Review Paper

Is there a need for greater integration and shift in policy to tackle food waste? Insights from a review of European Union legislations

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Abstract
Within the European Union, there is an increasing recognition about the negative environmental impacts of food waste making it a prominent policy issue. But there is no clarity whether policies aimed at food waste minimisation are based on sound legislative frameworks that actually empower the relevant actors. By carefully reviewing existing European Union legislations that are linked directly or indirectly to food waste, we identify the difficulties encountered by stakeholders and assess whether adaptations to the rules-in-use are beneficial and desirable. Our general finding is that liability for donated foodstuffs, date marking provisions, the flexibility principle provided by the European Union Hygiene Package and fiscal rules are the main policy elements affecting, either positively or negatively, food waste generation and management. Food donation for charitable purposes emerges as the predominant Pan-European Union waste management solution. While removing existing barriers for food donors and banks is fundamental—as it makes redistribution more effective—this does not tackle prevention of excess food generation. We conclude that while there are several European Union food legislations which include and impact food waste management options, they are hardly direct. Moreover, they often generate incentives that are at odds across stakeholders, thereby dampening the intended impact. There is, therefore, need for an integrated policy framework to tackle food waste specifically. For that to happen though, a prerequisite is lot more empirical research on the interaction effects of various food waste legislations.

Keywords Food waste · Food donations · Waste framework directive · Policy and legislations · EU

1 Introduction

Food waste has become increasingly important in the eyes of European Union (EU) institutions and the public at large. There are multiple and interconnected factors behind waste generation in food systems, resulting in a complexity that can be quite challenging to disentangle and propose solutions to BCFN (2012), [1], Vittuari et al. (2015). Moreover, a solution for one stakeholder may merely mean transferring the burden to another [2]. A case-by-case approach, developed together with solid communication, networking and collaboration among all the actors involved in the chain, is thus necessary for any meaningful measures to be formulated. However, given the complexities in minimising food waste, such measures risk being ineffective unless supported by a more systemic legislative approach and financial mechanisms. Policy instruments including both market-based (economic) instruments and non-market-based (regulatory) instruments, or a combined system involving both these policy instruments, are

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therefore needed at the European level. 'Command and control' regulations compel the actors involved to meet specific environmental standards, while sanctions prevent indiscretion (Sinclair 1997). On the other hand, regulatory standards entail detailed rules, requiring wide knowledge on the issue in order to set appropriate standards and an authority to monitor compliance at all levels [3, 4]. The softer and flexible approach of market-based instruments, instead, involves a set of economic incentives in the form of tax exemptions, deductions and refund schemes, which trigger behavioural changes accommodating the desired policy goals. These self-regulatory measures leave discretionary space for lower levels of governance and are cost-effective related to command and control instruments. They can also be iterated more easily to adjust the appeal of continued reduction in pollution (Héritier 2002) [4]. However, incentive taxes and similar control measures may not be effective when stakeholders pollute for non-economic reasons [5]. A mixed system of economic instruments and legislation that define environmental standards but encourage low implementation costs is thus necessary to properly tackle food waste reduction targets. In some circumstances, additional legislations may not even be needed to achieve a transition towards reduced food waste generation. If the barriers presented to stakeholders by the existing frameworks are better understood, half the work may be done.

While there is some literature on policy implications of—or framework for—food waste management in various stages of the food supply chain [6–8], there is hardly any attention granted to the role of legislations and their interactions in meeting food waste goals. Against this background, a review literature on EU legislations that directly or indirectly affect the generation of food waste was conducted. In addition, we examined EU projects and long-term strategies related to food waste prevention and reduction. Where available, examples of best practices adopted by some Member States (i.e. regulations promoting food donations in France and Italy) are presented in order to show the possible solutions to the obstacles that arise from the legislations examined. This investigation presents a first step, following which further analyses and discussions on Member States' food waste policy regimes can be conducted. This could help identify areas for improvement in rules-in-use and also areas where new legislation is needed. The mere introduction of new rules will not necessarily lead to the desired change. At the same time, however, without an appropriate policy environment tailored for use by the actors concerned, no integral transitions can occur, due to the lack of a legislative foundation on which new initiatives can be built. The rapid and constant evolution of food waste policy, given its extreme actuality and relevance, make it difficult to be up to date. Nevertheless, it is still important to recapitulate the current situation, investigate the possible alternatives and offer plausible steps forward. Moreover, this may provide important insights to other countries that are outside EU and grappling with food waste having even less coherent or direct thinking on legislative factors influencing food waste.

