

# Food Loss and Waste Prevention

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Preventing food losses and waste is a potential strategy for better balance food supply and demand and is essential to improve food security while reducing environmental impact and providing economic benefits to the different actors in the food supply chain.

Keywords: food waste ; food loss ; policy ; legislation ; SDG 12.3 ; national strategies ; food supply chain ; food redistribution ; multi-stakeholder cooperation

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## 1. Introduction

One-third of the food produced globally for human consumption, corresponding to about 1.3 billion tonnes, is lost or wasted each year along the food supply chain (FSC) <sup>[1][1]</sup>. FSC includes the series of related activities used to produce, process, distribute and consume food <sup>[2]</sup>. Each stage of the FSC consists of several operations, both agricultural and industrial, within which different types of losses and waste occur. Understanding the causes and identifying why food is lost and wasted is a key step in improving resource efficiency in the long term <sup>[3]</sup>. Losses along the FSC generally depend on socioeconomic, biological and/or microbiological, chemical or biochemical, mechanical and/or environmental factors <sup>[4]</sup>. Some of these are related to the technologies, methods, techniques and practices employed and used by the several actors in the food system, such as mechanisation, agronomic practices and farm management practices. Other factors are related to natural causes, such as the presence of insects, pests, mould, temperature conditions and humidity, or to the socio-economic environment, such as access to market information. Indeed, the combination of these elements can considerably influence food loss and waste (FLW) <sup>[5][6]</sup>.

Urbanisation is one of the causes linked to the production of large quantities of food waste, as it has led to the expansion of the FSC to meet the population's food needs <sup>[7]</sup>. Therefore, it is important to improve storage, transport and sales techniques and conditions to avoid losses and waste due to the increasing distance between the production site and the final consumption site <sup>[8]</sup>. To confirm these global trends, Parfitt, et al. <sup>[9]</sup> considered the differences in post-harvest losses between developing, transition and developed countries. As developing countries grow economically, the condition of their infrastructure and techniques improves and the nature of their food losses changes. With rudimentary post-harvest infrastructure, most food losses occur at the harvest and post-harvest stages, whereas in countries with more advanced infrastructure, food waste occurs at the retail and consumption levels <sup>[10]</sup>. So, the richer a country becomes, the more its food losses nature is voluntary. The amounts of losses also depend on a change in diet composition especially in countries with transition economies such as India, Russia or Brazil, which, as a result of increasing income, consume more and more fresh products such as meat, fish and fruit and vegetables which are more perishable <sup>[11]</sup>. Furthermore, in a scenario of expanding commerce and large-scale distribution, many retailers in emerging countries such as Asia, South America and Africa are being replaced by supermarkets <sup>[12]</sup>. In addition, there is an increasing trend towards higher quality products, which has a significant impact on the amount of food waste produced <sup>[13]</sup>. FLW vary according to the stages of the FSC: the production stage is considered to be the most important point for food loss, particularly during product processing (interrupted production; product change, human error, etc.) while at the household level the most waste occurs <sup>[14]</sup>. However, there are also differences depending on the type of raw material. Generally, as fresh foods that are easily perishable, fruits and vegetables, partly due to their high water content, are characterised by higher levels of loss than cereals and pulses <sup>[15]</sup>. The high humidity of the climate can have a negative impact on food preservation, especially in developing countries where there are more losses during the early stages of the food chain, also due to an increase in production as a result of the need to follow the seasonality of products, which results in a lack of sales of excess goods. However, errors in management and in adopting the correct methods of harvesting, storage, processing, etc., can also affect levels of vegetable products losses. Meat losses, on the other hand, are less pronounced and show smaller differences between countries <sup>[11]</sup>.

## **2. Food Loss and Food Waste along the Food Supply Chain**

### **2.1. Definition of “Food Loss” and “Food Waste”**

In order to understand what is meant by food loss and food waste, it is important to refer to the correct definitions of “food”. With the latter term is indicated any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be, consumed by humans <sup>[16]</sup>. Food includes beverages, chewing gum and any substance, including water, intentionally incorporated into food during its manufacture, preparation or processing <sup>[17]</sup>. Therefore, it should be possible to distinguish between food loss and food waste according to the stage where they occur along the FSC.

