



Drivers of current food waste generation, threats of future increase and opportunities for reduction

Reducing food waste through social innovation

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Editor:	Massimo Canali , University of Bologna, Italy;
Authors:	Massimo Canali , University of Bologna, Italy; Karin Östergren and Pegah Amani , SIK – The Swedish Institute for Food and Biotechnology, Sweden; Lusine Aramyan and Siet Sijtsema , Wageningen UR, Netherlands; Otso Korhonen and Kirsi Silvennoinen , MTT – Agri-Food Research, Finland; Graham Moates and Keith Waldron , IFR – Institute of Food Research, UK; Clementine O'Connor , BIO by Deloitte, France.
Contributors:	Sophie Easteal , Andrew Parry and Tom Quested , WRAP – Waste & Resources Action, UK; Silvia Gaiani and Matteo Vittuari , University of Bologna, Italy; Séverine Gojard , INRA – Institut National de la Recherche Agronomique, France; Felicitas Schneider , BOKU – University of Natural Resources and Life Sciences, Vienna, Austria; Han Soethoudt and Hilke Bos-Brouwers , Wageningen UR, Netherlands;
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Project leader	Toine Timmermans and Hilke Bos-Brouwers ; Wageningen UR, Netherlands (FUSIONS Project Coordinators);
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Abstract

At the present time, a considerable wastage of resources seems to be inherent in the industrial production, processing and distribution of food destined for mass consumption. The impressive growth of productivity, that has taken place in the agricultural and food sector in the last century, allowed an increasing industrialisation and urbanisation of society, made the organisation of the food supply chain much more complex, but multiplied the possibilities for wastage to occur.

Expert views and a literature review were a basis to inventory and categorise, in this study, what has been seen as the primary causes of food waste, the aspects which threaten an increase in food waste, and the aspects which suggest possibilities for reduction in food waste in the future. The inventory recorded a total of 597 items. This preliminary work allowed a qualitative analysis identifying 271 food waste drivers, which witness a wide and multifaceted problem, interconnected problem across all stages of the food supply chain, from primary production in farms, up to final consumption in food services and households.

By referring to the current food waste causes, it is possible to distinguish:

- A. food waste related to the inherent characteristics of food products and the ways through which they have to be produced and consumed (e.g. perishability of food and limited predictability of supply and demand);
- B. food waste related to social factors and dynamics in population habits and lifestyles that are non-readily changeable (e.g. single-person households, young age of household members, young couples with small children, increased consumption of meals out-home, etc.);
- C. food waste related to individual behaviours and general expectations of consumers towards food that are non-readily changeable (e.g.: good aspect, freshness, possibility of acceding to broad quantities and varieties of food independently on places, season, and time);
- D. food waste related to other priorities targeted by private and public stakeholders (the possibility of generating food waste may be a minor concern with respect to other priorities of private and public stakeholders: like cost reduction, sales increase, product safety, quality standards, etc.);
- E. 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.

If we consider the above items, the possibility of intervening in the food system and reducing food waste increase from the top to the bottom of this list (from A to E). For food waste causes at the top of the list, most of the potential change lays in technological innovations that reduce the constraints related to intrinsic characteristics of food products and to the ways they are produced and used. The opportunities for intervention increase moving to the bottom of the list, where 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.

The inventory indicates that food wastage may be difficult to eradicate, but it also brings out that a lot can be done to reduce food waste effectively at all stages of the food supply chain. The extreme complexity of the food supply chain does not allow the adoption of easy solutions applicable to all circumstances. The causes of wastage need to be clearly identified within each single activity and process of the supply chain. It is then necessary to set very specific proceedings for monitoring food waste generation in the different chain segments and in each type of activity, and find out appropriate methods for any single situation. This will be mostly a task of individual operators: companies, researchers, campaigners, and consumers. The task of public authorities and policy makers will be to create the framework to enable society to undertake the necessary engagement to prevent and reduce a largely avoidable wastage of resources.

Summary Report

Aim of the study, methodology and development of the research work

The aim of the study was to identify the main causes of food waste generation along the food supply chain and how technology development (i.e. the Technological Context), food supply chain management (i.e. the Institutional Context), and consumers' behaviours and lifestyles (i.e. the Social Context) may lead to an increase or reduction in food waste in the future. Within the food supply chain management context (the Institutional context), two main fields of analysis were identified: (i) business management and economy and (ii) food legislation and policies. The three contexts represented the categories of drivers for the analysis.

The main geographical reference of the inquiry was the European Economic Area (EEA), but information regarding non-EEA countries was also collected. In fact, very interesting experiences on this specific issue have been developed outside Europe (e.g.: Japan, USA), and it needs to be taken into account that the food supply chains, in many cases, are global.

The food waste generation and the related trends in the different segments of the food supply chain were investigated on the basis of the three categories of drivers (or context categories) mentioned above. Seven food supply chain segments were identified: primary production, processing of agricultural staples, food processing and packaging, wholesale and logistics, retail and markets, food services, and household consumption. The analysis was organised according to a matrical scheme, where the seven food chain segments and the three context/drivers categories could be respectively identified as the rows and the columns of a hypothetical matrix (Table S.1).

Table S.1 – Analytical approach of the study

<i>Food supply chain segments</i>	<i>Context Categories</i>			
	<i>Technological</i>	<i>Institutional</i>		<i>Social (consumer behaviours and lifestyles)</i>
		<i>Business and economy</i>	<i>Legislation and policies</i>	
Primary production				
Processing of agricultural staples				
Food processing and packaging				
Wholesale and logistics				
Retail and markets				
Food services				
Households				

The main steps of the research were:

- Inventory of food waste causes, future threats of increase, and opportunities for reduction

The FUSIONS' experts were asked, through a questionnaire, to indicate the main causes of food waste generation, by providing their information sources. In particular, for each segment of the food supply chain it was requested to indicate:

- the current causes of food waste generation (current causes);
- the main threats of food waste increase in the future (future threats);
- the main opportunities for food waste reduction in the future (future opportunities).

13 questionnaires were filled in by the FUSIONS' experts, who indicated 286 current causes of food waste, 133 future threats of increase, and 178 future possibilities of reduction: a total of 597 inventoried items. The inquiry was mainly based on the analysis of the available scientific literature. The entries were drawn from 171 different bibliographic references, and also from the direct experience of the responders.

- Identification of drivers by chain segment

After the inventory of food waste causes, the seven segments of the food supply chain were analysed to identify the drivers from which the inventoried causes of food waste are originated. The drivers identified in each segment were classified according to the three categories of drivers. Seven reports, one for each chain segment were produced, and this concluded the first stage of the study.

- Analysis of the food supply chain by category of drivers

In the second stage of the study the whole supply chain was analysed vertically through the perspective of the three categories of drivers, as indicated by the columns of the above matrix. For each category the drivers related to current food waste causes, future threats of increase, and opportunities for reduction were made evident.

The relative importance of the different food supply chain segments for the current food waste production and for the future threats of increase and possibilities of reduction were estimated through paired comparison tests based on the qualitative judgments of the experts of the FUSIONS Project. The methodology chosen for the paired comparisons for the food supply chain segments attributed three different levels of relative importance: "high importance", "moderate importance", and "low importance" for the current food waste generation, for the future threats of increase and for the future possibilities of reduction.

- Final Report

A report was drafted and circulated among the FUSIONS' experts for a consultation and the final version of the study was developed on the basis of all the feedbacks received.

Identified drivers of current causes of food waste generation

105 drivers for the current causes of food waste generation were identified by this study. 28 drivers are related to technology, 38 to business management and economy, 23 to legislation, and 16 to consumer behaviour and lifestyles (Social drivers).

The relative importance of the different food supply chain segments for current food waste generation, as resulting from the paired comparisons, is quite variable depending, not only, on the category of drivers

considered, but also on the number of original causes identified in the reports dedicated to the food chain segment analysis. However, the Households segment was indicated to have a relatively high importance in all the categories of drivers. The Primary production segment scored high importance in the Technological drivers and in the Institutional (Legislation and policies) drivers, and a relative low importance in the Social drivers. A third segment judged to have a relatively remarkable importance for food waste generation was the Retail and markets, which was indicated of high importance for the Social drivers, and of moderate importance in the other two categories of drivers.

Within each context category, three different groups of identified drivers have been defined: (i) the Technological drivers have been grouped according to possibilities of intervention through application of available technologies, (ii) the drivers related to Business and Economy according to possibilities of business management solutions, and (iii) the Social drivers according to efficacy of actions increasing social awareness and information. In the Institutional (Legislation and Policies) context the groups of drivers have been formed following the type of legislation and policy to which the identified drivers are referred (Table S.2).

Table S.2 – Grouping of identified drivers of current food waste causes

<i>Context categories</i>	<i>Grouping of identified drivers of current food waste causes</i>		
<i>Technological</i>	Drivers inherent to characteristics of food, and of its production and consumption, where technologies have become limiting	Drivers related to collateral effects of modern technologies	Drivers related to suboptimal use of, and mistakes in the use of food processing technology and chain management
<i>Institutional (business management)</i>	Drivers not easily addressable by management solutions	Drivers addressable at macro level	Drivers addressable within the business units
<i>Institutional (legislation and policy)</i>	Agricultural policy and quality standards	Food safety, consumer health, and animal welfare policies	Waste policy, tax, and other legislation
<i>Social</i>	Drivers related to social dynamics which are not readily changeable	Drivers related to individual behaviours which are not readily changeable	Drivers related to individual behaviours modifiable through information and increased awareness

- Technological drivers of current causes of food waste generation

The identified *Technological drivers* have been grouped according to the following criteria:

- drivers of food waste inherent to the characteristics of food, and of its production and consumption, where technologies have become limiting;
- drivers of food waste which are inherent to the process design and a consequence of technologies utilised. In this case, food waste can be considered a technological collateral effect of modern production practices, which is accepted by enterprises and consumers according to a cost/benefit ratio;
- drivers related to sub-optimal use of, and mistakes in the use of available food processing technology and chain management.

Food waste related to the first criterion (*drivers of food waste inherent to the characteristics of food, and of its production and consumption, where technologies have become limiting*) is difficult to be avoided, because there is still lack of technological capacity. These drivers are related to phenomena like perishability of food and unpredictability of food production and consumption, which have waste-related

consequences, for example, in the correct programming of the volumes of supply and demand, and reflect on the generation of food waste.

The second criterion (*food waste as a technological collateral effect*) relates to the fact that supply chain technologies may evolve by optimising not only the use of food staples in the different chain segments, but also other economically important factors of production, e.g.: energy, land, buildings, equipment, finance, workforce. Therefore, the implementation of new technologies which create more waste of food staples, but reduce the use of other more costly factors may be perfectly rational for enterprises and consumers, especially if they do not pay for the environmental damages caused by waste increase. These phenomena are related to the concepts of *asymmetry of technological progress* and *externalities*. The third criterion relates to the *sub-optimal use of, and mistakes in the use of available food processing technology and chain management*. Drivers like '(no) access to modern technologies', '(scarce)equipment reliability', 'ease of equipment operation', 'cold chain inefficiencies', '(poor) storage conditions' have been included in this group.

Food waste related to the first group of drivers could be considered in relation to technological progress, in order to achieve a more sustainable control over the variety of natural factors that still constrain production, processing, marketing, and consumption of food.

Food waste derived from the second group of drivers could be faced with policy measures targeted to balance the asymmetries of technological progress and the externalities generated along the food supply chain. To this aim, typical measures may be represented by market-based instruments such as green taxes and subsidies, and tradable permits that change the cost/benefit ratio for firms and consumers, by addressing their choices towards solutions that reduce food waste.

The causes of food waste derived from the third group of drivers may be opposed by reinforcing the technological skills of production units, by improving the skills of their staff and consumers' information and awareness. This could be obtained by policy measures stimulating investments, modernization, and professional training in firms and by campaigns for consumers.

- Institutional (business and economy) drivers of current causes of food waste generation

The identified Institutional (business and economy) drivers have been grouped according to the following criteria:

- drivers of food waste which are not easily addressed by management solutions, since they are related to the natural characteristics of food staples or to entrenched societal obstacles difficult to be removed. These drivers are related to phenomena like perishability of food and unpredictability of food production and consumption, rooted behaviours of consumers difficult to change, and huge social problems like extreme poverty;
- drivers of food waste which can be addressed at the macro level (e.g. by policy measures, inter-professional agreements, social campaigns) and not at the level of the single business unit. Examples are the drivers originated by different government policies (agriculture, waste, taxation), market conditions, and unequal bargaining power of food supply chain operators.
- drivers of food waste which can be addressed within the business units through better organisation and improved management. Identified drivers like communication, staff training, supply chain/cold chain inefficiency, information sharing, and portioning, have been included in this group.

By definition the first group of the identified drivers are not easily addressed through management solutions within the business units. They could be contrasted with technological progress and huge policy initiatives, mostly at international level.

The second group of drivers is affordable at macro level by specific policy measures (e.g. agricultural market and infrastructure, food safety, health and consumer, animal welfare, waste, etc.), by inter-professional agreements, and by consumer campaigns.

The causes of food waste derived from the third group of drivers may be addressed within the business units, for example by improving organisation, information and training of staff, communication with suppliers and customers, and with final consumers.

- Institutional (legislation and policy) drivers of current causes of food waste generation

The criteria for grouping the identified Institutional (legislation and policy) drivers are directly related to the subjects of legislation impacting on food waste, in particular:

- the first group of drivers is concerned with the legislation derived from the agricultural policy and agricultural product quality regulations; for example: product grading, overproduction, market conditions and market price, and marketing standards;
- the second group of drivers is related to legislation derived from food safety, consumer health, and animal welfare policies. Drivers like 'best before date' and 'ban on feeding ABP (animal by-products) and catering waste to animals' have been included in this group;
- the last group of drivers is concerned with legislation originated by waste and tax policies and by other policies. Some identified drivers included in the group are 'tax on donations', 'tax policy', 'low cost for discarding food', and 'lack of policies to encourage redistribution'.

The causes of food waste derived from the three groups of drivers can be dealt with by intervening in the respective legislations and policies.

- Social drivers of current causes of food waste generation

The identified Social drivers have been divided according to the following criteria:

- a first group includes the drivers related to socio-demographic factors, e.g. food waste causes related to households' characteristics, gender, population age and income, average culinary skills, etc.;
- the second group of drivers is related to unconscious preferences that can be hardly modified as the preferences for certain aesthetic standards or typologies of food);
- the third group of drivers is related to consumers' individual behaviours modifiable through information and strengthened awareness. The drivers classified in this group, although defined with very generic terms, refers for example to consumer attitudes towards food shopping, the way food is served by restaurants, the level of general information and awareness about food, social norms, and so on.

The causes of food waste from the first group of drivers often depend on wide social dynamics that in most cases are not readily changeable (like demographic trends, population age, household structure, income, education, etc.). Regarding the causes derived from the second and the third group, their definition indicates the possible types of intervention, and many actions around these are already taking place across Europe.

Identified drivers of future threats of food waste increase

77 drivers for the future threats of food waste increase were identified. 18 drivers are related to technology, 32 to business management and economy, 19 to legislation, and 8 to the social context.

The food supply chain segment that has been considered the most problematic for future threats of food waste increase is the Retail and markets segment, which has been perceived of high importance in the Legislation and in the Social contexts and of moderate importance in the Technological context. The Food processing and packaging segment follows with high importance perceived for Legislation and moderate importance in the remaining two categories of drivers.

Table S.3 shows the criteria chosen for grouping the identified drivers of future threats of food waste increase.

Table S.3 – Grouping of identified drivers of future threats of food waste increase

<i>Context categories</i>	<i>Grouping of identified drivers of future threats of food waste increase</i>		
<i>Technological</i>	Future threats related to changes driven by environmental, policy, and macroeconomic developments	Future threats related to changes driven by business decisions	Future threats related to changes driven by consumers choices
<i>Institutional (business management)</i>	Future threats related to changes driven by policy and macroeconomic developments	Future threats related to changes driven business decisions	Future threats related to changes driven consumers choices
<i>Institutional (legislation and policy)</i>	Future threats from current regulations and changes in the agro-food policy and legislation	Future threats from current regulations and changes in other legislation and policies	Future threats from insufficient regulation
<i>Social</i>	Future threats related to current social dynamics	Future threats related to individual behaviours which are not readily changeable	Future threats related to individual behaviours modifiable through information and increased awareness

- Technological drivers of future threats of food waste increase

Technological drivers of future threats of food waste increase should identify some main forthcoming challenges for technology with respect to changes that are taking place in the current general context in which the food supply chain's firms operate. For that reason, they have been grouped according to the nature of these changes, in particular:

- drivers related to changes determined by environmental, policy, and macroeconomic developments;
- drivers related to changes determined by business decisions;
- drivers related to changes determined by consumers choices.

The drivers of the first group express concern regarding the consequences on food waste of four main areas and the technological capacity to respond to their evolution: climate change (losses from foodstuffs subject to adverse climatic conditions), globalization (losses from long-distance trade of foodstuffs), increasing use of bio-waste for energy production, pressure to limit the use of packaging in marketed goods.

The second group indicates threats from: the increasing mechanisation of harvesting and processing of foodstuffs, which may increase losses through damaged products and for products with non-standard shapes that cannot be processed by machinery; the wider availability of short shelf life products; the trend to excessive portioning of many packaged products; the improving capacity of detecting product quality; and in possible diminishing quality of home appliances.

The third group of drivers indicate threats from consumer preference for wider product choice, from increasing consumption of fresh products, from rising demand for "healthier" food, which tend to reduce content of preservatives and may reduce food shelf life .

- Institutional (business and economy) drivers of future threats of food waste increase

Institutional (business and economy) drivers have been grouped by following almost the same criteria used for the Technology drivers, i.e.:

- drivers related to changes determined by policy and macroeconomic developments;
- drivers related to changes determined by business decisions;
- drivers related to changes determined by consumers choices.

The drivers of the first group are related to globalization and to the policy evolution regarding the fishery sector, bio-fuel production from food waste, tightening of food standards, low taxation of waste, public budget cuts, and the lack of the food waste issue in education curricula.

The second group's drivers relate to five challenges: contractual relations along the food supply chain (shift of food waste costs towards the weaker part of supplier-customer agreements); risks of not complying, also unintentionally, with food standards (penalties, damage to brand image); priority given to economically optimal solutions which are suboptimal from viewpoint of food waste reduction; marketing strategies inducing bad practices and behaviours in consumers; inadequate training of staff.

The third group of drivers refer to the evolution of the global demand towards wider assortments of products, more fresh products and higher quality standards related to phenomena like urbanization and healthier lifestyles.

- Institutional (legislation and policy) drivers of future threats of food waste increase

Institutional (legislation and policy) drivers of future threats of food waste increase have been grouped after the following criteria:

- changes in agri-food policies and legislation;
- changes in other sectors of legislation and policies;
- future threats from lack of regulation.

The drivers of the first group refer to fishery policy and to hindrances to food waste reduction and prevention from quality and safety standards.

The drivers of the second group indicate threats from bio-energy policies, inadequate taxation of waste disposal, increasing cuts in public budgets, and new taxes on donations.

The last group's drivers indicate fears for several challenges already pointed out in the analysis of the institutional drivers related to business and economy.

- Social drivers of future threats of food waste increase

Social drivers of future threats of food waste increase have been grouped according to the same criteria seen for the current causes of food waste generation:

- drivers related to socio-demographic trends;
- drivers related to individual behaviours which may be difficult to change;
- drivers related to patterns in consumers' individual behaviours potentially modifiable through information, skills and heightened awareness.

The drivers included in the first group point out the long term effects of several global social dynamics.

The second group's drivers are concerned with increasing demand for more food variety.

The third group's drivers indicate future threats from consumers' attitude of not feeling guilty about food wastage, inefficacy of awareness campaigns, reduced incentive to avoid food wastage due to new

affluence, and negative influence on consumer behaviours from promotional sales of food and from the practice of selling packaged food in large portions.

Identified drivers of future possibilities of food waste reduction

89 drivers for future possibilities of food waste reduction were identified: 20 drivers in the Technological context, 37 in the Institutional (business management and economy) context, 27 in the Institutional (legislation and policy) context, and five in the Social context.

The food supply chain segments that have been considered the most promising for future possibilities of food waste reduction are the Retail and markets segment, which has been perceived of high importance in the Legislation and in the Social contexts and of moderate importance in the Technological context. The Food processing and packaging segment follows with high importance perceived for the Technological context and moderate importance in the remaining two categories of drivers.

Table S.4 shows the criteria chosen for grouping the identified drivers of future possibilities of food waste reduction.

Table S.4 – Grouping of identified drivers of future possibilities of food waste reduction

<i>Context categories</i>	<i>Grouping of identified drivers of future possibilities of food waste reduction</i>		
<i>Technological</i>	Future possibilities driven by development of new technology	Future possibilities driven by improved use of existing technology	Future possibilities driven by improved organisation and skills
<i>Institutional (business management)</i>	Future possibilities driven by policy and macroeconomic developments	Future possibilities driven by improvements in organisation and technology	Future possibilities driven by improvements in information management, knowledge and communication
<i>Institutional (legislation and policy)</i>	Future possibilities from improvements in current regulations and policies	Future possibilities from (non-regulatory) initiatives undertaken by governments	Future possibilities from new initiatives undertaken by enterprises and society
<i>Social</i>	Future possibilities from improved consumers' behaviour directly induced by food waste information and campaigning	Future possibilities from improved consumers' behaviour not directly induced by food waste campaigning	-

- Technological drivers of future possibilities of food waste reduction

The identified Technological drivers of future possibilities of food waste reduction have been grouped according to the following criteria:

- future possibilities of food waste reduction driven by development of new technology;
- future possibilities of food waste reduction driven by improved use of existing technology;
- future possibilities of food waste reduction driven by improved organization and skills.

The drivers of the first group indicate future possibilities of food waste reduction from the development of new selective fishing gear, advances in plant and animal breeding, electronic ordering systems, automatic storage management systems, new refrigeration technology, improvements in packaging, and new technologies for households.

The second group indicate prospects from improved storage and farm equipment, proper conservation and transport techniques, product handling, improved redistribution logistics of food banks, and better equipment for customers of restaurants and canteens (trays, plates, buffet trays, etc.).

The third group include drivers mainly related to improvement of knowledge and information along the food supply chain.

- Institutional (business and economy) drivers of future possibilities of food waste reduction

The identified Institutional (business and economy) drivers of future possibilities of food waste reduction have been grouped according to the following criteria:

- possibilities from policy and macroeconomic developments;
- possibilities from improvements in organisation and technology;
- possibilities from improvements in information management, knowledge and awareness.

The drivers included in the first group mostly indicate possibilities from policy actions: reform of fishery policy, measures on waste disposal (different taxation and improved waste separation), changes in marketing standards and product labelling, incentives to food redistribution, renegotiation of contracts along the food supply chain by which the stronger firms tend to displace the cost of food waste disposal towards the weaker counterparts.

The drivers collected in the second group indicate possibilities related to: enhanced utilisation of food at risk of disposal; better food supply chain organisation; technological improvements in processing, storage and refrigeration; ameliorated capacity of complying with food quality and safety standards; improved correlation between meal preparation and customers' orders in food services (i.e. anticipation of the so-called 'customer order decoupling point').

The last group's drivers mainly refer to the opportunities from: management and marketing solutions more careful towards the food waste issue; increased cooperation and sharing of information among the food supply chain stakeholders; improved capacity of demand and ordering forecasting; and better staff training.

- Institutional (legislation and policy) drivers of future possibilities of food waste reduction

The identified Institutional (legislation and policy) drivers have been grouped according to the following criteria:

- improvements in current legislation and policy which may reduce food waste;
- possibilities from new non-regulatory initiatives undertaken by governments;
- possibilities from new initiatives voluntarily undertaken by stakeholders.

A majority of the first group's drivers indicates possibilities of food waste reduction from changes in legislation that: stimulate the utilisation of food products presently destined for disposal; increase tax on waste disposal and improve separate waste collection; limit by-catches in fisheries; and sanction unfair deals of big retailers with suppliers.

The second group's drivers relates to actions addressed to: improve people's information and awareness on different aspects of the food waste issue; ameliorate distribution logistics, waste collection infrastructures (favouring separate collection) and research in advanced packaging; promote new business models based on utilisation of imperfect and downgraded foodstuffs.

A majority of the third group's drivers indicate initiatives to be launched by enterprises as regards marketing, technology, and organisation of production, while others are related to initiatives requiring active involvement or, at least, improved awareness of consumers, like: implementation of community

supported agriculture initiatives, development of farmers markets and farm shops, and encouragement to consumption of leftovers and use of “doggy bags”.

Social drivers of future possibilities of food waste reduction

The identified Social drivers for future possibilities of food waste reduction focus on opportunities related to an improved behaviour of consumers towards food waste. A distinction could be set on the causes of that progress and two groups of drivers were formed:

- possibilities of food waste reduction from improved consumers’ behaviour directly influenced by food waste information and campaigning;
- possibilities of food waste reduction from improved consumers’ behaviour not directly influenced by food waste information and campaigning.

By definition, the first group’s drivers refer to opportunities arising from increasing food waste campaigning and information. The second group relates to possibilities of improved consumers’ awareness towards food waste influenced, for example, by good marketing practices of retailers (e.g.: do not implement strategies which can lead to buying too much; expose the goods with the shortest shelf life; reduce prices of the goods which are close to the use-by or to the best-before date) and caterers (improved quality, correct portioning, and anticipation of the customer order decoupling point).

Limitations of the study

A main limitation is inherent to the nature of the study which was set on the information provided by the FUSIONS experts on the basis of their personal experience (i.e. previous studies performed, knowledge of scientific literature, initiatives for food waste prevention and reduction, etc.). Therefore the study should be considered as a qualitative research since its results relate to perceptions, opinions, and judgements of individual experts. For these reasons the study did not aim to achieve a statistical significance or an objectively complete identification and classification of the food waste drivers, but to collect and group, into drivers and driver categories, a wide exemplification of food waste causes, future threats to increased food waste and possibilities of reduction of food waste derived from the know-how of the FUSIONS network.

The qualitative nature of the study had also consequences on the comparative analysis of the importance of the different food supply chain segments for food waste generation and possible reduction. This was also based on experts’ judgements, then conditioned by personal experience and by the quality of the information on which the judgements were based.

Main conclusions

Expert views and a literature review were a basis to inventory and categorise, in this study, what has been seen as the primary causes of food waste, the aspects which threaten an increase in food waste, and the aspects which suggest possibilities for reduction in food waste in the future. This preliminary work allowed a qualitative analysis which identified 271 food waste drivers summarised in Tables S.5-S.8 (see in the end of this Summary).

Although the identified drivers can provide only a partial picture of the food waste issue – the drivers are the outcome of a qualitative study, essentially set on the subjective evaluations of the experts involved – the inventory on which they are based may be considered a unique and comprehensive overview not yet present in existing literature. On this basis, the identified drivers testify a wide and multifaceted problem, which involves deeply and in very intricate ways all the segments of the food supply chain, from primary production in farms, up to final consumption in food services and in the households. If we consider, as

we did in this study, the food supply chain as a whole, there are not one or few main determinants that are clearly 'responsible' for food waste, rather waste results from a complex pattern of extremely diversified and interconnected causes.

A common point is that, at the present time, a considerable wastage of resources seems to be inherent to industrial production, processing and distribution of food destined to large urban markets and mass consumption. The impressive growth of productivity, that has taken place in the agricultural and food sector in the last century, has allowed an increasing industrialisation and urbanisation of society, has made the organisation of the supply chain much more complex, and has multiplied the possibilities for waste to occur.

These types of phenomena are not limited to the food sector. Industrial production and massive consumption of goods and services often lead to a significant waste of resources. A remarkable example is in the energy sector: despite being so critical for the whole economic system and the awareness that it basically depends on non-renewable sources, about 54% of the energy globally generated from all the different sources is estimated to be lost and the ratio seems to be higher in the most industrialised countries¹ (Smith C. *et al.*, 2011).

In the previous pages, the criteria utilised to group the identified drivers within the examined context categories and sub-categories have been displayed. At the end of this Summary, Tables S5-S8 show all the identified drivers by context category and by food supply chain segment.

The section below highlights a crosswise classification indicating priorities for possible actions by individual stakeholders, interest groups, and policy makers aimed at reducing the current generation of food waste. If we consider the current food waste causes, it is possible to distinguish:

- A. Food waste related to the characteristics of food products and the ways through which they have to be produced and consumed (perishability of food, limited predictability of supply and demand, limited capacity of control on many factors of production that constrains the possibility to adapt quickly the supply to the evolution of demand, limited possibility of consumers to accumulate individual stocks of food, etc.);
- B. Food waste related to social factors and dynamics in population habits and lifestyles that are non-readily changeable (for example: single-person households, young age of household members, young couples with small children, increased consumption of meals out-home, etc. These are all factors and long term developments that are positively correlated with food waste generation);
- C. Food waste related to individual behaviours of consumers that are non-readily changeable (this refers to behaviours depending on general expectations of consumers towards food, for example: good aspect, freshness, possibility of acceding to broad quantities and varieties of food independently on places, season, and time, etc. These expectations determine behaviours in both the consumers and the food supply chain operators that generate wastage. Progress in technology and management can deal with the problem, but its originating causes – the consumers' expectations – are unlikely to be eradicable).
- D. Food waste related to other priorities targeted by private and public stakeholders (the possibility of generating food waste may be a minor concern with respect to other priorities of the private and public stakeholders. For example, for private companies profit is a first priority and this justifies choices in technology, management, and marketing solutions that balance potential wastage of food with increase of product sales, reduction of production costs or diminished risks of damages to the company's brand image from non-complying with safety or other commercial standards. For public authorities legislative provisions improving issues like food safety, food security, consumer information, and animal welfare may overcome the worry for a potential generation of food waste derived from the implementation of such legislation).

¹ For example energy losses are 63% in the USA and France, 58% in the UK and Japan, and 56% in Germany.

-
- E. 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. This group includes a wide range of food waste causes that could be considerably reduced by improving technological and organisational efficiency of supply chain operators, the quality of legislative provisions potentially implying impacts on food waste, and the consumer behaviours and attitudes towards food.

The probability to modify the causes of food waste in the above list is increasing from A to E. In the first part of the list most of the potential change lays in technological innovations that ease the constraints related to intrinsic characteristics of food products and to the ways they have to be produced and used. At the end of the list, changes are potentially more feasible, since they largely depend on improvement of efficiency along the food supply chain through correct application of available technology, better organisation, more accurate policy design, and increased consumer awareness.

This inventory of food waste causes indicates that food wastage may be difficult to eradicate in the future, but it also suggests that a lot could be done in a relatively short term. The extreme complexity of the food supply chain does not allow easy solutions applicable to all circumstances.

The causes of wastage need to be clearly identified within each single activity and process of the supply chain. It is then necessary to set very specific proceedings for monitoring food waste generation in the different chain segments and in each type of activity, and find out appropriate methods for any single situation. This will be mostly a task of individual operators: companies, researchers, campaigners, and consumers. The task of public authorities and policy makers will be to identify priority areas of intervention, to design appropriate policy measures and to create a framework which enables society to undertake the necessary engagement to prevent and reduce a largely avoidable wastage of resources.

Table S.5 – Identified drivers related to the Technological context category

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
Primary production	<ul style="list-style-type: none"> - Harvest loss & damage - Livestock mortality - Milk waste caused by drug contamination - Non selective fishing - Microbiological quality / storage 	<ul style="list-style-type: none"> - Insufficient forethought to climate change - Harvesting technology (increase of mechanical harvesting and related losses) 	<ul style="list-style-type: none"> - Selective fishing gear - Advances in plant and animal breeding - Improved storage (ethylene control) - Development of farm facilities (e.g. mastitis detector) - Good agronomic practices
Processing of farm staples	<ul style="list-style-type: none"> - Climatic conditions - Access to modern technology 	<ul style="list-style-type: none"> - Climate change (increase of storage losses related to adverse climate) - Government policy on bio-fuel production - Globalisation (increasing post-harvest losses with growth of imports from developing countries) 	<ul style="list-style-type: none"> - Access to modern equipment and techniques (various items)
Food processing and packaging	<ul style="list-style-type: none"> - Production planning - Improved traceability - Access to modern technology - Equipment reliability - Ease of equipment operation 	<ul style="list-style-type: none"> - Government policy on bio-fuel production - Failure of new packaging solutions (trend towards minimal packaging) - Lack of suitable technology (for processing non standardised agricultural staples) 	<ul style="list-style-type: none"> - Access to modern equipment and techniques (various items)
Wholesale and logistics	<ul style="list-style-type: none"> - Storage handling and conditions - Packaging - Cold chain inefficiencies - Poor management and forecasting 	<ul style="list-style-type: none"> - New short shelf-life products - Increasing consumption (losses of fresh products in transportation) - Increasing demand for greater product variety 	<ul style="list-style-type: none"> - Electronic ordering systems and automatic storage management systems - Advanced packaging (Proper conservation and transport techniques) - Advanced handling - Improved redistribution logistics (of food banks) - Customer knowledge/awareness

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
Retail and markets	<ul style="list-style-type: none"> - Forecast/Ordering system - Damage during transport - Poor handling and storage - Packaging - Minimum food safety failures - Customer knowledge 	<ul style="list-style-type: none"> - Better measurement of quality (may increase product recalls) - Packaging (related to inappropriate portioning) - Service as business idea (related to increase of product variety) 	<ul style="list-style-type: none"> - New technology (refrigeration) - Improvements in packaging - Better inventory management
Food Services	<ul style="list-style-type: none"> - Storage - Equipment and containers - Lack of good practice 	<ul style="list-style-type: none"> - Biogas production 	<ul style="list-style-type: none"> - Better Equipment (trays, plates, buffets trays, etc.) - New ordering system for customers - Better measurement systems (intelligent scale and statistics systems) - Advanced management (menu planning)
Households	<ul style="list-style-type: none"> - Insufficient product life - Limited access to / incorrect use of suitable storage systems - Inappropriate packaging / inappropriate use of packaging 	<ul style="list-style-type: none"> - Inappropriate packaging (trend towards minimal packaging) - Inadequate appliances e.g. low-end fridges (do not help to reduce waste at home) - Health drivers (reduction of salt, sugar, and fats may increase food perishability) 	<ul style="list-style-type: none"> - New Technology (various items e.g. packaging, appliances, smart phones)

Table S.6 – Identified drivers related to the Institutional (Business and economy) context category

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
Primary production	<ul style="list-style-type: none"> - Consumer demand ("cosmetic" fruit standards, scarce use of by-products for cultural reasons) - Poverty/starvation (premature harvesting) - Lack of infrastructure and facilities - Supply and demand forecasting - Government subsidies (favouring production surpluses) - Market conditions/market price (price does not cover harvest costs) 	<ul style="list-style-type: none"> - Fishery policies - Bio-fuel - Excessive power of retailers over producers - Food safety (risks) - Demand, customer expectations, and the market (related to product standards expected by consumers) 	<ul style="list-style-type: none"> - Fishing policy (reform) - Increased use of imperfect fruits and vegetables, and fish and meat by-products - Retail variety (increased offer of out-graded products) - Responsiveness, shorter supply chain - Regionalization and localization of food production - Farm to shop cooperation, information sharing and knowledge development
Processing of farm staples	<ul style="list-style-type: none"> - Access to finance (lock in to existing practices) - Government regulations - Profitability (non profitability of best practices) - Communication (bad information exchange) 	<ul style="list-style-type: none"> - Government policy on bio-fuel production - Profitability / Globalization (waste from increase of traded food staples) - Customer demand 	<ul style="list-style-type: none"> - EU and national government legislative and taxation policy (on food waste disposal) - Profitability (higher price of foodstuffs) - Access to finance (allow technological improvements and reduce losses in processing and storage) - Raise food safety (in food production practices) - Knowledge and communication (increased for all stakeholders)

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
Food processing and packaging	<ul style="list-style-type: none"> - Marketing strategies and customer demand - Customer expectations and demand - EU & national government legislative and taxation policy - Contracts/agreements - Knowledge & communication - Profitability (discarding of low value components and by-products) 	<ul style="list-style-type: none"> - EU and national government legislative & taxation policy (packaging, marketing and food safety standards) - Profitability (related to low cost of disposal due to waste policies) - Government policy on bio-fuel production and anaerobic digestion - Contracts between customers and suppliers - Protection of brand image (waste to prevent food quality/safety risks) - Customer demand and expectations 	<ul style="list-style-type: none"> - EU & national government legislative and taxation policy (eliminate marketing standards) - Access to finance (to improve technology and vertical integration) - Profitability and supply chain structure (horizontal and vertical integration of the food supply chain) - Market awareness and demand management (for increased use of out-graded products and improved labelling) - Knowledge and communication (increased for all stakeholders) - Enhancement of brand image (through food waste reduction initiatives)
Wholesale and logistics	<ul style="list-style-type: none"> - Deterioration of food (mainly related to characteristics of food products) - Market demand (determining product recalls) - Staff training and communication - Supply chain/cold chain inefficiencies - Forecasting of stocking/ordering (mainly related to management inefficiencies) 	<ul style="list-style-type: none"> - Profitability, costs and benefits (food waste generated by savings of other more costly factors of production) - Increase of returns/pre-store waste (related to supplier/retailer contracts) - Precautionary measures with respect to public health risks / food safety / quality and the brand image - Customer expectations and demand 	<ul style="list-style-type: none"> - Investments and financial incentives (improved transport infrastructure, incentives to reduce food waste disposal and increase redistribution) - Alternative usage of out-graded products - Proper conservation and transport techniques - Food customized logistics solutions (more attentive to food safety) - Communication (improved sharing of information in the food industry logistics) - Marketing strategies and standards (more aware of food waste issues)

