

Jennifer Schinkel

Review of policy instruments and recommendations for effective food waste prevention

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*Jennifer Schinkel a,**

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a Wuppertal Institut für Klima, Umwelt, Energie gGmbH,
Wuppertal, Deutschland

* Corresponding author:
Jennifer Schinkel
Wuppertal Institut für Klima, Umwelt, Energie gGmbH
Döppersberg 19
42103 Wuppertal
Germany

E-mail: jennifer.schinkel@wupperinst.org

Phone: +49 202 2492-197

Fax: +49 202 2492-250

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Abstract

Each year, approximately one-third of the food produced for human consumption is lost or wasted worldwide. The waste of resources used for this food has significant environmental impacts in terms of land and water use as well as greenhouse gas emissions. Consequently, one of the targets of the UN Sustainable Development Goals is to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains by 2030. However, sufficient knowledge about the suitability of instruments for food waste prevention is still lacking. The purpose of this article is therefore threefold: First, it outlines the generation and causes of food losses and waste. Second, it discusses good practices from different countries, such as laws to reduce food waste, voluntary agreements, awareness campaigns and results from behavioural economics. Finally, based on these findings, this article identifies barriers, as well as requirements for the implementation of effective and efficient instruments.

Keywords: Waste management & disposal; Sustainability; Environment

Introduction

According to calculations on behalf the Food and Agriculture Organization of the United Nations (FAO), about one-third of all food produced for human consumption is lost or wasted worldwide each year. This corresponds to approximately 1.3 billion tonnes per year (Gustavsson *et al.*, 2011). This amount of food loss and waste accounts for a considerable squandering of resources used for production, processing, and transport. The causes of food losses and waste in high-income countries, which this article primarily addresses, include consumer behaviour, cosmetic requirements for fruit and vegetables, surplus supply as well as policies and regulations (Gustavsson *et al.*, 2011; FAO, 2015). Policy-makers have acknowledged the importance of reducing food losses and waste and the associated environmental impacts. At the international level, as part of the Sustainable Development Goals (SDG), the United Nations in 2015 committed to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses, by 2030 (SDG 12.3). In order to achieve the policy goals and reduce food losses and waste along the entire value chain, modifications in several aspects are necessary.

Against this background, this article explores conditions required for the introduction of successful strategies to reduce food losses and waste on different stages of the value chain. To this end, it outlines the generation and causes of food losses and waste and discusses instruments already used in practice. Subsequently, it identifies barriers, as well as requirements for the implementation of effective and efficient instruments. The proposed approaches are based on the analysis of various studies and results from research projects. In addition, findings from expert workshops and expert interviews as part of a project on the effective reduction of food waste on behalf of the German Environment Agency (Wilts *et al.*, 2018) are taken into account.

1. Definitions and extent of food losses and waste

The statistics for the generation of food waste are subject to considerable uncertainty due to insufficient data availability. They are often based on estimates and extrapolations. So far there is no common definition of food losses and waste. The methods used to record the quantities of food waste also differ.

In 2011, a study commissioned by the FAO evaluated the global incidence of food loss and waste (Gustavsson *et al.*, 2011). The definition used in the study states that: “Food losses refer to the decrease in edible food mass throughout the *part of the* supply chain that specifically leads to edible food for human consumption.”

(Gustavsson *et al.*, 2011, p. 2). According to the definition adopted from Parfitt *et al.* (2010), food losses occur

at the beginning of the value chain, on production and processing stages, while wastage at the end of the value chain, the retail and consumer's level, is referred to as food waste.

The study of Gustavsson *et al.* (2011) relies on the evaluation of available data and results from the literature on global food waste. In cases where data was lacking, assumptions and estimations were made.

According to the calculations, 1.3 billion tonnes of food is lost or wasted each year. For North America and Europe, per capita food losses and waste are estimated at 280–300 kg/year. At the consumer level, an amount of 95–115 kg/year is calculated.

In a recent study, Stenmarck *et al.* (2016) analysed waste volumes for Europe. The study defines food waste as: “Fractions of ‘food and inedible parts of food removed from the food supply chain’ to be recovered or disposed (including - composted, crops ploughed in/not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea).” (Stenmarck *et al.*, 2016, p. 7). In this context, the term food waste covers both food waste and food losses. The estimates were determined on the basis of a combination of national waste statistics and the results of selected research studies.

In the European Union (EU-28), food waste amounts to approximately 88 million tonnes or 173 kg per person and year. This means 20 per cent of the total amount of food produced in the EU is wasted. Considering the individual stages, 53 per cent of food waste is generated in households, 19 per cent in processing, 12 per cent comes from food service, 11 per cent from primary production and 5 per cent from wholesale and retail (figure 1). The authors emphasise that there are considerable uncertainties involved with the data, as there were not enough studies of sufficient quality available.

The differences between the underlying definitions of food waste can also be recognised in the two studies presented. While the results by Gustavsson *et al.* (2011) contain waste of edible foods, the calculations by Stenmarck *et al.* (2016) also include non-edible parts.

