



Food and Agriculture
Organization of the
United Nations

Working paper

Background paper on the economics of food loss and waste



Global Initiative
on Food Loss
and Waste Reduction

SAVE FOOD: Global Initiative on Food Loss and Waste Reduction

**Background paper on the economics
of food loss and waste**

Working paper

by

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ROME, 2014

This document is unedited and made available as presented by its authors.

Acknowledgements

For their thoughtful comments and feedback on earlier drafts of this paper, appreciation is extended to Nomathemba Mhlanga, Camelia Bucatariu, Robert van Otterdijk, Dominique Van Der Mensbrugge, Seth Meyer, Piero Conforti and Lorenzo Giovanni Bellù.

Recommended citation

Segrè A., Falasconi L., Politano A., Vittuari M. 2014. Background paper on the economics of food loss and waste (unedited working paper). Rome, FAO.

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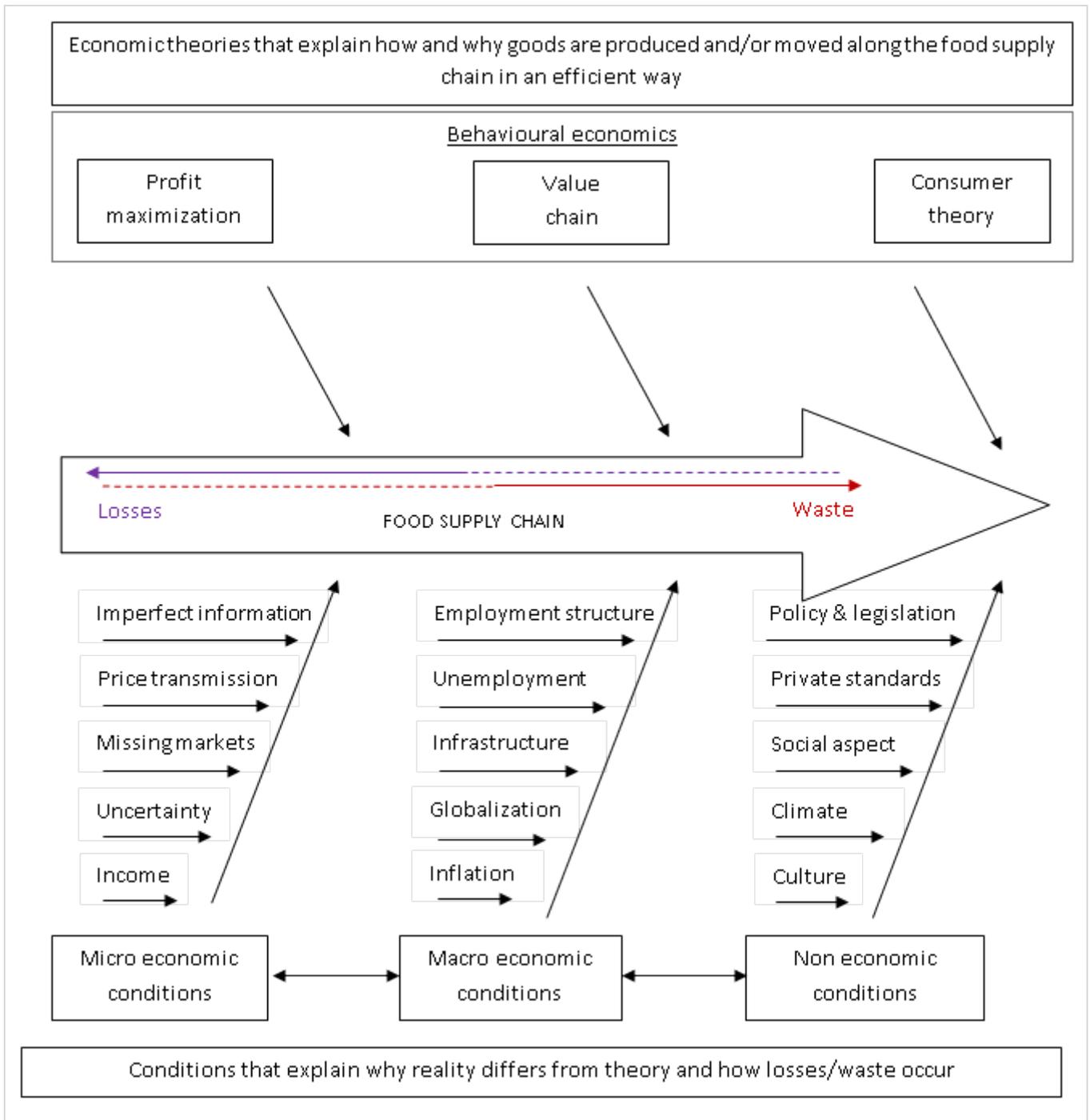
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KEY MESSAGES

Basic conditions that explain the formation of food losses and waste



Note: Also appears as Figure 2 in the main document

Source: author's elaboration

Microeconomic, macroeconomic and non economic conditions for the formation of food losses and waste

Food Losses				Food Waste	
Farming industry	Post Harvest	Food processing Industry	Wholesaling Supermarkets	Food services	Domestic consumption

a) Microeconomic drivers

Production theory and profit maximization

Information asymmetry or imperfect information; uncertainty; inefficient mechanism of price transmission; elasticity; weak competitiveness; low level of technology innovation; limited market access; inappropriate food contact materials (FCM); weak management capacity (bad planned procurement and weak stock management); not reaching “optimal efficiency” in agri-food products.

Value chains: inadequate storage; imperfect information; lack of access to financial resources; missing markets; out-dated technology; lack of technical knowledge or lack of access to technical knowledge; limited market access; out-dated, inadequate or inefficient production and harvest techniques; transportation of food over long distances; technology innovation; other, as all elements that could impact on the value chain efficiency.

Consumer theory: distance of the real consumer from the “ideal consumer” with a “representative behaviour” suggested by the neoclassical theory; low planning capacity; new values guiding consumer choices (aesthetic characteristics, social status/prestige); relationship between low purchasing power and the consumption of low nutritional food; new food preferences; increased opportunity cost related to housework and food preparation; high use of precooked and ready to eat products; portion size; lack of information related to food labels, standards and expiration dates.

Behavioural economics: decisions are taken on the basis of intuition and previous experiences rather than following a strict optimization scheme; two utility functions: expected utility and effective utility; goods are created by economic agents other than those expressing the preferences therefore they might not respond to the real needs; traditional theory does not investigate the relationship between performances and needs. Lack of capacity for medium to long term evaluation of investment and return on investment opportunity.

b) Macroeconomic conditions

Infrastructure: improvement of harvest techniques in absence of relevant infrastructural investments; lack of links between producers and consumers; lack of market access and knowledge; lack of links with international markets and weak local policies that lead to a failure in infrastructural investments; lack of infrastructure that allow farmers to search new products and diversify their activities.

Employment structure: changes in the employment structure and decline of work force engaged in the agricultural sector and related rural – urban migration; implications of the transformation of the social organization on consumption habits, food related needs and diets (increased consumption of meat, fish, fresh fruit and vegetables with a decline in starchy food staples. Shift towards more perishable products and shorter shelf life items); loss of labour force in the post-harvest segment of the food supply chain with potential implications for the organization of the work; lack of skills and knowledge among the operators of the agri-food supply chain (as well as among consumers); high labour cost with a consequent staff reduction to manage damaged or imperfect products; unemployment has an effect similar to inflation determining a reduction of consumer purchasing power with a consequent contraction and re-orientation of consumption.

Trade and globalization: rise of global supply chains characterized by complex logistics and increased distances between the actors involved in the different production phases; processed food imports and the development of retail chains in low-income countries might have an impact on local food systems reducing the competitiveness of local producers that do not meet certain quality and

safety standards; lack of integration among the segments of the food supply chain.

Food price inflation: food price inflation might cause inability to allocate the entire food production on the market, a reduction and re-orientation of consumer choices and preferences, a progressive reduction in the consumption of certain typology of products (i.e. meat, fish and other more expensive food items), increased preference of consumers on discounts and special offers with a potential effect on consumers' planning capacity.

c) Non-economic conditions

Cultural dimension and capacity

Lack of knowledge about the characteristic of a certain product might lead to difficulties in combining it with other ingredients; reduced cooking skills; lack of capacity of reducing waste by combining leftovers from previous meals or creating meals from available ingredients; bad food management due to a changing cultural environment leading to food related differences; bad planning due to weddings, religious and traditional holidays (might cause overproduction); life style lead to changes in consumption and food preferences; generational change can have an impact on food preferences and the overall approach to food (including food related skills); low price and high availability of food might cause a decline of the non-economic (environmental, ethical, social) value of food.

Social dimension

Household composition (size, education, age, job, sex); lack of experience in planning/ preparing meals; uncertainty in the number of meals at home per week; reduced information and knowledge; living standards and new life style; low civic sense and institutional trust; low perception of the impact of food loss and waste; gender roles.

Environment and climate

Weather adversities; natural disasters; climate change; seasonality; slow and

inadequate governmental responses to climate change; lack of farmer responses to climate change; lack of innovation and climate smart agricultural practices.

Policy

Inadequately designed subsidies to production (i.e. direct subsidies to production); lack of capacity to provide agro meteorological forecasts; lack of capacity to provide price forecasts; poor information; lack of preparedness or delays in adaptation to climate change; absence or poor insurance schemes or strategies for risk reduction. Weak horizontal and vertical coordination.

Legislation

Ineffective legislation and regulation on food safety and quality standards; unclear labels; lack of harmonization, information and implementation capacity of different labels (i.e. "best before", "use by").

Private standards

Aesthetic or functional standards set by producers and retailers.

Source: author's elaboration

Note: Also appears as Table 4 in the main document

1. INTRODUCTION

Estimates by FAO (2011a) that the world loses or wastes nearly a third of the food produced for human consumption has sent shock waves across the globe and led to calls for action by world leaders and civil society groups. What exacerbates the concern is that the food loss and waste is occurring at a time of increasing food prices and worsening food insecurity for many. The issue is of high importance for FAO in its efforts to combat hunger, food insecurity and malnutrition, at the same time enabling inclusive and efficient agricultural and food systems. Food losses and waste have a negative impact on the environment since they represent a waste of production factors and energy resources, and contribute to greenhouse gasses emissions. Consequently, the issue relates to the third goal of FAO to promote the sustainable management and utilization of natural resources, for the benefit of present and future generations.

It is against this background that FAO launched the Global Initiative on Food Loss and Waste Reduction (also called SAVE FOOD) in 2011 jointly with the private sector trade fair organizer Messe Düsseldorf GmbH¹. The initiative comprises four dynamically inter-related pillar of undertaking research and assessments, supporting evidence based policies, strategies and programmes; awareness raising; and the supporting pillar of coordination and collaboration of worldwide initiatives and partnership.

Under the initiative, there have been attempts to define and delineate between food losses and waste. Food loss refers to the decrease in edible food mass available for human consumption throughout the different segments of the supply chain. In addition to quantitative loss, food products can also face a deterioration of quality, leading to a loss of economic and nutritional value. Food waste refers to food losses resulting from decisions to discard food that still has value. Food waste is most often associated with the behaviour of the retailers of the food service sector and of the consumers, but food waste and losses take place all along food supply chains (FAO, 2012).

¹ SAVE FOOD: Global Initiative on Food Loss and Waste Reduction - www.save-food.org/

Food loss is mainly caused by inefficiencies in the use and allocation of resources along the food supply chain, like poor infrastructure and logistics, lack of technology, insufficient skills, and knowledge and management capacity of supply chain actors, as well as poor access to markets. In addition, natural disasters, weather and climatic conditions, negative economic trends might play a role too.

Food waste relates mainly to the behaviour of retailers and consumers and it is a major problem at the global level, since throwing away food is often cheaper than using or re-using, and in many situations - mainly, but not only, in industrialized nations - consumers can afford to waste food. Food waste is a major concern as more and more countries become urbanized. The world population is expected to increase by 2.3 billion by 2050, passing from 7.0 billion to 9.3 billion (United Nations, 2011). The *2011 Revision of the World Urbanization prospects* acknowledged that half of the population of Asia is expected to live in urban areas by 2020, while Africa is likely to reach a 50 percent urbanization rate in 2035. Population growth is becoming largely an urban phenomenon concentrated in the developing world (David Satterthwaite, 2007). Urbanization is expected to keep on rising in both the more developed and the less developed regions so that, by 2050, urban dwellers will likely account for 86 percent of the population in the more developed regions and for 64 percent in the less developed ones. Overall, the world population is expected to be 67 percent urban in 2050 (United Nations, 2012) putting more pressure on dwindling resources to feed the growing population.

A fundamental question on food loss and waste is on economic and market conditions that explain them. Essentially, why these losses and waste occur given the rational behaviour expected of farmers, firms, consumers, and other stakeholders along agri-food supply chains. Moreover, we live in a world of scarce resources. This background paper is an attempt to shed light on this question.