2 Methodology

The methodology followed to achieve this essentially comprises of reviewing the EU Regulations and Directives on food hygiene (Reg. 2002/178/EC; Reg. 2004/852/EC; Reg. 2004/853/EC; Reg. 2004/854/EC; Reg. 2004/882/EC; Reg. 2005/2073/EC; Reg. 2005/2074/EC; Reg. 2015/1375/EC; Reg. 2016/759/EC), on food labelling (Reg. 2011/1169/EC), on waste management (Directive 2018/851/EU; Directive 2008/98/EC; Directive 2009/28/EC; Directive 1999/31/EC), on fiscal rules (Directive 2006/112/EC) and on food marketing standards (Reg. 2007/1234/EC; Reg. 2011/543/EC; Reg. 2013/1308/EC). The review also included the EU guidelines and reports on specific issues, such as those on the Value-Added Tax (VAT Guidelines 2017), on donations (EC 2017) and on the flexibility provided by the Hygiene Package (EC 2010a, b, 2016), as well as the reports of major EU funded projects addressing the food waste issue (FUSIONS, REFRESH), reports from EU associated organs such as those from Directorates General (DG-Environment 2012; DG-SANCO 2011), from the European Court of Auditors (ECA 2016) and reports from EU-associated organisations and federations such as the European Consumer Organisation (BEUC 2014) and the European Food Banks Federation (FEBA 2018). Reports from international organisations, the Food and Agriculture Organisations (FAO 2009; [9]; FAO 2013a, b) and the United Nations Environment Programme (UNEP 2009) have also been included. Other than these, publications and reports from Swedish institutions, including the Swedish National Food Agency (SNFA) and the Swedish Environmental Protection Agency (SEPA) have been investigated (SNFA 2018a, b, SEPA 2012, 2013, 2015, 2017), as well as publications from other Member States institutions including national reports (WRAP—UK Waste and Resources Action Programme, DEFRA—UK Department for Environment Food and Rural Affairs; EVIRA—Finnish Food Safety Authority, FASFC—Belgian Federal Agency for the Safety of Food Chain) and directives (Law 155/2003; Royal decree 2003-11-14/41) in order to provide a comprehensive review, displaying solutions already adopted to overcome specific legislative hurdles.

We started by standard literature search using the relevant key words (e.g. food waste, European Union, supply chain, legislation, policy, directive etc.) in all important

bibliographical online search engines and databases. In the second stage, we combined and created a smaller set of literature that contained publications referring to all EU Member States, EU legislations, Regulations and Directives. The information gathered as a result of this review work was then examined and re-elaborated with the aim of offering a condensed but comprehensive overview of the EU policy environment influencing generation of food waste.[1]

3 Food waste and the European Union

3.1 Impacts and causes

Food production represents an important driver of environmental pressures (FAO 2013a). Globally, food crops that are produced but then lost or wasted account for 24% of all freshwater used in agriculture [10] and requires an arable area the size of China (FAO 2013a). Emissions related to food waste account for about 8% of annual greenhouse gas global emissions (FAO 2013a). Food production contributes to biodiversity loss when expansion of crop land happens on forestry and natural habitats. When a sizeable proportion of this food produced for consumption is either lost or wasted, the impacts become severe and irreversible. Therefore, a reduction in food waste at global scale, by cutting down the need for excessive food products would contribute to preservation of scarce natural resources. Food waste can also result in monetary costs which include, for example, the maintenance of landfills or waste management facilities. Food that is wasted usually is high in moisture content and low in calorific value, which means lower energy efficiency of combustion plants [11]. Since resources are used at every step in the food value chain, wastage becomes socially costlier when it happens further downstream (Eriksson and Strid 2013). Wastage of edible food also raises important equity questions given that large numbers of people globally are below the poverty line and do not have access to even bare minimum food (O'Connor et al. 2014). In the EU as well, 16 million are dependent on food from charity organisations (EP 2011) which raises some questions about the wisdom of dumping of edible food in landfill or incineration for energy production (O'Connor et al. 2014).

Food waste in the EU is defined by Article 1 of Directive (EU) 2018/851 as all food as defined in Article 2 of Regulation (EC) No 178/2002 that has become waste. Food waste can have many and greatly varied causes [12] and Canali et al. [1] identified 271 drivers responsible for the generation of food waste, which they classified into three main categories: drivers related to technological development, to institutional requirements and to the social context. The first category of drivers is dependent on the intrinsic characteristics of food such as the ingredients and composition, technological parameters such as pH and water activity, any heat treatment performed, storage conditions and temperature as well as the type of packaging used. These factors, alone and in combination, strongly determine the shelf-life of different types of food and thus the probability of them being sold before they spoil or reach the "best before" or "use by" date, respectively. This category of driver also includes erroneous or suboptimal use of processing technologies that inevitably lead to food waste generation, since the products obtained do not comply with the necessary safety standards. The second category, institutional requirements, includes regulations and legislations, in particular those related to the areas of agriculture, food safety, animal welfare, food quality standards, waste management, taxation, food labelling and donations that directly or indirectly affect food waste. The last category includes the social dynamics of food and food consumption, aspects that are often not readily modifiable. Despite increased globalisation, attitudes to food vary greatly with cultures and what is considered food in one country might not necessarily be considered food in another. This category also includes individual behaviour when purchasing food and when using it at household level, poor information about the consequences of food waste and dietary choices. Finally, a crucial role is played by consumer expectations on the freshness of fresh fruit and vegetables and their availability, irrespective of season or geographical location.

According to Canali et al. [1], there is no single clear determinant of the generation of food waste and instead it results from a complex pattern of extremely diversified causes. Food waste has implications at all levels of the supply chain, which also involves local authorities, consumers, the retail supply chain and catering services and the processing industry. Furthermore, increased industrialisation and urbanisation have made the food supply chain much more complex, thereby multiplying the possibilities for waste generation. From a legislative point of view, this multi-sector structure means that food waste is addressed by different policy areas with interconnected effects. This is a particular problem in Europe, since the EU is made up of different Member States, often with differing political approaches. The result is a variety of government plans, laws and initiatives on food waste that are difficult to schematise and fully harmonise. Moreover, the food waste policy arena is constantly and rapidly evolving

[1] The listing of all reports, regulations, directives and projects reviewed are given along with their web-links (wherever available) in the Supplementary Material.

due to the pressure of civil society and changes in each national government's political agenda, making the issue even more complex. The extent and complexity of areas directly and indirectly affected when dealing with the food waste issue can be clearly understood by looking at the number of Directorates General (DGs) (departments of the European Commission) that are currently involved. Vittuari et al. (2015) estimate that at least seven DGs are involved in food waste, each with at least one policy area. These are: rural development and agriculture (DG AGRI), maritime affairs and fisheries (DG MARE), food safety and health (DG SANTE), industry, entrepreneurship, internal market and SMEs (DG GROWTH), energy (DG ENER), environment (DG ENV) and customs union and taxation (DG TAXUD). In addition, since food waste represents one of the important causes of greenhouse gas emissions (FAO 2013a), the Directorate General for Climate Action (DG CLIMA) is also directly concerned.