2. Environmental impact of food losses and waste

Food losses and food waste have significant environmental impacts (FAO, 2013, pp. 7–37). The production, processing, transport, and storage of food intended for human consumption, which is lost or wasted, are responsible for greenhouse gas emissions and cause the loss of land, water, and biodiversity (figure 2). The carbon footprint of food losses and waste amounts to 3.3 Gtonnes of CO₂ equivalents, without emissions due to land use change. This means that food waste ranks third behind the USA and China as the largest emitters of

greenhouse gases. The products with the highest share of greenhouse gas emissions caused by food waste are cereals with 36 per cent. The reasons for these emissions lie in particular in the production and use of nitrogen fertiliser and furthermore in the use of diesel for agricultural operations. The waste of products of animal origin generates 33 per cent of greenhouse gas emissions, although it accounts for only 15 per cent of food waste and losses. Regarding meat and dairy products, the reasons can be found in feed provision and manure management. The wastage of vegetables is responsible for 21 per cent of the emissions. While the production of vegetables causes relatively low greenhouse gas emissions, these are significant due to the high amount of waste generated in this category. Food products that become waste in the consumption phase have the highest carbon footprint, as they contain emissions from this phase, such as energy for preparation, as well as those from previous phases (FAO, 2013; Scherhauser *et al.*, 2018). Besides, food that ends up as food losses and waste occupies 1.4 billion hectares of land. This equals about 28 per cent of the world's agricultural land area. The use of surface and groundwater for wasted food measures approximately 250 km³.

3. Causes of food losses and waste

A variety of reasons have been identified as causes (figure 3) for the generation of food losses and waste (Bond *et al.*, 2013; Canali *et al.*, 2014; FAO, 2011; Kranert *et al.*, 2012; Monier *et al.* 2010). In the production of food, for example, harvesting technology and processing facilities, improper storage, pest and fungus infestation, overproduction and legally required quality and size standards or retail norms can lead to food losses and waste. At the processing stage, losses and waste can occur due to technical malfunctions in the manufacturing process, rejects due to deviations from the required product characteristics and overproduction. In the case of large-scale consumers and out-of-home consumption, incorrect storage, standard portion sizes (e.g., in hospitals and canteens), fluctuations in demand and hygiene regulations can be responsible for the generation of food waste. At the retail level oversupply due to an extensive range of goods that is available anytime and fluctuations in demand from customers lead to food waste. This applies in particular to perishable products such as bakery products, fruit, and vegetables as well as dairy and meat products. Products that have reached the best before date are usually removed from sale. In addition, transport damage, improper storage and damage to sensitive products in the sales area can cause food waste. At the consumer level, inadequate or inefficient purchasing and meal planning, improper storage, incorrect preparation and a lack of knowledge about the use of leftovers play a significant role. Furthermore, a deficient understanding of the shelf life of products can lead to the disposal of

food that is still edible.

While in low-income countries food losses tend to occur at the early and middle stages of the value chain and are often the result of financial and technical limitations in harvesting, storage, and cooling, in medium- and high-income countries food waste arises to a high extent at the consumer level and is related to consumer behaviour (Gustavsson *et al.*, 2011; IMECHE, 2013; Quested *et al.*, 2013). However, it has to be stated that significant losses and waste of food arise as well at the earlier stages, which is, among other things, caused by insufficient coordination between the actors of the food supply chain (Gustavsson *et al.*, 2011).

It should be noted that food waste often does not occur at the stage of the value chain, which is responsible. For example, norm requirements from retail due to logistical reasons or consumer expectations can cause food waste at the level of production if products cannot be marketed. It is therefore essential not only to consider the individual stages when identifying solutions but also to take into account the cooperation of actors across the interfaces of the value chain (Göbel *et al.*, 2015).

The generation of waste, especially at the consumer's level, is also fostered by social factors. For example, rising prosperity combined with low food costs, which reduces the value of food. Other social factors are an increase in smaller households, more out-of-home consumption and less time due to the reconciliation of household and work (Jörissen *et al.*, 2015).

Canali *et al.* (2014) point out that causes of food waste linked to social factors, individual behaviour and other priorities of private and public actors are difficult to tackle. The situation is different for “food waste related to non-use or sub-optimal use of available technologies, organisational inefficiencies of supply chain operators, inefficient legislation, and bad behaviours of consumers depending on unawareness, scarce information, and poor food skills” (Canali *et al.*, 2014, p. 5). They state that considering these causes, “changes are potentially more feasible, since they largely depend on improvements in manufacturing or production efficiency along the food supply chain, correct application of available technology, better organisation, more accurate policy design, and increased consumer awareness” (Canali *et al.*, 2014, pp. 5–6).

4. Instruments to decrease food losses and waste used in practice and research projects

A variety of instruments aimed at reducing food losses and waste have already been applied in practice or research projects. The following section introduces examples of good practice, presents the findings obtained from science and practice, and points out perspectives and potential key success factors. The selection of the instruments presented exemplarily is aimed at addressing various actors along the food supply chain and targeting either the prevention of food waste or alternative food recovery. The instruments refer to different approaches to the reduction of food waste, of which economic values or non-financial impacts are expected, and respond to causes of waste generation described in chapter 3. With the Voluntary Commitments, an instrument has been chosen which objective is to foster cooperation between actors of the food sector. A significant financial benefit to consumers, businesses, and other stakeholders is assumed to be obtained through consumer campaigns (ReFED, 2018). In addition to consumer campaigns, approaches from behavioural economics such as nudges seek to reduce food waste at the consumer level, where the largest amount of waste is generated along the value chain. Laws on food waste and tax benefits for food donations are discussed as an example of governmental strategies. Calculations also showed that donation tax incentives are an efficient measure to recover perishable food (ReFED, 2018).