2. OBJECTIVES, ORGANIZATION AND METHODOLOGY OF THE STUDY

The general purpose of the study is threefold:

- i. Conceptualise food losses and waste in terms of micro, macro and non-economic conditions that can explain them;
- ii. Establish a theoretical framework for quantitative studies on the economic impacts of food losses and food waste, for example the role of imperfect information, missing markets, uncertainty, price transmission etc.;
- iii. Identify necessary and sufficient conditions for food losses and waste prevention and reduction and elucidate potential policy levers that would help minimization.²

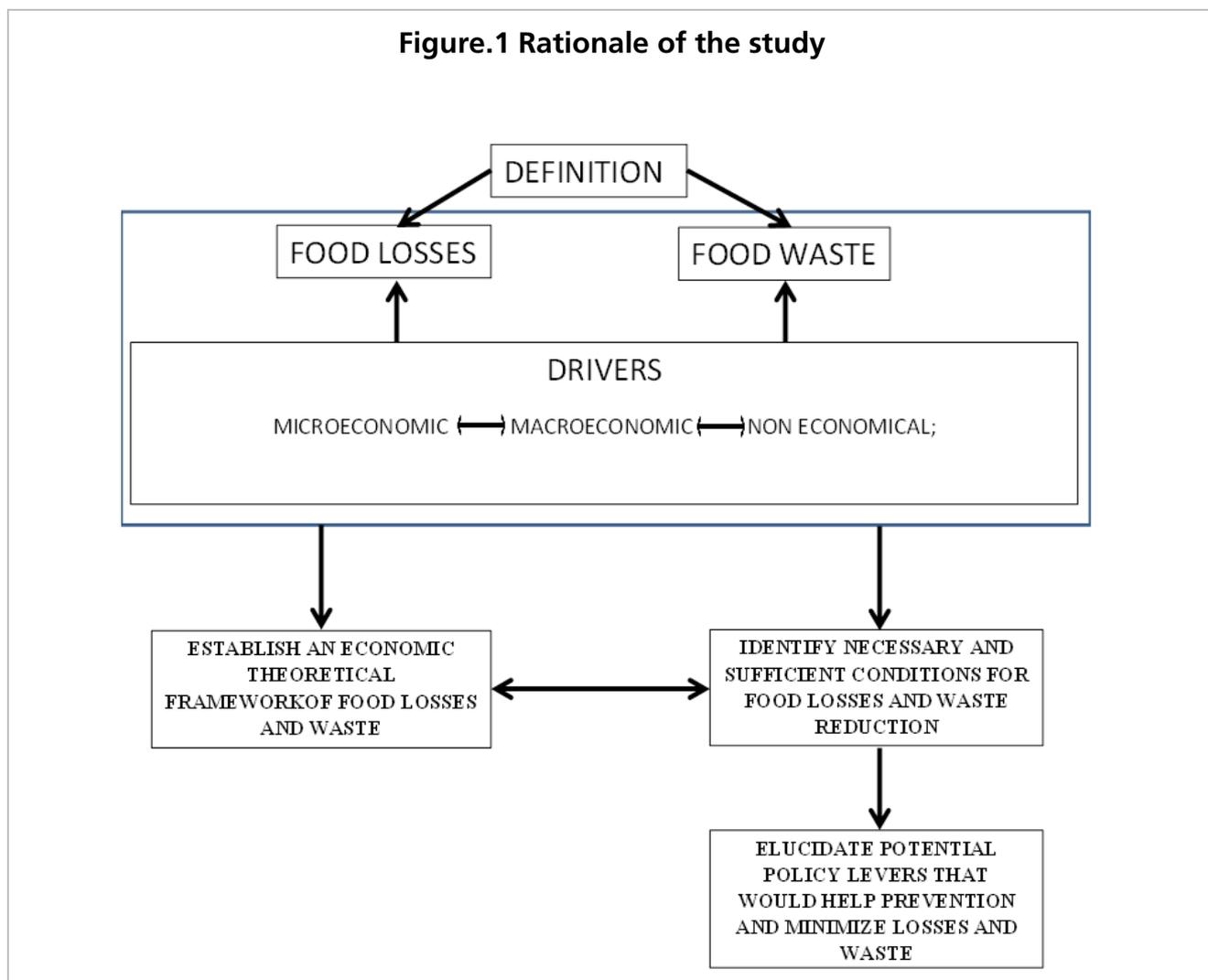
The study finds its basis in the definition of food losses and waste (Section 3) in order to achieve a better identification of boundary issues and to analyse the economic and non-economic conditions that contribute to the occurrence of food losses and waste (Section 4 and 5).

Looking at some of the major economic theories, this paper investigates how production, prices, income, consumption are tied to food losses and waste behaviour. Due to the complexity of the relationships characterizing the supply chain and the implications related to a number of sub-disciplines of the economic theory, the analysis will focus on four main theoretical approaches: production theory, value chain analysis, consumer theory and behavioural economics. Such limitation imply the risk to fail the identification of implications related to other theoretical approaches, but at the same time it allows a more in-depth focus on some of the most important theories for the field under investigation. Furthermore, the study tries to identify the necessary conditions and the policy levers to prevent and/or reduce food losses and waste (Section 7), while Section 8 concludes.

Overall, the research benefits from a literature review that is based on collection, analysis, cross-checking and validation of available data from articles, publications, official databases,

² It is known a priori that zero loss and waste are not economically feasible but there seems to be a general consensus that there is room for reducing food losses and waste.

and reports by international organizations. The theoretical analysis is complemented by examples of initiatives that can provide potential solutions and additional insights on the subject. Figure 1 provides a schematic illustration of the study.



Source: Author's elaboration

3. DEFINITION OF FOOD LOSSES AND WASTE

There is a rather wide literature on food losses and waste, but there is no general consensus over a common definition. Differences in definitions have significant implication in methodological design, data collection, data analysis and interpretation. Largely two major groups can be identified: those definitions attempting to locate food losses and waste along the food supply chain and those mainly focusing on the distinction between edible and inedible food losses and waste. A third (rather limited) group includes definitions that take into account potential yield and over-nutrition as a form of food loss and waste.

Looking at the first group of definitions attempting to identify food losses and waste along the food supply chain, a definition of food loss given by FAO includes all agri-food products intended for human consumption that are instead discarded, lost, degraded or consumed by pests at any stage of the food chain (FAO, 1981). In a more recent study FAO proposes a distinction between food losses and food waste: "*food losses take place during agricultural production, post-harvest, and processing stages in the food supply chain*", while "*food waste occurs at the end of the food chain (distribution, sale and final consumption)*" the former is due mainly to logistical and infrastructural limitations, while the latter is primarily related to behavioural factors (FAO, 2011a P. 2).

Grolleaud (2002) also stress that "*food losses refer to the decrease in food quantity or quality, which makes it unfit for human consumption*" (Grolleaud, 2002). Parfitt et al (2010) adopts this definition and applies the term food waste to the later stages of the food supply chain, and explains that food waste generally relates to behavioural issues. Food losses/spoilage, conversely, relate to systems that require investment in infrastructure (Parfitt et al., 2010 p. 3066).

The Agricultural and Rural Commission of the European Parliament defines food waste as the "*whole of the discarded products of the food supply chain which, for economic or aesthetic reasons, or for closeness to the expiry date, despite still being edible and therefore potentially intended for human consumption, in the absence of a possible alternative use, are eliminated and disposed of, producing negative effects from the environmental point of view, economic costs and missed revenue for companies*" (European Parliament, 2011).

The second group of definitions focuses on the distinction between edible and inedible food losses and waste. For instance, the Environmental Protection Agency (EPA) of the United States identifies food waste as "*uneaten food and food preparation waste from residences and commercial establishments such as grocery stores, restaurants, bars, and company cafeterias*" (EPA, 1997 P. 11). For the California Department of Resources Recycling and Recovery (CalRecycle), the definition of food waste is equal to that of food scraps. Therefore, by food waste it is intended any discarded food, including overproduction, leftovers, unsold food (for example remains such as onion skins or carrot tips), as well as any leftovers in dishes (CalRecycle, 2009). This last definition specifically includes the edible food that becomes waste because it is not used by the final consumer (avoidable waste from eaten food), and the inedible scraps (unavoidable waste from eaten food).

This approach and classification has been taken over also by the Waste and Resources Action Program (WRAP). WRAP clusters households food and drink waste into three groups according to its avoidability: avoidable, possibly avoidable and unavoidable. The first two categories are composed of "*edible food waste*" and include or food that is thrown away that was, at some point prior to disposal, edible (e.g. slices of bread, apples, meat), or food that some people eat and others do not (e.g. bread crusts, potato skins). The third category is composed of "*inedible food waste*" that includes waste arising from food preparation that is not, and has not, been edible under normal circumstances (e.g. bones, egg shells, pineapple skins) (WRAP, 2009).

The concept of "inedible" food losses and waste might have different implications in the different stages of the agri-food supply chain. The "optimal efficiency" of an agri-food product may not be reached if derived raw materials such as bones and egg shells are considered inedible at all stages. For example, fish bones that are a rich source of micro-nutrients or the heads/eyes of the fish that are a valuable source of essential fatty acids could be used as a raw material to be processed for human consumption if the appropriate technology is available and the market allows its integration. Another raw material of a high nutritional value is blood. Nutritional deficiencies such as iron and vitamin A have great impact on the productivity of a human being. In this sense the boundaries of the definition of what should be considered "inedible" needs to be contextualized based on food safety, available technologies, culture and consumption trends and the forecasted innovations

The USDA's Economic Research Service (ERS), developed methods to adjust food availability data for spoilage and other losses in the mid-1990s and rectified the official statistics on food availability in the USA. ERS has identified three different types of losses recorded along the food supply chain: (i) losses from primary (e.g., farm) to retail weight; (ii) losses at the retail level; and (iii) losses at the consumer level both at home and out of the home (e.g., restaurants, fast-food outlets, etc.). The latter phase includes edible food that becomes waste because it is not eaten by the final consumer (cooking losses and uneaten food such as plate waste) "*from the edible share*", avoidable or possibly avoidable waste from eaten food, and the inedible scraps (e.g., asparagus stalk, apple core, unavoidable waste from eaten food).

The third group of definitions that considers over-nutrition as a form of food waste considers food waste as an individual's excessive nutrition, or the difference between the energy value of consumed food per capita and what a person really needs (Smil 2004). There is a heated debate and controversy on the appropriateness of these definitions particularly as they relate to the complex issue of obesity.

The present study is based on the revised version of the definition that FAO proposed in 2011. Food Loss and Waste refer to the decrease in mass (quantitative) or nutritional value (qualitative) of food -edible parts- throughout the supply chain that was intended for human consumption. Food that was originally meant for human consumption but which gets out the human food chain is considered as food loss or waste, even if it is then directed to a non-food use (feed, bioenergy). Food Loss refers to food that during its process in the food supply chain gets spilled, spoiled or otherwise lost, or incurs reduction of quality and value, before it reaches its final product stage. Food loss typically takes place at production, postharvest, processing and distribution stages in the food supply chain. Food Waste refers to food that completes the food supply chain up to a final product, of good quality and fit for consumption, but still doesn't get consumed because it is discarded, whether or not after it is left to spoil. Food waste typically (but not exclusively) takes place at retail and consumption stages in the food supply chain.

Within the frame of this definition, additional boundaries are applied as follows:

- food that is fit to enter the food supply chain for human consumption, but discarded in the postharvest phase of sorting and grading (fruits, fish by-catch, etc.), is food waste.

- by-products that could be edible (bones, organs, skins, seeds, peels, hulls, bran, etc.), but that in specific supply chains are not intended for human consumption and are discarded or used as non-food, are not food waste or loss.
- food discarded that is redirected to food banks and/or other recovery and redistribution systems and eaten by people, is not food waste.
- food materials that are used for the production of alcoholic beverages or confectionery are excluded from the scope of work (see scope below).
- it is important to know the alternative use or destination of lost or wasted food, in order to assess the impact on the use of resources when producing this food. If food losses and waste are replacing (as animal feed, as biofuel, etc.) new production, then the impact on resources is reduced.

In this paper the main reference will be the definition proposed by FAO in 2011 that is: *"food losses take place during agricultural production, post-harvest, and processing stages in the food supply chain"*, while *"food waste occurs at the end of the food chain (distribution, sale and final consumption)"*.

4. MICRO AND MACRO ECONOMIC THEORY: APPLICATIONS TO FOOD LOSSES AND WASTE

The analysis of the empirical evidence and conditions is carried out through different perspectives: economic, cultural, social and environmental. Moreover causes related to policy, legislation and private standards are investigated as well. Economic elements are divided into micro and macro. The former analyses the behaviour of individual actors in the food supply chain (i.e. consumers, producers etc.) and their impact on food losses and waste. Theoretical concepts such as *production theory*, *value chain analysis*, *consumer theory*, *behavioural economics* etc. belong to this field. In the macroeconomic analysis the core is not the single operator but the aggregated variables. Thus, the entire economic system is observed to highlight its connection with the formation of losses and waste. For instance, *inflation*, *trade*, *employment structure*, *infrastructure*, belong to this field.

Micro and macroeconomic dimensions are interrelated. The aggregate variables are, in short terms, the sum of the variables referred to the individual economic actors (Blanchard, 1997); therefore the same elements are investigated under different perspectives.

Causes of food losses and waste do not only have economic implications. Instead, there is a complex intersection between food, culture and society therefore food and the entire agri-food chain are strongly interrelated with cultural and social aspects and with environment and climate. Moreover policy, legislation and standards (e.g. private quality standards for fruits and vegetables) play a significant role in driving the behaviour of consumers as well as the behaviour and the choices of producers and of the other stakeholders of the agri-food chain. Even in this case, since these dimensions are closely related, the same conditions could be investigated through the different perspectives that characterize the fields of analysis previously mentioned.

4.1 Micro economic conditions

This section looks at factors that affect decision making at farm/firm-level and consumer level that can explain food losses and waste. The discussion is grounded on the theories of production and consumer behaviour.

4.1.1 Production theory: food losses and waste at the farm / firm level

Production activities entail the employment of limited resources - natural, human, financial and technical capital – in alternative uses to produce goods. Considering that an enterprise seeks to maximize its profit (total revenues - total costs), each rational enterprise will evaluate which goods produce by comparing the expected revenues and expected costs of different products feasible. In agriculture labour, assisted by financial and technical capital, utilizes natural resources such as soil and water to transform inputs (e.g. seeds) in outputs (e.g. cereals). This process adds value to the final product. Every enterprise engaged in the agri-food system, tries to maximize their own profit, conducting several value-generating activities that can be modelled as a chain according to economic theory.

In order to maximize profit, the levers on which the enterprise can take action to achieve its objective (keeping unchanged the state of technology) are then two, the prices of factors of production and the prices of the goods produced. Both are set by the market. The market, however, is not unique. There are, in fact, at least two major forms of markets: perfectly competitive markets and markets with imperfect competition. Under perfect competition, enterprises, taken individually, are not able with their own choices to influence the selling price of the good they produce. On the contrary, an individual enterprise has the potential to influence the selling price of the produce under imperfect market conditions (Samuelson, 2009). Perfectly competitive markets are characterized by a relatively high number of small and medium enterprises. Basically in perfect competition, enterprises cannot choose the price of the goods they produce, and for this reason are defined price-takers. In conditions of perfect competition the price of output is the same for all enterprises. The structure of production costs, however, can vary from company to company. Some enterprises might be more efficient than others in combining together the factors of production (in some cases thanks to more modern plants). For these reasons, at a given market price, some companies realize a profit, while others suffer losses and, finally, some break-even, equal to the opportunity cost of capital employed (that is the tendency of perfectly competitive market) (Messori 2010).

This situation can also be analysed from an alternative perspective, namely the formation of waste and losses, i.e. products not collected or harvested. The market of agricultural products is often characterized by a high number of "small" enterprises (atomistic supply). Therefore farmers are in the position of not being able to set the price of the goods they produce (price-

taker). This situation combined with information asymmetry or imperfect information and the mechanism of price transmission might lead to the following cases: imperfect information does not allow the farmer to predict the exact time of planting or transplanting, the final production and the market price of the crop. Due to the rigid structure of its cost of production the final price may not always allow the producer to cover his/her harvesting costs, so in some instances, a producer is forced to leave the crop in the field in order to minimize economic losses; price fluctuations might led a farm to have financial losses. Also in this case, a farmer may find it more convenient not to harvest the produce to reduce economic losses (e.g. if the price of the goods on the market does not cover the harvesting cost). However, if this is the case, the producer is wasting something that has little value (i.e. less than the harvesting costs). This would imply that in general terms, wasting at that level should not be a major issue. In that case, the issue is more for the farmers themselves that are left without income. If all the resources were priced, the farmer would have produced less, saving natural resources (water, carbon emissions land erosion, salinization etc.).

