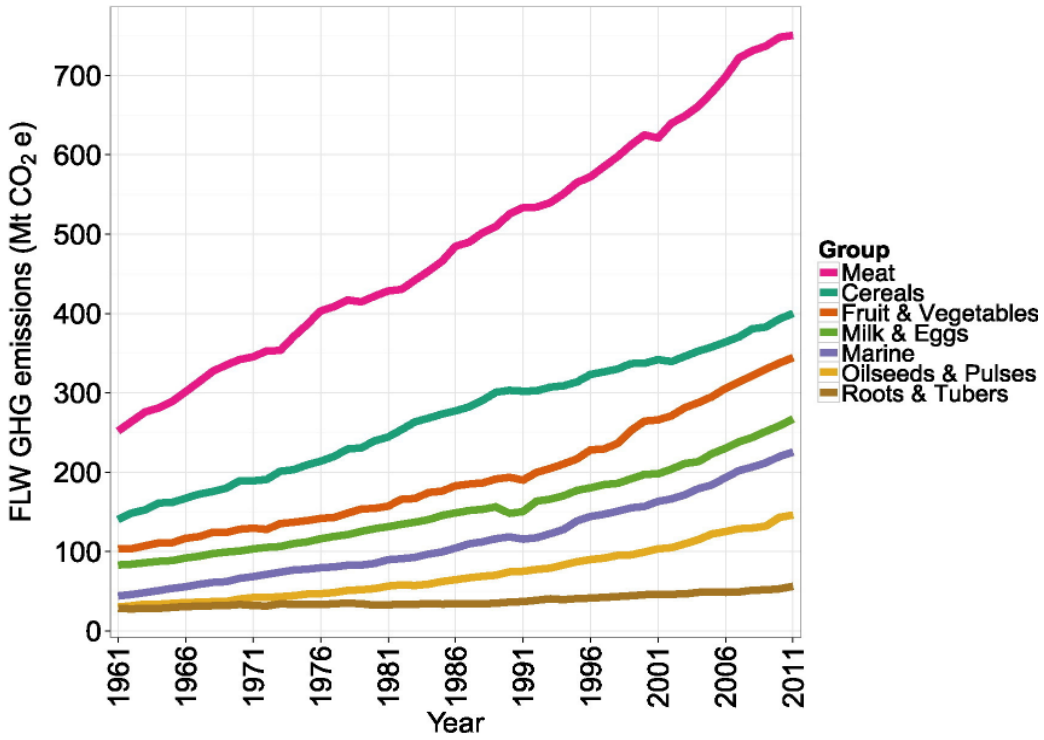

Figure 4. The trend in total annal emissions from FLW since 1961 by product group, as available from the FAO Food Balance Sheet database (modified from: Porter et al., 2016a). FLW GHG = Food Loss and Waste Greehouse Gas [Megatonnes of carbon dioxide equivalents].

Similarly to the concept of embedded carbon, any quantity food that is lost or wasted takes with it a large amount of natural resources that have been 'embedded' onto its ecological footprint. FLW accounts to the waste of up to 250 km^3 of water (the volume of Lake Geneva) and near 200 hectares of land (area size of Mexico) per year (FAO, 2013; Vilariño *et al.,* 2017). Furthermore, the use of nitrogen and phosphorus in fertilisers depletes these already scarce resources. Similarly, the common use of fossil fuels for fuel in agriculture and for electricity production for operations throughout the FSC, contributes not only to increased carbon pollution, but also to the depletion of the non-renewable resources of coal, oil and natural gas (Leach *et al.,* 2015; figure 5).

Finally, the use of fertilisers, pesticides, herbicides and other chemicals in agriculture lead to environmental pollution. Excess nitrogen and phosphorus disrupt the regular functioning of the biogenic cycles leading to e.g. eutrophication, while pesticides can cause significant harm to local biodiversity and even human health (Scherhaufer *et al.*, 2015). Generally, biodiversity is under grave threat from agricultural systems via deforestation, pollution and habitat fragmentation and degradation (Leach *et al.,* 2015). Leaching of wastewater from landfills overburdened with FLW can also be a cause of environmental pollution (Papargyropoulou *et al.,* 2014).

It is clear that all steps of the Food Supply Chain, especially agriculture, are always a burden on the climate and the environment. Thusly, preventing or redistributing FLW, decreasing demand, using resources more efficiently and prioritising redistribution to human consumption would significantly ease these negative effects. The current FSC, or in a broader sense: the 'European food system', is not designed to minimise its environmental and climate impacts. Food Banks can greatly contribute to the sustainable transformation of our prevalent food system (figure 5) towards a new sustainable food system paradigm (figure 6; see blue dotted lines). Furthermore, notwithstanding the many momentous challenges, Food Banks can facilitate the connection between elements of the food system and the social, political, economic and ecological systems to positively transform society (Hebinck *et al.*, 2018).

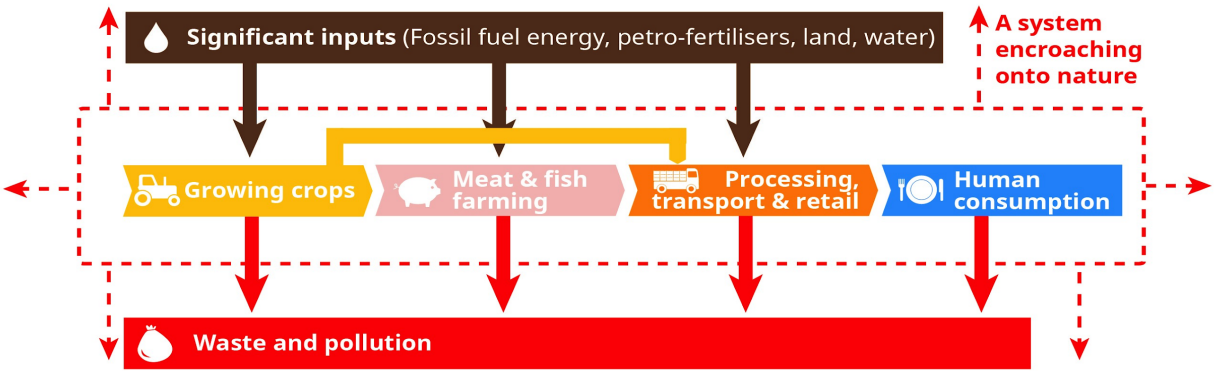

Figure 5. The linear flow model of the prevalent food system (modified from: FeedBack, 2018).

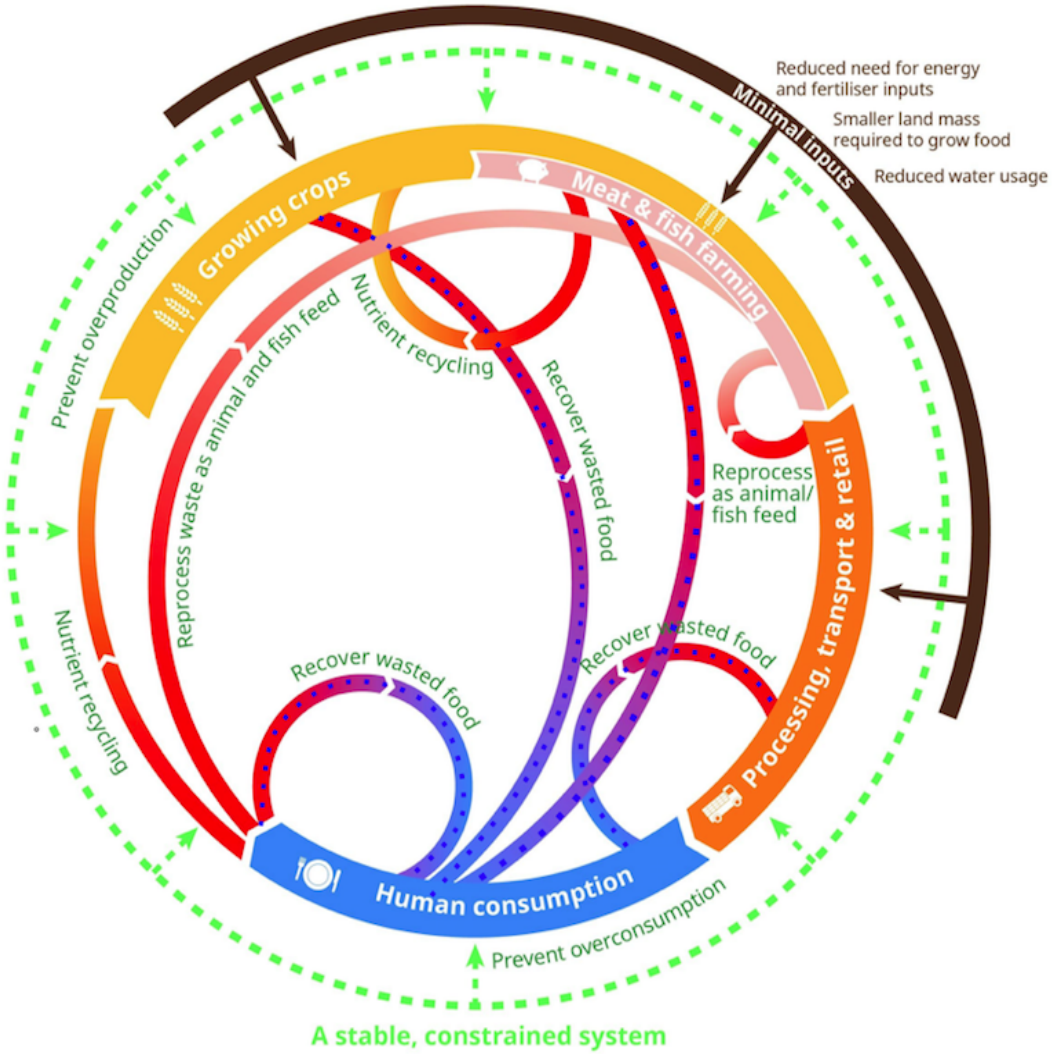

Figure 6. Holistic model of a low-input food system, complemented by food donation and redistribution, while increasing social and economic capital at points of intersection with society. Blue dotted lines added to mark flows which Food Banks can facilitate. Modified from: (FeedBack, 2018).

2. Methodology

2.1. Data acquisition

The qualitative and quantitative data needed to explore the research questions were gathered through diverse channels. Firstly, a liaison with the five Case Study Organisations (CSOs) was established to enable mutual sharing of information. These five organisations were selected by a mixture of personal and academic interest [10] and convenience sampling [11]. Quantitative data on the amounts and types of redistributed food, and the size of the CSOs' operations, were acquired by a standardised 'Global Analysis'- datasheet (Annex II), normally used by FEBA for internal reporting and monitoring. The emission factors to calculate the climate impacts of the CSO operations were acquired by a meta-analysis of relevant LCA and other literature.

Qualitative data on the legal framework, and socio-economic and cultural idiosyncrasies concerning FLW, and the redistribution of food surplus in each target country, were acquired by an extensive review of literature and interviews with the five partner organisations, the Federation of Finnish Food Aid Associations [12] and FEBA. The interviews also shed light into the day-to-day activities, concerns and opportunities of each CSO, and the future of food redistribution in Europe. The interviews were recorded and later transcribed, but not analysed by any theoretical framework, beyond screening the transcripts for novel information or confirmation of facts found in literature. Rather, the main intent of the interviews was to establish a good collaboration with the partner organisations and acquire direction for literature review and discussion. The interviews were ultimately used for a rudimentary review of the main themes arising from more than one of the discussions (for more information see: Interviews)

Some of the CSO members and staff were also made acquaintance with, for example, in private meetings and conferences, where more information was exchanged. A notable mention of such an event was the 'LIFE Food Waste Platform' meeting in Budapest in October 2018. The author met and consulted many experts on the most recent scientific and policy instances regarding FLW and food redistribution in Europe, including Vytenis

[10] The author's Master's degree is split between Austria and Denmark. Author is a citizen of Finland
[11] The BOKU Institute of Waste Management had pre-existing contacts with Poland and Hungary through common projects
[12] "Ruoka-apu yhdistysten liitto ry" = Federation of Finnish Food Aid Associations

Andriukaitis, the Commissioner of DG SANTÈ. The information gained in this meeting significantly directed the discussion and conclusions made in this Thesis work.

The next section summarises the data on the target country policies and measures with relevance to FLW prevention, reduction and redistribution, followed by a short profile of each of the case study partner organisations.

2.2. Target Countries and Case Study Organisations

Five case study organisations from five European target countries were selected to study the socioeconomic and climate impacts of ROs: Austria: 'Wiener Tafel'; Denmark: 'Fødevarebanken'; Finland: 'Yhteinen Pöytä'; Hungary: 'Élelmiszerbank Egyesület'; and Poland: 'Banki Żywności'. It is important to note that these organisations cannot be here referred with the blanket term 'Food Bank', but instead, the term 'Redistribution Organisation' or 'RO' is used. Yhteinen Pöytä does not self-identify with the term, and it is unclear whether it fits the FEBA definition of a Food Bank. Secondly, 'Banki Żywności' or 'Federacja Polskich Banków Żywności' is in fact a Federation of 31 autonomous Food Banks operating in Poland. Recognising these organisational differences - and the inherently dissimilar cultural and socio-economic context each partner organisation operates in - all CSOs are treated individually or as one, but not compared to each other per se. Inferences of best practises are drawn from the analyses, but any form of ranking or grading between the different organisations would be impractical and unrealistic.

Next, the status quo of FLW management and legislation in each target country is described, followed by a outline of the voluntary agreements and food redistribution activities with a focus on the Case Study Organisations.

2.2.1. Austria

Food loss and waste legislation

The new Status Report [13] of April 2018 (BMNT, 2018a) tells us that from the 1,436,700 tonnes of Austrian municipal waste, 16.5% is avoidable food waste. Austria recently updated its Federal Waste Management Plan (FWMP) for the year 2017, with the English translation of the Part 1 released as recently as December 2017 (BMNT, 2017). This and the previous management plans address Austrian food waste prevention as an Action Area, although a specific national plan addressing food waste does not exist (Schneider & Lebersorger, 2016).

[13] *Statusbericht* - presently only available in German

The FWMP recalls UN's 2030 Agenda for Sustainable Development and the halving of food waste by 2030. The Action Area 5.5.4. of the Plan "Prevention of Food Waste" specifies five 'Packages of measures': 1) Food production, processing and trade; 2) Welfare organisations; 3) Consumption away from home; 4) Private households; & 5) Principles. The packages describe 'measures', yet it is left unclear when, how and by whom these are implemented. The FWMP then describes the anticipated effects of the portfolio of packages, although again it is left open whether there will be resources and funding allocated to achieving these effects, or what will be the consequences whether they are not achieved. Below, a summary table of select measures and anticipated effects is given.

Table 2. A summary table of the packages of measures and their anticipated effects by 2030 as described by the Federal Waste Management Plan of Austria 2017.

Package	**Measures**	**Anticipated effects**
Food production, processing and trade	• Pilot projects for optimising implementation of mitigation potential • Collection & publication of best practises • Studies on prevention in production & processing • Continuation of training programmes • Awards for exemplary enterprises • Updating the handbook "Redistribution of food to social organisations"[1] • Certification for enterprises donating food	• More efficient production, processing and distribution of food • Food waste prevention potential in enterprises realised • Donation to social markets increased • **By 2030, food waste in the retail trade is reduced by 50 %**
Welfare organisations	• Preparing quality standards for welfare organisations redistributing food • Training courses for welfare organisation employees • Establishing a joint planning platform • Support for expanding storage and cooling infrastructure of welfare organisations • Monitoring quantities of redistributed food	• Unsellable foodstuffs donated to social markets and food banks • Reduced resource consumption and waste treatment costs • Supply and demand buffered
Consumption away from home	• Pilot projects for optimising implementation of mitigation potential • Collection & publication of best practises • Training programmes for employees • Promoting the Austrian Ecolabel in the group catering, catering trade and accommodation services • Integrating topic into guidelines of public bodies (e.g. canteens & hospitals) • Designing measures to prevent food waste in	• Increased awareness for food waste prevention options in commercial kitchens in hospitality and accommodation • Reduced resource consumption and waste treatment costs

	the context of public procurement	
Private households	• National & regional awareness campaigns • Developing measures to steer citizen behaviour towards a more mindful approach to food • Information campaigns on date labelling • Integrating topic in education including training programmes for teachers	• Increased awareness and motivation to prevent food waste in households • Avoidable food waste in households has diminished • **By 2030, a 50% reduction in household food waste**
Principles	• Standardising compilation methods • Reviewing and developing criteria on the Austrian Ecolabel and public procurement	• Analyses of different provinces comparable • **Principles for determining food waste quantities; and estimate of prevention potential improving**

Despite these efforts, Austrian legislation directly or indirectly promotes FLW generation and limits the opportunities for food redistribution, and many of its laws and regulations are stricter than the EU requires (table 1). Below, table 3 based on Schneider & Lebersorger (2016) gives a summary of the Austrian policies with relevance to either furthering or preventing FLW generation.

Table 3. Summary of Austrian regulation with implications and relevance to FLW (modified from: Schneider & Lebersorger, 2016). BGBI. = Bundesgesetzblatt (Federal Law Gazette); LGBI = Landesgesetzblatt (State Law Gazette).

Legislation name and number	**Relevance**
Ordinance of food labelling BGBl. II Nr. 165/2008	Food products with an expired 'best before' date can be sold on the market. Food products with an expired 'use by' date cannot be sold or consumed.
Epizoonotic diseases law BGBl. I Nr. 80/2013	FLW prohibited from being fed to domestic and wild animals (for exceptions see: BGBl. II Nr. 141/2010). Identifies circumstances under which feeding pigs food waste should be legal.
Law on animal feed BGBl. I Nr. 189/2013	Regulates production, market and use of animal feed, pre-mixtures and additives in animal feed. Legal basis for using bread waste as animal feed.

Law on animal substances BGBl. I Nr. 23/2013	"Regulates the collection, storage, transport, treatment, processing, disposal or use and the placement on the market of animal by-products." Sets the EC Directive No. 1069/2009 in Austria into force, concerning animal by-products and derived products.
Ordinance on animal feed BGBl. II Nr. 316/2010	Includes provisions to implement the Law on animal feed (BGBl. I Nr. 189/2013). Concretes the legal basis of bread waste use as animal feed.
Ordinance on animal substances BGBl. II Nr. 141/2010	Defines exceptions for using FLW as feed for farm animals, given that no meat products other than dairy and eggs products were used. FLW can be used for biogas and compost plant input without pretreatment. Minimum standards however identified.
Ordinance on separate collection of biowaste BGBl. Nr. 456/1994	Requires organic waste collected separately unless "recovered by the household or generator."
General ordinance on sewage water emissions BGBl. Nr. 186/1996	Defines maximum permissible discharge into sewers, concerning food waste grinders and compactors on landfills. Authorization for food waste grinders and compactors needs to be obtained according to Waste Management Law.
Austrian Waste management law BGBl. I Nr. 193/2013 LGBl. Nr. 45/2013	Regulates the sustainable management of waste: "general principles, waste prevention and recovery, duties of waste holders, waste collection, waste treatment and transboundary movements. " LGBl. Nr. 45/2013 specifies regulations in different Federal States (e.g. Salzburg and Vienna) including "regulations on municipal solid waste collection, reporting and fees" and the "--eco-design of products and the behaviour of consumers."
Ordinance on compost quality BGBl. II Nr. 292/2001	Regulates quality requirements for compost from FLW; type, source, materials, labelling, marketing. Packaging material should not be discarded into the biogenous waste containers.
Waste catalogue ordinance BGBl. II Nr. 498/2008	"Regulates the assignment of hazardous and non-hazardous waste to a waste type."
Austrian landfill ordinance BGBl. II Nr. 39/2008	Bans landfilling of organic waste without pretreatment such as mechanical-biological or incineration. Even then the value is limited to 5% of total dry matter.

Voluntary agreements and initiatives

Voluntary agreements are non-binding (although targets are often defined) agreements between several stakeholders in the food chain, addressing FLW prevention and reduction, for example, via food redistribution, awareness-raising campaigns and food supply chain optimization (STREFOWA, 2016c). The agreements usually involve both public and private partners. There are some notable initiatives and voluntary agreements by the government fighting FLW generation and aiding food redistribution in Austria.

An action program was started by the Federal Ministry of Agriculture, Forestry, Environment and Water Management in 2013 to help raise awareness, improve and expand redistribution networks, optimize processes in the FSC and fund research. A sizeable stakeholder consultation was at the core of the program and many partnerships were created as the result of the program. In cooperation with the action program the Federal Ministry for Sustainability and Tourism's flagship project "Lebensmittel sind Kostbar!" or "Food items are precious!" has developed a number of projects mostly in awareness raising in cooperation with 69 partners from industry, consumers, communities and welfare organisations.

Some of the biggest Austrian food companies and 'Die Tafeln', the Association of Austrian Tafels [food banks], have formed an Action Platform to facilitate the promotion of donation activities and food waste prevention (BMNT, 2018b). REWE International AG, SPAR Austria, HOFER und LIDL Austria are a part of the platform, and in the future more platforms following the concept are to be established in the areas of wholesale, production, agriculture and catering (BMNT, 2018b). Furthermore, ECR (Efficient Consumer Response) has developed a Best Practises catalogue for companies to reduce food waste, detailing food donation as one of the 'Action Fields' (ECR, 2016).

Food redistribution

Many of the regulations detailed in Table 3 have relevance to food redistribution in Austria, both in promoting and preventing it. However, quantitative strategies addressing food donation are very few. Furthermore, while encouraging to expand the redistribution of food, the 2017 Federal Waste Management Plan remains merely descriptive about the issue. However, the report "Guidelines for the redistribution of food to social organisations - Legal Aspects" [14] by the Federal Ministry of Agriculture and Forestry, Environment and Water Management describes the Austrian legal frameworks regarding donation of food to social

[14] Unofficial translation by author, originally: "Leitfaden für die Weitergabe von Lebensmitteln an soziale Einrichtungen - rechtliche Aspekte" - called "Handbook for passing on foodstuffs to welfare organisations" in FWMP 2017.

organisations (BMLFUW, 2015). These guidelines aid the understanding between food charities, food banks and enterprises donating food, but yet fall short on certain aspects desirable for the national guidelines on food donation as described further in the the Discussion. Below, another summary table shortly describes the Legal framework concerning RO operations in Austria as given by the "Guidelines for the redistribution of food to social organisations - Legal Aspects" (BMLFUW, 2015) [15]. Some descriptions include comments by author.

Table 4. Legal frameworks with relevance to Food Bank operations in Austria (BMLFUW, 2015) with author comments.

Section & laws, regulations and guidelines mentioned	**Description**
Product liability and warranty Product Liability Act (BGBl. I Nr. 98/2001) General Civil Code (ABGB: BGBl. I Nr. 58/2010)	In the event of injury or damage, the manufacturer or importer (read: donor) of the product is liable. If this party cannot be identified or announced, the distributor (RO) becomes liable. The obligation to pay cannot be excluded nor limited. There is no warranty obligation between the company and the distributor.
Food Safety Regulation (EC) 596/2009	Food Banks are considered fully compliant food businesses and are responsible for food safety. Ensuring food safety is top priority, even if best before date has not passed. The Austrian Agency for Health and Food Safety GmbH (AGES) oversees product warnings and recalls, but it is the full responsibility of the business to withdraw product and inform authorities.
Expiration dates and labelling Ordinance of food labelling (BGBl. II Nr. 165/2008)	After appropriate scrutiny (although this is not legally clearly defined) the Food Bank may donate a product further even if the 'Best before' date has passed. However, the 'expiration' has to be clearly indicated. Eggs may not be placed to market 21 days after laying, except if they are cooked or processed. Ultimately responsibility of safety remains with the RO putting the food on the market. The guidelines give a list of competent experts and authorities who to consult for questions.

[15] German translation into English generated by the 'translate document' function of Google Translate.

Hygienic transfer of goods Hygienepraxis: BMGF75220/0003-IV/7/2007 Brot und Gebäck: BMGF75220/0009-IV/7/2007	Same hygienic requirements apply to the employees and volunteers of Food Banks as other food business operators. These conditions need to be met, although the guidelines do not provide the source for them. Practical recommendations for employee hygiene and open transport of bread and pastries given as links to the Bundesministerium für Arbeit, Soziales, Gesundheit und Konsumentenschutz (bmg.gv.at) website. These links are broken however and should be reviewed.
Traceability General Food Law Regulation (EC) 178/2002 idF 596/2009	Food must be traceable through all production, processing and distribution to allow rapid action in case of food safety concerns. All food business operators, including ROs, must be able to provide information on where its products come from and go to, one step back and forth in the FSC. The guide directs the reader to the homepage of the Ministry of Health for further information on traceability.

Wiener Tafel

Austria has a vast number of food charities (both front- and back-line), social supermarkets and other initiatives and projects dealing with the prevention and redistribution of food waste (Schneider & Lebersorger, 2016). The capital city of Vienna is unsurprisingly the hotspot for these activities. The biggest Food Bank in Vienna and therefore Austria is the Wiener Tafel. Wiener Tafel works with 117 social institutions and 200 companies in the Greater Vienna area, distributing up to three tonnes of food per day to an estimated 19,000 end-beneficiaries (Wiener Tafel, 2018). Founded in 1999, Wiener Tafel is very established in Austria, and in the forefront of innovation in the fight against FLW, as demonstrated by their work with the Action platform.

Although Wiener Tafel reaches several companies, initiatives and socially deprived people, redistributing large quantities of food waste, its full potential is hardly met. According to City of Vienna (Stadt Wien, 2018) only 55% of the people in need are reached by food donations, 47% of which attributable to Wiener Tafel. The remaining food (45%) needs to be purchased. This seems like a gap that could yet be closed, given that in Vienna 'only' 2,126 tonnes of food were redistributed by social organisations in 2013 (Bernhofer & Pladerer, 2013), while a gargantuan 157,000 tonnes of avoidable food waste were generated in total in Austria (Schneider *et al.*, 2012).