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
Retail and markets	<ul style="list-style-type: none"> - Forecast/ordering system (mainly related to characteristics of food products) - Customer expectations, demand and marketing strategies (mainly related to consumer behaviours) - Rejection of delivery/returns - Deterioration of food, food safety (mainly related to management inefficiencies) - Power and trust, transparency, communication, and information sharing 	<ul style="list-style-type: none"> - Shelf life, turnover order sizes and pack quantity - Marketing strategies (various types of food retailers' strategies may cause waste) - Lack of knowledge (firms' staff) - Consumer expectations and demand - Shelf life, turnover order sizes and pack quantity - Marketing strategies (various types of food retailers' strategies may cause waste) 	<ul style="list-style-type: none"> - Food redistribution programmes - Alternative use of products (low graded products) - Maintenance of food quality and safety (improvement of capacity to comply with food safety standards) - Forecast/ordering system (improvement of) - Knowledge development (improvement of staff training and information systems) - Market demand management and market strategy (more attentive to food waste reduction)
Food Services	<ul style="list-style-type: none"> - Difficulty to estimate and calculate the right amount of food to cook (related to consumer preference for wide assortment of products) - Consumer expectations prediction and demand forecasting - Inflexibility in portioning - Situational reasons "food being served but not eaten" - Operational reasons "food being prepared, but not served" 	<ul style="list-style-type: none"> - Contracts/agreements (imposing caterers too wide assortments of food) - Economic considerations: turnover and consumer satisfaction (are priorities with respect to reduce food waste) - Variety in choices offered 	<ul style="list-style-type: none"> - Supply-based contracts with the requesting party (renegotiation of) - Decoupling point anticipation (preparing meals as late as possible) - Leftover solutions (reuse of leftovers and doggy bags) - Menu variety (reduction of) - Education and awareness of personnel and consumer - Demand forecasting (improved in hospitals)
Households	<ul style="list-style-type: none"> - Food safety concerns - Consumer behaviour (preference for wide food variety) - Low price of food / proportion of income spent on food - Waste collection infrastructure - Dietary guidance - Incorrect application of date marks 	<ul style="list-style-type: none"> - Education strategy (refers to education policy) - Funding cuts (public budget) - Pricing strategies (of retailers may stimulate over-shopping) - Health strategy (trend towards wellness-driven lifestyles) - Standards (quality expected by consumers) 	<ul style="list-style-type: none"> - Collection infrastructure (improved waste separation) - Application of date marks (more accurate date labelling)

Table S.7 – Identified drivers related to the Institutional (Legislation and policies) context category

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
Primary production	<ul style="list-style-type: none"> - Grading (cosmetic and quality standards for fruit and vegetables) - Overproduction (stimulated by inadequate policy measures) - Market conditions/market price (lack of regulation) - Tax on donations - Tax policy 	<ul style="list-style-type: none"> - Fishery policies - Government policy on bio-fuel production - Contracts between supplier and retailers 	<ul style="list-style-type: none"> - Fishing policy (reform) - Information / awareness (about imperfect fruit and vegetables) - Farm to shop cooperation (community supported agriculture initiatives) - Selling by weight (fruit and vegetables, not by piece)
Processing of farm staples	<ul style="list-style-type: none"> - Profitability - Access to finance 	<ul style="list-style-type: none"> - Government policy on bio-fuel production 	<ul style="list-style-type: none"> - Use of by-products (for animal feed production)
Food processing and packaging	<ul style="list-style-type: none"> - Legislative measures e.g. regulatory standards - Taxation policies 	<ul style="list-style-type: none"> - Legislative measures, e.g. regulatory standards (refers to quality standards and to the ban on ABP) - Government policy on bio-fuel production & anaerobic digestion - Taxation policies (inadequate taxation on waste disposal) - Take back clause-related losses and other contractual commitments 	<ul style="list-style-type: none"> - Policies for resale/use of 'sub-standard' products - Food standards (eliminate food standards non related to safety)
Wholesale and logistics	<ul style="list-style-type: none"> - Specific marketing standards - Legal restrictions with respect to best before/consumption dates - Blemish of packaging - Low cost for discarding food 	<ul style="list-style-type: none"> - Disposal costs - Financial support non-profit distribution (decrease of financial support) - Blockages in alternative use chains (refers to non legislative limitation to food waste prevention) 	<ul style="list-style-type: none"> - Disposal costs (landfill tax increase) - Incentive for donations by financial law - Improving distribution logistics - Encouraging research into advanced packaging - Encourage the development of new business models around imperfect produce
Retail and markets	<ul style="list-style-type: none"> - Marketing standards - Dates labelling - Measurement and pricing of food waste - Rejection of delivery>Returns 	<ul style="list-style-type: none"> - Food safety standards - Redistribution (hindrances to redistribution related to healthy risks and new fiscal policies) - Cost of food waste (inadequate taxation of 	<ul style="list-style-type: none"> - Food redistribution programmes (new legislation for) - Reduce prices on sell before/best before date products (interventions in legislation) - Sanction unfair deal of big retailers with

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
	<ul style="list-style-type: none"> - Lack of policies to encourage redistribution 	<ul style="list-style-type: none"> waste disposal) - Ending of voluntary agreements (related to food waste prevention/reduction) 	<ul style="list-style-type: none"> suppliers - Raising-awareness initiatives - Alternative use of products - Encourage closer contact between farm production and consumers (farmers markets and farm shops) - Limits to price promotions with discounts on volumes (by retailers' initiatives) - Purchase per weight of fruit and vegetables - Eco-labelling of stores - Improved packaging
Food Services	<ul style="list-style-type: none"> - Ban on feeding ABP and catering waste to animals - Expiry dates (insufficient information in labelling) 	<ul style="list-style-type: none"> - Contracts - Public procurement laws (do not take care of food waste concerns) 	<ul style="list-style-type: none"> - Encourage separate collection of food waste and quantification (through improved legislation) - Encourage consumption of leftovers and use of doggie bags (voluntary initiatives)
Households	<ul style="list-style-type: none"> - Price of food / proportion of income spent on food - Waste collection infrastructure - Dietary guidance (lack of food knowledge in education curricula) 	<ul style="list-style-type: none"> - Public funding (decrease of) - Food skills and diet guidance (related to public education policy and public health campaigning) 	<ul style="list-style-type: none"> - Application of date marks (new regulation on food information for consumers) - Waste collection infrastructure (improving waste separation) - Dietary guidance (education programmes)

Table S.8 – Identified drivers related to the Social context category

<i>Food supply chain Segments</i>	<i>Drivers of current food waste generation</i>	<i>Drivers of future threats of increase</i>	<i>Drivers of future possibilities of reduction</i>
Primary production;	- Consumer preference	-	- Consumer Awareness/Stimulation (better information on consumption of sub-standard fruit and vegetables)
Processing of farm staples;	- Consumer preference	-	-
Food processing and packaging;	- Consumer preference	- Growing demand for processed food (urbanisation and changing lifestyles)	-
Wholesale and logistics	- Consumer preference	-	-
Retail and markets	- Behaviour - Consumer preference - Tools	- Consumer preference (for wider variety of food) - Consumers attitude (do not feel responsible)	- Consumer Awareness (information campaigns) - Consumer Stimulation (marketing strategies stimulating correct behaviours of consumers)
Food Services	- Behaviour/attitude - Consumer preference	-	- Consumer Stimulation (by improved quality, correct portioning and anticipation of customer order decoupling point)
Households	- Demographics - Attitudes - Behaviours/skills - Consumer preferences - Knowledge/awareness - Social norms - Tools	- Socio-demographics (increasing single-person households and population ageing) - Awareness (efficacy/prevalence of awareness campaigns, joined up messaging) - Affluence (reduced stimulus to reduce food waste) - Drivers to buy too much to get a saving (e.g. Buy One, Get One Free (BOGOF) and too large portions)	- Awareness (by information, campaigning, and social innovation initiatives)

Technical Report

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1 Methodology

1.1 Background

This study was developed within the framework of FUSIONS, a project funded by the European Commission (FP7-Coordination and Support Action - Contract No 311972) from August 2012 to July 2016.

FUSIONS (Food Use for Social Innovation by Optimising Waste Prevention Strategies) aims to achieve a more resource efficient Europe by significantly reducing food waste. The project has 21 partners from 13 countries of the European Economic Area: FUSIONS' partnership includes universities, knowledge institutes, businesses and NGOs engaged in food waste prevention and reduction. In addition, a number of organisations from different sectors have pledged their support to FUSIONS.

1.2 Aim of the study and geographical reference of the analysis

The study aimed at identifying the main causes of food waste generation along the food supply chain and how current developments in (a) technology (i.e. the Technological Context), (b) food chain management (i.e. the Institutional Context), and (c) consumers' behaviours and lifestyles (i.e. the Social Context) will increase or reduce food waste in the future.

Within the food chain management context (the Institutional context), two main fields of analysis were distinguished: (i) business management and economy and (ii) food legislation and policies.

The three contexts – technological, institutional (formed by business management and economy, and food legislation and policy), and social – represented the categories of drivers for the analysis.

The main geographical reference of the analysis was the European Economic Area (EEA), but information regarding non-EEA countries was also collected. In fact, very interesting experiences on the food waste issue have been developed outside Europe (e.g.: Japan, USA), and it needs to be taken into account that food supply chains in many cases are global.

1.3 Approach

The study was mainly based on investigating the existing information, scientific literature and results of previous research. In practical terms, it was developed in 3 stages:

- i. investigate food waste generation and related developments in the different segments of the food supply chain (seven segments were identified: primary production, processing of agricultural staples, food processing and packaging, wholesale and logistics, retail and markets, food services, and household consumption) on the basis of the three categories of drivers (or context categories): (a) Technological, (b) Institutional (business and legislation), and (c) Social.
- ii. analyse the whole food supply chain from the perspective of the three context/driver categories.
- iii. draft the final report.

1.4 Organization and development of the study

As shown in Table 1.1, the analysis was organised according to a matrical scheme, where the seven food chain segments and the three context/drivers categories could be respectively identified as the rows and the columns of a hypothetical matrix.

Table 1.1 – The matrical scheme of the analysis carried out by context category and food-supply chain segment

<i>Food supply chain segments</i>	<i>Context categories</i>		
	<i>(A)</i> <i>TECHNOLOGICAL</i>	<i>(B)</i> <i>INSTITUTIONAL</i>	<i>(C)</i> <i>SOCIAL</i>
i – Primary production			
ii - Processing of agricultural staples			
iii - Food processing and packaging			
iv – Wholesaling and logistics			
v – Retail and markets			
vi - Food services			
vii - Household consumption			

The main steps of the research work are briefly described in the below sections.

1.4.1 Inventory of food waste causes, future threats of increase, and opportunities for reduction

The study was developed on information collected through a questionnaire submitted to the experts of the FUSIONS project. For each segment of the food supply chain the questionnaire requested to indicate:

- the current causes of food waste generation (current causes);
- the main threats of food waste increase in the future (future threats);
- the main opportunities of food waste reduction in the future (future opportunities).

The FUSIONS' experts filled in 13 questionnaires, in which they indicated 286 current causes of food waste generation, 133 future threats of increase, and 178 future possibilities of reduction: a total of 597 inventoried records.

1.4.2 Identification of drivers by chain segment

After the inventory of food waste causes, the different segments of the food supply chain were analysed to identify the originating drivers. The drivers identified in each segment were classified according to the three context categories, as shown by the matrix rows (i to vii) of Table 1.1. Seven analyses, one for each chain segment were produced, and this concluded the first stage of the study.

1.4.3 Analysis of the food supply chain by context category

In the second stage of the study the whole supply chain was analysed vertically through the perspective of the three context/driver categories, as indicated by the matrix columns (A, B, and C) of Table 1.1. This work was based on the analyses of the seven chain segments (§ 1.4.2).

For each context category the drivers related to current food waste causes, future threats of increase, and opportunities for reduction were made evident. The relative importance of the different food supply chain segments for the current food waste production, and for the future possibilities of both increase and reduction was also estimated through paired comparison tests based on the qualitative judgments of the FUSIONS' experts (see § 0).

As mentioned in § 1.2, two main fields of analysis had been identified within the Institutional context - (i) business management and economy and (ii) food legislation and policies – therefore it was decided to carry out separate investigations for this context.

In total four analyses were produced for the context (or driver) categories:

- | | | | |
|----------------|---|---|------------|
| 1) Technology; | 2) Institutional
(business and economy); | 3) Institutional
(policy and legislation); | 4) Social. |
|----------------|---|---|------------|

As regards the qualitative comparisons among the food chain segments (§ 0), for the Institutional (business and economy) context, the degree of subjectivity of the comparisons was considered too high, because of the very scarce availability of quantitative information (see § 2.2, 3.2, and 4.2). As a consequence for Institutional (business and economy) context the paired comparison test was not performed.

1.4.4 Final Report

A report was drafted and circulated among the FUSIONS' experts for a consultation and the final version of the study was developed on the basis of all the feedbacks received.

1.5 Qualitative evaluation of importance of the different food supply chain segment for the identified context categories

For each context category, the experts involved in the study were asked to express their qualitative judgements about the relative importance of the different food supply chain segments with respect to the current food waste production, and the future possibilities of increase and reduction. The judgements were based on the paired comparison between the seven segments of the food supply chain for a total of 21 paired comparisons (see Table 1.2).

In each comparison the respondent experts had to indicate, according to their experience and knowledge and with respect to the context category they were analysing, which of the two compared segments had to be considered the most important for the current food waste generation and the intensity of this importance (Table 1.2 and Table 1.3). The procedure of the 21 paired comparison between the food supply chain segments had to be repeated for the future threats of food waste increase and for the future opportunities of food waste reduction

Table 1.2 – Scheme for paired comparisons among the food supply chain segments

<i>n.</i>	<i>First term of comparison</i>	<i>Intensity of importance*</i>	<i>Second term of comparison</i>	<i>Intensity of importance*</i>
1	PRIMARY PRODUCTION		PROCESSING OF FARM STAPLES	
2	PRIMARY PRODUCTION		FOOD PROCESSING AND PACKAGING	
3	PRIMARY PRODUCTION		WHOLESALE AND LOGISTICS	
4	PRIMARY PRODUCTION		RETAIL AND MARKETS	
5	PRIMARY PRODUCTION		FOOD SERVICES	
6	PRIMARY PRODUCTION		HOUSEHOLDS	
7	PROCESSING OF FARM STAPLES		FOOD PROCESSING AND PACKAGING	
8	PROCESSING OF FARM STAPLES		WHOLESALE AND LOGISTICS	
9	PROCESSING OF FARM STAPLES		RETAIL AND MARKETS	
10	PROCESSING OF FARM STAPLES		FOOD SERVICES	
11	PROCESSING OF FARM STAPLES		HOUSEHOLDS	
12	FOOD PROCESSING AND PACKAGING		WHOLESALE AND LOGISTICS	
13	FOOD PROCESSING AND PACKAGING		RETAIL AND MARKETS	
14	FOOD PROCESSING AND PACKAGING		FOOD SERVICES	
15	FOOD PROCESSING AND PACKAGING		HOUSEHOLDS	
16	WHOLESALE AND LOGISTICS		RETAIL AND MARKETS	
17	WHOLESALE AND LOGISTICS		FOOD SERVICES	
18	WHOLESALE AND LOGISTICS		HOUSEHOLDS	
19	RETAIL AND MARKETS		FOOD SERVICES	
20	RETAIL AND MARKETS		HOUSEHOLDS	
21	FOOD SERVICES		HOUSEHOLDS	

* In each of the 21 paired comparisons, besides the term of comparison regarded as the more important, the respondent experts had to indicate the absolute value of intensity of importance (see Table 1.3) they considered the most appropriate.

Table 1.3 – Scale of absolute numbers indicating the intensity of importance (Saaty’s Scale)

<i>Values of intensity of importance</i>	<i>Definition</i>	<i>Explanation</i>
1	Equal importance	The two segments contribute equally
2	Slightly, weak	
3	Moderate importance	Experience and judgment slightly favor one segment over the other
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one segment over the other
6	Strong plus	
7	Very strong or demonstrated importance	A segment is favored very strongly over the other; its dominance is demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one segment over the other is of the highest possible order of affirmation

Table 1.2 and Table 1.3 served to orient the FUSIONS’ experts in their qualitative judgments. For the final evaluation of the comparison’ results, it was used a simplified method of Paired Comparison Technique², which takes into account only if one of the two terms of comparison is more important than the other or if they have equal importance. An example is shown in Table 1.4, which was elaborated on the basis of the results of the 21 paired comparisons related to current causes of food waste driven from the Social context (consumer behaviour and lifestyles).

Table 1.4 – Example of evaluation matrix: relative importance of the different food supply chain segments for current causes of food waste related to the Social drivers (consumer behaviour and lifestyles)

<i>Food supply chain segments</i>	<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>	<i>V</i>	<i>VI</i>	<i>VII</i>	<i>Fake seg.</i>	<i>Total score</i>	<i>%</i>
I) PRIMARY PRODUCTION		0.5	0.5	0.5	0	0	0	1	2.5	9
II) PROCESSING OF FARM STAPLES	0.5		0	0	0	0	0	1	1.5	5
III) FOOD PROCESSING AND PACKAGING	0.5	1		0	0	0	0	1	2.5	9
IV) WHOLESALE AND LOGISTICS	0.5	1	1		0	0	0	1	3.5	13
V) RETAIL AND MARKETS	1	1	1	1		1	0	1	6	21
VI) FOOD SERVICES	1	1	1	1	0		0	1	5	18
VII) HOUSEHOLDS	1	1	1	1	1	1		1	7	25
Fake segment	0	0	0	0	0	0	0		0	0
Grand total									28	100

Legend: the Roman numerals in the column headings refer to the food supply chain segments as indicated in the first column.

Scores: 0 = less important; 0.5 = equal importance; 1 = more important.

² Bazzani, G., Grillenzoni, M., Malagoli, C., Ragazzoni, A. (1993). *Valutazione delle risorse ambientali*. Bologna. Edagricole: pp. 85-88.

In Table 1.4, it can be observed that a “fake segment” losing the comparisons with all the “real” segments was introduced in order to avoid the occurrence that one of the food supply chain segments may result to have zero importance, if it is considered “less important” in all the comparisons with the other “real” segments.

With the utilized methodology and the scoring shown in Table 1.4, one segment may obtain a total score varying from 1 to 7 points, out of grand total of 28 points distributed in all the paired comparisons: i.e. from 3.6%, up to 25% of the grand total. On this basis, it was decided to establish the following qualitative evaluations to define the importance of the different food chain segments in the food waste issues considered here:

	<u>Low importance</u>	<u>Moderate importance</u>	<u>High importance</u>
possible scores:	1; 1.5; 2; 2.5;	3; 3.5; 4; 4.5; 5;	5.5; 6; 6.5; 7.

Referring to the example of Table 1.4, with the above assumptions, it results that, for current food waste generation related to the Social context (Consumer behaviour and lifestyles), comparatively the chain segments ‘Households’ and ‘Retail and markets’ have a relative high importance, the segments ‘Food services’ and ‘Wholesale and logistics’ have moderate importance, and the segments ‘Primary production’, ‘Processing of farm staples’, and ‘Food processing and packaging’ have low importance (Table 1.5).

Table 1.5 – Assignment of relative importance to food supply chain segments for current food waste generation related to the Social context (Consumer behavior and lifestyles) on the basis of the scores obtained in the paired comparisons

<i>Food supply chain segments</i>	<i>Total score</i>	<i>%</i>	<i>Relative importance for food waste generation</i>
I) PRIMARY PRODUCTION	2.5	9%	Low
II) PROCESSING OF FARM STAPLES	1.5	5%	Low
III) FOOD PROCESSING AND PACKAGING	2.5	9%	Low
IV) WHOLESALE AND LOGISTICS	3.5	13%	Moderate
V) RETAIL AND MARKETS	6	21%	High
VI) FOOD SERVICES	5	18%	Moderate
VII) HOUSEHOLDS	7	25%	High
Grand Total	28	100%	

2 Drivers of current food waste causes

2.1 Technological drivers of current food waste causes

2.1.1 Identification of drivers

The identified technological drivers of current food waste causes along the food supply chain are summarised in Table 2.1.

Primary production: Five technological drivers were identified for the 'Primary production' segment of the food supply chain. The drivers were all diverse in nature and related to the individual sub-sectors of primary production, e.g.: crop production, livestock, milk production, fishing, etc.

Three of the drivers ('livestock mortality', 'milk waste caused by drug contamination' and 'trawl fishing') were considered to have no further relationship with food waste taking place in other segments of the food supply chain since the waste would remain confined to the primary production sector.

'Microbiological quality / storage' and 'Harvest loss & damage' can lead to further losses in onward stages of the food supply chain since damaged produce will inevitably have a shorter shelf-life and this can lead to increased waste at any onward stage where it becomes unusable or requires additional trimming.

Processing of farm staples: Two technological drivers were identified relating to the causes of food waste in the 'Processing of farm staples' segment of the food chain: 'access to modern technology' and 'climatic conditions'.

The most-cited underlying causes related to these drivers are losses during storage and losses due to moisture & moulds. Both of these are reduced to minimal levels in the industrialised countries through access to good drying facilities and modern storage facilities.

Residual losses for the 'Processing of agricultural staples' sector after deducting by-products used within other industries e.g. animal feed are likely to be very low as a proportion of the volumes processed. The United Kingdom Food and Drink Mass Balance study (C-Tech Innovation, 2004) calculated that unused

wastes from the UK grain mill & starch products industry were 105,000 tonnes out of an input of 8.08 million tonnes of grain (1.3%) whilst unused wastes from the UK oils & fats industry were reported to be 6000 tonnes out of an input of 2.3 million tonnes of raw seeds (0.3%).

'Climatic conditions' are an ever-present driver leading to food waste and less controllable than 'access to modern technology'. Resultant losses can occur because of moisture & moulds or contamination from soil, for instance, on fallen crops (i.e. those that have undergone lodging).

Relations with food waste and losses occurring in other parts of the food chain were thought to be quite limited due to the low volumes of wastes produced in this segment in industrialised countries and the quality control measures in place to ensure production of a bulk, consistent commodity product. In addition, the products of this sector are sold in the greatest amounts to food manufacturers i.e. a 'business to business' transaction rather than a 'business-to-customer' transaction. Any product failing to meet quality control measures is likely to be rejected either by the processor of the farm staples or by the food manufacturer upon receipt thereby limiting the involvement of other actors further along the supply chain.

Food processing and packaging: Five technological drivers related to the causes of food waste were identified for the 'Food processing and packaging' segment of the food supply chain along with a total of seventeen underlying causes of food waste. It is possible that this may reflect the large number of reports in recent years surrounding the issue of food waste as well as the complexity of the modern food processing systems and supply chains. It should be noted however that causes of food waste are often cited with little or no quantitative evidence so it remains difficult to establish which of the causes are the most significant in terms of overall volumes of food waste.

Two of the technological drivers ('access of modern technology' and 'equipment reliability') are related to the type and age of the equipment being used along with the maintenance regime being employed.

Other drivers ('ease of equipment operation' and 'production planning') include a human factor related to how the equipment is actually being used and the training that the operatives have received.

It should be noted that waste created at this stage of the food supply chain, e.g. through over-production or production errors, also represents a waste of resources in all the previous segments of the chain.

Wholesale and logistics: The first selected driver is 'storage handling and conditions'. This is the major cause for the wholesale sector because the products spend a considerable time in storage in this segment. Lack of fungal spore control technologies within packing plants (including covered bins to reduce atmospheric spore counts) can potentially increase the rate of product deterioration. Failure to comply with minimum food safety standards can lead to food losses by store recalls. Storing and handling of food in an incorrect manner can lead to increased food loss. For example food not being stored at the right temperatures (such as when it sits too long on loading docks) or in the wrong light, or avocados stored next to tomatoes (discharging ethylene causing the avocado to ripen faster and shortening the shelf life).

The majority of the transportation in the supply chain is done in this segment which is why it is one of the drivers for food waste. During transportation products are vulnerable to mechanical and heat damage. Improper transport facility causes damage of foods and generates wastes. Increased use of reduced packaging during transit seems to lead to more food waste as the food is not properly protected. Extreme changes in temperature during shipment can spoil or shorten the shelf life of food products. Meat and fish products are particularly sensitive to temperature conditions during transportation.

Packaging is closely bound to storage and transportation loss. Sound packaging can help to reduce these losses by protecting the produce. Thus, e.g. packed meat or other fresh products within a damaged packaging are not protected against microbes etc. and spoilage. Damage to packaging may occur during the 'Food processing and packaging' stage but this also has an impact on the level of waste during

'Wholesale and logistics' and 'Retail and markets'. Sometimes it leads to wastage of food although the food was not harmed at all even though the product inside is fresh/correctly produced.

For fresh produce the cold chain is essential for the shelf life of the products. In wholesale and logistics, the cold chain has an important role because of the time that the products spend in storage in this segment. Possible solutions are training staff (it takes a long time to learn how to calculate the right amounts to order) and using computer systems. Better coordination between retailers, distributors, wholesalers and manufacturers can reduce food waste and avoid it being shifted across the supply chain. Poor communication with the market and retailers can lead to wrong deliveries and returns.

Retail and markets: In this segment the causes of waste are similar to 'wholesale and logistics'. 'Packaging' and 'handling and storage' are again the main causes of food waste and this indicates the similarity of the problems in the two segments.

'Forecasting customer demand' and 'order planning' are important steps in reducing food waste at the retail level. What the customers buy is dependent on the weather, the season, the offers of the week, and on the general mood of the customers. All this makes it difficult to order. For instance if consumers lack knowledge about when papaya is ripe, how to prepare it, and how to use it as an ingredient, papaya loss will be high.

Expiring "sell by" dates create food waste in the segment especially with the customer demand of full shelf and product variety. Large variety and full shelves mean that stores have to keep a lot of products in hand to meet these demands. This wastage can be reduced by improving communication from grocery companies to retail shops, better planning of inventory and staff can be taught to take the right decisions on time about expiring goods. Increasing turnover speed is another solution.

Unsound packaging can leave fresh produce vulnerable to microbes and lead to spoilage. Package damage may occur during food processing and packaging leading to increased food waste in the wholesale and retail segments of the food chain. Often the ordered products cannot be sold within the best before date as the wholesale packaging size is too large. Reducing wholesale package size has to be implemented in cooperation with wholesale/producers and retail.

'Minimum food safety failures' can cause major food loss if a whole shipment of goods has to be recalled. Some examples of unsafe food causes are naturally occurring toxins in food itself, contaminated water, unsafe use of pesticides, veterinary drug residues. Products which are recalled by producers are often wasted by the retailer. Thus, even if the cause can be categorized to the level of producer, the waste is generated at the retail stage.

Food Services: 'Inadequate storage' in the food service segment is a source of food loss. Mainly the lack of possibility to store leftovers for later use creates this food waste. Caterers also use hot chain instead of cold chain which reduces the possibility to store the food for later.

'Inadequate equipment' is a problem with catering because they have to get by with the equipment that is provided by the client. The cooling facilities are not always ideal for preventing food waste and, for example, salad containers can be too large. A chiller could cool hot meals down quickly, so that they do not have to be thrown away (it was observed that it is not necessary for all locations to have chillers.) - the storage temperature of products/product groups varies (e.g. dairy 4°C).

'Lack of good practice' includes poor ordering system and service losses. Poor ordering system or absence of it can mean the caterer has to produce food for an unknown number of people. Usually this means producing more food than needed to ensure that everybody gets fed. Over production, plate leftovers and kitchen waste are major sources of food waste in restaurants.

Households: A major part of food losses occurring in households seems to be from inadequate cool storage equipment or their misuse. There were four individual causes listed that related to cold storage at home. One related cause was the visibility of products at the back of fridge and the freezer.

Large packages are problematic for most small households. These are often sold at a cheaper unit price compared to smaller packet sizes. This can lead to situations where the contents spoil faster than it can be eaten increasing household food waste. Package shape can also be a source of food waste if the package is not easily emptied. This might leave residual product inside the package when thrown away.

Shelf life is an important factor in reducing food waste in households. The longer a product stays edible the higher the probability that it gets eaten, both before & after opening. The time that a product remains edible is often due to its packaging. Problems related to packaging functionality, e.g.: missing resealability and seal failure are all contributors to food spoilage at home. Also lack of on-pack guidance on storage & freezing may inhibit a household's ability to effectively preserve purchased food.

Table 2.1 – Identified technological drivers of current food waste causes and some related examples

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of current causes of food waste</i>	<i>References³</i>
Primary production	Microbiological quality / storage	<ul style="list-style-type: none"> • Mycotoxin / fungal contamination and bacterial spoilage. Decreasing quality • Losses of grain & potatoes during storage 	<ul style="list-style-type: none"> • 22, 296, 297, 324 • 314
	Harvest loss & damage	<ul style="list-style-type: none"> • Damaged fruits, vegetables, and grains • Losses of oilseeds during harvest / pod shatter 	<ul style="list-style-type: none"> • 285 • 298, 299
	Livestock mortality	<ul style="list-style-type: none"> • Piggery conditions • Poultry death during transportation. 	<ul style="list-style-type: none"> • 254 290 • 132
	Milk waste caused by drug contamination	<ul style="list-style-type: none"> • Mastitis 	<ul style="list-style-type: none"> • 259
	Non-selective fishing	<ul style="list-style-type: none"> • Trawl fishing and non-selective gears produces by-catch that can be considered as food waste 	<ul style="list-style-type: none"> • 55, 133, 256
Processing of farm staples	Access to modern technology	<ul style="list-style-type: none"> • Losses due to mechanical damage during harvest. • Losses during handling and logistics. • Losses during storage. • Wastes used as by-products. • Losses due to quality / safety. 	<ul style="list-style-type: none"> • 1, 82, 180 • 1, 82 • 1, 27, 82, 85, 159, 180, 296, 297 • 27, 76 • 1, 296, 297
	Climatic conditions	<ul style="list-style-type: none"> • Losses due to moisture, moulds, etc. • Increased contamination in harvested crops. 	<ul style="list-style-type: none"> • 1, 27, 82, 85, 159, 180, 296, 297 • 27, 76
Food processing and packaging	Access to modern technology	<ul style="list-style-type: none"> • Avoidable slaughtering & processing losses. • Cutting & trimming losses. • Losses due to production errors. • Losses during storage. • Losses caused by rudimentary control measures. • Moisture losses during processing, and peel loss. • Transport losses during processing resulting in bruising and damage. • Processing waste e.g. pastry trimmings • Overfilling losses. • Failure of heat seal on packaged foods 	<ul style="list-style-type: none"> • 104 • 1, 4, 70, 83 • 1, 56, 82, 109, 110, 293, 312 • 4, 85, 150, 164 • 164 • 4 • 4, 180 • 92, 312 • 4, 25, 249 • 104

³ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of current causes of food waste</i>	<i>References³</i>
	Equipment reliability	<ul style="list-style-type: none"> • Losses due to production errors. • Losses during storage. • Losses due to spillage and degradation. • Failure of heat seal on packaged food. • Over-production losses 	<ul style="list-style-type: none"> • 1, 56, 82, 109, 110, 293, 312 • 4, 85, 150, 164 • 1 • 104 • 21, 24, 56, 109, 248, 312
	Ease of equipment operation	<ul style="list-style-type: none"> • Losses due to production errors. • Losses during storage. • Losses due to spillage and degradation. • Failure of heat seal on packaged foods. 	<ul style="list-style-type: none"> • 1, 56, 82, 109, 110, 293, 312 • 4, 85, 150, 164 • 1 • 104
	Production planning	<ul style="list-style-type: none"> • Product changeover losses. • Processing waste e.g. pastry trimmings. • Residual product loss. • Losses due to insufficient remaining product shelf-life. • Over-production losses. 	<ul style="list-style-type: none"> • Expert contributions • 92, 312 • 139, 248 • 89, 94 • 21, 24, 56, 109, 248, 312
	Improved traceability	<ul style="list-style-type: none"> • Labelling errors 	<ul style="list-style-type: none"> • 24
Wholesale and logistics	Storage handling and conditions	<ul style="list-style-type: none"> • Lack of fungal spore control in packaging and storage can increase product deterioration rate. • Storage environment and handling (wrong storage temperature; wrong air conditions e.g. ethylene). 	<ul style="list-style-type: none"> • 69 • 69,286
	Damage during transport	<ul style="list-style-type: none"> • Improper transportation of products. Increased use of reduced packaging for transport may lead to more food waste as the food is not properly protected. Lack of proper packaging. • Extreme temperature changes during transport. 	<ul style="list-style-type: none"> • 21, 24, 295 • 24, 32, 87, 92
	Packaging	<ul style="list-style-type: none"> • Food waste occurs due to unsound packaging and broken and damaged food items. • The food cannot be sold if the packaging is mismarked / mislabelled. 	<ul style="list-style-type: none"> • 2, 21,87, 92, 167 • 238
	Cold chain inefficiencies	<ul style="list-style-type: none"> • Cold chain abuse, caused by equipment failure. 	<ul style="list-style-type: none"> • Expert contributions
	Bad management and forecasting	<ul style="list-style-type: none"> • Miscalculation of market request; Improving forecasting and working in partnership with suppliers could result in reductions in costs and waste generated throughout the supply chain. • Waste occurring because of logistical management mistakes and/or lack of proper logistic management processes and systems. 	<ul style="list-style-type: none"> • 272 • 58

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of current causes of food waste</i>	<i>References³</i>
Retail and markets	Poor handling and storage	<ul style="list-style-type: none"> Product damage due to poor handling, particularly in store sometimes by customers. Failure in refrigeration equipment leads to wastage of chilled and frozen foods. 	<ul style="list-style-type: none"> 2, 6, 87, 95 6, 24, 104
	Forecast/Ordering system	<ul style="list-style-type: none"> Challenges related to ordering. Difficulties to order the right amounts of food at the right time, especially fresh food and perishables. Products past its 'sell by date' or post holiday discard of seasonal items (e.g. at Christmas or Halloween). Managing the inventory of food products in relation to expiring dates is thus the main reason for generation of food waste in the retail chain 	<ul style="list-style-type: none"> 21, 92, 148, 251 21, 66
	Packaging	<ul style="list-style-type: none"> Food waste occurs due to unsound packaging and broken food item Type of packaging used is decided at retail and/or production but sometimes results in waste at consumer level. What is good for retail must not be good for other stakeholders 	<ul style="list-style-type: none"> 104, 167 174, 182, 217, 237
	Minimum food safety failures	<ul style="list-style-type: none"> Product recalls; Failure to comply with minimum food safety standards can lead to food losses 	<ul style="list-style-type: none"> 24
	Customer knowledge	<ul style="list-style-type: none"> A general lack of consumer knowledge of a product (for instance, papaya, fresh mustard greens) may contribute to a high level of food waste. Demand for fresh products at all times 	<ul style="list-style-type: none"> 5 5
Food Services	Storage	<ul style="list-style-type: none"> Lack of possibilities to store food left from cooking and serving: <ul style="list-style-type: none"> Chilling fridges Storage space Waste occurring because most caterers are using the "hot-chain" instead of the "cold-chain" in the catering process 	<ul style="list-style-type: none"> 52, 53, 173, 308
	Equipment and containers	<ul style="list-style-type: none"> Proper size of the plates, trays and containers. Inadequate equipment: the caterer's customer manages the materials, equipment, location, etc. 	<ul style="list-style-type: none"> 267, 268, 269 50, 66
	Lack of good practice	<ul style="list-style-type: none"> Absence of ordering systems for school meals leading to kitchens catering for unknown total numbers of pupils. Overproduction serving losses, e.g. kitchen waste, plate leftovers. 	<ul style="list-style-type: none"> 267, 268, 269

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of current causes of food waste</i>	<i>References³</i>
Households	No access to suitable storage systems	<ul style="list-style-type: none"> • Suitable storage containers / systems (e.g. bag clips, potato bag, bread bin etc.). • Working fridge / fridge temperature indicator / alert, door open alert. • Food not visible at the back of the fridge/freezer. • Cool pantry. • Working freezer, good capacity, and door open alert. • Planning & ordering tools & alerts, recipe / shopping list builder tools, fridge inventory tool e.g. Smartphone, internet 	<ul style="list-style-type: none"> • 29, 30 • 66, 67, 116, 232 • 83 • 293 • 229 • 116
	Insufficient packaging	<ul style="list-style-type: none"> • Some packs are not provided in range of sizes (due to pack to product cost ratio / store format requirements / open life means it's less an issue etc.) or with appropriate functionality. • Inability to empty the pack completely, residues left in pack. • Food not always packaged to maximize its shelf life. • Packaging seals may not be effective, product spoils / leaks. • Resealable packaging not always available e.g. for drinks cans. • Some products not given clear / consistent date marks, storage & freezing guidance on-pack 	<ul style="list-style-type: none"> • 35, 169, 171, 234, 236, 237, 274 • 139, 174, 293 • 92 • 167 • 108 • 35, 238
	Insufficient product life	<ul style="list-style-type: none"> • Too short shelf-life (total & once open) / variable product life available. 	<ul style="list-style-type: none"> • 35, 314

2.1.2 Importance of the different food supply chain segments for current food waste generation

The importance of the different food supply chain segments for current food waste production were compared and assigned an absolute number indicating the intensity of importance. Whilst this is subject to a degree of subjectivity, input was sought from two members of the project team at IFR and independently from two members of the project team at MTT. The results of the two initial evaluations were then compared and averaged if similar. Where the initial evaluations were different, the results were discussed and modified as appropriate if agreed.