4.1 Voluntary Commitments

An example of a voluntary commitment in the food sector is the Courtauld Commitment (WRAP, 2018a) from the United Kingdom. It was launched in 2005 and is now in its fourth phase. The objectives are to improve the resource efficiency and to reduce waste from food packaging as well as food waste in households and along the value chain. The implementation is financed by the British, Scottish, Welsh and Northern Irish Governments. The Waste & Resources Action Programme (WRAP) is responsible for the coordination. The agreement was signed by about 90 per cent of the UK's food companies. To achieve the agreed objectives, WRAP supports companies with research, guidelines, tools, case studies, and expertise. Also, meetings and workshops are organised to foster the exchange and adoption of best practices.

In the first phase of the agreement, the signatories have committed themselves in terms of food waste to the target of reducing food waste in UK households by 155,000 tonnes by 2010 compared to 2008. As a result, food waste was reduced by at least 270,000 tonnes in 2009/10 compared to 2007/08 (Swannell, 2010). The second phase of the agreement (WRAP, 2013a) ran from 2010 to 2012. The target of a 4 per cent reduction in

household waste from food and beverages was narrowly missed. The total amount of household food waste has been reduced by an estimated 270,000 tonnes per year, corresponding to 3.7 per cent. In the third phase (WRAP, 2017) the target was a 5 per cent reduction in the amount of food and beverage waste in households by 2015 compared to the 2012 baseline. The goal was not achieved. The estimated amount of household food waste in the UK for 2015 was around 7.3 million tonnes compared to around 7.0 million tonnes in 2012, an increase of 4 per cent or 2 per cent for a per capita calculation. WRAP indicated factors such as population growth, falling food prices and an increase in single households as possible reasons why food waste increased despite the efforts.

Another example for a voluntary commitment can be found in the Netherlands (Piras *et al.*, 2018, pp. 55–59), where companies of the Dutch food industry in 2013 formed the Sustainable Food Alliance (SFA). One of its goals is a 20 per cent reduction in food waste by 2020. In 2017, the Taskforce for Circular Economy in Food (TCEF) was founded to unify all initiatives tackling food waste. Members are the SFA, other food industrials, retailers, caterers, NGOs, and the Ministry of Economic Affairs. Their aim is a coordinated and collaborative approach to combat food waste. Also in Norway, an agreement to reduce food waste has been signed between the Norwegian government and the food industry (Norwegian Ministry of Climate and Environment, 2018). The goal is a reduction of 50 per cent by 2030.

Perspectives and potential key success factors

A successful voluntary commitment requires precise and consensual objectives that can be realistically achieved. The evaluation has to be carried out and documented by an independent institution. For this purpose, consistent definitions and procedures are necessary. Regarding the publication of the results, WRAP has stressed the importance of anonymising data of individual companies to ensure confidentiality.

As an incentive to participate, the Courtauld Commitment offers its signatories concrete added value and cost savings. On the one hand, by research funds used for the optimization of processes. On the other hand, through instruments, study results and the opportunity to share practical experiences with other companies. A coordinating unit can identify the needs of the companies, encourage cooperation and exchange of experience between companies and support them in reaching their objectives. WRAP emphasises that a collaborative approach is essential to the success of the commitment.

4.2 Laws on food waste and tax benefits for food donations

In February 2016, France was the first country to adopt a law (Loi n° 2016-138, 2016) obliging supermarkets with a sales area of 400 m² and more to donate unsaleable food that is still edible to social institutions or to respectively turn it into animal feed or compost. The supermarkets are required to sign contracts with food banks or other charities. Stores can be fined for violations of the law. In Italy, a similar law (Legge 19 agosto 2016, n. 166, 2016) was passed in August 2016. It regulates the distribution of surplus products to charitable institutions. This includes, among other things, groceries. In Italy, companies receive tax benefits for their donation and the distribution is facilitated. Penalties such as those that can be imposed in France are not intended in Italy. Another country that has introduced a law to reduce food waste is the Czech Republic (amendment 180/2016 of the Food Act 110/1997). In Finland, more than 100 out of 200 members of parliament have signed a bill proposing that edible foodstuffs removed from sale should be used in a beneficial way or set for distribution (FAO, 2018b).

Currently, there are no concrete figures regarding the reduction of food waste as a result of the introduction of laws to prevent food waste. The European Court of Auditors has pointed out that there are no requirements for the amount of food donated in France. For instance, an agreement to donate 1 per cent of the surplus food would be sufficient (European Court of Auditors, 2016, p. 22).

Perspectives and potential key success factors

A law of this type can increase not only the quantity of food supplied to social institutions but also its quality. If, in addition to packaged and processed goods, more fresh products such as vegetables and meat are donated, a wider range of foods and products with a higher nutritional value are available in food banks.