Table 5. Wiener Tafel information (data based on organisation website and FEBA datasheet information)

wiener tafel		
INFORMATION		
Name	Wiener Tafel	
Founded	1999	
Range	Vienna Greater Area, Austria	
Umbrella organisation	Die Tafeln (Verband der österreichischen Tafeln) FEBA (European Federation of Food Banks)	
Website	https://wienertafel.at/	
Contact	office@wienertafel.at	
SIZE OF OPERATIONS		
	2016	**2017**
Number of registered Food Banks	1	1
Number of warehouses	1	2
Number of charities served	117	117
Number of beneficiaries	19,000	19,000
Products delivered (kg)	508,242	615,241
Delivered products estimated value (€)	1,354,941	1,149,798
Employees total (full-time equivalent)	13	15

2.2.2. Denmark

Food loss and waste legislation

A grand total of 715,000 tonnes of avoidable FLW is generated every year in the Danish Food Supply Chain (Miljøstyrelsen, 2017). Although Denmark is globally considered a pioneer in FLW management and waste management in general, it does not have a national plan for food waste prevention (Juul *et al.,* 2016). Instead, similarly to Austria, FLW is addressed in the national waste management strategies: The Resource Plan for Waste Management 2013-2018 (Miljøstyrelsen, 2014) and the Resource Strategy "Denmark without waste II" (Danish Government, 2015). These strategies call for a 50 % increase in recycling and a 50 % increase in food waste separation and treatment. These targets are crucial, as Denmark has one of the highest amounts of waste per capita in Europe and incinerates 80 % of their municipal waste (Juul *et al.,* 2016). While incineration has been considered a green strategy over landfilling and other forms of energy and heat generation, it is in conflict with the Waste Hierarchy and results in disposal of materials and resources (e.g. FLW) that may have otherwise been reused or recycled. The plan 'Denmark in work - Growth plan for food'[16] promises to support food waste reducing solutions in the market though the 'Grøn Omstillingsfond' or 'Green Conversion Fund', initiate analysis of resource efficiency in FSC and promote recycling and waste stream valorisation (Danish Government, 2013). The table below summarises the Danish regulations relevant to Food Loss and Waste.

Table 6. Summary of Danish regulations with implications and relevance to FLW (modified from: Juul *et al.,* 2016).

Legislation name **Legislation number**	**Relevance**
Environmental Protection Act N. 698 of September 22, 1998	Prevent and combat air, water and soil pollution. Provide regulation on hygienic standards. Reduce use and wastage of raw materials and resources. Promote use of cleaner technology. Promote recycling and reduce problems in waste management.
Statutory Order No. 48 on Waste of 13 January 2010	Specifies framework for waste incineration, and an efficiency and environmental report on the incineration plant. Specifies the regulatory duty of municipalities for waste management planning and regulation.
Statutory Order No. 1650 of 13 December	Regulates the FLW input quality for biogas production and composting.

[16] Translated by author. Original: "Denmark i arbedje - Vækstplan for fødevarer"

2006	
Waste Tax 1987	Supports the Action Plan for Waste and Recycling by providing fiscal mechanisms prioritising techniques towards the top of the Waste Hierarchy.
Taxation of waste and raw materials Act No. 311 of 1 April 2011	Ensures that all businesses extracting materials or producing waste are taxed.

Voluntary agreements and other initiatives

A plethora of governmental initiatives exist in Denmark. Several conferences connecting public and private stakeholders, and a range of studies on the Danish Food Supply Chain have been conducted (Halloran *et al.,* 2014). The Danish Ministry of the Environment came to support this effort by establishing a voluntary 'Initiative Group Against Food Waste' in 2011, which precipitated into the creation of the 'Charter on Less Food Waste' signed by 19 major stakeholders, inter alia, COOP, the Danish Crown, McDonalds and the Danish Agriculture & Food Council (MFVM, 2011). Little evidence can be found of its current or past activities, and its former website (mindremadspild.dk) seems to be permanently down. The campaign has likely been transcended by the initiative 'Denmark against Food Waste' in 2018, which boasts an even more sizeable portfolio of public, private and non-profit stakeholders from Arla, Nestlé and Unilever to Stop Spild af Mad and the Danish Food Bank, FødevareBanken (Danmark mod Madspild, 2018). The initiative commits its members to the UN Sustainable Development Goal 12.3. of halving food waste by the year 2030. The mechanisms to achieve this or consequences on non-compliance are not discussed on the initiative's website. The companies do however promise to establish a common and transparent methodology for monitoring and reporting the FLW generated by their operations.

The Stop Wasting Food (Stop Spild af Mad) movement is the largest non-profit in Denmark working against FLW. Its objective is to promote public awareness, mobilise media and empowering consumers to decrease their personal food print (Juul *et al.,* 2016). In August 2018, the Danish Ministry for the Environment and Food announced the establishment of a food waste think tank (MFVM, 2018).

Additionally, a food waste supermarket - 'Wefood' - was established in 2016, and now has three branches, two in Copenhagen and one in Aarhus. The shop is run by volunteers, and all

of Wefood's profits from the sold goods are directed to development aid through the umbrella organisation 'DanChurchAid' (Wefood, 2018). In its first 2 years Wefood has sold 250 tonnes of surplus foods.

Food redistribution

In 2012 Pedersen *et al.* reported that 13 % of Danes cannot buy sufficient amounts of food, while 24 % cannot afford a desired quality and diversity of foods. Therefore, in Denmark like in all EU countries, Food Security and Nutrition (FSN) is not a given for many citizens. According to the Danish National Board of Health (2012) 2,200 premature deaths are attributable to insufficient nutrition, i.e. low intake of fruits and vegetables. This gap is attempted to be closed by Danish food aid, headlined by charity organisations like Dansk Røde Kors (Danish Red Cross), Dansk Folkehjælp (Danish People's Aid), Folkekirkens Nødhjælp (DanChurchAid), KFUM/KFUK (YMCA/YWCA), Frelsens Hær (Salvation Army), and Blå Kors (Blue Cross). Danish municipalities do not receive and redistribute food donations, despite running many social initiatives (Hanssen *et al.,* 2015). The only food bank currently in operation in Denmark is 'Fødevarebanken'.

Food redistribution is mentioned in Danish legislation, but often in a very tangential manner, and no specific guidelines or quantitative strategies have been put forward. The closest to governmental guidance on redistribution are the FAQ Guidelines on retail food waste and donation to food banks [17] ; launched by the Danish Veterinary and Food Administration, as described by Gram-Hanssen *et al.* 2016 in their report on 'Food Redistribution in the Nordic Region - Phase II'. Moreover, according to the same report, Denmark interprets EU regulations more strictly than other Member States (see table 6), and 'interpretation of regulation' is still considered as one of the biggest barriers for food donation in Denmark. More importantly however, it is shown that one third of all actors involved in food redistribution in Denmark feel uncertain or uninformed about some part of their legal obligations. This uncertainty is likely to be pervasive through all food business and contributes to the strict interpretation of available legislation or unwillingness to partake in food redistribution in the first place. Similarly, O'Connor *et al.* (2014) show that the fear of liability, and financial and PR repercussions is the biggest barrier for food donations Europe-wide. Fear of fees in the event of noncompliance with control requirements is also a concern for food businesses, especially because the traceability and food hygiene legislation in Denmark requires vast amounts of documentation and added burden (Gram-Hanssen *et al.*

[17] FAQ available on the Ministry website: foedevarestyrelsen.dk/ under the title "Sådan kan virksomheden undgå madspild, fx ved donation" [Accessed: 30/08/2018].

2016). Businesses donating food to FødevareBanken do not pay VAT as the value of products is set 'close to zero' due an official interpretation of the EU VAT Directive as recommended by the European Union (VAT Committee, 2012) and the Danish Customs and Tax Administration (SKAT, 2015).

Political prioritisation of food redistribution over, e.g. biogas or energy generation, is not set in Denmark. Even though dissolving the VAT now removes the cost of food donation and diverts food from the landfill, national subsidies and investments on biogas infrastructures might still make disposal of waste more attractive than donation. As the Waste Hierarchy is not implemented by law in Denmark, redistribution for human consumption is not necessarily prioritised over energy and nutrient recovery, despite its higher calorific conversion efficiency.

Political will for food waste prevention and reuse has emerged increasingly in recent years however - at least in the form of plans and promises. In June 2017, the Nordic Council of Ministers for Fisheries and Aquaculture, Agriculture, Food and Forestry (MR-FJLS) met in Ålesund for an annual meeting, issuing a statement in coherence with the UN 50 % reduction target. They also called for a harmonisation of the rules and removal of barriers for food redistribution (Nordic Council of Ministers, 2017).

Table 7. Legal frameworks with relevance to Food Bank operations in Denmark (modified from: Hanssen et al., 2015).

Law, regulation or guideline	**Description**
Danish Act on Food No. 46 13th February of 2017 Danish Order on Approval and Registration of Food Business Operators Order No. 1365 of 9th December 2013 Official Controls Regulation (EU) 2017/625 General Food Law Regulation (EC) No 178/2002 Food Hygiene Package Regulation (EC) No 852/2004 Regulation (EC) No 853/2004	Supplements EU General Food Law and Food Hygiene Package by requiring registration and approval by the Danish Veterinary and Food Administration (DVFA). Food businesses with 'limited food activities' as defined by the Order do not need to seek approval. Food Banks registered as retail food business with wholesale. The Order also restricts the supply of food from one food business to another. The value of delivery as a fraction of original value of sales is limited up ⅔ for non-animal and ⅓ for food of animal origin, because ordinary retail does not pay for Official Controls and because delivery of food of animal origin must be "a marginal, localized and restricted activity" (Regulation (EC) No. 853/2004). Wholesale cannot be supplied by ordinary food businesses

Guidance No. 9789 of 10th December 2013 on the approval and registration of food businesses, section 6 & 7	except in the case of food donation. Foods from festivals may be donated even if the donating food business is below the minimum limit of activity and organisation. Food must be unopened with appropriate continuous cold chain (No. 9789, 2013).
Hygiene of Foodstuffs Order No. 788 of 24th July 2008 Food Hygiene Package Regulation (EC) No 852/2004 Regulation (EC) No 853/2004	Supplements the EU Food Hygiene Package. Storage temperatures of food and market standards are defined. Food not fit for consumption must be sorted at site of the donor retail food business but can be done by food banks employees. Sorting at the Food Bank or by recipient requires derogation of EU law.

FødevareBanken

Established in 2008, this young food bank has expanded rapidly and as of 2018 now has warehouses in Copenhagen, Aarhus and Kolding, thusly covering the most populous parts of Denmark (FødevareBanken, 2018). FødevareBanken requires an annual 10,000DKK (~1340 €) fee from the charities it serves, but according to Economists without Borders, the partner organisations do not consider this an obstacle in working with the Food Bank due to the overall economic saving (ØUG, 2016). In contrast to other ROs, FødevareBanken do not accept or redistribute food products that have an expired 'Best Before' date.

Table 8. FødevareBanken information (as provided by Food Banks' official website and their FEBA datasheet). *) in 2018 FødevareBanken has opened two more warehouses: Aarhus and Kolding.

INFORMATION		
Name	FødevareBanken	
Founded	2008	
Range	Copenhagen, Capital Region, Zealand, Lolland-Falster, South Denmark & Central Jutland	
Umbrella organisation	FEBA (European Federation of Food Banks)	
Website	http://foedevarebanken.dk/	
Contact	info@foedevarebanken.dk	
SIZE OF OPERATIONS		
	2016	**2017**
Number of registered Food Banks	1	1
Number of warehouses	1	1*
Number of charities served	150	200
Number of beneficiaries	195,000	260,000
Products delivered (kg)	812,000	914,000
Delivered products estimated value (€)	2,617,859	2,946,704
Employees total (full-time equivalent)	27	32

2.2.3. Finland

Food loss and waste legislation

According to the Natural Resources Institute of Finland, between 400 to 500 million tonnes of avoidable food waste is generated every year in Finland, representing 15% of all food produced (Katajajuuri *et al.,* 2014). On the national level FLW is addressed by the snappily named "From Recycling to a Circular Economy - National Waste Plan to 2023" by the Ministry of the Environment (Laaksonen, *et al.,* 2018). The plan, despite its name, addresses waste management targets for the year 2030, but will be later updated for the period 2024 to 2030. The plan contracts the Finnish government to a "high standard of waste management as a part of the sustainable circular economy", and as a part of Target 6 to "halving food waste by 2030", following SDG 12.3. by the UN and the Circular Economy Package by the European Commission. Through Target 6.1 the Ministry of Environment orders a roadmap from the Ministry of Agriculture and Forestry for reducing food waste, by defining indicators and control systems to monitor food waste, and the further development of food waste determination and calculation methods. Target 6.2 introduces a voluntary material efficiency commitment for the food sector, while 6.3 channels funding for food systems research, experimentation, advisory services and communications. Calling for the Ministry of Education and Culture, the plan recalls that *"the earlier children and young people are provided with skills and knowledge, the better they can adjust their personal consumption habits--"* and sets target 6.4 to reinforce food waste awareness in basic education, food service education and day care centres. Targets 6.5 to 6.7 call for extended internal research by food businesses on waste composition, expansion of 'leftover lunch' (selling leftover school lunch to third parties) and concreting of the Nordic Swan Ecolabel standards in the retail and hospitality sectors (Laaksonen, *et al.,* 2018).

The recent study 'LexFoodWaste' scrutinises all European Union and national legislation that might hamper food waste prevention, reduction or redistribution in Finland. This 98-page report thoroughly examines all stages of the food supply chain, and identifies several areas for improvement, including non-legislative factors. Here, a summarising LexFoodWaste, the FUSIONS country report (Silvennoinen, 2016) and other research, describes the most impactful EU and national legislation with relevance to FLW prevention and food redistribution, with reference to appropriate EU legislation (recalling table 1).

Table 9. Summary of Finnish legislation with implications and relevance to FLW with author's comments (collated from: Silvennoinen, 2016; Laaksonen, et al., 2018). MMM = Ministry of the Agriculture and Forestry.

Legislation name **Legislation number**	**Relevance**
Food Act 23/2006	Defines the conditions of how food business operators must handle and control food at all stages of production, processing and distribution. Food hygiene requirements during handling, storing and transportation of food are addressed by Section 11. Strict implementation leads to FLW.
Waste Act 646/2011 Waste Decree 179/2012	Aims to reduce the quantities and impacts of waste and promote sustainable use of resources. Waste Decree calls sections 8, 13 and 15 of the Waste Act to organise separate collection and recycling of materials.
Common organisation of the markets in agricultural products; Regulation (EU) No 1308/2013	Withdrawals of fruits and vegetables that do not fit the shape, colour, size or uniformity often end up as FLW. Relaxing these standards should be examined to prevent food waste and promote food redistribution.
Decree of the Ministry of the Agriculture and Forestry (MMM) 1367/2011	Foods served hot must be kept at minimum 60°C when stored. Cold storage temperature for easily spoiled food is 12°C and 6°C for highly perishable foods. Donating warm food can be donated if it is cooled to 6°C. Extending this ruling to retail would significantly reduce FLW.
Food Safety, Packaging Regulation (EU) No 178/2002 & 1169/2011 MMM 384/2014	Products withdrawn due labelling errors on packaging have been growing due to strictened regulation. Discarding is often chosen over relabelling due to high costs and complexity of legislation ensuring subsequent food safety. Increased analytics and knowledge on allergens in products has also increased FLW. Extended transition period and relaxed labelling on donated products could mitigate the quantities of FLW. Best-before dates should be only marked on products that are easily spoiled and can incur health risk. It is common that products with an expired best-before date are removed although this is not required by law.
Food Safety, Storage MMM 1367/2011 MMM 818/2012 Regulation (EU) No 852/2004 & 853/2004	In the food industry significant FLW is generated due to strict temperature regulations for different categories of product, some not present in EU regulations. Unifying legislation would prevent FLW in the food industry, and in retail. Relaxing storage temperature ranges on fish would especially mitigate these effects. Evira's 'Oiva' self-monitoring system for storage temperatures should be redesigned to avoid FLW due to human error resulting in misunderstanding and misinterpretation. Range of storage temperatures during transport should be extended beyond the

	+/- 3 degrees, especially regarding safer products like bread. IT systems on board distribution vehicles should be utilised better for monitoring and decision-making.
Environmental Protection Act 86/2000, 527/2014	Applies to all operations and activities with implications to environmental pollution. The act also applies to waste generation and disposal.
Waste Tax Act 1126/2010	Waste tax applies for waste placed to landfills when recovery on technical, safety or environmental counts is not possible.
MMM 16088/5, 2013 Evira Instructions 1192/2011; 1193/2011	Retail food businesses must document the amount of waste of animal origin. If the quantity is more that 50kg per week, waste must be separately collected and handled. Food can be donated but not landfilled.
Evira Instructions 16035/2 – Under Decree 1367/2011	Food donations are permitted under conditions that differ from commercial operations. Food safety cannot be compromised however. Donating and redistributing parties both responsible to ensure successfulness of this approach. The Finnish Food Safety Authority Evira and the Ministry of Agriculture and Forestry have jointly prepared guidelines for food redistribution (see table 11).

Voluntary agreements and other initiatives

The Finnish Innovation Fund 'Sitra', supports several projects and initiatives fighting to prevent, reduce or redistribute FLW. One of the most successful campaigns: 'Leftover Lunch' started in 2014 to prevent food waste from school cafeterias by selling leftover food with a bargain price of 1.5€ per portion. Since, 'Leftover Lunch' has since spread to dozens of cities across Finland, and if it were implemented nationwide it could save two million meals, or 2,500,000 kg.CO_2eq. per year. Sitra has also been integral at establishing the 'Hävikki- mestari' or 'Food surplus Master' app launched by Finland's largest waste management company 'Lassila & Tikanoja'. With the app food businesses (normally food service) can monitor their FLW and receive data visualisations and food waste reducing training materials (Sitra, 2017).

The 'Saa syödä!' or 'License to Eat!' project by the Ministry of the Environment, launched 2013, and its food waste week (in 2018 between 10th and 16th of September) has become a very important platform for disseminating knowledge on FLW and reduction methods across society. Their website includes information on food waste, statistics, recipes, hints and calculators on personal FLW. The 'Food Waste Battle' challenges schools to compete on FLW reduction efforts (Saa syödä!, 2018).

The food waste supermarket 'Wefood', established in Denmark 2016, opened its first store in Helsinki, Finland in September of 2018. The Finnish Wefood runs an identical business model, offering 30 - 50 % reductions on the regular market prices of products, and is operated

primarily by volunteers. The profit is directed to foreign aid through Kirkon ulkomaanapu or 'Finn Church Aid', operating under the same umbrella organisation as Dan Church Aid; the ACT Alliance (Kirkon ulkomaanapu, 2018).

Food redistribution

Finland is one of the rare countries in the European Union that has published guidelines on food donations to clear up EU and national regulations and enhance redistribution of FLW for human consumption (Evira, 2017). The 'Evira Guidelines on Foodstuffs Donated to Food Aid' 16035/2 (amending the 2013 Guidelines 16035/1) were produced for food business operators receiving or redistributing food, but just as much for local and municipal food control authorities, especially to clarify liability concerns and other matters seen as hindering effective food redistribution. The Finnish Food Safety Authority 'Evira' oversees the correct interpretation and implementation of the food donation regulations, which include number of exemptions to the usual food safety regulations. For one, food business operators receiving, and donating food are not required to go through a strict registration process as for example in other Nordic countries. This is, among other reasons, legacy of the Finnish food redistribution history which has always been very decentralised and localised, enabling short supply chains and periods of storage (Gram-Hanssen et al., 2016). To reduce bureaucratic burden, the local authorities act in a reactive principle whenever inadequacies in redistribution systems are suspected. The Guidelines offer relief for charitable organisations compared to the otherwise strict Finnish national Food Law and its interpretation of European food hygiene and safety regulations. While a number of exemptions exist, the Guidelines still necessitate stringent self-monitoring, traceability and customer information, never forgetting to concrete how foodstuffs donated to food aid must in all cases be safe, and that responsibility is on all parties involved in the redistribution process (Evira, 2017). In the following table the guidelines are summarised.

Table 10. A summary table of the Finnish Evira Guidelines on 'Foodstuffs donated to food aid' (collated from: Evira, 2017 & Gram-Hanssen *et al.*, 2016).

Reference legislation	**Guideline**
Registration Food Act 23/2006 General Food Law Regulation (EC) No	Charitable organisations must notify local food control authority about the operation and premises four weeks prior to starting operations. An own-check plans must be prepared, including a full risk assessment. Organisations distributing only dry products, vegetables and other products stored at ambient temperatures do not need to notify authorities.

178/2002	Limits administrative burden.
Control Official Controls Regulation (EU) 2017/625 Decree 1367/2011	Food business operators involved in food redistribution will only be controlled under reasonable doubt from authorities about the safety conduct of the operations. As audits normally happen at the own cost of FBOs, this guideline cuts down the costs of redistribution for all parties.
Labelling Regulation (EU) No 1169/2011 MMM 384/2014	Regular food labelling ('use by' & 'best before'; consumer information, language etc.) regulation applied, with the exception of: Permitting the redistribution of wrongly labelled food conditional to giving the correct information in another form, reaching the end-user.
Expiration dates Regulation (EU) No 1169/2011 MMM 384/2014	Food with an expired 'use by' date can be donated as long as the food has been frozen prior to the date and donated no later than two months after the freezing date. Recognising that many food products with a 'use-by' date in Finland would in fact be eligible for a 'best before' one, a case-to-case based evaluation is permitted for foodstuffs yet one day after the expiration if foods are prepared by heating of at least 70°C. Responsibility and liability remain with the charity organisation.
Storage & premises MMM 1367/2011 Regulation (EC) No 852/2004; 853/2004	Storage and distribution facilities must fulfil the norms of regular legislation and personnel must follow Evira's hygiene guidelines for FBO employees. Toilets and hand washing facilities are mandatory. Waste disposal must be organised to avoid odours and pests.
Cold and heat-chain MMM 1367/2011 MMM 818/2012 Regulation (EC) No 852/2004; 853/2004	Ice boxes are permitted in the absence of a refrigerated vehicle. Short-term deviations in temperature requirements for perishable foodstuffs are allowed, as many redistribution actors have reported refrigerated vehicles as a major barrier for compliance. Cooked food can be passed for redistribution if this takes place within four hours of cooking and the 60°C heat-chain and the 6°C cold-chain (for chilled food) is not broken.

Finland has a long history in food aid and redistribution but has not until recently had any centralised mechanisms and most activities take place on the local level. As previously stated, low level of organisation and complexity shorten the supply chain, storage times and hence save costs and minimise risks. However, challenges arise when demand and operations grow.

Yhteinen Pöytä

In 2014 Finland got its first official (according to the FEBA definition) Food Bank, Yhteinen Pöytä, supported by the city of Vantaa as a part of its food aid program. Unlike others before it, Yhteinen Pöytä has a central warehouse, a fleet of vehicles, and modern standards for monitoring and reporting (Yhteinen Pöytä, 2018; Sitra, 2018). Yhteinen Pöytä is not a member of FEBA, and data on the quantities and categories of food saved by the organisation were reported in a different format to the other food banks. These data were fitted into the nine categories by the author, often matching the donor company with the right product group. In some instances, donations were only labelled as 'groceries' or 'market items', and thusly were given the mean EF of all the categories, labelled as 'category 10: Average' (see: 10 average). Data on the operations were collected from Yhteinen Pöytä using the FEBA Global Analysis sheet.

Table 11. Yhteinen Pöytä information (as provided by Food Banks' official website and their FEBA datasheet).

INFORMATION	
Name	Yhteinen Pöytä - 'Common Table'
Founded	2014
Range	Vantaa, Finland
Umbrella organisation	Ruoka-apu yhdistysten liitto ry (Federation of Food aid Associations Finland)

Website	http://yhteinenpoyta.fi/	
Contact	hanna.kuisma@vantaa.fi	
SIZE OF OPERATIONS		
	2016	**2017- 2018**
Number of registered Food Banks	1	1
Number of warehouses	1	1
Number of charities served	40	50
Number of beneficiaries	5,000	6,000
Products received (kg)	not monitored	515,194
Delivered products estimated value (€)	not estimated	not estimated
Employees total (full-time equivalent)	24	24

2.2.4. Hungary

Food loss and waste legislation

According to the Hungarian National Waste Management Plan (2014 - 2020), the total amount of 'Agriculture and food industry waste' [18] generated in 2011 in Hungary was 743,701 tonnes (NWMD, 2011). Like several other European nations, Hungary does not have a specific national plan on FLW but does address it in the aforementioned National Waste Management Plan. The plan details many mechanisms and their priorities for FLW prevention and management; inter alia, green procurement, circularity, biogas, eco-design and redistribution. However, no clear responsibilities for different levels of government are defined. Secondly, the Food Chain Safety Strategy 2013 - 2022 (Act n°2008. XLVI) addresses food waste through its strategies to improve the knowledge and responsibility in the food supply chain and consumption in particular. The strategy involves all of society and has a focus on building networks and education (MRD & NÉBIH[19], 2014; STREFOWA, 2016a). A summary table below details the Hungarian policies with relevance to either furthering or preventing FLW generation.

[18] "Mezőgazdasági és élelmiszeripari hulladék" in Hungarian. Direct translation as generated by Google Translate - 31st of August 2018.
[19] MRD = Ministry of Rural Development; NÉBIH = National Food Chain Safety Office

Table 12. Summary of Hungarian regulations with implications and relevance to FLW (modified from: FUSIONS, 2016; STREFOWA, 2016a).

Legislation name **Legislation number**	**Relevance**
Act on the food chain and its regulatory supervision and monitoring (National Act n° XLVI./2008)	Defines legal requirements and regulations concerning monitoring in the FSC. Details that the producer is responsible for declaring the 'best before' and 'use by'- dates, and all parties are prohibited from selling goods with expired date labels. Like elsewhere in the EU, the self-reporting and interpretation of 'best before' dates have potentially significant effects on FLW generation, and redistribution. Also defines storage requirements for product categories.
Usage of food-waste for feeding animals (Regulation 75/2002 (VIII.16.))	Aims to minimise all risks related to animal health. Redirecting FLW to feed for pigs is prohibited (28. § (1)), preventing the closing of certain by-product loops and valorisation methods and resulting in increased FLW.
Food-health requirements applied in public catering (regulation 37/2014 (IV.30.))	Defines the healthy nutritional contents and quantities of meals in public catering (hospitals, canteens, schools etc.). The definition of minimum portion size may lead to increased plate waste and thus elevated FLW.
Act on Waste (National Act n° CLXXXV/2012)	Implements the Waste Framework Directive (2008/98/EC) in Hungary.
Producing and marketing of products by catering and hospitality (regulation 62/2011 (VI.30.))	Regulation on food safety conditions in catering and hospitality.
Landfill and related rules and conditions (Regulation 20/2006 (IV.5.))	Implements the EU Landfill Directive (1999/31/EC) in Hungary.
Conditions and methods of food disposal (Regulation 56/1997	Concerns products that are produced and traded within Hungary and have become waste due to 'lost function' for example through expiration. This food waste has to be treated in an environmentally

(VIII.14.))	sound principle. The costs are paid by the producer of the waste, i.e. the owner of the product at the time of it becoming waste.
Hungarian Food Book (Codex Alimentarius Hungaricus)	Defines quality, safety and labelling requirements for food products. Strict interpretation of the Codex requirements may lead to FLW.

