

# Food waste reduction and food poverty alleviation: a system dynamics conceptual model

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## Abstract

The contradictions between food poverty affecting a large section of the global population and the everyday wastage of food, particularly in high income countries, have raised significant academic and public attention. All actors in the food chain have a role to play in food waste prevention and reduction, including farmers, food manufacturers and processors, caterers and retailers and ultimately consumers. Food surplus redistribution is considered by many as a “win-win” solution for food waste reduction and food poverty mitigation, while others criticize charitable initiatives as inadequate responses, that inhibit governments from responsibly protecting the citizens right to food.

This paper frames food assistance as “hybrid systems”, situating at the intersection of territorial food, public welfare and third sector voluntary systems. Based on available literature and reflections from previous research examining the discourse surrounding food banks in Italy, we develop a system dynamics conceptual mapping. The aim is to model a set of relations and dynamic mechanisms associated with variables relevant to food waste generation, food recovery for social purposes and food poverty alleviation. The analysis of feedback interactions highlights the (actual and potential) vulnerabilities of food assistance systems that occur when addressing food poverty *by* reducing food surplus. In summary, as the awareness on food poverty and food surplus rises, incentives to food recovery and redistribution strengthen the role of (voluntary) food assistance actors, increasing their exposure to drivers of change, such as retailers’ standards for food surplus prevention. This paper contributes to the current academic debate on charitable food assistance, with insights for policy makers and other system actors.

## Keywords

food surplus, food poverty, food banks, third sector, food system, system dynamics,

## Abbreviations

SDG	Sustainable Development Goals
FEAD	Fund for European Aid to the most Deprived
PEAD	<i>Programme Européen d’Aide alimentaire aux plus Démunis</i>

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## Introduction

This paper addresses two major food system societal and political challenges that currently affect affluent societies: the generation of food waste and the lack of economic access to food. In recent decades prominent academic literature has contributed to conceptualizing food systems as an entry point to understanding sustainability and food and nutrition security outcomes (Candel et al. 2014; Lang and Barling 2012; Ingram 2011; Mooney and Hunt 2009). These concepts have gained relevance also in terms of policy action, as shown by recent high-profile reports on food and nutrition security (SCAR 2018; HLPE 2017; IPES 2017).

Both the waste of excess food and food poverty are ethical problems that affect the functions of food systems as a whole and the behaviour as individuals. They are at the core of two Sustainable Development Goals (SDGs), which altogether relate to morally relevant aspects of life, represent an ethical stance and principles to a global joint political effort (Keitsch, 2018; Salamat, 2016). By 2030, UN states are committed to meeting SDG 12 “Ensuring sustainable consumption and production patterns”, which targets halving per capita food waste and reducing food losses and SDG 2, aimed at “ending hunger and ensuring access by all people, the poor and the vulnerable to safe, nutritious and sufficient food”. Although SDGs are implicitly linked and should be implemented as an “indivisible whole” (Nilsson et al. 2016) these two goals do not show an explicit connection in their formulation. Beyond achieving coherence across multiple stated principles, objectives and targets, a critical challenge lies in the implementation (Rogge and Reichardt, 2016). Analysts, policy-makers and practitioners acknowledge the possibility of trade-offs and reinforcing relationships as the goals and targets are implemented and the need to further understand interactions, particularly to identify gaps and anticipate unexpected negative consequences (Kopainsky et al. 2018).

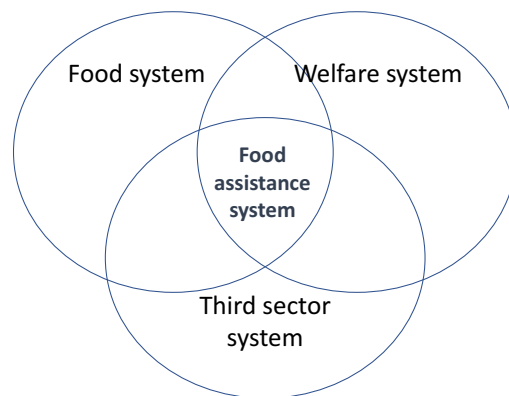
The disparity between food waste and food insecurity data in high income countries highlights a sort of functionality between recovering food to reduce waste and donating it to people in need to address food poverty. As shown in the next paragraphs, increasing literature addresses food waste prevention entry points and strategies (e.g. Canovas Creus et al, 2018; Priefer et al. 2016; Schneider, 2013a) and food recovery, redistribution and donation mechanisms (Sert et al. 2018; Vlaholias et al. 2015; Schneider, 2013b; Alexander and Smaje, 2008). The so-called paradox of “scarcity within abundance” (Campiglio e Rovati, 2009) draws attention to the social and ethical implications of food waste (Papargyropoulou et al. 2014) and charitable food assistance is arguably being framed as a “win-win solution” (Caplan, 2017).

