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Food losses and waste: Navigating the inconsistencies

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ABSTRACT

In recent years, the question of food losses and waste (FLW) has been the subject of much debate. When it comes to food security, the preservation of natural resources and potential economic benefits, the general public, scientists and politicians all agree that FLW needs to be reduced. However, there are numerous inconsistencies in terms of how the problem of FLW has been presented and analysed. This article aims to highlight these inconsistencies and help identify the areas of research that could contribute to a more effective handling of FLW issues. The article examines: (i) whether the choice of definition(s) adopted are consistent with the problem(s) targeted; (ii) the efficiency of the methodologies used to address the issues raised, and (iii) the relevance of arguments put forward concerning FLW reduction.

1. Introduction

According to the FAO, one third of world food production is lost or wasted along the food supply chain (FSC) (Gustavsson et al., 2011). The reduction of food losses and waste (FLW) has been identified as an essential means to enhance food security while reducing pressure on natural resources (Smith, 2013; Timmermans et al., 2014; FAO, 2013; Lundqvist et al., 2008). Other studies suggest that households and firms would also economically benefit from FLW reduction (Buzby and Hyman, 2012; Lipinski et al., 2013; Parry et al., 2015). There is a consensus that FLW must be reduced and numerous action plans have been announced in recent years (e.g., Save Food, French National Pact to fight against food waste, The European Union action plan for the Circular Economy, etc).

Despite this consensus, there are several inconsistencies in the way that the FLW problem has been presented and analysed. The objective of this article is to highlight and discuss these inconsistencies, suggest how they could be overcome, and identify areas of future research. To this end, the article first discusses the definition(s) used for FLW and their relevance to specific issues targeted (Section 2). It then considers whether the methodologies used to analyse the FLW problem are efficient (Section 3). Finally, the article examines the relevance of the arguments that have been put forward about food security, environmental sustainability and economic benefits in relation to reducing FLW (Section 4).

2. Inconsistency between definitions and target issues

2.1. Complexity of definitions

There is no single definition of FLW. To facilitate understanding of the multiple definitions that exist, we developed a framework of analysis (see Chart 1). Similarities and differences between definitions are presented below, with the numbered paragraphs referring to key elements in Chart 1.

With regard to (1) timing and (2) scope, existing definitions are similar:

(1) FLW is only taken into account from the moment crops are ready for harvest (Fusions, 2014) or after harvest (FAO, 1981). Non-yields[1] from pre-harvest stages are not taken into consideration, i.e., FLW from resources used in agricultural production are excluded.[2]
(2) Only agricultural products originally and directly intended for human consumption are considered (FAO, 2014; Fusions, 2014). Agricultural products intended for animal feed or non-food use (bioenergy, biomaterial and industrial systems, etc.) are overlooked.

The definitions diverge, however, when it comes to the (3) terminology used, (4) criteria considered, (5) perspectives adopted, and (6) type of FLW considered. These points are discussed individually below.

(3) For a given definition of FLW, the terminology used may differ

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[1] The difference between the expected or optimal yield and the yield obtained.

[2] Starting from the point of view of FLW, there is a risk of neglecting non-yields in pre-harvest stages. The pre and post-harvest approach may help overcome this limitation.