Voluntary agreements and other initiatives

On the EU level Hungary has been active in driving the attention towards the issue of FLW. At the Council Meeting of Ministers of Agriculture in 2013, the Hungarian Minister for Agriculture Sándor Fazekas called for an EU level debate on FLW. On the basis of this debate the Hungarian Food Bank Association and the Ministry of Rural Development jointly initiated a Forum "Food is Value" against FLW. The signatories for the Forum commit to a non-binding agreement to reduce FLW in the areas of the FSC relevant to them (Az Élelmiszer Érték, 2016).

The campaign Esélyt az ételnek! (Chance for food) is an initiative by the Hungarian Food Bank Association, launched in 2012 to disseminate information about food loss and waste through their website, network and events. The website includes information, tips, recipes, applications and games on FLW prevention, reduction and redistribution (Hungarian Food Banks Association [20], 2012).

The National Environmental Education Strategy of Hungary, developed by 200 civil society organisations, aims to increase awareness raising, education and capacity building for sustainable development in Hungary at all levels of education and society (Hungarian Environmental Education Association [21], 2010).

As a part of the four pilot countries for the EU REFRESH project, Hungary's Pilot Working Platform (PWP) includes key stakeholders from the Hungarian food sector to develop and test effective national actions against FLW. As a part of the PWP, the Hungarian Food Chain Safety Office (NÉBIH) organises quarterly Round Table meetings (most recently March 2018) to discuss both opportunities and barriers in the legal, organizational and communication frameworks that the donating companies operate within. For example, the usability of 'expired' long-lasting products and the improvement of date labelling. The meetings aim to address the current needs and challenges of the food sector. The meetings

[20] "Magyar Élelmiszerbank Egyesület"
[21] "Magyar Környezeti Nevelési Egyesület"

include representatives from the ministries, NÉBIH, the Hungarian Food Bank Association, the National Association of Food Processors and food companies, like Spar and Tesco (REFRESH, 2018). The PWP has launched other pilot projects as well, including: 'Ugly but Tasty', promoting the use of 'low quality' fruits and vegetables; 'Just like at home', furthering the understanding of realistic supply and demand in the food chain and 'Broadening the bridge', modelling the costs, funding and return on investment of the food redistribution chain (REFRESH, 2018).

Food redistribution

Hungary does not have legislation specifically concerning food redistribution. However food donations are incentivised by two governmental policies: Corporate tax deductions (National Act n° CLXXV/2011) and VAT exemptions (National Act n° LIII/2010) for donations. The former allows companies to deduct up to 40% [22] of the value of the goods from their corporate tax base. This overcomes the issue of discarding food being financially beneficial than donating it. The Act on VAT enables an exemption of the Value Added Tax for food donations for all parties involved. Only charitable donations to public-benefit organisations are allowed the VAT exemption. As aforementioned in Table 12, the Act on the food chain and its regulatory supervision and monitoring (National Act n° XLVI./2008) prohibits the donation of food past its 'use by', but also its 'best before' date. This misinterpretation of the EU regulation remains a key barrier for food donations, but is extensively discussed by Hungary's Pilot Working Platform[23].

Magyar Élelmiszerbank Egyesület

As mentioned before, the Hungarian Food Bank Association oversees many FLW related activities, projects and multi-stakeholder initiatives. They are a central player in facilitating knowledge transfer and driving change in Hungary. Established in 2005, the Association has a clear mission of saving food and reducing hunger, while raising awareness and creating partnerships across the food chain (Hungarian Food Bank Association, 2018). Since their foundation the Food Bank has reached over 300,000 people by working with over 350 non-governmental organisations and municipalities.

Table 13. Magyar Èlelemiszerbank Egysület information (as provided by Food Banks' official website and their FEBA datasheet).

[22] See: 4. Discussion on New European Food Law 2030
[23] HFCSO Forum 1st meeting on expiry dates: https://eu-refresh.org/hfcso-forum-food-waste

Magyar Élelmiszerbank Egyesület

INFORMATION		
Name	Magyar Élelmiszerbank Egysület - Hungarian Food Bank Association	
Founded	2005	
Range	Hungary	
Umbrella organisation	FEBA (European Federation of Food Banks)	
Website	www.elelmiszerbank.hu	
Contact	elelmiszerbank@elelmiszerbank.hu	
SIZE OF OPERATIONS		
	2016	**2017**
Number of registered Food Banks	1	1
Number of warehouses	1	1
Number of charities served	325	354
Number of beneficiaries	85,000	155,000
Products received (kg)	4,973,926	9,222,510
Delivered products estimated value (€)	9,483,770	16,117,923
Employees total (full-time equivalent)	19	21

2.2.5. Poland

Food waste and loss legislation

Accurate estimates for the annual quantities of 'avoidable food waste suitable for human consumption' generated in Poland are hard to come by. Food waste is addressed in the Polish National Waste Management Plan [24] 2022 (KPGO, 2016), but the categories of municipal waste make reliable estimates difficult. 'Group 02' -waste or 'waste from agriculture, horticulture, aquaculture, fisheries, forestry, hunting and food processing' is reported as 3,965 thousand Megagrams, i.e. 3.9 million tonnes, but this includes many inedible portions (KPGO, 2016). The 2006 estimate by STREFOWA [25] estimate of Polish FLW is 9 million tonnes per year (STREFOWA, 2016b), which matches the fast decreasing trend in FLW also reported by the Polish National Waste Management Plan 2022 (KPGO, 2016). Besides reporting on national waste generation and management, the Plan implements and interprets the relevant EU directives and regulations concerning FLW (table 1) on the national level. Together with the KPGO, the Polish Ministry of the Environment (mos.gov.pl) through the General Director for Environmental Protection, also produced the 'National Programme for the prevention of waste' (NWPP, 2014), defining waste prevention objectives and reference levels to monitor and evaluate progress.

Table 14. Summary of Polish regulations with implications and relevance to FLW (modified from: STREFOWA, 2016c).

Legislation name **Legislation number**	**Relevance**
Law on Food safety and nutrition. No. 171, item. 1225 of August 2006 No. 21, item 105. January 2010	Defines the basic legal framework regulating food safety and nutrition, the rules of conduct for regulatory authorities. Implements the European Hygiene package. Interprets EU law strictly to disallow redistribution of products with an expired 'best before' date.
Law on Waste Dz.U. 2013 item 21	Defines measures to protect human life and health, and the environment and reduce negative impacts from waste. Waste generation and management should have minimum impact on resource use.
Waste transfer No. 75, item. 527 April 2006	Defines a list of types of waste that may be transferred to individuals or agencies who are not 'entrepreneurs'. Also describes the appropriate and acceptable ways of recovery, conditions for storage and allowed quantities of waste.

[24] Krajowego Planu Gospodarki Odpadami, KPGO = National Waste Management Plan, NWMP
[25] Strategies to Reduce Food Waste in Central Europe

Voluntary agreements and other initiatives

Poland does not currently have any voluntary agreements directly concerning FLW, as understood by the FUSIONS definition: *"alternative courses of actions… developed by the industry generally aimed to deliver the policy objectives faster and/or in a more cost-effective manner compared to mandatory requirements."* (Aramyan *et al.,* 2016). In the interview (see next section: 'Interviews') however the central food bank "Federacja Polskich Banków Żywności" reminds that they facilitate a lot of voluntary redistribution from industry.

Food Sharing Poland is a branch organisation of the original, and very successful, German initiative foodsharing.de platform, allowing food surplus redistribution between citizens. The polish initiative focuses specifically on 'Jadłodzielnia'; food sharing fridges and shelves, placed in popular areas of the city. Established by the Federation of Polish Food Banks, the 'Council of Sustainable Use of Food' is a group of industry, social and research organisations who in collaboration with public institutions develop principles for effective FLW prevention. Like in the case of many similar initiatives, however, information on progress is scarce and the website is not functioning.

Food redistribution

Poland does not have a national plan addressing food redistribution, and donations are only briefly mentioned in the NWPP as good communal practise in the field of municipal waste prevention. Redistribution is encouraged by an amendment [26] on the VAT regulations however, so that donations from food producers and distributors are exempt from VAT. On the other hand, the strict interpretation of the EU Food Hygiene Package [27] prevents the donation and redistribution of all food products with an expired 'best before' dates.

Federacja Polskich Banków Żywności

Organised food redistribution in Poland is largely overseen by 'Federacja Polskich Banków Żywności' or 'the Federation of Polish Food Banks' [28], which is in charge of monitoring and aiding the operations of 31 ROs across Poland. This results in a sophisticated network of autonomous associations, with an established flow of information and a democratically elected board. These qualities enabled the redistribution of 65,500 tonnes of food, worth 65.9 million euros, to almost 1.5 million people in 2017 through over 3,000 Charity Organisations (COs) across Poland (FPBŻ, 2018).

[26] Amendment of Art. 43 of October 2013 of Act of 11th March 2011 on value added tax (tax on commodity and services) J. of L. of 2011 No. 177, item 1054, with later amendments.
[27] Regulation (EC) No 852 & 853/2004
[28] Federacja Polskich Banków Żywności = FPBŻ

Table 15. Federacja Polskich Banków Żywności information (as provided by Food Banks' official website and their FEBA datasheet).

INFORMATION		
Name	Federacja Polskich Banków Żywności Federation of Polish Food Banks	
Founded	1997	
Range	Poland	
Umbrella organisation	FEBA	
Website	www.bankizywnosci.pl	
Contact	federacja@bankizywnosci.pl	
SIZE OF OPERATIONS		
	2016	**2017**
Number of registered Food Banks	31	31
Number of warehouses	31	31
Number of charities served	3,626	3,342
Number of beneficiaries	561,666	514,763
Products received (kg)	92,774,021	68,642,219
Delivered products estimated value (€)	55,719,926	68,259,712
Employees total (full-time equivalent)	252	238

2.2.6. Summary and interviews

Below, a summary table of the 2017 operational data for each CSO is shown. Note that the food worth is estimated by each organisation independently.

Table 16. A summary table of select operational data from the year 2017 of each CSO. *) in the original tables some organisations report only products received, not delivered **) Value of 1,365,522 € if 3.00 € per kilo assumed.

SIZE OF OPERATIONS					
	Wiener Tafel	**Fødevare Banken**	**Yhteinen Pöytä**	**Hungary**	**Poland**
Country	Austria	Denmark	Finland	Hungary	Poland
Number of registered Food Banks	1	1	1	1	31
Number of warehouses	2	1	1	1	31
Number of charities served	117	200	50	354	3,342
Number of beneficiaries	19,000	260,00	6,000	155,000	514,763
Products received (kg)*	615,241	919,685	515,194	9,222,510	68,642,219
Delivered products estimated value (€)	1,149,798	2,946,704	not estimated**	16,117,923	68,259,712
Employees total (full-time equivalent)	15	32	24	21	238

Interviews

A contact person from each Case Study Organisation and from FEBA were interviewed for the purpose of receiving auxiliary and validitative information. These interviews proved to have much value for the Discussion and Conclusions sections. However, the contents of the interviews cannot be fully utilised, due to the consent and disclaimer agreement used before each interview, as serving the original intention of the interviews:

"Thank you again for agreeing to an interview. Is it ok if I record this interview and later transcribe it? [wait for consent] *Thank you. Just to let you know, this interview will be used for inspiration and direction, and not for specific keywords analysis or similar, and I will not disclose any personal information in the written work of my Thesis"*

As mentioned, this format was devised early in the Thesis process, when the intent was to focus predominantly on the climate impacts of food redistribution. However, main themes were derived, as they arose from more than one interview. Table 33 in the Results section summarises the themes.

2.3. Climate impact of Case Study Organisations

This section will describe the methodology used to determine the carbon accounts of the Case Study Organisations. It loosely follows the structure and rationale of a Life-Cycle Analysis (LCA) study but will also deviate from this framework.

2.3.1. Goal & Scope

The goal of this impact analysis is to estimate the amount of carbon that the Case Study Organisations' (CSOs') operations are saving by redistributing food that would otherwise be discarded. An analysis of the operational footprint relating to the organisations' activities (e.g. kmt logistics, m^3 cold storage) is also conducted to investigate how much the CSOs emit carbon pollution. Lastly, whether the amount 'carbon saved' is indeed greater to that of 'carbon emitted' by the organisations is accounted. It is important to note that this Thesis work does not attempt a full organisational Life Cycle Assessment, but rather a simplified accounting of the organisations' emissions linked to their logistics and storage. This is largely due to the lack of appropriate granularity of data for a full assessment.

2.3.2. Functional unit

This Thesis work does not directly compare organisations, products or services to each other and hence the use of a functional unit as the common denominator is not necessary. Rather, all saved and emitted carbon is accounted over each organisations' operations in year 2017. The unit that flows through the system is '1 kg of food', which is recommended as the functional unit if such a study were replicated and organisations were compared. It is to be noted however that the composition and footprint of 1 kg of food is contingent on place and time, and a universal mean needs to be decided on in the case of such studies.

2.3.3. System boundaries

The food redistributed by the organisations was assumed to replace similar products on the market, and to embody the carbon from these activities from the primary production, processing (inc. packaging) and retail, including transport, up until consumption. Thusly, the

stages of consumption and end-of-life are excluded from analysis, as shown by figure 7 below. Further rationale behind this explained in the following two paragraphs.

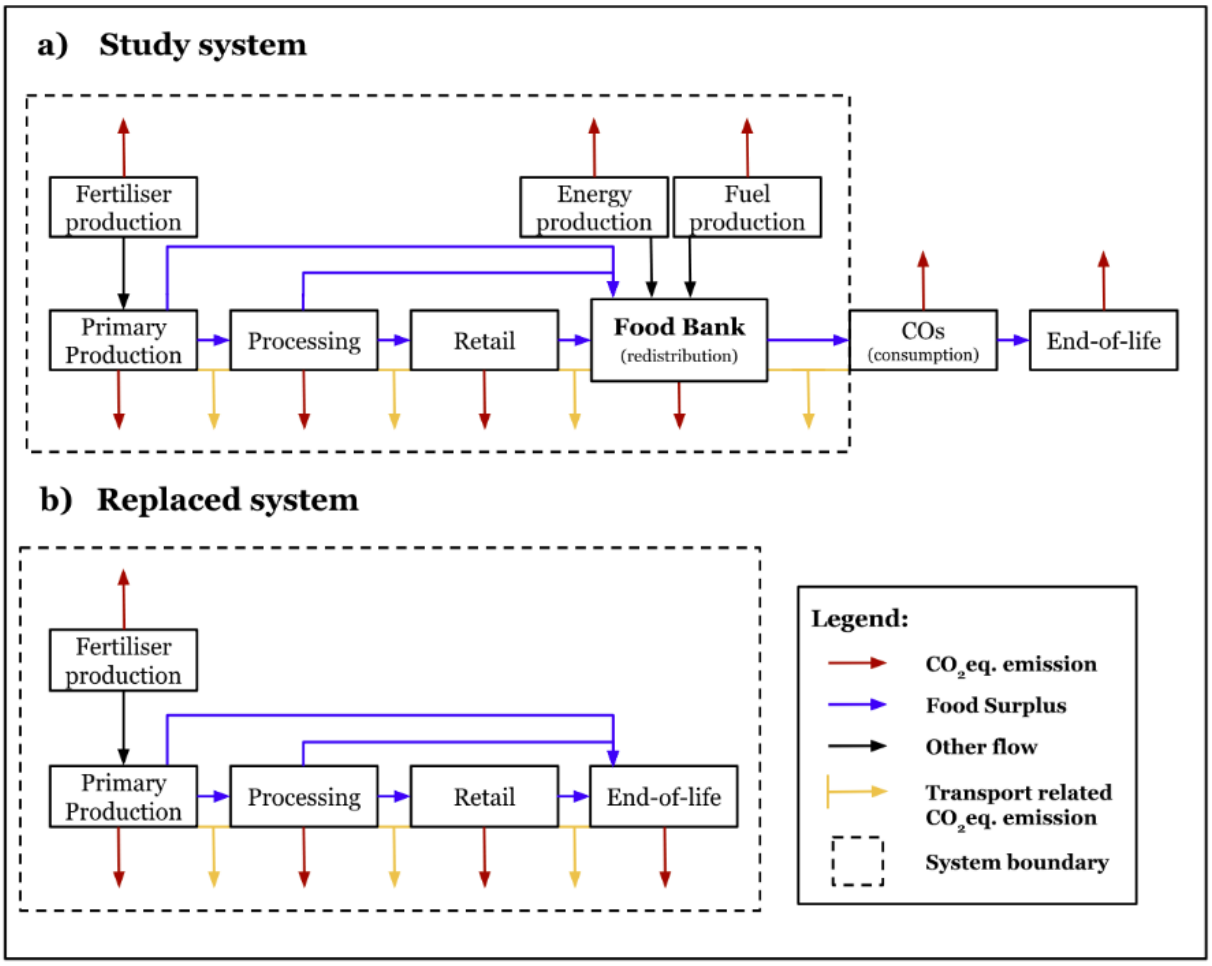

Figure 7. System boundaries of the a) Study system and b) Replaced system showing the primary processes and flows as inputs and outputs.

The stage of consumption, namely home refrigeration, preparation and cooking, is known to have a significant effect on the overall CF of a product (Scherhaufer *et al.,* 2015). Naturally, in most cases the stage of consumption is not yet accounted for in the EF of supermarket food products. However, in the case of food redistribution, consumption still occurs e.g. in households or in charities receiving and distributing the food. This stage would not take place in the replaced system, where the products skip this step and head to end-of-life instead. In some rare cases however, authors choose to include the stage of consumption in the EF of a foodstuff, and as several meta-analysis sources are also used in this study, it is possible that some fraction of the impact of consumption has made it to the estimates. However, these effects would be negligible and well within the margin of error.

The climate impact of the end-of-life options, e.g. biogas production, incineration or landfilling, are also excluded from analysis. The end-of-life stage of a food affects its Carbon Footprint (CF = EF * mass) greatly and country differences are significant. End-of-life takes place both in the replaced and study system, but its effects are far smaller in the study system as only a fraction of the product leaves the consumption stage as scraps. End-of-life is excluded here due to a design choice, as the system boundaries need to be set. However, were the stage included in analysis it would show that consumption is a less carbon intensive option than disposal (as per the Food Waste Hierarchy; figure 2).

2.3.4. Life Cycle Inventory (LCI):

The Life Cycle Inventory process involves the collection of appropriate data and modelling the inputs (e.g. energy and materials) and outputs (e.g. products and emissions) of the study system. Refer back to figure 7 for the processes, and input and output flows of the study and replaced systems. The data on the amount (kg) of products received and donated; and the size of operations were acquired through close collaboration with five Case Study Organisations (CSOs): Wiener Tafel, Austria; Fødevarebanken, Denmark; Yhteinen Pöytä, Finland; Élélmiszerbank Egysület, Hungary; and Federacja Polskich Banków Żywności, Poland. As aforementioned, these data were acquired by sending out FEBA's 'Global Analysis datasheet' (Annex II) to the CSOs. As members of FEBA, the datasheet was familiar to the most organisations, with the exception of Yhteinen Pöytä of Finland, who are not a FEBA member. Yhteinen Pöytä reported their data in their own format, which was then entered into the FEBA format by the author.

Within the datasheet the quantities of Food Surplus received and delivered are recorded in nine product categories: 1) Fruits and vegetables; 2) Dairy products; 3) Biscuits, cereals, starchy food; 4) Drinks, sauces, baby food; 5) Prepared food; 6) Meat, Fish; 7) Sweet products; 8) Fats, oils; 9) Others. Although more granular data can be recorded in the form of sub-categories, since 2017 FEBA requires reporting only on the level of the nine 'super-categories', having determined the workload of such monitoring overly burdensome and counterproductive.

The data on the CSOs' operations are similarly recorded in a few indicator categories. The ones used for this Thesis work are information on: square meters of warehouse and office space; cubic meters of positive and negative cold room storage; numbers of positive and negative cold transport vehicles on the road; and numbers of hand pallet trucks and forklift trucks in operation.

To determine the 'carbon saved' through the rescued Food Surplus and the 'carbon emitted' through the operations of the CSOs, Emission Factors (EFs) of each product and operation category need to be determined. Methodology on estimating the final carbon accounts in section 2.3.6. Carbon Accounts.

2.3.5. Emission Factors

The Emission Factor (EF; kg CO2eq. per unit) of a product or an activity includes all carbon and other emissions embedded into it throughout its lifecycle including, inter alia, the electricity, fertiliser and fuel production, packaging, storage and transport. In a regular LCA the Emission Factors (EF) are determined by a LCA database that the Life Cycle analyst has chosen for the study. Here, however, each FEBA product category includes several items and the author did not have access to an adequately diverse LCA database. Therefore, the decision to scour LCA literature for product EFs and determining the product category Emission Factors 'manually' was made. This also enabled the author to tailor the EFs based on knowledge on what types and quantities of products ROs normally receive; determined by a weighted mean of selected indicator products. Similarly, the Emission Factors related to the operations of the CSOs were determined by a review of relevant literature. Further descriptions can be found in the following chapters: 'FEBA Product Categories' and 'CSO Operations'.

In addition to carbon emissions, all products and operations have other great impacts on the environment, inter alia, resource depletion, stratospheric ozone depletion, nutrient enrichment and ecotoxicity (Zampori *et al.,* 2016), that are commonly included as impact categories in LCA studies. This work however specifically concentrates on the contribution to climate change; the carbon saving from of the redistributed food products, adjusted to the carbon emissions resulting from the CSOs' operations related to redistribution.

Terminology

The notation 'CO_2eq.' refers to 'carbon dioxide equivalents', which takes into account the mix of different greenhouse gases (GHGs) emitted by an activity (e.g. energy production or diesel use by a harvester). Different GHGs have different Global Warming Potentials (GWP), meaning that they differ in their strength to absorb infrared radiation. As one mass unit of carbon dioxide (CO_2) is used as a reference gas, e.g. methane (CH_4) and nitrous oxide (N_2O) emissions are converted to match the greenhouse gas potential of CO_2 over a 100-year period. As the GWP of a GHG changes through time (e.g. methane is very potential but decays faster in atmosphere compared to CO_2), a standard time scale needs to be used. Following the

standard of the Intergovernmental Panel on Climate Change (Pachauri *et al.,* 2014). The GWP over 100 years is used, as commonplace across the LCA literature.

FEBA Product categories

As previously described; FEBA's 'Global Analysis datasheet' (Annex II) includes nine product categories that received foodstuffs and other items are recorded in: 1) Fruits and vegetables; 2) Dairy products; 3) Biscuits, cereals, starchy food; 4) Drinks, sauces, baby food; 5) Prepared food; 6) Meat, Fish; 7) Sweet products; 8) Fats, oils; 9) Others. As all product categories are comprised of several different products, two or more indicator products were chosen to represent each category. Literature and databases were consulted for individual indicator product's EFs. Relative weights within each product category were assigned per indicator product, based on information on the average composition of products arriving at CSOs. Additional verification and validation of weights was based on interviews, site visits, datasheet information (subcategories) and literature. This enabled the calculation of the final weighted average EF of each product category.

The indicator products chosen, and the format used to collate and calculate the Emission Factors were inspired by the FUSIONS project's bottom-up database (Scherhaufer *et al.*, 2015), considered the golden standard for food waste research in the EU. However, many additional sources were incorporated to include products not covered by Scherhaufer *et al.* (2015) and to add sensitivity to the product categories installed by the FEBA (see: ANNEX VI). The literature was chosen to represent diversity of geographical locations to arrive at representative pan-European averages. It was thusly assumed that all product categories share the same EF despite the location of the partner organisation and redistribution efforts. Similarly, assumptions were made on the share of domestic product donations to imported product donations. Products coming from out of the country often have a higher carbon footprint due to higher food miles, but depending on the production method and season, a domestic greenhouse tomato for example may include more embedded carbon. As our data lacks the granularity of production method (e.g. organic, field or greenhouse), origin (e.g. China, Morocco or France), transport (e.g. freight, ship or van) and operations' energy mix (e.g. renewable, natural gas or coal), many specific assumptions were needed to be made per product category. Additionally, the FEBA categories are based on shared nutritional and calorific content, not their similar embedded carbon content. Therefore, large variability within-category exists, as only the 'super-category' level quantities are known. It is assumed that the CSOs categorise products into the super-categories informed by the subcategories. For example, the subcategory 'coffee, chicory, tea, cacao' is under category 4) 'Drinks,

sauces, baby food', making coffee and cacao powder category 4 products; which might not happen in the absence of the subcategories. These uncertainties are attempted to be mitigated by the weighting method, and reporting on the range of indicator product EFs from literature.

All reported Emission Factors (EFs) within the FEBA product categories are given as one kilogram of carbon dioxide equivalents per kilogram of product ($kgCO_2eq./kg$).

The next sections will explain the specific assumptions and the justification for sources, ranges, weights and methodologies used for each product category.

1) Fruits and vegetables

This large category includes everything from a locally sourced potato (low energy cost, short supply chain) to a can of exotic fruit salad (multiple origins, complex processing and packaging, long supply chain), making it a very sensitive category for uncertainty. Instead of including separate low, medium and high impact scenario analysis, a few indicator products were chosen to represent the category. For example, tropical fruits were left out, because although their impact can be significant (Karlsson-Kanyama & González: fresh fruit from overseas by plane: 11.0 $kgCO_2eq./kg$), their share in donations is low.

Table 17. The Emission Factor (EF) of 'Category 1: Fruits and vegetables' as the weighted mean of the EFs of indicator products. Potato and tomato represent the average vegetable, and apple the average fruit in the European market.

Category 1: Fruits and vegetables					
	EF	Range	Weight	Sources [29]	Notes
Potato	1.02	0.17 - 2.37	0.3	a., b., c., e., f., g.	High values relate to high processing
Tomato	2.74	0.08 - 9.3	0.3	a., b., c., g.	The max value 9.3 comes from a study with heated tunnel tomatoes
Apple	0.55	0.24 - 0.82	0.4	a., b., c., e., f., g.	The FUSIONS meta-analysis a 1.28 EF is found with NZ apples, but median value from study used here.
Weighted Mean	**1.35**				

2) Dairy products

This category includes common dairy products like milk, cheese, and butter. Eggs are also included in this category. Again, a few indicator products were chosen to represent the EF of the entire product category.

[29] a. WWF Austria, 2015; b. Taylor, 2000; c. FUSIONS, 2015; d. Schneider, 2013; e.Karlsson-Kanyama & González, 2009; f. Barilla, 2010; g. Wallén *et al.,* 2004; h. Carbon Trust, 2008

Table 18. The Emission Factor (EF) of 'Category 2: Dairy products' as the weighted mean of the EFs of indicator products.