This paper contributes to the reflection on the functionality between food recovery and donation by unravelling the implications of treating food surplus reduction and food aid as a “win-win” strategy. We propose and adopt a system dynamics perspective to examine the nexus between food surplus reduction and re-distribution for social purposes, to address the following questions: what happens on

the side of surplus food reduction if food redistribution for social purposes consolidates its role in food poverty mitigation? And what happens to food assistance if food surplus is reduced through waste prevention measures? To what extent these objectives will stay in balance and how such balance may be maintained?

Before moving into the analysis, a premise should be made on what we mean by food assistance “systems”. The food assistance system addresses two main outcomes related to the sub-systems involved in food assistance delivery: food surplus reduction and food poverty alleviation. To these ends, it relies on resources, both public and private, and represents a gateway to social services, in an interaction between public, private and third sector actors. This enables a dynamic framing that understands food assistance as “hybrid systems” (Galli et al. 2018; Arcuri et al. 2016; Abdussamad 2014) situated at the intersection between food systems, welfare systems and third sector systems (Figure 1). The understanding of food assistance dynamics and the identification of expected and unexpected consequences is only possible if this hybridity is explicitly considered, bridging different streams of literature and policy domains.

Our analysis draws upon the academic debate taking stock of literature analysis integrated by previous case study research and the authors personal experience (more detail in the material and methods section).



*Figure 1 - Food assistance systems at the intersection of food, welfare and third sector systems*

Mapping systemic interdependencies and uncovering potential areas of synergy and conflict are an important assignment for sustainable development, in relation to food surplus and waste management (Halloran et al. 2014). Building visual representations to observe dynamic interactions in food assistance systems supports a better understanding of the implications and raises questions for policy makers, as well as food system and third sector actors about ethical dilemmas and tensions that may derive from reducing food poverty and food waste as a win-win solution. The model responds to the need to make connections explicit, which enables to identify situations in which there is convergence between policy objectives, while highlighting the –less visible –circumstances that may compromise the achievement of the one or the other goal.

In the next sections: a methodological note on the system dynamics concept mapping with reference to data and materials used followed by a section on background literature on food surplus reduction strategies and food poverty alleviation. Hence, the system dynamics conceptual mapping applied to food surplus reduction and re-distribution for social purposes is presented and discussed. The concluding section reflects on the systemic and individual dimensions of food waste and food donation, highlighting key propositions for social and environmental sustainability and equity across multiple settings (food system, welfare, civil society).

### **System dynamics conceptual mapping: methodology and data**

The “food system” approach provides an analytical framework for conceptualizing food related actors, relations and processes and for introducing a policy focus on the socio-ecological sustainability of food production and consumption (van Berkum et al. 2018; HLPE, 2017). The food system framework embeds the activities of food producers, processors, distributors, retailers and consumers in social, political, economic, historical and environmental contexts and connects these activities to food security and socio- environmental outcomes. Environmental, social, economic and political drivers affect how food system activities are performed, their impacts and outcomes, which in turn generate feedbacks that alter the functioning of the system (Ingram, 2011; Ericksen et al. 2010; Ericksen, 2008). Academic literature documents system dynamics as applied to natural resource management issues such as water resource planning, land use and soil erosion, food and nutrition security and resilience, and small farm holder development (see Turner et al. 2016 for a review).

System dynamics models are used to support learning in complex systems and for explaining observed behavior, building theory and identifying the impact of policy and management actions (Sterman, 2000). System dynamics draws upon qualitative and quantitative methods, emphasizes stakeholder involvement to define mental models and encourages researchers to adopt a non-linear thinking to seek and describe the feedback processes of a problem’s dynamics (Turner et al. 2016: 2). Kopainsky (2018) lists different contributions that system dynamics modelling makes to the development of theories of change for sustainability transitions in food systems: calibration of simulation models to location specific food systems and identification of leverage points, identification of structure and building blocks for specific applications and guidelines for involving stakeholders in the modelling process, anchoring simulation models in ongoing community development. Relevant to the latter aims, structural thinking tools such as system diagrams can be used for qualitative conceptualization of theories of change (Brzezina et al., 2016; Stave and Kopainsky, 2015).

System dynamics are described by representations of feedback processes, stock and flow variables, time delays and nonlinearities. Stock variables are accumulations, which characterize the state of the system and generate the information upon which decisions and actions are based. Flow variables (inflow

and outflow) change the level of a stock over time and are influenced by the stock levels and other functions. Feedback is at the heart of the system dynamics approach and a feedback “loop” exists when results of some action in a system impacts on its point of origin, potentially influencing future action (Kopainsky et al. 2018). Feedback loops can be “reinforcing” (R) when the reaction determines a growth or acceleration, acting as a destabilizing force (e.g. the ‘poverty trap’, a situation where households with poor asset endowments are unable to invest in productive assets, which exacerbates food insecurity). Feedback loops can be “balancing” (B) when they counter-act the initial force, having a stabilizing effect (e.g. the higher the supply, the lower the price and in turn the lower the supply). Feedbacks involve nonlinearities, time delays and accumulations, that complicate information and material flows, create instability and may lead to counterintuitive system behavior (Stave and Kopainsky, 2015).