Table.1 Agricultural output, total production, harvested production & field residues in Italy

	2010			
	Total Production - TP (tons)	Harvested Production - HP (tons)	Field residues - RF (tons)	RF/TP %
Fruit	5,919,201	5,780,831	138,370	2.34
Citrus	3,984,619	3,789,120	195,499	4.91
Olive¹	3,404,159	3,117,756	286,402	8.41
Grapes²	8,023,832	7,839,721	184,110	2.29
Full field vegetables³	5,555,046	5,358,849	381,412	6.87
Green house vegetables	1,423,349	1,366,115	57,234	4.02
Legumes and potatoes	1,768,171	1,725,845	42,326	2.39
Total fruit	21,331,812	20,527,429	804,383	3.77
Total vegetables	8,746,567	8,450,809	480,973	5.50
Total fruit and vegetable	30,078,380	28,978,239	1,285,356	4.27
Total cereals	17,132,709	16,905,194	227,514	1.33
Total	47,211,089	45,883,434	1,512,870	3.20

Source: Segrè, 2012

Probably, this would not solve the issue of missing farmer's income but, at least, would reduce environmental impacts of food overproduction. A quantitative example of the losses in field is provided by **Box 1** which shows some data for the Italian agricultural sector.

Box.1: Losses in the field: The case of Italy

At the farm level, food losses fall into four major categories: i) losses linked to productions that may not be harvested because damaged by pests, disease, and weather; ii) losses linked to economics causes. If market prices are too low at the time of harvest, growers may leave a part of production in the field because they cannot cover the related costs (in the some case the market prices did not cover even the cost of collection); iii) losses linked to commercial imperfection of the goods. Products that not respect minimum quality standards in terms of shape, size, colour, and time to ripeness; iv) there may be a fourth cause linked to the fact that farmers seek to increase the production to prevent losses from bad weather and pest or because they predict high prices on the market. In favourable years (in which neither bad weather nor diseases occur) it might happen to have an overproduction with a consequent generation of waste. Usually unharvested products are ploughed under. This practice might do not represent a complete loss because crops are returned to the soil as organic matter, but it surely represents a loss in terms of human nutrition and of resources - water, energy, manual work, chemicals - that have been employed for the production of the good.

In Italy in 2010 about 3.2 percent of the total agricultural production (1.512.870 tons) remained in the field: 14.71 percent of the production of cherries, 6.12 percent of the oranges, 6.82 percent of the fennels, 8.41 percent of the olives (Segrè, 2012). Some of the figures can be considered physiological since they are relatively consistent with the trends of the past decade in terms of losses on the field (See Table 1).

These figures are relatively consistent also with those collected in the United States where each year about 7 percent of planted fields remain unharvested (Kantor et al., 1997). Also the United States Department of Agriculture (USDA) emphasizes that in 2006-2011 about the 2 percent of potatoes, 8 percent of sweet corn, and 15 percent of wheat remained unharvested.

Price and elasticity of supply

The price of goods on the market will determine the quantity with which they become available. The reactivity with which the quantity supplied of a good reacts to the change in its price, is defined as the price elasticity of supply. Even the own-price elasticity of supply may play a role in the waste formation. An in-depth analysis about the relationship between supply elasticity and losses is provided in **Box 2**.

Box 2: Elasticity of supply and food losses

Agricultural production is subject to large variations resulting from factors that go beyond human control and from production choices that are often guided by prices registered on the market during the previous year. In such a framework, prices are also characterized by fluctuations depending by internal and external factors. In the short run, an opportunity such as conservation and storage of the product could allow mitigation of price fluctuations by gradual placement on the market - in accordance with the demand – of the stored product.

However, due to infrastructural deficiencies particularly in developing countries, storage can be technically expensive and difficult to implement and maintain, especially in the case of perishable products such as fruits, vegetables, butter, milk.

Therefore, the possibility of storing the products, and the related costs, tend to influence the rigidity or the elasticity of supply.

Generally, the greater is the time available to producers to respond to price changes, the higher is the elasticity. Supply is generally more elastic in the long-run as the available time allows the producer to modify the means of production. In the short-run, only variable factors of production can be adjusted. In case of a long term run supply curve available time allows to modify also equipment and existing equipment: the elasticity is of long run (Messori 2010). Additionally, in the long run the response of the elasticity of the supply to a positive variation of price is different from a negative variation of price of the same magnitude.

This relation can be partially explained by analysing the behaviour of a producer who, in case of a price rise, has an incentive to introduce new technologies and process innovation to increase resource productivity at a faster rate than when prices decline. In these cases, there is an increase in the quantity supplied resulting from the price increase and technical progress. Evidence of this phenomenon, can be found in the case of the application of the set aside measure under the Common Agricultural Policy of the European Commission. One of the objectives of the programme was to reduce large surpluses produced by the guaranteed price system but seems to have been largely ineffective. The reduction of surpluses was relatively low. Its poor effectiveness can be explained at list partially with technological progress that has partially offset the benefits of set-aside. In fact, on the one hand production has fallen because a higher share of uncultivated utilized agricultural area, while on the other hand the use of new varieties, more productive and more resistant to pests, and the increased responsiveness to fertilizers, led to a growth of the yields in the area not under set aside (**Box 3**).

Box.3 Set aside, technological progress and surplus production

Set aside or non-cultivation of land, following the reception of an incentive, was a measure adopted by the EU in order to reduce the supply and stabilize the market. It was introduced in the EU for the first time in 1988 on voluntary basis, made mandatory in 1993 and it has been one of the major CAP instruments for limiting supply (Segrè 2008 a).

Its effects on the reduction of EU agricultural surpluses were relatively low. Its poor effectiveness can be explained, at least partly, by technological progress that has partially offset the benefits of set-aside while production has fallen due to, among others, higher share of uncultivated agricultural land and the use of new varieties that are more resistant to pests leading to increased yields.

The evidence suggests that, under protective practices, the rational behaviour of the producer tends to maximize profits by increasing production and adopting new technologies in the long run, that might lead to the formation of surpluses in the contexts in which markets are subject to a check.

Consequently, the overall increase in the quantity supplied is larger than that assumed on the basis of the sole price effect. Therefore when price decreases, the negative shift of the supply has a smaller magnitude than the previous positive shift, since the new technique of production remains in use and it leads to higher production. This can lead to overproduction.

However, it should be noted that overproduction is the consequence of a rational behaviour of the entrepreneur who acts on the basis of the principle of profit maximization. In fact, from a producer' viewpoint, this behaviour is consistent with the optimal use of the production factors which depends on the relationship between the price of the factor and that of the product. So even if the price of the product falls, the use of the factor (its marginal productivity) remains the same. This happens if the price decreases in the same proportion reaching - in absence of alternative employment – values lower than those of the market (See **Box.3** for an example of the connection between technological progress and production surplus).

However, food losses and waste can occur at each stage of the food supply/value chain.

In developing countries production is dominated by small farmers with limited or not existent access to financial resources (Mittal 2007). Production, harvest and post-harvest techniques and technology are often out-dated. In addition, technical, regulatory, and financial capacities are often inadequate. The lack of information and more in particular the limited access to markets are also major barrier to development and efficiency. Another aspect is represented by unsuitable storage infrastructure that might have adverse effects on production volume and quality. Food stored in inappropriate ways is exposed to toxins produced by fungi or pests and cross-contamination and has negative effects on the health and nutritional status of final consumers.

Moreover there are factors causing reduction in value and in efficiency. For instance, the size reduction and sophistication of households over the decades, the changes in lifestyle, the transportation of food over long distances, the trend towards urbanization which creates longer distances between food producers in rural areas and consumers in urban areas, the higher demand for convenience food (frozen, pre-cooked) are all elements that could impact on the value chain efficiency. These are also elements which increase the demand of food contact material. Packaging helps to maintain safety and quality and provide information to the consumer, but it might also aggravate losses, by improper contact materials (for example leafy vegetables are highly sensitive and some mechanical damages produced by the lack of

proper packaging from farm to market cause high losses) and waste in different stages of the agri-food chain, for instance due to the difficulty in identifying proper portion sizes for convenience foods.

Finally, technical innovations and new production techniques can facilitate the reduction of food losses and waste, but at the same time socio-cultural issues should be carefully considered to evaluate their cultural acceptability and to facilitate a successful adoption. It has been observed that the same intervention can receive appreciation depending on specific circumstances. For example, metal silos have been successfully introduced in Central America but not yet in Africa, where households used to store grains at home (World Bank, 2011).

In developing countries, many small-scale farmers have access to inefficient storage facilities that cause huge losses.

For instance, according to Swaminathan (2006), most India's post-harvest infrastructure is extremely weak "... even now, paddy rice could be spread for drying on the roads. The spoilage can be as high as 30 percent in the case of vegetables and fruits". Other sources, such as the Food Corporation of India, report a share of losses ranging between the 10 and the 15 percent of the total production. The Ministry of Food Processing Industries (MFPI) estimate losses of 23 million tons of grains, 12 million tons of fruits and 21 million tons of vegetables for a total approximate value of about 4,4 billion USD while total value of food loss and waste generated is supposedly 10,6 billion USD (Rediff News 2007).

In many African countries, post-harvest losses of food grains are estimated at 25 percent of the total harvested production while for fruits and vegetables post-harvest losses can reach 50 percent (Lundqvist, 2008).

Part of the difference in the figures is related to the utilization of different methods for their calculation: in the case of India losses are reported as a percentage of the total production, in the case of African Countries (Lundqvist, 2008) losses are reported as percentage of the harvested production. However, in both cases losses cover a significant share of production.

Dairy sector high economic losses in East Africa and the Near East are about 90 million USD per year (FAO, 2004a): (i) Kenya dairy losses amount to about 60 million litres of milk or about 19 million USD/year (FAO, 2011b); (ii) Tanzania losses reach about 59.5 million litres of milk each year and represent over 16 percent of total dairy production during the dry season

and 25 percent in the wet season for annual losses of around USD 14.3 million; (iii) Uganda losses are close to 27 percent of total milk production with a value equivalent to 23 million USD/year (FAO, 2004a).

Value chain inefficiencies and their link to food losses and waste

The value chain concept was first popularized in the 1980s by Michael Porter to analyse the firm business as a chain of value-creating activities. In this context, the term “value” must be understood as “value-added”, which is the difference between the value of final goods and the value of goods (resources) purchased by a firm and used in the production.

This theory states that a firm can obtain value implementing two set of activities: *primary activities*, aimed at governing the input materials, transforming the inputs into the final product, delivering or purchasing the finished product; and *support activities*, aimed at improving the quality of the product, the finance and the legal issues, the *resource management, the technology development*.

Thus, the food value chain refers to the activities required to bring a good from conception to consumption (Kaplinsky, 2000), adding value to the product and ensuring a profit margin for the producers³. However, according to the literature, there are several elements that play a relevant role in this framework, such as the actors participating in the value-creating activities, the form of relationships among the actors (governance of the value chain), the capability of actors in terms of (product and process) innovation and seizing market opportunity, the distribution of benefits along the chain (Altenburg, 2006; Breite, Vanharanta, 2002; Della Rovere, Schipani, 2007; Kaplinsky, 2000; Kaplinsky and Morris, 2001; Porter, 1980 and 1990; Rich et al. 2009; Gereffi and Korzeniewicz, 1994; Gereffi et al., 2005). Furthermore, the efficacy of a value chain strategy stands upon some assumptions such as the ability of the actors to allocate resources, the effective management of materials, the availability of information and the price level that should be profitable.

³ The profit margin is based on pricing strategy and cost structure (Rich et al. 2009) and it measures the difference between the value created by the firm and the costs incurred in carrying out the activities that generate value.

At times, some economic and non-economic conditions connected to the mentioned elements, do not allow the efficient carrying out of the value-creating activities and contribute to the occurrence of food losses and waste.

Value chain theory takes into account many aspects to explain how to increase the value of the production activities. However, certain conditions cause the opposite result, the loss of value, which could be linked to the occurrence of food losses and waste.

First, in the framework of the value chain theory, the relationships among main actors should be win-win and collaborative. The main actors, like farmers, significantly add value to food products and for this reason they should receive a proportional profit from the selling of final products. However, the interactions among the various operators are often of win-lose and not transparent type, because they are in competition with each other.

In addition, in developing countries farmers are, generally, the smallest actors of the value chain, the most numerous and not effectively organized. Farmers have to interact with bigger and more powerful stakeholders, like industry and retail, which have the capacity to impose the parameters of contracts and subcontracts within the chain (Gereffi et al., 2005). For instance, they can define specific standards, quantities and conditions of delivery by which dominant firms can reject some agricultural products, even if edible, resulting in food losses or waste.

In food losses and waste generation, the asymmetric price transmission, the way in which upstream prices affect downstream prices, plays a role in relation with the food value chain characteristics. In economic theory, it is known that upstream and downstream prices are connected and in absence of external shocks, equilibrium between them exists. An external shock triggers some adjustments towards a new equilibrium, while economic agents try to maximize their profit. The actors try to increase selling prices and reduce their costs.

Since the real governance structure of the food value chains is strongly affected by only some firms, often retailers and industries in the food sector, a limited number of agents have a competitive advantage which allows profits above the average. "Dominant" agents can consider primary producers as interchangeable and sometimes "exploitable" suppliers of raw materials. Farmers, for their part, cannot react equally when a shock or a price change occurs. Thus, when selling prices decreased excessively, to under the production cost level, farmers may decide not to harvest the products. The result being food waste.

Missing markets and underdeveloped infrastructure

Other factors that explain losses and waste and are closely linked to value chain efficiency are missing markets and underdeveloped infrastructure. They are a sign that the market is out of equilibrium, which means a condition in which the demand for goods is equal to the supply. Missing markets occurs when suppliers are unable to produce a specific good or when the supply of a specific good cannot meet the demand of this good. In other words, the food cannot reach the consumers, despite being needed.

These conditions are more frequent in developing countries where both demand and supply of food exist, but the distribution is absent or limited for a number of reasons, such as the lack of infrastructures, in terms of roads, railways, ports etc. Therefore, although the products are in an area, they cannot physically reach the consumers and finally are lost (above all if they are perishables).

The lack of infrastructure is a condition that contributes to the food losses and waste occurrence. An in-depth description is provided in paragraph 4.2. Here, some short considerations are reported, especially with respect to the relationship with urbanization that amplifies the lack of infrastructure. Urbanization reduces the number of farmers and increases the quantity of citizen consumers. In addition, it extends the distance between production zones (rural areas) and consumption places (urban districts). Thus, more efficient infrastructure is needed to feed all people away from rural areas. Unfortunately, in several developing countries, roads and lines of communication are inadequate to achieve a good distribution. So, food can be lost before it arrives at destination. Under such conditions, physical flows of produce are not organized in an optimal way. In other words, contrary to the above-mentioned theoretical assumptions of the value chain strategies, actually the management of materials is not always effective.

Losses can be both quantitative and qualitative. Quantitative losses relate to the reduction of the volume of a product while qualitative losses are measured as the decrease in the nutritional level and/or a worsening of the hygiene and safety of a good. They could also be dangerous for the consumers as in the case of aflatoxin contamination.