Category 2: Dairy products					
	EF	Range	Weight	Sources [30]	Notes
Milk	0.98	0.41 - 1.40	0.4	a., b., c., e., f., g.	-
Yogurt	1.21	0.89 - 1.60	0.25	a., b., f.	-
Cheese	8.84	6.64 - 11.0	0.1	a., b., e., f., g	-
Butter	4.80	0.98 - 8.80	0.1	a., b., f., g.	-
Eggs	3.20	1.35 - 2.48	0.15	a., e., f., g.	-
Weighted Mean	**3.70**				

3) Biscuits, cereals, starchy food

This diverse category includes bakery and confectionary items, pasta, rice, flour, cereals, biscuits and so forth. The main contributor to this category is bread (although not specifically named as a product by FEBA), which is one of the largest waste streams for supermarkets and other food business operators. Bread has a significant climate footprint, although the EF per unit is low (Møller *et al.,* 2014)

Table 19. The Emission Factor (EF) of 'Category 3: Biscuits, cereals, starchy food' as the weighted mean of the EFs of indicator products.

Category 3: Biscuits, cereals, starchy food					
	EF	Range	Weight	Sources [31]	Notes
Bread	1.01	0.76 - 1.29	0.7	c., f., g.	-
Biscuits	1.88	0.69 - 2.64	0.15	b., f., g.	-
Wheat flour	1.01	0.39 - 0.63	0.1	a., e., g.	-
Rice	2.91	1.3 - 5.58	0.05	a., b., e., f., g	-

[30] a. WWF Austria, 2015; b. Taylor, 2000; c. FUSIONS, 2015; d. Schneider, 2013; e.Karlsson-Kanyama & González, 2009; f. Barilla, 2010; g. Wallén *et al.,* 2004

[31] a. WWF Austria, 2015; b. Taylor, 2000; c. FUSIONS, 2015; d. Schneider, 2013; e.Karlsson-Kanyama & González, 2009; f. Barilla, 2010; g. Wallén *et al.,* 2004; i. Killian *et al.,* 2013

Weighted Mean	**1.24**

4) Drinks, sauces, baby food

Although this category includes a diversity of food products from condiments to soft drinks, all with relatively low and uniform Emission Factors, with the exception of the 'coffee, chicory, tea, cacao' subcategory (see: ANNEX II). Coffee is used as an indicator product for this subcategory, as it accurately reflects its large variability, depending on origin, production method and certification. No reliable Emission Factor for baby food could be found in literature, but was estimated to be close to that of the indicator product: 'Condiments', assuming a vegetarian recipe and recycling of the glass jar container.

Table 20. The Emission Factor (EF) of 'Category 4: Drinks, sauces, baby food' as the weighted mean of the EFs of indicator products.

Category 4: Drinks, sauces, baby food					
	EF	Range	Weight	Sources [31]	Notes
Soda drink	0.48	0.4 - 0.56	0.6	a., g.	-
Coffee	4.45	0.4 - 7.96	0.3	a., g., i.	The low threshold value from WWF Austria study traced back to Vieux *et al.,* 2013 but rationale for such low value not discovered.
Condiments	0.7	0.07 - 1.47	0.1	a.	Taken as the average by categories: sauce, mayonnaise and salad dressing.
Weighted Mean	**1.69**				

5) Prepared food

This category includes cooked products that are either canned, frozen or fresh. Studies on the carbon footprints of pre-prepared foods are few, but relatively consistent. Thusly, one extensive study with multiple scenarios, was used to find an estimate of the median EF:

Rivera *et al.,* 2014. Canned, frozen and fresh meals have a relatively similar life-cycle emissions, with consumption contributing most on the footprint (removed). High early production intensity for canned food levels off as storage temperatures are ambient, and while frozen foods need constant freezing temperatures, the refrigerant use, leakage and wastage are smaller than for fresh, chilled meals on display at retailers (Rivera *et al.,* 2014). Ingredients for the indicator meal are: Chicken & vegetables: British from conventional farm and tomato paste: Spanish tomatoes from a conventional farm. Transport to and preparation in the United Kingdom.

Table 21. The Emission Factor (EF) of 'Category 5: Prepared food' as the weighted mean of the EFs of indicator products.

Category 5: Prepared food					
	EF	Range	Weight	Sources [32]	Notes
Frozen	3.00	2.4 - 3.6	0.7	j.	-
Fresh	3.1	2.2 - 3.4	0.3	j.	-
Weighted Mean	**3.03**				

6) Meat, Fish

Despite the high carbon footprint, meat and fish are quite rare as items of donation, due to low wastage, high cost and food safety concerns. Due to lack of better information on relative amounts of meat products received by Food Banks, weights were assumed to be uniform between indicator products.

Table 22. The Emission Factor (EF) of 'Category 6: Meat, fish' as the weighted mean of the EFs of indicator products.

Category 6: Meat, fish					
	EF	Range	Weight	Sources [33]	Notes
Beef	27.7	19.1 - 31.4	0.25	a., c., e., f.	-

[32] a. WWF Austria, 2015; j. Rivera *et al.,* 2014

[33] a. WWF Austria, 2015; b. Taylor, 2000; c. FUSIONS, 2015; e.Karlsson-Kanyama & González, 2009; f. Barilla, 2010

Pork	7.64	5.36 - 9.3	0.25	a., c., e., f.	-
Chicken	4.15	2.78 - 4.83	0.25	a., c., e., f.	-
Fish	4.13	4.02 - 4.27	0.25	a., c., f.	-
Weighted Mean	**10.9**				

7) Sweet products

Emission Factors of sweet products were found quite variable within literature, mostly pertaining to the origin and production method of sugar. Chocolate and 'other candy' were used as indicators, with the knowledge that chocolate makes up a large proportion of donations in this category.

Table 23. The Emission Factor (EF) of 'Category 7: Sweet products' as the weighted mean of the EFs of indicator products.

Category 7: Sweet products					
	EF	Range	Weight	Sources [34]	Notes
Chocolate	2.4	1.8 - 3.0	0.5	a., g.	-
Other candy	2.34	1.53 - 3.7	0.5	b., f., g.	-
Weighted Mean	**2.37**				

8) Fats, oils

As with many other categories, variability between data sources was high. Cooking oils especially exhibited a high range, depending on the crop that the cooking oil was based on.

Table 24. The Emission Factor (EF) of 'Category 8: Fats, oils' as the weighted mean of the EFs of indicator products.

Category 8: Fats, oils					
	EF	Range	Weight	Sources [34]	Notes

[34] a. WWF Austria, 2015; b. Taylor, 2000; e. Karlsson-Kanyama & González, 2009; f. Barilla, 2010; g. Wallén *et al.,* 2004

Margarine	1.59	0.54 - 2.12	0.4	a., b., g.	-
Cooking oils	2.66	0.35 - 3.9	0.6	a., b., e., f., g.	-
Weighted Mean	**2.23**				

9) Others

This category includes cleaning and hygiene products, but also products that the Food Banks have deemed not suitable for the other categories, making the EF inherently uncertain. Nevertheless, the category Emission Factor was calculated by using shampoo and laundry powder as indicator products. As the redistribution of these products does not replace the use [consumption] stage of these products, the emissions of the wash cycle are excluded from the emission factor.

Table 25. The Emission Factor (EF) of 'Category 9: Others' as the weighted mean of the EFs of indicator products.

Category 9: Others					
	EF	Range	Weight	Sources [35]	Notes
Shampoo	0.59	-	0.5	h.	Wash cycle not included
Laundry powder	0.50	-	0.5	h.	Wash cycle not included
Weighted Mean	**0.55**				

10) Summary and average 'groceries'

The summary table on the final EFs for each FEBA product category can be found below. Category 10: 'Average', was used for Yhteinen Pöytä's 'groceries' category. The average of 2.0 $kgCO_2eq.$ for a kilogram of food is consistent with the meta-analysis by Porter & Reay (2016b) where the EF of one kilogram of food produced in the EU ranges from 1.9 to 3.9 $kgCO_2eq./kg$, and the fact that Yhteinen Pöytä otherwise receives little products in the high

[35] a. WWF Austria, 2015; b. Taylor, 2000; c. FUSIONS, 2015; d. Schneider, 2013; e.Karlsson-Kanyama & González, 2009; f. Barilla, 2010; g. Wallén *et al.,* 2004; h. Carbon Trust, 2008

EF categories (figure 11). Furthermore, the study by Monier *et al.* (2010) determines the Emission Factor of avoidable food waste as 2.0 tCO2e t^{-1}, i.e. 2.0 $kgCO_2eq./kg$.

Table 26. A summary table of all FEBA product category EFs and the weighted average EF for a kilogram of food. Weights of each category based on the mean relative proportions of categories across the five CSOs.

	FEBA Product Category	EF ($kgCO_2eq./kg$)	Mean relative proportion (%)
1	**Fruits and vegetables**	1.35	35.11
2	**Dairy products**	3.70	15.19
3	**Biscuits, cereals, starchy food**	1.24	28.96
4	**Drinks, sauces, baby food**	1.69	9.90
5	**Prepared food**	3.03	2.18
6	**Meat, Fish**	10.91	2.66
7	**Sweet products**	2.37	2.37
8	**Fats, oils**	2.23	0.97
9	**Others**	0.55	1.09
10	**Average**	**2.00**	

CSO Operations

The size of operations of each case study organisation were estimated by extracting the information from FEBA Global Analysis datasheet (Annex II) on categories: 1) 'Premises' (warehouse, office space & cold storage space), 2) 'Vehicles' (number of refrigerated and non-refrigerated transport vehicles) and 3) 'Handling equipment' (number of pallet trucks & forklift trucks). Again, with only access to certain type and resolution of data, multiple assumptions were made in order to estimate the energy and fuel expenditures, and henceforth the carbon emissions related to the operations of each organisation. For example, the energy expenditure is referred from the size of warehouse as m^2, as there was no access to direct energy use data from organisations. Furthermore, would there ever be a need in the future to refer estimates of the carbon emissions and carbon savings of other FEBA members, the models created here could be used to use the information from the FEBA Global Analysis spreadsheet.

Similarly to the previous section on the food product Emission Factors (EF), the next paragraphs show the rationale, assumptions and arithmetic behind the EFs of each CSO operational category: 1) Premises; 2) Vehicles; and 3) Handling equipment.

1) Premises

Warehouses and offices

As all countries generate their electricity with a dissimilar mix of systems, from predominantly renewable to coal and lignite-based grids, the carbon intensity of each kilowatt hour produced (gCO_2/kWh) per country is affected. For example, in 2014 Poland still generated over 80 % of their electricity from coal and lignite (EEA, 2016). This results in a very high emission intensity; ten times as high as that of Austria, which in turn generates over 80 % of its electricity from renewable sources. Data on energy intensity is obtained from the European Environment Agency's indicator assessment report on European electricity production and use (EEA, 2016).

The EF of one square meter of 'Warehouse' is estimated as the product of a country-specific emission intensity of one kilowatt hour and the energy consumption of a non-residential building in that country. The EF of one square meter of 'Office' is estimated similarly, with the difference of using the average energy consumption of a residential building. Thusly, it is assumed that the data on the energy consumptions of average non-residential and residential buildings, in a given country, are representative of the energy consumption of the case study organisations' warehouse and office space respectively. The country-specific values on energy consumption per square meter of different building types are obtained from the European Union's Building Stock Observatory database (EC, 2018a), based on building stock characteristics and shell performance.

Table 27. The Emission Factors for one square meter of Warehouse and Office space in the five target countries and the EU-28 average for reference. Carbon intensity data from 2014 (EEA, 2016); non-residential and residential energy consumption data from 2013 and 2014 respectively (EC, 2018).

	Austria	**Denmark**	**Finland**	**Hungary**	**Poland**	**EU-28**
a1. Carbon intensity of kWh electricity produced 2014 (**gCO_2/kWh**)	60.1	166.1	106.4	206.6	670.6	275.9
b1. Non-residential energy consumption per m² 2014 (**kWh/m²/year**)	147.1	199.2	276.0	194.8	188.1	250.2
c1. Residential energy consumption per m² 2014 (**kWh/m²/year**)	173.16	148.33	208.78	128.7	212.11	158.76

ab1. **Warehouse EF** per m^2 as: a1 * b1 / 1000 (**$kgCO_2/m^2$/year**)	**8.8**	**33.1**	**29.4**	**40.3**	**126.2**	**69.0**
ac1. **Office EF** per m^2 as: a1 * c1 / 1000 (**$kgCO_2/m^2$/year**)	**10.4**	**24.6**	**22.2**	**26.6**	**142.2**	**43.8**

Positive and negative cold rooms

Although the Food Hygiene Package of the EU (EC Regulations No 852/2004 and 853/2004) does not specify the storage temperatures of chilled and frozen foodstuffs, all organisations redistributing food have to comply with the cold-chain requirements set by national legislation as food business operators. According to the European Commission Regulation 2015/1095 on the ecodesign requirements for refrigerated storage, the temperature of 'chilled' foodstuffs needs to be maintained between – 1 °C and 5 °C, and lower than – 15 °C for 'frozen' foodstuffs (EC, 2015). This regulation however specifically excludes walk-in and medium sized storage, because of their "unique characteristics". As no other EU Regulation governs the temperatures of walk-in positive and negative cold rooms, these temperatures will assumed as standard in the analyses of this Thesis work.

Estimating the energy consumption of cold rooms, operating either in positive (or 'chilled') or negative (or 'frozen') temperatures, is a notoriously difficult task. As identified by the 'ICE-E' or "Improving cold storage equipment in Europe" project, the variation in the specific energy consumption (SEC) between operators may range from 4 to 250 kWh/m^3/year (Evans, 2014). The project names twenty-one factors that affect the energy efficiency and functionality of a cold room, inter alia; refrigerant cycles, compressors, heat exchangers, pumps, insulation and structure; control systems (defrosts, lighting, fans) and maintenance. Furthermore, as the relative humidity and temperature outside of the cold room dictates the temperature gradient which the compressors need to maintain, the geographical location of the storage factors into its energy consumption. However, as the access to the cold rooms may or may not occur through an already heated area (e.g. a warehouse), the ability to construct predictive models or reliable averages is complicated further. In general, analyses like ICE-E (Evans, 2014) find that relationships between annual energy consumption and factors recorded from businesses are hardly ever linear and have low predictive power. Therefore, it goes without saying that the estimates presented in this Thesis work, for the organisations' average energy consumption, have significant margins of error.

These uncertainties are in part resolved by reiterating the assumption by aforementioned ICE-E report (covering 21 countries) that the extremes of low and high energy consumption cold rooms are relatively rare. Cutting 10 % of the extreme ends of the distribution helps in stabilising the mean, and arriving at roughly similar global estimates as the IIR (International Institute of Refrigeration; 30 to 50 kWh/m^3/year; Duiven *et al.,* 2002). The below table shows the annual energy consumption of one cubic metre of positive and negative cold storage and its resulting EF as adjusted for the carbon intensity of one kilowatt hour of electricity produced in each country.

Table 28. The Emission Factors for one cubic meter of positive and negative cold room space in the five target countries and EU-28 for reference. Data for mean SEC (10 % upper and lower values removed) from ICE-E report by Evans (2014) and data for the 2014 Member State carbon intensity (gCO2 per kWh electricity produced) from European Environment Agency (2016).

	Austria	**Denmark**	**Finland**	**Hungary**	**Poland**	**EU-28**
a2. Carbon intensity of kWh electricity produced 2014 (**gCO_2/kWh**)	60.1	166.1	106.4	206.6	670.6	275.9
b2. Positive cold energy consumption (**kWh/m^3/year**)	52.2	52.2	52.2	52.2	52.2	52.2
c2. Negative cold energy consumption (**kWh/m^3/year**)	66.3	66.3	66.3	66.3	66.3	66.3
ab2. EF positive cold as: a2 * b2 / 1000 (**$kgCO_2$/m^3/year**)	**3.14**	**8.67**	**5.56**	**10.78**	**35.01**	**14.40**
ac2. EF negative cold as: a2 * c2 / 1000 (**$kgCO_2$/m^3/year**)	**3.98**	**11.01**	**7.06**	**13.70**	**44.46**	**18.29**

2) Vehicles

Positive and negative cold transport

The information in the FEBA Global Analysis on the Members' car fleet is recorded as number of vehicles. Thusly also the EF is reported here per vehicle, rather than per kilometer or tonne-kilometer as often customary in LCA studies. Therefore, the most critical

assumption here will be the average distance driven by a vehicle per year. It is assumed that the average vehicle drives a **distance** of 70 kilometers per day [36] over six full operating hours, six days a week, through the whole year (288 days). The system boundaries include diesel consumption of the vehicles, diesel production and processing, and diesel use of running refrigeration units. Manufacturing and end-of-life of the vehicles is not included in the impact assessment. The main deciding factors therefore for a vehicle's EF well-to-wheel are: the emissions of diesel production, distribution and use; as emissions per kilometer driven in Europe. Subsequently, the emissions related to the use of positive and negative cold refrigerations units on the vehicles is added.

The average **efficiency** (fuel use per km), which directly relates to the EF of operating vehicles ($kgCO_2eq.$ per vehicle per year), depends on several factors: vehicle size, fuel type, age, class, country, make, typography of route, driver behaviour, payload, % capacity used et cetera. The reference vehicle chosen for this Thesis work is a standard Diesel DICI [37] van / Light Goods Vehicle (LGV) up to 3.5 tonnes gross vehicle weight. Although the European average mass of an LGV is 1.83 tonnes (based on market share of different models; ICCT, 2014), a higher average is taken to account for the inclusion of the payload. The EU Regulation No 510/2011 defines the mean CO_2 emission target for new [empty] LGVs at 175 gCO_2 per kilometre by 2017. Due to the added mass from the average payload, other GHG emissions, and the age structure within fleet; the average emissions per kilometer are set as 220 $gCO_2eq./km$ (Edwards *et al.,* 2014).

As the **LGV fleet** in Europe is approximately 95% **diesel** (ICCT, 2014) all emissions here are calculated using diesel as a reference fuel. The emissions of producing one megajoule (MJ) of diesel was based on a meta-analysis by Eriksson and Ahlgren (2014)[38]. The life-cycle emissions are described from well-to-tank, including, inter alia; extraction, crude oil production, diesel refining, VFF [39] and transport to filling stations. Most extreme values identified in the analysis were related to processes with high uncertainty like oil exploration, accidents, and construction and decommission of plants and machinery, and were thusly excluded from the mean; 10.9 $gCO_2eq./MJ$, used in this Thesis work. As the energy density of diesel is 36 MJ per kilogram (Kolb & Siegmund, 2017), the carbon emissions of one litre diesel produced for the European market is 0.39 $kgCO_2eq$, representing an average also found

[36] Based on information from three CSOs. As an estimate was not received from all CSOs, a differential calculation between organisation could not be run.
[37] DICI = Direct Injection Compression Ignition technology in an Internal Combustion Engine
[38] Mean calculated based on data in p. 21 Table 2. of Eriksson & Ahlgren (2014)
[39] VFF = Venting, Flaring, Fugitive

in EU literature (DG ENER, 2015). Based on efficiency of new vehicles, the fuel consumption at 220 $gCO_2eq./km$ is 6.3 litres per 100 kilometers (ICCT, 2017).

The emissions related to the running of the **Transport Refrigeration Units** (TRUs) in the vehicle are also very cumbersome to estimate. The most impactful factors on TRU diesel use (and thusly their carbon emissions) are the refrigeration technology, temperature gradient, and engine type and speed (Ryska, 2007; Barnitt *et al.,* 2010). Most commonly the refrigeration units on small vans in Europe are vehicle-powered installations, where the compressor is driven by the the engine crankshaft via a belt-drive. The electric fans and blowers responsible for moving the air in the cargo hold are usually supplied by the vehicle alternator. Most EU documents focus on the issue of emissions from Heavy Goods Vehicles (HGV; > 3.5 tonnes) and estimates for fuel consumption of small refrigeration units are not readily available. Thusly, assuming a standard engine [40] and a standard alternator [41] at standard temperature conditions (0/+30°C) [42] and standard refrigeration unit and fan power [43], the fuel consumption of a standard TRU installation is 1.9 litres per hour (Ryska, 2007). Furthermore, Tassou *et al.* (2009) show that, in ambient conditions of +30°C, the infield fuel consumption is higher for 'frozen' (-25°C) compartments vehicles with 2.5 to 3.0 litres per hour, compared to 0.5 to 1.0 l/h of 'chilled' (+3°C) compartments, due to equipment cycles on/off as doors are opened and closed [44]. However, as the average ambient temperatures in our target countries are routinely below +30°C, this difference is likely not be as stark [28]. Thusly, based on these two studies, it is assumed that positive cold TRUs (0 to +3°C) consume 1.8 litres and negative cold TRUs (-20 to -25°C) 2.6 litres of diesel per one hour of operation. The carbon emissions of one litre of diesel are calculated as 2.67 $kgCO_2$ as per a study by the DG Environment (Valsecchi *et al.,* 2009).

The FEBA information sheet also reserves a cell for reporting the quantity of 'other' vehicles on the road. These vehicles are assumed to have the same size, fuel efficiency, mileage and emissions as the refrigerated LGVs [45].

[40] Standard engine specific fuel consumption = 165 g/kW
[41] Standard vehicle alternator: 24V DC, 100 A to 150 A with 50% efficiency (6000 RPM)
[42] Inside temperature in van 0 °C and +30 °C outside of van
[43] Electric refrigeration unit power = 9.5 kW; Electric fans power = 2.36 kW
[44] Data based on infield fuel consumption rates for a dual compartment 13.6m semi-trailer in +30°C ambient temperature. Study also shows that refrigeration duty (W) is lower for freezing than chilling.

[45] Some of the 'other' cars are known to be passenger vehicles, but adjusting for this would not change the carbon arithmetic significantly due to original uncertainty in payload and kilometers driven.

Counterintuitively, the inclusion of an extra vehicle to an organisation's fleet might actually decrease the overall emissions from distribution as the logistics can be optimised. Increases in efficiency by optimisation are difficult to estimate.

Table 29. The Emission Factors for Light Goods Vehicles (>3.5 t) operating with either a positive (0 to +3°C) or a negative cold (-20 to -25°C) compartment temperature. TRU = Transport Refrigeration Unit. LGV = Light Goods Vehicles.

	unit	value
REFRIGERATION		
Positive cold TRU fuel expenditure per hour	L/h	1.80
Negative cold TRU fuel expenditure per hour	L/h	2.60
Hours in operation per year	h/year	1,728
1 L Diesel emissions	$kgCO_2eq./L$	2.67
Positive cold refrig. per vehicle per year EF	$kgCO_2eq./year$	**8,304.77**
Negative cold refrig. per vehicle per year EF	$kgCO_2eq./year$	**11,995.78**
DRIVING		
Fuel direct emissions LGV	$gCO_2eq./km$	220
Distance driven per day	km/d	70
Full days operated per year	d/year	288
Distance driven per year	km/year	20,160
1 vehicle year driving related EF	$kgCO_2eq./year$	**4,435.20**
PRODUCTION		
Fuel production emissions	$kgCO_2eq./L$	0.39
Fuel consumption LGV at 220 $gCO_2eq./km$	L/km	0.063
Distance driven per year	km/year	28,800
Positive cold refrigerant diesel use / year	L/year	3,110.40
Negative cold refrigerant diesel use / year	L/year	4,492.80

Positive cold vehicle diesel prod. related EF	$kgCO_2eq./year$	**1,920.67**
Negative cold vehicle diesel prod. related EF	$kgCO_2eq./year$	**2,459.81**
TOTAL		
Annual positive cold vehicle EF	**$kgCO_2eq./year/vehicle$**	**16,561.44**
Annual negative cold vehicle EF	**$kgCO_2eq./year/vehicle$**	**20,791.58**
Annual other vehicle EF	**$kgCO_2eq./year/vehicle$**	**7,043.62**

3) Handling equipment

Hand pallet trucks and forklift trucks

Hand pallet trucks are hand-powered jacks used in the warehouses to lift pallets of food around. As they use commonly no fuel or electricity, with the rare exception of a few models, they incur no direct emissions. As manufacturing and end-of-life emissions are excluded from this study, the pallet trucks are also excluded.

Similarly to the LGVs, the forklift trucks are assumed to operate 6 hours a day, six days a week throughout the year (288 days). The most common forklifts run either on electricity or Liquefied Petroleum Gas (LPG). The well-to-wheel emissions from both of these technologies are roughly equal throughout the literature. The biggest differences are found in the use-phase, depending on assumption made on recharging efficiency and suboptimal operation. Based on a meta-analysis of LCA studies on forklift emissions by Johnson (2009), the average EF for the 'reference forklift' used in this study is set as 9.78 $kgCO_2eq.$ per hour.

Table 30. The annual Emission Factor calculation for a standard forklift truck operating either by LPG or electricity.

	unit	value
Forklift operation emissions per hour	$kgCO_2eq./h$	9.78
Hours operated per year	h/year	1,728
Annual forklift EF	**$kgCO_2eq./year/vehicle$**	**16,912.80**

2.3.6. Carbon Accounts

To account for the final balance between 'carbon saved' and 'carbon emitted' by the CSOs, the 'functional units' (kg food; m^2 storage; n vehicles etc.) were multiplied with the Emission Factors (EF). This gave the Carbon Footprint (CF) of food (carbon saved) and operations (carbon emitted). The difference between these two CFs gives the final Carbon Account or 'climate impact' (in tCO2eq.) of the CSOs.

2.3.7. Socioeconomic indicators

Carbon pricing has become an established concept in Europe and can serve as an **economic indicator** of the viability or desirability of a project or other undertaking. Not all emissions are accounted to incur a payment for a company or an organisation, nor do avoided emissions incur them profit per se. However, it can be argued that as countries strive to fulfill their Nationally Determined Contributions as a part of the UNFCCC COP [46] Agreements, organisations preventing carbon emissions ought to be recognised for their mitigative capacity, also in monetary terms. Therefore, each tonne of carbon emissions avoided by CSO activities carries a value in euros as well. The price for a tonne of carbon depends of the Emissions Trading Systems (ETS) in question. The ETSs are a tools for, e.g. municipalities or countries to meet their commitments by becoming more carbon efficient through issuing companies with a limited number of carbon allowances. If the company is able to become more efficient and reduce its emissions it may sell surplus allowances with a determined carbon price, determined by the market. Although many ETS and carbon tax trials have faced great difficulties in implementation and operation, globally 51 are running today, covering 11 gigatons of CO_2eq. or 20 % of the global GHG emissions (World Bank & Ecofys, 2018). The combined value of these schemes in 2018 is 71 billion euros, up 56 % from 2017. Although Denmark, Finland and Poland have their own carbon tax, i.e. they have a nationally determined price for carbon, the European ETS carbon price is the most fitting base of reference to be used in this Thesis work. The current price for carbon stands at 21.25€ as of October 2018 [47]. The CSO-specific economic indicators were extracted from the FEBA Global Analysis datasheet. Following the request by some CSOs, the decision was made not to disclose specific financial information. The Social Cost Benefit Ratio (SCBR) was reported as the mean of the ratio between 'Food worth' (self-reported by CSOs) and money invested (not disclosed here) into the organisations. Importantly, the purpose of this Thesis

[46] UNFCCC = United Nations Framework Convention on Climate Change; COP = Conference of Parties

[47] The price per tonne from Markets Insider (2018). 3-month variability between 16.22 & 25.61 €

work is not to compare the organisations to each other, but to explore the approximate magnitude of positive impacts that food redistribution can have in Europe.