For social institutions, the challenge of an increase in donations is to organise the collection, storage, and distribution of food as well as the compliance with hygiene regulations. Here support for the establishment and maintenance of logistic structures may be necessary.

In addition to the obligation to donate, an alternative approach is to provide tax credits to food producers and retailers so that all costs they incur for handling, storage, and transport, are covered, and the distribution of food to charities would be cost-neutral (Rayner, 2017). This could help to increase the transfer of surplus food to social institutions instead of using it for other purposes such as energy production or sending it for disposal.

4.3 Awareness Campaigns

In the United Kingdom, the campaign *Love Food Hate Waste* (WRAP, 2018b) was launched in 2007. It aims to reduce the amount of food waste by raising awareness and offering solutions and practical advice, such as tools and recipes, for the reduction of food waste at the consumer's level. It has now spread to Australia, New Zealand and Canada. The initiative *Too good for the bin!* (BMEL, 2015) informs consumers as well as companies, municipalities, and multipliers such as teachers about the reduction of food waste in Germany. The initiative bundles various information and actions, such as a campaign, encouraging restaurants and guests to take home leftovers. Furthermore, each year initiatives and companies are awarded for innovative concepts for the prevention of food waste. On an internet platform, interested parties can also find out about instruments, activities and best practices. It is intended to develop the initiative into a national strategy.

In the case of consumer campaigns in particular, in addition to the lack of data and inconsistent methods for the monitoring of food waste, the difficulty is to identify a causal link between the concrete measure and avoided food waste. An evaluation (WRAP, 2013b) of the campaign *Love Food Hate Waste* carried out in West London between October 2012 and March 2013 showed that avoidable food waste decreased by 14 per cent. However, it is pointed out that other factors such as increasing food prices and difficult economic conditions must also be taken into account. In an analysis of 27 solutions for the prevention of food waste a finding was that consumer education campaigns ranked in the middle of the measures examined in terms of the amount of waste diverted from landfills and on-farm losses. But they seem to be more effective than most of the measures in terms of aggregated financial benefit to society, water saved and emissions reduced (ReFED, 2018).

Perspectives and potential key success factors

Awareness campaigns designed to support consumers in reducing food waste should focus on specific target groups and tackle the concrete reasons for the generation of food waste. This requires reliable data on the volume of waste and its causes. It is important to understand consumers' motives and to find out what kind of communication and actions are actually effective (Wilts *et al.*, 2018). In addition to further research, the monitoring of the campaigns through evaluations is necessary in order to make successes in the reduction of food waste measurable and, if necessary, to adjust the campaign. In addition to consumers, other actors in the food supply chain should be addressed and involved in order to promote solutions across interfaces.

4.4 Behavioural economics: Nudges

Nudges are an approach from behavioural economics and describe the influencing of people with the aim to trigger behavioural changes without imposing bans or creating economic incentives. The concept was mainly shaped by Thaler and Sunstein (2008). The underlying assumption is that people act rationally only to a limited extent and that the context influences their decisions. With the help of nudges, the context is changed in a way that the decision is guided in the direction of the option assumed to be preferable. This might be beneficial to the common good, to health or the environment. Examples are the arrangement of a buffet, which makes it easier to pick fruit than biscuits or a presetting of computers for double-sided printing. However, freedom of choice should not be restricted.

A study of the OECD (2017) presents findings of behavioural research from various case studies, including approaches to reduce food waste by nudges: On behalf of the Executive Agency for Consumers, Health, Agriculture and Food (Chafea) it was tested whether consumer acceptance of fruit and vegetables that do not meet the norm can be improved by means of messages (figure 4). One result of the case study carried out at the Milan Expo 2015 was that with a message about food waste (“Embrace imperfection: join the fight against food waste!”) 41 per cent and with a message that addresses authenticity (“Naturally imperfect: Apples the way they actually look!”) 42 per cent would buy products that do not appear perfect. Without a message, 26 per cent opted for the imperfect product and 74 per cent for the flawless product. These results indicate that nudges can make a significant contribution to the reduction of waste generation. However, it must be examined which approaches have a positive effect on waste-reducing consumer decisions since not all measures achieve the intended effect.

Perspectives and potential key success factors

The use of nudges is currently gaining importance in the debate on fostering more sustainable consumption patterns (Kameke and Fischer, 2018; Lehnera *et al.* 2016; Schubert 2017). On the other hand, however, there are warnings of manipulation, paternalism, and intervention in the individual's freedom of choice caused by nudges. For this reason, it is primarily important to enable consumers to make informed decisions. Potential nudges are to be designed transparent and alternative possibilities without disadvantages have to be easily accessible. It should be considered that usually nudges only support individual decisions, but in most cases cannot lead to comprehensive changes in behaviour.