3.2 Position on food waste

As part of the UN's 2030 Sustainable Development Goals (UN 2015) and the Circular Economy Package (EC 2015), the EU has committed itself and its Member States to reducing by 2030 the amount of wasted food by half and to finding new and more efficient ways for food waste utilisation. According to the European Commission, a life cycle approach extended to all European organisational levels will generate several benefits, for example it will boost the EU's competitiveness by protecting businesses against volatile prices and scarcity of resources, contribute to new business opportunities, local jobs at different skills level and opportunities for social integration. It will also promote a sustainable economy to help avoid the damage caused by depletion of natural resources that currently exceeds the capacity of the Earth to renew them (EC 2015). Based on these principles, programmes aimed at food waste reduction have been adopted by the European Union. The EU has developed two projects specifically targeted at the food waste issue, which together cover the period 2012–2019.

The first project, FUSIONS, which ran from 2012 to 2016, tried to understand drivers of food waste to clarify what is meant by food waste by furnishing a common, uniform definition. Developing definitions and indicators is essential in tracking progress on objectives and in evaluating the efficacy of waste prevention strategies (Bio Intelligence Service 2009). Until a few years ago, the absence of common definitions on food waste meant that data were not always transparent or comparable [12]. The diversity of definitions is due to the fact that food consists of a large group of diverse products with different production processes and distinct supply chains. Thus for instance, some food derivate may represent a waste for one particular production stream, but not for others. For these reasons, the concept of food wastage is described in various terms which are similar, but have slightly different connotations. For instance, the literature is replete with different expressions such as "food loss" (Gustavsson et al. 2011; Strid and Eriksson 2014), "food waste" (DEFRA 2010), "food loss and waste" (Hanson et al. 2016), "post-harvest loss" [13], "food and drink waste" ([14]; Lee and Willis 2010), "edible and inedible food waste" (Östergren et al. 2014), "avoidable, possibly avoidable and unavoidable food waste" (WRAP 2009) and "spoilage of food" (Lundquist et al. 2008). Some of these expressions overlap and some are used to define different types of waste, often leading to confusion [12]. In principle, it can be presumed that the different definitions of food waste echo the different types of difficulties that stakeholders associate it with [15]. One of the main aims of the FUSIONS project was to formulate a single definition of food waste and other related terms, in order to allow uniform and comparable data collection in EU Member States.

The second project called REFRESH, started in July 2015 and ended in June 2019. Its main aim was to develop agreements between stakeholders in Spain, Germany, Hungary and the Netherlands. This work was intended to serve as a basis for developing and testing new approaches, designing technological innovations aimed at improving the valorisation of food waste, creating ICT-based tools to support new or already existing solutions and ultimately supporting the implementation of national and EU-level policy frameworks. Despite the large efforts put in these two projects, it is still to be seen how the policy recommendations will be implemented in EU food waste policy.

4 European Union framework linked to food waste

This section reviews EU frameworks and legislations relating to food waste, directly or indirectly, and the effects it have on food waste generation or prevention. Wherever available, examples of Member States initiatives are given. For greater clarity of presentation, the frameworks and legislations related to food waste are categorised based on their target/objective.

4.1 Waste management legal frameworks

The main EU policy frameworks and legislations about the management of all types of waste comprises the waste framework directive (WFD) and the Landfill Directive. Together with these two policies, an overall strategy adopted by the EU (known as the Circular Economy

Package) has also been adopted recently. The WFD has been repeatedly updated (EC 2012). The version currently in use is Directive EC 851/2018 which amends the previous Directive 98/2008 on waste. The current version encompasses food waste under the definition of bio-waste, a category represented by biodegradable garden and park waste, food and kitchen waste from restaurants, canteens, caterers, households, wholesale, offices, retail premises and comparable waste from food processing plants [Article 1(3b)]. It has updated the definition of bio-waste which also includes the first EU definition of food waste [1(3)], the boosting of food redistribution [1(10); Annex 4a (3)] and the clarification for the use of former foodstuff as animal feed [1(2)].

One of the most relevant provisions set by this directive is establishment of the waste hierarchy which grades waste management alternatives in terms of their environmental effect. According to this hierarchy, the priorities apply when dealing with waste management is disposal as the least favourable followed by energy recovery, recycling, preparing for re-use and prevention as the most favourable. The WFD, however, does not define a specific waste management order of preference for the waste generated in the food chain. However, indications on this are provided by the EU guidelines on food donations (EC 2017), which specify that prevention is the default favourable option. When this option is not applicable, the next best alternative is redistribution of surplus food for human consumption that guarantees the high worth use of the edible food. Furthermore, in its reply to European Court of Auditors report (ECA 2016), the European Commission states that the waste hierarchy from the WFD fully applies to food waste. Hence, when prevention and food donations are both not applicable, other less highly prioritised waste management options may be considered.