In general, 'Primary production', 'Food processing & packaging' and 'Households' were considered to be the most important segments when considering their contribution to food waste within the technological context. As such, these segments were favoured in the paired comparisons. The absolute importance of losses from primary production may be obscured to some extent by boundary issues and definitional issues of exactly when lost production is considered and recorded as waste. Evaluation of the importance of the 'Food service' segment was considered not to be reliable because there were so few causes and drivers listed that it was hard to compare with the other segments of the food chain.

The results of the paired comparison are summarised in Table 2.2.

Table 2.2 – Relative importance of the different food supply chain segments for current food waste generation (technological drivers)

<i>Relative importance for food waste generation</i>	<i>Food supply chain segments</i>
High	Primary production Food processing and packaging Households
Moderate	Retail and markets
Low	Wholesale and logistics Food services Processing of farm staples

* Evaluation of the importance of the 'Food service' segment was considered not to be reliable (see explanation in the above text).

2.2 Institutional drivers (business management and economy) of current food waste causes

2.2.1 Identification of drivers

The identified institutional drivers (in the field of business and economy)⁴ of current food waste causes along the food supply chain are summarised in Table 2.3.

Primary production: The primary institutional driver for the majority of food loss is the consumers' desire for a specific appearance of food products. Retailers – as well as government regulations to some degree – respond to this by establishing a grading system: products are discarded despite being completely safe to eat because they don't look right or are the wrong size. Additional losses due to consumer expectations are driven by changing dietary preferences of the consumers, e.g. preferring high quality meats or cheese over milk.

Government subsidies in some cases drive overproduction of certain crops, exceeding the market demand and thus bringing the price below the feasibility threshold for harvest. It will then be for the farmer to plough crops into the ground rather than bringing them to market.

Developing countries face additional institutional effects due to a lack of infrastructure and facilities, enhanced by climate-induced problems of perishability since vegetables, roots, and tubers require proper storage to pass grading. Poverty can also drive farmers to prematurely harvest their crops in order to quickly acquire revenue or to bridge a food shortage, leading to loss due to the vulnerable condition of the harvested crops.

Processing of farm staples: The primary causes of food loss in this context are an unwillingness or inability to replace existing practices with modern ones, including in particular technological innovations, on the one hand and on the other, a failure to implement best practice measures. The former is driven principally by two factors: one is a direct lack of finances or, related to this, the concern that any investments in new practices rather than maintaining the tried and proven approaches will actually decrease the quality. In the latter, this is primarily represented by the food safety standards that governments institute.

Similar concerns about profitability may lead to best practices not being implemented. Poor communication across the levels of a company, despite managerial willingness, can also result in best practices not being put in place, leading to losses through inefficiency or inappropriateness.

Conversely, though, the question of profitability can encourage a company to institute better waste reduction methods, for example through increased taxation on waste disposal or landfill use.

A positive example of responding to these drivers is given by the UK flour milling industry which has consolidated to a significant degree and invested in modern technology allowing it to continue its production with almost no waste.

Food processing and packaging: Six institutional drivers were identified. Three of those are common to most areas of business activities – knowledge and communication, government legislative and taxation policy as well as profitability – which in food production are related to e.g. inefficient or incorrect processing, storage, or overproduction; losses through grading or a resistance to change practices;

⁴ The author of the report on the Institutional Context (Business and Economy) underlines a definition of drivers and causes: drivers are perceived as "the forces at the root of any situation. They trigger reactions and results which we see as the causes of waste. As such, they are the start of a chain of effects, creating the impetus for a cascade of reactions".

decision to discard hard to sell by-products. The customer demand is a market-related driver that affects nearly all factors related to food products. Similar to the latter, the over-specification of ingredient quality is based both on consumer interests and government regulations; the desire to preempt consumer concerns may lead to products being wasted despite still being good to use or to excessive waste during processing. General food processing issues drive waste through prohibitive contracting or inefficient changes of production procedures.

Wholesale and logistics: Mishandling goods is a significant cause of food loss, driven by such issues as insufficient training of staff as well as a lack of appropriate supervision or communication of better practices. As such it can lead for example to damage through pressure effects, e.g. improper stacking of produce, temperature damage, or blemished packaging. The combined effect of a number of driving influences are likely to render an improvement of this cause difficult.

Drivers related to management questions are inefficiencies in the supply/cold chain or the forecast for stocks and orders needed in the future.

Deterioration of food is the constant opponent for food production and retail; accordingly, it drives the processes and technology for as well as the demands on the products to a significant degree. The remaining shelf life is an important factor in the sales process, for example, and even made worse by retailer methodology.

Finally, the market demands drive issues such as recalls, low sales turnovers, or rejections and returns; it is, once again, the consumer and his desire for his food to have certain appearance characteristics at the heart of many decisions at any level.

Retail and markets: At the retail level as well, the deterioration of food and the related factor of food safety are primary drivers for the causes of food loss or waste, influencing e.g. poor handling that can speed up the process, the premature discarding of organic produce, among others. Related to food safety, delivery rejections or returns are important aspects that retailers wish to avoid due on the one hand to the losses accrued but also to avoid such public relations disasters. Fittingly, the customer expectations, demands, and respective marketing strategies are also powerful drivers at this level, affecting similar demands on product appearances as before but now adding demands on the surrounding presentation of the product itself, the availability (i.e. opening hours) – both of which influence (usually negatively) a product's shelf life.

Another driver are failures in forecasting market developments and placing orders accordingly; for instance, misjudged price developments or demand can lead to the amount of produce exceeding demand and thus leading to waste. Issues of power and trust, transparency communication, and information sharing form the final institutional driver in this area, retailers effecting their power on the suppliers, e.g. through the threat or actual de-listing, while a lack of mutual understanding and appropriate communication may lead to waste.

Food Services: At the food service level - including mainly the restaurants, catering, canteens (in schools, hospitals, etc.) and commercial kitchens - the primary driver of food waste is the difficulty of estimating and calculating the correct amount of food to cook, due to the complexity of predicting consumer expectations as well as forecasting demand. Next to that primary driver, other factors can also account for food being served but not eaten: among these, there are too extensive menus and assortments of buffet food as well as non-adapted portioning or timing (i.e. too short time for lunch at schools). Food deterioration is also regarded as a main driver behind food waste at the food service level as the knowledge about expiration dates – especially for food exposed to the open air – is limited.

Households: Strong drivers in this area are the interactive components of consumer behaviour/attitude as well as retailer marketing/presentation, collectively creating the image of food as just another type of product that can be bought and discarded at a whim, be it through price or lacking information on the customer's part of such issues as perishability or the nutritional values of the various types of food on offer. There does not appear to be any incentive for the retailer to change this attitude as it is in his interests to sell as many of his products as possible, regardless of the potential waste on the consumer side.

Also important to mention is the question of collection of waste in the household. Driven by the available infrastructure for collection as well as its management, the choice of how to dispose of food in the home can have environmental benefits, for example, avoiding landfill by using council food-waste collections where available or home composting food waste. However, the largest environmental benefit comes from preventing food from being wasted in the first place – this has the potential to reduce the energy, water and other resources used to grow, harvest, transport, process and sell the food, as well as emissions associated with storage and cooking in the home.

Table 2.3 – Identified institutional drivers (business and economy) of current food waste causes and some related examples

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
Primary production	Consumer demand	<ul style="list-style-type: none"> Grading: <ul style="list-style-type: none"> Strict cosmetic and other quality standards of the retail industry for fruit and vegetables cause farmers to waste a large percentage of their crops. Food culture and consumption patterns: <ul style="list-style-type: none"> Losses from animal production, organs and blood that is not used for food Especially diets with low carbohydrate contents can increase usage of meat 	<ul style="list-style-type: none"> 1, 150, 281, 312, 315 Expert contributions
	Government subsidies	<ul style="list-style-type: none"> Overproduction: The production exceeds the demand. Government programs that encourage farmers to overproduce certain foods, failure to harvest at all owing to low market prices or poor yields 	<ul style="list-style-type: none"> 20, 78
	Market conditions/market price	<ul style="list-style-type: none"> Product price doesn't cover the cost of harvest and transport to markets <ul style="list-style-type: none"> A product's price may not warrant the labour and transport costs required to bring the crop to market Due to marked demands on certain sizes etc, farmers choose to plough the entire production (if the majority of the production is imperfect), because it is too expensive to harvest the crop 	<ul style="list-style-type: none"> 2
	Poverty/starvation	<ul style="list-style-type: none"> Premature Harvesting: Poor farmers sometimes harvest crops too early due to food deficiency or the desperate need for cash 	<ul style="list-style-type: none"> 1
	Lack of infrastructure and facilities	<ul style="list-style-type: none"> Perishability of the fresh roots and tubers, which make these products easily damaged during harvest and postharvest activities Occurs especially in the warm and humid climates of many developing countries. Lack of basic harvesting, transport and storage infrastructure causes post harvest losses in developing countries 	<ul style="list-style-type: none"> 1, 316
	Supply and demand forecasting	<ul style="list-style-type: none"> Inaccurate forecasting / crop planning, mainly due to poor communication and difficulties in predicting demand accurately due to factors such as weather changes 	<ul style="list-style-type: none"> 30, 95, 150
Processing of farm staples	Access to finance	<ul style="list-style-type: none"> Lock-in to existing practices 	<ul style="list-style-type: none"> 1
	Government regulations	<ul style="list-style-type: none"> Risk of not complying with food safety standards 	<ul style="list-style-type: none"> Expert contributions
	Profitability	<ul style="list-style-type: none"> Failure to implement best practice cause of they are not profitable 	<ul style="list-style-type: none"> Expert contributions
	Communication	<ul style="list-style-type: none"> Food losses through the production errors leading to unsafe food: Failure to implement best practice 	<ul style="list-style-type: none"> 1, 296, 297

⁵ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
Food processing and packaging	Knowledge & communication	<ul style="list-style-type: none"> • Cutting & trimming losses; Losses due to production errors; Losses during storage; Moisture losses due to over-cooking; Product changeover waste; Food safety scares leading to product recall; Over-production losses; Lock-in to existing practices • Production losses caused by inappropriately prepared ingredients, incorrectly run processes, the production of off-specification products, damages in packaging with or without affecting the safety, taste or nutritional value of the food, incorrect labelling or packaging and inefficient cleaning of equipment which leads to product contamination 	<ul style="list-style-type: none"> • 1, 4, 70, 83 • Expert contributions
	EU & national government legislative and taxation policy	<ul style="list-style-type: none"> • Grading & sorting losses; Overfilling losses; Waste due to labelling errors. 	<ul style="list-style-type: none"> • 1, 4, 30, 82, 164, 291
	Profitability	<ul style="list-style-type: none"> • Discarding of low value components (meat processing) 	<ul style="list-style-type: none"> • Expert contributions
	Marketing strategies and customer demand	<p>Cutting & trimming losses; Grading & sorting losses; Processing waste; Over-production losses; Bread returns from retail and markets; Non-utilization or underutilization of meat by-products; Wastes due to production of seasonal items; Losses due to insufficient remaining product shelf-life.</p> <ul style="list-style-type: none"> • Inaccurate forecasting may lead to waste, mainly due to difficulties in predicting demand accurately due to factors such as weather changes, promotions and production of seasonal items. Wastage may be due to inefficient information sharing between manufacturer and retailer. • Traditions, culture and religion are often important when a meat by-product is being utilized for food. Regulatory requirements are also important because many countries restrict the use of meat by-products for reasons of food safety and quality. It happens that animal organs such as hearts, livers, lungs, intestines, testicles, brains, tongues etc. may be discarded in abattoirs despite having good nutritive value. Due to the current EU wide ban on feeding animal by-products to pigs and chickens this waste cannot be fed to livestock. 	<ul style="list-style-type: none"> • 21, 24, 56, 109, 248, 291, 312, 328, 329, and expert contributions • 24, 251, and expert contributions • 94, 282, 312

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
	Customer expectations and demand	<ul style="list-style-type: none"> • Over-specification of ingredient quality: <ul style="list-style-type: none"> ◦ Peel loss (over-peeling). ◦ Grading, sorting & packing losses. • Over-specification of ingredient quality: <ul style="list-style-type: none"> ◦ Overfilling of bottles / packets to ensure product meets declared nominal volume • Product variety: <ul style="list-style-type: none"> ◦ Product losses when changing between recipes ("border" products get mixed with other flavours and become waste). ◦ Other product losses due to non-optimized use of processing line 	<ul style="list-style-type: none"> • 27 • Expert contributions • 56
	Contracts/agreements	<ul style="list-style-type: none"> • Contracts in the chain: wastes and by-product wastage caused by own-label manufacturers not being able to redirect overproduction to different customers in keeping with their contractual agreements with the retailers • The sell-by date, the allocated time supplied to the manufacturer, has been exceeded. Retailers will refuse to take product with insufficient shelf-life remaining. This is in part because customers prefer fresh product over those with only a short shelf-life remaining. 	<ul style="list-style-type: none"> • 16, 24, 94 • Expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
Wholesale and logistics	Staff training, and communication	<ul style="list-style-type: none"> • Wrong handling and storage: Mishandling of food – for example food not being stored at the right temperatures or in the wrong light. Stacking of fruits and vegetables may result in fruit in the middle or bottom of the pile being damaged and needing disposal. Potential rotten fruit in the deck infect the surrounding fruit. This is a common reason for food waste in the wholesale sector. Mishandling can both lead to physical damage and bacterial damage on the products • Wrong handling and storage / Disregarding first-in first-out principle: If the storing system is insufficient and the staff is not properly instructed, newly delivered products may be put onto the shelf instead of those from storage. This leads to older products being rejected by the retailer. • Wrong handling and storage / Packaging damage of package, blemish of packaging: <ul style="list-style-type: none"> ◦ Food waste occurring because of damaged packaging, e.g. broken glass of oils. Sometimes it leads to wastage of food although the food was not harmed at all. ◦ The food cannot be sold if the packaging is mismarked/ mislabelled, even though the pro-duct inside is fresh/correctly produced. • Low cost for discarding food: Lack of incentive for higher accuracy in stock management due to low cost of discarding food. • Wrong handling and storage / Mechanical damage during transport: Improper transport facility causes damage of foods and wastes. Increased use of material-efficient packaging for transport may lead to more food waste as the food is not properly protected. 	<ul style="list-style-type: none"> • 1, 2, 6, 21, 87, 330, 331 • 251 • 6, 21 • 87 • 6, 21, 298
	Supply chain/cold chain inefficiencies	<ul style="list-style-type: none"> • Waste occurring because of logistical management mistakes and/or lack of proper logistic management processes and systems. Insufficient communication with the market and retailers leads to wrong deliveries and returns. Management root-causes (practices): waste management responsibilities, information sharing, promotions management, forecasting, performance measurement, packaging, cold chain management, quality management and training. • Damage during transport due to temperature. Extreme changes in temperature during shipment can spoil or shorten the shelf life of food products. Meat and fish products are particularly sensitive to temperature conditions during transportation. Also other refrigeration problems during transport may occur, e.g. for chilled food. 	<ul style="list-style-type: none"> • 6, 21 87, 92, and expert contributions • 2, 6, 21, 87, 92, and expert contributions
	Forecasting of stocking /ordering	<ul style="list-style-type: none"> • Miscalculation of market request; improving forecasting and working in partnership with suppliers could result in reductions in costs and waste generated throughout the supply chain. Seasonal variations are not sufficiently focused on but primarily, it has to be said, knowledge of the customer is crucial. • Retailers' service level requirements. Wholesale overstock to prevent penalties as the time to react on orders from retail is not enough for later orders at production. 	<ul style="list-style-type: none"> • 21, 73, 94, 251, 293 • 24

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
	Deterioration of food	<ul style="list-style-type: none"> • For fish in developing countries, high losses at the distribution level can be explained by high levels of deterioration occurring during fresh fish and seafood distribution. For milk for all developing regions, waste of milk during postharvest handling and storage, as well as at the distribution level, is relatively high. For fruit and vegetables losses during postharvest and distribution stages are also severe, which can be explained by deterioration of perishable crops in the warm and humid climate of many developing countries as well as by seasonality that leads to un-saleable gluts. • Natural surplus of products during season: Mainly fruit and vegetables which mature very quickly during good weather conditions have to be sold very quickly after harvest during season to avoid spoilage. • Requirement of 75% remaining shelf life: When retail takes over products from wholesale or producers in most cases the remaining shelf life has to be 60-75 %. The wholesalers have taken initiatives to keep these products past the "internal best before date" from being wasted • Wholesale packaging size: Often the ordered products cannot be sold by the best before date as the wholesale packaging size which is offered by the producer is too large. Has to be implemented in cooperation with wholesale/ producers and retail. 	<ul style="list-style-type: none"> • 1 • 95 • 6 • 21, 251

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
	Market demand	<ul style="list-style-type: none"> • Requirements to off-grade products: Some processors may not be bound by contractual obligations with suppliers and may therefore be willing to accept off-grade products, but frequently, such processors are not close enough to be financially feasible for small and medium size farmers. • Recalls due to consumers' complaints: The producer has supplied something to the market that is not right, and the consumer detects a discrepancy in taste, and if the complaints system has logged multiple complaints for this product, it will be recalled. • Low turnover: Sometimes e.g. organic produce have a lower turnover and therefore a higher share of wastage in comparison to conventional products. Also other products with a low turnover often have a high percentage of wastage. As long as retail wants to have the product at shelf, wholesale also has to provide it or will lose retail as customer. • Rejections/returns from market (retail): The right to return unsold/ damaged products without cost for the retailer or last minute cancelation of orders generates wastes in the wholesale sector. • Specific marketing standards: 11 specific marketing standards are still in use in the EU for apples, pears, strawberries, sweet pepper, kiwi fruit, tomato, peaches and nectarines, lettuce, grapes as well as citrus fruits. This leads to sorting out products at the level of primary production resp. processing of agricultural staples but the prevention measure has to be implemented at the level of retail and markets. The level of wholesale is only effected indirectly. Also the retail has own standards and there are also regional standards for specific products such as potatoes. 	<ul style="list-style-type: none"> • Expert contributions • 94 • 251 • 2, 21, 87, 92, 332 • 95, and expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
Retail and markets	Deterioration of food, food safety	<ul style="list-style-type: none"> • Poor handling: Product damage due to poor handling, particularly in store, sometimes by customers (e.g. bruised fruits, broken jars). To expose the merchandise the most attractive way, it is placed without proper temperature, light and association. Improper stock rotation. Presence of ethylene and microbial increase the rate of product deterioration, e.g. good air circulation system; fungal spore control technologies within pack-houses, potentially including the use of covered bins to reduce atmospheric spore counts. Poorly stacked fruits may spread rot. Newly delivered products may be shelved instead of products from storage, allowing the latter to perish • Premature discarding of organic produce: There is no clear reason for this, one might be that ecologic fruit and vegetables have a shorter lifetime but are treated as if they have the same lifetime as ordinary products and are therefore ordered in the same way. • Although in most countries it is legal to sell products past their best before date, it is not clear how to handle such products. Legal authorities (e.g. in Austria) do not give official advice on this topic. In fact, most food banks do not offer such products as it is too dangerous to them if something happens. • Confusing dates on packaging: Dates are set by producers but can be influenced by large retailers with respect to their own brands. Sell by, use by, and best before dates can cause confusion for the consumer and lead to wastage at the household level. Prevention measures could be set at retail level. • Untrained staff: Retail has a high share of part-time employees, frequently shelf support (filling the shelves with new products) has been outsourced. In addition, retail does not want to invest a lot of money in education of staff as there is a high rate of employee turnover. Thus, skilled staff may be lacking, leading to the wrong handling of food products and wastage. • Packaging size: Products are sold in preset quantities according to case size. This limits buyer flexibility and may lead to buying excess amounts of produce which leads to wasted food items. Often the ordered products cannot be sold by the best before date as the wholesale packaging size is too large. Has to be implemented in cooperation with wholesale/ producers and retail. • Cold chain: Limits of the technology used to preserve products, particularly fresh products as well as lack of knowledge and care during transport. 	<ul style="list-style-type: none"> • 1, 6, 21, 69, 85 • 21 • Expert contributions • 223 • 6 • 83, 251 • 6, 32, 92

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
	Forecast/ordering system	<ul style="list-style-type: none"> Challenges related to ordering. Predicting customer behaviour is difficult as it is affected by many factors, such as the weather, the season, the offers of the week, and on the general mood of the customers. In regions with a high share of tourists in specific times of the year, critical times are the weeks after high season when the share of tourists decreases quickly. Also seasonal products such as Easter and Christmas are difficult to forecast. Surplus of products during season: Mainly fruit and vegetables which mature very quickly during good weather conditions have to be sold very quickly after harvest during season to avoid spoilage. Low cost for discarding food: Lack of incentive for higher accuracy in stock management due to low cost of discarding food. Inaccurate forecast promotions: Irregular demand caused by promotions, such as lowered price and campaigns for certain products will make similar products less attractive (or, if the campaign fails, there will be too much of that product), thus the campaigns will lead to more food loss. Promotions create more unpredictable demand patterns, both for the specific products on promotion and for substitute products that may have their sales impacted, a process known as cannibalisation. Despite retailer actions to reduce this, it is recognized that it is hard to achieve. 	<ul style="list-style-type: none"> 1, 6, 18, 21, 85, 92, 148, 251, 312 Expert contributions 87 6, 95, 302, and expert contributions
	Rejection of delivery/returns	<ul style="list-style-type: none"> Poor quality delivery from the wholesale to the store: The routine of producers taking back unsold products without charging for them (depending on contract) will not encourage the staff to order the right amount of the product. Furthermore, the cost for the waste may be passed to the supplier. Thus, retail has no incentive to reduce the return flow. But prevention measures have to be implemented at both levels. Product recalls/unfit for human consumption: Product recalls; failure to comply with minimum food safety standards can lead to food losses. Some examples of unsafe food causes are naturally occurring toxins in food itself, contaminated water, unsafe use of pesticides, veterinary drug residues. Products which are recalled by producers are often wasted by the retailer. Thus, even if the cause can be categorised to the level of producer, the waste is generated at retail. 	<ul style="list-style-type: none"> 1, 18, 21, 87, 92, 148, 251 6

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
	Customer expectations, demand and marketing strategies	<ul style="list-style-type: none"> • Some produce is rejected at the farm gate due to rigorous quality standards concerning mass, size, shape and appearance of crops. Therefore, large portions of crops never leave the farms. Farmer-buyer sales agreements may contribute to quantities of farm crops being wasted. This leads to sorting out of products at the level of primary production resp. processing of agricultural staples but the prevention measure has to be implemented at the level of retail and markets. • Low turnover: Higher rate of organic product waste compared to conventional due to lower turnover rate This rate can be increased by increasing the range of products offered. Season influences sales volume of specific products. This could lead to higher percentage of wastage of those products which are offered despite negligible demand. • Most retail stores operate under the assumption that customers buy more from brimming, fully stocked displays, preferring to choose their apples from a towering pile rather than a scantily filled bin. This leads to overstocking and over-handling by both staff and customers and damage to items on the bottom from the accumulated weight. Customers expect full shelves throughout the opening periods of shops, thus shops order or produce more than will be sold. The in-store bakery makes more bread than they expect to sell in order to satisfy the consumers. • Cosmetic perfection including freshness: Cosmetic perfection. Many customers select stores based on the quality of fruit and vegetable, and therefore retailers feel compelled to have products of perfect shape, size, and colour, leading too much of food waste. Even without a formal "best before date", the look of the product is decisive. This also includes the beliefs that it will not be possible to sell "wonky" fruits and vegetables. Packed e.g. fruit and vegetables can not be sold if one piece is spoiled 	<ul style="list-style-type: none"> • 1, 312 • 148, 251, 333 • 334 • 2, 5, 21, 291

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
		<ul style="list-style-type: none"> Opening hours: The opening hours of retail outlets have expanded more and more on recent decades. In combination with the increasing number of outlets, experts worry about increasing food waste amounts as freshness has to be ensured on a continual basis during a store's opening hour. Expiration date: Customers choose products with the longest shelf life. Sometimes food is discarded even before the expiration of the "Best before end" date, because consumers will not buy the goods when they come too close to the expiration date. Disposal of products before the expiration date is a relevant issue. Buy one, get one free (BOGOF): Retail stores offer large packages and "getting one for free" bargains. Special offers lead to the consumer buying too much and wasting food. The food waste is generated at the household level but the prevention measure has to be implemented at the retail level. Relaunch packaging: Promotional products becoming waste after the promotion's end because of special packaging. Some products have to be wasted as their packaging was redesigned, and retail does not want to have "old fashioned" products. 	<ul style="list-style-type: none"> 148 291 315 6, and expert contributions
	Power and trust, transparency, communication, and information sharing	<ul style="list-style-type: none"> Coordination producer-retailer: Production companies sell as much as possible to retailers without taking into account if the products really can be sold within the shelf life of their product. Better coordination between retailers, distributors, wholesalers and manufacturers can reduce food waste and avoid it being shifted across the supply chain. Market power of retail: A small number of large retailers in the UK exercise market power over the 7000 suppliers within the sector. To avoid being 'de-listed', food manufacturers will often over-produce in case extra quantities are required at short notice. De-listing: Waste occurring because of de-listing products from the retail portfolio (products are taken off the shelves) Measuring waste: Key performance indicators (for example, tonnes of waste per tonne of product) allow baseline data to be developed against which progress in reducing waste can be tracked. Lack of transparency and non-mandatory reporting of food waste encourages wasteful practices in the retail industry. Lack of trust/knowledge in redistribution: Destroying consumable products rather than donating them because of lack of trust in charity organisations; destroying products because of lack of information on how/where to donate, reluctance to donate food because of fears of litigation should a charity beneficiary fall ill. 	<ul style="list-style-type: none"> 87, 92, 164, and expert contributions 18, 82 Expert contributions 70, 312 312, and expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
Food Services	Difficulty to estimate and calculate the right amount of food to cook	<ul style="list-style-type: none"> Overproduction; overly extensive menus in canteens 	<ul style="list-style-type: none"> 8, 169
	Inflexibility in portioning	<ul style="list-style-type: none"> Too much on plate and assortment which is not adapted to consumer/patient 	<ul style="list-style-type: none"> 150
	Situational reasons "food being served but not eaten"	<ul style="list-style-type: none"> Portions are too large or with undesired accompaniments. Time for lunch is short at schools: Food is left uneaten on the plate and thrown away because of stress and perceived lack of time to sit down and eat in the school canteen. Assortment does not match children's requests (e.g. more un-healthy food); the single largest source of loss is the food left over on the plates (plate scrap), constituting about 10% in all kitchens (in one study). Plate scrap in restaurants is mostly vegetables; since customers have already paid, restaurants are not interested in reducing waste here. In school canteens, pasta, potatoes, and rice make up most of the plate scrap for various reasons, such as food appearance or a desire to get out and play. 	<ul style="list-style-type: none"> 52 52
	Operational reasons "food being prepared, but not served"	<ul style="list-style-type: none"> There are rules that leftovers cannot be used for new meals. Production errors, packaging errors, or the like prohibit the meal being served. The packaging size is larger than the required quantity. Better matching portion sizes would help reduce the waste. 	<ul style="list-style-type: none"> 94
	Consumer expectations prediction and demand forecasting	<ul style="list-style-type: none"> Assortment too wide: Extended menus complicate inventory management and require more ingredients to be kept on hand. Menus are planned centrally and cannot be adapted to regional preferences; similar inflexibility concerns the composition of plates or size of portions. Menu options and alternatives are not sufficiently communicated. Incorrectly forecast orders result in products passing their expiration date. (Weather, seasonality, and the periods before and after holidays also have an impact). Better training and computer systems can minimize this. Difficulty to estimate and calculate the right amount of food to cook: varying estimates of customers, needed preparation times, unpredictable factors such as weather, etc. 	<ul style="list-style-type: none"> 21, 50, 53, 87, 94, 335 52, 338 94 20, 21, 52, 206, 336
	Food deterioration	<ul style="list-style-type: none"> Knowledge about expiration dates is limited, including what to do after opening a product. Providing information on the label can offer a solution for users. 	<ul style="list-style-type: none"> 94
Households	Price of food	<ul style="list-style-type: none"> 'Cheap' food may erode its perceived value. Food industry may prioritize volume sales over value. 	<ul style="list-style-type: none"> Expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁵</i>
	Application of date marks	<ul style="list-style-type: none"> Incorrect date used, conservative date used (associated with brand integrity buffer). NB links to consumer knowledge/skills (social). 	<ul style="list-style-type: none"> Expert contributions
	Collection infrastructure	<ul style="list-style-type: none"> How consumers view their food waste & extent to which it is 'seen' can depend on access to separate collection infrastructure (e.g. separate local authority collection, its frequency & system, access to home composting, presence of pets). The interplay between these is complex and on the one hand may raise awareness of how much is wasted, on the other may legitimize wastefulness. 	<ul style="list-style-type: none"> Expert contributions
	Dietary guidance	<ul style="list-style-type: none"> Healthy living guidelines play a role in shaping definitions of 'proper' food. Notably, a lot of 'proper' food is perishable and so at risk of being wasted. Lack of knowledge / inconsistent marketing around the nutritional benefit of frozen / tinned foods. Additionally, choice editing (restricting what's available) e.g. in terms of salt reduction targets may lead to reduced shelf life. 	<ul style="list-style-type: none"> 106
	Food deterioration and food safety	<ul style="list-style-type: none"> Food safety: cannot eat food past its 'use by' date. Food safety / quality: some foods given 'wrong' date (e.g. 'use by' on cheddar / hard cheese) providing consumers less flexibility to eat it later; shelf life may be set conservatively. 	<ul style="list-style-type: none"> 92 29, 35
	Consumer behaviour (wide range of food variety and availability)	<ul style="list-style-type: none"> Emotional neutralization: perception that edibles are products instead of something vital for life, e.g. through similar presentation in store of flour and washing powder. Customers associate food with the constant supermarket display rather than the producers. A package of milk for example is hard to associate with a cow or pre-crumbed fish sticks with a fish. 'Conscious consumption' (better planning by grocery shoppers) tends to be inconsistent with the 'convenience foods' promoted by some food retailers. The free provision by some retailers of plastic shopping bags, for example, highlights the manner in which grocery outlets encourage customers to shop first and plan second. Consumers may over-purchase because retailers' profits are contingent on the amount of food sold rather than the amount of food consumed. Consumers may purchase food without fitting into their meal plan. 	<ul style="list-style-type: none"> 150 117 1, 92, 121, 152, 154, 312

2.2.2 Importance of the different food supply chain segments for current food waste generation

Qualitative judgements on the importance of the different food supply chain segments for current food waste generation in the Institutional (Business and Economy) Context were not expressed in the specific Context Category report, because very few general conclusions could have been drawn based on available information and knowledge. In particular, it was found very difficult to express judgements referred to some quantitative knowledge, since very few studies exist on this subject: consequently, the degree of subjectivity was considered too high. In fact, in each segment of the food supply chain the food waste generation also depends on a cascade of decisions and events taking place in other segments. This complex of interrelations among the food supply chain segments has been so far seldom analysed in detail. Therefore, at least considering the Business management and Economy Context, to decide if one segment is comparatively more important than another would require a thorough analysis, that could not be performed within the terms of this Task.

2.3 Institutional drivers (legislation and policies) of current food waste causes

2.3.1 Identification of drivers

The identified Institutional drivers (related legislation and policies) of current food waste causes along the food supply chain are summarised in Table 2.4.

Primary production: Strict cosmetic and other quality standards imposed on farmers and agricultural actors by the retail industry for fruits and vegetables represent the largest institutional driver related to primary production food waste. Other contributing factors include overproduction, caused by EU policy subsidies combined with other factors and related market conditions, which could be controlled by policy or institutional actions. Other causes include tax policies for food redistribution.

Processing of farm staples: The drive towards profitability of farm staple segments actors and a lack of appropriate economic pricing for food waste (e.g. via economic instruments for waste management such as pay as you throw or landfill taxes) drives food waste generation and a lack of efforts for reduction. Access to finance for upgrading equipment or aligning it with best practices for food waste reduction is also important; waste reduction could be included in financing criteria.

Food processing and packaging: The key institutional driver related to legislation and policies for the food processing and packaging sector is regulatory standards which limit the resale, reuse or recovery of food items. This could be due to mis-packaging or labelling or related to bans imposed by culture/country on which types of food waste items can be recovered or alternatively used. A secondary driver is taxation policies.

Wholesale and logistics: The largest institutional driver related to policies and legislation in the wholesale and logistics segment is legal restrictions related to best before or consumption dates. Specific marketing standards for certain types of produce also strongly contribute. Legal limitations related to damaged or mis-marked packaging as well as the low cost of food waste discarded are other causes.

Retail and markets: Date related issues are the largest policy and legislation institutional drivers of food waste in the retail and market segment. Notably guidance is lacking to help consumers interpret various dates and this leads to wastage at consumer level. Other contributing drivers include a lack of measures on the reporting and pricing of food waste, regulations on the rejection of deliveries/returns by retail actors (this leads to wastage in the previous segments of the food supply chain), marketing standards on produce and insufficient policies to encourage redistribution.

Food Services: Institutional drivers on policy and legislation regarding the food services sector are related to confusion about 'best before' / 'use by' dates or other date information on packaging as well as the EU wide ban on use animal by-products (ABP) and catering waste for feeding animals, which results in food waste which could be sold for animal feed or otherwise recovered.

Households: Institutional drivers in the household sector related to policy and legislation are primarily linked to making food waste visible to consumers – physically or financially. The relatively low cost of food, which does not take into account the water and other resources involved for food production, as well as a lack of separate collection or pay as you throw schemes for food waste, do not incentivise consumers to reduce their waste. Guidance on diet, food preparation and food storage is also important in helping consumers limit their food waste.