The **social indicators** were similarly extracted from the Global Analysis datasheet (ANNEX II); in the form of number of charities, beneficiaries, meals served, and people employed or volunteered. These numbers are used to show the purely social side of the socioeconomic impacts of the CSOs. The economic influence of the meals provided is reflected in part by the SCBR as it involves the worth of the food in the economy, but the social value of the meal and the volunteer and social contracts were not attempted to be quantified here in monetary terms. Quantifiable positive knock-on effects have been found to exist however, as described in the Discussion section later.

3. Results

3.1. Research question 1: Policy Frameworks

Table 31 describes the policy mix relating to Food Loss and Waste in the five Target Countries. These headings do not necessarily address food redistribution directly but have implications on the operations of the CSOs through availability of Food Surplus, regulatory burden, cost of food business operations etc. The table is collated from the FUSIONS country reports. The indicators determining how conducive the Target Countries' policy mix is for FLW prevention, food donation and food redistribution can be defined as follows: *'Reduction / prevention target'*: a set 'binding' target in national law on reduction and/or prevention of Food Loss and Waste - other than recalling the EU or UN general targets; *'Market-based instruments'*: increasing FLW prevention, recycling & recovery from a financial point-of-way by incentives and disincentives; *'Regulations and regulatory instruments'*: Regulations like a national Waste Management Scheme governing safety, food business law and donation etc.; *'Voluntary agreements'*: Agreements between the different stakeholders; industry, food banks, charities, government institutions etc. to facilitate food donation or other prevention methods; *'Technical reports and research'*: Government or academia led documents and publications on the issue of food loss and waste; *'National / Regional communication and campaigns'*: Materials released to the public sphere schools, workplaces etc. either physically or electronically - via various media e.g. pamphlets, classes, workshops, radio, TV, websites; *'Projects and other measures'*: Projects relating to FLW that do not fit in the previous categories; *'FLW included in other national plans / strategies'*: Direct or indirect mentions and knock-on effects on FLW in national plans and strategies not directly related with waste or food.

Table 31. Summary table of case study countries' FLW Policy Mix as collated from FUSIONS country-specific reporting (Country template in ANNEX V). Poland does not have a FUSIONS country report and hence its information was collated from other sources. Hungary's 'projects and other measures' were updated as 'implemented' due to its recent involvement in the REFRESH Pilot Working Platform (REFRESH, 2018).

Indicator	Austria	Denmark	Finland	Hungary	Poland
Reduction / prevention target	not in force	not in force	not in force	not in force	not in force
Market-based instruments	not in force	in force	not in force	in force	in force
Regulations and regulatory instruments	in force	in force	in force	in force	in force
Voluntary agreements	in force	in force	not in force	in force	in force
Technical reports and research	available	available	available	available	available
National / Regional communication and campaigns	implemented	implemented	implemented	implemented	implemented
Projects and other measures	implemented	implemented	implemented	implemented	implemented
FLW included in other national plans / strategies	yes	yes	yes	yes	yes

Table 32 describes the Best Practises relating to Food Loss and Waste, and more specifically to food donation and food redistribution in the Target Countries, affecting the operations of the Case Study Organisations (CSOs). These Best Practises have been collated from literature, interviews with the CSOs and FEBA, and from personal interactions in the field. Although the original purpose of the interviews conducted for this Thesis work was to serve as auxiliary information only; the main themes arising from more than one interview, were used to inform this section. The Best Practises can be defined as laws, regulations and measures determined most enabling of food redistribution can be defined as follows: *'VAT exemption'*: Value Added Tax entirely removed from when foods are donated and

redistributed.; *'Zero-value food'*: Value of food set to zero so that the VAT becomes zero as well. Less preferred than previous method; *'Good Samaritan'*: A form of a law where liability is shifted from donor to person / organisation receiving donation in the case of food safety issues; *'Tax deduction'*: Deduction from corporate tax base of some percentage of the value of food donated; *'Fiscal incentives'*: Other fiscal incentives like the Tax Deduction, making donation more attractive by decreasing direct or tax costs, or increasing incomes; *'Voluntary agreements'*: As with the Policy mix (table 31), but particularly pertaining to agreements on donation and redistribution; *'Fiscal disincentive'*: Every tonne wasted incurs a fine or a higher tax bracket, a.ka. Pay-as-you-Throw (PAYT); *'MSHP: Multi StakeHolder Platform'*: A platform where different actors in the food supply chain come together to discuss potential ways to facilitate food donation and transfer knowledge; *'National Guidelines'*: Specific guide published by a government body that describes the issue and rules of FLW and food donation. Meant for citizens, companies and charities alike.

Table 32. Legislative and other best practises conducive for food redistribution. *MSHP = Multi-Stakeholder Platform

Best Practise	Austria	Denmark	Finland	Hungary	Poland
VAT exemption	no	no	no	yes	yes
Zero-value food	yes	yes	yes	no	no
Good Samaritan	no	no	no	no	no
Tax deduction	yes	no	yes	yes	no
Fiscal incentives	yes	no	no	yes	no
Voluntary agreements	yes	yes	no	yes	no
Fiscal disincentive	no	no	no	no	no
MSHP*	yes	yes	no	yes	yes
National Guidelines	yes	yes	yes	no	no

Additionally, to Best Practises, multiple other themes arose from the CSO, the Federation of Finnish Food Aid Associations and FEBA interviews. They are shortly summarised in the table below to inform the Discussion section. Interviewee details cannot be disclosed due to a disclaimer sentence used before every interview (see: Interviews).

Table 33. A summary table of the main themes arising from multiple interviews with the CSOs, the Federation of Finnish Food Aid Associations and FEBA.

N	Theme	Description
1	Resources	Main constraints for operations are lack of staff, vehicles and warehouse space.
2	Investment	Investment is semi-stable but not enough to increase capacity as much as supply (Food Surplus) or demand (COs and beneficiaries) would allow. Large point investment needs for infrastructure growth, e.g. building or acquiring more storage or vehicles. Fundraising takes time and resources away from 'regular' activities.
3	Hygiene	Strict regulations make work sometimes cumbersome, especially in training volunteers, but not a constraint for growth.
4	EU Law	Different interpretations of the vague EU legislation cause uncertainty in bilateral agreements, but also within ROs. Especially Food Hygiene Package and food labelling and expiry mentioned. Also, questions of liability were common, but not linked necessarily to knowledge of certain law package. Good Samaritan concept or Gadda laws mentioned often. Incentives thought to be good to increase donation. Disincentives (PAYT) mentioned less but also thought to be good. Having the exact same responsibilities and scrutiny as all food business operators seen as sometimes 'unfair' or 'unsensible' and causing harm.
5	ICT	Many wish for better solutions for ICT (Information and Communications Technology) infrastructures to ease monitoring and reporting, and remove burden and confusion of paperwork. Would also significantly increase number of possible partner COs and DOs. A common European system is postulated and mentioned as an ideal future Best Practise.
6	Donations	Lack of donations is not a large issue. In many cases there would be more available Food Surplus to redistribute but ROs constrained by capacity. In Multi-Stakeholder-Platforms and other interactions with donors, food safety and hygiene concerns are found to dominate unwillingness; which in turn is attached to confusion and misunderstanding of the legislation and donation guidelines (proper national guidelines with legitimacy are wanted across EU).
7	VAT	Value-Added-Tax used to be a significant issue, but now this milestone has been reached and the battle for conducive legislation has moved to other mechanisms.
8	FEBA	Mostly a good relationship and occasional to frequent interactions. Knowledge and Best Practises sharing, funding and lobbying mentioned as biggest strengths. FEBA is doing a good job but has to find stronger purpose, communication and efficiency. Also visits between neighbouring countries ROs very important.
9	FEAD	Zero to 40 % of food coming from FEAD. FLW sourced from FEAD not seen as food waste reduction. There should be a redesign of FEAD. Additional funding mechanisms under FEAD seen as more beneficial and sustainable for the future.
10	Purpose	All CSOs want to prevent both food waste and poverty, increase awareness (schools, companies, general public), education (+innovation: home economics, meal planning etc.), provide more meals, lobby for FLW prevention and reduction - but multipurpose work is found difficult due to lack of investment and resources. Many ROs across Europe have different emphases, and countries differ from each other greatly also because types of poverty are different.
11	Social capital	It is agreed that food banks and the charities they serve bring a large variety of social benefits around their activities and these could be expanded much more with additional investment; elderly, young people, refugees and migrants need to be included more. Already ROs serve as a community for a diversity of different

		people from different backgrounds and reasons (also unemployed, disabled, students, businessmen) but could expand much more.
12	Government	It is difficult being almost but not quite an institution of the government. Many goals align, and dialogue is frequent, but investment is low and often support is in word only. Strengthening of food security is expected. Level and type of liaison between ROs and different government offices (agriculture, environment, health, education, social ministry etc.) differs between countries.

3.2. Research question 2: Socioeconomic and climate impacts

3.2.1. Socioeconomic impacts

As shown in the methodology, the average price for a kilo tonne of carbon in the European market was 21.25 € in October 2018. If the carbon savings in $tCO_2eq.$ equated into euros - without accounting for the worth of food saved or the value of social capital generated - the socioeconomic outcomes of CSOs become evident (table 34). Although a significant result, the social cost of carbon is yet less tangible and contested as a socioeconomic indicator than traditional return-on-investment or cost-benefit-ratios. Therefore, as further detailed below, the focus here is shifted towards the ratio between 'money invested in' and 'value reclaimed by' the CSOs.

The CSOs receive funding for example in the form of private donations, and government and municipality grants. These are used to, inter alia, cover salaries, transport and rent costs, and marketing materials. Not all CSOs share this financial information on their incomes and expenses and again, in the interest of not comparing the CSOs between each other, the Social Cost Benefit Ratio (ratio between funding received and cost saved for society - from table 34) is given as an average only and displayed graphically in figure 8.

Table 34. The economic savings of the CSOs. *Social Cost of Carbon calculated with the carbon price in the ETS on October 2018; 21.25€ per tonne. ** as self-reported by the CSOs in the FEBA Global Analysis, method of calculation unknown. *** Yhteinen Pöytä did not report food worth, number referred by kilo price of 3.00 €. **** SCBR = Social Cost Benefit Ratio calculated as the mean of the € saved to the € invested ratios, excluding the Social Cost of Carbon. [a] mean.

	Wiener Tafel (AT)	**Fødevare-Banken (DK)**	**Yhteinen Pöytä (FI)**	**Élelmiszer-bank (HU)**	**FPFB (PL)**	**Total CSOs**
Carbon saved ($tCO_2eq.$)	1,051.94	2,189.83	703.77	13,093.63	172,360.45	189,399.63
Social Cost of	22,353.82	46,533.86	14,955.14	278,239.70	3,662,659.5	4,024,742.0

carbon (€)*						
Food saved (kg)	615,241	919,685	455,174	9,222,510	68,831,874	80,044,484
Food worth (€)**	1,149,790	2,946,704	1,365,524***	16,117,923	68,259,712	88,474,129
Food price (€/kg)	1.87	3.20	3.00	1.75	0.99	2.16[a]
SCBR**	**10.4[a]**	**10.4[a]**	**10.4[a]**	**10.4[a]**	**10.4[a]**	**10.4[a]**

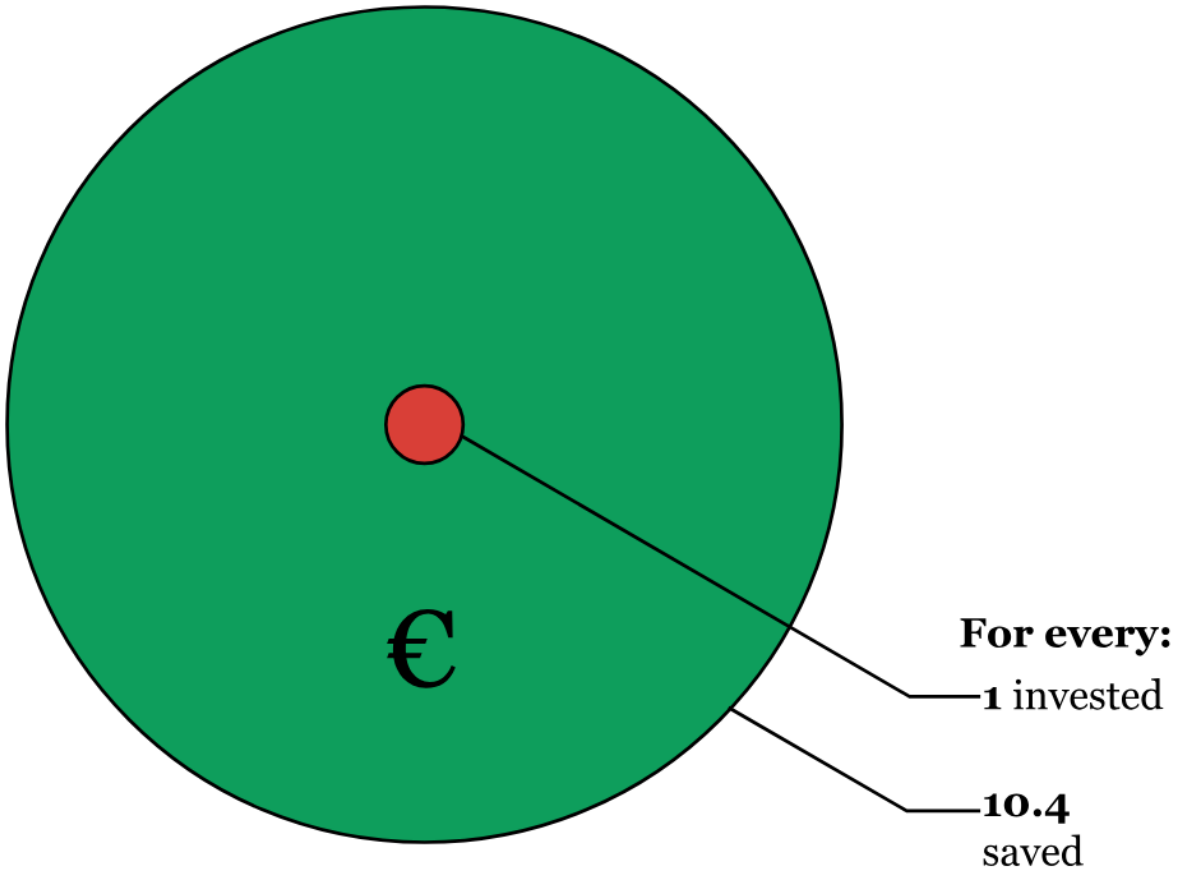

Figure 8. Graphical representation of the Social Cost Benefit Ratio of 10.4 (return-on-investment of 9.4 €), as the ratio between and funding received in € and cost saved for society in € in 2017.

Table 35 on the next pagesummarizes the social impacts, as represented by employment, social services and meals provided by the CSOs among and around their network. The far-right column of *'Total CSOs'* shows the social benefits brought to society through the indicators. It is evident that the organisations are fulfilling their duty of preventing food waste while providing meals to their beneficiaries on a daily basis. The CSOs also generate social

capital in the form of volunteer, social contract and paid positions. Social capital is likely additionally provided by services not quantified in and monitored by the FEBA datasheet in the form of, for example: groups and networks, trust and solidarity, collective action and cooperation, social cohesion and inclusion, information and communication, and food security and food safety (Scherhaufer *et al.,* 2015).

Table 35. Summary table of the quantified social benefits based on the FEBA Global Analysis sheet and FEBA's 2017 Annual Report. *Number of beneficiaries reported by CSOs, with significant discrepancy between Organisations, and calculation methods unknown. **Number of meals per day calculated based on FEBA method of 1.98kg food per meal; note: numbers rounded to closest hundred. ***Number significantly higher than other CSO's implying different method measuring.

	Wiener Tafel (AT)	**Fødevare-Banken (DK)**	**Yhteinen Pöytä (FI)**	**Élelmiszer bank (HU)**	**FPFB (PL)**	**Total CSOs**
Charities	117	200	50	354	3,342	**4,063**
Beneficiaries*	19,000	260,000	6,000	155,000	514,763	**954,763**
Food kg / yr	615,241	919,685	455,174	9,222,510	68,831,874	**80,044,484**
Meals / day**	3,300	5,000	2,500	50,000	373,300	**434,100**
Volunteers	18	180***	10	40	174	**422**
Paid	12	14	4	10	202	**242**
Social contract	1	3	20	0	39	**63**
Total employment	31	197	34	50	415	**727**

3.2.2. Climate impacts

Table 36 summarises the amount of food received as donation and the related carbon savings by each CSO in the year 2017. A more detailed data table on the quantities of food saved by the CSOs in each of the nine FEBA categories, the Emission Factors and emissions can be found in ANNEX III.

Table 36. Food received, and carbon saved in the year 2017 by the Case Study Organisations. Country of CSO in brackets. Note: different number of significant figures due to different errors.

	Wiener Tafel (AT)	Fødevare-Banken (DK)	Yhteinen Pöytä (FI)	Élelmiszer-bank (HU)	FPFB (PL)	Total CSOs
Food Received (kg)	615,241	919,685	455,174	9,222,510	68,831,874	80,044,484
Carbon saved ($tCO_2eq.$)	1,126.28	2,499.86	756.41	13,290.70	178,239.05	195,912.31

The following doughnut charts show the breakdown of the food received (left), and carbon saving incurred (right) in each of the nine FEBA categories by the five Case Study Organisation. In the case of Yhteinen Pöytä 'category 10: Average' is also used (refer back to 10) 'Summary and Average groceries' and '2.3.5. Emission Factors'.

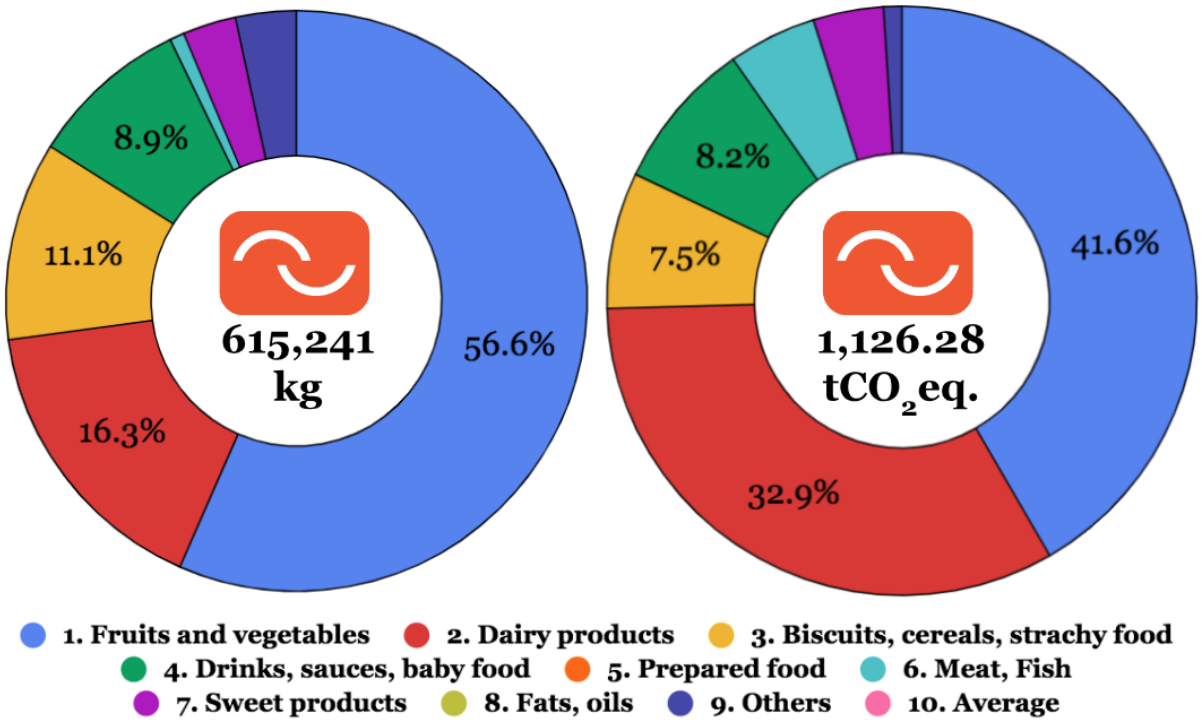

Figure 9. The food received [left] and carbon saved [right] by Wiener Tafel in Austria in the year 2017, broken down according to the nine FEBA categories.

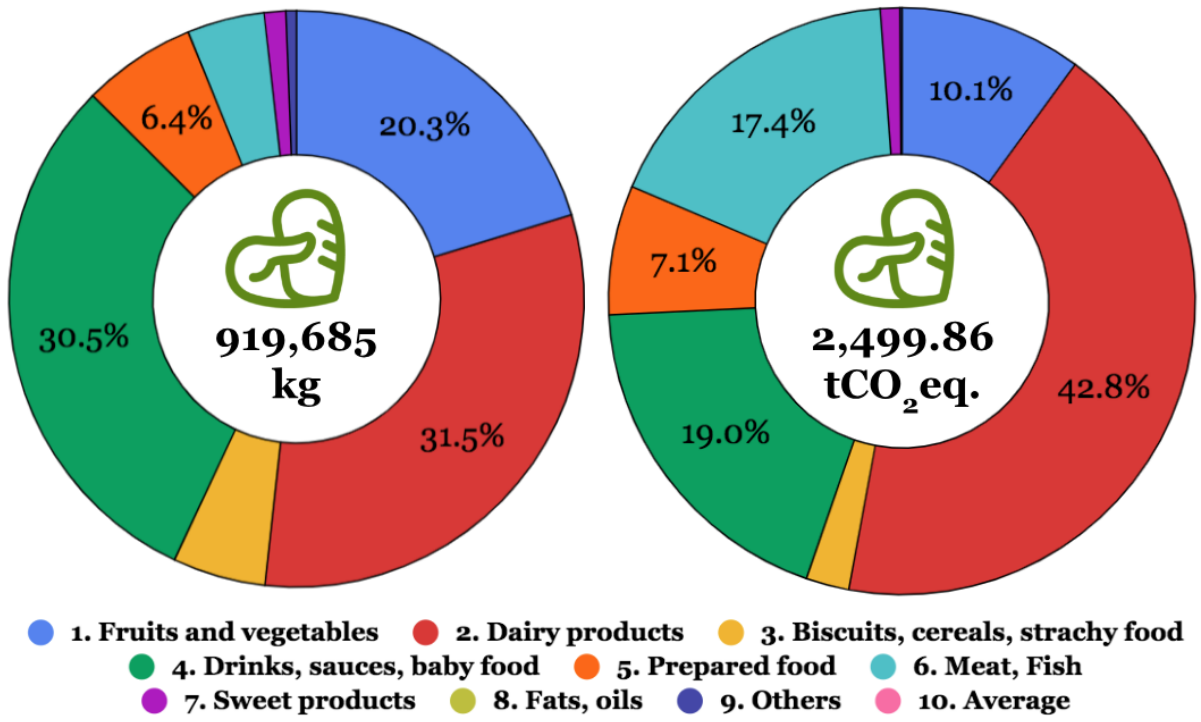

Figure 10. The food received [left] and carbon saved [right] by FødevareBanken in Denmark in the year 2017, broken down according to the nine FEBA categories.

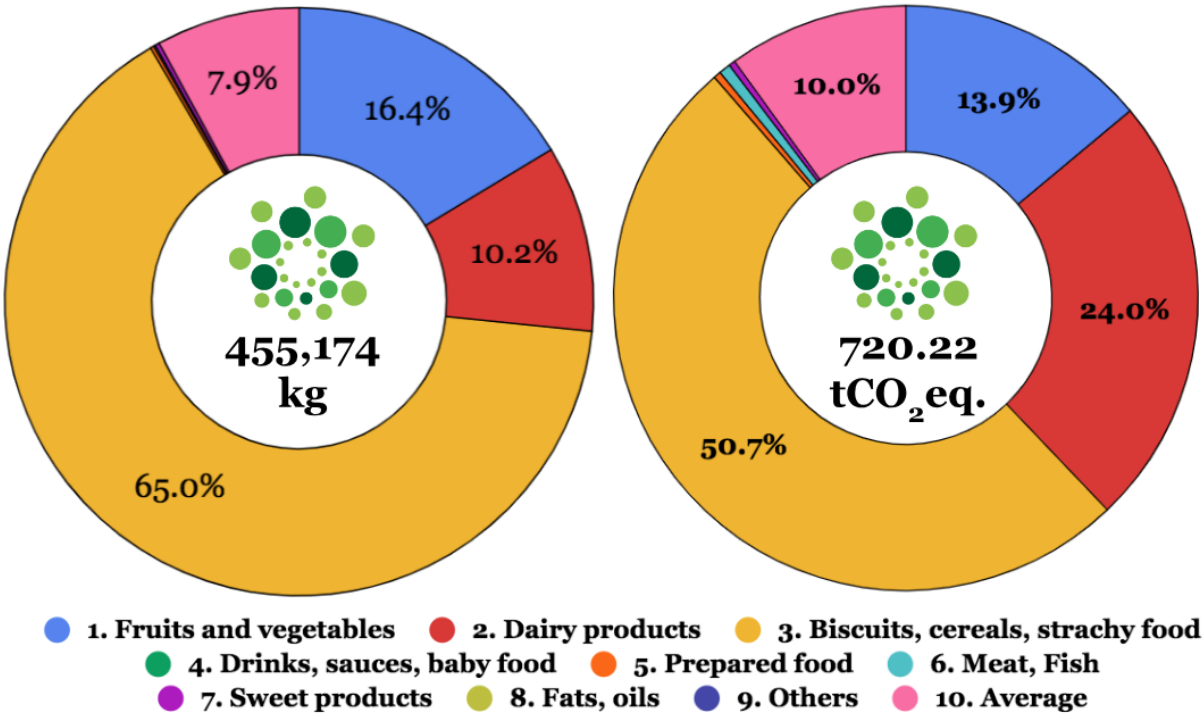

Figure 11. The food received [left] and carbon saved [right] by Yhteinen Pöytä in Finland in the year 2017, broken down according to the nine FEBA categories and one special 'Average' category.