The Landfill Directive (1999/31/EC) has the target of achieving a staggered reduction in the amount of biodegradable municipal waste (BMW) going to landfill. It directs Member States to reduce the amount of biodegradable waste in landfill by 65% compared to the 1995 level. Since food waste constitutes a significant portion of BMW, this policy affects the amount of food waste sent to landfill. However, the Landfill Directive does not include binding specifications on how to dispose BMW not sent to landfill, which have led many Member States to opt for incineration (Vittuari et al. 2015).

The Circular Economy Package is an action programme aimed at stimulating transition of the EU towards a sustainable, resource-efficient and competitive economy, so as to create a new model of business which protects the economy from volatile prices and scarcity. Regarding food, the EU Action Plan for a Circular Economy (EC 2015) marks the commitment, ratified by each Member State (MS) as part of the 2030 Sustainable Development Goals (SDGs), to halving food waste along the retail and consumer levels, while reducing food losses along production and supply chains. It calls on the EU and its Member States to meet this target. Furthermore, the Annex to the Action Plan (EC 2015) provides a specific timetable for the future initiatives. It entails the development of a standard procedure and indicators to quantify food waste, a stage to examine how to achieve the 2030 SDGs on food waste and an analysis of options for more effective understanding and use of date marking. Finally, the Action Plan aims at sharing best practices, evaluating progress and clarifying relevant EU legislations on surplus food, that intend to facilitate donations or re-utilisation for animal feeding. The Circular Economy Package can be seen as an aggregation of previous and current initiatives dealing with waste management strategies that in some cases may partly overlap with each other, but are all oriented towards the same aim. An overview of the main strategies adopted is given in Table 1.

Despite these initiatives, there has been some recent criticism regarding the excessively soft approach adopted and the lack of concrete results. For example, while a definitional framework and a methodology for measuring and monitoring the amount of food waste have been established by the FUSIONS project, the European Court of Auditors (ECA 2016) points towards lack of a baseline that food waste minimisation achievements can be compared with. A specific baseline, setting out the current level of food waste for a given year, is necessary in order to assess and compare the relative success of initiatives adopted to reduce food waste. As long as a baseline is not set, there are no possibilities to verify the achievement of halving per-capita food waste by 2030. The subsequent risk is that efforts targeted at reducing food waste might hinge on qualitative statements, rather than tangible facts.

In 2016, the FUSIONS project published methodology for quantifying and monitoring food waste (Tostivint et al. 2016), with instructions addressed to each level of the supply chain (households, food services, retail and wholesale, processing and primary production). Yet, so far no data on food waste quantification have been reported by Member States and no deadlines have been set. Moreover, although the REFRESH project was pitched to be a continuation of FUSIONS, it has not focused on fostering data collection by Member States on food waste following the definitions and the methodology of FUSIONS, but has instead started a new research task. While this new work "takes an innovative, systemic approach to curb food waste […] and builds on and goes beyond existing initiatives […]" (REFRESH 2018), it does not aim to establish the fundamental baseline necessary to verify the true effectiveness of strategies adopted. Hence, no real large-scale comparison can be made to check the results potentially

Table 1 European strategies which fall under the scope of the circular economy package

Initiative	Objective	References
EU sustainable development strategy	Aims to improve the management and avoid the overexploitation of natural resources through efficient use of natural resources	DG-Environment (2012)
Thematic strategy on waste prevention and recycling	Sets out the general policy framework: modernising legislation, introducing an approach based on product life cycles, preventing waste generation and promoting recycling	EC (2005) Bourguignon (2016)
Seventh environmental action plan (7EAP)	Aims to protect the EU's natural capital, to turn the EU into a resource-efficient and competitive economy and to safeguard EU citizens from environment-related pressures and risks to health and well-being	Decision 1386/2013/EU Bourguignon (2016)
Sustainable industrial policy (SIP) and sustainable consumption and production (SCP) action plans	Supports the economic competitiveness of EU industry through improved energy and resource efficiency, as well as improved capacity to develop appropriate technological solutions	EC (2008) DG-Environment (2012)
Roadmap to a resource-efficient Europe	Sets targets for waste management to be achieved by 2050: re-use and recycling should reach the maximum feasible level and be economically attractive, energy recovery should be limited to non-recyclable waste and landfilling should be virtually eliminated	EC (2011) DG-Environment (2012)

Table 2 European union regulations belonging to the "hygiene package"

Regulation	Issue regulated	
Reg. (EC) 178/2002	Lays down the general principles and requirements of food law, establishes the European Food Safety Authority and defines the procedures in matters of food safety	General food law
Reg. (EC) 852/2004	Establishes the rules on the hygiene of foodstuffs	Hygiene package
Reg. (EC) 853/2004	Defines specific rules for food of animal origin	
Reg. (EC) 854/2004	Lays down specific rules for the organisation of official controls on products of animal origin intended for human consumption	
Reg. (EC) 882/2004	Regulates the official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules	
Reg. (EC) 2073/2005	Establishes the microbiological criteria for foodstuffs	
Reg. (EC) 2074/2005	Lays down implementing measures for Regulations 852/2004, 853/2004 and 854/2004	
Reg. (EC) 1375/2015	Establishes specific rules on official controls for *Trichinella* in meat	
Reg. (EC) 759/2016	Draws up lists of third countries, parts of third countries and territories from which Member States are to authorise the introduction into the EU of certain products of animal origin intended for human consumption, lays down certificate requirements and amends Regulation 2074/2005 and repeals Decision 2003/812/EC	

achieved. Furthermore, confusion arose due to REFRESH using terms and definitions that FUSIONS excluded. For instance, the terms "possibly avoidable food waste" and "unavoidable food waste" were introduced,[2] whereas "[edible] food" and "inedible parts of food" were used in FUSIONS definitional framework. "Avoidable food waste" and "unavoidable food waste" were previously used by WRAP, which also introduced a third category, "possible avoidable food waste".