Causes of food losses that can be grouped into three general categories: (i) technique that refers to the procedure to accomplish a task, (ii) technology that refers to a set of inputs usable to produce a set of outputs, as represented e.g. by a production function and (iii) management that refers to the organization and coordination of the activities necessary to achieve defined objectives.

The first category includes harvest methods, handling procedures, drying techniques etc. For instance, grains are often subject to bio-deterioration, due to an excessive moisture content which favours attack by parasites. In many developing countries, drying techniques used by small farmers to reduce the relative humidity of the crop until a correct level for storage, are based on exposure to the sun. If weather conditions are too cloudy or humid the crop will not be dried sufficiently (World Bank, 2011). Thus, the level of (quantitative and qualitative) losses will be high. A more detailed analysis on the grain losses is provided by the **Box.4** that takes into account as case study the sub-Saharan Africa.

Box.4 Grain post-harvest losses in Sub-Saharan Africa

Food loss reduction complements efforts to enhance food security through improved farm level productivity, thus tending to benefit producers and, more specifically, the rural poor. In the case of food loss in grains in Sub-Saharan Africa (that are up to 20% of total production), assuming only a 1 percent reduction could bring annual gains of US\$40 million, with producers as a key beneficiary.

Viewed in a different perspective, the annual value of the loss estimated is of US\$4 billion that (i) exceeds the value of total food aid SSA received over the last decade; (ii) equates to the annual value of cereal imports of SSA, which had an annual range of between US\$3–7 billion over the 2000–07 period; and (iii) is equivalent to the annual caloric requirement of at least 48 million people (at 2,500 kcal per person per day).

*Source: Missing Food: The Case of Postharvest Grain Losses in Sub-Saharan Africa
The World Bank, NRI, FAO 2011*

The second category of conditions refers both to the excessive costs and the lack of technologies able to protect the products. Actually, a good drying technique alone is not sufficient to preserve agricultural commodities, because insects, rodents and birds may attack them on the field before harvest and/or in the store after harvest. So the use of appropriate inputs is desirable and sometimes necessary.

The third category includes all the aspects that, usually interrelated with the management, can reduce the access to market, as well as procurement, storage, marketing, distribution policies, cash flow, financing, payments aspects, price stabilization programs etc. For instance, sometimes a new

technology, useful to decrease the percentage of losses, is available but not accessible for economic reasons. In this case, financing supports are needed to improve the production and to expand facilities for trading and export. Otherwise, a low level of organizational capacities of the value chain actors causes non-efficient informative and physical flows among producers, traders and exporters. The lack of business plans and market access strategies reduces the opportunity to allocate food products on the market and increase the risk to loss or waste food. A low degree of integration between local, national and international markets reduces the opportunity to link small farmers to the demand.

Moreover, the actors involved in the value chain and operating in an economic way should identify how optimizing the available resources, in order to add value to products. However, the presence of food losses and waste test a partial ability to allocate these resources. In fact, together with food also inputs, such as raw materials, water, fertilizers, and work etc., used in the production are thrown away. Hence, losses within food losses are the final result.

The opportunity cost of food loss and waste to bear by the food supply chain actors and consumers is still quite low in the high-level income countries where, thanks to domestic production and/or imports, the availability of food is enough to satisfy the demand of the population. In some cases, the investments required to reduce waste seem higher than the cost of disposing of excessive supply. However, it is relevant to emphasize, that this may be from the point of view of a short-term evaluation of investment and return on investment opportunity. In addition, there is no relevant incentive to decrease food losses and waste, although they represent a cost at each step of the chain. For instance, data from UK shows that wasting food costs the average family £480 a year (WRAP, 2013).

However, in the next years, considering trends in population growth and natural resources pressures, the opportunity cost of food loss and waste should increase with potential subsequent stimulation of investments in prevention and reduction.

Imperfect information plays a key role in the food losses and waste occurrence and could affect every agent of the value chain. For instance, after acquiring a number of incorrect information elements, farmers may plan a higher output than real demand, causing a surplus of production. By contrast, consumers might buy foodstuffs with undesired characteristics if not well communicated. This lack or distortion of information raises the risk that food supply chain actors, including consumers, generate loss and/or waste food.

At the economic level, post-harvest losses cause a reduction of market opportunities with an impact on prices, which could increase. In fact, according to the neoclassical economics when the supply of a good decreases and the demand does not adapt quickly, the price tends to rise. Actually, literature has not yet investigated the relationship between food losses and price changes. This should be addressed in further studies. At the social level, a deterioration of living conditions, due to a worsening of food security, can be observed. Finally, at environmental level, post-harvest losses cause the waste of all the resources used for producing such as irrigation water, fertilizers, energy resources, etc. In addition, the issue of environmental costs of food production/waste should be systematically addressed in further work.

Table.2 Grain post harvest losses for Eastern and Southern Africa, 2005–07 average

	Production for 16 countries of Eastern and Southern Africa (million tons)	Local average price (US\$/ton)	Grain losses (% of production)	Value of grain losses (US\$ million)
Maize	27.01	194.72	17.5	920
Sorghum	4.72	250.02	11.8	139
Millet	1.67	305.34	11.7	60
Rice (paddy)	5.15	405.53	11.5	240
Wheat	5.25	274.36	13.0	187
Barley	1.71	281.53	9.9	48
Total	46.18			1,594

Sources: World Bank 2011 - calculations based on FAOSTAT and APHLIS data

The level of the grain losses in Sub-Saharan Africa (SSA) is not certain. For some observers it is very high, almost 50% of production. However, according with APHLIS (African Postharvest Losses Information System) which provides estimates on these issues, grain losses could vary from 10 to 20%, which is still a relevant percentage. APHLIS highlights that in Eastern and Southern Africa grain losses amount to approximately 1.6 billion US dollars a year. There is no data for other African areas. Assuming similar magnitudes in other regions, the value of the post-harvest losses in Sub-Saharan region could be as high as 4 billion USD a year. This means that a 1% decrease of losses could lead to a recovery in terms of economic value of approximately 4 million USD.

To reduce grain losses in SSA it is necessary to adopt techniques and technologies to improve post-harvest management to satisfy the needs of both small farmers and big producers. The choice of suitable measures depends on the context which in turn is defined by the scale of production, the type of crop, the weather conditions and the socio-economic conditions.

Governments and donors involved in development cooperation promote the adoption of many technologies to improve practices along production, process and storage phases. For instance, the diffusion of metal silos in many rural areas has significantly reduced post-harvest losses. In fact, the silos are able to protect the grains from the attacks of birds, rodents, fungi and to store these products for long time without qualitative losses.

However, the adoption of certain technologies, while successfully adopted in many areas of the world, has instead proved unsuccessful in other places. For instance, the silos have been very effective in Central America, but have been adopted in a very limited number in Africa, especially for traditional grains (maize, sorghum, millet). This case can be taken as a reference for the choice and the mode of application of every possible measure to reduce losses.

According to the World Bank, in some Developing Countries the choice of technology was a failure because its adoption required an investment focused only on the farm level, so on a technical / production point of view, without providing at the same time any proportionate economic incentives; in this way, the investment became financially unsustainable. Other times, the failure was related to the lack of attention paid to the cultural dimension of small farmers (e.g. diffusion of silos where local populations prefer to keep stocks in their homes) (World Bank, 2011).

An analysis of the value chain can improve the effectiveness of support interventions and cooperation policies, resulting in a reduction of losses and consequently in an increase of agri-food sector efficiency.

4.1.2 Consumer theory: conditions that explain food losses and waste

Consumer theory (CT) is a combination of positive and normative theories aiming at explaining consumer preferences and behaviour identifying the nexus among what an agent would like to purchase (depending on the preferences and therefore on her/his utility function), what s/he can purchase (depending on the purchasing power and so on income and on the cost of goods) and finally what a consumer buys (Messori, 2010). Some families of

consumer theories assume rational maximizing behaviour. Others may not, as explained in the section “behavioural economics” below. The classification of consumer theories could be possibly improved.

CT is based on a number of assumptions. Each economic agent operates in a context of perfect information and is perfectly rational therefore each consumer has access to all the relevant information about the quality of a good and will choose the best products, and the market will reward those who make the best products with higher sales. Beside perfect information traditional neoclassical assumptions includes also that agents are price takers (i.e. according to this assumption a consumer takes prices as known, fixed and exogenous, therefore without looking for better prices or a discount), that prices are linear (i.e. so that any unit of a particular good has the same price and therefore there are no quantity discounts) and that goods are divisible (Mas-Colell et al., 1995).

In an increasing number of circumstances neoclassical models are not capable to explain reality, however, at the same time, there are no significant new theoretical basis to replace traditional theoretical models that therefore still remain a major milestone.

Assumptions have been used to simplify models. For instance, in some cases to overcome some limitations neoclassical theory refers to a “ideal consumer” with a “representative behaviour”. Such simplification, as also others, is particularly difficult in a society that is increasingly globalized, it is characterized by a rising diversity in economic, social and cultural terms and by the continuous attempts of producers and retailers to diversify the supply and to respond to the individual needs of consumers. In the US the ideal consumer should choose between 15,000 different products in an average supermarket and 25,000 in a superstore (The Food Institute, 2012). In such a situation agents might not have enough information to maximize their utility function especially considering that average consumers tend to have a relatively low purchase planning capacity and that many households are characterized by decreased home economic skills (Moomaw et al., 2012; WRAP, 2011a) also due to a lifestyle that keep them often out of home. This relates to the issue of dynamic demand characteristics of consumers leading to the wide choice. It can be considered a risk/uncertainty mitigating exercise (hedging behaviour by producers).

There is an increased number of situations where the capacity of consumers to plan their food purchase might be under risk. It could be the case of the “*buy two get the third free*”

sales and other special offers that require additional knowledge in food planning. In this case the economic theory suggests that a consumer is able to identify the marginal utility of a specific good, however the capacity to rationally recognize the marginal utility is challenged by the opportunity to purchase a product for a reduced price.

Economic trends show that poverty has diminished in significant areas of the planet both in absolute and relative terms (Moomaw et al., 2012, United Nations, 2011). In case of an increased purchasing power consumers have the opportunity to buy more than what it is strictly necessary to satisfy their basic nutritional needs. In such a situation individual needs and new values (i.e. aesthetic characteristics, social prestige or innovation) tend to be transferred to food, modifying consumer preferences. Therefore the traditional hierarchy of values related to subsistence (i.e. frugality, saving, nutritional value) is often abandoned. (Messori, 2010). In a situation characterized by an increased purchasing power, price loses some importance among factors guiding consumer food purchases.

While, in circumstances of low purchasing power, consumers tend to make their decisions on the base of price, choosing for the cheapest products with the low nutritional value, that is usually high in calories and fat and in most of the cases it is sold as frozen, pre-cooked and pre-portioned items.

This is suggested also by the level of obesity in OECD countries where overweight individuals are more common among the poor and the less educated. Moreover in several OECD countries, women with lower education are two to three times more likely to be overweight than more educated women, but smaller or no disparities exist for men (OECD, 2012). Evidences are different in non OECD countries. Recent studies (G. D. Dinsa et al, 2012) suggest that *"in low-income countries or in countries with low human development index (HDI), the association between socioeconomic status and obesity appears to be positive both men and women: the more affluent and/or those with higher educational attainment tend to be more likely to be obese. However, in middle-income countries or in countries with medium HDI, the association becomes largely mixed for men and mainly negative for women. This particular shift appears to occur at an even lower level of per capita income than suggested by an influential earlier review (G. D. Dinsa et al, 2012, pp. 1)"*.

Obesity is a global problem. Worldwide it has more than doubled since 1980 and in 2008, more than 1.4 billion adults, 20 years and older, were overweight. Of these, over 200 million

men and nearly 300 million women were obese. According to WHO (2012) more than 40 million children under the age of five were overweight in 2010. These figures suggest that consumers are not always rational: obese/overweight individuals fail to recognize the reduction of marginal utility in additional food intake. In some cases globalization lead to penalization of local traditional products characterized by higher quality and a relative higher price and an advantage – in comparative terms – for industrial products of lower quality that are characterized by lower prices, longer shelf life, and high content of sugar and fat.

Moreover both in industrialized and developing countries economic and social changes lead to new food preferences. The average age is growing as well as the number of single households. The level of education and the role of women - who in certain societies has/had the task to manage and prepare food (including the management and recovery of ingredients left from previous meals) - are also changing. Therefore the opportunity cost related to housework and food preparation increase as well as the need to look for pre-cooked and ready to eat food products and to consume meals outside the home (process of substitution between work and capital inside the household). These lead to the usage of standard portions (i.e. family packs, mono portions) that are not always adjusted to the need of the household and that can lead to an excess of consumption (in caloric terms) or to the formation of food waste (WRAP, 2009).

Most of foodstuffs are perishable and might experience random changes in quality between the time of sale and delivery, resulting in markets characterized by potential adverse selection where buyers and sellers have access to asymmetric information. The potential presence of adverse selection in food markets required the identification of label, standards and indications aimed at providing all the relevant information about foodstuffs to the consumer. These tools provide a number of information to the consumer about food safety, quality and organoleptic characteristics reducing the risk of adverse selection, while on the other side they increase the potential creation of products that although still perfectly edible are not consumed or left in the field.

Behavioural economics and food losses and waste

Consumer demand is influenced by a number of cultural, psychological and social aspects that do not always follow criteria related to economic rationality and does not always fall under the concepts identified by neoclassical economics. This evolution lead to a

segmentation of the market that is functional to life style, consumption opportunities and working activities, cultural trends, globalization, migration, technological development, products standardization and other factors that are driving modern society. At the theoretical level the consequence of these trends is the development of alternative theories that consider consumers as rationale, but uncertain about some specific characteristics of the products (i.e. the taste in case of some food products) or try to introduce the contributions of other social sciences into economics. In order to explore the interconnections between different scientific disciplines an approach that combines the insights of psychology and economics to better understand and predict human decision is the behavioural economics theory (OECD, 2012). According to literature factors driving to behavioural change can be classified in three areas: external factors (financial and efforts costs), internal factors (habits and cognitive processes) and social factors (societal norms and cultural attitudes) (Prendergrast, 2008). In addition behavioural economics brings in the theoretical debate also the fact that consumers do not always behave in their own best interests. All these elements (external, internal and social) are subject to extremely rapid transformations that lead to other changes in consumer behaviours and also in food industry decisions (Messori 2010). For instance, fast changes might lead to rapid obsolescence of certain systems in the agro-food industry, leading to the formation of waste.

Traditional economic theory foresees changes in preferences in relation to exogenous conditions only, while the consumer behaviour approach extended the field of investigation to preference changes related to endogenous conditions. Consumer behaviour suggest different conditions for change including price, product's commercials, interdependent preferences (consumer preferences in relation to the consumption decisions of other actors) (Postlewaite, 1998), technological progress that increasing and modify the possible alternatives lead to a change of preferences, the relative economic and social position of the consumer. In such a context the conditions that can lead consumers to take different choices can be based on the different information they might have, on the different preferences or the fact that a consumer had a non rationale behaviour. The identification of a non rational behaviour as the driver of a choice would lead to a problem of identification and measurement since economic theory is not able to qualify and quantify the consequences of the violation of the rationality assumption because the assumption is simply a postulate: there are no errors because economic agents are rationale and maximize their utility function. This theoretical shortcoming has been underlined by a number of authors including Herbert A.