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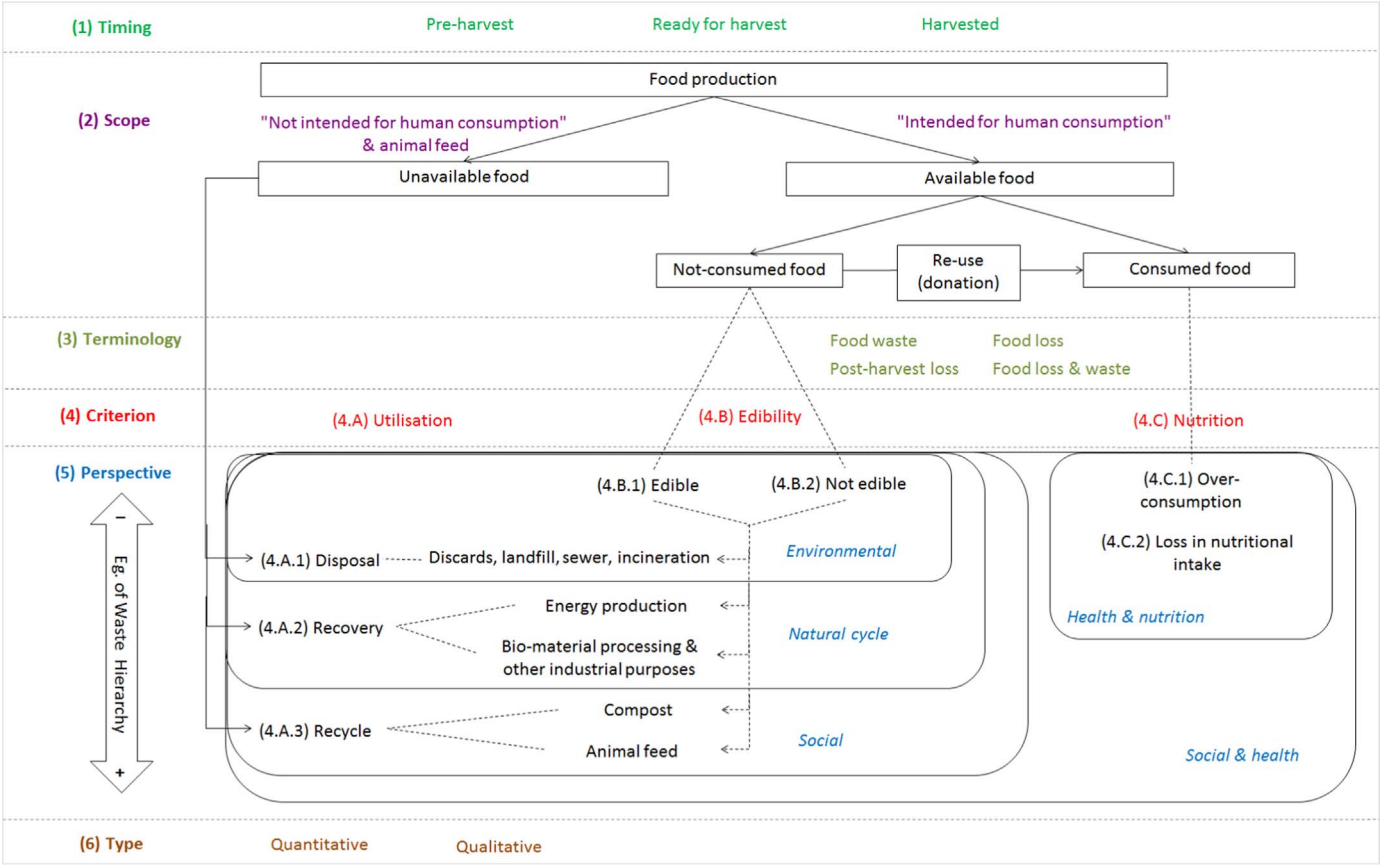

Chart 1. FLW framework: flows and definitions.
Source: developed by the authors

(food waste, FLW, etc.). A single term may have different meanings (FAO, 2014). For example, the Fusions project uses the term "food waste" for all stages of the FSC (Fusions, 2014), whereas the FAO uses this term only in relation to the distribution and consumption stages (Gustavsson et al., 2011).

(4) FLW are interpreted in various ways based on three criteria: (4. A) the use and destination of food products, (4. B) the edible aspect of food products, and (4. C) the nutritional value of FLW.

(4.A) Some definitions describe FLW as all products originally intended for human consumption but not consumed, even when products have other final uses (e.g., animal feed or non-food use) (Gustavsson et al., 2011). However, to differentiate between FLW and non-FLW, other definitions consider the use and destination of food that is not consumed (e.g., landfill, energy production, bio-material processing, animal feed, compost, etc.) (Garrone et al., 2014; Papargyropoulou et al., 2014). For example, in some definitions food not consumed and redirected for animal feed or other industrial processes is not regarded as FLW (Fusions, 2014).