4.2 Food hygiene regulations

Regulation 178/2002, also known as General Food Law, and a group of additional regulations constitute the so-called Hygiene Package for the EU, as listed in Table 2.

Some of the provisions defined in these regulations, especially those provided in the Regulations 178/2002, 852/2004 and 853/2004, have repercussions for the

[2] https://eu-refresh.org/about-refresh, https://eu-refresh.org/sites/default/files/REFRESH_D3.3_EU%20policy%20screening_18052018_25072018.pdf.

practice of food donations, as the case of the liability[3] of food business operator. The liability for the redistributed food is an important hurdle for food business operators willing to donate surplus food instead of discarding it. When food is donated to charity organisations, the suppliers/retailers have no control over it but are still fully liable if any food safety issues arise, with potential serious legal consequences. The risk of a reputational loss is also a crucial concern for the actors involved which is why food business operators are often driven to discard the food instead. Article 7 of EU Directive 1985/374/EEC establishes that producers are not liable if they prove that the food was produced only for donation purposes without profit (Vittuari et al. 2015). However, the Directive excludes from liability only those manufacturers which can demonstrate that the food was originally intended to be donated. It does not consider food donations as a choice to decrease food waste. Rather, it defines the possibility to produce food with the aim of donating it and raising the objective of pre-planned food donations. Although business operators might be able to demonstrate that their food was intended to be donated, even though it was originally intended to be sold, this cannot be adopted as official routine procedure.

Several studies cite the example of the Good Samaritan Law in Italy (Law 155/2003), that limits the liability exposure of companies donating food for charitable purposes (BCFN 2012; [1]; O'Connor et al. 2014; Hanssen 2014; Vittuari et al. 2015; Azzurro et al. 2016). Under this law, the liability of food donors towards safety are only for the food banks, and not to the consumers who receive food from charitable organisations. By recognising food banks as the final step of the food supply chain, the Good Samaritan Law prevents people receiving food from charitable organisations from suing the food donors (O'Connor et al. 2014). However, this provision is applicable only in cases where the safety of the donated food is guaranteed by the business operator, as for any other product routinely placed on the market, and where all required hygiene rules regarding transportation, storage, utilisation and serving of the food are fully respected by the food banks. Hence, this law facilitates the donation process, while at the same time guaranteeing compliance with EU Regulation (EC) 178/2002. According to O'Connor et al. (2014), this high level of assurance provided by this legislation, without jeopardising food safety and operator responsibilities, can determine whether or not companies donate surplus food (Martindale and Schiebel 2017; [16]).

[3] The liability principle has been defined in the Council Directive 1985/374/EEC (Article 1) and re-stated in Article 21 of the General Food Law (Reg. EC 178/2002).

Another issue related to the hygiene regulations is the *zero tolerance* parameter set for some contaminants in food. To ensure food safety, the legislation has set Maximum Residue Levels for contaminants in food. However, when the zero tolerance criterion is used as Maximum Residue Levels (e.g. Salmonella limits as defined in Annex I of Reg. EC 2073/2014), food waste may occur. Since technological advancements makes it easier to detect tiny amounts of excluded substances, products that were previously considered safe may be discarded when new instruments are adopted. Therefore, more knowledge about the implications of these substances for human health are needed to avoid food waste (Vittuari et al. 2016).

Food waste may also occur when the hygiene prescriptions are applied as standard, without considering the specific situation or the nature of the establishment. For instance, food business operators are compelled to implement a hazard analysis and critical control point (HACCP) system to guarantee food safety, which requires a wide range of documentation. In the case of donations, food business operators must follow the same rules as for ordinary sales, since the foodstuff is given to the final consumer, but they do not get revenue from the donated foodstuff. Therefore, wasting food instead of donating it often proves to be easier, as well as less hazardous, unless specific simplifications and incentives are provided. In this context, the flexibility measures provided by the EU Hygiene Package may help to overcome the problem. For several years after its introduction, the flexibility provision was poorly understood by Member States due to lack of specific details. For instance, some of the flexible measures in the Hygiene Package are described such as "if the competent authority so permits", "with authorisation of the competent authority", "unless otherwise authorised by the competent authority", "if necessary", "if applicable" etc. which has led to ambiguities and different interpretations among Member States (SEC 2009/1079; DG-SANCO 2011). Recently the EU Commission released guidelines on food donations that clarify the adoptable flexible measures for food donors and food banks (EC 2017). Example of flexible measures already applied by some MS, or potentially applicable to reduce food waste, is listed in Table 3.