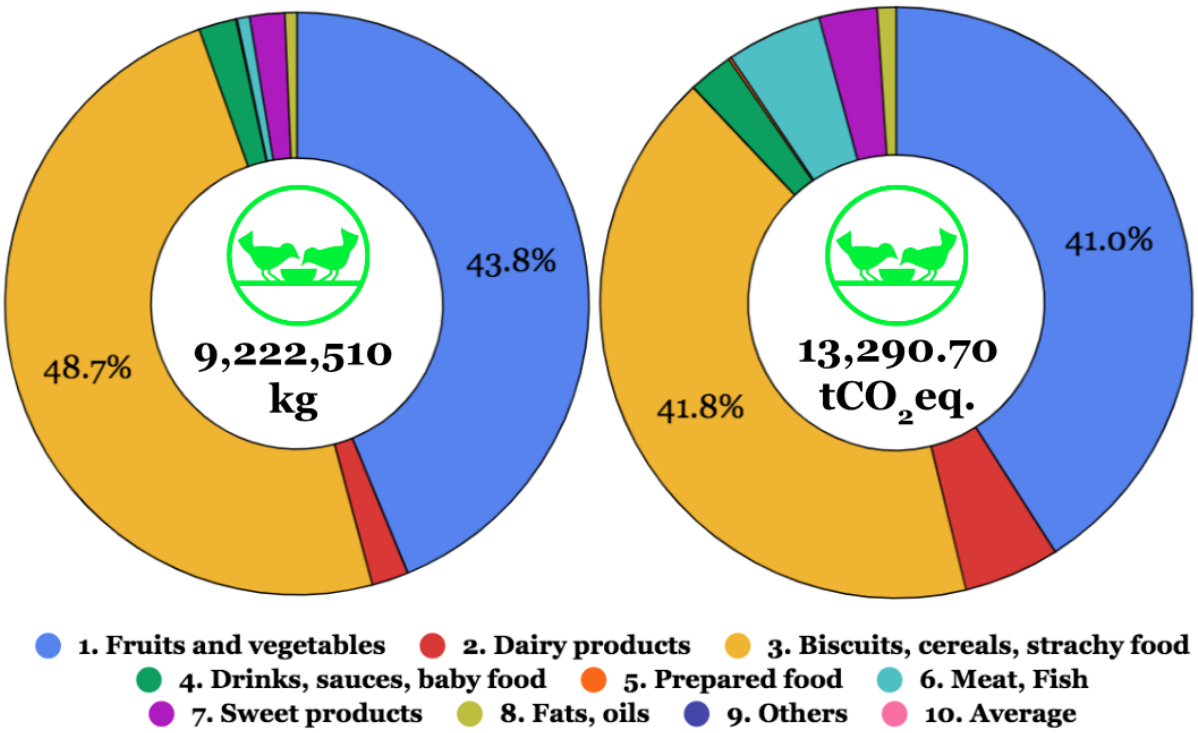

Figure 12. The food received [left] and carbon saved [right] by Élelmiszerbank (Magyar Élelmiszerbank Egyesület) in Hungary in the year 2017, broken down according to the nine FEBA categories.

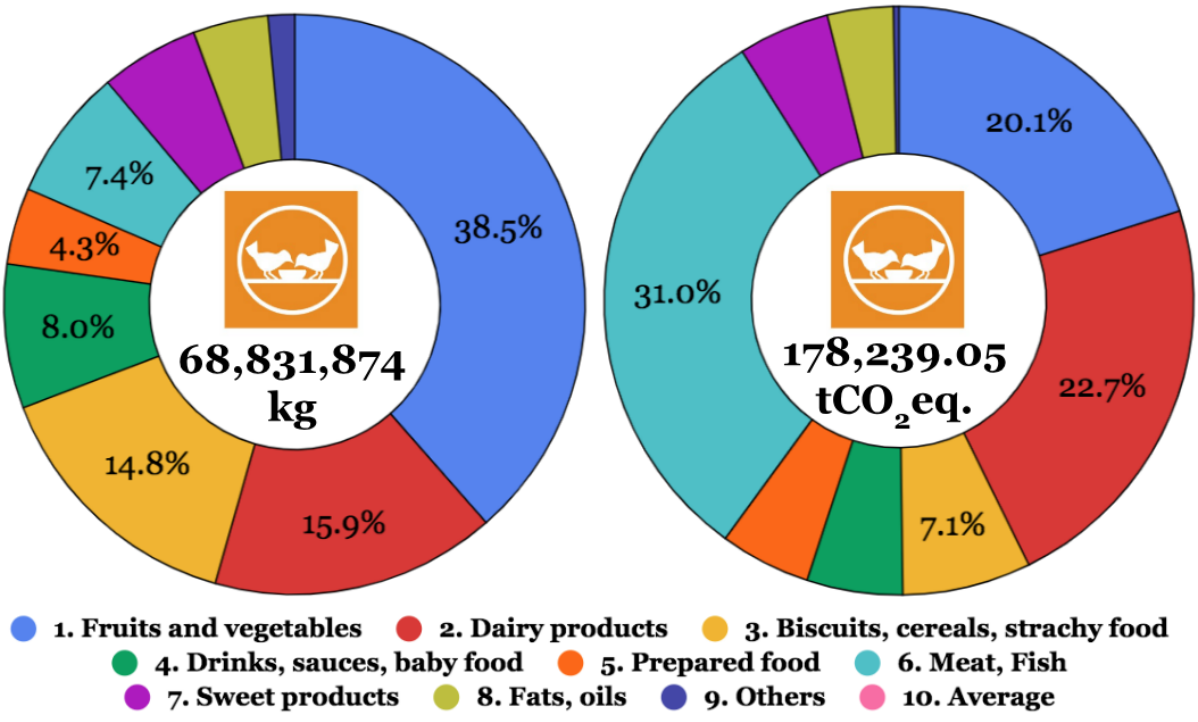

Figure 13. The food received [left] and carbon saved [right] by FPFB (Federacja Polskich Banków Żywności) in the year 2017, broken down according to the nine FEBA categories.

Figure 14 below summarises the carbon emissions released to the atmosphere due to the CSOs' operations, broken down by the operation indicators. A more detailed data table on the Emission Factors, size of the CSOs' operations and their related emissions can be found in ANNEX IV. Note that the total emissions in $tCO_2eq.$ can be found on the top of the stacked columns and differ by orders of magnitude due to the big difference in size of operations.

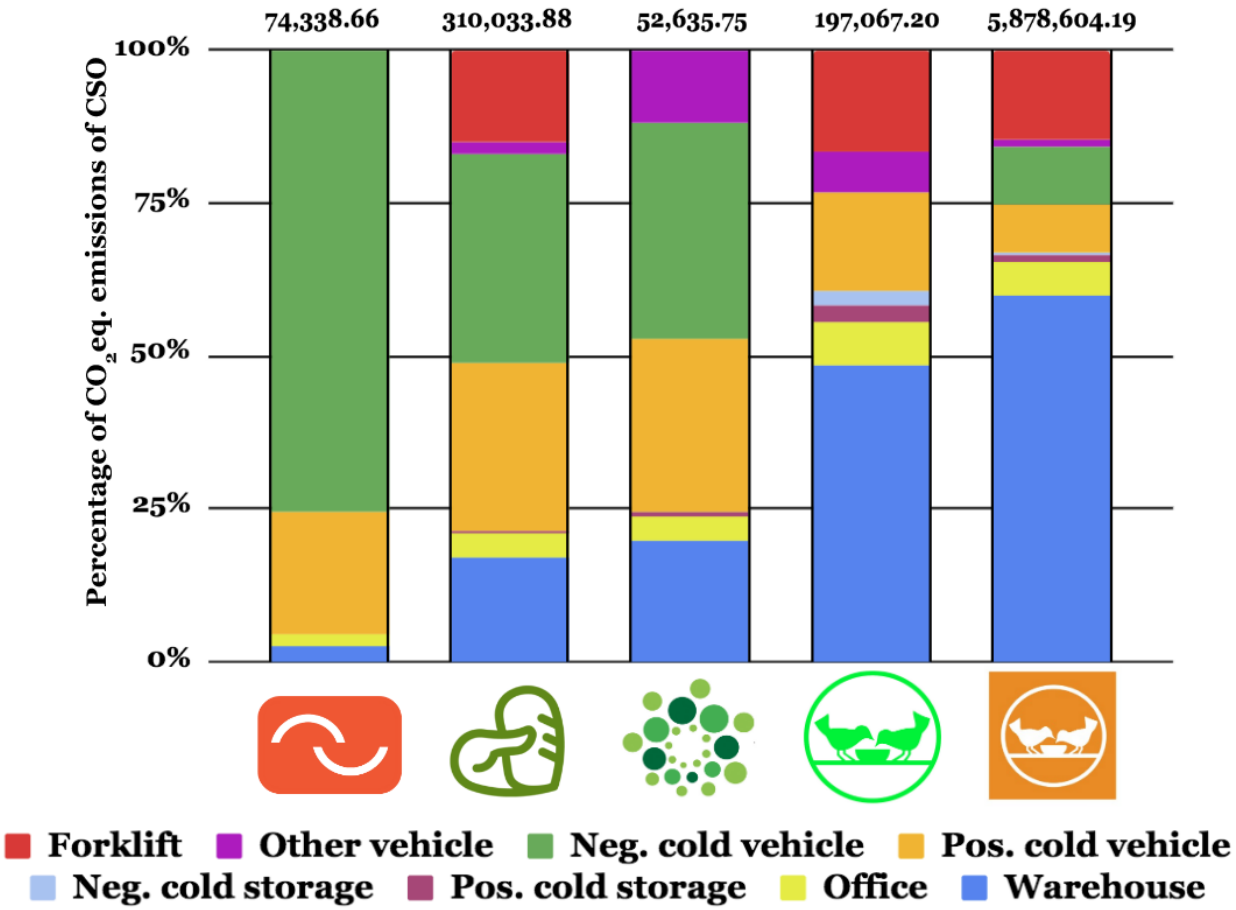

Figure 14. The carbon emissions of the CSOs per operation indicator. Numbers on the top of the column stacks are the total emissions of each CSO as tonnes of carbon dioxide equivalents ($tCO_2eq.$). The CSOs from left to right are: Wiener Tafel (AT), Fødevare Banken (DK), Yhteinen Pöytä (FI), Élelmiszerbank (HU) and FPFB (PL).

Table 37 shows the difference between the carbon saving and carbon emitted by the CSOs. It is evident that the organisations save more carbon than they emit. This data is difficult to show graphically as the differences between CSOs, and between carbon saved vs emitted are considerable. However, the average 'carbon efficiency', i.e. how many kilo tonnes of carbon dioxide equivalents are saved by each one emitted by the CSOs, is shown by figure 14. Only the mean carbon efficiency of the five CSOs is reported here because, as discussed before,

comparing the organisations to each other is not the purpose of this Thesis work, or even realistic due to their many idiosyncrasies.

Table 37. The final carbon account of each CSO as the difference between carbon saved and carbon emitted in kilo tonnes of carbon dioxide equivalents. The country of each CSO can be found in brackets following its name.

	Wiener Tafel (AT)	**Fødevare Banken (DK)**	**Yhteinen Pöytä (FI)**	**Élelmiszer-bank (HU)**	**FPFB (PL)**	**CSO Total**
Saved ($tCO_2eq.$)	1,126.28	2,499.86	756.41	13,290.70	178,239.05	195,912.30
Emitted ($tCO_2eq.$)	82.79	335.39	58.98	205.52	6018.07	6,512.68
Saved - Emitted ($tCO_2eq.$)	**1,043.49**	**2,164.47**	**697.43**	**13,085.18**	**172,220.99**	**189,399.63**

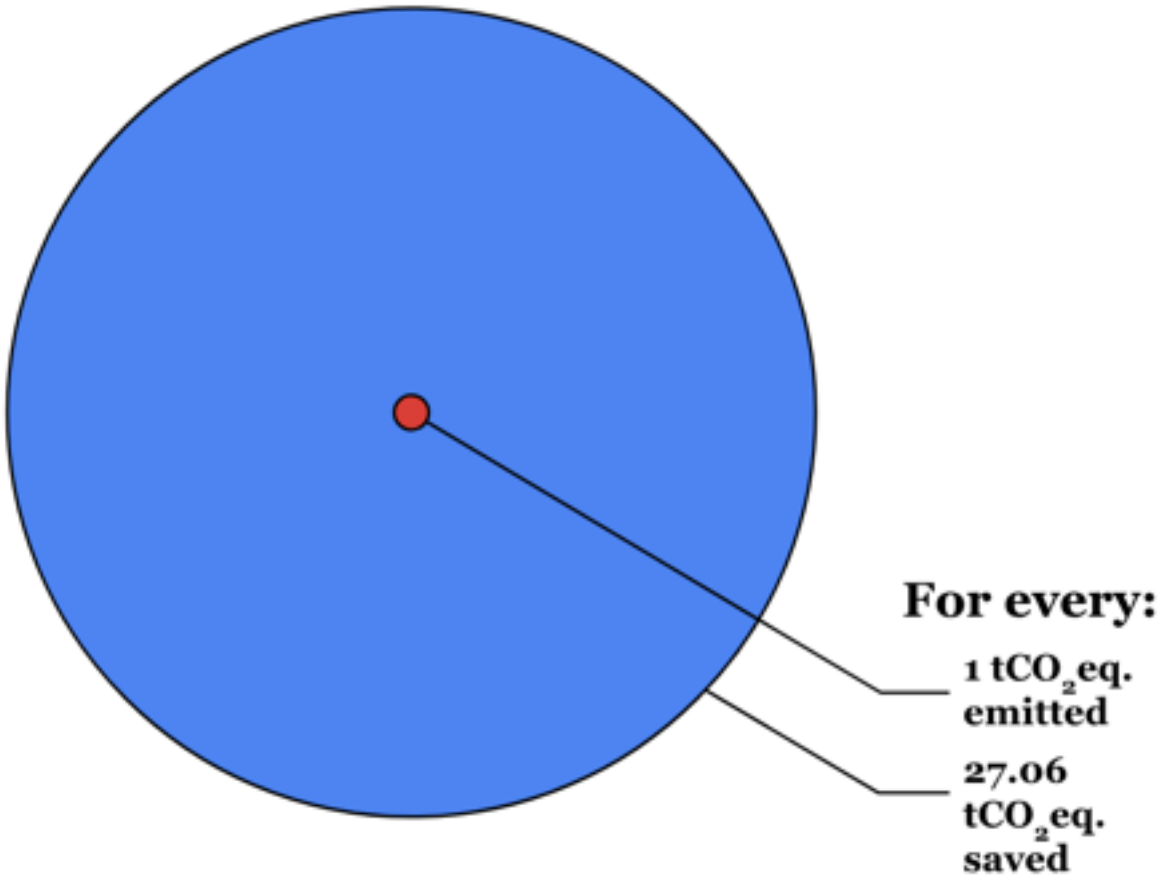

Figure 15. The average ratio between tonnes of CO2eq. emitted and tonnes of CO2eq. saved by the CSOs in 2017.

4. Discussion

Firstly, this section will discuss how the current **policy frameworks** affect food redistribution in Europe, as reflected by the specific frameworks in place in the five **Target Countries**. This will lead to a discussion on how the five **Case Study Organisations** in those five countries are **constrained** and or **enabled** by these frameworks. The specific areas for **reform** and opportunities for the implementation of **Best Practises** are then explored with the frame 'New European Food Law in 2030'. Secondly, the **current capacities** of Redistributive Organisations (ROs) in Europe, and specifically the Case Study Organisations (CSOs), to deliver positive **socioeconomic** and **climate impacts** for society are discussed. These capacities are then extrapolated on, exploring the question: what are the **potential capacities** for ROs to mitigate climate change and deliver positive social and economic impacts in Europe in the future?

4.1. European food policy frameworks now and in the future

The study of the policy frameworks present in the Target Countries, embedded within the laws and regulations of the European Union, revealed constraints for the operation of the CSOs and generally all ROs in the EU. Furthermore, a recent report by the European Court of Auditors (ECA, 2016) concludes that despite the high-level political focus and the several strategies, also discussed in this Thesis work, adequate measures and impacts have not materialised. Nevertheless, policies conducive for food redistribution do exist, although their implementation is rarely EU-wide (see: tables 31 & 32). Furthermore, many voluntary agreements and initiatives were found to facilitate food redistribution significantly even where the absence or constraints of policy would predict low commitment from Donor Organisations (DOs), ROs and COs. Evidence of worst and best practises can inform the inclusion of most effective measures in national policies, but also direct the invent of entirely new holistic European Food Law and policy. The next paragraphs will address several stand-alone, yet interlinked policy areas and packages, with reference to the discoveries detailed in the Results section. The larger policy **frameworks** will be addressed first, with a gradual shift to discuss specific **policies**, **Best Practises** and theoretical **concepts**. Instead of the use of subheadings, keywords and terms are **bolded** to emphasise the interlinkedness of **policies**, **practises** and **concepts**.

As identified by the literature review and the interviews, most widely discussed barriers to expanded food redistribution in Europe are **food safety** and **hygiene** concerns. While EU regulation, principally the **General Food Law**, permits the donation, redistribution and consumption of Food Surplus (FS) under fairly amiable conditions; the fears of contamination, disease and the resulting litigation are common. The narrative of **liability** and risk of bad reputation is understandably prevalent among DOs. The interviews, the literature (e.g. Baglioni *et al.,* 2016) and the author's personal interactions in the field confirm that the common notion is that donation does often not take place due to food hygiene and safety concerns. General uncertainty surrounding legal obligations are reported to be the major reason throughout Europe, and the fear of risk of financial or reputation damage dominates even when donor's are reportedly informed on the prevailing legal framework (O'Connor *et al.,* 2014; Gram-Hanssen, 2016). A related issue is the widespread confusion of both industry, retail and consumers on **date-labelling** (EC, 2015), creating unnecessary barriers to donation and food waste recovery. Although the EU guidelines on food donation (2017) clarify the differences between 'best before' and 'use by' dates, and has launched many information campaigns [48], the issue of liability is not solved. Food Business Operators (FBOs) are responsible for setting a safe 'best before' date. Even though the donation is permitted, many err on the side of caution, especially as determining food safety on a case-to-case basis requires extra work and resources (EC, 2017). The Opinion of the European Committee of the Regions on food waste (Martikainen, 2017) reinstates the popular current opinion that "*food expiration and labelling practises*" cause edible food being thrown away unnecessarily. The report underlines **food donation** as a Best Practise and recalls the need for more multi-stakeholder education and communication on the issue. Subsequently, the sub-group on date marking has been established (under the EU Platform on Food Losses and Food Waste in April 2018) to deliver direct legislative and non-legislative solutions to the issue, likely including a form of a '**Good Samaritan**' law, shifting legal liability from donor to donatee. A similar law is in place in the United States and Italy, the only Member State in Europe having adopted it. Such clauses could be added to a new revision of the 2002 **General Food Law** (GFL) of the EU. According to a 2018 European Commission-led Fitness Check of the GFL (No 178/2002), the legislation is not 'fit for purpose' in addressing food sustainability, and Food Loss and Waste in particular. Concurrently, the Fitness Check proposes however that specific and dedicated legislation should come to address the complex issues of FLW and

[48] https://ec.europa.eu/food/sites/food/files/safety/docs/fw_lib_best_before_en.pdf and http://ec.europa.eu/food/safety/docs/fw_eu_actions_date_marking_infographic_en.pdf

food sustainability in general rather than a forced revision of the GFL itself (Council of the European Union, 2018). Revising and clarifying the language around 'safe' and 'unsafe' food and attending to the concerns of food business operators on liability, is crucial to solve the long conflict between food safety and food donation.

Further highlighting the current metamorphic status of European food policy, is the coming revision of the **Common Agricultural Policy** (CAP), with a heavy intention to check its impacts of FLW. Since the latest iteration (the 3rd Common Market Organisation, CMO) of the CAP in 2007 (No 1182/2007), 100% of the **withdrawals** from farms are compensated, up to 5% of the total production. In the past, the FLW due to the CAP withdrawal policies were tremendous, amounting to 5.1 MtCO2eq. between 1989 and 2015 (Porter *et al.*, 2018). Since the 1st CMO the average quantity of fresh fruits and vegetables (FFV) withdrawn from EU markets has decreased by 96% to 80 kt per year in 2015. Additionally, the fraction of this food redistributed to human consumption has risen to 38%. A significant amount of unnecessary production remains however, with a large portion of FFV yet destroyed every year (Porter *et al.*, 2018). Assuming that FEBA members had the capacity to receive and redistribute the withdrawals under **CAP**, an additional 90,000 meals could be distributed every year. The new CAP could significantly reduce the instance of FLW by stimulating efficient production and processing, and financing practises and initiatives that transcend the conventional produce-use-discard systems into a **circular bio-economy** (Council of the European Union, 2018). Under the CAP, the **EU Withdrawal programme** has been very important for the members of FEBA, and other forms of food aid in Europe (EC, 2018b; Regulation 891/2017).

As resource-efficient and circular thinking becomes more prevalent within EU policy-making, other old programmes such as **FEAD** (Fund for European Aid to the Most Deprived) will have to redesign themselves. In line with the comments from the CSO interviews; the Open Public Consultation, a part of FEAD's Mid-term evaluation, raised the issues of inadequate attention to food waste **reduction** and focus on **nutrition**. In some cases, large quantity donations under FEAD were even reported to create additional food waste, as organisations did not have the capacities to handle such amounts (Brodolini, 2017). Moreover, the common horizontal goal of food waste prevention and food security should also be explored by for example providing direct funding to food banks; especially when most ROs are constrained by **lack of investment** and not by **lack of donations** (see: Table 33). Therefore the FEAD network, consisting of Managing Authorities and partner organisations implementing FEAD goals, should consider new ways for supporting FEBA

members and other ROs by under the articles 26 and 27.4 of Regulation (EU) No 223/2014. These articles could be extended to provide support in **ICT**, staff training and straightforwardly covering the actual **operational costs** of food waste recovery (FEBA, 2016). Strengthening **partnerships** between the many EU programmes and organisations involved in food waste recovery and redistribution should also be addressed by any **new Food Law** as it considers the sustainability and circularity of the entire Food Supply Chain.

The **Circular Economy Package** and especially the Directive (EU) 2018/851 amending the **Waste Framework Directive**, underlines many critical steps still needed to be address FLW and food donation and redistribution in future legislation. EU-wide **definitions** of many critical concepts, including food waste, is yet to be determined. Additionally, as identified by the Target Country profiles strengthening the **National Waste Management Plans** and reporting on FLW is also yet underway. Critically, a common EU food waste reduction **target** does not exist, and the Commission's **deadline** to finally set one is on the 31st of December 2023; hardly an ambitious goal. After a few attempts, the delegated act on a **common methodology** for food waste measurement is set to be adopted by the Commission by the 31st of March 2019. Critically, the Directive (EU) 2018/851 also recalls the role of the private sector in fighting FLW by establishing a definition and minimum requirements for **Extended Producer Responsibility** (EPR). The EPR concept is central to establish legitimacy, e.g. for the positive and negative **fiscal instruments**, and in general to ensure the involvement of the industry in the fight against FLW, and compliance with the concept of the **Circular Economy**.

As identified by the literature review and the food banks themselves; **fiscal instruments** can be one of the most impactful ways of facilitating food donations and food redistribution (table 33; O'Connor *et al*, 2014; Aramyan *et al.,* 2016). Positive instruments such as **tax credits** or **deductions** are especially effective but are in fact only in place in very few countries, like France, Spain, and Hungary where a percentage [49] of the value of the donated product can be deducted from the **corporate tax** base (EC, 2017). To halve all food waste by 2030 and adequately stimulate donations of all Food Surplus however, the model of Portugal should be more widely adopted where 140 % of the original value may be deducted (limited to 0.008 % of turnover). Conversely, **negative fiscal instruments** tax companies for the food that is not donated - despite the opportunities for doing so - in a "pay-as-you-throw" (**PAYT**) manner

[49] In Hungary, if donor makes longer contract with the food bank this is increased to 40% (presentation by the Hungarian Food Bank Association 9th October, LIFE Food Waste Conference, Budapest)

(Vittuari *et al.,* 2016). Following the evidence of the implementation and early results of the 2016 Italian '**Gadda law**' (providing '**positive**' incentives [50]) and the 2015 **French** legislation (providing '**negative**' incentives [51]) it seems as that the former case has brought more tangible change and has been received better by the wider society and stakeholders (Vaqué, 2017; Nébih, 2018, Wunder *et al.,* 2018).

However, it was also found that **Voluntary Agreements** (VA) - where there are necessarily no legal **obligation** or extrinsic **motivation** for donation - are much more effective than the standard theses of economics would presume (table 31; Cecere *et al.,* 2014; Hirschnitz-Garbers *et al.,* 2015; Nébih, 2018). Although it is possible for donors to benefit financially from these agreements, their voluntary nature, the '**moral** good' and heightened **visibility** play an important role. A REFRESH report on the issue found that a long-lasting and effective VA needs funding preferably both from public and private sources, realistic targets, and robustness and transparency of reporting (credibility). VAs can complement legislation, but also be adapted around it quickly when political ambitions change (Piras *et al.,* 2018). A strong and credible **third party**, for example a central RO [52], is crucial to the management and success of a VA.

Many Member States, including the Target Countries for this Thesis work, have recently directly or indirectly removed **VAT** on donated products. The indirect method is used for example in Denmark in the case of FødevareBanken, where the value of food donated is set effectively to **zero**, in line with the VAT Directive (2006/112/EC). This encourages food donation by making it equally or slightly less expensive for donors, and food banks, than managing the food as waste. However, entirely **abandoning VAT** is considered a Best Practise here, as if countries later want to implement corporate tax credits based on the value of food donated, near-zero-valued food nullifies these instruments (O'Connor *et al,.* 2014). Abandoning the VAT has been a good start, but this merely removes the disincentive to donate. This is not in line with the **EU Food Waste Hierarchy** which should in principle either coerce or incentivise donation over disposal through legislation.