(4.B) Some definitions of FLW consider the edible and potentially edible parts of food products (e.g., peels) (Gustavsson et al., 2011; Ventour, 2008). Other definitions do not distinguish between edible and inedible parts of food products (Fusions, 2014).

(4.C) The definitions also may take nutritional value into account. Some authors refer to over-consumption as a form of FLW. As a result, it is the positive difference between the number of calories ingested and the recommended calorie intake (Smil, 2004). Other authors consider a decrease in the nutritional value of food products or the non-optimal use of food products in relation to their nutritional potential as FLW (Kling, 1943).

(5) In principle, it may be assumed that the different definitions of FLW reflect the different problems that stakeholders and/or institutions associate with FLW (Rutten, 2013). Chart 1 indicates several examples of these perspectives. One definition is based on an environmental perspective (Garrone et al., 2014): the social cost of waste treatment. Here, FLW is defined as all food surplus that is discarded. Another definition that favours a social perspective defines FLW as all food not consumed (Garrone et al., 2014; Rutten, 2013). Other dimensions may be added, such as health and nutrition or food safety. The measure of FLW changes according to the target problem and the definition adopted. For example, the quantity of food referred to as FLW is greater when a social rather than an environmental perspective is adopted.

(6) The definition may change depending on which type of FLW is considered, quantitative or qualitative. "Quantitative" refers to volume and mass. "Qualitative" refers to an alteration in the physical-chemical and/or organoleptic characteristics of a product (FAO, 2014). Both quantitative and qualitative FLW can lead to an economic loss and possibly, in the case of qualitative FLW, nutritional loss.

2.2. *Origin of definitions and issues raised by institutions*

As part of a programme for the prevention of post-harvest losses launched in 1977 (Hodges et al., 2010), the FAO (1981) defines the terms "post-harvest", "food product" and "loss", which indirectly define post-harvest losses:

– The post-harvest stage starts from the moment a product is harvested;

Table 1
FAO and Fusions' definitions: similarities and differences.
Source: Adapted from Redlingshöfer (2015)

Definitions		FAO (2011)	FAO (2014)	Fusions (2014)
(1) Timing		*Unspecified*	Ready for harvest/slaughter	Ready for harvest/slaughter
(2) Scope		Food supply chain	Food supply chain	Food supply chain
(3) Terminology	Terms	Food loss and waste	Food loss and waste	Food waste
	Stages	Food losses take place at production, post-harvest and processing stages; food waste takes place at retail and consumption stages	Food waste is a part of food loss: it refers to the removal by choice or food that has been left to spoil or expire as a result of negligence	Food waste is used for all stages of the food supply chain (from production to consumption)
(4) Criterion	Utilisation	Non-food-use	Non-food-use	Non-food-use except bio-material processing & other industrial purposes and animal feed
	Edibility	Edible	Edible	Edible & non-edible
(5) Perspective		Food security	Food security	Resource efficiency of the food system
(6) Type		Quantitative, Qualitative	Quantitative, Qualitative	Quantitative

– Food products are edible parts of agricultural products that were originally harvested for consumption;
– Post-harvest losses are all food products produced for human consumption which have undergone a change in availability, wholesomeness or quality, rendering them unfit for human consumption.

In 1977, the FAO's objective was to promote policies designed to improve and guarantee food availability, a stance that is reaffirmed today with strategies for food security. To this day, there have been three slight modifications in the definition: (i) the introduction of the concept of waste, (ii) FLW is now considered from the moment products are ready for harvest (i.e., not just post-harvest), and (iii) food not consumed and redirected to alternative uses is included as FLW (Gustavsson et al., 2011).

According to the FAO's 2011 definition, food losses occur in the early stages of the FSC, while food waste occurs in the distribution and consumption stages (Gustavsson et al., 2011; Parfitt et al., 2010). While this definition is still the most commonly referenced in the literature, it is being reviewed. According to the FAO's current definition, the use of the term "waste" depends on the underlying causes of a loss rather than on the stage that the loss occurs along the FSC (FAO, 2014).