Simon (Simon, 1957) who developed the concept of *bounded rationality* that emphasize the limits of utility functions and recognize the costs related to information collection and interpretation. A useful example of bounded rationality is provided by **Box.5**, which examines the connections between the information contained in a label and the waste generation. According to Simon (1957) decisions are taken on the base of intuitions and previous experiences rather than following a strict optimization scheme because agent are not able to collect and analyse all the information required to compare the utility of each alternative action.

Box.5 The “best before” and “use by” challenge

The concept of bounded rationality is related to the costs of information collection and interpretation. Food expiry dates and indications about conservation are among the most critical information for a consumer and, at the same time, has been indicated as one of the major causes of food waste at household level.

Food date labels may not always be clear and may represent a possible source of misunderstanding for the consumer. At the same time, consumers may not interpret date labels in the same way.

In the EU, the most common indications are (i) “use by” that is related to the safety of the product that can be consumed until and not after the indicated date; and (ii) “best before” that is related to the organoleptic characteristics of the food item, meaning that the food can be consumed also after the indicated date, although it may have different organoleptic properties.

Worldwide, different jurisdictions have different regulatory requirements, and the literature provides various estimates on the share of consumers interpreting correctly, in their respective jurisdictions, the “best before” and “use by” dates.

Several new theoretical models have been developed following the idea that consumers do not maximize any utility function, but make their choices on the basis of previous experiences adjusting their behaviour according to the solutions that lead to the best results.

According to these models, a consumer is characterized by two utility functions: an expected utility that is aimed at measuring the consequences of a decision that has never been taken in the past, and an effective utility function aimed at evaluating the consequences of the decisions already taken in the past. In case of a gap between the two utility functions, the agent tends to modify the expected utility on the basis of the future decisions. However, the end of the process is not necessarily the traditional utility function and the consequences could be that both the equilibrium and the consumer demand could be modified in their form or relative position with a consequent modification of their properties. **Box.6** explores the case of food waste related to consumer behaviour in relation to available quantity and cost of food.

Box.6 Consumer behavior, quantity, discounts and food waste

“Buy two get the third free” and “buy one get one free” offers are potential source of food waste since they are attracting consumers due to their favorable conditions in terms of cost, but at the same time they are challenging consumers’ planning capacity and home management skills. The debate over the potential consequences and distortions of this typology of offers is involving a variety of stakeholders engaged in the food sector including governments and retailers (Stop Wasting Food Movement Denmark, Danish Agriculture & Food Council and Danish Consumer Council, 2012). In UK, the Government discussed about the opportunity to phase out “buy one get one free” offers under the governmental plans to reduce waste (Irvine C., Prince R., 2009).

Actions to reduce the distortions of “buy one get one free” offers have been taken also by some of major UK retailers that are introducing offers based on the possibility to claim the free product in the following week/s with a voucher (Poulter, 2013).

An alternative framework for analysing human behaviour is the Capability Approach as proposed by Amartya Sen (1985). The Capability Approach is based on the substitution of utility with the “functionings” or the states and activities constitutive of a persons’ being (Sen, 1985). The alternative combinations of functionings a person is feasibly able to achieve are the capabilities. Following this approach, each need could be satisfied within different forms of consumption (individual, familiar, social) and, within each of them, with different

good and services. Each person recognizes the goods that can satisfy his/ her needs among those that are available in the market (preference functions are addressing on market goods). At the end of the process, goods that consumers are choosing are defined and created by other economic agents (i.e. producers). The fact that goods and services are not defined by the same agents that expressing the needs might lead to goods and services that are not fully able to satisfy the needs. Traditional theory does not investigate the relation between preferences and needs taking as assumption that preferences are a perfect representation of the needs.

Additionally, what makes consumer behaviour theory a better fit for examining food losses and waste is the interest on the different implications in the stages preceding and succeeding the purchase of a good or a service. *“Consumer behaviour entails all consumer activities associated with the purchase, use and disposal of goods and services, including the consumer emotional, mental and behavioural responses that precedes, determine or follow these activities”* (Kardes et al, 2010). Therefore, consumer behaviour approach also considers the ultimate destination of the purchased good, an element that is not investigated in the neoclassical framework.

Empirical evidence on date marking and food loss and waste

According to WRAP (2008a), it is possible to cluster the conditions that influence the understanding the changes in date labels and storage guidance in three groups:

- a. **Age:** younger people have a stronger understanding and confidence in food labels and they are likely to follow the indications more firmly. While older people rely more on their own experience and are less keen on respecting the indications provided by the labels and therefore more reluctant in adjusting their behaviour according to the new indication provided by the label. However, the relationship between age and the understanding and confidence in food labels is not univocal and it is presented differently in different researches: some studies (Stop Wasting Food Movement Denmark, Danish Agriculture & Food Council and Danish Consumer Council, 2012) suggest that older people have a stronger trust in food labels.
- b. **Products:** consumers pay attention to the date labels of certain categories of products as meat and dairy products while the indications for products as cereals, fruit and veggies are considered as less important. Considering these evidences WRAP suggests

that potential changes on the date label should be done taking in consideration the characteristics of different products and therefore adjusting the message to the product.

- c. **Risk:** risk averse consumers are generally unwilling to eat the food they consider potentially unsafe or of low quality. In this regard, WRAP suggests the utilization of different communication methods and channels to increase awareness among this group.

WRAP suggests that different studies provide rather different estimations, ranging from 15% of consumers understanding properly the date indications to 83% (WRAP, 2011a), but that the variations are strongly influenced by the way of addressing the question (wording, format, survey method) (WRAP, 2011a). WRAP also investigated the use of the double date labels in UK. If “use by” or “best before” that are coupled with “display until” that applies to the supply management of retailers, the share of consumers that confuse the meaning of the “use by” with “best before” increases of the 6-7%. Therefore, the double date label is considered a source of additional food waste since it could potentially lead consumers to through away foodstuffs that are still perfectly edible. Following these evidences the Department of environment, food and rural affairs (DEFRA) has recently decided to remove the “display until” indication leaving only “use by” or “best before” depending on the typology of product (DEFRA, 2011).

The date label issue is at the centre of public debate also in Switzerland where consumer organizations pointed out that dates indicated by Swiss authorities are generally shorter by 1/3 if compared to the same products in Germany or France with no significant benefits in terms of food safety, but a relevant increase in the creation of avoidable food waste (Swiss.info, 2011)

Quantity discounts and some types of advertising also has implications for food loss and waste. “All you can eat” buffets, oversized portions in restaurants, super-sized packages in supermarkets often attract consumers that have the perception of “buying more for less”.

In the case of a “all you can eat” buffet, a customer assumes to eat more of the expected final price while at the same time for the restaurant the average amount of eaten food should not exceed the price of the meal or the restaurant will go out of business. The economic theory of adverse selection suggests that “all you can eat” buffets should not exist because

restaurants should always increase the price of the meal if the average amount of eaten food is exceeding the price. Theoretically, price adjustment should end when only a single consumer willing to eat the exact amount of food the restaurant is charging for. According to this theory “all you can eat” buffets should not exist (Ozimek, 2012).

There are also other economic reasons that can explain the existence and the relative success of “all you can eat” buffets: the biological limit of individual to eat over a certain amount of food, the fact that the price/quantity relation is not the only criteria utilized by consumers that are also looking for the experience of “all you can eat” and so usually accept prices that overcome expectations, the relatively low labour cost and some economies of scale in food purchase. What is often missing both in the consumer and restaurant manager perspective is the inclusion of food waste disposal in their utility and profit maximization functions. “All you can eat” buffets usually generate a high amount of food waste. Recognizing this inefficiency, some restaurants in Denmark, Singapore, Japan and the UK are testing systems to cover food waste costs: any uneaten food is weighed, and the customers charged accordingly.

Box.7 A potential food waste profile for households

Although scientific literature did not reach a consensus over the quantification of food waste at the household level, studies (Schneider, 2008; WRAP, 2009) suggest that large amounts of food waste come from households. Consumer purchasing behaviour can be identified among the most important causes behind the generation of food waste at domestic level.

The way consumers plan their food shopping, how is it influenced by special offers, the skills in meal planning, and lifestyle, are factors that have an effect on the creation of food waste. Different studies attempted to find a correlation between food losses and waste and household composition in terms of size, education, age, job and sex. A study carried out in Austria (Schneider, 2008) suggests a positive correlation between the amount of generated waste and some individual characteristics. The study identified a positive correlation between age (a negative correlation in this case), income, the level of education, the typology of employment (full time in particular) and the amount of wasted food. Younger people (20-59 years old) generate more waste than people older than 60 years.

The study identifies as possible solutions the system of value of the “post war generation”, probable financial restriction of retired individuals, an higher amount of free time available and therefore a different perception of the cost of time if compared with economically active individuals. Additional reasons could also be linked to the different role of women inside the household and home management skills developed by older generations. Income has also a positive correlation with food waste generation: the higher the income is the higher the tendency to generate food waste. Households composed by individuals with a full time employment also tend to be less efficient since they are less present at home, with more difficulties in meal planning and in forecasting food utilization, they usually utilize less fresh products and more canned, pre-portioned and pre-cooked food that is usually more difficult to be reutilized as leftover ingredient for other recipes.

The study was based on the use of interviews combined with waste sorting analysis of residual waste to identify information about the quantitative composition of residual waste. The limitation of the use of waste sorting analysis focused on residual waste is the lack of information about items disposed of with other methods (kitchen sewer, home composting, separate collection) (Schneider, 2008). At the same time, this methodology allows to integrate the information gathered through the interviews that are often underestimating the generation of waste.

4.2 Macro economic conditions

4.2.1 Infrastructure

Infrastructure is a set of basic physical and organizational structures necessary for an economy to function (O’Sullivan, Sheffrin, 2003). Beyond specific value chain-related infrastructures, there are also macro issues due to spill-over across sub-sectors and sectors, between agricultural production activities and provision of social services (health, education) etc.

In developing countries, out-dated harvest techniques and postharvest handling combined with a lack of storage facilities result in significant losses in quality, and, in some cases, in the complete spoilage of the food products. The improvement of harvest techniques in absence of infrastructural investments (e.g. ameliorated food storage or transportation infrastructure) can lead to the formation of oversupply. This aspect could lead on the one hand to relatively

low prices and on the other hand to increasing challenges in the conservation of the oversupply and therefore to the formation of food losses (INRA/CIRAD 2011).

Moreover, food loss will be greater where links between producers and consumers are weak (Beddington et al 2012).

The reduction of the post-harvest losses is recognized as an important component of food security (Nellemann et al., 2009). FAO emphasized this interrelation already in 1974, but as highlighted in Box.4 post-harvest losses reduction has been characterized by rather poor results. Moreover, further investigation both on the qualitative and quantitative dimension of post-harvest losses are required in order to identify the most appropriate corrective actions.

Market infrastructure development can lead to a significant amelioration of the agri-food chain infrastructures and therefore to a reduction of food losses and waste. These investments often facilitate the development of the rural economy in countries that suffer from bad infrastructure and lack of market access and knowledge (WFP, 2009).

In developing countries the improvement of the efficiency of infrastructural investments in the entire agri-food chain (from producers to consumers) and their long term sustainability depend also on the implementation of appropriate public policies targeted towards the different segments of the agri-food chain. The priorities are the amelioration of the access to local markets and the creation of adequate links to the international ones. In developing countries, in a situation characterized by the absence of links with the international markets and weak local policies, also infrastructural investments often failed (FAO 2003; Kader 2005).

This is also because the domestic demand is not always able to absorb the entire offer, either for quantitative reasons (supply > demand) or for the low purchasing power of local consumers. Therefore, there is the need to explore the linkages with the international market and to identify policies (employment policies, economic development policies, etc.) able to increase the consumer purchasing power and therefore the domestic demand.

In industrialized countries, according to Parfitt (2010), the development of a more efficient infrastructure system has led to a significant growth in the food-processing sector. On one side, better infrastructures allowed farmers to "branch out into new foods, diversifying their incomes" (Parfitt et al., 2010, p. 3069), while on the other side they have increased the distance between economic agents leading to a significant modification of their relationships

and to a reduction of consumers' bargaining power. Improvements in infrastructure also led to a consistent decrease in post-harvest losses with a positive impact on the food availability. However, research on post-consumer food waste suggests that the improvement in the upstream stages of the agri-food chain has partially transferred the problem of losses and waste in the downstream stages. Indeed, consumers waste significant amounts of food, thus reducing the benefits of infrastructure improvements in the upstream of the agri-food chain.

Box.8 Magnitude of post-harvest losses

At the first World Food Conference in 1974, one of the solutions to address hunger was identified in the reduction of post-harvest losses (Parfitt 2010). For this reason FAO, that estimated the post-harvest losses represents the 15% of the total production, created a Special Action Program for the Prevention of Food Losses aiming at a reduction of the 50%.

As emphasized by Grolleaud, who studied several FAO projects focusing on post-harvest losses during the '80s and '90s, the results of the Special Action Program were relatively poor. The studies underlined how after two decades postharvest losses ranged from 13 to 22% of the production in the case of rice, from 15 to 18% for maize, from 8 to 27% for millet and sorghum.

Recent FAO data on post-harvest losses do not show a significant improvement. FAO (2011) highlights that food losses in Europe and North America amounted to 280-300 kg/year/per capita (for a per capita production of edible parts of food for human consumption of about 900 kg/year) while in Sub-Saharan Africa and South/Southeast Asia losses amounted to 120-170 kg/year/per capita (for a per capita production of edible parts of food for human consumption of about 460 kg/year).

It is in this framework that Lundqvist et al. (2008) called for action to reduce food waste by aiming at a reduction of the 50% to be achieved by 2025.

**Table.3 Per Capita food losses and waste, at consumption
and pre-consumptions stages (kg/year)⁴**

	Production to retailing	Household	TOTAL
Europe	180 - 190	90 - 100	270 - 280
North America & Oceania	170 - 180	120 - 130	290 - 300
Industrialized Asia	150 - 160	80 - 90	230 - 240
Sub-Saharan Africa	150 - 160	10 - 20	160 - 170
North Africa, west & Central Asia	170 - 180	40 - 50	210 - 220
South & Southeast Asia	110 - 120	10 - 20	120 - 130
Latin America	190 - 200	30 - 40	220 - 230

Source: authors elaboration from FAO 2011a

4.2.2 Urbanization and socio-economic growth

The rapid change of employment structure at global level affects also the food system. Urbanization has accelerated in recent years. The proportion of the world's population employed in agriculture has declined in last decades and 50 percent of the world's population now lives in urban areas. Since 2007 the global population is predominantly urban and the United Nations estimates that in 2050, 70 percent of the population will live in cities (United Nations 2008). This means that an extended food supply chain is needed to link the countryside to the cities, in order to feed urban populations. Moreover, the changes in the employment structure often lead to a transformation of the social organization and in consumption habits and food related needs. For instance, increasing urbanization in combination with income growth, particularly in emerging economies such as the BRICS (Brazil, Russia, India, China and South Africa), has accelerated the diversification of diets. In these countries has significantly increased the consumption of meat, fish, fresh fruit and vegetables and has declined the consumption of starchy food staples (Parfitt et al., 2010). This shift towards more perishable products and shorter shelf life items - associated also with lack of infrastructure - might lead to increase the possibility of formation of food losses or waste.