5. Requirements and barriers to the successful reduction of food waste

Considering the quantities of food losses and waste and the associated environmental impacts, it is evident that the reduction of losses and waste is a relevant issue. As shown in the examples presented above, there are already many promising attempts for the prevention of food waste. Based on the identified perspectives and potential key success factors, concrete approaches that are suitable to support the effectiveness of instruments are outlined below (figure 5). These have either have been considered to be useful in the literature (Aramyan *et al.*, 2016; European Court of Auditors, 2016; Gustavsson *et al.*, 2011; Jepsen *et al.* 2016; Kranert *et al.* 2012; Priefer *et al.*, 2013; Priefer *et al.*, 2016) or respectively identified as promising in the expert interviews and workshops of the project *Effectively Reducing Food Waste* (Wilts *et al.*, 2018). Besides, this chapter describes possible barriers that currently hinder a successful implementation of instruments and how these can be overcome.

5.1 Improve the quantification of food losses and waste

As described in the remarks on the generation of food waste, reliable data for the different stages of the food value chain is still missing. However, these are essential to determine the extent, identify the sources within the value chain and detect the most affected product groups. This is fundamental to develop and design targeted instruments. Also, the assessment of the effectiveness of instruments requires reliable data. Several efforts are currently being undertaken to improve the monitoring of food losses and waste. The United Nations has included the *Global Food Loss Index* (FAO, 2018a) as an indicator within its Sustainable Development Goals to measure the achievement of SDG 12.3. The European Commission in cooperation with the members of the *EU Platform on Food Losses and Food Waste* is working on a methodology for the monitoring of food waste at the European level. According to the current schedule, January 2020 is the start of the first reporting period. The EU methodology shall be compatible with the methodology for the monitoring of SDG 12.3 (Zambrzycki, 2018).

5.2 Identify and communicate the added value of prevention measures for the actors

For all stages of the value chain, it is important to gain a concrete added value to encourage the willingness to implement instruments (Wilts *et al.*, 2018, p. 19). This is particularly the case for the participation in voluntary commitments. In the context of campaigns or educational activities, it is also helpful to communicate to consumers how their efforts can save them money or contribute to the protection of the environment to increase their motivation.

The stakeholder network ReFED (Rethink Food Waste Through Economics and Data) analysed the potential of solutions to food waste (ReFED, 2018). ReFED evaluated 27 solutions by financial benefit, waste diverted, emissions reduced, water saved, jobs created and meals recovered. The results show that prevention measures in many cases have considerable economic potential. Initially, however, often investments are necessary. Actors can perceive these as a risk. It should, therefore, be demonstrated that the implementation of measures to avoid food waste can be a worthwhile investment and that some achievements can already be realised with little effort. Besides the results of ReFED, preliminary results for costs and effectiveness of food waste prevention and reduction strategies were presented by Jensen and Teube (2017). Both evaluations show that the concrete added value can vary significantly depending on the measure. Further research is needed to specify the added value for the respective actors. In addition, it must be ensured that, besides economically reasonable measures, also measures whose financial added value is small but which have a high ecological and waste-avoiding potential are taken into account.

5.3 Support opportunities related to digitization and technology

The use of digital solutions offers a wide range of opportunities to contribute to the reduction of food waste along the entire value chain. For instance, they can assist in achieving objectives defined in voluntary commitments. Promising approaches have already been developed by companies, start-ups and in research projects. Technical solutions such as RFID (radio-frequency identification) chips, temperature sensors or food scanners (Fraunhofer, 2018) could support a dynamic shelf life (Buisman *et al.*, 2017) which, in contrast to a static best-before date, would provide information on the actual shelf life of products. Already tested in practice are apps that save leftover meals and products of restaurants, cafés, and bakeries from being thrown away. Other approaches include technologies that enable commercial kitchens to accurately analyse which types and

amounts of waste are generated and how to avoid them. There are also projects aimed at determining consumer demand for products based on weather forecasts and other data to reduce food waste (METI, 2017).

The support of start-ups and companies, as well as the funding of research projects, enables the development of innovative technologies. Within research projects, it is essential to test and analyse applications along the upstream and downstream stages of the value chain in order to ensure the functioning of data exchange at the interfaces. To cope with the complexity of today's supply chains, transnational projects are advisable.

5.4 Strengthen consumer education and involve psychological research

At the consumer level, the strengthening of education is seen as a relevant task to provide consumers with knowledge, for instance on the shelf life and storage of food and the use of leftovers. The purpose of this is to enable consumers to make informed decisions and thus contribute to a reduction of food waste. It is recommended to shift away from general campaigns and to implement education on food and food waste in existing structures such as kindergartens, schools and adult education (Wilts *et al.*, 2018, p. 19). The training of employees of supermarkets, canteens, and restaurants in vocational and professional training is also of relevance to raise their awareness and enable employees to avoid food waste in their daily work. Furthermore, it allows them to provide consumers with competent advice on the issue.

It is also suggested to integrate psychological research into the planning of tailored campaigns and communication measures (Wilts *et al.*, 2018, pp. 19, 26). In this way, the motives and behavioural patterns of consumers and actors can be better understood. This helps to identify at which specific points consumers are receptive and willing to receive certain forms of information.

5.5 Introduce legal requirements and voluntary agreements

Different strategies to reduce the disposal of edible food are legal requirements such as those introduced in France and Italy. In France, retailers are obliged to conclude contracts with welfare organisations to purchase leftover food. An extension to out-of-home catering and large-scale consumers such as restaurants, hospitals, and cafés seems sensible. Here, however, it must be precisely clarified who can receive and distribute the surplus goods. For the success of an approach of this kind, it is important to coordinate it closely with the social institutions receiving the donations, as it can involve a considerable additional logistical and personnel effort.