The Fusions project, funded by the European Commission (EC) FP7, proposes another definition of FLW (Fusions, 2014). Unlike the FAO, the EC primarily focuses on the use of resources in food systems. The EC applies the term "food waste" to all stages of the FSC. In addition, unlike the FAO, the EC does not differentiate between edible and inedible parts of food products, nor does it consider as FLW food redirected to animal feed or "bio-economy" production processes. This choice is explained by an action plan that the EU adopted in 2012 for sustainable resource use within a bio-sourced economy.

Table 1 (Redlingshöfer, 2015) compares the definitions of FLW used by the FAO (FAO, 2014; Gustavsson et al., 2011) and the EC (Fusions, 2014). As can be seen, the definitions depend on the institutions and their respective policies. Recently, a multi-stakeholder partnership designed a protocol to help different users (e.g., businesses, NGOs, international organizations, etc.) define, measure and report FLW in relation to their specific goals (Hanson et al., 2016).

2.3. Inconsistencies and ambiguities

The FAO and the EC have developed their respective definitions of FLW in relation to specific issues, namely, food security and resource efficiency. However, there are inconsistencies between the perspectives adopted and the definitions proposed. Koester (2014) questioned the appropriateness of the FAO's definition with regard to the objective of food security, highlighting the importance of defining FLW in line with given objectives (Koester, 2014; Koester et al., 2013).

Below, we identify four inconsistencies in the FAO definition:

1. It includes agricultural products originally intended for human consumption that are redirected for animal feed, but excludes agricultural products grown for animal feed. What is the reason for this distinction? Why include food products redirected to animal feed in FLW assessments? Consistency should be maintained between what is not considered as FLW in the scope of the definition (e.g., agricultural production intended for animal feed) and what is considered as FLW on the basis of food products not consumed and redirected (e.g., animal feed). As an example, if the definition of FLW excludes cropland intended for animal feed, then it also must exclude products that are redirected for animal feed. This choice is furthermore not justified in the light of the food security objective. Why is cropland used to produce animal feed excluded from the measurement of FLW? Given that 34% of cropland in the world is devoted to feed production (Stehfest et al. 2013), food availability is more likely to be impacted by the use of such land than by reductions in FLW.
2. The difference between edible, potentially edible and inedible parts of food products seems incompatible with the goal to propose a universal definition. Edible, potentially edible and inedible parts of food products vary over time and according to countries and cultures. For example, what is edible in one country may be considered inedible in another. The difference is subjective and, therefore, using this definition to measure FLW worldwide is problematic. Consequently, it may be more appropriate not to differentiate between edible and inedible parts of food products.
3. The distinction between the terms "loss" and "waste" in relation to the stakeholders involved in the FSC (Gustavsson et al., 2011) is unsuitable. The term "waste"[3] has moral overtones. While "waste" has an underlying negative and deliberate connotation, "loss" suggests a non-intended outcome. In other words, in the case of waste, the consumer (or distributor) is the "guilty party", while in the case of losses, actors higher up the FSC are the "victims". Why hold the consumer solely responsible for waste? Furthermore, regardless of the stakeholder involved in the FSC, the underlying reasons for behavioural practices make it difficult to differentiate between losses and waste. A consumer, like other actors in the FSC, does not buy food products with the intention of discarding them. If the consumer ends up discarding food, it may be for a good reason. We will come back to this issue later. The concept of FLW should be applied to all stages of the FSC regardless of the underlying causes of FLW.
4. The FAO's definition of FLW includes food redirected for animal

[3] In English the term 'waste' may be used both for discards and wastage. This is not the case in Latin languages (e.g., two separate terms exist in Italian, "rifiuto" and "spreco", in Spanish "residuos" and "despilfarro", and in French "déchet" and "gaspillage").

feed or non-food use because the FAO's primary focus is food security. However, it is important to note that giving priority to a specific dimension of sustainability could be detrimental to the sustainability of food systems more generally. For example, redirecting FLW for human consumption could increase environmental and economic costs. In certain countries, redirecting FLW for animal feed may help reduce imports. Is this actually a loss? Is it detrimental in terms of sustainability?