[50] Rewrites critical definitions to facilitate donation. Removes liability from food donors also if products 'expired'. Encourages and supports education and outreach. Offers tax reductions based on value of donated food. *Legge 19 agosto 2016, n. 166*

[51] Installs fines if Food Business Operators (FBOs) make safe food inedible, and obliges retailers to sign donating agreements with ROs and or COs. *Loi N. 2016-138 du 11 fevrier*

[52] The Hungarian Food Bank Association for example leads many Voluntary Agreements and projects in Hungary

As demonstrated by figure 2, the **Food Waste Hierarchy** is currently not being effectively implemented. This is also highlighted by Vittuari *et al.* (2016) who note that '**perverse financial incentives**' often prioritise e.g. biogas production over redistribution (through the EU Energy Policy). Fiscal instruments should be balanced according to the Hierarchy, where donation to human consumption over donation / selling for animal feed would be more attractive, and where landfilling, biogassing and incineration in the case of edible fractions of FLW would be heavily **disincentivized** [53]. Recalling the Food Waste Hierarchy it is critical to remember that at present in the EU **food** available for consumption **exceeds** the food security and nutritional **needs** by 30 to 40%. A large portion of this ends up as FLW or excess intake and obesity. In many cases, the solution ought not be food redistribution. This is the case especially in the case of limited capacity of ROs, where **additional** embedded **emissions** are incurred due to transport and storage for food that ultimately gets discarded despite good intentions. If this food replaces similar products on the market, however, overall demand and thus emissions are likely be lowered (Porter *et al.*, 2018). Additionally, as a significant proportion of Europeans go hungry or lack full nutrition, the current EU regulation needs to consider ways to **reform** the entire **design** of the **Food Supply Chain** (figure 6).

Designing **policies** that simultaneously **prevented FLW** and were fully **conducive** for food **redistribution** and the operation of Redistributive Organisations, would be a tremendous challenge. Due to the multidimensionality and **complexity** of the drivers causing FLW alone, many policy areas and sectors would need to be rallied up. All of the areas tangential to the food system from energy to employment; trade to food safety; and education to environmental protection, are siloed within their own policy and interest areas. Consumers expect safety and **nutrition**; farmers expect **employment**; municipalities expect **security** and supply; rural areas cultural preservation and **livelihoods**, and so forth (EEA, 2017). Tradeoffs between these conflicting areas has caused the total European approach to food to become a *"by-product of political compromises"* (IPES, 2017), and Food Loss and Waste **prevention**, not to mention **redistribution**, become **politically secondary** to those compromises. The fact that the multiple levels of governance all make decisions independently with, again, often conflicting views on the purpose and function of the food system further complicates the mission of establishing a new common food law for Europe. However, this outlook has not discouraged attempts to start creating such a policy. The integration of the goals of the

[53] Keeping in mind that there exists exceptions where energy recovery might be the only plausible option. Systems should be designed to be circular from the beginning, but also flexible to be able to address compromises.

Circular Economy Package, **Agenda 2030** and the **7th EAP** [54] (European Parliament, 2013), and shifting the focus from production and economic performance to a systems approach to sustainable food is in the core of these movements. The EEA report "Food in a green light" (2017) lists the major policy areas, stakeholders and processes required to address the issue, and the IPES [55] "Towards a Common Food Policy for the European Union" paper (2017) sets up a comprehensive road map of 'labs' and working groups required to actually embed the new ideas of the '**Common Food Policy**' into the decision-making of the EU.

Ultimately, a policy-led transformation of the European food system would need **innovation** in the levels governments and institutions, but also in technology, society, culture and citizen behaviour (EEA, 2017; IPES, 2017; Wunder *et al.,* 2018). Investment and space for innovation and research in all these areas are critically needed to upscale and increase adoption of the ideas. Critically, the environmental and social costs of food production should be factored into the final price of foods, to inform the market of the prioritisation of sustainability (Wunder *et al.,* 2018). Perhaps, driven by the current high-level political momentum in the form of, i.e. the Agenda 2030, the 7th EAP, the EU Circular Economy Action Plan, and informed by IPES, EEA, the Platform for Food Losses and Waste, and the Food Donation Guidelines, entirely **new legislation** addressing Food Sustainability and FLW holistically could emerge. This new European food policy would surely follow the principles of **EPR**, polluter-pays (and **pay-as-you-throw**) and the **Food Waste Hierarchy**, making the case for investment in food surplus redistribution undeniable.

Importantly however, as identified on multiple occasions by the literature review, the interviews and the author's personal experience in the field, the single most important element constraining the capacities of the CSOs and all ROs in Europe - beyond any legislation - is **lack of investment**.

4.2. Investment in food redistribution

In order to achieve the 50 % reduction in European FLW, as mandated by the United Nations and the European Commission and increase the quantities of Food Surplus redistributed for human consumption; conducive legislation and political will is absolutely required, as detailed in the previous chapter. What is additionally, and critically, needed however is extra **investment** and **support** for the actors involved in food donation, redistribution (table 33)

[54] Environment Action Programme (No 1386/2013/EU) Official Journal of the European Union 354/171
[55] International Panel of Experts on Sustainable Food Systems (IPES-Food)

and charity. Some of the possible policy-born funding mechanisms were discussed in the previous chapter, in the form of **tax credits** or **redesigning** funding mechanisms from the **FEAD** (FEBA, 2016). Secondly, support for redistribution activities is offered often as **reimbursement**, for example under the *Commission Regulation (EC) No 1580/2007* for transport cost of withdrawn fruits and vegetables or as tax deductions, claimable in the end of the fiscal year. Yet, many operational costs linked to other policy areas are not covered by subsidies by the European Union. As evident from the interviews, having stable and sufficient financing would enable ROs to scale-up their operations, but also extended risk-taking and absorbing higher upfront costs. In order to achieve the full potential of the Redistributing Organisations in a way where the Food Waste Hierarchy pyramid is actually realised (figure 2), **new funding designs** are required.

Food banks, and all ROs, are often viewed as '*unlimited capacity*' organisations. The assumption is that all food donated can be adequately handled and redistributed, and that the limiting factor is the low quantity of donated food; either due to the unwillingness to donate or aggressive food hygiene regulations. In reality, however, there exists a **huge gap** between the amount of edible Food Surplus available and technically ready for donation (~25,000,000 tonnes), and the food currently being redistributed (~500,000 tonnes [56]). ROs struggle to meet the demand, AND deal with the supply, and routinely have to turn donations and scale down their potential due to financial constraints. COs face the same issue of limited capacity due to lack of capital. The real **bottleneck** for the second level of the Food Waste Hierarchy pyramid (figure 2) is **investment**, not legislation (Cseh, 2017). As clear from the interviews and the Global Analysis datasheet, financing of ROs usually comes from a range of small private and public sources. However, they do not grow linearly with increased supply and demand and are prone to fluctuations and uncertainty (table 33). The issue has been recognised throughout literature and as noted by, among others, Teuber & Jensen (2016) and as identified by the analysis in this Thesis work (table 34): food redistribution is one of the most **cost-effective** ways of preventing FLW. It however yet remains under-financed and lacks systems organisation in many places in Europe. FEBA and its members with **centralised** models (e.g. FPFB, PL and Die Tafel, DE) present a good example of how the fragmented nature of redistribution can be ordered, making financing and fundraising more streamlined. This model has been found effective also by the Federation of Food aid Associations, Finland (non-FEBA), who applied for and received federal funding, which they

[56] By FEBA member organisations. FEBA (2017) estimates that around another 500,000 tonnes is redistributed by other organisations as well, including the German 'Tafel' - a recent FEBA member, but not accounted for yet in the statistics. Food and Drink Europe estimate that less than 10% of available food surplus is redistributed (FoodDrink Europe, 2016); contrasted to the 2% estimated here.

then distributed among their member ROs and COs (Valkoniemi, 2018). Hanssen *et al.* (2015) add that a model in which central food banks were established as *"systems operators"*, with good **collaboration** with regional and local redistribution activities, should be implemented. This could attract and streamline investment, increase efficiency and aid in FLW and redistribution quantification, monitoring and reporting; as already required by new EU and national targets and demanded by the CSOs (table 33). Like the example of FPFB shows, central food banks may additionally develop **agreements** with large food industry operators and pass these contracts down to the local levels. Clear central policies, contract templates, quality standard and systems and tool kits facilitate the efficiency of the entire national food redistribution. Capacity and competence building could be done via central training and workshops, and a shared network of resources. A critical requirement for the capacity increase for ROs to adequately address the ever-growing issue of FLW is the modernisation of their Information and Communication Technology (**ICT**) and logistics infrastructures (interviews: table 33). **Tracing** and **measuring** the extent and flow of foodstuffs in the system, ICT tools can function as a monitoring, planning and "ordering" systems (Hanssen *et al*., 2015).

More research on the ways to attract investments for food banks is needed. It is unclear why food redistribution, with its high positive **socioeconomic** and **climate** impacts (figures 8 & 15), is yet so under-funded by both public and private money. Perhaps these positive benefits are not widely recognised or prioritised, or simply not made attractive. Although the academic, political and media attention of FLW has been on the rise, this has not translated into investments into the solutions such as centralised food redistribution (Hanssen *et al.,* 2015). The attractiveness of redistribution as a strategy to mitigate climate change is not indeed as attractive to investors as for example clean-tech, as the **ROI** is measured only in socio-economic and climate benefits. If a tech company would announce that they could remove 27 tonnes of carbon dioxide from the atmosphere for every tonne emitted, all the while providing social cohesion and hope in the community that it functioned in, they would be lathered in investment. This is because carbon is a real **commodity** and companies and governments are scrambling to keep their carbon emissions in check and show the consumers, citizens and the global community that they are up to the task. This is unfortunately not the reality for initiatives working in prevention, as the units of 'carbon saved' through these initiatives are not so far tradeable in the open carbon market. For governments, from local to supranational, however the social and climate benefits of food redistribution ought to make the case for a sound investment. In a recent review Cristóbal *et*

al. (2018) show the **Food Waste Hierarchy** does not often materialise in practise due to economic criteria having a disproportionate weight in decision-making. Reuse and recovery are [seen as] more cost-effective, and prioritised, although their worse 'climate-performance' is well known. It should follow however that supporting food donation and redistribution would work as an early cost-effective reuse method to bridge the gap towards more cost- and strategy-heavy policies on prevention. On the other hand, this information is not necessarily making it to decision-makers, and where it does; food aid and redistribution is viewed as something for **civil society** and **charity** to self-organise (Hebinck *et al.,* 2018).

Ultimately, with the right investment, **central RO**s can develop a strong positive branding and understanding of food redistribution in the society, while informing science and policy about the extent of FLW and redistribution in Europe. In some exemplary cases this scenario has already been realized, while the potentials of the *"best-practise ROs"* are still much greater. Integrating the new circular food systems thinking and policies, discussed in the previous section, with advances in ICT, logistics, education (e.g. new diets, permaculture, food science), and a diversification of the associated social services, ROs could transform themselves and the society they are embedded in. Investment and advocacy remain the final bottlenecks. The second half of the next section assumes this **unlimited capital** and **political will**, and explores further the ways that ROs could potentially help to transform society in the future. However, first the current socioeconomic and climate impacts are discussed.

4.3. Current and potential impacts of food redistribution

The Case Study Organisations (CSOs), covered by this Thesis work, together received nearly 80,000 tonnes of food donations in 2017, representing over 195,000 tonnes of CO_2 equivalents, equal to the annual **carbon footprint** of **27,500** European **citizens** [57] (Eurostat, 2018c). The combined emissions, related to their operations, were only 6,500 tonnes, equating in an average '**Carbon Cost Benefit Ratio**' of 27 units of carbon saved for every one unit of carbon emitted (figure 15). Although this results represents only five organisations, and each not representing nearly all of the diversity of the redistribution activities in their respective countries, it is indicative of the general '**carbon efficiency**' trend of food redistribution in Europe. If this efficiency is indicative of the entire FEBA membership, the total positive environmental impact would 1.5 million tonnes of CO_2eq., equating to the **social carbon cost** saving of 30.5 million euros. FEBA members provided meals to 8,100,000 people and employed a further 16,200 in 2017 (FEBA, 2017). The **direct**

[57] EU's total carbon footprint equal to 7.1 tCO2 per person in 2016

cost of the food saved is a gargantuan 1.64 billion euros, which however only represents 1.1% of the total value of FLW in the EU-28.

The **social impact** of the CSOs is also tangible, with over 400,000 meals provided each day over a network of 4,000 charities, reaching nearly **one million individuals** per year (table 35). The CSOs also provide 'employment' in the form of 727 volunteer, social contract and paid positions (242 paid full-time employees), markedly boosting their local socio-economic areas. Besides providing employment, community and other social services, the CSOs also provide tangible positive **economic impacts**. Furthermore, they save the Charity Organisations (COs) they serve, close to 90 million euros in food purchasing expenses. On top of this, the **Social Cost of Carbon** of over 4 million euros that the CSOs save, is essentially represents those costs for society otherwise incurred on society later by **climate change**. Taking into account the low financial costs of operations driven by the high adaptive capacities of redistribution and charity organisations, the return on investment (**ROI**) or the '**Social Cost Benefit Ratio**' is on average 10 euros for every 1 euro invested [58] (figure 8). Furthermore, this figure does not capture the direct and indirect value of employment, social services and the plethora of avoided environmental impacts due to Food Loss and Waste redistribution (incl. the '**True Cost of Carbon**' [59]). Furthermore, if Goal 12 of the Agenda 2030 is reached and all Food Loss and Waste is cut to half, but European ROs are enabled to redistribute the avoidable and edible Food Surplus [60]; the positive economic impact, compared to a Business-As-Usual (**BAU**) one, would still be 124 billion euros. It seems clear that Food Redistribution would have the potential to cost-effectively mitigate the **socioeconomic** and **climate struggles** that are yet a reality in Europe.

It is essential to remember that despite the several positive impacts of Redistributive Organisations (ROs) described in this Thesis work, these organisations are still responding to a **growing need** for food assistance. This is indicative of profound issues with the European food system and its inability to deliver its main purpose: **Food Security and Nutrition** (FSN). Although most European people are food secure; economic downturn, unemployment, immigration and growing inequality translate into the *"growing normative culture of unhealthy diets"* (Hebinck *et al.,* 2018). This contributes to poor nutrition and has widespread cascading effects on everything from children's school performance to life contentment, and

[58] High variance; but all CSOs have a positive ROI
[59] The 'True' or 'Real' [Social] Cost of Carbon is a highly contested subject in science and politics with estimates ranging from 2 to 200 € per metric tonne (Havranek *et al.,* 2015; Pindyck, 2017)
[60] Assuming the average price for food and carbon remain unchanged, FLW otherwise halts to a 2018 level (-50 %), and a recovery rate of 80% of all avoidable FLW.

from costs of national **healthcare** to social cohesion (Scherhaufer *et al.*, 2015; Wahl *et al.,* 2017; Candari *et al.,* 2017). As in most Western societies the sale and marketing of food is largely in the hands of corporations, national governments have decreasing power over food governance within their own borders. Food redistribution (or in this context '**food assistance**') has already transformed from 'emergency' help to an institutionalised, and largely **expected**, part of the welfare state. Food assistance has to an extent normalised and depoliticized hunger and poor nutrition as it is often, somewhat, subsidised by governments (table 34). This Thesis work offers the argument that, as discussed before, by increasing **investment** for central ROs, governments may promote the **transformative capacity** of food redistribution; to providing not only improved FSN, but increasing also the socioeconomic and climate benefits of their operations.

Besides food assistance, ROs and COs help **reintegrate** those most socially deprived or outcast; give them work, purpose and a community. While these are services that food banks provide already, the organisations are presently unable to meet the growing demand of these social services, similarly to their inability to meet the demand of the COs for Food Surplus (table 33). Schneider (2013) marks that the money saved on food is mostly spent on meeting rent by the beneficiaries, but also on other goods and services, and cultural and sports activities. This shows that the **influence** of ROs can tangibly go outside of the confines of the physical organisations themselves. Moreover, Hebinck *et al.* (2018) further describe the potential of ROs to **transform** food systems and society. They can be simultaneously proactive and reactive, responding quickly to relevant local challenges (with global drivers), connect resources across multiple systems (e.g. social and ecological), and address all facets of the multidimensional problems of poverty (beyond simple monetary handouts).

Accordingly, food banks can become hubs for **social innovation** both in their ability to address food waste prevention and social services. The FUSIONS (Food Use for *Social Innovation* by Optimising waste prevention Strategies) project reiterates the need for innovation in providing incentives for donation, legislation and investment in capacity and infrastructure for food redistribution activities (Timmermans *et al.,* 2017). In some cases, ROs act as the **intermediary** or as *"systems operators"* between food industry, decision-makers, academia, local COs and citizens, but this role could be more pronounced and established EU-wide. This role takes the social innovation to the level of systems. By providing 'small wins' ROs have the capability to create awareness, new narratives and undercurrents for a large-scale change in the food system (Patterson *et al.,* 2017; Hebinck *et al.,* 2018). Redistributive Organisations can provide the space and framework for

transforming diets, ICT (e.g. tracing, monitoring, reporting), social services and policy in the context of food redistribution.

The recent special report of the **IPCC** "Global Warming of 1.5 °C" (2018) calls for **redistributive policies** across sectors, recognising them as the most efficient way of mitigating climate change, far beyond the syet ambiguous field of Carbon Dioxide Removal (CDR) technologies. Furthermore, the report emphasises that pathways which include *"low energy demand, low material consumption, and low GHG-intensive food consumption"* have the *"most pronounced synergies and the lowest number of trade-offs with respect to sustainable development and the SDGs"*. ROs are by definition, low energy, resource efficient, climate positive, and like discussed, can carry these benefits into the society beyond. In the example of low GHG-diets, ROs (and COs) may promote an increasingly plant-based diet, as fruits, vegetables and cereals form the large majority of the meals provided (see figures 9 through 13) and many ROs do or could offer meal planning and home economics education (table 33). Most importantly, every meal made of Food Surplus is 'freegan' and thusly zero units of CO_2eq., or even 'climate positive' by an average of 2.0 kgCO2eq. per kilogram of food, as shown by this Thesis work (see: table 26).

Furthermore, as discussed before, the modernisation of the **ICT infrastructure** within food redistribution would not only improve the efficiency of the organisation's activities and reduce costs and emissions, but critically would **streamline** food recovery throughout the Food Supply Chain. Establishing a standardised tracing, monitoring and reporting software through all actors involved in the process, would not only ensure food safety, but could also be used to **disseminate** information on practises and protocols. The usability of such software should be made priority however to ensure high adoption and use-rates by especially the many part-timers and volunteers working in ROs and COs (Gram-Hanssen *et al.,* 2016). Furthermore, this highly granular big data could be used to inform science and politics, and improve the socioeconomic and climate **metrics** of food redistribution. Estimating the number of beneficiaries served or meals provided is currently very non-standardised and thusly prone to large variability (see next section for more details). Using the data could also be adopted increasingly by the end-users, by providing information and tools for food waste recovery, food assistance and activities, e.g. peer-to-peer foodsharing.

All of the methods outlined here contribute in diverse ways to change the current system, by addressing its failures and highlighting the superiority of the new alternative. Furthermore, even in the unlikely event of the amount of FLW being cut drastically, the ROs would still be

relevant by providing good data, information and services. While the involvement of the government is needed, the ROs have been, and will continue to be predominantly citizens' movements and a dimension of the '**solidarity economy**'. This 'citizens for citizens' design also increases the **resilience** of these organisations in the face of political and societal change (Hebinck et al., 2018).

4.4. Uncertainty

This section will explore the uncertainties present in the models estimating the social, economic and environmental impacts of the CSOs. It will also give suggestions for any future iterations of such models.

As briefly discussed in the Methodology section, estimating the carbon footprints of food items is a very complicated task, fraught with assumptions and broad strokes. These uncertainties are multiplied when only a few products become the indicators for entire product categories such as 'Fruits & Vegetables', including everything from canned mandarin slices to a local head of lettuce. Nevertheless, the mean estimated uncertainty of +/- 0.3 kg of CO_2eq. per kg across categories does not affect the finding that CSOs are saving more carbon than they emit. The accuracy, or rather uncertainty, present in this study was deemed acceptable as the goal was to determine whether the CSOs, and all ROs, are carbon positive or negative organisations, and whether they are legitimate tools for mitigation of socioeconomic and climate issues. If the methodologies or results of this Thesis work were to be used for carbon accounting and pricing, the ranges of acceptable margins of error are to be reexamined [61]. Accordingly, several things can be done to mitigate the uncertainty in these estimates.

Expanding the system boundaries to include the energy needs of the use-phase (e.g. storage and cooking) at the Charity Organisation (CO) level and the end-of-life of foods. The end-of-life estimates would include both the carbon footprint of the food in the COs post-use-phase, and in the replaced system. Furthermore, COs will generate FLW, at minimum due to the inedible parts of foods. Quantifying the waste separation practises of the organisations and the carbon intensity of the end-of-life of these waste fractions would be very complicated but ultimately decisive for the final footprint of the organisation. Moreover, food waste from retail most often ends up in the mixed waste. In the example of a six pack of tomatoes on a

[61] Similarly, the use of other impact categories such as nutrient pollution and water resource depletion ought to be explored, *if other environmental effects are of interest,* for example in the case of justifying a new policy for water resources management in the Mediterranean; Vanham & Bidglio, 2013.

plastic tray and in a plastic wrap, donated to a RO, avoids landfill or incineration of the tomatoes, but not necessarily the plastics. How should these behaviours of different actors be monitored and reported? Most importantly however it would be relevant to know how organic waste is handled in the Target Countries (e.g. anaerobic digestion, incineration or landfill [62]). For the replaced system, this data would need to be more granular; i.e. are the foods donated from the EU withdrawals, FEAD, retail etc., and what would be their fate had donation not taken place. The geographical relevance of the end-of-life solutions should also be taken into account, as for example just within Poland, FLW will have very different fate depending on the region and the type of food waste (Malinauskaite *et al.,* 2017). Relating to the carbon footprint estimates of the 9 FEBA super-categories; changing them to be more balanced: concerning the embedded carbon of the foods they include. This would mitigate the uncertainty within the category means. However, the categories are presently allocated per the type nutrition they provide and switching this rationale would imply a shift from a 'food security and nutrition' to an 'ecological' focused mission. The data gathered now by FEBA does therefore have an emphasis on social rather than environmental indicators. Switching to a cloud-based ICT monitoring system would improve the granularity of the data and remove the need for difficult value-based decisions in data collection.

Mitigating the uncertainty in the estimation of the carbon footprint of the organisations would of course start at acquiring higher order data from the CSOs, e.g. statistics on energy use of the storage, and fuel used or kilometers driven by the car fleet. Another way to estimate the average distance travelled per vehicle would be to use the number of charities as a proxy for distance travelled per day. However, due to limited knowledge on the geography of the charities and warehouses, and the fact that the COs may collect the foodstuffs with their own vehicles from the ROs (with the exception of Fødevarebanken in Denmark who do not permit pick-up of goods by COs), this method becomes equally prone to uncertainty. Furthermore, a standardised methodology on estimating the number of beneficiaries served or meals provided would improve the understanding on the social metrics of each CSO. At present the number of beneficiaries reported by the CSOs are so highly variable (by orders of magnitude) that this may only be explained by drastically dissimilar method of calculation. Reporting the $kgCO_2eq.$ saved per beneficiary or meal provided would be a great communicative tool, but with the current uncertainties this is not plausible.

[62] if the FLW ended up in the landfill the CF would be: 4.2 t per 1 t food waste, and even the best case scenario, Anaerobic Digestion, would only recover 500 kg of $CO_2eq.$ per one tonne FLW. Prevention and redistribution have to remain the priority (DEFRA, 2011).

Finally, a full organisational Life Cycle Assessment would certainly yield the most accurate results on the carbon account of the CSOs. Although this is outside the goal, scope and purpose of this Thesis work, some learnings can be provided concerning any future LCA studies on food redistribution. Firstly, the temporal scope must be carefully selected, perhaps limited to one year, as a covering the entire life cycle would not be necessarily conducive for meeting the Goal of the LCA; a comparative assessment between the redistribution activity and the BAU [63] scenario. Geographical region will be critical concerning the emissions intensity of the replaced system as seen in Methodology (see: tables 27 & 28). On the subject of allocation: no real allocation effort would need since the replaced system does not have real co-products which affect the comparative sustainability of redistribution versus landfilling, biogas production or incineration. As redistribution of food to human consumption is more energetically [calorifically] efficient than its options, allocation is not applicable. Biogas or combined heat and energy would not be real co-products as understood by LCA methodology to begin with, but rather consequences of alternative systems. Secondly, although ROs do not generate co-products, they do generate co-benefits. A tough choice will be to decide which is the primary objective of a RO: food assistance or food waste prevention? This would determine whether, if any allocation would be done - and if this could be adequately quantifiable (for example in monetary terms). Lastly, as suggested by Campoy-Muñoz *et al.* (2017) the negative effects of FLW reduction on employment and GDP should be explored.

5. Conclusions

This Thesis work has shown that while the current **policy frameworks** and **investments** are not conducive to efficient redistribution of Food Surplus in Europe, the Case Study Organisations (CSOs) are able to deliver **tangible socioeconomic** and **climate benefits**. The CSOs bring hundreds of jobs, serve thousands of people, return 10 € on every 1 € invested and save 27 units of carbon equivalents for every 1 they emit. Accordingly, imagining favourable policies and adequate investments, the **potential** of these and other Redistributive Organisations (ROs) in the EU are **substantial**. Extrapolating based on the current activities of FEBA, up to 124 billion euros could be saved for society compared to a Business-As-Usual Europe. Food redistribution has the potential to **cost-efficiently mitigate** the socioeconomic and climate struggles that are yet a reality in Europe.

[63] Business-As-Usual

Shifts in legal and political frameworks are required. Despite the high-level political attention and several strategies on FLW and even food redistribution, adequate measures and impacts have not materialised. Nevertheless, Best Practises and specific policies conducive for food redistribution do exist. This Thesis work suggests the consideration and wider adoption of the following reforms and strategies:

- A reform of the 2002 **General Food Law** (GFL) of the EU: food expiration and labelling practises; risk and liability: a form of a '**Good Samaritan**' law, shifting legal liability from donor to donatee;
- A reform of the **Common Agricultural Policy** (CAP): stimulate efficient production and processing; finance practises and initiatives that transcend the conventional produce-use-discard systems into a circular bio-economy; orient the remaining **Withdrawals** to food redistribution (additional 90,000 meals / year);
- A reform of the **Fund for European Aid to the Most Deprived** (FEAD): consider new ways for supporting food redistribution under the articles 26 and 27.4 of Regulation (EU) No 223/2014;
- An EU-wide adoption of strong **fiscal instruments**: abandoning **VAT** on donated food (over simply setting donation value to zero); high **tax credits** and deductions; **PAYT** disincentives for discarding edible food, however prioritising positive over negative incentives following the Italian '**Gadda**' laws as Best Practise (*L19/2016 n. 166*)
- An EU-wide adoption of **Voluntary Agreements** (VAs): mediated by central ROs, establishing VAs between stakeholders with realistic targets and reporting transparency, financed by both public and private sources.