In the United Kingdom, a proceeding, which relies on the voluntary commitment of companies to reduce food waste and its packaging, was chosen. A voluntary agreement also facilitates the introduction of measures that would otherwise not be possible due to feared competitive disadvantages. Stores can thus, for example, agree on not to restock perishable goods shortly before closing time. The advantages of a voluntary commitment to a law are its flexibility, a potential higher acceptance of the target group and the usually easier introduction.

5.6 Facilitate the transfer of surplus food and provide economic incentives for donations

To enhance the transfer of excess food, whether through laws or incentives, donations should be facilitated. There are often still uncertainties about legal obligations and the liability associated with the transfer. Here, a legally secure framework is needed that simplifies the transfer of food, taking food safety and food hygiene into account. Communication of food transfer possibilities and information on legal conditions as well as hygiene regulations should be strengthened (Wilts *et al.*, 2018, pp. 24–25). The establishment of logistical structures can help to support donations for both the donor and the recipient side. For businesses, it is often easier and more cost-effective to discard food that can no longer be sold. Nevertheless, many are willing to donate surplus food. Ways to increase their motivation are tax benefits on donated products.

6. Conclusions

This article discussed several instruments (table 1) targeted to avoid food losses and waste. Apparently, a considerable number of approaches already exist, and some are used in practice. As the cited studies on food waste generation show, the lack of data on food losses and waste remains a major problem. Reliable and sufficient data is essential to identify sources and quantities of waste. This, in turn, is the key to establish target-oriented instruments and assess their efficiency and effectiveness.

With regard to the target groups, it is necessary to address all stages of the value chain. On the one hand, addressing the consumer level is of particular importance due to the high volumes of waste at this stage. Additionally, as the studies on the impacts of food waste confirm, food waste generated at the end of the value chain has the highest negative environmental impact. On the other hand, it must be taken into account that the upstream stages also produce large quantities of waste. In addition, it is often easier to implement suitable measures at these stages and thus reduce food losses and waste.

The studies also indicate that it is relevant to identify and implement instruments that are particularly targeted to reduce food waste with high environmental impact. For this reason, two dimensions are important. One is the intensity of required resources for production. Therefore the waste of meat and dairy products is particularly harmful. The other dimension is the volume of waste. Here the waste of vegetables and bakery products are prominent examples.

Research on costs and effectiveness of strategies on food waste such as those of ReFED (2018) illustrate that some measures have high economic potential, while others have high ecological advantages. It is therefore necessary to prioritise measures in order to identify both economically and ecologically sensible approaches. Based on the discussion of practical examples, this article identified six promising solutions to prevent food losses and waste. Besides the improvement of the data mentioned above, these include: identifying and communicating the added value of prevention measures for the actors, the support of opportunities related to digitization and technology, the strengthening of consumer education and psychological research as well as the introduction of legal requirements and voluntary agreements. Moreover, the facilitation of the transfer of food and the provision of economic incentives for donations would help to prevent surplus food from being disposed. At all levels of the supply chain, the cooperation between the respective stakeholders needs to be strengthened.

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Table 1. Discussed instruments and derived solutions for the prevention of food waste

Discussed instruments	Voluntary Commitments	Laws and tax benefits	Awareness Campaigns	Nudges
Derived solutions for the prevention of food waste	1. Improve the quantification on food losses and waste			
	2. Identify and communicate the added value for the actors			
	3. Support opportunities related to digitization and technology			
	4. Introduce legal requirements and voluntary agreements			
	5. Facilitate the transfer of surplus food and provide economic incentives for donations			
		6. Strengthen consumer education and involve psychological research		

Figure captions

Figure 1. Share of food waste at different stages of the value chain in the EU-28 (Source: Stenmarck *et al.*, 2016)

Figure 2. Global impacts of food losses and waste (Source: FAO, 2013)

Figure 3. Causes for food losses and waste along the food supply chain (Sources: Canali *et al.*, 2014; FAO, 2011; Kranert *et al.*, 2012; Monier *et al.* 2010)

Figure 4. Findings of a Chafea study on information nudges (Source: OECD, 2017)