Table 2.4 – Identified institutional drivers (legislation and policies) of current food waste causes and some related examples

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁶</i>
Primary production	Grading	<ul style="list-style-type: none"> • Strict cosmetic and other quality standards from the retail industry for fruit and vegetables. 	<ul style="list-style-type: none"> • 1, 150, 281, 312, 315
	Overproduction	<ul style="list-style-type: none"> • Inaccurate forecasting / crop planning, mainly due to poor communication and difficulties in predicting demand accurately due to factors such as weather changes. Overproduction of crops as insurance against weather-related crop destruction. • The production exceeds the demand: government programs that encourage farmers to overproduce certain foods; failure to harvest at all owing to low market prices or poor yields; EU policy subsidies: cultivation of certain crops because of subsidies; surplus in certain kinds of agricultural products, which exceeds the demand needs for specific agricultural products. 	<ul style="list-style-type: none"> • 6 • 20
	Market conditions/market price	<ul style="list-style-type: none"> • A product's price may not warrant the labour and transport costs required to bring the crop to market; due to marked demands on certain sizes etc, farmers choose to plough the entire production (if the majority of the production is imperfect), because it is too expensive to harvest the crop; variable market price 	<ul style="list-style-type: none"> • 20, 78
	Miscellaneous, other drivers to consider	<ul style="list-style-type: none"> • Tax on donations appearing in several countries, making transfer of waste for charity purposes economically loss making for companies (Tax policy) 	<ul style="list-style-type: none"> • Expert contributions
Processing of farm staples	Profitability	<ul style="list-style-type: none"> • Failure to implement best practice: A commercial organization will not utilize or further process any waste or by-product unless it is cost-effective to do so. Increased taxation on wastes disposed of to landfill is encouraging a greater focus on waste reduction. 	<ul style="list-style-type: none"> • Expert contributions
	Access to finance	<ul style="list-style-type: none"> • Lock-in to existing practices: This may occur for a range of reasons e.g. lack of finance for upgrading equipment, fear of litigation over food hygiene and safety issues. 	<ul style="list-style-type: none"> • 56

⁶ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁶</i>
Food processing and packaging	Legislative measures e.g. regulatory standards	<ul style="list-style-type: none"> Waste occurring because of the prohibited selling of goods with wrong marking of regulatory information on the packaging. The food cannot be sold if the packaging is mismarked, even though the product inside is fresh/ correctly produced. Traditions, culture and religion are often important when a meat by-product is being utilized for food. Regulatory requirements are also important because many countries restrict the use of meat by-products for reasons of food safety and quality. Animal organs such as hearts, livers, lungs, intestines, testicles, brains, tongues etc are discarded in abattoirs across the Western World despite having good nutritive value. Due to the current EU wide ban on feeding Animal By Products to pigs and chickens this waste cannot be fed to livestock. 	<ul style="list-style-type: none"> 21, and expert contributions 94, 312, 337
	Taxation policies	<ul style="list-style-type: none"> Taxation policies 	<ul style="list-style-type: none"> Expert contributions
Wholesale and logistics	Legal restrictions with respect to best before/consumption dates	<ul style="list-style-type: none"> Although in most countries it meets the legal conditions to sell products which already passed their best before date, it is not clear how to handle products after they passed their best before date. Legal authorities do not give official advice about that topic. In fact, most food banks do not offer products after their best before date as it is too dangerous to them if something happens. "not to be used after"-dates are set with a too long margin. One example is eggs where EU regulations forces Nordic producers to set very short best before dates because in southern Europe eggs are stored differently and also have the risk for containing salmonella. Since this is not the case in the some of the Nordic countries, it is an argument that a longer shelf-life would save a lot of eggs going to waste in these countries. 	<ul style="list-style-type: none"> Expert contributions 21
	Specific marketing standards	<ul style="list-style-type: none"> 11 specific marketing standards are still in use in the EU for apples, pears, strawberries, sweet pepper, kiwi fruit, tomato, peaches and nectarines, salad, grapes as well as citrus fruits. This leads to sorting out of products at the level of primary production resp. processing of agricultural staples but the prevention measure has to be implemented at the level of retail and markets. The level of wholesale is only affected indirectly. Also the retail sector has its own standards and there are also regional standards for specific products such as potatoes. 	<ul style="list-style-type: none"> 95, and expert contributions
	Blemish of packaging	<ul style="list-style-type: none"> The food cannot be sold if the packaging is mismarked/mislabeled, even though the product inside is fresh/correctly produced 	<ul style="list-style-type: none"> 21, 6
	Low cost for discarding food	<ul style="list-style-type: none"> Lack of incentives for higher accuracy in stock management due to low cost of discarding food 	<ul style="list-style-type: none"> 87

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁶</i>
Retail and markets	Dates labelling	<ul style="list-style-type: none"> • In most EU countries it meets the legal conditions to sell products which already passed their best before date if specific rules are met. Anyway, in practice it is not clear how to handle products correctly after they have passed their best before date. Legal authorities do not provide an official advice about that topic. In fact, a lot of companies do not donate and a lot of food banks do not offer products after their best before date as it is too doubtful to them if there is some problem. • Setting dates is done by producers but can be influenced by large retailers with respect to their own brands. Sell by, use by and best before dates can create confusion for consumers and lead to wastage at the household level. Prevention measures could be set at the level of retail actors. • The “best before dates” are set by the producers with a large marginal – with longer best before dates the shelf lives of the products will be longer and hence the food losses will decrease. But customers want to buy fresh food and are suspicious of overly long best before dates (one reason for this scepticism is the debate on additives and why they are added) therefore the trend is going in the other direction – with shorter and shorter shelf-lives. Products are wasted at the level of retail, measures have to be introduced at the level of producers but in cooperation with retail. 	<ul style="list-style-type: none"> • Expert contributions • 223 • 21, 239
	Measurement and pricing of food waste	<ul style="list-style-type: none"> • Lack of incentive for higher accuracy in stock management due to low cost of discarding food. • Provide key performance indicators (for example, tonnes of waste per tonne of product) and developing baseline data against which to track progress in reducing waste. Lack of transparency and non-mandatory reporting of food waste encourages wasteful practices in the retail industry. 	<ul style="list-style-type: none"> • 87 • 70, 312

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁶</i>
	Rejection of delivery>Returns	<ul style="list-style-type: none"> The delivery from the wholesale to the store is of bad quality. The routine of producers taking back un-sold products without charging for them (depending on contract) will not encourage the staff to order the right amount of the product. More waste will be generated. Contracts between supermarkets and their suppliers may have take-back clauses, so that the cost of waste is not necessarily picked-up by the waste producer. In the Czech Republic, a new law has recently been enacted to prohibit the return of unsold produce to suppliers. Most food retailers in Austria pay money to the supplying bakeries only for the bread and pastry which is sold to the consumer. The return flows of bread and pastry from retail to central bakery production where the products are disposed of have to be paid by the bakery. Thus, the retail has no incentive to reduce the return flow. Although waste bread is generated at the retail level, it is recorded, handled and paid at the production level. But prevention measures have to be implemented in both levels. Take back systems involve the right to return to suppliers unsold merchandise that has exceeded a given level of remaining shelf life (usually 75%). 	<ul style="list-style-type: none"> 1, 21, 92, 87, 92, 148, 251
	Marketing standards	<ul style="list-style-type: none"> Some produce is rejected at the farm gate due to rigorous quality standards concerning weight, size, shape and appearance of crops. Therefore, large portions of crops never leave the farms. Farmer-buyer sales agreements may contribute to quantities of farm crops being wasted. 11 specific marketing standards are still in use in the EU for apples, pears, strawberries, sweet pepper, kiwi fruit, tomato, peaches and nectarines, salad, grapes as well as citrus fruits. This leads to sorting out of products at the level of primary production resp. processing of agricultural staples but the prevention measure has to be implemented at the level of retail and markets. 	<ul style="list-style-type: none"> 1, 312
	Lack of policies to encourage redistribution	<ul style="list-style-type: none"> Instead of donating consumable products rather destroying them because of problem of trust in charity organisations; destroying products because of lack of information on how/where to donate, reluctance to donate food because of fears of litigation in the eventuality that a charity beneficiary might fall ill. 	<ul style="list-style-type: none"> 312, and expert contributions
Food Services	Ban on feeding ABP and catering waste to animals	<ul style="list-style-type: none"> The current EU wide ban on feeding ABP and catering waste to pigs and chickens results in the waste of surplus food not fit for human consumption that could be sold for animal feed. 	<ul style="list-style-type: none"> 312
	Expiry dates	<ul style="list-style-type: none"> Knowledge about expiration dates is limited, including what to do after opening a product. Providing information on the label can offer a solution for users. 	<ul style="list-style-type: none"> 94
Households	Price of food	<ul style="list-style-type: none"> 'Cheap' food may erode its perceived value. Food industry may prioritise volume sales over value. The price of food (cheap) may mean consumers can 'afford' to waste food. 	<ul style="list-style-type: none"> 1, 62, 78, 83, 87, 312

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁶</i>
	Collection infrastructure	<ul style="list-style-type: none"> How consumers view their food waste & extent to which it is 'seen' can depend on access to separate collection infrastructure (e.g. separate local authority collection, its frequency & system, access to home composting, presence of pets). The interplay between these is complex & on the one hand may raise awareness of how much is wasted, on the other may legitimise wastefulness: <ul style="list-style-type: none"> Access to home composting, food waste collection (type of food waste collection & its frequency). Household food waste generation is broadly affected by user charges for municipal waste collection and treatment. Unit pricing policies use marginal price structures that penalise higher levels of waste generation by charging on the basis of the volume (e.g. "Pay-As-You-Throw") or weight of trash discarded instead of a flat tax or monthly fee. Size of food waste collection containers provided may legitimise food wasting. 	<ul style="list-style-type: none"> 47, 117, 147, 169, 224, and expert contributions
	Dietary guidance	<ul style="list-style-type: none"> Healthy living guidelines play a role in shaping definitions of 'proper' food. For example, fresh fruits and vegetables were positioned as good, whilst processed foods that are high in salt or sugar were seen as bad. Notably, a lot of 'proper' food is perishable and so at risk of being wasted. Lack of food preparation skills & home economics classes (school & adult education). People do not have a correct understanding of what can be frozen, how to freeze, defrost & use it. Labelling can be inconsistent & unclear. 	<ul style="list-style-type: none"> 106 230, 235, and expert contributions 233

2.3.2 Importance of the different food supply chain segments for current food waste generation

For institutional drivers related to policy and legislation, key areas of loss seem to be most related to households, primary production and the processing of farm staples. The causes found across these sectors remain similar, a lack of physical or financial visibility on the amount of food waste generated, the application of marketing standards and confusion on date labels.

The results of the paired comparison are summarised in Table 2.5.

Table 2.5 – Relative importance of the different food supply chain segments for current food waste generation (Institutional drivers – legislation and policies)

<i>Relative importance for food waste generation</i>	<i>Food supply chain segments</i>
High	Primary production Processing of farm staples Households
Moderate	Retail and markets
Low	Wholesale and logistics Food services Food processing and packaging

2.4 Social drivers (consumer behaviours and lifestyles) of current food waste causes

2.4.1 Identification of drivers

The identified Social drivers of current food waste causes along the food supply chain are summarised in Table 2.6.

Primary production, Processing of farm staples, Food processing and packaging, and Wholesale and logistics: There are not many drivers of food waste causes found in the contexts of consumer behaviour and lifestyle related to the primary production, the processing of farm staples, the food processing and packaging, and the wholesale and logistics. The main driver related to current cause of food waste/loss is consumer preference, where the expectations of the consumers for 'perfect' food conditions and ability to buy products all year around are considered to be main items.

Retail and markets: The main identified drivers related to current causes of food waste are: consumer preference, consumer behaviour and tools. Consumer preferences is related to the consumer expectations concerning to 'perfect' food conditions, product freshness and ability to buy broad variety of products all year around. Consumers behaviour is related to the food waste occurring due to the purchasing behaviour, mainly due to purchase frequency and purchase volumes. The driver 'tool' is related to the availability or lack of means/tools that causes food waste.

Food Services: The main identified drivers related to current cause of food waste are: consumer preference, and consumer behaviour/attitude. For consumer preferences see comments at retail segment. Consumer behaviour/attitude is related to increased cooking portions that lead to leftovers and cooking, serving too much food, availability of unlimited food at fixed prices which encourages people to fill their plates with more food than they can actually eat and the attitude of customers to filled out buffet, where the expectations is that nothing will run out, causing businesses to prepare and cook substantially more than will be consumed.

Households: The household segment is identified as having the most drivers related to current causes of food waste. There are 7 main drivers identified: consumer preferences, knowledge/awareness, behaviour, attitude, tools, social norms and demographics. Consumer behaviour has by far the most items ranging from consumers' behaviour related to their shopping, planning, portioning activities till the consumers' behaviour related to housekeeping activities such as checking and maintaining the stocks. Also important is consumers' (lack of) knowledge/awareness and consumers' attitude.

Table 2.6 – Identified social drivers of current food waste causes and some related examples

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Social)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁷</i>
Primary production; Processing of farm staples; Food processing and packaging; Wholesale and logistics	Consumer preferences	<ul style="list-style-type: none"> • Consumers expect food to be in 'perfect' condition, for all types of food products, but mostly fresh fruits and vegetables • Consumers expect to be able to buy all types of food (mostly fresh fruits and vegetables) all year round, not related to seasons 	<ul style="list-style-type: none"> • 1, 21, 83, 124, 152 • 1, 87, 117, 152
	Consumer preferences	<ul style="list-style-type: none"> • Consumers expect food to be in 'perfect' condition, for all types of food products, but mostly fresh fruits and vegetables • Consumers expect to be able to buy all types of food all year round (mostly fresh fruits and vegetables) without reference to the seasonality of the product • Customers choose products with the longest shelf life. Sometimes foods are discarded even before the expiration of the "Best before end" date, because consumers will not buy the goods when they come too close to the expiration date. Customers place great emphasis on freshness often rejecting products with a short remaining shelf life, e.g. the release of fresh milk before its expiry date • Broad Variety: Consumers are spoiled and want the best and newest products. They demand a broad variety of products and full shelves, expect wide range of products to be available in stores, expect store shelves to be well filled. 	<ul style="list-style-type: none"> • 1, 21, 83, 124, 152 • 1, 87, 117, 152 • 291 • 21, 146, 148
	Consumer behaviour	<ul style="list-style-type: none"> • Purchase frequency - Consumers purchase food at different frequencies / quantities (how long things last for / meal planning is therefore important). • Purchase volume - Consumers buy large packs / bulk offers (to maximise value for money / due to limited range availability). 	<ul style="list-style-type: none"> • 1, 117, 174, 169, 313 • 1, 34, 59, 87, 92, 154, 174, 226, 293, 307, and expert contributions
	Consumer Tools	<ul style="list-style-type: none"> • What access is there to transport systems / local stores to make shopping visits easy e.g. carrying home heavy items, for example potatoes. May over-purchase if need to shop infrequently. 	<ul style="list-style-type: none"> • 30, 169

⁷ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Social)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁷</i>
Food Services	Consumer preference	<ul style="list-style-type: none"> • Consumers expect food to be in 'perfect' condition, for all types of food products, but mostly fresh fruits and vegetables • Consumers expect to be able to buy all types of food (mostly fresh packed fruits and vegetables) all year round, not related to seasons • People want to shop for food everywhere: Food can be bought not only in food retail shops but also at petrol filling stations. • Expectations of consumer with respect to opening and offer: The opening hours are extended during the last decades. With the increasing number of outlets experts worry about increasing food waste amounts as absolute freshness has to be available at every second of opening hour. • Broad Variety: Consumers are spoiled and want the best and newest products. They demand a broad variety of products and full shelves, expect wide range of products to be available in stores, expect store shelves to be well filled. 	<ul style="list-style-type: none"> • 1, 21, 83, 124, 152 • 1, 87, 117, 152 • 148 • 148 • 21, 146, 148
	Consumer behaviour/attitude	<ul style="list-style-type: none"> • Cooking portions have increased over time and large portions can lead to uneaten leftovers. • Mis-portioning & cooking, serving too much • A lot of restaurants serve buffets at fixed prices, which encourages people to fill their plates with more food than they can actually eat. Buffets, where food is served via a buffet, customers often expect that nothing will run out, particularly in the luxury market, causing businesses to prepare and cook substantially more than will be consumed. 	<ul style="list-style-type: none"> • 47, 83, 87, 92, 108, 226, 242 • 1 • 87
Households	Consumer preference	<ul style="list-style-type: none"> • May know how to use up leftovers but cannot because of domestic context (e.g. preferences / presence of family members / culinary repertoire is relatively fixed and provisioning highly routinized). • Smelly leftovers e.g. fish not appealing to store in fridge. • Consumers differ in what they are prepared to eat, e.g. some people do not want to eat, for example apple peel, while others will. 	<ul style="list-style-type: none"> • 106, 152, 226, 274 • 150 • 78, 87, 293
	Consumer knowledge/awareness	<ul style="list-style-type: none"> • Lack of knowledge on how to use food efficiently, e.g. making the most of leftovers, cooking with available ingredients. • Consumers do not know how to manage food not in 'perfect' condition / belief that potentially a food safety risk. • Not understanding / using food storage & use instructions provided on-pack. • Not understanding what date labels mean / not using it to plan usage in the home. • Lack of awareness of (1) the quantity of food waste generated individually, (2) the environmental problem that food waste presents, and (3) the financial benefits of using purchased food more efficiently. • Lack of food skills lead to food being spoilt in preparation. 	<ul style="list-style-type: none"> • 87, 92 • 152, 30 • 238 • 83, 87, 92, 238 • 87 • 92

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Social)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁷</i>
	Consumer behaviour	<ul style="list-style-type: none"> • How responsibility for shopping & preparing meals is managed within the household can lead to food waste, e.g. it may entail a mismatch between food that is bought and food that is actually used for the preparation of meals and eaten. It may also lead to waste because those with less responsibility may be less confident about food management, storage etc. in the home. • Not planning shopping trips / making a shopping list / meals in advance / checking stocks (routine takes over). • Consumers want to eat healthy food, so buy it but discard it when they prefer to eat something else (unhealthy). • Cooking portions have increased over time and large portions can lead to uneaten leftovers. Mis-portioning & cooking, serving too much. • A busy / 'lived' lifestyle makes it hard to avoid wasting food, easy to forget food, knowing which household members will be in, in advance. • Less willing to risk food safety with children. • High sensitivity to food hygiene leads consumers to throw away food which is still edible. • Not using cool bag to bring chilled food home, leading to spoilage. • Consumers may not use packaging functionality e.g. take some products out of packaging when they get home losing the protection of modified atmosphere packaging (MAP / protection). • From time to time consumers clear their storage cupboards / fridge / freezer and waste food which is deemed to be 'past it'. • Consumers may not undertake effective stock rotation in the home / plan meals according to the date mark. • Purchase frequency - Consumers purchase food at different frequencies / quantities (how long things last for / meal planning is therefore important). • Purchase volume - Consumers may buy large packs / bulk offers (to maximise value for money / due to limited range availability). • Food consumption plays a role in performing social identities and social relations. Informational campaigns may not adequately acknowledge the complex and contradictory concerns that individuals juggle as they make 'food choices' in their everyday lives. • Consumers want variety in their meals (e.g. may not want to eat leftovers; same thing two days in a row). 	<ul style="list-style-type: none"> • 152, 169 • 83, 87, 92, 121, 152, 226, 274 • 152, 274 • 47, 83, 87, 92, 108, 242, 226 • 47, 92, 106, 152, 154, 169, 179, 226, 293, 307 • 124, 238 • 226 • 66, 70 • 30, 231 • 66, 152, 231 • 152 • 1, 117, 169, 174, 313 • 1, 34, 62, 87, 92, 154, 174, 226, 293, 307 • 106 • 106, 152, 313

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Social)</i>	<i>Related examples of current causes of food waste</i>	<i>References⁷</i>
	Consumer attitude	<ul style="list-style-type: none"> Food which is given as a gift from guests or family members (e.g. home-made jam) may not be eaten and wasted, since such food can be difficult to integrate into the meal planning routine or not liked. (Linked to not wanting to share excess food with neighbours / family). There are no food 'shortages' as there have been in the past. Consumers do not view feeding food to their pets / birds as waste & some do not view unavoidable food waste as waste Disposal of drinks / liquid waste to sewer is not considered to be a problem, belief that it is better to dispose of liquids via the sewerage system than to put them in the household bin. If consumers do not see wastage as a problem they will be less motivated to prevent / manage their food better. The imperative to eat 'properly'. 'Proper' food is understood to encompass fresh, healthy ingredients that are used to prepare cooked meals from scratch whilst incorporating a variety of flavours and ethnic cuisines. Some cultures aim to 'over cater', belief that it is better to have more than is needed rather than not enough. Exaggerated at 'events' e.g. Christmas. In fear to fall short in supply for consumers retailers place excessive orders, which in its turn leads to overproduction in processing segment. 	<ul style="list-style-type: none"> 152 150,83 179 108 106, 274 18, 92, 106, 150, 300
	Consumer tools	<ul style="list-style-type: none"> What access is there to transport systems / local stores to make shopping visits easy e.g. carrying home heavy items, for example potatoes. May over-purchase if need to shop infrequently. 	<ul style="list-style-type: none"> 30, 169
	Social norm	<ul style="list-style-type: none"> Not storing fruit in the fridge because wish to have it on display in the fruit bowl in the kitchen 	<ul style="list-style-type: none"> 66, 231
	Demographics	<ul style="list-style-type: none"> Household size (single households tend to waste more, large larger households wasting less per person than smaller households), composition (households with children tend to waste more than households without children), age (young people tend to waste more than older people), culture, rurality. Employment status, type & education. Different approaches to managing food between women / men. Price/income -lower food loss in low-income than in high-income households. The households that noted price to be more important wasted less than the households that noted price to be less important. Generational differences in food management skills (e.g. older generation may have better food skills). 	<ul style="list-style-type: none"> 82, 87, 242, 79, 92, 121, 150, 119, 154, 147, 225, 169, 152 154, 169 179, 92, 119, 87 82, 242, 79, 121, 119, 154, 174 Expert contributions

2.4.2 Importance of the different food supply chain segments for current food waste generation

Comparing importance of the different food supply chain segments for current food waste production with reference to the context category Consumer behaviour and lifestyle, we have given the following judgment:

- in comparison of primary production segment with six other segments food services, retail and households have been considered as highest contributors to the current food waste production. The other segments have received equal importance;
- in comparison of processing and food staples segment with 5 other segments again retail and households have been considered as highest contributors to the current food waste production, while other segments received moderate and moderate plus importance;
- in comparison of retail and markets with food services we feel that retail and markets are slightly (weakly) more important in producing waste, while households have moderate (plus) importance over food services and retail markets in producing food waste.

The results of the paired comparison are summarised in Table 2.7

Table 2.7 - Importance of the different food supply chain segments for current food waste generation (Social drivers)

<i>Relative importance for food waste generation</i>	<i>Food supply chain segments</i>
High	Households Retail and markets
Moderate	Food services Wholesale and logistics
Low	Primary production Processing of farm staples Food processing and packaging

2.5 Analysis of drivers and intervention strategies

2.5.1 The identified drivers and their importance for current food waste generation along the food supply chain

The FUSIONS' experts indicated in total 105 drivers for the current causes of food waste generation. 28 identified drivers are related to technology, 38 to business management and economy (institutional), 23 to legislation (institutional), and 16 to social (consumer behaviour and lifestyles). The distribution of the identified drivers among the different supply chain segments is quite balanced: it varies from 13 drivers identified in the food services segment, to 19 in the households segment. An exception to this uniform distribution is in the Processing of agricultural staples segment, which counts only 9 drivers, (see Table 2.8).

Table 2.8 - Distribution of the identified drivers of current causes of food waste by context category and food chain segment

<i>Food supply chain segments</i>	<i>TECHNOLOGY DRIVERS</i>	<i>INSTITUTIONAL DRIVERS</i>		<i>SOCIAL DRIVERS</i>	<i>Total</i>
		<i>Business</i>	<i>Legislation</i>		
Primary production	5	6	5	1	17
Processing of agricultural staples	2	4	2	1	9
Food processing and packaging	5	6	2	1	14
Wholesaling and logistics	5	5	4	1	15
Retail and markets	5	5	5	3	18
Food services	3	6	2	2	13
Households	3	6	3	7	19
Total	28	38	23	16	105

The relative importance of the different food supply chain segments for current food waste generation, as resulting from the paired comparisons, is quite variable depending on the category of drivers considered. However, the Households segment was indicated to have a relatively high importance in all three categories of drivers available (see Table 2.9).

The Primary production segment scored high importance in the Technological drivers and in the Institutional (legislation) drivers, and a relative low importance in the Social drivers. A third segment judged to have a relatively remarkable importance for food waste generation was the Retail and markets, which was indicated of high importance for the Social drivers, and of moderate importance in the other two categories of drivers.

The segments Households, Primary production, and Retail and markets were also assigned of the highest number of drivers (see Table 2.8), and this type of correlation between the data of Table 2.8 and Table 2.9 exists also for the segments indicated as of relatively low importance for current food waste generation.

Table 2.9 – Relative importance of the different food supply chain segments for current food waste generation, results of paired comparisons*

Food supply chain segments	TECHNOLOGY DRIVERS	INSTITUTIONAL DRIVERS		SOCIAL DRIVERS
		Business	Legislation	
Primary production	High	n.a.	High	Low
Processing of agricultural staples	Low	n.a.	High	Low
Food processing and packaging	High	n.a.	Low	Low
Wholesaling and logistics	Low	n.a.	Low	Moderate
Retail and markets	Moderate	n.a.	Moderate	High
Food services	Low	n.a.	Low	Moderate
Households	High	n.a.	High	High

* Data should be read according to columns and not to rows.

2.5.2 Investigating the possibilities of intervention

The identified drivers and the mentioned related causes give a wide picture of the magnitude of food waste as a phenomenon related to the massive production of food mainly destined to large urban markets. Within each context category three different groups of identified drivers have been defined.

In the context categories related to the Technological, Institutional (Business and Economy), and Social drivers, the criteria for the grouping of the food waste drivers have followed the common principle of the possibilities of intervention within each specific context: (i) the Technological drivers have been grouped according to possibilities of intervention through application of available technologies, (ii) the drivers related to Business and Economy according to possibilities of business management solutions, and (iii) the Social drivers according to efficacy of actions increasing social awareness and information. In the Institutional (Legislation and Policies) context the groups of drivers have been formed following the type of legislation and policy to which the identified drivers are referred.

The classification of the identified drivers within the groups of each context category has not been performed on the basis of the mere terminology used by the authors of the Context Category Reports to define the drivers. It has been worked out by examining the food waste causes to which the drivers were associated in the Context Category Reports.

2.5.2.1 Technological drivers

The identified Technological drivers have been grouped according to the following criteria:

- drivers of food waste inherent to the characteristics of food, and of its production and consumption, where technologies have become limiting;
- drivers of food waste which are inherent to the process design and a consequence of technologies utilised. In this case, food waste can be considered a *technological collateral effect* of modern production practices, which is accepted by enterprises and consumers according to a cost/benefit ratio.
- drivers related to sub-optimal use of, and mistakes in the use of available *food processing technology and chain management*.

Food waste related to the first criterion (*drivers inherent to the characteristics of food, and of its production and consumption, where technologies have become limiting*) is difficult to be avoided, because there is still lack of technological capacity. These drivers are related to phenomena like

perishability of food and unpredictability of food production and consumption, which have consequence, for example, in the correct programming of the volumes of supply and demand, and reflect on the generation of food waste.

The second criterion (*food waste as a technological collateral effect*) relates to the fact that supply chain technologies may evolve by optimising not only the use of food staples in the different chain segments, but also other factors of production, e.g.: energy, land, buildings, equipment, finance, workforce. Therefore, the implementation of new technologies which create more waste of food staples, but reduce the use of other more costly factors may result perfectly rational for enterprises and consumers, especially if they do not pay for the environmental damages due to waste increase. These phenomena are related to the concepts of *asymmetry of technological progress* and *externalities*. The group includes, for example, the drivers of “physiological” waste consequent to increasing mechanization of agricultural practices, modern fishing techniques, industrial husbandry, and transportation.

The third criterion simply refers to sub-optimal use of, and mistakes in the use of available food processing technology and chain management. Drivers like ‘(no) access to modern technologies’, ‘equipment reliability’, ‘ease of equipment operation’, ‘cold chain inefficiencies’, ‘(poor) storage’ conditions have been included in this group.

Table 2.10 shows the grouping of the identified technological drivers.

It is not always possible to define clear boundaries between the three groups of drivers. The classification of each driver was decided after an analysis of the related causes of food waste and of the references mentioned in the Context Category Reports and in the Food Supply Chain Segment Reports.

This may have also led to drivers with similar names being classified under different groups. For example, the driver “Production planning” of the first group is similar to the “poor management and forecasting” driver of the third group, but the former refers to general difficulties in production planning of processors due to the natural variability of agricultural production and food consumption, the latter to misapplication of good practices of business management and planning within the enterprises of the wholesale and logistics segment.

17 technological drivers out of the 28 identified results related to the sub-optimal use of, and mistakes in the use of available food processing technology and chain management (the third group of drivers). All the food supply chain segments are relatively well represented in this group.

Seven technological drivers have been collected by the second group (*food waste as technological collateral effect*), the majority belong to the Primary production segment. The first group (*drivers of food waste inherent to the characteristics of food, and of its production and consumption, where technologies have become limiting*) contains four drivers from the Processing of agricultural staples, Food processing and packaging, Retail and markets, and Households segments of the food supply chain.

The three criteria used for the grouping also respond to different possible strategies for reduction of food waste. In particular, the food waste related to the first group of drivers could be contrasted only with technological progress, in order to achieve a more sustainable control over the variety of natural factors that still constrain production, processing, marketing, and consumption of food.

The food waste derived from the second group of drivers could be faced with policy measures targeted to balance the asymmetries of technological progress and the externalities generated along the food supply chain. To this aim, typical measures may be represented by market-based instruments such as green taxes and subsidies, and tradable permits that change the cost/benefit ratio for firms and consumers, by addressing their choices towards solutions that reduce food waste.

The causes of food waste derived from the third group of drivers may be opposed by reinforcing the technological skills of production units, by improving their staff’s skills and consumers’ information and awareness. This could be obtained by policy measures stimulating investments, modernization, and professional training in firms, and by campaigns for consumers. An important role may also be played by grassroots initiatives and social innovation.

Table 2.10 – Grouping of the identified technological drivers of current food waste causes (see Table 2.1)

1 - Drivers inherent to characteristics of food, and of its production and consumption, where technologies have become limiting*		2 - Collateral effects of modern technologies*		3 Sub-optimal use of, and mistakes in the use of food processing technology and chain management*	
Climatic conditions	II	Harvest loss & damage	I	Microbiological quality / storage	I
Production planning	III	Livestock mortality	I	Access to modern technology	II
Forecast/Ordering system	V	Milk waste caused by drug contamination	I	Access to modern technology	III
Insufficient product life	VII	Non selective fishing	I	Equipment reliability	III
		Improved traceability	III	Ease of equipment operation	III
		Storage handling and conditions	IV	Packaging	IV
		Damage during transport	V	Cold chain inefficiencies	IV
				Poor management and forecasting	IV
				Poor handling and storage	V
				Packaging	V
				Minimum food safety failures	V
				Customer knowledge	V
				Storage	VI
				Equipment and containers	VI
				Lack of good practice	VI
				No access to suitable storage systems	VII
				Insufficient packaging	VII
Total drivers: 4		Total drivers: 7		Total drivers: 17	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

2.5.2.2 Institutional (business and economy) drivers

The identified Institutional (business and economy) drivers have been grouped according to the following criteria:

- drivers of food waste which are *not easily addressed by management solutions*, since they are related to the natural characteristics of food staples or to entrenched societal obstacles difficult to remove. These drivers are related to phenomena like perishability of food and unpredictability of food production and consumption, rooted behaviours of consumers difficult to change, and huge social problems like extreme poverty;
- drivers of food waste which are *affordable at the macro level* (e.g. by policy measures, inter-professional agreements, social campaigns) and not at the level of the single business unit.

Examples are the drivers originated by different government policies (agriculture, waste, taxation), market conditions, and unequal bargaining power of food supply chain operators;

- drivers of food waste which are *affordable within the business units* through better organisation and improved management. Identified drivers like communication, staff training, supply chain/cold chain inefficiency, information sharing, and food portioning, have been included in this group.

Table 2.11 shows the grouping of the 38 identified Institutional (*business and economy*) drivers. 13 drivers have been classified in the first group (*not easily addressed by management solutions*). All the food supply chain segments are represented, except the 'Processing of agricultural staples'. The second group (*food waste drivers affordable at the macro level*) includes 11 drivers from six food supply chain segments, only the 'Food services' is not represented. The third group (*food waste drivers affordable within the business unit*) is the largest with 14 drivers from all the segments, except Primary production.

As said, the second group of drivers is affordable at macro level by specific policy measures (e.g. agricultural market and infrastructure, food safety, health and consumer, animal welfare, waste, etc.), by inter-professional agreements (for example in the case of the 'Rejection of delivery/returns' driver and the 'Contracts/agreements' driver), and by consumer campaigns as for the 'Diet guidance' driver.

The causes of food waste derived from the third group of drivers may be addressed within the business units, for example by improving organisation, information and training of staff, communication with suppliers and customers, and with final consumers.

As regards the possible strategies for food waste reduction, by definition the first group of the identified drivers are not easily addressed through management solutions within the business units. They could be contrasted with technological progress and huge policy initiatives (at international level) depending on their kind.

Table 2.11 – Grouping of the identified institutional drivers (business management and economy) of current food waste causes (see Table 2.3)

<i>1 – Not easily addressed by management solutions *</i>	<i>2 - Affordable at macro level*</i>	<i>3 - Affordable within the business units*</i>
Consumer demand ("cosmetic" fruit standards, scarce use of by-products for cultural reasons) I	Government subsidies (favouring production surpluses) I	Profitability (non-profitability of best practices) II
Poverty/starvation (premature harvesting) I	Market conditions/market price (price does not cover harvest costs) I	Communication (bad information exchange) II
Lack of infrastructure and facilities I	Access to finance (lock in to existing practices) II	Knowledge & communication III
Supply and demand forecasting I	Government regulations II	Profitability (discarding of low value components and by-products) III
Marketing strategies and customer demand III	EU & national government legislative and taxation policy III	Staff training and communication IV
Customer expectations and demand III	Contracts/agreements III	Supply chain/cold chain inefficiencies IV
Deterioration of food (mainly related to characteristics of food products) IV	Market demand (determining product recalls) IV	Forecasting of stocking/ordering (mainly related to management inefficiencies) IV
Forecast/ordering system (mainly related to characteristics of food products) V	Rejection of delivery/returns V	Deterioration of food, food safety (mainly related to management inefficiencies) V
Customer expectations, demand and marketing strategies (mainly related to consumer behaviours) V	Cheap price of food VII	Power and trust, transparency, communication, and information sharing V
Difficulty to estimate and calculate the right amount of food to cook (related to consumer preference for wide assortment of products) VI	Collection infrastructure VII	Inflexibility in portioning VI
Consumer expectations prediction and demand forecasting VI	Diet guidance VII	Situational reasons "food being served but not eaten" VI
Food deterioration and food safety VII		Operational reasons "food being prepared, but not served" VI
Consumer behaviour (preference for wide food variety) VII		Food deterioration (related to insufficient information for customers) VI
		Incorrect application of date marks VII
Total drivers: 13	Total drivers: 11	Total drivers: 14

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

2.5.2.3 Institutional (legislation and policy) drivers

The criteria for grouping the 23 identified Institutional (legislation and policy) drivers are directly related to the subjects of legislation impacting on food waste, in particular:

- the first group of drivers is concerned with the legislation derived from the *agricultural policy and agricultural product quality regulations*; for example: product grading, overproduction, market conditions and market price, and marketing standards. 6 drivers have been included in this group, a half of them are from the Primary production segment;
- the second group of drivers is related to legislation derived from *food safety, consumer health, and animal welfare policies*. Drivers like 'dates' and 'ban on feeding ABP and catering waste to animals' have been included in this group, which collects a total of 6 identified drivers. They are all from the central segments of the food supply chain: from the Food processing and packaging segment, up to the Retail and market and the Food services segment;
- the last group of drivers is concerned with legislation originated by *waste and tax policies and by other policies*. Some identified drivers included in the group are 'tax on donations', 'tax policy', 'low cost for discarding food', and 'lack of policies to encourage redistribution'. For this category of drivers it represents the most numerous group by gathering 11 drivers.

Table 2.12 shows the grouping of the 23 identified Institutional (*legislation and policy*) drivers. The causes of food waste derived from the three groups of drivers can be dealt with by intervening on the respective legislations and policies.

Table 2.12 – Grouping of the identified institutional drivers (legislation and policy) of current food waste causes (see Table 2.4)

1 - Agricultural policy and quality standards*		2 - Food safety, consumer health, and animal welfare policies*		3 – Waste policy, tax, and other legislation*	
Grading (cosmetic and quality standards for fruit and vegetables)	I	Legislative measures e.g. regulatory standards	III	Tax on donations	I
Overproduction (stimulated by inadequate policy measures)	I	Legal restrictions with respect to best before/consumption dates	IV	Tax policy	I
Market conditions/market price (lack of regulation)	I	Blemish of packaging	IV	Profitability	II
Specific marketing standards	IV	Dates labelling	V	Access to finance	II
Marketing standards	V	Ban on feeding ABP and catering waste to animals	VI	Taxation policies	III
Cheap price of food	VII	Expiry dates (insufficient information in labelling)	VI	Low cost for discarding food	IV
				Measurement and pricing of food waste	V
				Rejection of delivery>Returns	V
				Lack of policies to encourage redistribution	V
				Collection infrastructure	VII
				Diet guidance (lack of food knowledge in education curricula)	VII
Total drivers: 6		Total drivers: 6		Total drivers: 11	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

2.5.2.4 Social drivers

The 16 identified Social drivers have been divided according to the following criteria:

- a first group includes the drivers *related to social factors*. Only one driver, from the Household segment has been included in this group: 'demographics', it drives food waste causes related to households' characteristics, gender, population income, average culinary skills, etc.;
- the second group of drivers is related to *individual behaviours which are not readily changeable*, like general expectations of consumers towards food (for example: good aspect, possibility of acceding to broad quantities and varieties independently on places and time). The group include 7 drivers, but in fact it is always the same driver which was repeated for the seven segments, the driven causes show some changes in the three final segments of the food supply chain (i.e. Retail and markets, food services, and Households: see Table 2.6);
- the third group of drivers is related to consumers' *individual behaviours modifiable through information and increased awareness*. The drivers classified in the group, although defined with very generic terms, refers for example to the consumer attitudes towards food shopping, the way food is served by restaurants, level of information and awareness about food, social norms, and so on. A total of 8 drivers have been included in the group. Only the final segments of the food supply chain are represented, five drivers come from the household segment.