We conceptualize food surplus recovery and donation as a dynamic system based on academic literature supported by reflections grounded in empirical data examining the discourse surrounding food assistance. The latter research has been collected in the Transmango project<sup>1</sup>. The variables and the connections in the system diagram are defined according to relevant literature. The analysis of the feedback loops and their implications have been developed during two years of case study work which entailed a direct contact with food assistance operators (food banks, policy makers, retailers, third sector actors involved in the distribution of food to people in need). From 2015 to 2017 in-depth interviews with food banks leaders and workshops have been developed with reference to the Italian context. More details on the empirical studies can be found in Galli et al. (2018, 2016) and Arcuri et al. (2016).

## **Food surplus reduction AND food poverty alleviation: evidence and challenges**

### ***Food waste prevention and responsible management***

Surplus food generation is a symptom of modernized food systems, linked to industrialization, economic growth, urbanization and globalization (Thyberg, Tonjes, 2016). In Europe, there is a pressing call to waste reduction in view of improving resource efficiency (Vanham et al 2015), as emphasized by the recently revised EU Waste Legislation (European Parliament and Council, 2018). A waste hierarchy prioritizes waste treatment actions from the most preferred to the least preferred based on environmental impacts (EU waste framework directive, 2008/98/EC). This hierarchy must be adapted to the specificity of food waste because European legislation or the application of the EU waste hierarchy to food is lacking. Figure 2 synthesizes existing food waste hierarchies, based on the EU Court of Auditors (2016). Food waste prevention, as part of the Commission's Circular Economy Action Plan (EC, 2015), means acting at the source by limiting the generation of surplus food at each stage in the supply chain (i.e. production, processing, distribution and consumption). The European guidelines on food donation (EU,

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<sup>1</sup> [www.transmango.eu](http://www.transmango.eu)

2017) supports waste prevention, to limit the generation of surplus at the source, however “*once food surpluses occur* –italics added –the best destination, which ensures the highest value use of edible food resources, is to redistribute these for human consumption”. Recovery of surplus means to “receive, with or without payment, food (processed, semi-processed or raw) which would otherwise be discarded or wasted from the agricultural, livestock and fisheries supply chains of the food system” and redistribution is to “store or process and then distribute the received food pursuant to appropriate safety, quality and regulatory frameworks directly or through intermediaries, and with or without payment, to those having access to it for food intake”.

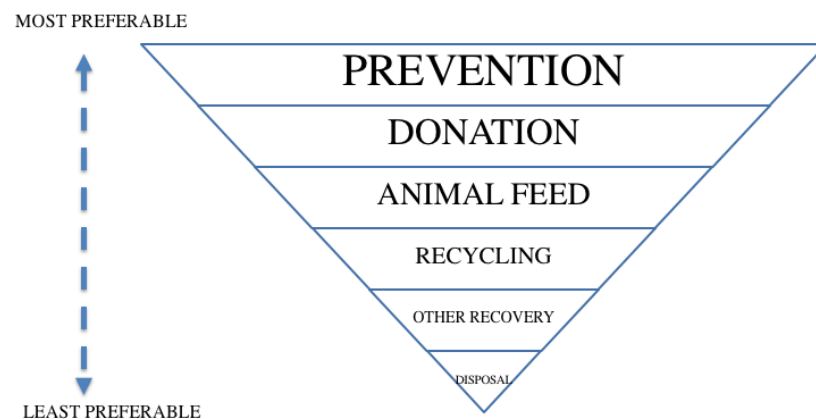


Figure 2 - Food waste hierarchy

Source: Adapted from European Court of Auditors, 2016

The European guidelines on food donation mentioned aim to align and facilitate compliance with food safety, hygiene, traceability, liability, and fiscal requirements. Despite these policy efforts, “responsible” surplus food management remains a key challenge.

Food waste monitoring and assessment is a necessary condition to effective prevention and reduction strategies (Corrado and Sala, 2018; outcomes of the FUSIONS project). The European Commission is currently committed to define a common methodology for food waste accounting and to propose relevant indicators (EC, 2015). Throughout the literature the definitions of food losses and waste are not consistent and the methodologies – generally based on direct and indirect measurements derived from secondary data – are multiple (Roodhuyzen et al. 2017; Beretta et al., 2013; Buzby and Hyman, 2012).

A first key distinction is between ‘food surplus’ (i.e. edible food that is produced, manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer) and ‘food waste’ (i.e. the surplus food that is not recovered to feed people, to feed animals, to produce new

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<sup>2</sup> <https://www.eu-fusions.org/>

products e.g. jams or juices, new materials e.g. fertilizers or energy) because often the subtle difference between the two terms is missed (European Commission, 2018; Garrone et al. 2014). Food surplus is food produced beyond someone's nutritional needs, and waste is a sub-product of food surplus (Papargyropoulou et al. 2014). According to a conceptual model by Garrone and colleagues (2014)—Availability, Surplus, Recoverability, Waste — available food can be consumed or become surplus, and the latter can become waste from a social perspective (i.e. food not used for feeding humans), zootechnical (i.e. food that not used for feeding humans or animals) or environmental perspectives (i.e. food not re-used or recovered in any form and disposed of). Surplus food may occur at different stages of the food chain, as a result of marketing strategies, date marking<sup>3</sup>, product and packaging deterioration or errors in forecasting demand, and is considered inevitable to some extent (EU Court of Auditors, 2016; BCFN 2012), while a significant share of surplus could in fact be avoided.