⁴ Catering services are not included. The following segments are taken into consideration: agricultural production, postharvest handling and storage, processing, distribution, consumption (household level).

Rural - urban migration might also lead to the loss of labour force in the post-harvest segment of the agri-food supply chain with potential implications for the organization of the work.

Additional implications in terms of employment are related to the emerging needs in the field of food waste. The fight against food losses and waste and the focus on practices that prevent their creation require new skills and new capacities among the different operators of the agri-food chain as well as among consumers. New capacities are required at all levels, from planning to operational activities, and in all the stages. The need for new capacities might be negatively affected by strategies focusing on staff reductions. For instance at the retail level, if staff support is low, there is less workforce to manage damaged products (Gunders 2012).

4.2.3 Trade and globalization

Intersections between trade and food are deep and complex. Due to the reduction of protectionist policies like high tariffs and export subsidies, the improvement of transport conditions and other elements, between 1961 and 2003, world food trade increased from 1500 Gkcal/day to over 7000 Gkcal/day (INRA/CIRAD 2011).

Globalization played a significant role in the review of agricultural policy measures and in the enhancement of market integration, providing also opportunities for the export of agricultural products. In this frame in 2011 agricultural products counted for the 9.3 percent of the trade in total merchandise and in primary products (WTO, 2012). In low-income countries processed food imports and the development of retail chains might have an impact on local food systems reducing the competitiveness of local producers that do not meet certain quality and safety standards. Possible effects include a reduction of the resilience of local food production systems and implications in the generation and management of food losses and food waste.

With increased globalization and offshore sourcing a growing number of supply chains are developed at the global level with a consequent augmented complexity in the identification of logistical solutions and in the relationship among the stakeholders. Although the relationship between global supply chains and food losses and waste is not well understood (FAO, 2011a) different authors suggest that an improved connectivity between the different

stakeholders and a better integration among the segments can facilitate a reduction of food losses (Beddington, 2012).

Price inflation is a rise in the general level of prices of goods and services over a period. Its effects on the economy cover a wide range of issues including the erosion of purchasing power.

Price inflation, especially for lower income groups and therefore with limited purchasing power, can cause a reduction and re-orientation of consumption. In case of a reduction in the short term a reduced food demand could cause imbalances in supply and therefore to the inability to allocate the entire food available in the market. In case of a re-orientation, consumers with low-income power might look at low nutritional food products, that are usually inexpensive but high in calories and fat, or to cheaper products and staple food. Possible results might include also a progressive reduction of the consumption of certain typologies of products (i.e. meat, fish and other more expensive food items). Additionally, a high price inflation could lead consumers to be increasingly interested by discounts and special offers that might challenge consumers' planning capacity and home management skills.

4.2.4 Unemployment

Unemployment is a condition that occurs when people are without work and actively seeking work (International Labour Organization, 1982). It is measured as a rate (percentage of unemployed individuals on all individuals in the labour force).

Unemployment can have an effect similar to inflation. Job losses cause a reduction of consumer purchasing power, which determines a contraction and re-orientation of consumption. Also in this case it could generate imbalances between demand and supply of food, however its impacts on the formation of losses and waste might have different implications: a) more losses due to a less efficient organization of the work and of the entire food chain; b) more waste due to the imbalance between supply and demand; c) less waste due to the need to improve food management at the household level.

5. Non economic conditions that cause Food losses and Waste

5.1 Culture and societal norms

Cultural and capacity aspects might refer to tradition and traditional food related skills and knowledge, for instance the lack of knowledge on a certain product might lead to difficulties in combining it with other ingredients and therefore to use it (Segrè, 2012). At the same time limited cooking skills could result in the lack of capacity of reducing waste by combining leftovers from previous meals or creating meals from available ingredients (Lang, Heasman, 2004; Segrè, 2012). Cultural food related differences among groups and traditional cultural heritage and habits might lead to differences in food management: in the US Latinos waste about 25% less than non-Latinos (Jones, 2006). In this frame also weddings, and religious and traditional holidays might have an impact since they create additional complications in forecasting the demand for food products and might lead to overproduction that has to be managed either at the processing, retail or consumption level and that can be a potential source of food waste (BCFN, 2012).

At the same time also life style, in terms of change in consumption and food preferences, and generational change might have an impact due to a different approach and attention to food. This might be reflected also in the daily vocabulary as in the case of the Italian word "*scattivare*", that refers to the elimination of the bad part of fruit and veggies, that, as many other similar words, is moving out from the current vocabulary (Treccani, 2013).

Finally, it should be stressed that in many societies the low price and high availability caused a decline of food in the scale of social, ethical and environmental values. This situation has meant that it is not morally reprehensible to waste food, as far as it is only a "small" part of what purchased and its economic value is reduced.

5.2 Social aspects

Social drivers elements potentially related to food loss and waste include household composition in terms of size, education, age, job and sex. Larger families tend to be more efficient due to a lower waste per capita, while smaller households tend to have a higher waste per capita. Families with children also tend to be bigger wasters than those without, although this is offset to some extent by economies of scale that come with catering for

larger numbers (WRAP, 2007a). However the relationship between household size and food waste is not a simple one and it not just size of the household that is influencing food waste but also its make-up (WRAP, 2008b). In this case, an additional issue might be packaging and size of portions that are often targeting large families and not to single person households (WRAP, 2008a). According to a report of the Danish Agriculture & Food Council (Stop Wasting Food Movement Denmark, Danish Agriculture & Food Council and Danish Consumer Council, 2012) single households are the worst food wasters: 98,8 kilo per capita per year, while a person in average family of 4 generates 57,2 kilo food waste per capita per year.

Planning capacity might refers also to decision making processes: larger families have often more experience, evidences and information to forecast what are their weekly needs therefore it is easier to purchase what is likely to be necessary (WRAP, 2007a).

Civic sense and institutional trust might also have a significant impact related to the understanding of the diverse impacts (economic, social, environmental at least) of food losses and wastes reducing the effectiveness of information campaigns (Segrè, 2008 b). A better understanding of the negative externalities of food losses and wastes can lead to the reduction of behaviours that takes to the creation of a higher amount of waste (WRAP, 2007b). In this frame, the lack of information and knowledge sharing within households can be considered as a major driver of food losses and waste creation.

Gender differences might also have relevant implications in the generation and management of food losses and waste.

5.3 Environment and climate

Environmental and climatic aspects refer to extreme weather conditions such as drought or frost that might lead to important implications on food losses and waste due to a decreased production capacity. The capacity of farmers and governments to respond to these events might vary considerably on a country basis: there are areas where climatic conditions are more severe and in certain countries the capacity of farmers and governments to respond to these situations is likely to be rather weak. Similar effects can be find also in natural disaster as floods or earthquakes that lead to emergency situations characterized by a reduced operational capacity, damages in infrastructures and production facilities and more complex management and decision making process. In addition, climate change might have a role due

to the need of farmers to adjust to new crops or varieties and therefore with a potential lack of knowledge on the related agronomic and management techniques.

In this framework, an important role should be played by innovation focusing on climate change adaptation through the selection of better varieties or the identification of more sustainable and flexible agricultural practices. Current climate might be characterized by droughts that are more frequent, flooding, and heat waves that can lead to significant losses and to the deterioration of the productivity of the agricultural sector in many countries. Although the magnitude of the impact of climate change on crop production remains unclear and it is still far from being fully predicted, there is a growing appreciation on the availability of information on the subject. The agricultural sector is exposed to natural disasters and therefore extremely vulnerable. The identification of climate smart agriculture⁵ solutions to reduce losses and yield fluctuations include innovations for crop and livestock production and good agricultural practices as agro-forestry, sustainable soil management, increasing crop diversity, improving food production from existing livestock, diversifying livestock breeds, integrated forest, farm and fish systems, agro-ecological and organic farming, support to small scale farmers etc. (Worldwatch Institute 2012).

⁵ FAO defines climate smart agriculture as an agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation) while enhancing the achievement of national food security and development goals.

Box.9 Natural resources and environmental impact of food loss and waste

The nexus among water, land, food and energy is increasingly raising concerns both at the global and at the local level and it has further interrelations with the major global transitions as the urban population transition; the nutrition transition, with demand for new foodstuffs that rely on increased consumption of animal products and other high-value foods; the climate transition; the agricultural transition, with huge increases in food demands; and the energy transition, with a move from fossil fuels to renewable energy resources (Peter P. Rogers, 2013).

Food loss and waste have several natural resources and environmental implications that can be related both to the loss of the resources that have been utilized for food production, and to emissions of greenhouse gases that are released during the entire production cycle and through waste management operations.

For instance, food loss and waste are characterized by a “double” waste of energy, because, on one hand, the chemical energy contained in the food, and, on the other hand, the productive energy inputs that are wasted alongside with food. Furthermore, this waste could be considered as threefold if further energy is required during waste management.

According to estimates from the University of Texas (M. Webber, 2012) in the U.S. the energy consumption attributed to food losses and waste represents about the 2.5% of the total final energy consumption. In Italy, where food losses and waste represent about the 20% of the overall production of food, they are equivalent to the 3% of the total final energy consumption that represents roughly the consumption of about 1.6 million Italians (A. Segrè, M. Vittuari, 2013).

Wasting food also has consequences in terms of waste of water used either directly or “virtually” over the entire production cycle. Wrap (2011b) estimated that the water footprint of food wasted at the household level, amounts to 6,3 million m³ of virtual water per year and that 5,4 million m³, or the 5% of the total UK water footprint, are associated to avoidable food waste. It must be emphasized, however, as 71% of this waste virtual water, is related to imported products. Therefore, the waste of this resource not goes to make a dent to UK's water resources but those of other countries.

In Italy, considering the products left on the field after harvesting (**Box 1**), the water footprint is approximately 1,2 million m³ per year. More than 200 million cubic meters of blue and gray water are wasted, representing the 16.7% of the total amount of virtual water waste, a quantity of water that would satisfy, according the estimates for the Italian household water use (68 3^M per capita), the needs of approximately 3 million people or the 5% of the Italian population (A. Segre, L. Falasconi, 2012).

Furthermore, the environmental impact of food losses and waste includes also the GHG emissions generated to manage FLW. For instance Wrap (2011b) estimated that in UK the carbon footprint of household food waste amounts to 25,7 million tonnes CO₂ equivalent per year, with about the 78% related to avoidable food waste. Avoidable food waste emissions are equivalent approximately to 3% of the UK's domestic greenhouse gas emissions. These emissions correspond to those produced by over 7 million cars per year. In US, according to Venkat (2011), the carbon footprint of food waste linked to the stages of production, processing, packaging, distribution and disposal amounted to about 113 million tons of CO₂ equivalent, with 16% of total emissions generated by the beef industry. These emissions are equivalent to 2% of net US GHG emissions, and are equivalent to 14,27 % of US total national food emissions.

5.4 Policy

Agricultural and food policy include sets of rules and mechanisms aimed at regulating the agricultural sector and the entire food supply chain. However, there are situations when measures, especially under certain conditions, might have negative impacts leading to the creation of food losses and waste. It was, for instance, the case of the tools utilized in the past by the EU Common Agricultural policy that lead to the overproduction of food supplies with serious implications in terms of waste⁶. **Box.10** provides a detailed example on the potential connections among policy, fishing, and waste. The lack of capacity to provide adequate agro-meteorological forecasts as well as a weak capacity to provide price forecasts can also lead to the creation of food losses and waste due to bad planning. In general, it is the lack of information - out-dated or not reliable information about agricultural structures,

⁶ The EU Common Agricultural Policy undergone a number of reforms that lead to a reduction of the most distortive measures leading to the formation of food losses and waste. However the extensive use of direct support measures historically caused significant amounts of losses and waste.

land use, production - that in certain countries affect policy making and it can lead to the creation of negative externalities.

Losses have shown a positive correlation with climate variability and extreme weather events. Considering the acceleration of long-term climate change, in the short medium run this typology of losses are forecasted to raise and to increasingly affect farmers' income, agricultural production (yields), prices and food availability. Although the strategies for adaptation and mitigation in agriculture are still rather limited important tools that is increasingly used in agricultural policy design and implementation are those concerning on-farm measures as crop diversification, vertical integration, the selection of products with short production cycles, and those related to risk sharing including marketing and production contracts and agricultural insurance schemes. Crop insurance schemes allow agricultural producers to protect their produce from hail, drought, and floods, or from the loss of revenue due to the fall of price of agricultural commodities. A significant development of these instruments has characterized the agricultural policies of Canada, India and US.

Overall, the formation of food losses and waste are related not only to agro-food and rural policies, but also to a wider set of sectorial policies that need to be harmonized and better coordinated horizontally and vertically.

Box.10 Fish loss and waste

As any renewable resource, fish is characterized by a regeneration ratio. This means that, if a stock is composed of 1000 fish with a regeneration ratio of 10% per year, a sustainable management allows the capture of not more than 100 fish in a year. This proportion is not respected in every part of the world. Since fish cannot be owned until caught, the stocks have to be considered as a common resource. In other words, a shared and collective management is required. However, policies and strategies are different in every country (Turner et al, 1994).

In this sector, one of the most relevant waste stream is represented by the discards and by-catch. There are political and economic reasons of this phenomenon: the existence of political quotas in certain regions (e.g. EU) and market conditions. In the first case, when the limit, established by the quota system, has already reached for one or more species, fishermen throw back the caught animals. Many of them are dead by the time reaching the water again. In the second case, too small dimensions or species not required by the market go back to the sea (Koch, 2013).

The EU decided to reform its common fisheries policy. The attempt to modernize this policy should make fishing more sustainable and reduce overfishing, stressing the linkages between EU and other countries (above all developing countries), because fish must be considered as a global resource in a global market.

5.5 Legislation

Beside the role in protecting consumers, legislation and regulations on food safety and quality standards, as well as on labelling and food contact materials, can constitute potential sources of food loss and waste (See Box.5). It is the case of products that, although they are perfectly edible, are left on the field since do not respect certain criteria as size, shape or colour (Segrè, Falasconi, 2011; United Nations Economic Commission for Europe, 2008). **Box.11** provides an example of food waste formation due to market standards in the case of fruit and vegetables.