4.3 Food labelling regulations

Food labelling is linked to food waste through the date marking provisions. Regulation EC 1169/2011 defines the labelling requirements for food sold in European markets. According to this regulation, it is the food business operators that are required to determine which wording is appropriate, i.e. "use by" or "best before" for the date marking. Although the difference between the concepts

Table 3 Examples of flexible measures to reduce food waste

Flexibility provision	Description	References
HACCP system	Flexible measure aimed at reducing the administrative burden associated with food donation in Belgium. The decree contains a derogation according to which the list of retailers or manufacturers who donated the foodstuff can serve as a record of incoming products and the list of food banks and charities can serve as a record for outgoing products	FASFC (2003) O'Connor et al. (2014)
Cold chain	Flexible measure applied in Finland in order to facilitate the chilled transportation of surplus food for redistribution. Many redistribution actors mention the lack of refrigerated vehicles and temperature controls as a significant barrier to receiving and transporting frozen foods. The cool chain is allowed broken momentarily as long as it does not cause health risks for the end-users. In addition, if refrigerated vehicles are not available, coolers can be deployed during transport and if no refrigeration is possible whatsoever, the transportation should be done in a timely manner to avoid significant change in temperature of the food items. This point thus allows actors to make decisions on a situation-to-situation basis on when it is safe to transport food in unrefrigerated vehicles, depending on the type of food, the distance and the timeframe for using the food	EVIRA (2013) Gram-Hanssen et al. (2016)
Donation of imperfect food products	Provided that they are fit for human consumption and compliant with all food safety requirements the following food categories can be redistributed: (a) products which do not meet manufacturer or customer specifications; (b) have altered packaging and/or labelling but do not compromise either food safety or consumer information; (c) are time marked, such as products intended for a specific holiday season or promotional activity; (d) are harvested in the fields with the consent of the producer; (e) have passed the "best before" date but can still safely be consumed; (f) have been collected and/or confiscated by regulatory authorities for reasons other than food safety; (g) products which are made up of multiple units, some of which may not be fit for human consumption (e.g. multi-pack yogurts where one may have a broken seal)	EC (2017)
Freezing of surplus food to facilitate redistribution	Reg. (EC) 853/2004 prescribes that food of animal origin intended for freezing must be frozen without undue delay after production. The possibility of freezing such products at the end of their shelf-life is thus excluded for hygiene and quality reasons. However, this requirement does not apply to retailers supplying other food business operators such as food banks provided that such retailers' activity stays marginal, localised and restricted in accordance with Article 1 of the same Regulation. This measure allows to extend the shelf-life and facilitate safe redistribution since food received by the charities cannot always be donated to the customer by the "use by" date	Reg (EC) 853/2004 EC (2017)
Use of former foodstuff as feed	The possibility to simplify certain administrative and logistical requirements necessary to facilitate the use of former food for animal feed is currently under development. Significant volumes of food that are not fit for human consumption could be used as animal feed, but are instead currently wasted. The requirements necessary to send former foodstuff to feed are considered too burdensome by many food business operators to justify such operation, e.g. registration procedure, compliance with zero tolerance for contaminants. Two proposals have been suggested: a) Support food business operators to comply with feed law (e.g. simplified HACCP system as feed business operators); b) Food business operator places the relevant products as 'food' on the market, so that they would not need to be registered under the feed hygiene Regulation (Reg 183/2005) because the product he supplies is still food as such (i.e. rules for food apply) and not yet a feed	EC (2018) Wunder et al. (2018)

is substantial,[4] the similarities between these two terms generate considerable confusion, especially among consumers, but also among food banks and food manufacturers (BEUC 2014). This lack of clarity often leads to food that passed its "best before" date being discarded unnecessarily.

Despite the general misunderstandings around date marking, selling food that is beyond its "date of minimum durability" is allowed, given that the products are still safe and free from misleading presentation (EC 2017). However, it is still not always clear how to handle such products and some food banks do not donate goods after their "best before" date, out of caution [1]. Another problem related to date marking is that the "best before" date assigned by the manufacturer is often excessively limiting and short, leading to wastage of food that would have kept its edibility for much longer (Vittuari et al. 2015). This is the case, for instance, with dairy products. The European Consumer Organisation points out that similar products may have completely different expiration dates in different countries (BEUC 2014). Hence, the definition of "best before" date seems to depend more on the manufacturer's choice or perception, or on the retailer's requirements, rather than on measurable parameters. However, the definition of measurable parameters for the "best before" date may not be as simple as it seems. When a food product does not have a compulsory limit given by its microbiological perishability, different aspects might be taken into consideration for setting the "best before" date. Besides, the question of how to uniformly establish the threshold above which a food is considered as having lost specific properties such as mouthfeel, aroma or creaminess must be taken into account. Moreover, it is an open question whether producers shorten the shelf-life to make products appear fresher, or whether consumers prefer short shelf-life products (Møller et al. 2015). The role of consumers is important for another reason, namely the general concern that food that passed its "best before" date may be of inferior quality and that people receiving donated surplus food should not receive products of inferior quality (O'Connor et al. 2014).

To decrease the food waste created from the erroneous use of the best before date, it has been proposed to extend the list of food of Annex X of Reg. EC 1169/2011 that do not require the date marking, such as vinegar, wine, fresh fruit and vegetables (Council of the European Union 2014). However, according to the European Consumer Association (BEUC 2014), exempting additional types of food from date labelling might have counterproductive effects on food waste reduction targets and on consumer information. In fact, "best before" dates help consumers manage their stock of food at home and, without this information, it would not be possible to check the age of a certain food they have bought. Without any information of shelf-life, consumers could even end up throwing more food as a precautionary measure (BEUC 2014). Thus, removal of the "best before" date from products might simply shift the responsibility for food waste from the retail to the household level. Safety concerns could also arise from removal of "best before" dates, such as migration of certain components like bisphenol-A from can coatings into the food after a certain period (BEUC 2014).