Corrado and Sala (2018) define “avoidable” and “unavoidable” food waste as relevant criteria to assess the potential for food waste prevention (of the avoidable part). Avoidable food waste is “food that at some point prior to disposal was edible” (p. X). Papargyropoulou et al. (2014) discuss avoidable food waste as including foods or parts of foods that are considered edible by the vast majority of people and unavoidable food waste as waste arising from food that is not, and has not been, edible under normal circumstances. However, the distinction between avoidable and unavoidable waste may be influenced by cultural and behavioral aspects and edible may not always mean avoidable (e.g. some fruit or vegetable peels may be edible but be considered unavoidable waste). ‘Possibly avoidable’ food waste is suggested for “food that some people might eat, and others might not” (WRAP, 2009). As most studies often refer to the consumption stage, it should be recalled that manufacturing may be a source of avoidable food waste due to non-optimal organization and coordination between actors, and to consumers' expectations on a wide availability of products (Beretta et al., 2013). How much of the surplus food is inevitable cannot be defined in principle and depends on several aspects. While some authors question whether surplus food is really inevitable or already included in consumer prices by retailers (Tarasuk and Eakin, 2005), it can be said that for sure it is hard to assess, and consequently manage.

Another distinction which may give rise to some confusion is between food waste prevention and management, (Papargyropoulou et al. 2014). Waste prevention includes activities to avoid *undesirable* (italics added) food surplus generation. Therefore, the priority for food waste reduction is to prevent overproduction and oversupply of food beyond human nutritional needs at all of the stages of the food supply chain. Waste management includes the options available to deal with food waste once it has been generated, such as composting and anaerobic digestion, according to the food waste hierarchy. Garrone et al. (2014) emphasize the importance of “responsible” food surplus management once the surplus food

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<sup>3</sup>A recent study commissioned by the EU promotes a better understanding and use of date marking on food, i.e. “use by” and “best before” dates, by all actors concerned, in relation to food waste in the EU. See <https://publications.europa.eu/en/publication-detail/-/publication/e7be006f-0d55-11e8-966a-01aa75ed71a1/language-en>



is generated. To this end the “degree of recoverability” plays a key role (Garrone et al. 2014, see par 4 for a description).

Overall there is a subtle difference between food surplus prevention and food donation, as first and second option of the food waste hierarchy. For example, Schneider (2013a) identifies the donation of edible food as a food waste prevention measure because donating food means bringing it back to its original purpose (i.e. human intake). The examination of a range of food wastage drivers provides insight into the best policy approaches to manage food waste and to support prevention (Thyberg and Tonjes, 2016). There is need for guidance in the application of the waste hierarchy (O’Connor et al. 2014) that clearly prioritizes feeding humans, through donation to charities, over waste management options such as composting, anaerobic digestion and landfilling: this implies identifying incoherence in policy measures and mitigating possible conflicts, thought suitable incentives.

### ***Food surplus donation for poverty alleviation***

Donation of food has a long history and has evolved over time (Schneider et al. 2013b). This has many reasons, not least a tradition of charities across Europe in delivering of basic goods, either in case of emergency or to support particularly vulnerable groups (Baglioni et al. 2017). The role of third sector, non-profit organizations, is widely discussed by recent literature (Galli et al. 2018; Hebinck et al. 2018; Baglioni et al. 2017; Garrone and Melacini, 2014; Gentilini, 2013). Civil society networks and associations actively contribute to redistributing recoverable food surpluses to those who live in a either a permanent or a temporary period of disadvantage. The role of non-profit actors has been particularly prominent in most European countries in addressing food poverty since welfare state regimes have gradually devolved their capacity and responsibility to societal actors. Food surplus redistribution takes place either through everyday exchanges, within proximity networks, or via more structured and formalized charitable initiatives, often in connection with public social services, depending on institutional context, history and culture. The European Food Banks Federation (FEBA) represents 388 member Food Banks, in 24 EU countries, who helped 8.1 million people in 2017 ([www.eurofoodbank.eu](http://www.eurofoodbank.eu)). In addition, the Tafel (German “food banks” which are not members of FEBA) distributes some 220.000 tons of food annually to approximately 1.5 million people (European Commission, 2017)<sup>4</sup>. Food bank networks provide for the supply, storage, processing and distribution in safety conditions of food surpluses while public action is often limited to allowing third sector initiatives to carry on their activities.