An additional case of legislation that can be a potential cause of food loss and waste is labelling. Misinterpretation or confusion over date labels is recognized for its contribution to household food waste as consumers tend to give the same meaning to terms as “best before”, “use by”, “sell by”, and “display until” (See Box.5). The result is waste of a significant amount of products that are still edible (European Commission 2010; Parfitt et al. 2010; WRAP, 2008a).

Box.11 Marketing standards for fruit and vegetables and food loss and waste

The assurance of food safety and quality standards are objectives of agricultural policies and aim at ensuring protection (from products adulteration, false information etc.) of health and consumers’ interests and facilitate the movement of goods. Recently standards have also been identified as a possible cause of food losses and waste. Literature and studies suggest different interpretations depending also on the function of the standards and on the specific characteristics of the product.

Some authors identify in aesthetic or functional standards, as those that lead to discard bent cucumbers and carrots, a potential source of food losses and emphasize how marketing standards might lead to discard products that are perfectly meeting food quality and safety criteria only due to these aesthetic issues or packaging defects (Stuart 2009; BIOS 2010).

A study lead for the EC to analyse (i) how specific marketing standards for fruit and vegetables in the EU are useful for producers, traders, packers and retailers and (ii) to assess the validity of the arguments against or in favour of repealing specific marketing standards, proposes a different interpretation (AND International, 2010). The study focuses on 5 countries (France, Germany, Italy, Poland, and United Kingdom) and emphasized the usefulness of having common and controlled standards. The only exception reported in the study is the United Kingdom where standards are defined by large-scale retailers. The analysis suggests that repealing marketing standards have not a significant impact on the reduction of food waste and that the presence of unsorted products could lead to a growth of waste at the retail level with the consequence that products, instead of being reoriented, upstream, towards parallel channels (transformation, animal feeding, etc.), would be thrown away at

the end of the chain (AND International, 2010). This evidence suggests the need for a value chain/supply chain or life cycle approach especially in the case of highly integrated supply chains since different products and materials might have different potential utilizations in different segments of the agro-food chain. Food losses and waste need to be addressed as a food system problem and managed accordingly. Impacts and solutions might vary also depending on the characteristics of the product and on the market conditions of each species (AND International, 2010).

5.6 Private standards

Beside formal standards, set by laws and regulations, private standards, often set by producers, might be a source of food losses and wastes. It is the case of aesthetic or functional standards as those that lead to discard bent cucumbers and carrots (Stuart, 2009) even if the products fulfil food quality and safety standards. Private standards are often set to answer to consumers request for products with a perfect shape and a certain size and colour (high cosmetic food standards) so there is a reciprocal influence between consumers and retailers.

6. CONDITIONS THAT EXPLAIN THE FORMATION OF FOOD LOSSES AND WASTE. A THEORETICAL FRAMEWORK

The relationship between individuals and food cannot be explained only via economic theory since it is characterized by a set of interconnected dimensions including a number of non-economic factors related to cultural, environmental, social and political elements. This complex relationship influence the behaviour and the choices of economic agents along the entire supply chain from production to consumption. The result is a gap between the real behaviour of economic agents and the predictions suggested by economic theory.

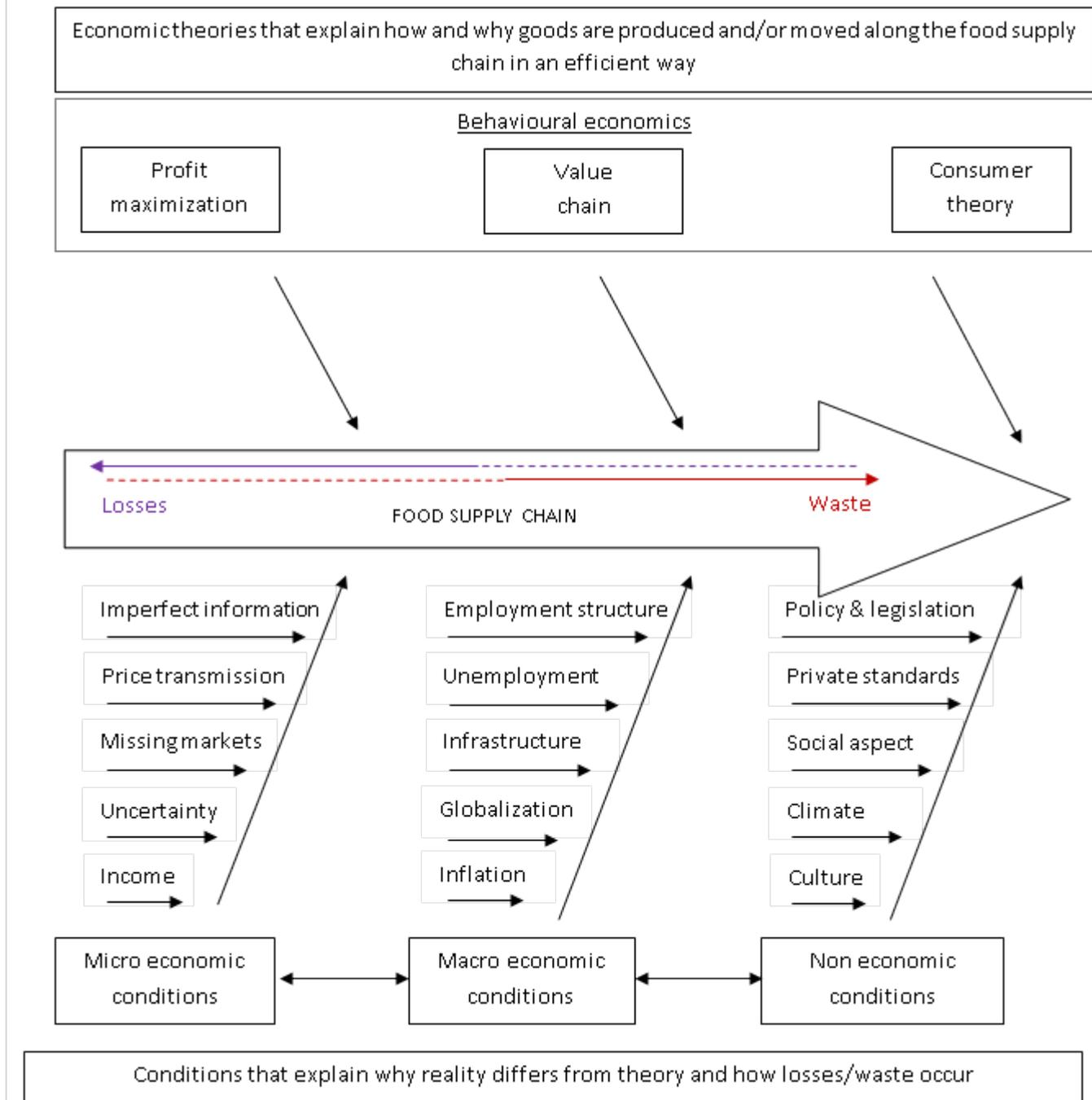
As represented in figure 2 micro and macroeconomic dimensions are interrelated. The aggregate variables are, in short terms, the sum of the variables referred to the individual economic actors (Blanchard, 1997), therefore the same elements are investigated under different perspectives.

In general microeconomics explain the economic behaviour of individual operators (entrepreneurs, consumers), while macroeconomics reflect the implications of the system where the individual operators work.

For instance the implications of infrastructures on food losses and waste are analysed both at the micro and at the macro level. In general terms infrastructures are a macroeconomic condition, but it interacts also with the microeconomic sphere, for example contributing to the generation of missing markets where supply cannot reach the demand for the lack or poor conditions of roads, train stations, ports etc.

This simple example suggests that additional research should be carried out focusing on the interaction between the different conditions, on the negative or positive effects and on the magnitude of their combination.

Figure.2 Basic conditions that explain the formation of food losses and waste



Source: author's elaboration.

As emphasized in section 4 decisions are taken on the base of intuitions and previous experiences rather than following a strict optimization scheme because agents are not able to collect and analyse all the information required to compare the utility of each alternative action (Simon, 1982). Therefore the behaviour of economic agents within the food chain is conditioned by economic factors (micro and macroeconomic), non economic factors and by

what Simon defines bounded rationality that consists in the limited information agents have, the cognitive limitations of their minds, and the finite amount of time they have to make a decision (Simon, 1982).

Table 6.1 summarize the different factors influencing the behaviour of economic agents leading to the formation of food losses and waste.

Table.4 Microeconomic, macroeconomic and non economic conditions for the formation of food losses and waste

Food Losses				Food Waste	
Farming industry	Post Harvest	Food processing Industry	Wholesaling Supermarkets	Food services	Domestic consumption

a) Microeconomic drivers

Production theory and profit maximization

Information asymmetry or imperfect information; uncertainty; inefficient mechanism of price transmission; elasticity; weak competitiveness; low level of technology innovation; limited market access; inappropriate food contact materials (FCM); weak management capacity (bad planned procurement and weak stock management); not reaching “optimal efficiency” in agri-food products.

Value chains: inadequate storage; imperfect information; lack of access to financial resources; missing markets; out-dated technology; lack of technical knowledge or lack of access to technical knowledge; limited market access; out-dated, inadequate or inefficient production and harvest techniques; transportation of food over long distances; technology innovation; other, as all elements that could impact on the value chain efficiency.

Consumer theory: distance of the real consumer from the “ideal consumer” with a “representative behaviour” suggested by the neoclassical theory; low

planning capacity; new values (aesthetic characteristics, social prestige, innovation) guiding consumer choices; relationship between low purchasing power and the consumption of low nutritional food; lack of recognition of the reduction of the marginal utility in the additional food item an obese/overweight individual intakes; new food preferences; increased opportunity cost related to housework and food preparation; high use of precooked and ready to eat products; portion size; lack of information related to food labels, standards and expiration dates.

Behavioural economics: decisions are taken on the basis of intuition and previous experiences rather than following a strict optimization scheme; two utility functions: expected utility and effective utility; goods are created by economic agents other than those expressing the preferences therefore they might not respond to the real needs; traditional theory does not investigate the relationship between performances and needs. Lack of capacity for medium to long term evaluation of investment and return on investment opportunity.

b) Macroeconomic conditions

Infrastructure: improvement of harvest techniques in absence of relevant infrastructural investments; lack of links between producers and consumers; lack of market access and knowledge; lack of links with international markets and weak local policies that lead to a failure in infrastructural investments; lack of infrastructure that allow farmers to search new products and diversify their activities.

Employment structure: changes in the employment structure and decline of work force engaged in the agricultural sector and related rural – urban migration; implications of the transformation of the social organization on consumption habits, food related needs and diets (increased consumption of meat, fish, fresh fruit and vegetables with a decline in starchy food staples. Shift towards more perishable products and shorter shelf life items); loss of labour force in the post-harvest segment of the food supply chain with potential implications for the organization of the work; lack of skills and knowledge among the operators of the

agri-food supply chain (as well as among consumers); high labour cost with a consequent staff reduction to manage damaged or imperfect products; unemployment has an effect similar to inflation determining a reduction of consumer purchasing power with a consequent contraction and re-orientation of consumption.

Trade and globalization: rise of global supply chains characterized by a complex logistic and by high distances between the actors involved in the different production phases; in low income countries processed food imports and the development of retail chains might have an impact on local food systems reducing the competitiveness of local producers that do not meet certain quality and safety standards; lack of integration among the segments of the food supply chain.

Food price inflation: food price inflation might cause inability to allocate the entire food production on the market, a reduction and re-orientation of consumer choices and preferences, a progressive reduction in the consumption of certain typology of products (i.e. meat, fish and other more expensive food items), increased preference of consumers on discounts and special offers with a potential effect on consumers' planning capacity.

c) Non economic conditions

Cultural dimension and capacity

Lack of knowledge about the characteristic of a certain product might lead to difficulties in combining it with other ingredients; reduced cooking skills; lack of capacity of reducing waste by combining leftovers from previous meals or creating meals from available ingredients; bad food management due to a changing cultural environment leading to food related differences; bad planning due to weddings, religious and traditional holidays (might cause overproduction); life style lead to changes in consumption and food preferences; generational change can have an impact on food preferences and the overall approach to food (including food related skills); low price and high availability of food might cause a decline of the non-economic (environmental, ethical, social) value of food.

Social dimension

Household composition (size, education, age, job, sex); lack of experience in meals planning; uncertainty in the number of meals at home per week; reduced information and knowledge; living standards and new life style; low civic sense and institutional trust; low perception of the impact of food loss and waste; gender.

Environment and climate

Weather adversities; natural disasters; climate change; seasonality; slow and inadequate governmental responses to climate change; lack of farmer responses to climate change; lack of innovation and climate smart agricultural practices.

Policy

Inadequately designed subsidies to production (i.e. direct subsidies to production); lack of capacity to provide agro meteorological forecasts; lack of capacity to provide price forecasts; poor information; lack of preparedness or delays in adaptation to climate change; absence or poor insurance schemes or strategies for risk reduction. Weak horizontal and vertical coordination.

Legislation

Ineffective legislation and regulation on food safety and quality standards; unclear labels; lack of harmonization, information and implementation capacity of different labels (i.e. "best before", "use by").

Private standards

Aesthetic or functional standards set by producers and retailers.

Source: author's elaboration

The paper pointed out the main conditions that are leading to the formation of food losses and waste and emphasized the need for further investigation in order to cover the informational gap about the implications of food losses and waste both in qualitative and quantitative terms. Among the major open questions, the following should be included:

- *Are food losses and waste among the causes of food insecurity?*
- *To what extent addressing food losses and waste contribute to environmentally, economically and socially sustainable development?*
- What are the linkages between food losses and waste, natural resource use, natural resource pricing and environmental externalities in food production and consumption processes?
- What are the possible distributional implications (within and across countries) of addressing food losses and waste?
- To what extent, charging to producers (and/or consumers) the full cost of natural resources used in production processes could bring food production on a long-term sustainable path?
- Food production and consumption are often based on scarce resources that are under-priced. Moreover their price to users does not fully reflect the opportunity cost (at least in the long run). Is this one of the fundamental issues behind food losses and waste?
- Would the internalization of externalities reduce food losses and waste?
- Would net producing countries benefitting more/less than net consuming countries from food losses and waste reduction (in different locations)? To what extent? Would rich countries benefit more/less than poor countries?
- What are the most likely channels through which food losses and waste reduction would spread their impacts across/within countries in the short, medium and long run? Local and international food price? Agricultural inputs shifts? Shifts in GHG emissions and possible compensatory schemes based on “polluter pays” principle? Shifts in energy prices?
- The Impact of food losses reduction on prices is one of the crucial issues that may need to be deepened as food prices possibly are one of the channels through which impacts of food losses reduction would spread within countries and, to some extent possibly also across countries
- What are the policy implications considering food losses and waste? What policies have a relevant impact beside the agro-food and the rural ones? What measures could be adopted for food losses and waste prevention and reduction?
- To what extent and through which mechanisms the lack of information can lead to negative externalities? Which type of externalities? What implications for food losses and waste?