Table 2.13 shows the grouping of the 16 identified Social drivers.

Table 2.13 – Grouping of the identified social drivers of current food waste causes (see Table 2.6)

<i>1 - Related to social factors*</i>	<i>2 - Related to individual behaviours which are not readily changeable *</i>	<i>3 - Related to individual behaviours modifiable through information and increased awareness*</i>
Demographics VII	Consumer preference I Consumer preference II Consumer preference III Consumer preference IV Consumer preference V Consumer preference VI Consumer preference VII	Behaviour V Tools V Behaviour/attitude VI Knowledge/awareness VII Behaviour VII Attitude VII Tools VII Social norms VII
Total drivers: 1	Total drivers: 7	Total drivers: 8

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

The causes of food waste driven from the first group often depend on wide social dynamics that in most cases are not readily changeable (like demographic trends, population age, household structure, income, education, etc.). Regarding the causes derived from the second and the third group, their definition already indicates the possible types of intervention.

3 Drivers of future threats of food waste increase

3.1 Technological drivers of future threats of food waste increase

3.1.1 Identification of drivers

The identified technological drivers of future threats of food waste increase along the food supply chain are summarised in Table 3.1.

Primary production: Two technological drivers were identified which were related to expected threats of a future food waste increase in the Primary Production segment of the food supply chain: 'Insufficient forethought to climate change' and 'harvesting technology'.

Sources of evidence identified from the FUSIONS database were limited for one of the two drivers ('harvesting technology'). Six quotations were however found for the climate change driver.

Losses related to harvesting technology are likely to involve damage to the product being harvested. As such, the damage may result in product deterioration at later stages of the food chain and consequently increased wastes.

Processing of farm staples: Three technological drivers related to the possibility of a future increase in food waste were identified: 'Government policy on bio-fuel production', 'climate change' and 'globalisation'. In common with the 'primary production' segment, the most-cited causes were related to the 'climate change' driver with only one reference for each of the 'Government policy on bio-fuel production' and 'globalisation' drivers.

Food processing and packaging: Three technological drivers were identified related to the possibility of an increase in food waste for the 'Food processing & packaging' segment of the food supply chain: 'Government policy on bio-fuel production', 'lack of suitable technology', 'failure of new packaging solution. It should be noted that the three drivers identified were all independent of each other. In

addition, the fact that only three technological drivers were found related to the possibility of an increase in food waste perhaps reflects the current focus on sustainability and competitiveness.

Wholesale and logistics: Increased consumption means that more produce has to be transported to the stores. During storage, the fruit that are in the middle or bottom of piles are more easily damaged in transportation. In stores this means increased waste if products are not stored properly. Selling larger packages at a cheaper unit price encourages customers to over buy and so creating more waste. Also increasing consumption requires more transportation during which especially fruit are vulnerable to damage and spoilage. All this combined with the customers' expectations of full shelves are possible major causes for food waste increase.

Product variety can cause food loss because the amount of niche products increases. Due to the increasing food intolerance (e.g. lactose, gluten) a lot of different specific food products were and will be introduced to the market in addition to the standard ones. Thus, one can choose not only between different "normal" products but also organic, without lactose, without gluten, low fat and so on.

Retail and markets: Better quality measurements have increased store recalls. This increases food waste but at the same time improves customer safety and food chain reliability. This may help in keeping food safety scares to a low level.

Growing customer demand of fresh-cut produce with shorter shelf-life may increase amount of food waste. Offering unfamiliar product to customers to increase product variety leads to increased food loss because most of the customers don't know how to prepare these foods. This is why unfamiliar products have higher waste percentage.

Major obstacles in reducing food waste are customer expectations for full shelves and growing demand for product variety. Both these increase the amount of food moving through the chain so they increase the amount of waste in almost every segment of the chain. The full shelves expectation especially would be a good place to start reducing waste because the procedure itself is unnecessary. Without the full shelves the efficiency of almost the whole chain could be improved.

Food Services: The food service segment only had one driver and cause related to food waste. Biogas production gives new value to food waste and therefore can have an effect on its generation and management. If food waste is known to end up in a biogas plant, that can make wasting food more acceptable. This can increase the amount of food waste but the energy efficiency for using discarded food for energy is probably not high.

Households: For households, reduced packaging might be one of the sources for future increased food waste. Reduced packaging can lead to product damage.

Other drivers for households may be inadequate equipment. This might increase food waste in the future if cheap household appliances become more common. These cheap appliances might not have as good functionality as more expensive equipment.

Consumption patterns may also have an effect on food waste. "Health products" that have lower sugar, fat or salt content may also have a reduced shelf-life. This has the possibility to increase food waste by limiting the time available for them to be consumed.

Table 3.1 – Identified technological drivers of future threats of food waste increase

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of future threats of food waste increase</i>	<i>References⁸</i>
Primary production	Insufficient forethought to climate change	<ul style="list-style-type: none"> Increased rainfall / flooding, change in temperatures, invasive alien species, changing overall growing conditions. 	<ul style="list-style-type: none"> 118, 260, 318
	Harvesting technology	<ul style="list-style-type: none"> Product can be damaged during harvest through the use of mechanical harvesting technologies. 	<ul style="list-style-type: none"> 30
Processing of farm staples	Government policy on bio-fuel production	<ul style="list-style-type: none"> The use of waste for higher generation bio-fuel production may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118
	Climate change	<ul style="list-style-type: none"> Losses due to storage, moisture, moulds, etc. Increased contamination in harvested crops. Increased infestation of crops by pests and insects (including non-native invasive species) leading to higher losses during processing. Overproduction (through lower yield stability). 	<ul style="list-style-type: none"> 1, 27, 82, 85, 159, 180, 296, 297 27, 76 118 Expert contributions
	Globalisation	<ul style="list-style-type: none"> Sourcing of agricultural staples from less-developed countries leading to increased post-harvest losses. 	<ul style="list-style-type: none"> 18
Food processing and packaging	Government policy on bio-fuel production	<ul style="list-style-type: none"> The use of waste for higher generation bio-fuel production may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118, 312
	Lack of suitable technology	<ul style="list-style-type: none"> Processing equipment will not work with non-standard shape fruits & vegetables leading to increased blockages / downtime and hence product waste. 	<ul style="list-style-type: none"> 143
	Failure of new packaging solutions	<ul style="list-style-type: none"> Consumer rejection of new packaging solutions e.g. vacuum and skin packs. The trend towards minimal packaging can increase food waste in the supply chain and at the consumer stage because appropriate packaging can lengthen the shelf-life of foods. 	<ul style="list-style-type: none"> 104 56
Wholesale and logistics	Increasing consumption	<ul style="list-style-type: none"> Lowering the prices of bigger packages and promoting products at lower prices lead to over buying. Increasing consumption of fresh fruits and vegetables requires more transportation and will increase the amount of products damaged in transportation. 	<ul style="list-style-type: none"> 180, 182 5, 21
	New short shelf-life products	<ul style="list-style-type: none"> Growing amount of fresh-cut produce with shorter shelf-life (e.g. fruit) may increase amount of food waste. 	<ul style="list-style-type: none"> 5

⁸ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of future threats of food waste increase</i>	<i>References⁸</i>
	Increasing demand for greater product variety	<ul style="list-style-type: none"> • Growing customer demand for greater variety of products may increase food waste when retailers try to meet the demand by ordering new product. • Full shelves expected by customers will lead to increased food waste with growing assortment of products available. 	<ul style="list-style-type: none"> • 5, 251 • 5, 21
Retail and markets	Better measurement of quality	<ul style="list-style-type: none"> • Number of recalls increased during the last years due to increased ability to measurement levels in quality control. 	<ul style="list-style-type: none"> • Expert contributions
	Service as business idea	<ul style="list-style-type: none"> • Customers expects for full shelves with a great variety and "fresh" food • Demand for greater variety of products 	<ul style="list-style-type: none"> • 5, 21
	Packaging	<ul style="list-style-type: none"> • Large quantity packs generate more wastes. The package opportunities have to cover all kinds of demands from small size to bulk without apparent discounts between them. 	<ul style="list-style-type: none"> • 5, 21
Food Services	Biogas production	<ul style="list-style-type: none"> • Wasting food can be regarded as more acceptable in society as new biogas solutions are introduced and promoted 	<ul style="list-style-type: none"> • 8, 90
Households	New packaging	<ul style="list-style-type: none"> • Costs for packaging materials and political drivers to reduce packaging lead to packaging 'failing' to protect the product / extend its life (total & once opened). Intelligent packaging: customer may not trust his own senses anymore or over-rule date mark. 	<ul style="list-style-type: none"> • Expert contributions
	Increasing poor quality appliances	<ul style="list-style-type: none"> • Poor quality, cheap white goods appliances on the market don't have functionality to help reduce waste in the home. 	<ul style="list-style-type: none"> • Expert contributions
	"Health products"	<ul style="list-style-type: none"> • Not able to mitigate impact of health-related activities e.g. formulation changes to meet salt reduction targets leads to reduced shelf life of products. (Similar problems may arise from fat & sugar reduction activities.) 	<ul style="list-style-type: none"> • Expert contributions

3.1.2 Importance of the different food supply chain segments for future threats of food waste increase

The segments were compared in the same manner as described following § 2.1. Comparison of the possible technical drivers and causes increasing food loss was a challenging task. It was felt that the level of evidence was weaker than found for the current causes and therefore the scores assigned were generally lower.

The biggest threat was thought to be lack of adaption to climate change impacting mostly on the 'Primary production' and 'Processing of farm staples' segments. This, however, is not well quantified. The current focus on reducing food waste, particularly from retail, industry and households, is likely to outweigh drivers acting in the opposite direction. Hence, in the paired comparisons, low (but higher) scores have been assigned to those segments where there may have been less focus on reducing food waste e.g. wholesale & logistics and food services.

In the case of the 'Food services' segment, the low number of causes and drivers compared to other segments makes comparisons potentially unreliable.

The results of the paired comparison are summarised in Table 3.2.

Table 3.2 - Importance of the different food supply chain segments for future threats of food waste increase (technological drivers)

<i>Importance for future threats of food waste increase</i>	<i>Food supply chain segments</i>
High	Primary production Processing of farm staples
Moderate	Wholesale and logistics Food processing and packaging Retail and markets Food services
Low	Households

3.2 Institutional drivers (business management and economy) of future threats of food waste increase

3.2.1 Identification of drivers

The identified institutional drivers (in the field of business and economy) of future threats of food waste increase along the food supply chain are summarised in Table 3.3.

Primary production: Fishery policies are a powerful driver of food loss through issues such as the discarding of less profitable fish or by-catch even though these discarded fish rarely survive. These issues can be affected e.g. by banning the discard practices but also by influencing consumer demand on the range of fish asked for. Retail power over producers can drive a number of causes for waste, such as overproduction to meet the quantities contractually agreed upon (set higher in order to create buffer amounts of food to ensure steady supply of shelves). Another factor is that retailers are not necessarily forced to purchase goods from one supplier but may switch, leaving that supplier to look for a new purchaser. Harsher contract conditions would benefit the producers but are difficult to implement due to the retailers' power. Given that and the variations of market prices, falling prices may make it more economic for a farmer to plough his crop under rather than try to harvest and sell it.

While bio-fuel is still considered environment-friendly and growing, it is a driver on several layers: on the one hand, using waste for energy production may increase its value and therefore the desire to reduce waste can decrease. On the other hand, the production of bio-fuel crops on agricultural area competes with food production space (potentially increasing food prices).

Both customer demand and government regulations will continue to affect primary production with their expectations of certain appearance and conditions (grading) as well as meeting the demands for food safety.

Processing of farm staples: Government policy on bio-fuel will continue to exert the same influences on farm staples as on primary production, as it may raise the value of waste as a resource rather than encouraging waste reduction. Issues of profitability in a globalized world are drivers that at first glance promote competition but at second glance allow for greater losses due to the lacking infrastructure, climate, and the like in the developing world. Customer demand is not likely to lose its importance as a driver in causes like overproduction or waste through less appreciated animal body parts.

Food processing and packaging: Contractual agreements, such as take-back clauses or prohibitions on re-selling overproduction items, drive waste in the processing area through the retailers' power, as well as customer demand for increased variety, as well as specific product appearance. Interestingly, a recent development in European legislation has been to scrap a number of marketing standards for products, recognizing the negative impact of these regulations. Another development in European and national regulations has affected the driver profitability which in terms of waste had previously seen disposal as a cheaper option, but landfill taxation has started making food waste reduction a financially preferable choice.

Another driver in relation to consumer demands is the protection of the brand image, pre-empting any concerns over shelf life by setting the best before date well before the actual expiration date.

The current EU-wide ban on using animal by-products in animal feed was introduced in the wake of the Bovine spongiform encephalopathy (BSE) crisis. This is cited as a cause of increased abattoir waste although politically this may be a very controversial area with 188,579 reported cases of BSE having occurred in Europe along with 271 deaths due to the human form of the disease, Creutzfeldt-Jakob disease (variant CJD).

Wholesale and logistics: Acting on the driver of profitability, the approach of increasing disposal costs through policy and legislation is not certain to continue to be effective since some member states have negotiated delays for the implementation of such measures. This threat therefore is likely to continue to be a factor in food waste.

Quality requirements driven by consumer demand and government regulations will very likely influence waste production in the future as well. Returns and pre-store waste are increasing and will require new solutions for disposal or reusability. Other effects likely include precautionary measures to protect the brand image with respect to food safety and or quality, such as predating best before dates, or expanding the product variety to previously niche markets like food intolerance customers, taking into account increased waste through the unequal sale of the diverse variants.

Retail and markets: The primary driver for retail and market actions has been consumer demand and will continue to be so, with all the attended effects on waste production, regarding such issues as product variety – making order forecasts more difficult -, freshness of products, and overstocked products. Related to this are such drivers as returns and redistribution which continue to create waste or be hampered in their efforts to find new uses for still edible food products intended to be discarded.

Efforts of reducing waste have been focusing on pack quantities, shelf life, and order sizes; such efforts are likely to play a role in the future, with varying effects as they will have to counteract the consumer demands as well as the retail companies' desire to play into the latter's hands.

Market strategies such as promotion activities, grading, and the increased production of ready-to-eat products are continuing to impact on waste production; while there are efforts underway to curb e.g. availability in promotions to prevent waste, these are generally counteracted by public dissatisfaction. A final driver continues to be a lack of training at the retailer, with subsequent poor ordering and other inefficient actions, such as e.g. mishandling.

Food Services: The trend to multiply varieties of food offered increases the complexity of planning and forecasting the appropriate amount of each assortment required. The caterer's interest lies in generating more turnover, e.g. through greater variety and making sure not to run out of product, which is an incentive to purchase and sell more than is needed. This is further enhanced by performance contracts requiring the caterer to reserve a percentage of turnover despite its likely impact on increasing waste. Suitable counteractions may focus on this and target the caterer's public image, or the caterer may be charged for waste disposal (e.g. by the kilogram). Furthermore, while quantities on sale are contractually negotiated in advance, renegotiations (when such a need is determined) might enable a reduction of waste.

Households: Based on identified threats of future food waste increase the main drivers for the households segment are: price strategies based on cheap food, education policy neglecting improvement of food knowledge and skills, excessive focus on healthy lifestyles and high quality standards for food, public funding cuts that reduce engagement at community level.

Table 3.3 – Identified institutional drivers (business and economy) of future threats of food waste increase

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future threats of food waste increase</i>	<i>References⁹</i>
Primary production	Fishery policies	<ul style="list-style-type: none"> Fishery policy can affect the amount of by-catch and discard 	<ul style="list-style-type: none"> 317, 319
	Excessive power of retailers over producers	<ul style="list-style-type: none"> Overproduction to meet contract quantities: Farmers overproduce to meet the agreed quantities in the contract with the retailer. Contracts between supplier and retailers: Retailers are not always loyal to their contracts with suppliers and may buy products elsewhere if those are cheaper. This leaves producers with their goods but nowhere to sell them. They may be forced to sell them at a lower price. 	<ul style="list-style-type: none"> 94 291
	Bio-fuel	<ul style="list-style-type: none"> The use of waste for higher generation bio-fuel production may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118
	Demand, customer expectations, and the market	<ul style="list-style-type: none"> Demand for certain size products generates food loss when farmers are left with produce that doesn't meet the standard (grading). If the market price for the product at harvest is too low to cover the costs of harvesting or other processes. 	<ul style="list-style-type: none"> Expert contributions 18
	Food safety	<ul style="list-style-type: none"> Food safety issues may leave products unharvested or unsold. 	<ul style="list-style-type: none"> 83
Processing of farm staples	Government policy on bio-fuel production	<ul style="list-style-type: none"> The use of waste for higher generation of bio-fuel production may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118
	Profitability / Globalization	<ul style="list-style-type: none"> Sourcing of agricultural staples from less-developed countries may increase post-harvest losses due to a greater resilience of smallholders, less access to storage facilities and increased occurrence of natural disasters Globalization may open opportunities for agricultural exports while representing a threat to development of internal markets through competition from inexpensive imports of higher quality than can be produced locally. 	<ul style="list-style-type: none"> 18 Expert contributions
	Customer demand	<ul style="list-style-type: none"> Customer demand causes overproduction and increased wastes caused by non-consumed parts. 	<ul style="list-style-type: none"> Expert contributions
Food processing and packaging	Contracts between customers and suppliers	<ul style="list-style-type: none"> Wastes due to take-back clauses. Wastes due to contractual commitments. Grading losses based on size and shape. With the use of private labels, by products or all other surplus products resulting from over production may not be sold to other parties and are thrown away. 	<ul style="list-style-type: none"> 18 Expert contributions

⁹ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future threats of food waste increase</i>	<i>References⁹</i>
	EU and national government legislative & taxation policy	<ul style="list-style-type: none"> Wastes due to insufficient packaging. Wastes due to customer rejection of new packaging solutions. Grading losses based on size and shape. Ban on using animal by-products in animal feed. 	<ul style="list-style-type: none"> 56, 104, and expert contributions
	Profitability	<ul style="list-style-type: none"> Disposal due to lack of financial penalty. For processors, disposal is often cheaper than using or re-using in industrialized countries which leads to food waste. The introduction of a financial stimulus such as charging for waste disposal on a weight basis might help. 	<ul style="list-style-type: none"> 94, 293, 312, and expert contributions
	Government policy on bio-fuel production & anaerobic digestion	<ul style="list-style-type: none"> The use of waste for higher generation bio-fuel production / anaerobic digestion may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118
	Protection of brand image	<ul style="list-style-type: none"> Reduction of shelf-life to reduce returns and complains. Wastes due to contractual commitments. 	<ul style="list-style-type: none"> Expert contributions
	Customer demand and expectations	<ul style="list-style-type: none"> Customer demand for increased product diversity leading to increased product changeover waste. Quality requirements regarding appearance, whether imposed by European or national legislation or by internal company rules, which stipulate the size and shape of fresh fruit and vegetables in particular, are at the basis of many unnecessary discards, which increase the amount of food wasted. 	<ul style="list-style-type: none"> 339 Expert contributions
Wholesale and logistics	Profitability, costs and benefits	<ul style="list-style-type: none"> The 'disposing is cheaper than using or re-using' attitude in industrialized countries leads to food waste. Retailers and distribution centres do not feel the impact of food waste in their wallets. Charging for waste disposal per kilo might help. Increase of unsold stock because of increasing of costs (e.g. fuel, energy). In order to improve vehicle capacity utilization of backhauls, orders were consolidated for two or three days in the warehouse. This option was cheaper due to low cost of capital of keeping inventory compared to the high freight levels. But this option also could have a negative impact on food waste as the quality and freshness of the food products is decreasing. Any activity that causes rework, unnecessary adjustments or returns. Examples include billing errors, inventory discrepancies and adjustments, and damaged/defective/ wrong/mislabelled product. 	<ul style="list-style-type: none"> 94, 293, 312 Expert contributions 340 341
	Increase of returns/pre-store waste	<ul style="list-style-type: none"> The contract between the wholesale and food stores is of importance for the amount of waste, e.g. bread. Full right to return means the supplier takes back the unsold products without charging the store for the products. The incentive to reduce the waste is minimised. Due to increasing level of quality requirements at retailers, the number of rejections of delivered products is increasing. Products are rejected by retail but sometimes have to be disposed by wholesale/producer. 	<ul style="list-style-type: none"> 341

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future threats of food waste increase</i>	<i>References⁹</i>
	Precautionary measures with respect to public health risks / food safety / quality and the brand image	<ul style="list-style-type: none"> If food is not delivered as it should be, the company's reputation may be affected. To avoid this, companies take precautionary measures - for example, by stating a short expiration date, or by supplying a standard product quality. Criticism with respect to perception of expiration dates: setting an expiration date with such a large margin that the supplier has to start delivering the product differently - for example by packing it differently or supplying it frozen/canned instead of fresh. 	<ul style="list-style-type: none"> 94
	Customer expectations and demand	<ul style="list-style-type: none"> Product variety: Growing customer demand for greater variety of products may increase food waste when retailers try to meet the demand by ordering new products. Due to increasing food intolerances (e.g. lactose, gluten), many different specific food products were and will be introduced to the market in addition to the common ones. Thus, one can choose not only between different "normal" products but also organic, those without lactose, without gluten, low fat, and so on. Increasing consumption of fresh fruits and vegetables requires more transportation and will increase the amount of products damaged in transportation or storage. Product availability: Full shelves expected by customers will lead to increased food waste with growing assortment of products available. Growing amount of fresh-cut produce with shorter self-life (e.g. fruit) may increase amount of food waste. 	<ul style="list-style-type: none"> 5, 21, and expert contributions 21 21 5
Retail and markets	Consumer expectations and demand	<ul style="list-style-type: none"> Product variety: Growing customer demand for greater variety of products may increase food waste since unfamiliar products have higher waste percentages at first and greater varieties slow down throughput speed. A solution would be to make the consumer aware of the fact that this results in a lot of food wasted. Freshness of the products: Retailers counter-bidding with the freshest fruit and vegetable as well as bread and pastry assortment. The value of "fresh" is stressed more and more within TV and radio commercials. Large variations in demand make it difficult for stores to order the right amounts of food. Overstock products: The main obstacle in reducing food waste is the supposed expectation of full shelves with a great variety and "fresh" food. Without changing consumer attitudes, no change in this area is likely. 	<ul style="list-style-type: none"> 5, 21, 94, and expert contributions Expert contributions 21 21
	Returns	<ul style="list-style-type: none"> Retailers have to choose the right quantities per unit time. Shifting waste from in-store to pre-store transfers the costs to the supplier, reducing the retailers' perceived need to reduce waste from grading, or poor ordering, planning, etc. 	<ul style="list-style-type: none"> 21, 251
	Redistribution	<ul style="list-style-type: none"> Risk of a hygienic disaster in the non-profit surplus re-distribution chain – halting donations. Also fraud occurring in the non-profit surplus redistribution chain - halting donations. 	<ul style="list-style-type: none"> Expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future threats of food waste increase</i>	<i>References⁹</i>
	Shelf life, turnover order sizes and pack quantity	<ul style="list-style-type: none"> Shelf life prolongation: Shelf life, turnover and order sizes, all together influence the amount of waste, wherefore waste reduction solutions need to be discussed with simultaneous consideration of all these factors. Examples: Shelf life prolongation through investments in packaging for products with lower turnover may lead to decrease in waste while for the products with higher turnover, increased shelf life has low potential to affect the waste as the food is sold before the best-before date. Large quantity packs cause more wastes. The package opportunities have to cover all kinds of demands from small size to bulk without apparent discounts between them. Lowering the prices of bigger packages and promoting products at lower prices lead to over-buying and more waste generation. Quantity discounts, e.g. price per kg is often much cheaper for large amounts of food Low turnover organic products: There are environmental policies that make decreasing organic range offered by supermarkets impossible while increasing turnover of organic products needs time to be achieved. Large wholesale order quantities: Limited opportunities to order goods in small quantities and only one product per supplier. 	<ul style="list-style-type: none"> 251 21, 180 251 21
	Market strategies	<ul style="list-style-type: none"> Promotions cause waste and therefore a clear promotion planning process can help to reduce the negative impact. Some companies even sacrifice availability during promotions to prevent waste or run promotions constantly. Market Price Fluctuations: Chinese small producers do not get a high enough return for their produce which leads to the situation that they let their harvest products rot. A positive market signal is necessary to change this situation. Marketing standards: Some production is rejected by the supermarkets due to rigorous quality standards concerning weight, size, shape and appearance Increase of short shelf life products: To increase the convenience of the costumer, retailers offer more products ready-to-eat. This means that more and more products have a very short shelf life and have to be wasted if not sold quickly. In addition, people do not want some preservatives added to the products. 	<ul style="list-style-type: none"> 6, 342 18 Expert contributions 6
	Lack of knowledge	<ul style="list-style-type: none"> Lack of knowledge among staff about ordering and how to calculate the correct quantities to order. Increase of the share of unskilled staff at retail due to increasing part-time employment and outsourcing, continuing the trend of the last decade. 	<ul style="list-style-type: none"> 21 Expert contributions
Food Services	Contracts/agreements	<ul style="list-style-type: none"> Due to agreements, the caterer will supply the whole assortment until closing time, which induces lots of waste since either the caterer's profits are too great for waste to matter or the customer is paying, anyway. 	<ul style="list-style-type: none"> Expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future threats of food waste increase</i>	<i>References⁹</i>
	Variety in choices offered	<ul style="list-style-type: none"> Greater variety of choices increases the difficulty of predicting the quantities to need, yet the use of more than one type of meal to be served each day is more and more common. 	<ul style="list-style-type: none"> 293
	Economic considerations: turnover and consumer satisfaction	<ul style="list-style-type: none"> Performance contracts are agreed which reserve a percentage of turnover for the caterer. Accordingly, it is in the caterer's interest to generate more turnover, e.g. through greater variety and making sure not to run out of product despite the likely increase of waste. Suitable counteractions may be highlighting this and affecting the caterer's image or charging for waste disposal by weight. 	<ul style="list-style-type: none"> 94
Households	Pricing strategies	<ul style="list-style-type: none"> Continued emphasis on volume rather than value, to help consumer budgets go further during recession. 	<ul style="list-style-type: none"> Expert contributions
	Education strategy	<ul style="list-style-type: none"> Limited emphasis on food skills in school curriculum / lack of budget & facilities. Lack of adult education opportunities to learn food skills. Increasing disconnection from where food comes from. 	<ul style="list-style-type: none"> Expert contributions
	Health strategy	<ul style="list-style-type: none"> Continued emphasis on reducing obesity / improving health may lead to purchase of products (with good intentions) that are then wasted. Food skills, ability to use fresh food flexibly. Focus on health increases food safety sensitivity (can blur boundary between nutrition / safety / waste behaviours). 	<ul style="list-style-type: none"> Expert contributions
	Standards	<ul style="list-style-type: none"> Ongoing pressure to sell products of high quality (real / perceived consumer demand for this). 	<ul style="list-style-type: none"> Expert contributions
	Funding cuts	<ul style="list-style-type: none"> Public sector funding cuts puts pressure on ability to deliver local community engagement / national waste prevention campaigns / materials for local groups 	<ul style="list-style-type: none"> Expert contributions

3.2.2 Importance of the different food supply chain segments for future threats of food waste increase

In the Institutional Context (Business and Economy) report, following the argumentation already given in § 2.2, no judgements were provided regarding the importance of the different food supply chain segments for future threats of food waste increase.

3.3 Institutional drivers (legislation and policies) of future threats of food waste increase

3.3.1 Identification of drivers

The identified Institutional drivers (related legislation and policies) of future threats of food waste increase along the food supply chain are summarised in Table 3.4.

Primary production: Policies related to fishing and by-catch, bio-fuel production and contracts between suppliers and retailers contribute to food waste generation in the primary production segment.

Processing of farm staples: The institutional threat related to the farm staples segment is, similarly to primary production, related to government policy on bio-fuel production.

Food processing and packaging: Institutional threats in the food processing and packaging segment relate to grading and take back clauses as well as regulatory standards such as the current EU-wide animal feed ban. Taxation policies and the way in which actors perceive the economic value of food waste also represent an institutional threat. Future government policies on bio-fuel production and anaerobic digestion are related.

Wholesale and logistics: If disposal costs remain low there will be a low incentive for actors to change their behaviour and find methods to prevent or recover food waste. Decreasing financial support for distribution of food is another future threat which could lead to increased food waste quantities. Regulatory blockages on the reuse or recovery of food waste could also contributed to increasing food waste.

Retail and markets: A threat is the continued lack of cost accounting for food waste or regulatory incentives to encourage retail and markets actors to reduce food waste generation. Tax or other regulatory blockages for food donation and redistribution are also a continued threat, as well as the end of voluntary agreements and strict food safety standards.

Food Services: Clauses in contracts allow for a large margin and can encourage food wastage, which will continue to increase in the future. Imposing specific regulations could help incentivise food waste prevention by catering and food service organisations. Public procurement laws applying to school canteens can lead to the service of low quality food – a trend leading to increasing food waste.

Households: A future threat related to households is the reduction of public funding for waste prevention initiatives. This is also coupled with continued insufficient budget and emphasis on food skills education. Some diet guidance relating to reducing obesity may have the adverse impact of encouraging consumers to purchase more food which they do not in fact eat and which ends up in the bin.

Table 3.4 – Identified institutional drivers (legislation and policies) of future threats of food waste increase

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future threats of food waste increase</i>	<i>References¹⁰</i>
Primary production	Fishery policies	<ul style="list-style-type: none"> By-catch; It is estimated that in Europe to 60% of the catch are thrown back to the sea, depending on the nature of the fishery. 	<ul style="list-style-type: none"> 317,319
	Government policy on bio-fuel production	<ul style="list-style-type: none"> The use of waste for higher generation bio-fuel production may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118
	Contracts between supplier and retailers	<ul style="list-style-type: none"> Retailer not respecting contracts made with producers. Retailers may break contracts mid season if they get products cheaper from somewhere else. 	<ul style="list-style-type: none"> 291
Processing of farm staples	Government policy on bio-fuel production	<ul style="list-style-type: none"> The use of waste for higher generation bio-fuel production may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118
Food processing and packaging	Take back clause-related losses and other contractual commitments	<ul style="list-style-type: none"> Take-back clauses: contracts between supermarkets and their suppliers may have take-back clauses so that the cost of waste is not necessarily picked up by the supermarket. 	<ul style="list-style-type: none"> 18
	Legislative measures, e.g. regulatory standards	<ul style="list-style-type: none"> Quality requirements regarding appearance, whether imposed by European or national legislation or by internal company rules, which stipulate the size and shape of fresh fruit and vegetables in particular, are at the basis of many unnecessary discards, which increase the amount of food wasted. The proposed review of the EU wide ban on using Animal By-Products in animal feed could be opposed by a number of Member States and as a result the practice of selling abattoir waste for animal feed would continue to be illegal causing this resource to be wasted or to be used as pet food at best, which is a highly inefficient use of such resource. 	<ul style="list-style-type: none"> Expert contributions 312
	Taxation policies	<ul style="list-style-type: none"> Disposal due to lack of financial penalty: For processors, disposing is often cheaper than using or re-using in industrialized countries which leads to food waste. The introduction of a financial stimulus such as charging for waste disposal on a weight basis might help. 	<ul style="list-style-type: none"> 11, 94, 312

¹⁰ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future threats of food waste increase</i>	<i>References¹⁰</i>
	Government policy on bio-fuel production & anaerobic digestion	<ul style="list-style-type: none"> The use of waste for higher generation bio-fuel production / anaerobic digestion may compete with the use of waste / co-products for animal feed leading in turn to a higher value for the waste and a lower incentive to reduce volumes. 	<ul style="list-style-type: none"> 118
Wholesale and logistics	Disposal costs	<ul style="list-style-type: none"> 'Disposing is cheaper than using or re-using' attitude in industrialized countries leads to food waste. Retailers and distribution centres do not feel the impact of food waste in their wallets. Charging for waste disposal per kilo might help. 	<ul style="list-style-type: none"> 94, 293, 312
	Financial support non-profit distribution	<ul style="list-style-type: none"> Reduction in sources of financial support for food banks may limit the potential surplus distribution capacity of these organisations 	<ul style="list-style-type: none"> Expert contributions
	Blockages in alternative use chains	<ul style="list-style-type: none"> By products for example pig ears can go to other markets which use them for human consumption such as China. With the use of private labels though, such by products or all other surplus products resulted from over production may not be sold to other parties and is thrown away. 	<ul style="list-style-type: none"> 94
Retail and markets	Cost of food waste	<ul style="list-style-type: none"> Retailers and distribution centres do not feel the impact of food waste in their wallets. Charging for waste disposal per kilo might help. 	<ul style="list-style-type: none"> 94
	Redistribution	<ul style="list-style-type: none"> Risk of a hygienic disaster in the non-profit surplus re-distribution chain - causing the stop of donations. Also fraud occurring in the non-profit surplus re-distribution chain - causing the stop of donations. Tax on donations appearing in several countries, making transfer of waste for charity purposes an economic loss for companies 	<ul style="list-style-type: none"> Expert contributions Expert contributions
	Ending of voluntary agreements	<ul style="list-style-type: none"> Failure in implementing and improving in the future existing voluntary agreements among stakeholders to reduce and prevent food waste 	<ul style="list-style-type: none"> 312
	Food safety standards	<ul style="list-style-type: none"> Food safety regulations becoming more strict thereby causing more waste in the retail chain. 	<ul style="list-style-type: none"> Expert contributions
Food Services	Public procurement laws	<ul style="list-style-type: none"> The law of public procurement makes it difficult to buy local and ecological food. Instead the most economically advantageous food with less quality is chosen. The food will taste less good than if the raw material was of higher quality. The result is more food waste. 	<ul style="list-style-type: none"> 293
	Contracts	<ul style="list-style-type: none"> Due to agreements the caterer will supply the whole assortment until closing time, which induces lots of waste; margins of catered food versus price of raw materials are so wide that caterers do not care about waste or transfer the cost of food waste to customers. 	<ul style="list-style-type: none"> 94

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future threats of food waste increase</i>	<i>References¹⁰</i>
Households	Public funding	<ul style="list-style-type: none"> Public sector funding cuts puts pressure on ability to deliver local community engagement / national waste prevention campaigns / materials for local groups. This can lead to a reduction of clear messaging to consumers, particularly linked to their waste collection system. 	<ul style="list-style-type: none"> Expert contributions
	Food skills and diet guidance	<ul style="list-style-type: none"> Limited emphasis on food skills in school curriculum / lack of budget & facilities. Lack of adult education opportunities to learn food skills. Increasing disconnection from where food comes from. Continued emphasis on reducing obesity / improving health may lead to purchase of products (with good intentions) that are then wasted. NB links to food skills, ability to use fresh food flexibly. Focus on health increases food safety sensitivity (can blur boundary between nutrition / safety / waste behaviours). 	<ul style="list-style-type: none"> Expert contributions Expert contributions

3.3.2 Importance of the different food supply chain segments for future threats of food waste increase

For institutional future threats related to policy and legislation, key areas of concern seem to be related to the retail and markets segment and the food processing and packaging segment, as reflected in the scores obtained.

The results of the paired comparison are summarised in Table 3.5.

Table 3.5 - Importance of the different food supply chain segments for future threats of food waste increase (Institutional drivers – legislation and policies)

<i>Importance for future threats of food waste increase</i>	<i>Food supply chain segments</i>
High	Food processing and packaging Retail and markets
Moderate	Food services Households
Low	Primary production Processing of farm staples Wholesale and logistics

3.4 Social drivers (consumer behaviours and lifestyles) of future threats of food waste increase

3.4.1 Identification of drivers

The identified Social drivers of future threats of food waste increase along the food supply chain are summarised in Table 3.6.

Primary production: In this stage of supply chain no relevant social drivers identified that directly effect on future threats of food waste increase. This is related to the fact that primary production is the first step in the chain, while social drivers are mostly related to the consumer behaviour which are at the end of the chain.

Processing of farm staples: This is similar to the situation described above.

Food processing and packaging: There is a growing demand for processed food is currently observed. This trend for processed food can result in higher levels of production of food ingredients with more waste.

Wholesale and logistics: In this stage of supply chain no relevant social drivers identified that directly effect on future threats of food waste increase.

Retail and markets: The main social drivers identified in this stage of food supply chain are consumers attitude and consumer preference. Consumers attitude towards food waste is that it is someone else's responsibility. There is a lack of interest that compounded by a feeling that business and retailers are more responsible for the waste problem than consumers. Consumers preference as a driver for food waste increase can be seen in growing customer demand for greater variety of products. This may increase food waste when retailers try to meet the demand by ordering new product. Besides, offering unfamiliar product to customers to increase product variety. Unfamiliar products have higher waste percentage. Consumer's preference for fresh-cut produce with shorter self-life may increase amount of food waste, since it will imply increase in the produce of this type of food.