Figure 5. Solutions for the prevention of food losses and waste

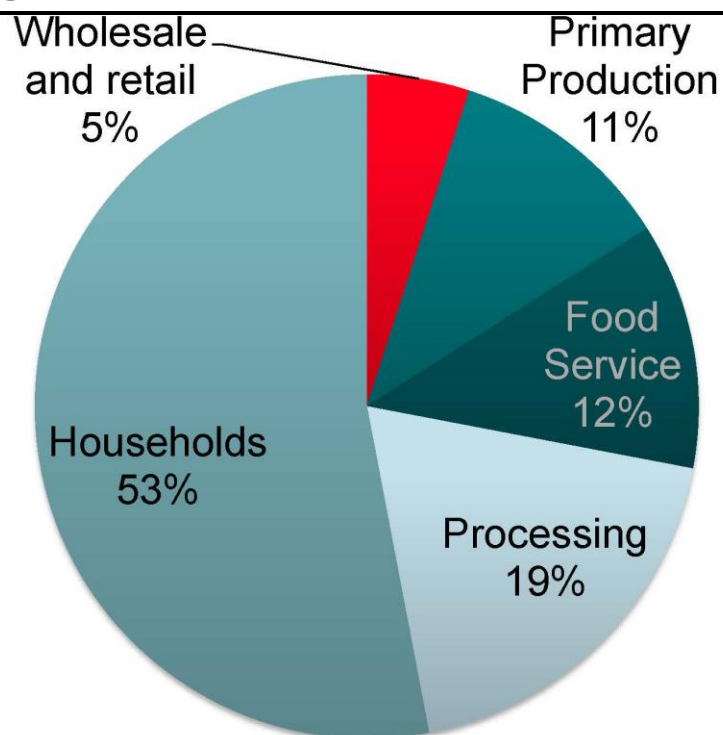


Figure 1

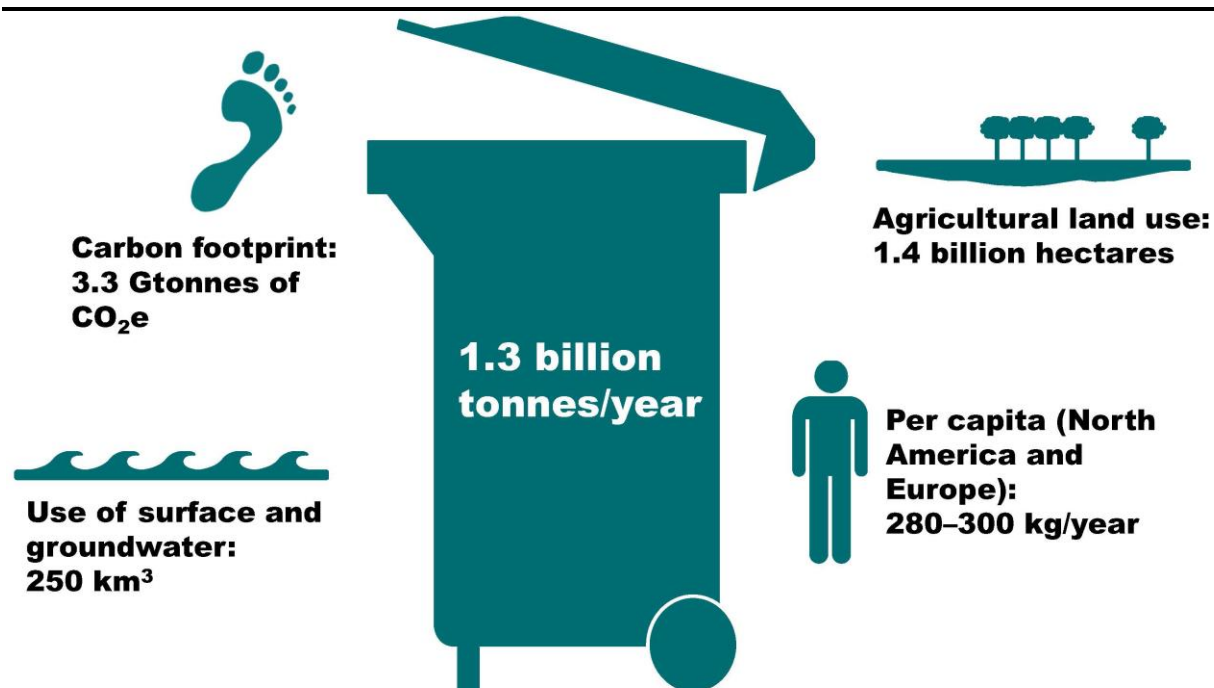