The EC focuses primarily on the link between FLW and resource efficiency in food systems. Two problems of inconsistency stand out:

1. FLW includes composted food products but not those used in animal feed. However, these two end uses may belong to the same category of waste treatment methods labelled"recycled" (Papargyropoulou et al., 2014). Similarly, food redirected to bio-economy processes is not considered as FLW, while food redirected to energy production is included in the definition. This may be explained by the fact that the EU's bio-economy strategy is primarily directed towards materials and not energy. Yet both processes can also be included in the same "recovered" category. Why differentiate when the end uses could be considered under the same waste treatment category? How are these differentiations justified? To date, the hierarchy of waste treatments proposed by the EU remains flexible and vague (e.g., prevention, re-use, recycling, recovery and disposal of waste products) (European Parliament, 2008).
2. Although the EC's objective is to promote efficient natural resource use, FLW are only considered from the moment products are ready for harvest. Therefore, non-yields or discrepancies in the performance of farming operations are not taken into account. A farmer may produce more than his neighbour using the same quantity of inputs or produce the same output with fewer inputs. Here, efficiency in resource use for agricultural production is not considered.

The definitions of both the FAO and the EC are ambiguous when it comes to differentiating between the "human" agricultural production chain (intended for human consumption) and the "non-human" agricultural production chain (intended for animal feed or non-food uses). The "non-human" agricultural production chain is excluded from both institutions' definitions. However, the difference between these two chains is not that obvious because the destination of agricultural production is not always clear. The use of agricultural products varies greatly and is not pre-determined. For example, a farmer who cultivates wheat may not know what the crop is intended for or who will buy it. A product's destination may also change depending on its quality or for reasons that cannot be anticipated. The concept of the "human" FSC remains unclear.

3. Inconsistencies between methodologies used and target issues

As discussed above, FLW are viewed as a problem of food security (FAO) and/or of natural resource use (Fusions). This section examines whether the methodologies used to address these issues are efficient and consistent.

Many articles focus on quantifying FLW, despite the fact that this is a challenging and expensive process (Parfitt et al., 2010). FLW are measured from production to consumption at a national level (Beretta et al., 2013; Katajajuuri et al., 2014; Nahman and de Lange, 2013) or at one or more stages of the FSC (Redlingshöfer et al., 2015; Lebersorger and Schneider, 2014; Nahman et al., 2012; Dou et al., 2016; Kaminski and Christiaensen, 2014; Monier et al., 2010) where the occurrence of FLW is most likely (Hodges et al., 2011). FLW may be assessed in terms of mass. Data is aggregated for different food products and/or for several supply chain stages.

The quantity of resources used, the economic value, and the calories of each food product vary depending on the product lost or wasted (Koester, 2014; Koester et al., 2013). For example, there is a difference between 1 kg of lettuce thrown away and 1 kg of beef lost and wasted. From a food security perspective, beef contains more calories than lettuce. However, in terms of natural resource conservation, beef production requires far more resources than lettuce production. The use of mass and data aggregation to assess FLW for different products fails to capture these differences (Koester, 2014; Koester et al., 2013). The same applies when data is aggregated for the different stages of FSC (Koester, 2014; Koester et al., 2013). The closer FLW are to the consumer stage, the more resources are used (e.g., transport, packaging, etc.) and the higher the economic value of the food lost and wasted. Nonetheless, this does not mean that reducing FLW further down the FSC is more efficient. The efficiency of FLW reduction depends also on the costs involved.

Most quantification studies assume that these limitations can be overcome by establishing equivalences in terms of the resources used (e.g., CO_2, water, croplands, etc.) (Grizzetti et al., 2013; Kummu et al., 2012; Venkat, 2011), money (Nahman and de Lange, 2013) or Kcal (Lipinski et al., 2013; Zorya et al., 2011). However, the quantification of FLW, even when measured in terms of CO_2, money or Kcal, does not allow an assessment of the impact of FLW reduction on food security and natural resource conservation. Paradoxically, few studies attempt to do this (Parry et al., 2015; Rutten et al., 2013). Some studies establish a model for the economic and environmental impact of FLW reduction (Okawa, 2015; Rutten and Kavallari, 2013; Rutten et al., 2013; Rutten, 2013). However, they presume that the cost of reducing FLW is zero, which is not the case in reality (at least in terms of opportunity cost). These analyses, with the exception of Höjgard et al. (2013), overlook the means (money, resources, time, etc.) required and the economic trade-offs involved in FLW reduction (Koester, 2014; Koester et al., 2013).