Food Services: The main social drivers identified in this stage of food supply chain are consumers attitude/preference. Free or all-you-can-eat buffets may furthermore increase the amount of food taken and not consumed by customers. The Doggy-bag taboo: Many see it as a taboo to ask for a doggy bag at a restaurant, even though the food/leftovers are "rightfully" yours to take.

Households: several social drivers have been identified as being of future threats of food waste increase:

-
- *Socio-demographics* drivers such as increase of single person households and food waste from nurseries and hospitals: the ageing population increases the people living in retirement homes and nursery homes.
 - *Awareness* as a driver- where consumers are confused with food waste campaigns (tone, content of consumer-facing food waste campaigns in relation to other food issues or switches them off). Campaigns do not recognize 'real world' lifestyles (time squeeze) that impact on food choices & behaviours. Lack of awareness Link to climate change not clear to consumers (so do not take action). Cannot prioritise actions towards sustainable diet. Information overload leads to paralysis. Lack of clarity around what is the scope of 'waste' e.g. includes food fed to pets, unavoidable, disposed to drain.
 - *Affluence*- Increased affluence reduces incentive to take action to reduce food waste.
 - *Negative consumer stimulation*- Continued emphasis on volume over value in terms of retail sales / household.

Table 3.6 – Identified social drivers of future threats of food waste increase

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Social)</i>	<i>Related examples future threats of food waste increase</i>	<i>References¹¹</i>
Food processing and packaging	Growing demand for processed food	<ul style="list-style-type: none"> Growing demand for processed foods would drive higher levels of production of food ingredients, with more waste. 	<ul style="list-style-type: none"> 21
Retail and markets	Consumers attitude	<ul style="list-style-type: none"> It is someone else's responsibility – attitude Lack of interest that compounded by a feeling that business and retailers are more responsible for the waste problem than consumers 	<ul style="list-style-type: none"> 271
	Consumer preference	<ul style="list-style-type: none"> Growing customer demand for greater variety of products may increase food waste when retailers try to meet the demand by ordering new product. Growing amount of fresh-cut produce with shorter self-life may increase amount of food waste. Offering unfamiliar product to customers to increase product variety. Unfamiliar products have higher waste percentage. 	<ul style="list-style-type: none"> 21
Food Services	Consumer behaviour/ attitude	<ul style="list-style-type: none"> Free or all-you-can-eat buffets may furthermore increase the amount of food taken and not consumed by customers. The Doggy-bag taboo: Many see it as a taboo to ask for a doggy bag at a restaurant, even though the food/leftovers are "rightfully" yours to take. 	<ul style="list-style-type: none"> 87 Expert contributions
Households	Socio-demographics	<ul style="list-style-type: none"> Increase of single person households. Food waste from nursing and hospitals: the ageing population increases the people living in retirement homes and nursery homes. 	<ul style="list-style-type: none"> 29, 106, and expert contributions 82, and expert contributions
	Awareness	<ul style="list-style-type: none"> Tone, content of consumer-facing food waste campaigns confuses consumers (in relation to other food issues) or switches them off. Campaigns do not recognize 'real world' lifestyles (time squeeze) that impact on food choices & behaviours. Emotional connection to certain foods not there (e.g. bakery vs. fruit or animal products). Link to climate change not clear to consumers (so do not take action). Cannot prioritise actions towards sustainable diet. Information overload leads to paralysis. Lack of clarity around what is the scope of 'waste' e.g. includes food fed to pets, unavoidable, disposed to drain. 	<ul style="list-style-type: none"> 29, 106, and expert contributions Expert contributions
	Affluence	<ul style="list-style-type: none"> Increased affluence reduces incentive to take action to reduce food waste. 	<ul style="list-style-type: none"> Expert contributions
	Negative consumer stimulation	<ul style="list-style-type: none"> Continued emphasis on volume over value in terms of retail sales / household portioning. NB links to obesity. 	<ul style="list-style-type: none"> Expert contributions

¹¹ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

3.4.2 Importance of the different food supply chain segments for future threats of food waste increase

Comparing importance of the different food supply chain segments for future possibilities of increasing food waste production with reference to the context category Consumer behaviour and lifestyle, we have given the following judgments:

- in comparison of primary production segment with six other segments food services, retail and households have been considered as highest contributors to the future threats of food waste increase. This is why it is listed as a main food waste driver in Table 3.7 (due to increasing competition between retailers and food services, thus serving more to consumers' needs and preferences, increasing income levels in households, increasing number of one person households, etc.). The other segments have received equal or slightly weak importance;
- in comparison of processing and food staples segment with 5 other segments again food services, retail and households have been considered as having highest importance in creating future threats of food waste increase (due to the same abovementioned reasons), while other segments received equal or slightly weak importance;
- in comparison of retail and markets with food services and households, and households with food services we feel that retail and markets are moderately more important in creating future threats of food waste increase compared to food services, while households have moderate (plus) importance over food services and strong importance over retail markets in increasing production food waste in future (due to lack of awareness among consumers, demographic reasons, affluence, etc.).

The results of the paired comparison are summarised in Table 3.7.

Table 3.7 - Importance of the different food supply chain segments for future threats of food waste increase (Social drivers)

<i>Importance for future threats of food waste increase</i>	<i>Food supply chain segments</i>
High	Households Retail and markets
Moderate	Food services Food processing and packaging
Low	Wholesale and logistics Primary production Processing of farm staples

3.5 Analysis of drivers and forthcoming challenges

3.5.1 The identified drivers and their importance for future threats of food waste increase

The FUSIONS' experts have indicated in total 77 drivers for the future threats of food waste increase. 18 identified drivers are related to technology, 32 to business management and economy, 19 to policy and legislation, and 8 to the social context. The distribution of the identified drivers among the different supply chain segments varies from 7 drivers identified in the Processing of agricultural staples and food service segment, 10 drivers in the Primary production, wholesale and logistics segment, up to 15 drivers in the Retail and markets segment (see Table 3.8).

Table 3.8 - Distribution of the identified drivers of future threats of food waste increase by context category and food chain segment

<i>Food supply chain segments</i>	<i>TECHNOLOGY DRIVERS</i>	<i>INSTITUTIONAL DRIVERS</i>		<i>SOCIAL DRIVERS</i>	<i>Total</i>
		<i>Business</i>	<i>Legislation</i>		
Primary production	2	5	3	0	10
Processing of agricultural staples	3	3	1	0	7
Food processing and packaging	3	6	4	1	14
Wholesale and logistics	3	4	3	0	10
Retail and markets	3	6	4	2	15
Food services	1	3	2	1	7
Households	3	5	2	4	14
Total	18	32	19	8	77

Table 3.9 shows the results of the paired comparisons related to importance of the different food supply chain segments for future threats of food waste increase. It can be observed that, for the Technological drivers, the main threats are perceived to come from the first segments of the food supply chain: the Primary production segment and the Processing of farm staples segment. The importance of perceived threats decreases by advancing towards the intermediate segments (Food processing and packaging, Wholesale and logistics, Retail and markets, Food services) and the final segment (Households).

Regarding the drivers related to Legislation, the major perceived threats result from the Food processing and packaging and the Retail and markets segments. The primary segments (Primary production, Processing of agricultural staples, and Wholesale and logistics) generate the smallest perceived threats, while the final segments (Food services and Households) are considered of moderate importance.

As for the Social drivers, the most important threats are perceived from two final segments of the food supply chain (Retail and Markets and Households). The initial segments (Primary production, Processing of agricultural staples, and Wholesale and logistics) have been judged of low importance and the Food processing and packaging and the Food services segments of moderate importance.

On the whole, the food supply chain segment that has been considered the most problematic for future threats of food waste increase is the Retail and markets segment, which has been perceived of high importance in the Legislation and in the Social contexts and of moderate importance in the Technological context. The Food processing and packaging segment follows with high importance perceived for Legislation and moderate importance in the remaining two category of drivers. On the other side, the Wholesale and logistics segment has been perceived as the less threatening (low importance for the Legislation and the Social drivers and moderate importance for the Technological drivers), it is followed by the Primary production and the Processing of agricultural staples segment (perceived high importance in the technological drivers and low importance in the legislation and social drivers).

It can also be observed that, as in the case of the current causes of food waste (§ 2.5.1), there is a correlation between importance perceived for the different food supply chain segments and the number of drivers identified for each segment (see Table 3.8 and Table 3.9).

Table 3.9 – Relative importance of the different food supply chain segments for future threats of food waste increase, results of paired comparisons*

<i>Food supply chain segments</i>	<i>TECHNOLOGY DRIVERS</i>	<i>INSTITUTIONAL DRIVERS</i>		<i>SOCIAL DRIVERS</i>
		<i>Business</i>	<i>Legislation</i>	
Primary production	High	n.a.	Low	Low
Processing of agricultural staples	High	n.a.	Low	Low
Food processing and packaging	Moderate	n.a.	High	Moderate
Wholesale and logistics	Moderate	n.a.	Low	Low
Retail and markets	Moderate	n.a.	High	High
Food services	Moderate	n.a.	Moderate	Moderate
Households	Low	n.a.	Moderate	High

* Data should be read according to columns and not to rows.

3.5.2 Future threats and forthcoming challenges for technology, business management, policy and consumers

3.5.2.1 Technological drivers

The Technological drivers of future threats of food waste increase should identify some main forthcoming challenges for technology to face changes that are taking place in the current general context in which the food supply chain's firms operate.

For that reason, the 18 identified Technological drivers have been grouped according to the nature of these changes (see Table 3.10), in particular:

- drivers related to changes determined by environmental, policy, and macroeconomic developments;
- drivers related to changes determined by business decisions;
- drivers related to changes determined by consumer choices.

i) Eight identified drivers have been included in the first group (related to changes determined by environmental, policy, and macroeconomic developments). These drivers express concern regarding the

consequences on food waste of four main areas and the technological capacity to respond to their evolution:

- A first area is climate change: the capacity to forecast the potential losses in farm production and the increasing problems for storage of agricultural staples due to adverse climate conditions are the main challenges.
- A second area is globalisation, with technical problems of losses consequent to growing volumes of agricultural products involved in long-distance trade, and especially from countries lacking modern storage and transportation systems.
- The third area is bioenergy policy. The huge European dependence on import of fossil fuels for energy production pressures policy makers to stimulate use of bio-waste for bio-fuel and bio-gas production. This contributes to valorise food waste and may inhibit the current growing concern for reducing wastage in the food processing industries and food services, with consequences on the improvement of food waste reducing technologies.
- The fourth is the policy area driven by the issue of general waste reduction, which encourages measures for limiting the use of packaging in marketed goods. Normally, to "minimise" packaging is considered a waste prevention practice, but in the specific circumstances of the food sector the "minimisation" of packaging may also result in several technical problems such as augmented perishability and reduced shelf life and quality of products, as well as risks for food safety, which are all important factors in food waste generation.

Table 3.10 - Grouping the identified Technological drivers of future threats of food waste increase (see Table 3.1)

<i>1 – Related to changes driven by environmental, policy, and macroeconomic developments*</i>		<i>2 – Related to changes driven by business decisions*</i>		<i>3 – Related to changes driven by consumers' choices*</i>	
Insufficient forethought to climate change	I	Harvesting technology (increase of mechanical harvesting and related losses)	I	Increasing consumption (losses of fresh products in transportation)	IV
Climate change (increase of storage losses related to adverse climate)	II	Lack of suitable technology (for processing non standardised agricultural staples)	III	Increasing demand for greater product variety	IV
Government policy on bio-fuel production	II	New short shelf-life products	IV	Service as business idea (related to increase of product variety)	V
Globalisation (increasing post-harvest losses with growth of imports from developing countries)	II	Better measurement of quality (may increase product recalls)	V	Health products (reduction of salt, sugar, and fats may increase food perishability)	VII
Government policy on bio-fuel production	III	Packaging (related to inappropriate portioning)	V		
Failure of new packaging solutions (trends towards minimal packaging)	III	Increasing poor quality appliances (do not help to reduce waste at home)	VII		
Biogas production	VI				
New packaging (trends towards minimal packaging)	VII				
Total drivers: 8		Total drivers: 6		Total drivers: 4	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

ii) The second group includes the six identified drivers, which can be considered the most related to changes determined by business decisions. In this group a first driver indicates the increasing mechanisation of harvesting, which may augment losses not only in the Primary production segment of the food supply chain, but also in the subsequent segments due to major damages suffered by products. Similarly, the increasing use of mechanisation in the processing of agricultural products may turn in increasing losses due to products with non standard shapes, that are more difficult to be processed by machinery.

Threats of food waste increase from this group of Technological drivers have been also identified in the increased supply of short shelf life products, like fresh fruit and vegetables, dairy products, and other animal products, in the trend to excessive portioning of many packaged products, in the improving capacity of detecting product quality (which may result in augmented recalls of products to avoid risks of no compliance with quality standards).

iii) The third group includes the four identified technological drivers related to changes in consumers' choices. Two of these drivers, in the Wholesale and logistic and in the Retail and market segments of the food supply chain, indicate threats of food waste increase caused by consumer preference for wider possibilities of choice. Also increasing consumption of fresh products has been indicated as a major challenge in the Wholesale and logistics segment, while for the Household segment it has been observed that the tendency to reduce the content of salt, sugar, and fats in food, to accomplish with the rising demand for "healthier" eating, may also reduce food preservability and become a cause of new wastage.

3.5.2.2 *Institutional (business and economy) drivers*

The 32 identified Institutional (business and economy) drivers of future threats of food waste increase have been grouped according to the same criteria used in the previous § 3.5.2.1 for the Technology drivers, i.e.:

- drivers related to changes determined by policy and macroeconomic developments;
- drivers related to changes determined by business decisions;
- drivers related to changes determined by consumers' choices.

The grouping is displayed in Table 3.11.

i) Nine identified drivers have been included in the first group related to changes determined by policy and macroeconomic developments. In contrast to Technological drivers, no drivers related to environmental challenges have been indicated for expected threats of food waste augmentation, and only one driver is related to macroeconomic developments. This one is globalisation and refers to the expected increase in global trade of agricultural staples that may result in augmented waste, especially for fresh products and for products from countries without efficient storage and transportation systems.

The remaining eight drivers of this group refer to developments in policy making and express concern for possible waste increase in the future from: fishery policies, incentives for bio-fuel production from food waste, tightening of food standards, improper tariffs on waste not discouraging food waste generation, public budget cuts reducing awareness campaigns on the issue, and lack of the issue in curricula of schools. Except the last two drivers mentioned, which have been indicated for the Household segment, the other drivers of the first group refers to the first three segments of the food supply chain (Primary production; Processing of agricultural staples; and Food processing and packaging).

ii) a majority of the indicated Institutional (business and economy) drivers of future threats of food waste increase, 15 drivers in total, have been included in the second group collecting the drivers related to changes derived from business decisions. The identified drivers relate to five types of trend:

- Contractual relations along the food supply chain, in which the parts more endowed of bargaining power (mostly the retailers) tend to discharge on the weaker counterparts the costs of waste disposal related to unsold products.

- Risks of penalties and for brand and corporate image related to possibility of not complying with food standard (also unintentionally): it has also been recorded that this risk may inhibit donations aimed at food recovery.
- Priority given to economic issues, like increase of sales and cost reduction, which may impose solutions that are suboptimal from viewpoint of food waste reduction and prevention within the firms.
- Marketing strategies that may induce poor practices and behaviours in final consumers or in other operators of the food supply chain.
- Inadequate training of firms' staff on this specific issue.

Almost all segments of the food supply chain are represented in this group of Institutional (business and economy) drivers, the only exception being the Processing of food staples segment.

iii) The third group of identified Institutional (business and economy) drivers of expected threats of food waste increase refers to changes determined by consumers' choices. It includes 8 drivers. In the first five segments of the food supply chain (from the Primary production segment, up to the Retail and markets segment) the identified drivers indicate generic expectations of consumer demand, which refer to global challenges towards an increase in the consumption of marketed food, not only in quantitative terms, but also in qualitative terms, i.e.: wider assortments of products, more fresh products and higher quality standards. In the Food services segment, the only identified driver of this group refers more specifically to risks in this sector from increasing diversification of the offer in restaurants and canteens. In the Household segment, there are two drivers, which respectively refer to the threats from the changes in consumers habits towards healthier lifestyles and from demand for higher food quality standards.

Table 3.11 - Grouping the identified Institutional drivers (business management and economy) of future threats of food waste increase (see Table 3.3)

<i>1 – Related to changes driven by policy and macroeconomic developments*</i>		<i>2 – Related to changes driven by business decisions*</i>		<i>3 – Related to changes driven by consumers' choices*</i>	
Fishery policies	I	Excessive power of retailers over producers	I	Demand, customer expectations, and the market (related to product standards expected by consumers)	I
Bio-fuel	I	Food safety (risks)	I	Customer demand	II
Government policy on bio-fuel production	II	Contracts between customers and suppliers	III	Customer demand and expectations	III
Profitability / Globalization (waste from increase of traded food staples)	II	Protection of brand image (waste to prevent food quality/safety risks)	III	Customer expectations and demand	IV
EU and national government legislative & taxation policy (packaging, marketing and food safety standards)	III	Profitability, costs and benefits (food waste generated by savings of other more costly factors of production)	IV	Consumer expectations and demand	V
Profitability (related to low cost of disposal due to waste policies)	III	Increase of returns/pre-store waste (related to supplier/retailer contracts)	IV	Variety in choices offered	VI
Government policy on bio-fuel production and anaerobic digestion	III	Precautionary measures with respect to public health risks / food safety / quality and the brand image	IV	Health strategy (trends towards wellness-driven lifestyles)	VII
Education strategy (refers to education policy)	VII	Returns (of unsold food to suppliers)	V	Standards (quality expected by consumers)	VII

1 – Related to changes driven by policy and macroeconomic developments*		2 – Related to changes driven by business decisions*		3 – Related to changes driven by consumers' choices*	
Funding cuts (public budget)	VII	Redistribution (hindrances to redistribution related to food safety risks) V Shelf life, turnover order sizes and pack quantity V Marketing strategies (various types of food retailers' strategies may cause waste) V Lack of knowledge (firms' staff) V Contracts/agreements (imposing caterers too wide assortments of food) VI Economic considerations: turnover and consumer satisfaction (are priorities with respect to reduce food waste) VI Pricing strategies (of retailers stimulate over-shopping) VII			
Total drivers: 9		Total drivers: 15		Total drivers: 8	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

3.5.2.3 Institutional (legislation and policy) drivers

The 19 identified Institutional (legislation and policy) drivers of future threats of food waste increase have been grouped according to the following criteria:

- future threats from current regulations and changes in agri-food policies and legislation;
- future threats from current regulations and changes in other legislation and policies;
- future threats from lack of regulation.

The grouping is displayed in Table 3.12.

i) Regarding the agri-food legislation and policies, the three identified drivers of this group refer to fishery policy and to hindrances to food waste reduction and prevention from quality and safety standards.

ii) Ten identified drivers have been included into the group related to legislation and policies other than agri-food. These drivers indicate threats from challenges regarding:

- bio-fuel and bio-gas policies (three drivers in the first three segments of the food supply chain);
- inadequate taxation of food waste disposal (three drivers);
- increasing cuts in public budgets (may reduce financial support to food redistribution and to awareness campaigns);
- new taxes on donations in some countries (with effects on food redistribution);

iii) The last group, relating to future threats of food waste increase from insufficient regulation, includes 7 identified drivers. Three drivers indicate fears for contractual relations along the food supply chain: as already seen in the previous § 3.5.2.2, the parts more endowed of bargaining power (mostly the retailers) tend to discharge on the weaker counterparts the costs of waste disposal related to unsold products. The remaining four drivers are concerned with: blockages on food waste prevention from non legislative obstacles (like use of overproduction of products under private labels), the ending of voluntary agreements for food waste prevention among the operators of the food supply chain, the lack of references to food waste prevention in public procurements, the need of programmes for reinforcing awareness on the food issues in public education and the emphasis on "healthy" diets in public health campaigns.

Table 3.12 - Grouping the identified Institutional drivers (legislation and policy) of future threats of food waste increase (see Table 3.4)

<i>1 - Future threats from current regulations and changes in agro-food policy and legislation*</i>		<i>2 - Future threats from current regulations and changes in other legislation and policies*</i>		<i>3 - Future threats from insufficient regulation*</i>	
Fishery policies	I	Government policy on bio-fuel production	I	Contracts between supplier and retailers	I
Legislative measures, e.g. regulatory standards (refers to quality standards and to the ban on ABP)	III	Government policy on bio-fuel production	II	Take back clause-related losses and other contractual commitments	III
Food safety standards	V	Government policy on bio-fuel production & anaerobic digestion	III	Blockages in alternative use chains (refers to non legislative limitation to food waste prevention)	IV
		Taxation policies (inadequate taxation on waste disposal)	III	Ending of voluntary agreements (related to food waste prevention/reduction)	V
		Disposal costs	IV	Contracts	VI
		Financial support non-profit distribution (decrease of financial support)	IV	Public procurement laws (do not take care of food waste concerns)	VI
		Redistribution (hindrances to redistribution related to healthy risks and new fiscal policies)	V	Food skills and diet guidance (related to public education policy and public health campaigning)	VII
		Cost of food waste (inadequate taxation of waste disposal)	V		
		Public funding (decrease of)	VII		
Total drivers: 3		Total drivers: 9		Total drivers: 7	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

3.5.2.4 Social drivers

The seven identified Social drivers of future threats of food waste increase have been grouped according to the same criteria already used in the chapter dedicated to the Social drivers of current causes of food waste generation (see § 2.5.2.4):

- future threats related to current social dynamics;
- future threats related to individual behaviours which are not readily changeable;
- future threats related to individual behaviours modifiable through information and increased awareness.

The grouping of the identified drivers is displayed in Table 3.13.

i) The two drivers included in the first group point out the future consequences on food waste generation of current global social dynamics related to increasing urbanization, population ageing and growing of single-person households, which imply growing demand for processed food and for more food variety.

ii) The second group related to future threats from individual behaviours which are not readily changeable includes only one driver concerned with increasing demand for more food variety.

iii) The third group related to individual behaviours modifiable through information and increased awareness includes four drivers which indicate future threats from consumer attitude of not to feel guilty for food wastage, inefficacy of awareness campaigns, reduced incentive to avoid food wastage due to new affluence, and negative influence on consumer behaviours from promotional sales of food and from the practice of selling packaged food in large portions.

Table 3.13 - Grouping the identified Social drivers of future threats of food waste increase (see Table 3.6)

1 – Future threats related to current social dynamics*		2 - Future threats related to individual behaviours which are not readily changeable*		3 - Future threats related to individual behaviours modifiable through information and increased awareness*	
Growing demand for processed food (urbanisation and changing lifestyles)	III	Consumer preference (for wider variety of food)	V	Consumers attitude (do not feel responsible)	V
Socio-demographics (increasing single-person households and population ageing)	VII			Awareness (inefficacy of awareness campaigns)	VII
				Affluence (lessening stimulus to reduce food waste)	VII
				Negative consumer stimulation to over-shopping food (e.g. BOGOF and too large portions)	VII
Total drivers: 2		Total drivers: 1		Total drivers: 4	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

4 Drivers of future possibilities of food waste reduction

4.1 Technological drivers of future possibilities of food waste reduction

4.1.1 Identification of drivers

The identified technological drivers of future possibilities of food waste reduction along the food supply chain are summarised in Table 4.1.

Primary production: Five technological drivers leading to a reduction in food waste were identified for the 'Primary production' segment. All five drivers are related to advances in technology e.g. better storage, better breeding, improved fishing gear. This, of course, is an on-going process and, as with any industry, there will be early adopters of new techniques and those that lag behind.

The research did not identify whether drivers leading to a reduction in food waste would outweigh those likely to cause an increase.

Processing of farm staples: Only one technological driver was identified related to the possibility of a reduction in food waste in the 'Processing of farm staples' segment: 'access to modern equipment and techniques'. This is probably because the current level of waste in this segment is believed to be very low with most non-food fractions utilised as animal feed.

Food processing and packaging: Given the number of reviews and articles in recent years on reducing food waste, it is perhaps not surprising that thirteen individual opportunities for reducing food waste were identified from the literature. All of the individual opportunities can be related to a single technological driver, namely 'access to modern equipment & techniques'.

Opportunities may be related to both the earlier or later stages of the food supply chain e.g. optimisation of packaging and best-before labelling have a direct relationship to the retail stage where the products are displayed and sold.

Wholesale and logistics: The need for advanced packaging materials was mentioned very clearly by the respondents of the data collection. It was the most cited item with respect to opportunities for food waste reduction for wholesale and logistics. The assumption is that advanced packaging could save food from spoilage as long as necessary to bring the food item in best quality to human consumption. Nevertheless, it should be borne in mind that food products are also thrown away although they are fine to eat and if it is the goal to wrap every food item into packaging material. Thus, advanced packaging material could only be part of the solution for pre-processed food or specific food items. Research on 'time temperature indicators' is currently underway. It aims to enable the tracking of temperature changes of food products during the supply chain, facilitating the identification of those areas where food spoilage occurs.

Improved packaging protects food and reduces food waste. New packaging materials can bind oxygen, may kill microbes, absorb ethylene or regulate moisture of the content. Although these technological improvements are developed by research and have to be implemented by producers, the trend could be fostered by request from the wholesale and logistics companies.

Handling of products goes hand in hand with packaging. Poor handling can damage the packaging and accelerate the spoiling of the product. This also includes storage procedures so that the products are stored in the right conditions and transported properly to site.

Raising awareness of the public on the effect of food waste might help in reducing it in the future.

Modern and electronic store management systems can greatly improve waste efficiency in stores. These systems can automatically order new products when they are sold. This removes the human error of over- or under-ordering and the stock should stay at the optimal level. Electronic ordering systems exist today but coming more popular in the future can decrease food waste generation.

Retail and markets: Better inventory management can help retailers to minimize food loss. They have to take account various indicators influencing the shopping behaviour of the consumer, e.g. weather, season, offer of the week, personal attitude. This can make ordering the right amount tricky and retailers usually over order to meet the full shelf expectation of the consumer. New and better refrigeration equipment can improve the shelf-life of products and help to buffer the changes in fluctuating demand.

Improvements in packaging can potentially lengthen the shelf-life of products and help to reduce food waste. Although these technological improvements are developed by research and have to be implemented by producers, the trend could be fostered by request from the retail sector.

Food Services: The suggested new service system for hospitals and workplace canteens lets customers order the food themselves in advance so that they have the amount and food that they want. In hospitals this is important because sick people usually have a reduced appetite so serving standard servings to all patients will lead to greater food waste. In workplace canteens this can possibly reduce food waste when people get food that they like.

Measuring accurately can help to manage food waste and money lost in the process. Accurate information can help to find problem areas where reductions to food waste can be done most efficiently. This is why intelligent scales and advanced statistics are a good way to reduce food waste.

Menu planning or a 'menu less' lunch can help to reduce food by improving the usage of previous days leftovers.

Households: Only a few causes were listed in the household segment both relating to new technology. Ordering from home and having smart appliances to monitor the foods already in the home (in cupboards & the fridge / freezer) can help to decrease food waste by improving meal planning. Improvements in packaging and processing can increase the products' shelf-life at home. Better transportation of goods and supply chain management can further improve shelf-life by reducing dwell time and temperature abuse, for example.

Table 4.1 – Identified technological drivers of future possibilities of food waste reduction

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of future possibilities of food waste reduction</i>	<i>References¹²</i>
Primary production	Good agronomic practices	<ul style="list-style-type: none"> Decrease fungi, toxins and drug contamination. 	<ul style="list-style-type: none"> 132
	Selective fishing gear	<ul style="list-style-type: none"> Developing, using and enforcing more selective fishing gear to reduce by-catch. 	<ul style="list-style-type: none"> 319
	Advances in plant and animal breeding	<ul style="list-style-type: none"> Plant breeding can increase yields and prevents diseases. 	<ul style="list-style-type: none"> 2
	Improved storage	<ul style="list-style-type: none"> Better storage e.g. ethylene control (fruit and vegetables). 	<ul style="list-style-type: none"> Expert contributions
	Development of farm facilities	<ul style="list-style-type: none"> New equipment e.g. mastitis detector. 	<ul style="list-style-type: none"> Expert contributions
Processing of farm staples	Access to modern equipment & techniques	<ul style="list-style-type: none"> Reduced mechanical damage during harvest. Reduced storage losses. Improved oil processing yields through the use of modern techniques (vegetable oil production). Extension of product shelf-life through technological and scientific manipulations on production/processing conditions. 	<ul style="list-style-type: none"> 2, 118
Food processing and packaging	Access to modern equipment & techniques	<ul style="list-style-type: none"> Identification of new markets for co-products. Use of out-graded ('sub-standard') fruits & vegetables. Reduction of off-cuts. Advanced software tools for production planning. Contingency planning for production line stoppages. Cleaning losses due to small batch size and design of the production line. Optimisation and effective use of packaging. Expiry-date / best before labelling. Enhanced / novel food processing techniques. Advances in dairy genomics. Extension of shelf-life. Waste minimization. Use of co-products as a substrate. 	<ul style="list-style-type: none"> 4, 56 164, 293 56 15 70 94 24, 30 24 27 1 82 24, 68, 70 14
Wholesale and logistics	Advanced packaging	<ul style="list-style-type: none"> Proper conservation and transport techniques extend the post-harvest life of foods. To use packaging effectively and responsibly to protect the product and extend its' life. 	<ul style="list-style-type: none"> 84, 166, 167
	Advanced handling	<ul style="list-style-type: none"> Better handling (incl. transport) of food – for example keeping products stored and exposed under right temperature and light, optimal packaging-size, etc. 	<ul style="list-style-type: none"> 58, 163

¹² For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (technology)</i>	<i>Related examples of future possibilities of food waste reduction</i>	<i>References¹²</i>
	Customer Knowledge / Awareness	<ul style="list-style-type: none"> More effort should be made on raising-awareness initiatives to inform about the causes and the effects of food waste, ways to reducing it and how to promote a scientific and civil culture guided by principles of sustainability and solidarity. 	<ul style="list-style-type: none"> 47
	Electronic ordering systems and automatic storage management systems	<ul style="list-style-type: none"> System automatically orders new products, when products are sold, thereby minimizing the risk of fault purchasing which could result in more food waste. Modern storage management systems register a lot of information and also monitor the best before date of products - thus, the human error of forgetting products somewhere in the storage seems to be outdated in some years. 	<ul style="list-style-type: none"> 21, 222 222
	Improved redistribution logistics	<ul style="list-style-type: none"> Development of logistics infrastructure of food banks (warehouses, transportation, etc). 	<ul style="list-style-type: none"> Expert contributions
Retail and markets	New technology	<ul style="list-style-type: none"> Better refrigeration equipment as well as control management 	<ul style="list-style-type: none"> 293
	Better inventory management	<ul style="list-style-type: none"> Management of orders in relation to sale – better predicting of the needs of the customers. Good knowledge of the customer is essential. Cooperation between producer and retailer to find out better material flow without having outdated products. 	<ul style="list-style-type: none"> 2, 87, 222
	Improvements in packaging	<ul style="list-style-type: none"> Improved packaging protects food and reduces food waste. New packaging materials can bind oxygen, may kill microbes, absorb ethylene or regulate moisture of the content. 	<ul style="list-style-type: none"> 87, 166, 167
Food Services	Better Equipment	<ul style="list-style-type: none"> Service equipment, trays, size of the plates and buffet trays. 	<ul style="list-style-type: none"> Expert contributions
	New ordering system for customers	<ul style="list-style-type: none"> New concepts in which patients choose what and how much at eating time (hospitals), and customers choose their lunch one day before knowledge about number of portions (Work place canteens). 	<ul style="list-style-type: none"> 266, 268, 293, 343
	Better measurement systems	<ul style="list-style-type: none"> Intelligent scale and statistics systems can measure food waste and count money and effort 	<ul style="list-style-type: none"> Expert contributions
	Advanced management	<ul style="list-style-type: none"> Careful menu planning or 'menu less' lunch: food left from previous days can be used more efficiently 	<ul style="list-style-type: none"> Expert contributions
Households	New Technology	<ul style="list-style-type: none"> Increase in online shopping / use of smart phones & smart kitchen appliances help with planning food and meals. Food production processes & packaging materials increase shelf life of products. Improved logistics and supply chain management maximizes shelf life for consumers. New intelligent fridges and freezers will display the content and the expiry date of certain food items (freezers will tell householders what products are being stored and potentially alert the householder to the forthcoming expiry date of certain food items) 	<ul style="list-style-type: none"> 116, and expert contributions 19, 231 Expert contributions Expert contributions

4.1.2 Importance of the different food supply chain segments for future possibilities of food waste reduction

The segments were compared in the same manner as described following § 2.1. It was felt that the level of evidence was weaker than found for the current causes although stronger than that found for the possibilities of an increase in food waste.

The best opportunity was thought to be access to new equipment & techniques impacting throughout the entire food supply chain.

The greatest opportunities for reduction in food waste will come from primary production, food processing & packaging, retail and households outweighing any drivers acting in the opposite direction. In the paired comparisons, moderate scores have been assigned to those segments.

The results of the paired comparison are summarised in Table 4.2.

Table 4.2 - Importance of the different food supply chain segments for future possibilities of food waste reduction (technological drivers)

<i>Importance for future possibilities of food waste reduction</i>	<i>Food supply chain segments</i>
High	Primary production Food processing and packaging
Moderate	Retail and markets Households Wholesale and logistics
Low	Processing of farm staples Food services

4.2 Institutional drivers (business management and economy) of future possibilities of food waste reduction

4.2.1 Identification of drivers

The identified institutional drivers (in the field of business and economy) of future possibilities of food waste reduction along the food supply chain are summarised in Table 4.3.

Primary production: Institutional drivers may contribute to reducing food waste in primary production, through efforts such as sales of lower grade products (e.g. as “value ranges”) or developing new types of products. Expanding the range products in fish, for example, would allow more species caught in one net to be saleable and thus reduce the fish considered by-catch. An effective governmental driver may be the fishing policy which, when appropriately revised, could reduce the amount of discarded – i.e. wasted – fish and also contribute to more sustainable fishing operations through e.g. better quotas.

Altering the supply chain is another development that may be driving reduced waste. One aspect would be cutting down the response time within the chain, another – not necessarily separate – consideration is improving the direct communication and cooperation between producers and retailers as this would information to be shared and used to develop better understanding in handling both the products themselves as well as the planning processes, ideally both avoiding overproduction and improving the retailer’s inventory management. Shorter supply chains will decrease the amount of transportation from the farm to the store and minimize the waste from transportation. Also the amount of handling will decrease further reducing product damage and loss.

Processing of farm staples: In agricultural staple processing, a better flow of information and sharing of information can significantly benefit the entire chain, in particular the production in developing countries. Closely related to this is the involvement of scientists in the information sharing and development process, working to reduce waste and production errors as well as to improve food safety through better processes.

However the amount of wastes in the processing of agricultural staples is generally considered to be low; therefore the involvement of legislative and/or taxation policies at the European or national level may be more successful in reducing waste through levying (higher) taxes on landfill use and similar aspects.

A final thought here should be given to the driver profitability which usually is opposed to the idea of reducing waste. But given the right conditions, it can deliver significant opportunities for waste reduction with the rise of commodity prices. One result could be that waste fractions currently considered useless could be turned into profitable by-products, allowing a more complete exploitation of the resource.

Food processing and packaging: An important driver in reducing waste institutionally is provided by the opportunity to spread knowledge and share information more effectively, especially through training of staff, resulting in better implementation of best practices, reduction of mishandling errors, as well as improving order accuracy and storage times.

Streamlining governmental policies and targeting them to the most relevant aspects of food production, i.e. food safety and reducing waste, is an opportunity to concentrate their effect, not least by targeting a

company's profitability. The latter is also an actor in the increasing consolidation of the food manufacturing and processing sector, which can allow e.g. the introduction of modern technology, reducing waste production significantly. Another factor of such consolidation would be that larger batches and production lines would not require frequent changeovers to different recipes with attendant cleaning losses.

Further integration – whether as part of direct consolidation or not – would also allow improved communications, further reducing opportunities for waste production, as well as sharing more information and knowledge along the chain. Better market awareness also feeds into these actions.

Opportunities driven by profitability concerns are also the sale of by-products to places outside Europe with different food preferences as well as usage of lower grade fruit and vegetables. The desire to enhance the brand image through actions appealing to ecologically minded consumers also acts as a driver in this regard.

Wholesale and logistics: Discounts are generally a retail action but can also work at the wholesale level, e.g. to shift product close to the best before or expiry date, to avoid it from becoming waste. Closely related is the driving force of finding alternative uses for such items through (i) last moment efforts as the discount activity, (ii) turning produce into pre-cooked ready meals at a supermarket, and (iii) processing lower graded products, e.g. into meals where the appearance imperfections can no longer be detected. It is here in particular that improved network communication can benefit the discovery and exploitation of such opportunities.