Figure 2

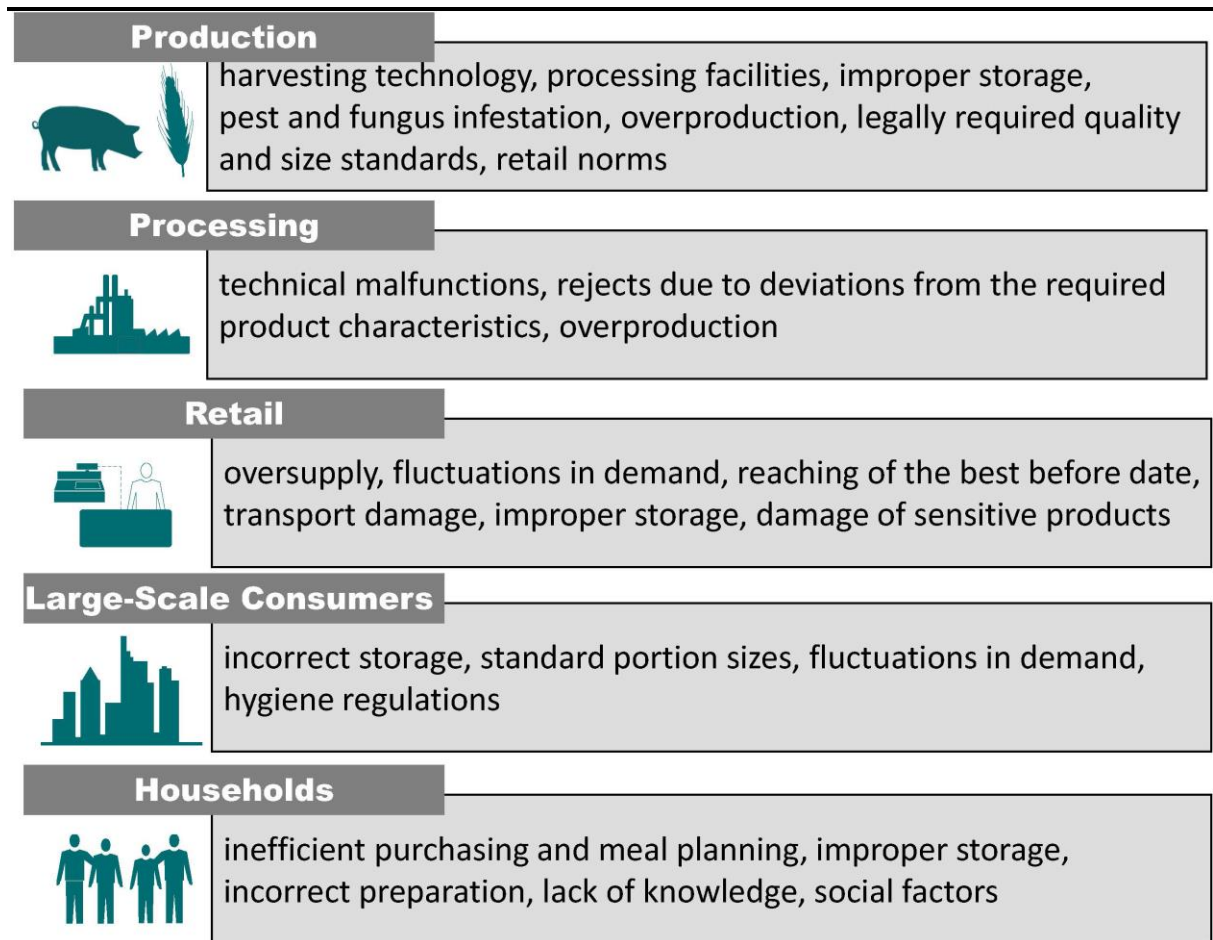


Figure 3:



Figure 4

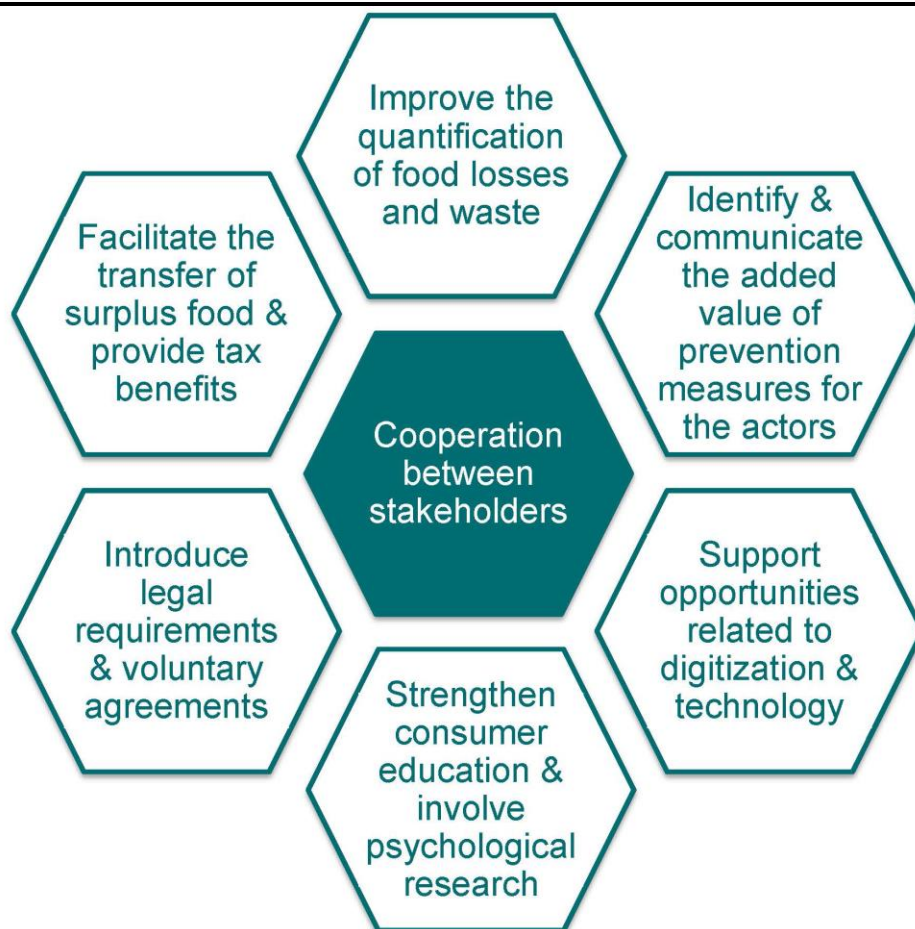


Figure 5