The lack of data and knowledge about FLW quantities is unquestionably a major obstacle to any progress in FLW reduction efforts (Affognon et al., 2015). However, quantification *per se* appears to be limited by time and resources. In addition, it does not really show how FLW reductions impact food security and the environment. In the future, it would be useful to enhance quantification approaches by using other methods, such as modelling, Life Cycle Assessment or econometric models. This could provide a more effective measurement of the impact of FLW reduction on food security and/or natural resource use.

4. Inconsistency between target issues and data obtained

The limitations and inconsistencies in FLW studies which were highlighted in the first two sections are discussed in more detail below. The arguments put forward remain controversial either because there is insufficient or inadequate data to draw scientific conclusions, or because FLW are not always the main cause of the issues of interest.

4.1. Food security

It is currently thought that a reduction of FLW would help improve food security (FAO, 2013; Gustavsson et al., 2011; Timmermans et al., 2014). Studies have shown that in some less developed countries, FLW reduction at the local level impacts households' food security. For example, it has been proven that using steel silos instead of sacks for storage helps reduce FLW and has a positive impact on households' overall food security (FAO, 2008; Gitonga et al., 2013; Tefera et al., 2011). However, there is almost no evidence indicating how FLW reduction impacts food security intra-household (e.g., women and children). The link between FLW reduction and greater food security may be true in some but not all cases. The cause and effect relationship is less evident in relation to food availability, price, accessibility and, consequently, to global food security.

The impact of FLW reduction on food security is therefore

debatable. First, food that is not consumed but redirected for animal feed or other non-food uses (e.g., bioenergy, industrial purposes, etc.) is considered to be FLW (e.g., FAO definition, 2011, 2014), although it is unlikely that this redirection decreases food availability (Koester, 2014; Koester et al., 2013). The redirection to non-food purposes does, however, prevent the use of other resources that contribute to food availability. Thus when FLW are redirected for animal feed, there is a corresponding reduction in the amount of agricultural land that would otherwise be used to produce cattle feed. Similarly, when FLW are transformed into compost, the need for fertilisers is reduced. Secondly, food security is primarily a problem of accessibility as opposed to availability. However, reductions in FLW are generally considered in terms of food availability.

Yet the impact of FLW reduction on food accessibility remains unclear. FLW, as defined, may be both a direct source of food for certain categories of the population and/or a source of income and employment for actors involved in recovery, recycling and the FSC. For example, FLW provide a direct source of food for people involved in recovery in "invisible networks" (as opposed to recovery organised by food banks which is officially recognised and consequently not counted as FLW). Every day, food products are collected from trash bins and agricultural products left on the ground post-harvest are gathered, etc. Similarly, products rejected by FSC stakeholders and redirected to "non-food" use provide a source of income for those who sell or recycle them.

On a global level, few studies have examined the link between FLW reduction and food security (Rutten, 2013). It is difficult to believe that reducing FLW in developed countries could improve food security in less developed countries through the simple mechanism of adjusting prices on the international markets. Although some studies model the economic impact of FLW reduction on prices (Okawa, 2015; Rutten et al., 2013; Stehfest et al., 2013), they tend to assume that the cost of reducing FLW is zero. However, a study based on the model IMPACT shows that reductions in FLW are not a low-cost alternative for achieving food security (Rosegrant et al., 2015). In addition, the scientific literature revealed the knowledge gap concerning the impact of international price fluctuations on the food security of vulnerable populations during the 2007/2008 food crisis (Daviron and Douillet, 2013; Daviron et al., 2008). Finally, studies sometimes fail to measure the impact, in terms of well-being, on the economy as a whole.

It is important that future research examines the use and destinations of food that is not consumed. This would help to clarify whether there is a corresponding impact on the supply/demand ratio and measure the impact on food accessibility. We therefore should be able to measure the weight of FLW in relation to the key components of food security. In addition, computable general equilibrium models are tools that could be used to study the relationship between FLW reduction and well-being while taking into account side-effects (e.g., prices).