A revision of marketing strategies can also support such endeavors, especially the marketing standards – e.g. company - or region - specific which reinforce the desire for a certain appearance and a high grading result. As difficult as a thorough revision of the standards is likely to be, given in particular the consumer demand and expectation, it is likely to be one of the most powerful factors in reducing waste.

Government influence is a powerful driver as well, given the possible improvement of infrastructure leading to reduced transport and storage times and therefore increased shelf life from the arrival in retail onwards, direction to reduce waste through landfill taxes, but also by encouraging donations to food banks through financial measures.

Retail and markets: Food redistribution programs are powerful drivers for the reduction of waste at the retail level, given that food, which would otherwise be destroyed, can find its way to consumption nonetheless. Problems in this area are possible legal ramifications, as well as a lack of incentives for retailers to join such programs. Appropriate legal actions can improve the situation, as well as the implementation of a centralized food bank organization.

Market demands and strategies can interact on several levels at retail, be it through price reduction on products nearing their expiry date or on damaged products but also through promotional activities. Many of these approaches bear possible risks for the retailer, for instance being seen to sell produce below grade, yet this may be counterbalanced by an increasing public recognition of the problem of waste and in particular, how misleading grading is as to the intrinsic quality of a food product. A further aspect in this regard is taking account of the changing demographics so that bulk purchases may be encouraged, but fewer and fewer customers represent the families for whom bulk purchases are worthwhile; different packaging sizes may be better suited to customers, e.g. single households, but may require appropriate encouragements, for instance financially.

Connected to a better sharing of information and development of knowledge, the forecasting system for orders could improve the prediction of consumer behavior and hence consumption patterns by involving data shared throughout the chain as well as external research. Related to this is the sharing of information on proper maintenance of the food products, disseminated throughout the chain to ensure the best possible quality product reaching the customer.

Finally, an important driver for all other activities, including other drivers, is the question of measuring waste. Key performance indicators allow for the creation of a suitable baseline yet the holistic tracking across the entire chain requires the cooperation of all stakeholders, with all the various factors involved, is a difficult challenge to fully implement. On the other hand, a better indication of where waste occurs to which degree and, ideally, for which reasons allows significant options for waste-reduction interventions.

Food Services: Solutions at the institutional level are:

- a) Introducing new concepts that shift the consumer's decision-making on product and amount as close as possible to the moment of consumption (decoupling point)
- b) Training and education for personnel and awareness for personnel and consumer including appropriate portioning, adjusting to consumer requirements (e.g. in schools, hospitals, and for in-flight meals), cost analysis related to food waste; keeping statistics on the number of guests and consumption of meals, involving staff in budgeting (e.g. cost of waste) and environmental issues which allows keeping track of the waste flows. A reduction of the menu can thus decrease the number of ingredients needed; accordingly, waste from e.g. prepared but not sold items can be reduced.
- c) Creating opportunities for leftovers (policy, doggy bags, changes to food laws which make this difficult), allowing the leftovers to be reused e.g. in making soups, fruit salad, smoothies, and croutons. With proper education in food hygiene, the staff can improve its handling of leftovers. Other opportunities include donating leftovers to food banks or, in schools, allowing teachers and parents to buy food leftovers.

Households: Improve the provision of information to consumers related to how to optimise use of any food waste collection systems. Ensure manufacturers and retailers choose the right date mark for their products, the maximum safe shelf life, and communicate what the date mark means clearly to consumers.

Table 4.3 – Institutional drivers (business and economy) of future possibilities of food waste reduction

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹³</i>
Primary production	Increased use of imperfect fruits and vegetables, and fish and meat by-products	<ul style="list-style-type: none"> • Possibility of selling lower grade products. Product development: e.g. new shape of vegetables or meat, like baby carrots, fish steaks. • Research into the fate of blemished or misshapen but edible food to provide data and hence awareness. 	<ul style="list-style-type: none"> • Expert contributions • 48
	Fishing policy	<ul style="list-style-type: none"> • Reform of the EU Common Fisheries Policy (CFP): a catch quota system would enforce changes in fishing behaviours. 	<ul style="list-style-type: none"> • 55, 319
	Retail variety	<ul style="list-style-type: none"> • Retailer willingness to market a wider range of fish would help to reduce fish waste from by-catch. • Lower demand for cosmetic quality, e.g. off-grade market. 	<ul style="list-style-type: none"> • 319 • Expert contributions
	Responsiveness, shorter supply chain	<ul style="list-style-type: none"> • Regional food networks, leading to less transport and likely reduced wastage short-lived and damaged products 	<ul style="list-style-type: none"> • Expert contributions
	Farm to shop cooperation, information sharing and knowledge development	<ul style="list-style-type: none"> • By creating a better process from farm to shop: <ul style="list-style-type: none"> ◦ improve cooperation; ◦ better planning in the chain from farm to shop; ◦ better inventory management; ◦ better logistics; ◦ co-operation causes improvement of lowering of returns. • Organizing small farmers and diversifying and scaling up their production and marketing. • Marketing cooperatives and improved market facilities. • Develop knowledge and capacity of food chain operators in how to produce safe food. The application of good agricultural and good hygienic practices by all food chain operators to comply with food safety standards and to ensure that the final food is safe for consumers. 	<ul style="list-style-type: none"> • Expert contributions • 1 • 289 • 1
	Regionalization and localization of food production	<ul style="list-style-type: none"> • Local food supply chain: Encourage and support initiatives geared to stimulating sustainable small- and medium-scale production that is linked to local and regional markets and consumption. 	<ul style="list-style-type: none"> • Expert contributions

¹³ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹³</i>
Processing of farm staples	Knowledge & communication	<ul style="list-style-type: none"> Reduced food losses through the production of unsafe food. Implementation of best practice e.g. measuring, auditing. Reduced storage losses. Increased use of by-products. Improved communication between stakeholders. Better interactions between scientists, producers, consumers and farmers. 	<ul style="list-style-type: none"> Expert contributions
	EU & national government legislative and taxation policy	<ul style="list-style-type: none"> Reduced total food waste volumes. 	<ul style="list-style-type: none"> Expert contributions
	Access to finance	<ul style="list-style-type: none"> May allow technological improvements which reduce food losses in processing and storage, especially in developing countries. 	<ul style="list-style-type: none"> Expert contributions
	Profitability	<ul style="list-style-type: none"> Reduced total food waste volumes. Increased use of by-products. Rising commodity prices could make it economic to further process current waste fractions into useful by-products. 	<ul style="list-style-type: none"> Expert contributions
	Raise food safety	<ul style="list-style-type: none"> Develop knowledge and capacity of food chain operators in how to produce safe food. The application of good agricultural and good hygienic practices by all food chain operators to comply with food safety standards and to ensure that the final food protects the consumer. 	<ul style="list-style-type: none"> 1
Food processing and packaging	Knowledge development exchange & communication	<ul style="list-style-type: none"> Maintaining or improving staff skills through formal training and awareness: <ul style="list-style-type: none"> reduced losses due to better communication in the food supply chain; effect on waste due to changes in retailer orders / overproduction; waste minimization. conduct regular food waste audits and set targets; disseminate and encourage best practices; develop knowledge of food chain operators in how to comply with food safety standards and to ensure that the final food is safe. Application of software tools & advanced methods to facilitate better production planning of multiple lines and to avoid over production. Increasing certainty over retailer orders, with no last-minute adjustments, could significantly reduce waste. Improving the ordering system (e.g. by use of computerised forecasting system) and avoiding wastage of seasonal goods by higher forecast accuracy using statistical sales data from the previous years. Use of automatically adjusted reorder point systems to avoid human errors. Better communication in the chain from producer to customer help to reduce the storage time at the manufacturer's site and thus increase the time for which products can stay with consumers. 	<ul style="list-style-type: none"> 1, 56, 83 15, 329, 339 24, 56 315

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹³</i>
	EU & national government legislative and taxation policy	<ul style="list-style-type: none"> Reduce / eliminate standards that are not related to food safety or waste minimization. 	<ul style="list-style-type: none"> Expert contributions
	Access to finance	<ul style="list-style-type: none"> Cleaning losses due to small batch size and design of the production line. Consolidation of the food manufacturing and processing sector. Vertical integration of supply chain. 	<ul style="list-style-type: none"> 94
	Profitability and supply chain structure	<ul style="list-style-type: none"> Use of out-graded ('sub-standard') fruits & vegetables. Voluntary initiatives. Export of by-products. Waste due to changes in retailer orders / overproduction. Waste minimization. Further consolidation of the food manufacturing and processing sector into a smaller number of larger units could increase efficiency of scale and hence reduce waste. Vertical integration of supply chain may reduce waste. One UK supermarket (Morrison's) operates a vertically integrated supply chain. For instance, the supermarket will buy a field of carrots (whole crop purchase) and then use carrots of different qualities for different purposes e.g. lower grade ones are made into soup or used in ready meals. 	<ul style="list-style-type: none"> Expert contributions 56 180
	Enhancement of brand image	<ul style="list-style-type: none"> Voluntary initiatives to reduce environmental impact. Waste minimization. 	<ul style="list-style-type: none"> 56
	Market awareness and demand management	<ul style="list-style-type: none"> Introduction of new value lines for certain fruits and vegetables to minimize grading losses combined with knowledge to consumers about the nutritional value of agricultural products of imperfect size/shape in order to reduce discards. In addition, both commercial and charity organizations could arrange for the collection and sale or use of discarded 'sub-standard' products that are still safe and of good taste and nutritional value. Expiry date / best-before labelling: The expiry date causes wastes due to consumers' hesitation about foods near their expiry date. Various references suggest changing the labelling to "best before", "durable until" or "at least preservable until" to make it clearer to the customer that the product could be consumed also after this date. 	<ul style="list-style-type: none"> 164, 293 21, and expert contributions
Wholesale and logistics	Investments and financial incentives	<ul style="list-style-type: none"> Investment in infrastructure and transportation: governments should improve the infrastructure for roads, energy and markets, allowing for improved storage and cold chain facilities, reduced waiting times, vehicle routing, etc. Reducing time to-market means less cost, reduced energy, and fresher products for sale through innovative logistics strategies. Disposal cost: Introducing landfill tax in countries where it doesn't exist, thereby making waste generation economically less favourable for companies. Incentive for donations through financial law: giving an economic incentive for companies to increase the amount donated to food banks and similar institutions. 	<ul style="list-style-type: none"> 340, 344, 345 Expert contributions 143

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹³</i>
	Find alternative usage	<ul style="list-style-type: none"> Sell products that will soon turn “un-saleable” to e.g. restaurants or produce ready-cooked food. Also through local cooperation between food wholesale and NGOs. Processing out-graded products: Cosmetically imperfect produce is one of the fastest growing sectors of the fresh produce market of the last three years in the UK. In recent years, there has been a marked increase in the demand for cosmetic out-grades in the processing industry. 	<ul style="list-style-type: none"> 21, and expert contributions Expert contributions
	Proper conservation and transport techniques	<ul style="list-style-type: none"> Advance packaging: effective and responsible packaging protects the product and extends its life. Research on ‘time temperature indicators’ currently underway aims to enable the tracking of temperature changes of food products during the supply chain, facilitating the identification of those areas where food spoilage occurs. New packaging materials can bind oxygen, may kill microbes, absorb ethylene or regulate moisture of the content. Requests from wholesalers could promote such developments. 	<ul style="list-style-type: none"> 6, 70, 87, 164, 166
	Communication	<ul style="list-style-type: none"> Improvement of logistics and sharing information with partners along the supply chain. Help to get more frequent deliveries and to order smaller volume per order. 	<ul style="list-style-type: none"> 293
	Marketing strategies and standards	<ul style="list-style-type: none"> Wholesalers have to serve both producers and retailers. Retailers could set marketing standards with lower requirements or use the general marketing standards for other products not effected by legal requirements. Although the decrease of food waste could be measured at the level of primary production and processing of agricultural staples, the prevention measures have to be implemented at the level of retail and markets. It has to be a cooperation between different stakeholders. Discount when “best-before date” is getting closer. This is also mentioned as a draw back in some shops – being afraid that they will not sell goods full-priced, or get a poor reputation. 	<ul style="list-style-type: none"> Expert contributions 21
	Food customized logistics solutions	<ul style="list-style-type: none"> Knowledge on good practices: Develop knowledge and capacity of food chain operators in how to produce safe food. The application of good agricultural and good hygienic practices by all food chain operators to comply with food safety standards and to ensure that the final food protects are safe for the consumer. 	<ul style="list-style-type: none"> 1
Retail and markets	Food redistribution programmes	<ul style="list-style-type: none"> Food redistribution programs are a useful way to reduce waste at the retail level, allowing products near their expiration date to be bought by people with low purchasing power. Centralizing the food bank system, setting up infrastructure to more easily and speedily connect retailer and food bank; this would promote the program as well as the food bank system. Redistribution law: greater spread of the “Good Samaritan Law”, thus limiting risks for donors. In addition, corporate tax breaks for food donations provide an economic incentive for companies to increase the amount donated to food banks and similar institutions. 	<ul style="list-style-type: none"> 21,146, 312 143, 312, and expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹³</i>
	Market demand management and market strategy	<ul style="list-style-type: none"> • Reduced prices to sell best before date products: retailers should substantially lower prices of fresh food when it is close to its sell-before/best-before date to reduce the amount of unsold food discarded and to allow consumers to buy quality food at cheaper prices. • Limit price promotions with volume discounts and large packs or introduce flexible volume discounts. For example, the British supermarket chain Tesco in January 2010 launched a concept called "Buy One, Get One Free Later" for fresh produce. • Introduction of purchase-per-weight of fruits and vegetables. • Retailers bake bread and pastries fresh within their outlets. It is also a measure to decrease waste bread as the demand can be covered onsite within a short time period. Retailers can offer pre-orders to their customers: thus, bread and pastry can be produced just before the consumer arrives, with short handling time due to the use of baking stations. • Local market: increased number of local markets and direct food distribution channels; selling farm crops closer to consumers without having to pass the strict quality standards set up by supermarkets on weight, size and appearance would possibly reduce the amount of rejected crops. This could be achieved through e.g. farmers' markets and farm shops. • Damaged products may be sold at reduced prices to avoid wastage. Packed fruit and vegetables could be unpacked, the spoiled pieces removed and the remaining sold loose as special offer. • Improved packaging sizes: a greater variety of packing sizes on offer might be better suited to the changing needs of the customer, particularly in view of the demographic shift to more single households in Europe. • Promotion campaigns for lower grade fruit and vegetables can reduce grading losses. Despite the decrease of waste being measured at the level of primary production and processing of agricultural staples, the prevention measures have to be implemented at the level of retail and markets. It has to be a cooperation between different stake-holders. • Legal issues on returns/rejections: since retailers in general have been shifting the costs of waste to the suppliers through their policies on returns and rejections, their interest in reducing waste has been limited. Legislative approaches can change that by encouraging or enforcing more fair treatment of the supplier, due to the increased awareness of the public as well as the cancellation of contracts by some large bakery companies. This could also promote greater competition, not least in terms of reducing waste. • Improved packaging protects food and reduces food waste. New packaging materials can bind oxygen, may kill microbes, absorb ethylene or regulate moisture of the content. Research on 'time temperature indicators' currently underway aims to enable the tracking of temperature changes of food products during the supply chain, facilitating the identification of those areas where food spoilage occurs. New packaging material decreases loss of moisture which increases shelf life of bread and pastry without using additional preserving agents. 	<p>18, 21, 83, 146, 251, 312, 334</p> <ul style="list-style-type: none"> • 315 • Expert contributions • 148 • 312, and expert contributions • 83 • 223 • 59, 164, 312 • 18, 148, 346, and expert contributions • 87, 164, 166

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹³</i>
	Alternative use of products	<ul style="list-style-type: none"> Lower grade products may be sold retail to restaurants or be directly used in shop to cook ready-cooked food. 	<ul style="list-style-type: none"> 146, 251, 312
	Forecast/ordering system	<ul style="list-style-type: none"> Management of orders in relation to sales volumes – better predicting of the needs of the customers. Good knowledge of the customer is essential. Cooperation between producer and retailer to find out better material flow without having outdated products. Various indicators influence the shopping behaviour of the consumer, e.g. weather, season, offer of the week, personal attitude. Some of those indicators can be predicted by using technical tools such as software featuring information from last year as well as current data on weather, specific consumer loyalty cards, and so on. More precise prediction of consumer behaviour will improve orders and decrease waste. 	<ul style="list-style-type: none"> 2, 21, 24, 148, 251
	Maintenance of food quality and safety	<ul style="list-style-type: none"> Improved knowledge and capacity of food chain operators in how to produce safe food. The application of good agricultural and good hygienic practices allows all food chain operators to comply with food safety standards and to ensure that the final food protects the consumer. 	<ul style="list-style-type: none"> 21, 148, and expert contributions
	Knowledge development	<ul style="list-style-type: none"> Staff education/better handling: Keeping control of stock and sales statistics as well as good knowledge of customers. Keeping products stored and exposed under right temperature and light, optimal packaging size. Trained staff is seen as a competitive advantage and allows the requirements of customers to be met. Business image and profitability: key performance indicators (for example, tonnes of waste per tonne of product) allow baseline data to be developed against which any progress in reducing waste can be tracked. Supermarket food waste consists mostly of vegetable trimmings and fruit, with some bakery products such as breads and pastries. Food waste from deli and seafood departments is minimal. Increasing transparency in food waste reporting can have phenomenal results. 	<ul style="list-style-type: none"> 21 70, 347, and expert contributions
Food Services	Education and awareness of personnel and consumer	<ul style="list-style-type: none"> Training and education on right portion sizing, cost analysis related to food waste; awareness campaign for consumer and personnel (e.g. monitor waste in public). To allow keeping statistics on the number of guests and consumption of meals, keeping track of the waste flows. Awareness-raising measures by involving staff in budgeting (e.g. cost of waste) and environmental issues. 	<ul style="list-style-type: none"> 1, 8, 21, 310 293
	Decoupling point	<ul style="list-style-type: none"> Decoupling point of offering food as late as possible: <ul style="list-style-type: none"> School: Food should be prepared in the kitchen at the school, in order to better adjust to the number of students each day. Hospital: More choice for patients fits their appetite and reduces waste while increasing patient happiness. Airlines: Ordering flight meals along with flight purchase itself allows better order planning, even granted that it can be changed until 1 or 2 days before the flight. 	<ul style="list-style-type: none"> 293, 343, and expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-business)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹³</i>
	Leftover solutions	<ul style="list-style-type: none"> Change of policy/legislation: introducing doggy bags. Reusing leftovers to e.g. make soups, fruit salad, smoothies, and croutons or donating leftovers to food banks. Education in food hygiene for the staff for correct handling of leftovers. In schools, teachers and parents may be permitted to buy food leftovers (doggy bags: 61% would like to receive a doggy bag if the waiter friendly and of itself offers to pack the extra food in a doggy bag.; restaurants: an average restaurant can reduce its food waste by 20% by making the right choice about the purchase, storage and preparation. Converted in food rubbish, there is 4 tonnes per year. Positive attitude seems to give good results). 	<ul style="list-style-type: none"> 8, 310, 348, and expert contributions
	Menu variety	<ul style="list-style-type: none"> Reduce the menu and thus the number of ingredients needed; accordingly, waste from e.g. prepared but not sold items can be reduced. 	<ul style="list-style-type: none"> 293
	Demand forecasting	<ul style="list-style-type: none"> Better communication between patient needs, the hospitals and the central kitchens has enabled a reduction to some degree of avoidable food waste. 	<ul style="list-style-type: none"> 8
	Supply-based contracts with the requesting party	<ul style="list-style-type: none"> While quantities on sale are contractually negotiated prior to the event and kept on sale throughout it, renegotiations might enable a reduction of waste. 	<ul style="list-style-type: none"> 94
Households	Collection infrastructure	<ul style="list-style-type: none"> Landfill diversion and increased collection infrastructure driving separate collection of food waste in households. If introduced with clear communication about the benefits of reduction, it may lead to a decrease in food waste. Nonetheless, wasteful behaviour may also be legitimized when waste can be converted to energy, & normalised by the collection container size and collection frequency. 	<ul style="list-style-type: none"> Expert contributions
	Application of date marks	<ul style="list-style-type: none"> New regulations (Food Information to Consumer; EU Regulation 1169/2011) drive motivation to review product labelling. Updated definition of 'use by' (unsafe) may lead to more products being placed on the market with a 'best before' date where appropriate. 	<ul style="list-style-type: none"> Expert contributions

4.2.2 Importance of the different food supply chain segments for future possibilities of food waste reduction

In the Institutional Context (Business and Economy) report, following the argumentation already given in § 2.2, no judgements were provided regarding the importance of the different food supply chain segments for future possibilities of food waste reduction.

4.3 Institutional drivers (legislation and policies) of future possibilities of food waste reduction

4.3.1 Identification of drivers

The identified Institutional drivers (related legislation and policies) of future possibilities of food waste reduction along the food supply chain are summarised in Table 4.4.

Primary production: Institutional opportunities related to policy and legislation for reducing food waste, include notably fishing policy and encouraging the development of community supported agriculture initiatives. Other opportunities include putting in place regulations to encourage the sale of fruits and vegetables by weight rather than unit and funding research into the fate of misshapen but edible food to provide data and increase awareness.

Processing of farm staples: The removal of the current EU ban on using animal by-products as feed is an opportunity and generally policy could be oriented to encourage the reuse or recovery of by-products rather than their disposal. Similarly legislative or tax measures aiming to make organisations more aware of their food waste production and encourage reduction activities could be put in place (e.g. separate collection, pay as you throw). Policies could also be put in place to guide investment in agricultural technology in developing countries; however, typically the investment itself would need to come from market actors.

Food processing and packaging: Policies for encouraging the resale or reuse of 'sub-standard' fruit and vegetables which are still safe to eat, as well as reducing or eliminating food standards which are not related to food safety, are future opportunities for reducing waste generated in the food processing and packaging segment.

Wholesale and logistics: For the wholesale and logistics segment, policies for increasing disposal costs (e.g. pay as you throw) and incentives for giving food to redistribution organisations could reduce food waste generated. Government support of infrastructure improvements and encouraging research into advanced packaging could help improve logistics chains and reduce food wastage. Governments can also encourage the development of new business models around imperfect produce, such as ready to eat food or reprocessing into smoothies.

Retail and markets: A number of future opportunities exist for reducing food waste in the retail and markets segment. Implementation of the Good Samaritan Law in more countries can help encourage giving unused food to redistribution organisations. Reducing prices on items beyond their sell before or best before date or selling damaged items at lowered prices can reduce food waste. This is also related to encouraging the alternative use of sub-standard products. Encouraging closer contact between farm crops and consumers can help avoid food loss via marketing standards and help raise the level of food education of consumers. A number of other opportunities exist including flexible promotions, eco labelling for food stores, encouraging the development of advanced packaging, and introducing legislation on the relationship between retailers and suppliers to reduce waste.

Food Services: In the food services segment, key opportunities for reducing food waste include encouraging separate collection and quantification of food waste generated, as well as fostering consumption of leftovers and the use of doggy bags.

Households: In the households segment, providing guidance for consumers on the meaning of date markings could be a large opportunity for reducing food waste given current levels of consumer confusion between the two mandatory date marks. Separate collection and quantification of food waste and supporting programmes on food education and dietary guidance could also contribute to household food waste prevention.

Table 4.4 – Institutional drivers (legislation and policies) of future possibilities of food waste reduction

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹⁴</i>
Primary production	Fishing policy	<ul style="list-style-type: none"> Reform of the CFP: a catch quota system would enforce changes in fishing behaviours, such as improved uptake of more selective gears and spatial or temporal fish avoidance, specifically whether fishermen adapt their fishing practices to avoid capturing fish that might otherwise be discarded. Implementation of this policy would be complicated by the more mixed nature (both politically and biologically) of North Sea fisheries, but the use of real-time area closures, gear modifications, and electronic monitoring systems could help ensure compliance and effectiveness. 	<ul style="list-style-type: none"> 55, 319 317
	Farm to shop cooperation	<ul style="list-style-type: none"> Development of CSA (community supported agriculture) initiatives 	<ul style="list-style-type: none"> Expert contributions
	Selling by weight	<ul style="list-style-type: none"> Selling fruits and vegetables with billing by weight rather than unit price (fruit and vegetables). 	<ul style="list-style-type: none"> 315
	Information / awareness	<ul style="list-style-type: none"> Research into the outcome of blemished or misshapen but edible food to provide data and hence awareness 	<ul style="list-style-type: none"> 48
Processing of farm staples	Use of by-products	<ul style="list-style-type: none"> The OECD could learn from the BRIC countries in using agricultural by-products for animal feed rather than relying so heavily on arable crops (this would reduce the pressure on agricultural production, with animal feed currently accounting for 25% of global food production.). 	<ul style="list-style-type: none"> 18
Food processing and packaging	Policies for resale/use of 'sub-standard' products	<ul style="list-style-type: none"> Policies to encourage the resale, reuse or recovery of discarded 'sub-standard' products that are still safe and of good taste and nutritional value. 	<ul style="list-style-type: none"> 164, 293
	Food standards	<ul style="list-style-type: none"> Reduce / eliminate standards that are not related to food safety. 	<ul style="list-style-type: none"> 124
Wholesale and logistics	Disposal costs	<ul style="list-style-type: none"> Introducing landfill tax in countries where it doesn't exist, thereby making waste generation economically less favourable for companies. 	<ul style="list-style-type: none"> Expert contributions
	Incentive for donations by financial law	<ul style="list-style-type: none"> Giving an economic incentive for companies to increase the amount donated to food banks and similar institutions. Including donations in the calculation of the tax base of companies in France, recently authorized by law, has encouraged distribution to food banks. 	<ul style="list-style-type: none"> 143

¹⁴ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹⁴</i>
	Improving distribution logistics	<ul style="list-style-type: none"> Investment in infrastructure and transportation. Governments should improve the infrastructure for roads, energy and markets. Subsequently, private sector investments can improve storage and cold chain facilities as well as transportation. Improving loading/unloading process to reduce waiting times (e.g. with hiring more staff, improve synchronization of tasks), also temporal order consolidation, vehicle routing and collaboration with other firms to increase capacity utilizations (e.g. through cross docking). With double digit increases in the consumption of perishable foods, it is crucial to reduce time-to-market. Reducing time to-market means less cost, reduced energy and fresher products for sale. This calls for innovative logistics strategies, which will help improve quality by optimizing shelf life and increase revenue and profit. 	<ul style="list-style-type: none"> 344 340 345
	Encouraging research into advanced packaging	<ul style="list-style-type: none"> Proper conservation and transport technology extends the post-harvest life of foods. To use packaging effectively and responsibly to protect the product and extend its life. Research on 'time temperature indicators' currently underway aims to enable the tracking of temperature changes of food products during the supply chain, facilitating the identification of those areas where food spoilage occurs. Improved packaging protects food and reduces food waste. New packaging materials can bind oxygen, may kill microbes, absorb ethylene or regulate moisture of the content. Although these technological improvements are developed by research and have to be implemented by producers, the trend could be fostered by request from wholesale. 	<ul style="list-style-type: none"> 6, 70, 87, 164, 166
	Encourage the development of new business models around imperfect produce	<ul style="list-style-type: none"> Cosmetically imperfect produce is one of the fastest growing sectors of the fresh produce market of the last three years in the UK. In recent years there has been a marked increase in the demand for cosmetic out-grades in the processing industry. Large companies in the UK are using out-grades for producing smoothies and juices. New business models in the UK produce jams and chutneys using surplus from wholesalers and logistics companies. Sell products that are soon turning "un-saleable" to restaurants etc. or use it in the shop to cook ready-cooked food; local cooperation between food wholesale and NGOs 	<ul style="list-style-type: none"> Expert contributions 21, 312, and expert contributions
Retail and markets	Food redistribution programmes	<ul style="list-style-type: none"> Implementation of the Good Samaritan Law in more countries, thereby limiting risks of donors. Introducing corporate tax breaks for food donations as is the case in the USA. The French government recently introduced a tax break for haulage used to transport donated food. Giving an economic incentive for companies to increase the amount donated to food banks and similar institutions. 	<ul style="list-style-type: none"> 143, 312, and expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹⁴</i>
	Reduce prices on sell before / best before date products	<ul style="list-style-type: none"> Changing 'best before' legislation in countries where products which passed their best before date have to be destroyed. Actions towards regulations and politics that might increase the amount of food waste in the retail sector such as the best before dates on eggs (and the like). Sell damaged products for reduced prices, e.g. damaged during transport, to avoid wastage. Packed fruit and vegetables could be unpacked, the spoiled pieces removed and the remaining sold loose as special offer. 	<ul style="list-style-type: none"> 21, and expert contributions 83
	Alternative use of products	<ul style="list-style-type: none"> Sell wonky products to restaurants etc. or use it in the shop to cook ready-cooked food. 	<ul style="list-style-type: none"> 146, 251, 312
	Encourage closer contact between farm production and consumers	<ul style="list-style-type: none"> Increased number of local markets and direct food distribution channels; selling farm crops closer to consumers without having to pass the strict quality standards set up by supermarkets on weight, size and appearance would possibly reduce the amount of rejected crops. This could be achieved through, e.g., farmers markets and farm shops. 	<ul style="list-style-type: none"> 312, and expert contributions
	Limits to price promotions with discounts on volumes	<ul style="list-style-type: none"> Limit price promotions with volume discounts and large packs or introduce flexible volume discounts. The British supermarket chain Tesco in January 2010 launched a concept called "Buy One Get One Free Later" for fresh produce, the consumer gets a volume discount by being able to pick up the pieces of the same product for free later, when they need the product. 	<ul style="list-style-type: none"> 315
	Purchase per weight of fruit and vegetables	<ul style="list-style-type: none"> Introduction of purchase-per-weight of fruits and vegetables 	<ul style="list-style-type: none"> Expert contributions
	Eco-labelling of stores	<ul style="list-style-type: none"> The label gives the store a goal to continue to work with waste minimising actions. Making the store show off their environmental work can work as a positive trademark for the consumers. 	<ul style="list-style-type: none"> 303
	Raising-awareness initiatives	<ul style="list-style-type: none"> More effort should be made on raising-awareness initiatives to inform the public and staff about the causes and the effects of food waste, ways to reducing it and how to promote a scientific and civil culture guided by principles of sustainability and solidarity. Due to the increasing awareness of the topic of food waste by the consumer, it will be more likely to transport information why a product is not available any more without negatively affecting consumer's satisfaction. 	<ul style="list-style-type: none"> 21, 148, and expert contributions

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹⁴</i>
	Sanction unfair deal of big retailers with suppliers	<ul style="list-style-type: none"> Groceries Code Adjudicator Bill introduced in the UK in December 2012. The Adjudicator will have the power to fine large supermarkets who deal with suppliers unfairly, including when retailers cause their supplier to waste large amounts of their product and bear the cost. A new voluntary code of practice was recently introduced into the UK supermarket sector in a bid to ensure the fair treatment of suppliers and address issues hindering competition in the market. As with the Czech legislation, the code attempts to address problems caused to suppliers when retailers pass on excessive risks and unexpected costs to their suppliers, including take-back clauses. Most food retailers in Austria pay money to the supplying bakeries only for the bread and pastry which is sold to the consumer. The return flows of bread and pastry from retail to central bakery production where the products are disposed of have to be paid by the bakery. Thus, the retail has no incentive to reduce the return flow. Due to the increased awareness of public as well as the cancellation of contracts by some large bakery companies in future there could be a change. 	<ul style="list-style-type: none"> 18, 148, 346, and expert contributions
	Improved packaging	<ul style="list-style-type: none"> Improved packaging protects food and reduces food waste. New packaging materials can bind oxygen, may kill microbes, absorb ethylene or regulate moisture of the content. Although these technological improvements are developed by research and have to be implemented by producers, the trend could be fostered by request from retail. Research on 'time temperature indicators' currently underway aims to enable the tracking of temperature changes of food products during the supply chain, facilitating the identification of those areas where food spoilage occurs. New packaging material decreases loss of moisture which increases shelf life of bread and pastry without using additional preserving agents. 	<ul style="list-style-type: none"> 87, 164, 166
Food Services	Encourage separate collection of food waste and quantification	<ul style="list-style-type: none"> Recommendation of separate collection of food waste/ biodegradable waste in member states from households and food service sector. Keep statistics on the number of guests and consumption of meals. Keep track of the waste flows. Having separate collection of food waste will increase the awareness of the staff. Let the staff be involved in the budget and let them understand the economical difference between throwing away food or not. Also involve them in the environmental issues and results of their work. 	<ul style="list-style-type: none"> 8 293

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Institutional-legislation)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹⁴</i>
	Encourage consumption of leftovers and use of doggie bags	<ul style="list-style-type: none"> Use leftovers! Make for example soups , fruit salad, smoothies and croutons; Introduce doggy bags (with information on how to reduce food waste etc); Give leftovers to food banks; change of policy so that food loss can be taken care of (Uppsala municipality policy: food that has left the kitchen is not allowed to return to the kitchen again); education in food hygiene for the teachers/staff for correct handling of leftovers; purchase of refrigerators to all pre-schools divisions so that food can be taken care of; make it possible for teachers/staff and parents to buy food leftovers; the majority of Danes want the good remnants from dinner at the restaurant with home in a doggie bag; by restaurants offer "day residue" menu with remaining ingredients; Doggie bags: 61% would like to receive a doggie bag if the waiter friendly and of itself offers to pack the extra food in a doggy bag. 	<ul style="list-style-type: none"> 8, 310, 348, and expert contributions
Households	Application of date marks	<ul style="list-style-type: none"> New Food Information Regulation provides motivation to review product labelling. Updated definition of 'use by' (unsafe) may lead to more products being placed on the market with a 'best before' where appropriate. 	<ul style="list-style-type: none"> Expert contributions
	Waste collection infrastructure	<ul style="list-style-type: none"> Landfill diversion and increased anaerobic digestion (AD) infrastructure driving household separate collection of food waste. If introduced with clear communication about the benefits of reduction (from reducing waste of avoidable waste),, it may lead to a decrease in food waste. NB it may also legitimise wasteful behaviour especially where energy is produced from the waste. 	<ul style="list-style-type: none"> Expert contributions
	Diet guidance	<ul style="list-style-type: none"> Provide comprehensive food preparation skills & home economics classes (school & adult education). 	<ul style="list-style-type: none"> 230, 235, and expert contributions

4.3.2 Importance of the different food supply chain segments for future possibilities of food waste reduction

For institutional future opportunities related to policy and legislation, key areas for food reduction seem to be related to the retail and market sector. Additional sectors with a strong set of improvement opportunities are food services and wholesale and logistics.

The results of the paired comparison are summarised in Table 4.5.

Table 4.5 - Importance of the different food supply chain segments for future possibilities of food waste reduction (Institutional drivers – legislation and policies)

<i>Importance for future threats of food waste increase</i>	<i>Food supply chain segments</i>
High	Retail and markets Food services
Moderate	Wholesale and logistics Processing of farm staples Food processing and packaging
Low	Primary production Households

4.4 Social drivers (consumer behaviours and lifestyles) of future possibilities of food waste reduction

4.4.1 Identification of drivers

The identified Social drivers of future possibilities of food waste reduction along the food supply chain are summarised in Table 3.6.

Primary production: In this segment consumer awareness / stimulation has been identified one of the main drivers to reduce food waste. The possibilities for future reduction of food waste could be the use of out-graded ('sub-standard') fruits & vegetables by providing knowledge to consumers about the nutritional value of agricultural products of imperfect size/shape in order to reduce discards.

Processing of farm staples, Food processing and packaging and Wholesale and logistics: No important social drivers of future possibilities of food waste reduction were identified in the Social Context for these segments of the food supply chain.

Retail and markets: In this segment Consumer Stimulation has been identified as one of the main drivers to reduce food waste. However, in this case the consumers behaviour and lifestyle itself is not a direct driver that creates opportunities for future reduction of the food waste. In this case the behaviour of retailers impacts the behaviour of consumers that may lead to reduction of food waste, thus it has indirect impact on food waste reduction. More effort should be made on raising-awareness initiatives to inform the public and staff about the causes and the effects of food waste, ways to reducing it and how to promote a scientific and civil culture guided by principles of sustainability and solidarity. Due to the increasing awareness of the topic of food waste by the consumer, it will be more likely to transport information why a product is not available anymore without creating an angry costumer. By increasing awareness on food waste issues consumer may shift to sustainable foods and local markets

Food Services: Stimulating consumers is the main driver related to opportunities of future food waste reduction., Consumer behaviour and lifestyle, however, in this case do not directly create opportunities for food waste reduction, but can be stimulated by means of actions and campaigns to reduce or avoid food waste. This will in its turn lead to changes in consumers' behaviour, thus food waste reduction opportunities.