Recently in some countries, governments are becoming more supportive by promoting awareness campaigns to reduce edible food waste, as well as introducing incentives to facilitate food surplus

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<sup>4</sup> [https://ec.europa.eu/food/sites/food/files/safety/docs/fw\\_eu-actions\\_food-donation\\_eu-guidelines\\_en.pdf](https://ec.europa.eu/food/sites/food/files/safety/docs/fw_eu-actions_food-donation_eu-guidelines_en.pdf)

donation. A notable example is Italy, which in 2016 passed a law<sup>5</sup> to reorganize the regulatory framework on food donation, simplifying and harmonizing food recovery and redistribution of surplus food for the most deprived. France also committed to cutting food waste by half by 2025 and adopted a law<sup>6</sup> to set up a panel of measures to reduce and manage waste, especially at the retail stage, scale and logistics, evolving with the growth of large-scale food recovery organizations (Riches, 2018; Lambie-Mumford, 2017; Arcuri et al. 2017; Caraher and Cavicchi, 2014; Poppendieck 1998).

The current extent of donation of food surplus is fairly well documented at EU level. Available sources state that donations have grown significantly in the EU in recent years. Around half of the food collected in Europe comes from the European programme of food aid for the most deprived (FEAD)<sup>7</sup>. Nonetheless, the amount of food redistributed still represents a small fraction of the overall edible surplus food available in the EU. For instance, in 2016, members of the European Federation of Food Banks (FEBA) distributed 535 000 tons of food to 6,1 million people which represents only a fraction of the estimated volume of food waste generated annually in the EU<sup>8</sup>. At the same time, and due to the lack of data monitoring on food and nutrition insecurity, the proliferation of food banks is considered to be one indication of the increasing incidence of food insecurity (Galli et al. 2018; Smith et al. 2018). However, the density of food banks is not a good proxy for the identification of food poverty and insecurity, as third sector actors set up food banks based on community resources and local social networks (which does not necessarily coincide with population needs) (Smith et al. 2018).

A set of barriers to donation are acknowledged: food safety, hygiene and tax legislation are identified as the main legal areas impacting the scale of donation while, other constraints refer to the lack of knowledge by donors on foodstuffs suitable for donation, insufficient logistical frameworks in place to facilitate large-scale donation and the burden on charities in managing food surplus recovery and redistribution (EU, 2017, Baglioni et al. 2017; Priefer et al. 2016; Schneider et al. 2013b).

The role of food banks in addressing food insecurity is increasingly researched. ‘Household food insecurity’ has been defined as the inability to acquire or consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so (Fabian Commission, 2015). A recent review affirms that while food banks have an important role to play in providing immediate solutions to severe food deprivation, they are limited in their capacity to improve overall food security outcomes (Bazerghi et al. 2016). The identification of how food poverty manifests itself and how it should be tackled is a challenge for social welfare and third sector actors. The Fabian Commission (2015: 12) identifies two key drivers: low incomes, relative to prices, which constrains

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<sup>5</sup> Law No 166/2016 of 19 August 2016, Provisions concerning the donation and distribution of food and pharmaceutical products for purposes of social solidarity and to limit waste, Official Journal No 202 of 30 August 2016.

<sup>6</sup> National Pact Against Food Waste Law n° 2016-138 of February 11, 2016.

<sup>7</sup> Data shows more specifically that 33, 22% comes from the food industry (manufacturers), 17% from the retail sector and 14% from individuals through national and local collections (O’Connor et al. 2014).

<sup>8</sup> European Federation of Food Banks (FEBA): <http://www.eurofoodbank.eu/> In addition, the Tafel (German ‘food banks’ which are not members of FEBA) distributes some 220 000 T of food annually to approximately 1,5 million people.

economic access (Dowler, 2014) and limited physical access to adequate quantities or sufficient quality of food. Several academic scholars raise doubts on food surplus recovery for social purposes as the primary response to food poverty, as these initiatives increase their visibility (Riches, 2018; Middleton et al. 2018; Riches and Silvasti, 2014; Caraher and Cavicchi, 2014; Lorenz, 2012), while some criticize the role of food banks, as being part of the problem not the solution (Booth & Whelan, 2014; Lambie-Mumford, 2013; Riches, 2011; Tarasuk et al., 2014). Some authors emphasize the role that food bank leaders play in ethical sensemaking around the dimensions of hunger and food-related illnesses (Elmes et al. 2016), the limits of charitable food aid regarding stigmatization and dependency (Tarasuk and Eakin, 2005) and the delivery of nutritionally adequate food (Simmet et al., 2017).

Campbell et al. (2013) conceptualized three groups of factors that play a role in influencing the nutritional quality of distributed foods: culture (i.e. volunteer staff and management attitudes, organizational intent regarding nutritious food inventory, stakeholder support), capacity (i.e. resources available for carrying out organizational intent regarding nutrition); and practices (i.e. the use of the resources and processes that contribute to a nutritious food inventory). These factors play a role together with the preferences of the ultimate recipients of emergency food. At times of serious economic crisis, such as the one registered since 2007-2008, food charities may operate at full capacity and incur in saturation as a higher number of requests cannot be fulfilled. User perceptions about the idea of being fed from food banks can be positive or negative and varies across studies, in relation to food bank operations and services, food quality and socio-psychological impact (Middleton et al. 2018). There seems to be a gap of insights on how people in need become food bank users and the processes that lead them to asking for help.