4.2. Environment and resource efficiency

The link between FLW and the overuse of natural resources is the second most widely debated point (Beretta et al., 2013; FAO, 2013; Lundqvist et al., 2008). FLW lead to a significant use of natural resources in vain, such as water, land, (etc.) from production to consumption. FLW also lead to negative externalities through pollution emitted during production processes and waste management. These points remain debatable insofar as the environmental effects attributed to FLW are closely linked to production activities. Are FLW or the production activities responsible for the pollution emitted and for the resources used in the upstream stages of the FSC?

Scientific literature highlights the environmental cost of FLW (Dorward, 2012). However, it fails to explain that reducing FLW at a consumer level eases pressure on natural resources higher up the production chain if the reduction in FLW involves a decrease in consumer purchases. Could the basic problem of FLW be more to do with the supply and structural over-production of food in developed countries than with consumer practice? Consumers buy more than necessary (Quested et al., 2013; Ventour, 2008) but the impact of supply on their behavioural practice should also be questioned. To reduce pressure on natural resources, should reducing production and/or consumption be the priority? Could reducing FLW actually be a way of diverting attention from the main problem: over-production and over-consumption in developed countries?

The problem is furthermore not just one of wastage and over-consumption, but of inefficient resource use. Irrespective of a product's final destination, there are discrepancies in performance along the various stages of the FSC, and specifically in agriculture. This point is probably not addressed in the literature because the definitions mentioned do not consider non-yields from the pre-harvest stage as FLW. This bias is nonsensical from the point of view of natural resource conservation.

As far as negative externalities are concerned, certain uses (e.g., animal feed) are considered to be FLW even if they do not necessarily have an additional environmental impact in terms of waste management or natural resource use. FLW are frequently re-used in other production processes and may be transformed into a source of innovation, employment, revenue, etc. Finally, the post-consumption stage also generates waste and, therefore, has an impact on natural resources. Products do not simply disappear. They always end up as waste products, which are potential sources of negative externalities. The issue of sustainability involves questions regarding how to reduce, as well as how to transform and re-use, FLW. Once again, the end-use appears to be critical to identify the optimal uses of FLW with regard to the environment.

It is clear that FLW may be reduced by increasing the use of other resources (natural resources, time, money, etc.). For example, setting up cold storage facilities for certain products in less developed countries is seen as one way to improve product conservation and reduce FLW (Parry et al., 2015). However, such a solution has an environmental impact. It is essential to identify FLW reduction methods that do not increase resource use. The social costs brought about by various economic choices (e.g., setting up cold storage vs. accepting a specific quantity of FLW) have yet to be fully explored.

Finally, it is important to note that we know little about the environmental impact of FLW compared to other determinants (e.g., production methods, distances covered by products and households, etc.). Future studies could help identify whether FSC which are "more wasteful" in terms of food products have a greater environmental impact than "less wasteful" FSC, and identify the key factors that determine the impacts.

4.3. Economic benefits and well-being

In terms of economic impacts, reducing FLW would help all of the stakeholders to save money. For example, the estimated gain for consumers in Great Britain is £470 per household, per year (€650[4]) (Quested et al., 2013), whereas the estimated gain in Italy is the equivalent of €365 (Segrè et al., 2014). This gain seems substantial and feasible for households if they change their behavioural practices: "the costs of decreasing food waste are relatively low, but the potential benefits are substantial" (Parry et al., 2015). FLW reduction is seen as a *win-win* strategy for both professionals and consumers. It is also referred to as "low hanging fruits" (Okawa, 2015).