7. NECESSARY CONDITIONS AND POLICY LEVERS TO PREVENT AND REDUCE FOOD LOSSES AND WASTE

Food losses and waste occur at every stage of the supply chain for the reasons explained in the previous sections. However, according to the definition adopted in this study, the former are more significant in the early stages (production, storage) and particularly in developing countries, while the latter has a more relevant dimension in developed countries and above all in the downstream segments of the food chain (consumption, retailers) (FAO, 2011a). The identification of the causes of food losses and waste and the adoption of appropriate policy leavers can facilitate their prevention and reduction.

Prevention and reduction of food losses and waste in developing countries

In developing countries, the major conditions for the reduction of food losses require the introduction of organized producers into the value chains and the promotion of a stable market access. Public incentives could be an effective policy lever to facilitate the integration of small farmers in associations or cooperatives, in order to increase their power along the value chain and their capacity to place more products on the markets.

A more integrated approach is desirable for all the stakeholders in order to achieve a higher level of transparency among the different actors. Institutional guidance, *ad hoc* regulations, public incentives are some of the levers that could lead to a better connection of the different supply chain segments. In an integrated system price and information flows are more transparent and effective (Government office for science, 2011).

Barriers to market access are also generated by the lack of technical schemes, business plans and medium/long term strategies. Therefore the improvement of technical skills and managerial capacities represents a further prevention lever. In this case, investments in **farmers' education** could enhance their economic behaviour and the efficiency of their choices, as - for instance - the typology of storage that is included among the major drivers of waste.

Beside public policies also development projects could represent a lever by establishing mechanisms to **link farmers to market**, for instance identifying new market opportunities, developing marketing strategies and business plans, integrating farm and off-farm value

chains, improving physical and information flows among the actors, supporting financial and the technical services etc. (Silveri, 2012).

Production **diversification** is another essential condition to prevent food losses, especially those related to premature harvesting that in developing Countries is a practice encouraged by the urgent need for money during the second half of the agricultural season (FAO, 2011a). A more diversified production, for example with different varieties or different sowing and harvesting periods, reduces the typical economic risk connected to agricultural activities because income sources are diversified and consequently food security is improved.

The globalization and urbanization processes lead to a rise of global supply chains with a consequent growth of the distance between production and transformation/consumption sites. In these situations investments in infrastructure are required to remove that causes that do not allow food supply to meet food demand (*missing markets*).

Furthermore, public and private incentives in research & innovation can improve efficiency at every stage of the supply chain. For instance, new technologies in the production and post-harvest segments - as better drying system, storage facilities, and cold chain - lead to a significant reduction in food losses and waste (Government office for science, 2011).

It is the case of grain post-harvest losses in Sub-Saharan Africa (Box.4) that is suggesting the need to introduce measures and technologies to improve practices along the production, processing and storage phases. The same case study is also emphasizing the need for place based tools and policy measures: silos that proved to be very effective in South America did not show the same results in Africa.

Moreover, food loss can be generated by unsafe food, potentially dangerous for human consumption. The application of **food safety standards**, as the respect of phytosanitary measures and the compliance with hygienic requirements, could be a key factor of prevention, which also helps to preserve consumers' health.

Prevention and reduction of food losses and waste in industrialized countries

Some of the above-mentioned measures may represent effective levers for the prevention and the reduction of food losses and waste in developed countries. For instance, vertical integration along the supply chain could facilitate information and physical flows, farmers' aggregation, investments in research and innovation to improve processes and products.

Some of these elements are emphasized in the case of the losses in the field in Italy (Box.3). Also in industrialized countries there are a number of factors contributing to the generation of food losses ranging from products that cannot be harvested because of damages by pests, diseases or weather (heavy rains), low prices leading farmers to leave part of the production on the field, products left on the field due to commercial imperfections. Policy and technical innovations and measures can contribute to reduce the amount of losses. For instance price support and control mechanisms have been largely utilized within the common agricultural policy. It is the case of the set aside measure adopted within the CAP as voluntary in 1988 and as mandatory in 1993. Set aside was aimed to help reduce the large and costly surpluses - leading to large amount of losses - produced in Europe under the guaranteed price system and to provide some environmental benefits. The effects of set aside were rather limited also due to the productivity growth led by to the introduction of new varieties (i.e. more resistant to pests) and to technological progress. Although set aside is no longer implemented with the EU CAP, it represents a case of lack of responsiveness of policy instruments.

However, since in this case food waste is generated mainly in the downstream segments, there are additional tools - as communication and dissemination campaigns - that are required to improve the prevention and reduction of food losses and waste. For instance, consumers' education is a basic step to improve their ability in food planning, purchasing and consumption.

This is particularly relevant since a large amount of food waste is produced at the household level (FAO, 2011a) with consumer purchasing behaviour being identified among the most important causes behind the creation of food waste. The scientific literature aimed at identifying a clear "food waster profile" (**Box.7**) is relatively poor and since it fails in providing relevant indications campaigns and educational activities should be addressed to the wider public. However, a better definition of the correlation between food waste and household composition in terms of size, education, age, job and sex could allow a better definition of the educational and informational needs and of the tools that could be implemented to prevent and reduce food waste.

The relatively low price of food could lead to consider food waste reduction as a more expensive and not convenient solution. In this case a limit is represented also by the fact that external costs are often not included in price formation. A potential lever is represented by the "polluter (waster) pays principle". The application of this principle could encourage

stakeholders to review production and consumption models adopting more sustainable solutions. According to this principle, environmental and social costs are charged to those who cause it. Fiscal incentives could represent an instrument to implement the “polluter pays principle”. For instance a growth on the taxation on waste but a special tax treatment for economic agents introducing solutions to reduce food waste, such as retailers who sell at a lower price products next to the expiration date.

Best practices (Box.6) related to retailers and consumer behaviour include for instance the actions promoted to reduce the distortions of “buy one get one free” offers as the initiatives of several UK retailers that are introducing offers based on the possibility to claim the free product in the following week. Similarly some “all you can eat buffets” are testing systems to cover food waste costs as the additional cost charged to the amount of food left in the plate.

Private standards, set by retailers to ensure certain characteristics of the products, often lead to waste food items that are still perfectly edible but not “attractive” due to the size, the colour or the shape. Selling these products at lower prices in the store or in an alternative food chain (e.g. farmers markets) allows consumers to have access to cheaper but perfectly edible products and to reduce food waste. Beside these evidences there are also studies underlining that marketing standards do not have a significant impact in the creation of food waste. As suggested by Box.11, a study leaded by the EC to analyse the effects of marketing standards for fruit and vegetables emphasized that marketing standards have not a significant impact for the creation of food waste and that the presence of unsorted products might lead to a growth of waste at the retail level with the consequence that products, instead of being reoriented through alternative market channels (transformation, animal feeding), would be disposed of at the end of the chain (AND International, 2010). **Boxes 12–15** gives select examples of initiatives for food loss and waste reduction.

Box.12 Model Agriculture Produce Marketing Committee (APMC) Act, India

The Indian horticultural sector is characterized by low productivity, high cost of production, significant post-harvest losses, inefficient supply chain (underdeveloped infrastructure support like cold storages, markets, roads, transportation facilities, etc.) and limited market knowledge. In this frame about the thirty percent of the fruit and vegetable production is wasted because of lack of cold chains (Mital, 2007). For all these reasons the agricultural markets and supply chains integration emerged as one of the major policy priorities.

The political instrument to remove the restriction on direct procurement and to improve the efficiency of the supply chain was identified in The Agricultural Produce Market Committees (APMC) Act. The main objective of the APMC is to provide a regulation for agricultural production markets. Most of the wholesale markets and some of the rural primary markets have been restructured under this regulation. Several regulated wholesale markets have been created organizing a large area and several sub-yards attached to the principal market, and by improving the infrastructure. The establishment of regulated markets has allowed setting clear and transparent marketing conditions in primary markets. This new framework has increased the access of farmers to such orderly market places.

This evolution, accompanied with the improvement of road networks linking primary markets with secondary wholesale, also improved the price formation process at the primary market level (MOFPI, 2008). These new structures, have allowed increasing the access of farmers to market places. Furthermore, there has been a reduction in the transaction costs that has helped small-farmers have lower surpluses.

According to data from the Ministry of Agriculture, only 17 states and Union Territories (UTs) out of 35 have amended their APMC Act to allow direct marketing, contract farming and markets in private and cooperative sectors. Key grain producing states, such as Haryana, Punjab and Madhya Pradesh, have initiated only partial reforms (Mital, 2007).

Box.13 Last Minute Market, Italy

Organizations are working for food waste prevention, reduction and recovery at international level.

The main experiences developed in industrialized and emerging countries can be grouped according to the typology of interventions that characterize their mission: (i) those providing food aid; (ii) those working for the reduction, recycling and reuse of food losses and waste; (iii) those engaged in raising campaigns on food waste.

In this frame the Italian initiative Last Minute Market (LMM), is rather unique since it is engaged in achieving all these three objectives, it has a dual nature, and it is a for profit organization (enterprise), that provides services to its stakeholders.

LMM is a spin-off company of the University of Bologna, founded in 1998 as research unit on food waste and since 2003 become a company that acts on the whole Italian territory, with projects for enterprises, aiming to provide them with tools for the reduction of waste and / or recovery of non-marketable goods for the benefit of charitable organizations. LMM uses an operational team supported by researchers of the University of Bologna.

The logistical and organizational models adopted allow on one hand to reduce the formation of waste, and on the other to safely recover all types of products. LMM, in fact, does not directly manage the unsold products, does not have warehouses or equity for the withdrawal: the organization promotes direct contact between demand and supply, taking care of safety measures for all stages of the system.

Awareness-raising initiatives fall into two broad categories, those dedicated to the promotion of legislative and those for citizens. Among the first it can be included:

The promotion of the "Anti-waste Law" (L. 244/24 December 2007), to facilitate the donation of non-food goods;

The design, launch and promotion of the "Joint Declaration against Food Waste," presented on the 28 of October 2010 at the European Parliament in Brussels;

The support to the European resolution approved by the European Parliament in plenary session to reduce food waste and improve the food supply chain efficiency.

Among the latter it can be included:

- The multi-year campaign "Year against waste", promoted with the patronage of the Commission on Agriculture and Rural Development of the European Parliament, which aims to raise the European awareness on the causes and consequences of waste, to promote a civic culture guided by the principles of sustainability and solidarity.

Box.14 Good Samaritan Law¹

Each year in the United States about the 40 percent of food is wasted (Gunders, 2012). At the same time, in 2011, 50.1 million Americans lived in food insecure households (33.5 million adults and 16.7 million children) (Coleman, 2012).

Despite this contrast between surplus and deficit donations of food to the most needy sections of the population are a relatively recent alternative. The Bill Emerson Good Samaritan Food Donation Act was signed in 1996 by President Bill Clinton. Before approval of this law most food companies were not donating to feeding programs due to consumer health related risks. Before 1996 laws protecting donors existed in all the 50 states, but the differences in the application process between states discouraged national companies to donate. With the national law, national donors have a unique legislation that protects them from civil and criminal liability.

The law protects food donors (corporations, partnerships, organizations, associations, governmental entities, wholesalers, retailers, restaurateurs, caterers, farmers, gleaners, including individuals, and non-profit organizations) who act in good faith, from civil and criminal liability in case the donated product causes damage to its recipient.

The law provides protection for food that meet all quality and labelling standards imposed by laws even though the food is considered no more marketable due to appearance, age, freshness, grade, size, surplus or other conditions.

Box.15 Fome Zero, Brazil

Brazil is a country characterized by an evident paradox. Millions of families do not have enough food to meet their nutritional needs, while Brazil is a country where food abounds and which is experiencing a raise in the export of agricultural products (da Silva, 2011). In 2003, to face this paradox, President Lula launched the program Fome Zero.

Fome Zero is a strategy of the Federal Government aimed to guarantee the access to adequate food for those who lack it. The strategy is placed in a context of promotion of food and nutritional security in an attempt to achieve social inclusion and citizenship rights for the population most vulnerable to hunger (MDS, 2003).

The Fome Zero Program is structured in over 30 complementary programs designed to fight causes of hunger and food insecurity. The complementary program dedicated to food access is divided into sub-areas: conditional cash transfer, nutrition programs, taxes incentive/inducement, tribute reduction (da Silva, 2011).

The sub-areas - nutrition programs - include a series of measures aimed at fighting food waste through the actions carried out by the Food Banks and other recovery and re-distribution entities. Food Banks work with donations of food suitable for human consumption. Food is distributed to non-profit institutions that re-distribute free meals to food insecure population (MDS, 2003).

Fome Zero promotes also the institutionalization of the Good Samaritan Statute. The goal of the Statute is to encourage food donations, reducing costs and eliminating improper responsibilities. The application of this law is expected to lead to a significant increase in the recovery of food products, and therefore to a reduction of food waste.

The Good Samaritan Law was approved by the Senate of the Republic (Bill n. 4,747/1998) and is currently under analysis at the Chamber of Representatives. However, a similar bill (n. 3,289/1997) is also under evaluation from the Chamber of Representatives and it is now waiting for an opinion from the Constitution and Justice Committee (da Silva, 20011).

In Fome Zero are also included other measures such as the modernization of food supply facilities, new relationships with retail chains, support to family farming, support production for self-consumption, that could play a positive role on the reduction of food losses and waste.

8. CONCLUSIONS

The study attempted to conceptualize food loss and waste from the economic theory viewpoint. The basic conditions considered and classified as economic (micro and macro) and non-economic were analysed to address the issue from different perspectives.

A number of policy levers and potential settings to prevent and/or reduce food loss and waste were identified according to the segment of the food supply chain and socio-economic context. In developing and emerging countries prevention measures should be targeted especially to the initial segments of the food supply chains where most losses occur, while in industrialized countries measures should be targeted particularly to the last steps. Worldwide, interventions should have a sustainable food systems approach (social, economic, and environmental).

The literature on the subject is still relatively poor. There are few quantitative studies – mainly based on life cycle approaches - and available data are often partial. Further research is needed to bridge the gap of knowledge about several fundamental aspects. For instance, it is considered urgent to collect and report data in a more systematic and harmonized way in order to provide evidence about the magnitude of food loss and waste. Furthermore, case studies on specific crops/commodities could allow a better understanding of the impacts of food loss and waste on specific food supply chains.

Concerning the knowledge gaps identified, the study proposes a theoretical framework in which economic theory and conditions (causes of food loss and waste) are summarized, and some of the connections between these elements are reported. Due to the lack of complete analysis and data, it has been necessary to make a number of assumptions therefore it would be relevant to carry out further analytical work to investigate how conditions interact with each other both in qualitative and quantitative terms.

Further research should also include the impacts of food loss and waste on (i) food and nutrition security; (ii) producing and consuming countries; (iii) distribution within and across countries; (iv) medium and long term investment and return on investment opportunities; (v) natural resources management and environmental implications; (vi) local and international food prices; (vii) the role of vertical and horizontal policy coordination.

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