### **System dynamics conceptual mapping applied to food surplus reduction and re-distribution for social purposes**

In this section we present a conceptual map of the interactions between food waste reduction, food surplus recovery and food poverty alleviation, providing a structured overview of the variables and the mechanisms that describe the nexus between food surplus recovery and food poverty alleviation. The analysis of system dynamics describes how the systems might be affected by disturbances, which may compromise the desired outcomes.

The model in Figure 3 identifies stock variables (in the boxes): *surplus food*, *food donation*, *food waste*, *people in need*, *food aid beneficiaries*. Inflow and outflow rates change the level of these stocks over time: *degree of recoverability*, *food banks capacity*. Other variables affecting stocks and rates are identified (out of the boxes). Four feedback processes, either reinforcing (R) or balancing (B), are found.

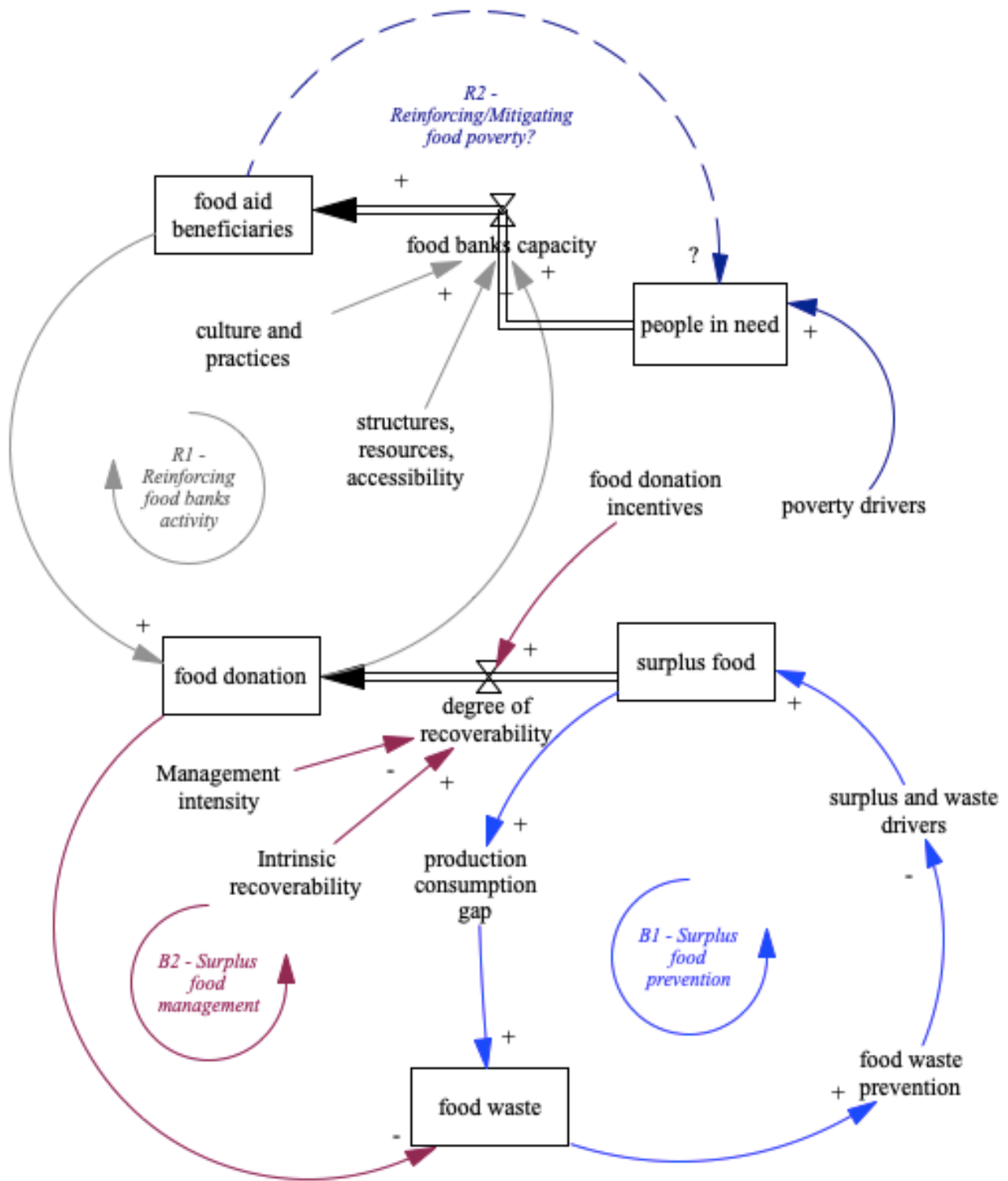


Figure 1 - Food waste reduction, food surplus recovery and food poverty alleviation dynamics: a conceptual model

The first balancing loop occurs in the lower right-hand side of Figure 3 and is synthesized as “*Surplus food prevention*” (B1), starting from “*surplus food*” generation. A higher food surplus contributes to widening the “*production consumption gap*” which in turn fosters “*food waste*”. The increased awareness on the implications of food waste as an ethical worldwide issue has altered the perceptions and attitudes, potentially yielding behavior changes in relation to prevention actions. The identification of “*food waste prevention*” measures requires understanding and mitigating “*food waste*”

*drivers*” which are cultural, personal, political, geographic, and economic and highly variable across countries. The identification of drivers of waste leads to a search for solutions that generate a change in marketing standards, aesthetical requirements, a better tailoring of expiry dates mechanisms thus impacting on the levels of surplus food.