Critically however, the current approach of the European Union towards food is merely the *"by-product of political compromises"* and Food Loss and Waste prevention, not to mention redistribution, politically secondary to those compromises. All areas tangential to the food system from energy to employment; trade to food safety; and education to environmental protection, are siloed within their own policy and interest areas. Envisaging a new Food Law for the EU, this Thesis work suggests the following strategies, concerning FLW and redistribution specifically:

- Adoption of the **Sustainable Development Goals** and the implementation of the tenets of the Circular Economy thinking on EU and Member State levels;

- Adoption of EU-wide **definitions** of critical concepts, including that of 'food waste'; a common EU food waste reduction **target**; a common methodology for food waste measurement; strengthening **National Waste Management Plans** and providing **National Guidelines** on donation and redistribution;
- A framework to ensure the implementation of the critical principles of: **Food Waste Hierarchy** (FWH); **Extended Producer Responsibility** (EPR); 'polluter-pays' or 'Pay-As-You-Throw' (**PAYT**); and '**internalising the externalities**' to be reflected in the prices of food.

Unfortunately, 'simply' by making the legislation conducive to food redistribution and enabling fantastic amounts of Food Surplus to be donated, the **capacities** of the ROs do not grow linearly. ROs are often viewed, wrongly, as 'unlimited capacity' organisations. However, the real bottleneck for the second level of the Food Waste Hierarchy pyramid is **investment**, not legislation or the amount of available food surplus. Financing of ROs usually comes from a range of small private and public sources, but do not increase with increased supply and demand, and are prone to fluctuations and uncertainty. Furthermore, with adequate investment ROs have the capacity to **transform** society in fundamental ways. Therefore, this Thesis work suggests the following strategies to attract investment and scale-up food redistribution in Europe:

- **Establish** central ROs (food banks) as '**systems operators**'; collaboration with governments, industry and local redistribution activities; streamline investment;
- **Modernise** and implement a strong **ICT** infrastructure; knowledge sharing; improved tracing, monitoring and reporting improves efficiency through the Food Supply Chain; inform science and politics, and improve the socio-economic, ecological and climate metrics of food redistribution;
- **Disseminate** clear central policies, contract templates, quality **standards**, and tool kits; facilitate the efficiency of the entire national food redistribution;
- **Establish** stronger **advocacy**; food donation and redistribution are cost-effective and can bridge the gap towards more cost- and strategy-heavy policies on prevention;

Food redistribution is responding to a growing need for food assistance in Europe. This is indicative of profound issues with the European food system and its inability to deliver its main purpose: **Food Security and Nutrition** (FSN). Current global trends predict growing inequality, mass migrations, unemployment and economic downturn, all translating to worsened FSN. This has widespread cascading effects on everything from children's school

performance to life contentment, and from national healthcare costs to social cohesion. Food redistribution has transformed from emergency help to a part of the welfare state and has effectively depoliticized hunger and social deprivation. Governments may now take their **responsibility** and invest in these organisations to help them transform society by providing a plethora of services brining substantial socio-economic and climate benefits. ROs can be simultaneously proactive and reactive, connect resources across multiple systems, and address the multidimensional problems of poverty. Accordingly, ROs can become hubs for **social innovation** both in their ability to address food waste prevention and social services.

In conclusion, for Redistributive Organisations to realise their transformative capacity across the economic, social and environmental pillars of sustainability; a shift towards a more circular European Union is required. The high-level political and scientific mandates from UN's Agenda 2030, the IPCC's 15th Special Report and the EU's own Circular Economy Package, all demand a future which ROs can be very effective in achieving: preventing and redistributing Food Loss and Waste (FLW), increasing socioeconomic wellbeing, and mitigating climate change. Recognising that food redistribution comes second to prevention, which should always be prioritised, investment in ROs has many positive impacts beyond the mitigation of FLW. ROs can become 'systems operators', facilitating knowledge sharing between governments, civil society and industry, while raising awareness on the issue of FLW. Significant investment, advocacy and political will are yet required however before ROs can reach their full potential in the transformation towards the equitable and circular societies envisioned by the United Nations and the European Union.

Finally, in order to **seal** this Thesis work and to **irrevocably assure** the reader of the real and proven positive impacts of redistributive policies, their cost-effectiveness, and yet the concurrent need for increased investments; a quote from IPCC's recent Special Report 'Global Warming of 1.5°C' serves the purpose well:

> *"Redistributive policies across sectors and populations that shield the poor and vulnerable can resolve trade-offs for a range of SDGs… Investment needs… are only a small fraction of the overall mitigation investments in 1.5°C pathways."*
>
> - The Intergovernmental Panel on Climate Change (IPCC), 2018

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ANNEX I - Definitions

There are as many definitions for food waste, loss, nutrition, quality, wastage etc. as there are reports and strategies written about the subject. This is of course but a reflection of the complexity of the Food Waste issue, rather than a lack of coordination. A harmonised global super-definition of these terms is probably unattainable, although many have tried (Vittuari *et al.*, 2016). Term definitions always reflect the scope, intention and rationale of the publication, and transparency of these aspects is important. On this principle, this Thesis work will disclose the reason and thought-process behind the various term definitions it uses, starting from overarching concepts and narrowing down the scope; to the level of study: Food Banks and Food Security in the EU.

Food system

The food system includes every element and activity related to the production, processing and manufacturing, distribution, preparation and consumption of food (HLPE, 2017). This includes not only the technical dimension, the Food Supply Chain, but also the '*food environment*': infrastructures (physical and economic access to food); personal determinants of food choices (e.g. income, education, skills and values); socio-political norms; and cultures. The socio-economic and environmental outputs of the food systems determine its sustainability. A "Sustainable Food System" (SFS) is a food system where food waste and loss is low, and equitable access to culturally acceptable nutrition is high (UN, 2016), while having high climate resilience and an ability to sustain human populations in the future (HLPE, 2014).

Food Supply Chain (FSC)

As one of the dimensions of the Food System: the Food Supply Chain (FSC) encompasses the journey of a food product from farm-to-fork, along which the loss and waste of food takes place. The High Level Panel of Experts of the Committee on world Food Security (HLPE of CFS) describes this as:

"...activities that help ensure the delivery of finished products to the consumer from the primary producer. Such activities can include storage, transport and distribution, processing, wholesale, retail and consumption." - HLPE, 2014

Food Loss & Waste (FLW)

By the FAO (2013) definition, food loss refers to the decrease in mass or quality of food due to inefficiencies in the FSC; infrastructural, managerial, technological, economic etc., where food waste refers to discarding of food whether expired or not, pertaining to consumer habits, market behaviour, oversupply etc. This work, among others, combines these into "Food Loss & Waste" (FLW). As the focal points of his work are food security, food donation and food banks (and their socio-economic and environmental impacts), the definition of FLW here concentrates on the aspects of *edibility* and *nutrition*, based on the CFS - HLPE (Committee on world Food Security - High Level Panel of Experts) report on food waste in the context of sustainable food systems:

"...a decrease, at all stages of the food chain from harvest to consumption, in mass, of food that was originally intended for human consumption, regardless of the cause". - HLPE, 2014

Side-streams of inedible food parts wasted along the FSC are not considered here as FLW, even if they could have contributed to the circular economy as, *inter alia*, raw materials and biofuels. The HLPE (2014) also identifies the decrease in food quality (nutrition, aesthetic etc.) as a dimension of FLW (food quality loss or waste [FQLW]). Reduced quality leads to loss in economic value and a risk of food becoming FLW. In this Thesis work quality will not play an integral part of the FLW definition *stricto-sensu*, as the level of data on reclaimed food, provided by the collaborating food banks, does not include quality metrics. Many products reclaimed and redistributed by the food banks are however either perceived to be or in truth towards the lower end of their 'life-span' and quality aspects. Moreover, changing perspectives and methods (e.g. use-by date markings) on food quality, aesthetics and edibility could have a large positive impact on FLW.

Food Surplus (FS)

The three-paragraph-long definition of 'Food Surplus' by the European Commission's 2017 '*EU guidelines on food donation*' can be roughly summarised as:

"*[Food that] may arise at any stage of the food production and distribution chain for a variety of reasons -- [and] may be redistributed provided that is fit for human consumption and compliant with all food safety requirements..."* - EC, 2017

These products are considered available for redistribution by Food Banks and other food redistributors, while this work considers the European Best Practises increasing the share of FS available for the redistribution of food. Where the term 'Food Waste and Loss' implies a

value judgement and a social contract (ADEME, 2016) to deem a goods 'waste', the term 'Food Surplus' is the other side of this coin: a decision to transform goods headed to the landfill into value to be redistributed. In some publications (e.g. Porter *et al.,* 2016; Hiç *et al.*, 2016) Food Surplus refers to the difference between food produced and food required by the global population. Hence, in this definition it is Food Surplus [production] that leads to FLW, highlighting the importance of term definitions in literature.

Food redistribution

Food redistribution or 'Redistribution of safe and nutritious food for human consumption' (FAO, 2015) is to recover, collect and provide food otherwise wasted to people, especially to those in need. This process must comply with all appropriate regulatory frameworks pertaining to *inter alia* liability, food safety, food hygiene, consumer information (European Commission, 2017). This process may take place with or without payment.

Within this work Food redistribution might also be referred to as: 'food donation', 'food assistance' or 'food aid' depending on the chapter, it's subject matter and language.

Food Bank (FB); Redistribution Organisation (RO); Charity Organisation (CO)

According to the European Commission's '*EU guidelines on food donation*' (2017) Food Banks (FB) are *'back-line'* Redistribution Organisations (RO), redistributing Food Surplus directly from donors to end beneficiaries or, more commonly, through qualified 'front-line' Charity Organisations (CO). The abbreviation 'RO' is used in this Thesis work somewhat interchangeably with 'food bank' - although not all ROs (e.g. Yhteinen Pöytä) self-identify with the term for various reasons. The principal function of a RO is to provide organised logistics, storage and redistribution in compliance with laws and regulations, but the operations of ROs vary greatly between EU Member States (European Commission, 2017). Furthermore, as Food Banks handle and distribute food they are considered as 'food business operators' under the General Food Law. This obliges them to operate within the Articles of this legislation. Furthermore, ROs are very central in food aid, alleviating symptoms of poverty and bettering modern Food Security and Nutrition. In the EU Food Waste hierarchy (fig. X), FBs are considered 'prevention' and thus are a preferred method of fighting Food Waste & Loss (FLW) (O'Connor *et al*, 2014).

Food Security and Nutrition (FSN)

Defining food security, and recently adding to it the concept of nutrition, has been a long-time discussion within Academia and especially the FAO. The traditional definition

emphasises the four dimensions of food security: the *availability, access, utilization and stability* of safe food and nutrition (FAO, 2008). For the purposes of this work, this definition is adequate. However, in the context of food security in modern developed countries in the EU, it is worth reiterating the statement of the Committee on World Food Security (2012), that food security is a precondition of nutrition, which itself necessitates the *"knowledge and supportive health and environmental conditions necessary to obtain adequate nutritional benefit from the food"*. This dimension of knowledge and culture are very relevant when considering modern food systems and the wastage they generate. Moreover, adding the social and cultural dimension to sustainable food systems and FSN becomes very important when discussing *modern food security & nutrition*; referring to food poverty and the need for food aid in developed countries. In some definitions, having to resort to food aid itself makes one food insecure, as the ability to acquire food in socially acceptable ways diminishes (ADA, 2010). In a truly sustainable food system high social justice maximises self-reliance and even the most unprivileged do not have to resort to food aid.

ANNEX II - FEBA Global Analysis datasheet

EUROPEAN FEDERATION OF FOOD BANKS

Member country:
Name of person who filled the form:

GLOBAL ANALYSIS - 2017 with 2016 COMPARISON

1. FOOD BANKS

	On Jan 1, 2017	On Jan 1, 2018
Number of registered food banks		
Number of satellites/antennae/branches		
Number of warehouses		

2. CHARITIES SERVED & END BENEFICIARIES

	2016	2017
Number of charities served		
Number of beneficiaries *		
of which children 0-17 years		

* Please, specify how this number is calculated

Weekly, monthly or quaterly average		
At year end		
Other** - describe		

** Comments on how the number of beneficiaries is calculated (if in the other category) :

3. FOOD COLLECTED & DELIVERED

	2016		2017	
	COLLECTED	DELIVERED	COLLECTED	DELIVERED
Weight of products in KG				
check with detail analysis				
Value (estimate) of delivered products in Euros				

4. FINANCIALS

	2016 K Euros	2017 K Euros		2016 K Euros	2017 K Euros
INCOME			**EXPENSES - OPERATING**		
EU grants - excluding FEAD			Rents (warehouse, office, vehicles)		
EU-FEAD costs coverage					
Subsidies/Grants - State, Regional, City			Salaries and related costs		
Donations - Corporations & Foundations			Transport costs		
Donations - Individuals			Administratio		
Solidarity Contribution charged to Charities			Communication and sales		
FEBA grants			Establishments cost		
Other - Specify if > 10% total			Other - Specify if > 10% total		
TOTAL			TOTAL		
Balance (Income - Expenses)					
			CAPITAL EXPENDITURES		
Cash & Cash equivalent at Year end					

5. HUMAN RESOURCES

	2016		2017	
	Number	Full time Equivalent	Number	Full time Equivalent
Volunteers "permanent" (1 to 5 days per week)				
Paid employees				
Social contracts				
Total				

6. PREMISES

		2016	2017
Warehouses	m 2		
Offices	m 2		
Cold rooms			
Positive cold	m3		
Negative cold	m3		

7. VEHICLES

	2016	2017
Number of Vehicles		
Positive cold		
Negative cold		
Others		
Total		

8. HANDLING EQUIPMENT

	2016	2017
Hand pallet trucks		
Forklift trucks		
Total		

EUROPEAN FEDERATION OF FOOD BANKS

Member country:
Name of person who filled the form:

ANALYSIS OF THE QUANTITIES RECEIVED AND DELIVERED

All weights are in net kg		2016										2017 (see note at the bottom of this page)									
		QUANTITIES RECEIVED FROM							QUANTITIES DELIVERED TO			QUANTITIES RECEIVED FROM							QUANTITIES DELIVERED TO		
		EU & national withdraw Fruits & Vegetables	EU FEAD	Industry	Distrib.	Collection	Other Food Banks	**Total Received**	Associations	Other Food Banks	**Total Delivered**	EU & national withdraw Fruits & Vegetables	EU FEAD	Industry	Distrib.	Collection	Other Food Banks	**Total Received**	Associations	Other Food Banks	**Total Delivered**
Fruits and vegetables																					
12	Dried fruits & vegetables																				
20	Canned fruits																				
21	Canned vegetables																				
30	Deep frozen fruits																				
31	Deep frozen vegetables																				
44	Fresh fruits																				
45	Fresh vegetables																				
Dairy products																					
09	Milk																				
43	Cheese, milk products, eggs																				
Biscuits, cereals, strachy food																					
01	Bakery confectionery																				
02	Biscuits- crisps - crackers																				
04	Breakfast drinks – cereals																				
10	Flour – mashed food																				
11	Pasta products – rice																				
Drinks, sauces, baby food																					
03	Coffee chicory tea																				
13	Soups																				
14	Condiments sauces																				
25	Baby food																				
28	Drinks and soda																				
Prepared food																					
24	Canned cooked food																				
34	Deep frozen cooked food																				
47	Fresh cooked food																				
Meat, Fish																					
22	Canned fishes																				
23	Canned meats																				
32	Deep frozen fishes, shell fishes & sea foods																				
33	Deep frozen meat, poultry, cooked pork																				
46	Fresh meat, poultry, cooked pork																				
49	Fresh fish																				
Sweet products																					
06	Chocolate																				
08	Creams – desserts																				
19	Sugar																				
35	Deep frozen creams & deserts																				
Fats, oils																					
17	Edible oils and fats																				
Others																					
51	Domestic cleaning products																				
67	Hygienic products																				
99	Others products																				
Total																					
Total without others																					

Total Received : EU & National Withdrawals + EU-FEAD + Industry + Distribution + Collection
Total Distributed to Associations
Delta
Total Regularisation inventory
Total sent to disposal
Comments on delta

Note on 2017 statistics : **Starting from 2017, quantities are requested by categories of products (for the 9 categories) not by products within each category**

ANNEX III - Raw data Food received

			AUSTRIA		DENMARK		FINLAND		HUNGARY		POLAND	
#	FEBA Category	EF ($kgCO_2$-eq /kg)	Food Received (kg)	Carbon saved (tCO_2eq.)	Food Received (kg)	Carbon saved (tCO_2eq.)	Food Received (kg)	Carbon saved (tCO_2eq.)	Food Received (kg)	Carbon saved (tCO_2eq.)	Food Received (kg)	Carbon saved (tCO_2eq.)
1	**Fruits and vegetables**	1.35	347,987.00	469.09	186,496.00	251.40	74,437.00	100.34	4,039,471.00	5,445.21	26,531,020.00	35,763.81
2	**Dairy products**	3.70	100,247.00	370.92	289,484.00	1,071.12	46,653.20	172.62	188,178.00	696.28	10,920,206.00	40,405.85
3	**Biscuits, cereals, starchy food**	1.24	68,142.00	84.19	48,108.00	59.44	295,706.60	365.35	4,493,192.00	5,551.34	10,184,121.00	12,582.48
4	**Drinks, sauces, baby food**	1.69	54,824.00	92.82	280,207.00	474.39	0.00	0.00	191,795.00	324.71	5,534,896.00	9,370.58
5	**Prepared food**	3.03	0.00	0.00	58,727.00	177.94	930.50	2.82	6,946.00	21.05	2,930,022.00	8,877.97
6	**Meat, Fish**	10.91	5,005.00	54.58	39,978.00	435.96	427.40	4.66	63,577.00	693.31	5,074,458.00	55,336.96
7	**Sweet products**	2.37	18,308.00	43.39	11,245.00	26.65	1,072.00	2.54	178,140.00	422.19	3,764,726.00	8,922.40
8	**Fats, oils**	2.23	0.00	0.00	0.00	0.00	0.00	0.00	61,211.00	136.62	2,879,443.00	6,426.92
9	**Others**	0.55	20,728.00	11.30	5,440.00	2.96	0.00	0.00	0.00	0.00	1,012,982.00	552.08
10	**Average**	3.01	0.00	0.00	0.00	0.00	35,948.00	108.08	0.00	0.00	0.00	0.00
	Total		**615,241.00**	**1,126.28**	**919,685.00**	**2,499.86**	**455,174.70**	**756.41**	**9,222,510.00**	**13,290.70**	**68,831,874.00**	**178,239.05**

ANNEX IV - Raw data CSO Operations

Data table on the size of operations at each case study organisation (represented here by their country)

	unit	AUSTRIA	DENMARK	FINLAND	HUNGARY	POLAND
EMISSION FACTORS						
Warehouse EF	$kgCO_2eq./m^2$	8.8	33.1	29.4	40.3	126.2
Office EF	$kgCO_2eq./m^2$	10.4	24.6	22.2	26.6	142.2
Pos. cold storage EF	$kgCO_2eq./m^3$	3.14	8.67	5.56	10.78	35.01
Neg. cold storage EF	$kgCO_2eq./m^3$	3.98	11.01	7.06	13.7	44.46
Pos. cold vehicle EF	$kgCO_2eq.$/vehicle	16,561.44	16,561.44	16,561.44	16,561.44	16,561.44
Neg. cold vehicle EF	$kgCO_2eq.$/vehicle	20,791.58	20,791.58	20,791.58	20,791.58	20,791.58
Other vehicle EF	$kgCO_2eq.$/vehicle	7,043.62	7,043.62	7,043.62	7,043.62	7,043.62
Forklift EF	$kgCO_2eq.$/vehicle	16,912.80	16,912.80	16,912.80	16,912.80	16,912.80
SIZE of OPERATIONS						
Warehouse	m^2	230.00	1,740.00	400.00	2,480.00	28,479.00
Office	m^2	170.00	500.00	100.00	529.00	2,350.00
Pos. cold storage	m^3	20.00	186.00	100.00	539.00	2,226.00
Neg. cold storage	m^3	0.00	60.00	6.00	340.00	672.00
Pos. cold vehicle	vehicle n	1.00	5.50	1.00	2.00	28.00
Neg. cold vehicle	vehicle n	3.00	5.50	1.00	0.00	27.00
Other vehicle	vehicle n	0.00	1.00	1.00	2.00	11.00
Forklift	vehicle n	0.00	3.00	0.00	2.00	52.00
EMISSIONS						
Warehouse	$kgCO_2eq.$	2,024.00	57,594.00	11,760.00	99,944.00	3,594,049.80
Office	$kgCO_2eq.$	1,768.00	12,300.00	2,220.00	14,071.40	334,170.00
Pos. cold storage	$kgCO_2eq.$	62.80	1,612.62	556.00	5,810.42	77,932.26
Neg. cold storage	$kgCO_2eq.$	0.00	660.60	42.36	4,658.00	29,877.12
Pos. cold vehicle	$kgCO_2eq.$	16,561.44	91,087.92	16,561.44	33,122.88	463,720.32
Neg. cold vehicle	$kgCO_2eq.$	62,374.74	114,353.69	20,791.58	0.00	561,372.66
Other vehicle	$kgCO_2eq.$	0.00	7,043.62	7,043.62	14,087.24	77,479.82
Forklift	$kgCO_2eq.$	0.00	50,738.40	0.00	33,825.60	879,465.60
Total emitted	**$tCO_2eq.$**	**82.79**	**335.39**	**58.98**	**205.52**	**6018.07**
Total saved	**$tCO_2eq.$**	**1,126.28**	**2,499.86**	**756.41**	**13,290.70**	**178,239.05**
Saved - emitted	**$tCO_2eq.$**	**1,043.49**	**2,164.47**	**697.43**	**13,085.18**	**172,220.99**

ANNEX V - FUSIONS Country Template

FUSIONS COUNTRY TEMPLATE - SUMMARY OF POLICIES AND LEGISLATION FOR FOOD WASTE PREVENTION AND REDUCTION

A) National strategy on food waste prevention

A method, strategy or plan specifically addressing food waste prevention. Three typologies can be identified:

- Specific National Food Waste Prevention Plan
- Specific National Food Waste Prevention Strategy
- Food Waste included in other National Plans/Strategies

B) Market-based instruments

Market-based instruments or economic incentives are policy tools that encourage behavioural change through market signals rather than through traditional regulations.Examples include environmentally related taxes, charges and subsidies, emissions trading and other tradeable permit systems, deposit-refund systems, environmental labeling laws, licenses, and economic property rights.

C) Regulations and regulatory instruments

Regulatory instruments are governmental or ministerial orders having the force of law.Regulatory instruments are sometimes called "command-and-control"; public authorities mandate the performance to be achieved or the technologies to be used.

D) Voluntary agreements

Voluntary agreements are alternative courses of actions such as self-regulations developed by the industry generally aimed to deliver the policy objectives faster and/or in a more cost-effective manner compared to mandatory requirements.

E) Technical reports and main scientific articles

Technical reports and scientific articles refer to publications that report results of experimental and/or theoretical scientific investigations to enhance the body of scientific knowledge (in this case about food waste and losses).

F) Communication and campaigns

Campaigns include national “umbrella” campaigns; campaigns; short campaigns and festivals; education and training activities; contests and competitions; exhibitions;

Communication include seminars and lectures; vocational trainings; books and manuals.

G) Projects and other measures

Projects and other measures refer to initiatives like neighbourhood projects, food sharing platforms, platform/networks, labelling, applications, etc that contribute and/or are connected to food waste reduction.

Please leave your comment below or send us your contribution atfusions.consultation@eu-fusions.org specifying for each law/initiative you add the policy sector it belongs to (i.e a) national strategy on food waste prevention, b) market-based instruments c) regulations and regulatory instruments.

Thank you!

ANNEX VI - Source list and descriptions

This Annex describes the data sources used for estimating an average Emission Factor (EF) per a FEBA product category. The entries in the 'Name' column contain a hyperlink to the original document. Full references can be found in 6. References.

ID	Name	Description
a.	WWF Austria (2015)	The document itself is a review of how the Austrian diet affects the climate. Annex 1 of the document includes an extensive meta-analysis of European foodstuff LCA studies.
b.	Taylor (2000)	The study is the Doctoral Dissertation of one Corinna Taylor who compares the ecological footprint of different European diets. The study therefore includes an extensive portfolio of Emission Factors for different foodstuffs collated across LCA literature.
c.	Scherhaufer *et al.* (2015)	The final FUSIONS report for Working Package 1 on reliable data and information sources, trends and assessment criteria. Includes assessment of the impacts of food waste on health, socio-economics, social impact of food redistribution and environmental impacts. The latter includes a complete assessment of the carbon pollution arising from central indicator products; e.g. potatoes, tomatoes, apples and beef.
d.	Schneider (2013)	The paper specifically addresses food donation in Austria, and the categories of Fruits and vegetables; and Dairy products was found useful in validating the means determined for those categories.
e.	Carlsson-Kanyama & González (2009)	The study concentrates on the example of the Swedish food system and the Emission Factors of Swedish products. This study was found useful in validating the EFs of products to also consider Northern production.
f.	Barilla (2010)	The Barilla Center for Food & Nutrition think tank considers the impacts of food and nutrition on the environment. This 2010 report 'the Double Pyramid' contains a diverse portfolio of different Emission Factors for European foods, sourced mainly from the Ecoinvent database; Environmental Product Declarations (EPD) and the LCA food database.
g.	Wallén *et al*. (2004)	The study addresses the environmental impact consumer choice, and bases it's Emission Factors on the data from the Swedish Environmental Protection Agency. This study was found useful especially in validating the EF's of categories 4) 'Drinks, sauces, baby food'; and 7) 'Sweet Products', which were otherwise scarcely found in literature.
h.	Carbon Trust (2008)	This technical report produced to inform the UK government on carbon footprinting of products was used particularly to validate the EFs in the category: 9) 'Others'.
i.	Killian *et al.* (2013)	This study on the Supply Chain of coffee was used especially to clarify the picture of the EF of coffee in the category 4) 'Drinks, sauces, baby food'. Coffee is a cumbersome product due to the range of estimates on its lifetime emissions, and its high EF in compared to the other items in category 4 (listed in the subcategories).
j.	Rivera *et al.* (2014)	This study on the life cycle environmental impacts of ready versus home-made meals was used exclusively to validate the Emission Factors for category 5) 'Prepared food'.