Eggs are the only food category for which the shelf-life is established by an EU legislation. For other food items, durability is set by food business operators. Durability of eggs is established by two Regulations: Reg. EC 589/2009 that sets the shelf-life of eggs to 28 days from laying and Reg. EC 853/2004 which states that eggs need to be delivered to the end consumer before a maximum of 21 days of laying has passed. The problem is that these durability limits assigned to eggs are based on room temperature, but a significant proportion of eggs are kept in refrigerated compartments at retailers, which substantially increases their shelf-life. Yet, regardless of the storage temperature at the retail point, after 21 days from laying eggs can no longer be sold. In order to reduce egg waste, the EU guideline for food donations (EC 2017) specifies that after 21 days from laying, eggs can be safely consumed within the next 7 days. Hence, they can be made available for redistribution, provided that the charitable organisation heat treat them to ensure sufficient food safety (EC 2017).

4.4 Fiscal instruments

Monetary incentives serve as effective economic instruments for some environmental programmes, because they affect people's attitudes and behaviour [5]. Fiscal instruments are important for food to be transferred from donors to charity organisations like food banks. Among them, value-added tax (VAT), corporate tax credits and tax deductions are relevant for food waste reduction. Each of these three fiscal measures may have either positive or negative impacts, depending on how they are applied and

[4] The "use by" date is about safety and is applied to highly perishable foodstuffs for which consumption after the "use by" date presents an effective threat to the health of humans. The "best before" date, also called "date of minimum durability", is the date to which a foodstuff retains its specific properties, provided that it has been stored in regulated conditions and that the packaging is intact and unopened. The "best before" date is not safety, only quality. A food that is past its "best before" date may partly lose its aroma, taste, structure and mouthfeel (crunchiness, softness, creaminess etc.) or any other claim made on the labelling (e.g. nutritional claims of particular vitamin content), but it is still totally safe to eat if stored under appropriate conditions.

adapted to the needs of food donors. For instance, the VAT on donated items is a hurdle for food business operators who donate food for charitable purposes. In normal situations, the VAT is paid by the consumer when purchasing the good, but for donations the donor generally has to pay the VAT since it's not paid by the final consumer. This leads to situations where it is both cheaper and easier to discard surplus food instead of donating it. In specific circumstances, however, exemptions from VAT or adaptations are allowed under EU rules (VAT Guidelines 2017). Firstly, if the donation is to be considered a small value gift, the food donor is not taxable (Directive 2006/112/EC, Article 16). Alternatively, if the donation happens close to the "best before" date of the product or when goods are unfit for sale, the VAT value may be set to zero (or close to zero), so that no taxes are paid for the donated product (EP 2013; EC 2017).

Despite such exemptions, difficulties concerning VAT and the other fiscal instruments still persist. Each Member State implements fiscal rules to suit its specific needs, which makes it difficult to identify the provisions that are most effective in fostering food donations. Moreover, the terminology used in Member States' own legal texts varies greatly, for instance, the value of food can be considered "low" or even "zero" when it is donated, or VAT could be "abandoned" or "exempted". These terms often do not have the same connotations across EU countries and their compatibility with the EU VAT Directive is unclear (O'Connor et al. 2014). The option of considering zero worth of donated food for the purposes of tax exemption may contradict rules that offer a credit on corporate tax to donor organisations. If the value of donated food is considered fairly low or zero, the value of the tax credit will also be zero, thus nullifying the fiscal incentive. Hence, "abandoning"VAT on donated surplus food, rather than valuing the donation at zero, could be a better incentive, since it is compatible with other, possibly more important, fiscal incentives such as tax credits. However, further research is needed to ensure that fiscal incentives do not encourage companies to stockpile until they are near to the expiry date, to avoid VAT liability (O'Connor et al. 2014).

4.5 Regulations the handling of food supply chain by-products

One other example of legislations related to food waste generation may be the legislation on animal by-products, the ABP-legislation. Animal by-products are materials from the animal kingdom that are not food and have not yet been processed or processed to be included in the concept of manufactured products. Animal by-products (ABP-products)' means entire bodies or parts of animals, products of animal origin or other products obtained from animals, which are not intended for human consumption, including oocytes, embryos and semen (article 3 1. Regulation (EC) No 1069/2009 of the European parliament and of the council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption). Examples of animal by-products are dead animals and by-products from slaughtered animals. Commercially caught fish and purified materials from such fish are also covered. It also makes wool, feathers, eggshells, food waste and natural manure included.

EU food legislation is linked to the legislation on animal feed. This legislation was written as a direct result of the epidemics of Creutzfeld–jacob disease and foot-and-mouth disease that ravaged the late 1990s. The result has become a legislation that puts higher demands on the handling of food of animal origin than does it apply to foods of vegetable origin. The purpose of ABP-legislation is to remove as far as possible the parts of the animals that could be infected, and to remove animal bodies that is not guaranteed free of, among other things, such infections. However, this high level of protection may mean that parts of carcasses that are completely healthy cannot be used and recirculated into the food system, as a result of a cautionary approach.

Another example of this impeding ABP-legislation is the possibility of introducing insects as food or as part of the food chain. The regulation involves, among other things, what preceded the use of fly larvae as protein food for animals to be slaughtered. If these larvae are reared on household waste, which may include waste of animal origin, that waste is not approved as food for these larvae even though the meat in this feed always comes from meat that is approved as food.

In addition to mentioned policies, there are also other EU directives and legislations that have an indirect influence on food waste generation. Table 4 lists a few examples of these.

5 Conclusions

We find that liability for donated foodstuffs, date marking provisions, the flexibility principle provided by the EU Hygiene Package and fiscal rules are the main policy elements affecting, either positively or negatively, food waste generation and management. Liability regulations allocate responsibility for unsafe donated food, which makes donation by producers or sellers precarious. Date marking affects waste generation mainly due to ambiguities in the meaning and implications of the terms "best before" and "use by". This is further complicated by variations in the interpretation of such terms across EU Member States.