The second balancing loop, positioned in the left-hand side of the figure, is responsible “***Surplus food management***” (B2). Given the definitions of food surplus, food waste and food donation discussed above, it can be affirmed that food waste and food donations represent a (hard to define, in light of the literature) share of food surplus.

The transition from surplus food to food donation is a function of the “degree to which surplus food generated by the food system can be recovered for human consumption” (Garrone, 2014: 133), which in turn depends on surplus food management policies. Recoverability for human consumption is inherently different at different stages in the food supply chain and for different kinds of products (e.g. grains must be transformed to be consumed while finished products are ready to eat). This parameter depends on the “*intrinsic recoverability*” of surplus food (i.e. the degree to which a potential beneficiary could use surplus food for human consumption in the absence of additional management efforts) which is affected by the type of product and the activities required (e.g. shelf life, need for refrigeration, certification). Another variable of recoverability is the “*management intensity*” (i.e. commitment and costs required by food system actors) required to make surplus food usable by beneficiaries, such as maintenance, preservation and enhancement. A higher rate of recoverability will allow a lowering of the amount of food wasted, as more food will be recovered for social purposes and less surplus will be used for other purposes (e.g. animal feed, energy production, composting). “*Food donation incentives*” act to enhance the degree of recoverability by clarifying regulatory requirements and suggesting economic incentives (European Commission, 2017; see notes 4 and 5).

Taken together, surplus food donation and surplus food prevention both contribute to reducing food waste, in line with the expectations of the food waste hierarchy. However, food donation for human consumption takes place through established linkages to the food assistance systems. These linkages generate reinforcing feedback loops, which are described in the upper half of the diagram. Food donation increasing “*food banks capacity*” is defined by Campbell et al. (2013: 265) as the “resources available for carrying out organizational intent regarding nutrition”. Other factors affect food banks capacity, including physical and technological *infrastructure and equipment resources* (warehouse, refrigeration, trucks), *accessibility* and food banks *culture and practices* (Arcuri et al. 2016; Campbell et al. 2013). A higher food aid capacity allows to serve a higher number of food recipients and reduces the number of “*people in need*”, identified here as all those who show some form of poverty and turn to (or are turned to, for example by social welfare entities) food assistance. Depending on food banks capacity to aid, people in need become food aid recipients.

**“Reinforcing food banks activity” (R1)** is a critical loop that takes place as more food surplus becomes food donation, encouraged by donation incentives, which reinforces food banks capacity to respond to food poverty needs and increases the number of beneficiaries. In turn, higher numbers of people served will call for more donations, and as food poverty is perceived as a social problem, this justifies food banks existence and action, thus reinforcing the feedback loop.

It should not be overlooked that the introduction of food surplus recovery incentives for social purposes, for example with the Italian law, was triggered after the transition from PEAD to FEAD, which caused a reduction of resources available to food bank actors at a time when the impacts of the economic crisis in 2007-8, were still evident. This was the case of the increased efforts devoted by Caritas and Banco Alimentare to raise new resources and to involve new partners, to face longer lines at their food pantries (Santini and Cavicchi, 2014). The emphasis was reinforced by the contrast with the abundance of food waste generated by the food system.

There are three caveats to this reinforcing feedback loop: the first is if food banks have sufficient structures and adequate human resources to manage more incoming donated food, including the logistics. Case study evidence in Italy shows that food assistance needs to find adequate spaces for carrying out their activity, and public authorities play a role in supporting with suitable locations (Arcuri et al. 2016).

The second – less evident caveat— derives from a decline of people in need. For example, thanks to economic upturn or new welfare measures (e.g. effective minimum income) that reduce poverty. If the number of people in need for food aid would reduce, this would mitigate the role of food banks but also the role of food donation as a waste reduction measure, increasing the relevance of food waste prevention or other options of the food waste hierarchy. However, evidence on the effectiveness of income measures in relieving food poverty is inconclusive.

A third consideration stems from the connection between B1, B2 and R1 and can be illustrated by an example. In a context of greater attention towards food waste several supermarket chains have started to sell at half the price food products close to the expiry date. The practice seems to be widespread both on the Italian territory and across major retailers:

*“Even those who are not below the poverty line can find it hard to make ends meet, but it is unlikely that they will go to the soup kitchen or to seek help from Caritas (i.e. food assistance actors). Obviously, no one is going to check who buys these products, but we can assume that individuals and families in need know the good moments to find them are the morning and the early afternoon, when we gather them”* (personal communication with an Italian retailer, 2015).