However, FLW reduction does not always go hand in hand with saving money. Stakeholders implicitly react to economic trade-offs. Reducing FLW may involve a cost or an effort that outweighs the cost of accepting FLW. There are situations where "it may be economically suitable to accept certain food losses" (Koester, 2013). Shopping daily

[4] Exchange rate on 18/05/15: http://www.xe.com/fr/currencyconverter

rather than weekly may help reduce FLW because it is easier to estimate the quantities required on a daily basis (Koester, 2013). However, shopping daily has a cost and increases the use of other resources (time, fuel, money, etc.), which may exceed the cost of the FLW. Therefore, a household may be acting rationally if it decides to shop once a week and risk losing or wasting some food products (Höjgard et al., 2013; Koester, 2013). The term "waste" and its moral connotation may overlook the fact that consumers are rational and pursue a logic of optimization just like firms. Similarly, some supermarkets emphasize the quality of their products by displaying them in an attractive way to boost sales. They accomplish this by selecting the best products and regular monitoring the stands. The reason for this is that the marginal gain from sales exceeds the marginal cost of the FLW. The reduction of FLW is often recommended even though we do not fully understand the economic trade-offs that stakeholders face. Research studies should improve our understanding of these trade-offs to shed light on the current situation and identify adequate incentives that could help reduce FLW.

If FLW reduction is generally perceived as "positive", an analysis in partial equilibrium of its economic impact on well-being leads to a counter-intuitive outcome. In fact, it indicates that FLW reduction at the consumer level results in a total loss of well-being for society as a whole because the loss for producers is greater than the benefits for consumers (Rutten, 2013).

In addition, FLW reduction for one stakeholder may lead to an increase in FLW for another. From production to consumption, the interdependency between stakeholders creates "transfer" mechanisms of FLW and/or of their costs from one actor to another. Two hypothetical cases are possible:

1. In the first case, the action of agent A, who strives to reduce FLW, increases the likelihood that agent B will have to deal with FLW. For example, retailer A, increases checks on the quality of deliveries in order to reduce and prevent FLW, the impact of FLW is transferred to producer B, because agent A will reject products with limited quality. Similarly, the discount sale of products with a very short shelf life in supermarkets allows retailers to prevent their FLW. On the other hand, they are likely to increase the probability that the consumer will discard and waste the product if it is not consumed immediately.
2. In the second case, the cause-effect relationship is indirect. The action or non-action of agent A, who intends to reduce his effort and/or production costs, generates FLW for agent B. For example, producer A may choose not to carry out certain production tasks in order to reduce his production costs/efforts. This will influence the quality and storage time of products that may not necessarily be visible to agent B (case of information asymmetry). One example would be if producer A switches to a high yield variety that is more difficult for agent B to store.

These issues call for an in-depth study of FLW using FSC analysis. This would ensure that all of the stakeholders, their interactions and influence on FLW are taken into account.

5. Recommendations and concluding remarks

Despite the amount of work required, studies on FLW have generated positive change. It has been estimated that the efforts initiated in Great Britain have already paid off by reducing household FLW by 21% between 2007 and 2012 (WRAP, 2013). We would like to emphasize the importance of conducting further in-depth studies to give the FLW debate more weight and credibility. The inadequacy of existing studies is probably due to a lack of investment (funds, institutions, publications, etc.) in this field (Affognon et al., 2015; Kader, 2005) and to the focus on quantifying FLW before trying to resolve more basic questions.

Although some FLW definitions have been developed with reference to major issues concerning society, there are still numerous inconsistencies and ambiguities. Some choices have not been justified. Most studies have overlooked the use of non-consumed food products. Regardless of their use or non-use, studies have presumed that non-consumed food was FLW. Yet we know little about the use and destination of non-consumed food products or the impact of their use on food availability, food accessibility and the environment. Focusing on the end use of FLW is, therefore, the first issue that should be explored. This would help make definitions more consistent with targeted objectives. Secondly, it appears necessary to identify the trade-offs facing actors in the FSC that are sources of FLW. This would help identify the prerequisites for encouraging these actors to adopt solutions for FLW reduction. Thirdly, it is important to identify whether FLW reduction methods generate an increase in the use of other resources. Fourthly, conducting studies on the entire FSC would improve our understanding of the interactions between stakeholders and their respective influence on FLW.

In conclusion, the issue of FLW provides information and raises awareness among consumers and professionals with regard to consumption and production in general. It represents an opportunity to move beyond the issue of food and deal with all forms of loss and wastage. Why focus on food alone when so many other commodities are also being wasted? The debate challenges so-called consumer societies where human well-being is based on unlimited resource consumption.

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