Table 4 Other EU directives and legislations affecting food waste

Policy	Consequences on food waste	References
Reg. EC 1308/2013	Encourages food waste reduction through free distribution of fresh fruit and vegetables withdrawn from the market. These can be donated to charitable organisations and to other establishments such as penal institutions, schools, children's holiday camps, hospitals, old people's homes, with the producer organisation being paid 100% (instead of 50%) of the incurred costs (Article 34). Although this regulation does not exempt food donators from safety liability laws, it represents valid legislative support for re-use However, it also sets marketing standards for a range of products (e.g. fruits and vegetables, eggs, pig meat, beef, milk, bananas etc.). Marketing standards set, e.g. conditions for shape, mass and aesthetic quality of products, in order to "take into account the expectations of consumers" (Article 75). The specific requirements are laid down in implementing regulations (e.g. see Reg. EC 543/2011)	Reg. EC 1308/2013 Vittuari et al. (2015) Wunder et al. (2018)
Reg. EC 543/2011	Sets specific marketing standards for some fresh fruit and vegetables. This regulation results in waste of products that, although edible, do not meet the aesthetic criteria, e.g. with regard to apples, these must be "clean, practically free of any visible foreign matter", are classified according minimum surface colour characteristics, size and shape of bruising and defects (for which some tolerances are allowed) are required to have a minimum size (60 mm, if measured by diameter or 90 g, if measured by mass), and need to be uniform within their package (and contain only apples of the same origin, variety, quality and size)	Reg. EC 543/2011 Vittuari et al. (2015) Wunder et al. (2018)
Common fisheries policy (CFP)	Regulates fisheries in the EU. It introduces two provisions important for food waste: the "total allowable catches" (TAC) and the "landing obligation" (LO). The TAC establishes that every year each MS is allocated for each fish a quota that can be taken. In order to not exceed the TAC, the vessels often discarded the unwanted catches/bycatches to the sea, thus generating high amount of food waste, because the fish thrown back to the sea often don't survive. The landing obligation has been introduced to reduce such food waste: all species subject to limitations (i.e. TAC) as well as those subject to minimum sizes in the Mediterranean, must be landed and counted towards the operation's quota. However, the following problems still persist: (a) how to sell the unwanted catches if they have no commercial value (the food waste might shift from the sea to the land); (b) fish quotas are often not set in line with scientific recommendations; (c) there are several exemption from the LO (e.g. for undersized fish, disproportionate costs of handling unwanted catches, catches of species with high survival rates); d) MS show different interpretations of landing obligations (e.g. on technical measures and reporting obligations)	Vittuari et al. (2015) Carpenter and Kleinjans (2015) Wunder et al. (2018)
Renewable energy directive (RED)	The Renewable Energy Directive (Directive 2009/28/EC) sets incentives for the use of food waste (as bio-waste) for energy production. This Directive is currently in contrast with the Waste Framework Directive which clearly favour waste prevention and re-use (use for human consumption, animal feed) over recycling and recovery for energy purposes (energy recovery from co-incineration, anaerobic digestion, biofuel production). Well-developed infrastructure and policy incentives for the anaerobic digestion (AD) currently make it more economically interesting for producers and waste managers to recover food waste via AD rather than re-use it through other alternatives. The European Commission presented a proposal for a recast of the RED, but since it is not yet approved, the mentioned objectives refer to the current version of the legislation	Directive 2009/28/EC Directive 2018/851/EU Wunder et al. (2018)

The flexibility in the hygiene rules across the EU encourages discrepancies between waste management and food safety, if an administrative authority is excessively strict, the likelihood of waste generation is higher, whereas if it is too lax, safety could be compromised. Fiscal benefits in the form of tax exemptions, credits or deductions can

help determine whether convenient, but inefficient, waste management practices such as landfilling and incineration, or more efficient options such as biological treatment and donations, are adopted. VAT also has an impact on the effectiveness of food donations as a tool to manage waste.

From the all-encompassing EU Waste Framework Directive, the best waste management tool that emerges is food donations. While removing existing barriers for food donors and banks is fundamental as it makes redistribution more effective, this does not seem to be the most efficiency solution as it does not tackle the core issue of prevention of excess food generation, at the first place. However, food donations could be considered as good starting point in line with the ambitions in the WFD, but could be supported by stronger policy instruments to make it easier and more beneficial for organisations with surplus food that can be donated.

We also conclude that while there are several EU food legislations which include and impact food waste management options, they are hardly direct. Moreover, they often generate incentives that are at odds across stakeholders, thereby dampening the intended impact. We reason that there is scope for an integrated policy framework to tackle food waste specifically. This will be important to support the transition to a circular economy for the food system with less waste generation. For that to happen, a pre-requisite is lot more empirical evidence on the effects of various legislations on food waste minimisation, that also identifies the interaction effects more carefully. This may require EU Member States to come together for cross-national synthesis of legislations, data integration and developing modelling platforms. Given the enormity of the problem and its effect on food security and environment, the benefits clearly outweigh the costs of doing so.

A limitation of the study is that it does not use a methodology that would help provide greater normative comparison across legislations and help rank order them on the lines of effectiveness. Following Kinach et al. [17] there could also have been an impact analysis of a particular policy or legislative option on food waste management. But these provide important research avenues for the future along with research on the interaction effects of various food waste legislations, so that the case for an integrated policy framework to tackle food waste specifically receives more granular and empirical backing.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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