It follows that organizations providing food assistance may no longer count on the relevant amount of surplus food previously received (which was compensated by more frequent food drives and

monetary donations, in the specific case considered). This highlights a trade-off between initiatives aiming at waste reduction and support to charitable organizations for food poverty alleviation.

The last (potentially) reinforcing feedback loop is in fact a question mark: what role do food banks actually play in “*reinforcing/mitigating food poverty*” (R2)? There are multiple reasons why people in need access food banks, but the literature is not clear on whether food aid is always the best response to situations of extreme need. When do food bank actors succeed in pushing people out of poverty or when do they contribute to generating dependence? Food bank users say diverging things in different cases, depending on situations and other socio- psychological factors (Middleton et al. 2018). Among the main criticisms, the fact that food banking is publicly unaccountable and not a right for all, at least in principle. However, this does not reduce the value and the challenge for the many who organize and operate charitable food banks and especially those who support them as volunteers giving their time, expertise, donations and most of all their human compassion to feed hungry people (Rombach et al. 2018; Baglioni et al. 2017).

## **Discussion and concluding remarks**

Food waste raises ethical and moral issues, perhaps more than any other kinds of waste, for two intuitive reasons: it is a waste of scarce natural and economic resources and it is food that could have been used to face hunger and inequality (Papargyropoulou, 2014; Gjerris and Gaiani, 2013). Frugality, thrift and sustainable consumption are to some extent linked to the prevention of waste (Evans, 2011; Edwards and Mercer, 2007). Donation of surplus food ranks high in the food waste management hierarchy, as it allows to maintain food’s primary function, namely human consumption. However, neither hunger can be solved by the donation of food, nor all edible foodstuff can be distributed to people in need (Schneider, 2013a and b).

Both food waste and food assistance have a systemic dimension. Nonetheless, they have very different root causes: partly different systems are involved, and multiple solutions need to be mobilized (Godfray et al. 2009) and implemented in coordination to avoid inconsistencies (Nilsson et al. 2016). The key factors and dynamics involved in food surplus prevention and donation (Figure 3) indicates that surplus food has a desirable and undesirable connotation, depending on the system perspective adopted. What is desirable from a food system view, i.e. that surplus food is reduced to prevent food waste, becomes to some extent desirable from a welfare system perspective, i.e. alleviating food poverty by delivering surplus food. On the opposite there can be situations in which prevention of food surplus clashes with surplus food redistribution for social purposes.

From the perspective of food system inefficiencies, we have seen from the literature that *avoidable* surplus food production should be the target for food prevention measures and that the food donation system should target *non avoidable* surplus, in order to prevent fostering some level of surplus

food production for social purposes. However, “inevitability” is not easy to define (it’s subjective), to identify (waste happens at all supply chain levels), and to quantify (from a methodological point of view). Nor is *non avoidable* surplus able to suit the needs of food assistance operators and recipients (in terms of food quality and nutrition).

The food donation system relies operationally on nonprofit organizations, which are by definition voluntary, therefore - as long as they comply with hygienic and liability rules - they cannot be fully controlled. From the side of poverty alleviation, (unavoidable and avoidable) surplus food is valuable. It is among the resources streams that support food banks capacity (with differences according to the food assistance governance models (Galli et al. 2018)). Third sector reliance (or *dependency*) on surplus food should be considered carefully (e.g. to avoid shortage of food) and closely planned to avoid excessive reliance and limit the sensitivity to possible fluctuations along the process of waste reduction within the food system. Further, structural food surplus destination for social purposes would challenge food banks in managing logistics and the storage of donations.

Our systematic reasoning based on available literature and reflections from empirical data examining the discourse surrounding food banks in Italy highlights a set of key questions that concern the intersection between food waste and food poverty that still remain to be answered. To what extent food surplus donation reduces food surplus generated into the food system? What are the consequences of the application of the food waste hierarchy, as proposed by policy makers, on third sector actors? What structural requirements and capacities are needed? Is it necessary to foresee and guarantee a stable share of surplus? Does the food banks dependency on food surplus delay solutions to food system surplus prevention? To what extent does food aid address poverty and foster social re-inclusion processes?

The “EU Platform on Food Losses and food waste” has been recently begun to monitor progress towards SDG 12.3, defining measure for food waste prevention, fostering inter-sectorial cooperation and sharing best practices. Within the Platform, subgroups on food donation, food waste measurement, action and implementation have been appointed (Caldeira et al. 2017). Impact assessment of specific food surplus management options are still incomplete and the monitoring of recent national measures (as in Italy and France) are still unavailable.

“Feeding the hungry is a moral imperative” (Riches, 2018) but evidence on the reduction and disappearance of food and nutrition poverty in high income countries is still limited; as is the role and effectiveness of the work food assistance in reducing food poverty. Literature calls for a “move from an approach based on offering food to the poor towards an approach that responds to the demands, needs and the aspirations of disadvantaged people”, however while this is already happening in some food banks, in part, it is not occurring everywhere (Middleton, 2018).



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