Households: Creating personal awareness among consumers of the food they are wasting, why it matters, the benefits to the householder of not wasting food and provision of the tips and techniques to take action to reduce food waste (behaviour change) is the main driver related to opportunities of future food waste reduction.

Table 4.6 – Social drivers of future possibilities of food waste reduction

<i>Food supply chain segments</i>	<i>Identified food waste drivers (Social)</i>	<i>Related future possibilities of food waste reduction</i>	<i>References¹⁵</i>
Primary production	Consumer awareness / stimulation	<ul style="list-style-type: none"> • Use of out-graded ('sub-standard') fruits & vegetables- knowledge to consumers about the nutritional value of agricultural products of imperfect size/shape in order to reduce discards. 	<ul style="list-style-type: none"> • 55
Retail and markets	Consumer Stimulation (Positive)	<ul style="list-style-type: none"> • Reduce or eliminate differences in price per kg for packaging items which can lead to over-buying. Expose the goods with the shortest shelf life. Reduce prices to sell-before/best before date products. 	<ul style="list-style-type: none"> • 21
	Consumer Awareness	<ul style="list-style-type: none"> • More effort should be made on raising-awareness initiatives to inform the public and staff about the causes and the effects of food waste, ways to reducing it and how to promote a scientific and civil culture guided by principles of sustainability and solidarity. Due to the increasing awareness on the topic of food waste, consumers would not be disappointed of lacking of specific products when shopping. • Consumer shift to sustainable foods and local markets. 	<ul style="list-style-type: none"> • 21, 148 • 164
Food Services	Consumer Stimulation	<ul style="list-style-type: none"> • Plate waste- better food quality, right portion size and menu choice. • Decoupling point of offering food as late as possible <ul style="list-style-type: none"> ◦ school: Food should be prepared in the kitchen at the school, instead of at another place. This way the amount can be easier adjusted to the number of students each day. ◦ hospital: new concepts are introduced, where patients decide what and how much they eat on the very moment they will eat, and hence it matches their preferences at the right time. ◦ airlines anticipate to food waste by asking people to order meals with their trip, that can be changed until 1 or 2 days before the flight. 	<ul style="list-style-type: none"> • 268 • 293
Households	Awareness	<ul style="list-style-type: none"> • Increased understanding & reality of climate change galvanises consumers to take action. Increased reliance on local food supply chains increases awareness of where food comes from / increasingly consumers 'value' food, and feel guilty when they waste it. • More large-scale campaigns on food waste prevention e.g. UNEP TES (http://www.thinkeatsave.org) put it onto consumers' radar and the media. Environmentally aware consumers may waste less food (be open to environmental messages). • Increased action at the community level (social innovation) leads to high levels of trust towards those promoting food waste prevention awareness & behaviours. Increased inter-generational activity e.g. through social media bridge skills gap. 	<ul style="list-style-type: none"> • 179, and expert contributions • 174, and expert contributions • Expert contributions

¹⁵ For the reference number see in the Bibliography. "Expert contributions" refers to direct experiences reported by the FUSIONS' experts involved in the study.

4.4.2 Importance of the different food supply chain segments for future possibilities of food waste reduction

Comparing importance of the different food supply chain segments for future opportunities of food waste reduction with reference to the context category Consumer behaviour and lifestyle, we have given the following judgments:

- in comparison of primary production segment with six other segments, food services, retail and households have been considered as having highest importance in reduction of food waste (by means of creating awareness among consumers and stimulating consumers over food waste reduction possibilities) The other segments have received equal or moderate importance;
- in comparison of processing and food staples segment with 5 other segments food services, retail and households have been considered as having highest importance in creating possibilities in reduction of waste production (due to the same abovementioned reasons), while other segments received equal or slightly weak importance;
- in comparison of retail and markets with food services and households, and households with food services we feel that retail and markets are moderately more important in creating possibilities for future reduction in waste compared to food services (providing actions to stimulate consumers to reduce food waste), while households have moderate (plus) importance over food services. The importance of households and retail markets in reduction of food waste has been judge equally, since the efforts and opportunities should be mutual between retail and household.

The results of the paired comparison are summarised in Table 4.7.

Table 4.7 - Importance of the different food supply chain segments for future possibilities of food waste reduction (Social drivers)

<i>Importance for future possibilities of food waste reduction</i>	<i>Food supply chain segments</i>
High	Retail and markets Households
Moderate	Food services Food processing and packaging
Low	Primary production Processing of farm staples Wholesale and logistics

4.5 Analysis of drivers and future opportunities

4.5.1 The identified drivers of future possibilities of food waste reduction and their importance along the food supply chain

The FUSIONS' experts have indicated in total 89 drivers for future possibilities of food waste reduction. 20 drivers have been identified in the Technology context, 37 in the Institutional (business management and economy) context, 27 in the Institutional (legislation and policy) context, and five in the Social (consumers behaviours and lifestyle) context. The distribution of the identified drivers among the different supply chain segments varies from seven drivers, identified in the Households segment and in the Processing of agricultural staples segment, to 16 drivers identified in the segments of Primary production, Wholesale and logistics, and to 21 drivers in the Retail and market segment (see Table 4.8).

Table 4.8 - Distribution of the identified drivers of future opportunities of food waste reduction by context category and food supply chain segment

<i>Food supply chain segments</i>	<i>TECHNOLOGY DRIVERS</i>	<i>INSTITUTIONAL DRIVERS</i>		<i>SOCIAL DRIVERS</i>	Total
		<i>Business</i>	<i>Legislation</i>		
Primary production	5	6	4	1	16
Processing of agricultural staples	1	5	1	0	7
Food processing and packaging	1	6	2	0	9
Wholesaling and logistics	5	6	5	0	16
Retail and markets	3	6	10	2	21
Food services	4	6	2	1	13
Households	1	2	3	1	7
Total	20	37	27	5	89

Table 4.9 shows the results of the paired comparisons related to importance of the different food supply chain segments for future possibilities of food waste reduction. It can be observed that, within the Technological context, the main possibilities are expected to come from the early stages of the food supply chain, in particular the Primary production segment and the Food processing and packaging segment. On the contrary, within the Institutional (legislation and policies) context and the Social context, the middle and final segments have been perceived to offer the best opportunities.

On the whole, the food supply chain segments that have been considered the most promising for future possibilities of food waste reduction are the Retail and markets segment, which has been perceived of high importance in the Legislation and in the Social contexts and of moderate importance in the Technological context. The Food processing and packaging segment follows with high importance perceived for the Technological context and moderate importance in the remaining two categories of drivers. On the other side, the Processing of agricultural staples segment could be considered the one which is perceived to offer the less possibilities, since it has been considered of moderate importance for

the Legislation and policy context and of low importance for the Social and for the Technological contexts.

Table 4.9 – Relative importance of the different food supply chain segments for future possibilities of food waste reduction, results of paired comparisons*

<i>Food supply chain segments</i>	<i>TECHNOLOGY DRIVERS</i>	<i>INSTITUTIONAL DRIVERS</i>		<i>SOCIAL DRIVERS</i>
		<i>Business</i>	<i>Legislation</i>	
Primary production	High	n.a.	Low	Low
Processing of agricultural staples	Low	n.a.	Moderate	Low
Food processing and packaging	High	n.a.	Moderate	Moderate
Wholesale and logistics	Moderate	n.a.	Moderate	Low
Retail and markets	Moderate	n.a.	High	High
Food services	Low	n.a.	High	Moderate
Households	Moderate	n.a.	Low	High

* Data should be read according to columns and not to rows.

By observing data in Table 4.8 and Table 4.9, the correlation between the importance perceived for the different food supply chain segments and the number of drivers identified for each segment is less evident than in the previous cases of the current causes of food waste (§ 2.5.1) and the future threats of food waste increase (§ 3.5.1).

4.5.2 Drivers of future opportunities

4.5.2.1 Technological drivers

The 20 identified Technological drivers of future possibilities of food waste reduction have been grouped according to the following criteria (see Table 4.10):

- future possibilities of food waste reduction driven by development of new technology;
- future possibilities of food waste reduction driven by improved use of existing technology;
- future possibilities of food waste reduction driven by improved organisation and skills.

i) Six identified drivers have been included into the first group. In the Primary production segment of the food supply chain they indicate future possibilities of food waste reduction from the development of new selective fishing gear and from advances in plant and animal breeding. Electronic ordering systems and automatic storage management systems are expected to improve the Wholesale and logistics segment. In the Retail and market segment the two indicated drivers refers to new refrigeration technology and improvements in packaging. The last driver, defined as 'new technology' in the Household segment is related to various opportunities: on line shopping and home meal planning; increase of product shelf life from new processing, packaging, and improved logistics; new intelligent fridges.

ii) The second group dedicated to future possibilities of food waste reduction driven by improved use of existing technology includes eight drivers. Two drivers have been identified in the Primary production segment of the food supply chain: they indicate prospects of food waste reduction from improved storage and farm equipment. In the Processing of agricultural staples segment and in the Food processing and packaging segments two drivers, both defined generically 'access to modern equipment and techniques',

have been indicated: they refer to a variety of technical possibilities of food waste reduction which are listed in Table 4.1. In the Wholesale and logistics segment there are three drives which refer to potentials of food waste reduction from improved packaging (proper conservation and transport techniques), product handling, and from improved redistribution logistics of food banks. The last driver of this group is in the Food services segment and refers to better equipment for customers of restaurants and canteens (trays, plates, buffets trays, etc.).

iii) The third group, which refers to possibilities of food waste reduction from improved organisation and skills, includes six technological drivers. Except for 'good agronomic practices' in the first food supply chain segment, all these drivers stress on aspects related to improvement of knowledge and information: 'customer knowledge/awareness' in the Wholesale and logistic segment, 'better inventory management' in the Retail and market segment, and 'new ordering system', 'better measurement systems', and advanced menu planning in the Food services sector.

Table 4.10 - Grouping of the identified Technological drivers of future possibilities of food waste reduction (see Table 4.1)

<i>1 – Possibilities driven by development of new technology*</i>		<i>2 – Possibilities driven by improved use of existing technology*</i>		<i>3 – Possibilities driven by improved organisation and skills*</i>	
Selective fishing gear	I	Improved storage (ethylene control)	I	Good agronomic practices	I
Advances in plant and animal breeding	I	Development of farm facilities (e.g. mastitis detector)	I	Customer knowledge/awareness	IV
Electronic ordering systems and automatic storage management systems	IV	Access to modern equipment and techniques (various items)	II	Better inventory management	V
New technology (refrigeration)	V	Access to modern equipment and techniques (various items)	III	New ordering system for customers	VI
Improvements in packaging	V	Advanced packaging (Proper conservation and transport techniques)	IV	Better measurement systems (intelligent scale and statistics systems)	VI
New Technology (various items)	VII	Advanced handling	IV	Advanced management (menu planning)	VI
		Improved redistribution logistics (of food banks)	IV		
		Better Equipment (trays, plates, buffets trays, etc.)	VI		
Total drivers: 6		Total drivers: 8		Total drivers: 6	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

4.5.2.2 *Institutional (business and economy) drivers*

The 37 identified Institutional (business and economy) drivers of future possibilities of food waste reduction have been grouped according to the following criteria (see Table 4.11):

- future possibilities of food waste reduction driven by policy and macroeconomic developments;
- future possibilities of food waste reduction driven by improvements in organisation and technology;
- future possibilities of food waste reduction driven by improvements in information management, knowledge and awareness.

i) The nine drivers included in the first group mostly indicate possibilities of food waste reduction from policy actions: reform of fishery policy, measures on waste disposal (different taxation and improved waste separation), changes in marketing standards and product labelling, incentives to food redistribution, renegotiation of contracts charging food waste costs on the weaker parts. The only driver related to macroeconomic factors refers to possibilities of food waste reduction related to the increasing trend of food prices.

ii) Out of the 16 identified drivers collected in the second group (food waste reduction from improvements in organisation and technology), five drivers indicate possibilities of food waste reduction related to enhanced utilisation of food that presently is often at risk of disposal: like out-graded and low-graded products, by-products resulting from processing, and leftovers of restaurants and canteens. Four drivers indicate gains related to better organisation of the food supply chain (shorter supply chain, localisation or regionalisation of primary production and processing, vertical and horizontal integration). Two drivers point out technological improvements in processing, storage and refrigeration. There is also emphasis on possibilities of food waste diminution related to ameliorated capacity of complying with food quality and safety standards in various segments of the food supply chain: three drivers underline these prospects. The last two drivers of this group refer to improvements, in the food services segment, from reduction of menu variety and from anticipation of the so-called 'customer order decoupling point'¹⁶ in meal preparation.

iii) The last group of drivers collects the possibilities of food waste reduction related to all kinds of improvements in information management, knowledge and communication along the food supply chain, including the increase in the general awareness and consensus of all stakeholders towards this topic. Twelve identified drivers form this group: four of them refer to the opportunities driven from management and marketing solutions inspired by more careful attention to the food waste issue. These drivers have been identified in the Food processing and packaging segment of the food supply chain (two drivers), and in the Wholesale and logistics and Retail and markets segments. A second sub-group of four identified drivers (in the Primary production, Processing of farm staples, Food processing and packaging, and wholesale and logistics segments) pertain to the field of increased cooperation and sharing of information among the food supply chain. The remainder four identified drivers are concerned with improved capacity of demand and ordering forecasting and with better staff training on food waste problems.

¹⁶ In value chain management the 'customer order decoupling point' is defined as the point of the value chain in which a product is linked to a specific customer order (Olhager, 2012). To anticipate the decoupling point in the catering industry means, for example, that a meal will be prepared only after a specific customer order: this may contribute to reduce food waste.

Table 4.11 - Grouping of the identified Food Waste Institutional (business management and economy) drivers of future possibilities of food waste reduction (see Table 4.3)

<i>1 – Possibilities driven by policy and macroeconomic developments*</i>		<i>2 – Possibilities driven by improvements in organisation and technology*</i>		<i>3 – Possibilities driven by improvements in information management, knowledge and communication*</i>	
Fishing policy (reform)	I	Increased use of imperfect fruits and vegetables, and fish and meat by-products	I	Farm to shop cooperation, information sharing and knowledge development	I
EU and national government legislative and taxation policy (on food waste disposal)	II	Retail variety (increased offer of out-graded products)	I	Knowledge and communication (increased for all stakeholders)	II
Profitability (higher price of foodstuffs)	II	Responsiveness, shorter supply chain	I	Market awareness and demand management (for increased use of out-graded products and improved labelling)	III
EU & national government legislative and taxation policy (eliminate marketing standards)	III	Regionalization and localization of food production	I	Knowledge and communication (increased for all stakeholders)	III
Investments and financial incentives (improved transport infrastructure, incentives to reduce food waste disposal and increase redistribution)	IV	Access to finance (allow technological improvements and reduce losses in processing and storage)	II	Enhancement of brand image (through food waste reduction initiatives)	III
Food redistribution programmes	V	Raise food safety (in food production practices)	II	Communication (improved sharing of information in the food industry logistics)	IV
Supply-based contracts with the requesting party (renegotiation of)	VI	Access to finance (to improve technology and vertical integration)	III	Marketing strategies and standards (more aware of food waste issues)	IV
Collection infrastructure (improved waste separation)	VII	Profitability and supply chain structure (horizontal and vertical integration of the food supply chain)	III	Forecast/ordering system (improvement of)	V
Application of date marks (more proper date labelling)	VII	Alternative usage of out-graded products	IV	Knowledge development (improvement of staff training and information systems)	V
		Proper conservation and transport techniques	IV	Market demand management and market strategy (more attentive to food waste reduction)	V
		Food customized logistics solutions (more attentive to food safety)	IV	Education and awareness of personnel and consumer	VI
		Alternative use of products (low graded products)	V	Demand forecasting (improved in hospitals)	VI
		Maintenance of food quality and safety (improvement of capacity to comply with food safety standards)	V		
		Decoupling point anticipation (preparing meals as late as possible)	VI		

<i>1 – Possibilities driven by policy and macroeconomic developments*</i>	<i>2 – Possibilities driven by improvements in organisation and technology*</i>	<i>3 – Possibilities driven by improvements in information management, knowledge and communication*</i>
	Leftover solutions (reuse of leftovers and doggy bags) VI Menu variety (reduction of) VI	
Total drivers: 9	Total drivers: 16	Total drivers: 12

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

4.5.2.3 Institutional (legislation and policy) drivers

The 27 identified Institutional (legislation and policy) drivers of future possibilities of food waste reduction have been grouped according to the following criteria:

- the first group of identified drivers indicates the improvements in current legislation and policy that may offer future possibilities of food waste reduction;
- the second group of drivers is related to future possibilities of food waste reduction from new (non regulatory) initiatives undertaken by governments;
- the third group of drivers refers to new initiatives voluntarily undertaken by enterprises, individuals, and grassroots movements which may contribute to food waste reduction in the future.

Table 4.12 shows the grouping of the 27 identified Institutional (*legislation and policy*) drivers.

i) The first group includes 11 drivers. A majority of these drivers indicates possibilities of foods waste reduction from changes in legislation stimulating an increase in the utilisation of food products which are presently destined for disposal. In particular: two drivers point out interventions favouring the resale and use of sub-standard products, also by eliminating all food standards not related to food safety; two drivers suggest legislation initiatives favouring donations and redistribution of food, e.g. through an easing of taxation; two drivers recommend actions on date labelling addressed to improve information on the real meaning of "best before" and "use by" dates; a last driver propose measures to increase the use of food by-products in animal feed production. A second topic emphasised by the drivers of this group is the waste policy as a tool to improve awareness on the food waste issue: in particular there are two drivers respectively calling for tax increase on disposal and for separate food waste collection. The last two drivers indicate possibilities of food waste reduction from a reform of the Common Fishery Policy aimed at limiting by-catches, and from the setting of sanctions against unfair deals of big retailers with suppliers.

ii) The second group, which refers to possibilities of food waste reduction from non-regulatory government actions, includes seven drivers. Three of these drivers relates to actions addressed to improve people's information and awareness on different aspects of the food waste issue: e.g. about blemished or misshapen but edible fruit, or regarding the opportunities from improving food skills and culture of population through the education policy. Three drivers of the second group deal with more technical subjects: amelioration of distribution logistics, infrastructures for waste collection (favouring separate collection) and research into advanced packaging. The last driver calls governments to encourage development of new business models on utilisation of imperfect and downgraded foodstuffs.

Table 4.12 - Grouping of the identified Food Waste Institutional (legislation and policy) drivers of future possibilities of food waste reduction (see Table 4.4)

<i>1 - Future possibilities from improvements in current regulations and policies*</i>		<i>2 - Future possibilities from (non regulatory) initiatives undertaken by governments*</i>		<i>3 - Future possibilities from new initiatives undertaken by enterprises and society*</i>	
Fishing policy (reform)	I	Information / awareness (about imperfect fruit and vegetables)	I	Farm to shop cooperation (community supported agriculture initiatives)	I
Use of by-products (for animal feed production)	II	Improving distribution logistics	IV	Selling by weight (fruit and vegetables, not by piece)	I
Policies for resale/use of 'sub-standard' products	III	Encouraging research into advanced packaging	IV	Alternative use of products	V
Food standards (eliminate food standards non related to safety)	III	Encourage the development of new business models around imperfect produce	IV	Encourage closer contact between farm production and consumers (farmers markets and farm shops)	V
Disposal costs (landfill tax increase)	IV	Raising-awareness initiatives	V	Limits to price promotions with discounts on volumes (by retailers' initiatives)	V
Incentive for donations by financial law	IV	Waste collection infrastructure (improving waste separation)	VII	Purchase per weight of fruit and vegetables	V
Food redistribution programmes (new legislation for)	V	Diet guidance (education programmes)	VII	Eco-labelling of stores	V
Reduce prices on sell before/best before date products (interventions in legislation)	V			Improved packaging	V
Sanction unfair deal of big retailers with suppliers	V			Encourage consumption of leftovers and use of doggie bags (voluntary initiatives)	VI
Encourage separate collection of food waste and quantification (through improved legislation)	VI				
Application of date marks (new regulation on food information)	VII				
Total drivers: 11		Total drivers: 7		Total drivers: 9	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

iii) The third group includes nine identified Institutional (legislation and policy) drivers which are related to future possibilities of food waste reduction from new initiatives undertaken by enterprises, individuals and grassroots movements. On the one side, a majority of these drivers indicate initiatives to be launched by enterprises: four drivers refers to marketing matters, like selling fruit by mass and not by piece (mentioned twice), limit promotions with discounts on volumes, and eco-labelling of stores; two drivers refers to technology and organisation of production (development of alternative use of products and improved packaging). On the other side, three identified drivers are related to initiatives requiring active involvement or, at least, improved awareness of consumers: implementation of community

supported agriculture initiatives, development of farmers markets and farm shops, and encouragement to consumption of leftovers and use of doggy bags.

4.5.2.4 Social drivers

Only five Social drivers of future possibilities of food waste reduction have been identified. All these drivers insist on opportunities related to an improved behaviour of consumers towards food waste. A distinction could be set on the causes of that progress and two groups of drivers were formed:

- possibilities of food waste reduction from improved consumers' behaviour directly induced by food waste information and campaigning;
- possibilities of food waste reduction from improved consumers' behaviour not directly induced by food waste campaigning;

Table 4.13 shows the grouping of the identified Social drivers.

i) The first group collects the drivers related to possible positive effects of increased information and campaigning against food waste and for a better use of food resources. The group includes three drivers identified in the Primary production, Retail and markets, and Households segments.

ii) The second group refers to effects of improved consumer behaviour not directly induced by food waste campaigning. It includes two drivers, identified in the Retail and markets and Food services segments. They relate to possibilities of improved consumers' awareness towards food waste induced by good marketing practices of retailers (e.g.: do not implement strategies which can induce to over-buying; expose the goods with the shortest shelf life; reduce prices of the goods which are close to the use-by or to the best-before date), or by good practices of caterers (improved quality, correct portioning, and anticipation of customer order decoupling point).

Table 4.13 - Grouping of the identified Food Waste Social drivers of future possibilities of food waste reduction (see Table 4.6)

<i>1 – Possibilities from improved consumers' behaviour directly induced by food waste information and campaigning*</i>		<i>2 – Possibilities from improved consumers' behaviour not directly induced by food waste campaigning*</i>	
Consumer Awareness/Stimulation (better information on consumption of sub-standard fruit and vegetables)	I	Consumer Stimulation (marketing strategies stimulating correct behaviours of consumers)	V
Consumer Awareness (information campaigns)	V	Consumer Stimulation (by improved quality, correct portioning and anticipation of customer order decoupling point)	VI
Awareness (by information, campaigning, and social innovation initiatives)	VII		
Total drivers: 3		Total drivers: 2	

* The Roman Numerals indicate the food supply chain segment in which each driver has been identified: I) Primary production; II) Processing of agricultural staples; III) Food processing and packaging; IV) Wholesale and logistics; V) Retail and markets; VI) Food services; VII) Households.

5 Conclusions

5.1 Main results

The FUSIONS' experts participating to the inventory, which was the main source of this study, listed 286 items classified as current causes for food waste, 133 items representing possible threats of food waste increase in the future, and 178 items indicating possibilities for reduction. On this basis, the experts reporting on the three context categories identified 105 drivers of current food waste causes, 77 drivers of future threats of food waste increase, and 89 drivers for future possibilities of reduction. Table 5.1 shows how the identified drivers are distributed among the different segments of the food supply chain.

Table 5.1 – Number of food waste drivers identified in the different segments of the food supply chain

<i>Food supply chain segments</i>	<i>Drivers of current food waste causes</i>	<i>Drivers of future threats of food waste increase</i>	<i>Drivers of future possibilities of food waste reduction</i>
Primary production	17	10	16
Processing of agricultural staples	9	7	7
Food processing and packaging	14	14	9
Wholesaling and logistics	15	10	16
Retail and markets	18	15	21
Food services	13	7	13
Households	19	14	7
Total	105	77	89

Although the identified drivers can provide only a partial picture of the food waste issue – these drivers are the outcome of a qualitative study, essentially set on the subjective evaluations of the experts involved – they are based on an inventory of food waste causes, which may be considered a unique and comprehensive overview not yet present in the scientific literature. On these premises, the identified drivers testify a wide and multifaceted problem, which involves deeply and in very intricate ways all the

segments of the food supply chain, from the primary production in farms, up to final consumption in the food services and in the households. If we consider, as we did in this study, the food supply chain as a whole, there are not one or few main determinants clearly definable for food wastage that come into sight, but wastage results from a complex pattern of extremely diversified and interconnected causes.

A common point is that, at the present time, a considerable wastage of resources seems to be inherent to industrial production, processing and distribution of food destined to large urban markets and mass consumption. The impressive growth of productivity, that has taken place in the agricultural and food sector in the last century, allowed an increasing industrialisation and urbanisation of society, made the organisation of the supply chain much more complex, and multiplied the possibilities for wastage to occur.

These types of phenomena are not limited to the food sector. The industrial production and massive consumption of goods and services often imply important waste of resources. A remarkable example is in the energy sector: despite being so critical for the whole economic system and the awareness that it basically depends on non-renewable sources, about 54% of the energy globally generated from all the different sources is estimated to be lost and the ratio seems to be higher in the most industrialised countries¹⁷ (Smith C. *et al.*, 2011).

Table 5.2 – Criteria chosen to group the identified drivers within the different Context categories. Table 5.2 displays the criteria utilised to group the identified drivers within the examined Context categories and sub-categories. In these conclusions it could be useful to show a crosswise classification indicating priorities for possible actions by individual stakeholders, interest groups, and policy makers aimed at reducing the current generation of food waste. If we consider the current food waste causes, it is possible to distinguish:

- A. Food waste related to the characteristics of food products and the ways through which they have to be produced and consumed (perishability of food, limited predictability of supply and demand, limited capacity of control on many factors of production that constrains the possibility to adapt quickly the supply to the evolution of demand, limited possibility of consumers to accumulate individual stocks of food, etc.);
- B. Food waste related to social factors and dynamics in population habits and lifestyles non readily changeable (for example: single-person households, young age of household members, young couples with small children, increased consumption of meals out-home, etc. These are all factors and developments that result positively correlated with food waste generation);
- C. Food waste related to individual behaviours of consumers non readily changeable (this refers to behaviours depending on general expectations of consumers towards food, for example: good aspect, freshness, possibility of acceding to broad quantities and varieties of food independently on places, season, and time, etc. These expectations determine behaviours in both the consumers and the food supply chain operator that generate wastage. Progress in technology and management can deal with the problem, but its originating causes – the consumers' expectations – are unlikely eradicable).
- D. Food waste related to other priorities targeted by private and public stakeholders (the possibility of generating food waste may be a minor concern with respect to other priorities of the private and public stakeholders. For example, for private companies profit is a first priority and this justifies choices in technology, management, and marketing solutions that balance potential wastage of food with increase of product sales, reduction of production costs or diminished risks of damages to the company's brand image from non-complying with safety or other commercial standards. For public authorities legislative provisions improving issues like food safety, food security, consumer information, and animal welfare may overcome the worry for a potential generation of food waste derived from the implementation of such legislation).
- E. 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 (this group includes a wide

¹⁷ For example energy losses are 63% in the USA and France, 58% in the UK and Japan, and 56% in Germany.

range of food waste causes that could be considerably reduced by improving technological and organisational efficiency of supply chain operators, the quality of legislative provisions potentially implying impacts on food waste, and the consumer behaviours and attitudes towards food.

The probability to modify the causes of foods waste in the above list is increasing from A to E. In the first part of the list most of the potential change lays in technological innovations that ease the constraints related to intrinsic characteristics of food products and to the ways they have to be produced and used. At the end of the list, changes are potentially more feasible, since they largely depend on improvement of efficiency along the food supply chain through correct application of available technology, better organisation, more accurate policy design, and increased consumer awareness.

This listing of food waste causes indicates that it is unlikely that food wastage may be completely eradicated in the future, but it also suggests that a lot could be done in a relatively short term. The extreme complexity of the food supply chain does not allow easy solutions applicable to all circumstances.

The causes of wastage need to be clearly identified within each single activity and process of the supply chain. It is then necessary to set very specific proceedings for monitoring food waste generation in the different chain segments and in each type of activity, and find out appropriate methods for any single situation. This will be mostly a task of individual operators: companies, researchers, campaigners, and consumers. The task of public authorities and policy makers will be to create a framework to enable society to undertake the necessary engagement to prevent and reduce a largely avoidable wastage of resources.

Table 5.2 – Criteria chosen to group the identified drivers within the different Context categories

<i>Context category</i>	<i>Drivers of current causes of food waste</i>	<i>Drivers of future threats of food waste increase</i>	<i>Drivers of future possibilities of food waste reduction</i>
Technological	Drivers inherent to characteristics of food, and of its production and consumption, where technologies have become limiting	Future threats related to changes driven by environmental, policy, and macroeconomic developments	Future possibilities driven by development of new technology
	Drivers related to collateral effects of modern technologies	Future threats related to changes driven by business decisions	Future possibilities driven by improved use of existing technology
	Drivers related to suboptimal use of, and mistakes in the use of food processing technology and chain management	Future threats related to changes driven by consumers' choices	Future possibilities driven by improved organisation and skills
Institutional (business management)	Drivers not easily addressable by management solutions	Future threats related to changes driven by policy and macroeconomic developments	Future possibilities driven by policy and macroeconomic trends
	Drivers addressable at macro level	Future threats related to changes driven by business decisions	Future possibilities driven by improvements in organisation and technology
	Drivers addressable within the business units	Future threats related to changes driven by consumers' choices	Future possibilities driven by improvements in information management, knowledge and communication
Institutional (legislation and policy)	Agricultural policy and quality standards	Future threats from current regulations and changes in agro-food policy and legislation	Future possibilities from improvements in current regulations and policies
	Food safety, consumer health, and animal welfare policies	Future threats from current regulations and changes in other legislation and policies	Future possibilities from (non regulatory) initiatives undertaken by governments
	Waste policy, tax, and other legislation	Future threats from insufficient regulation	Future possibilities from new initiatives undertaken by enterprises and society
Social	Drivers related to social dynamics not readily changeable	Future threats related to current social dynamics	Future possibilities from improved consumers' behaviour directly induced by food waste information and campaigning
	Drivers related to individual behaviours which are not readily changeable	Future threats related to individual behaviours which are not readily changeable	Future possibilities from improved consumers' behaviour not directly induced by food waste campaigning
	Drivers related to individual behaviours modifiable through information and increased awareness	Future threats related to individual behaviours modifiable through information and increased awareness	-

5.2 Limitations of the study

This final section of the Conclusions Chapter specifies the main limitations of the study, which also serves to indicate improvements for possible follow up research on food waste drivers.

Qualitative analysis and subjectivity of results

The study was set on the information provided by the FUSIONS' experts on the basis of their personal experience (i.e. previous studies performed, knowledge of scientific literature, initiatives for food waste prevention and reduction, etc.). Therefore, it was primarily a qualitative research and its results relate to perceptions, opinions, and judgements of individual experts. For this reasons the study did not aim to achieve an objectively complete identification and classification of the food waste drivers, but to collect and group, into drivers and driver Categories, a wide exemplification of food waste causes, future threats and possibilities of reduction derived from the know-how of the FUSIONS network.

Time extent planned for the task

The time extent originally planned for the completion of the study resulted relatively short with respect to the work load that was necessary to develop the research.

Overlaps and duplications among experts' contributions

Major difficulties were encountered in structuring a coherent framework to organise the information and the different contributions coming from the FUSIONS' experts. Despite the effort made to provide guidelines, appropriate formats for data collection, and templates to standardise the intermediate reports, it was not possible to avoid some overlaps and duplications among the experts' contributions, and imprecise categorisation of several items, for example:

- in various cases, a current cause of food waste (or a driver of current food waste causes) identified in a given segment of the food supply chain was also indicated in other segments, and the same can be found for the future threats of food waste increase and the future possibilities of food waste reduction (and respective drivers);
- some drivers of current food waste causes classified in a given Context category were also classified in other Context categories, similarly it happened for some drivers of future threats of food waste increase and of future possibilities of food waste reduction. The overlap among the Context categories has been particularly remarkable between the two sub-categories of Institutional drivers, i.e.: (i) Business management and economy and (ii) Legislation and policies. But a number of drivers belonging to the Technological and Social Contexts have been also indicated within the Business sub-category;
- some current causes of food waste and respective drivers were also indicated among the future threats of food waste increase. This does not match the aim of the distinction that was made between the current food waste causes and the future threats of increase. The formers were intended as producing effects in the present time, the latter as potential causes of food waste discernible in current patterns, but in producing their effects only in the future. An example are the current debates and claims for reducing packaging, that could induce policy makers to undertake specific measures in the future and create concern for potential effects on food waste.

In these cases, it seems that the intermediate reports - organised in two hierarchical levels: Segment Reports and Context Category Reports - did not filter the basic information from the questionnaires as they were expected to do.

Imprecise definition of drivers

In some cases, in the intermediate reports, the indicated drivers do not seem to be the factors at the origin of specific food waste causes, future threats, or possibilities for reduction. Instead, they seem to be by themselves the specific causes, the threats, or the possibilities for reduction¹⁸. In other cases, the drivers were indicated too generically, so that the links with specific food waste causes future threats, or possibilities for reduction were unclear¹⁹.

Non completely homogeneous interpretation of concepts used in the analysis

The problems of overlapping and imprecise definition of drivers, mentioned above, could be related to a non-completely homogeneous interpretation among the contributing experts of some basic concepts introduced for the analysis, such as “drivers”, “food supply chain Segments”, “Context categories” and “sub-categories”, etc. Although the study was essentially qualitative, and therefore largely conditioned by subjective evaluations and by accuracy of individuals in performing their respective assignments, a wider time extent for the study would have maybe allowed a deeper preliminary discussion on those aspects and led to a more shared understanding.

Paired comparisons based on qualitative judgements

A further aspect of the qualitative nature of the study regards the analysis on the relative importance of the different food supply chain Segments for current food waste causes, future threats, and future possibilities of reduction. Since this exercise was based on paired comparisons among the different Segments performed through expert judgements, it was conditioned by the personal experience of the experts and also by quantity and quality of the information collected for the study: i.e. by the number of current causes, future threats and possibilities for reduction identified by the experts who provided the primary information in the initial inventory, and by the accuracy of integrations made by the experts responsible for the analysis of the food supply chain Segments and the Context categories.

Transmission of food waste generation effects along the food supply chain

The food waste generated in a specific Segment of the food supply chain is not rarely driven by factors originated in other Segments of the chain. Some information was requested and provided on this aspect in the Context Category Reports, but the level of detail of the collected information and the time extent available for the study did not allow any relevant analysis. However, the transmission of food waste generation effects along the food supply chain is an issue which deserves an accurate investigation.

¹⁸ For example: “Milk waste caused by drug contamination” was indicated among the technological drivers of food waste. Maybe a definition like “Contamination of livestock products from drugs used in animal husbandry” would have been more appropriate and comprehensive.

¹⁹ Examples are drivers indicated as “Consumer behavior”, “Consumer attitude”, “Firm profit”, which do not specify anything about which aspect of consumers’ behavior and attitude or firm’s profit search are at the origin of a particular food waste cause of future threat.

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A. Numbered references

The numbered references match the quotations of current food waste causes, future threats of food waste increase, and future possibilities of food waste reduction reported in the tables of the Technical, Institutional and Social drivers of § 2, 3, and 4.

The list of the numbered references includes 171 references in total, which are enumerated from 1, to 348. The references enumerated from 1, to 327 use the same the numbering as FUSIONS Literature Database (updated at April 2013), the references enumerated from 328, to 348 had not yet been inventoried in the FUSIONS database when this text was written. All the numbered references are also reported in alphabetical order in the § 'B. Complete bibliography'.

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Title: Drivers of current food waste generation, threats of future increase and opportunities for reduction

The aim of this study was to identify the main causes of food waste generation along the food supply chain and how current trends in technology, food chain management and legislation, and consumers' behaviours and lifestyles will increase or reduce food waste in the future.

The whole food supply chain was analysed horizontally – by chain segment: from farms' production, up to households' consumption – and vertically by establishing three context categories: the Technological context, the Institutional context (referred to business management, economy, legislation, and policy), and the Social context (referred to consumer behaviours and lifestyles).

The main current causes of food waste generation, future threats of food waste increase, and possibilities for reduction were inventoried by chain segment and context category: 597 items were collected. This account was principally based on the available scientific literature. The collected entries were drawn from 171 different bibliographic references, but also from the experience of the specialists involved in the study.

The analysis of the inventory led to the identification of the food waste drivers, which have been classified according to possible strategies of intervention and type of legislation and policy involved depending on the concerned context categories.

Massimo Canali

Università di Bologna – Dipartimento di Scienze e Tecnologie Agro-Alimentari

Viale Fanin 50 – Bologna (40127) ITALIA

Phone +39 366 906 97 96;

E-mail: massimo.canali2@unibo.it;

Website: <http://www.unibo.it/docenti/massimo.canali2>

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