There are several products to consider and definitions proposed in the literature for the phenomena of FLW. The products to be considered are only those agricultural products originally intended for human consumption, ready for harvesting or post-harvesting <sup>[18]</sup>. However, the terminology used may be different. The FAO <sup>[18]</sup> uses the term “food waste” only in reference to the last stages of retail and consumption, and it can be distinguished according to the destination, the edible part and the nutritional value of the food lost or wasted. Moreover, the FAO <sup>[18]</sup> considers also the various problems associated with FLW: the impacts on the environment, the economy, on health and food safety. Many definitions also focus on the difference between “quantitative” and “qualitative” loss. Conceptually, it is easier to define and measure quantitative losses and waste than qualitative ones. Quantitative FLW refers to the decrease in the mass and volume of food for human consumption, while qualitative FLW refer to the decrease in the chemical/physical and/or organoleptic characteristics of food for human consumption <sup>[2][19]</sup>. In both previous cases, there may be a consequent economic loss: in the former case, farmers will have less volume or weight to sell, and in the latter case, the price offered for their products will be lower than that offered for higher quality food products <sup>[15][20]</sup>. In addition, with regard to the loss of quality of a product, there will also be a nutritional loss with a consequent health risk for the consumer <sup>[21]</sup>. The FAO <sup>[2]</sup> has produced a definitive picture of FLW as a global reference for stakeholders to use within their own operational context. Food loss is defined as the decrease in the quantity and quality of food resulting from the decisions and actions of food suppliers along the FSC, excluding retail, food services and consumers. Food losses therefore occur at the production, post-harvest and processing stages along the food chain. Food waste, on the other hand, refers to the decrease in the quantity and quality of food resulting from the decisions and actions of retailers, food service providers and consumers. Both depend more on the causes of food loss or waste than on the stage at which it occurs along the food chain. Causes that can be identified in the poor protection and conservation of the product along the FSC or refusal for product surplus <sup>[22][23]</sup>.

However, the European Commission's project FUSIONS “Food Use for Social Innovation by Optimising Waste Prevention Strategies”, whose aim was to make Europe more efficient in reducing food waste, applied the term “food waste” to all stages of the FSC, without differentiating between edible and non-edible parts of foodstuffs, nor considering products intended for animal feed or alternative uses. In fact, any food, or inedible parts of food, sent to animal feed, bio-material processing or other industrial uses was included in the terms “valorisation and conversion”. Thus, the term “food waste” described “any food, and inedible parts of food, removed from the FSC to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)” <sup>[24]</sup>.

### **2.2. Food Loss during Cultivation and Harvest**

In the cultivation and harvesting phases, various factors contribute to food losses such as biotic (e.g., insects and pests) and abiotic (e.g., climatic conditions) stresses, causing food waste to several degrees depending on the type of crop and where that crop is produced. In fact, more modern cultivation and harvesting techniques in developed countries result in higher yields than in non-industrialised countries where lack of knowledge of the best techniques to adopt at these stages and of appropriate equipment is the primary cause of losses <sup>[11][25]</sup>.

Rapid spoilage of goods is caused by an attack of pathogens that can act even faster if the foodstuffs are already damaged or have injuries sustained during the various stages of harvest, transport or sale <sup>[15][26]</sup>. This is especially true in developing countries, which often have inadequate infrastructure (such as barely passable roads) and non-ideal storage facilities <sup>[27]</sup>, and where the losses incurred are also due to a lack of adequate knowledge and sound management practices in warehouses, as well as limited technical, financial and managerial resources <sup>[15]</sup>.

Improper handling of products during harvesting, including the use of large machinery, can cause damage and injuries that facilitate the entry of pathogens that lead to faster deterioration of crops, especially roots and tubers. This is one of the major causes of loss in farms that, especially in industrialised countries, will produce more than the effective demand

also to prevent damage caused by unpredictable weather events <sup>[28]</sup>. This results in surplus crops being sold to processors or used as animal feed. However, this is not economically advantageous as prices in these sectors are lower than in retail <sup>[2]</sup>.

Food losses during the harvest stage also depend on harvesting methods and timing. In developing countries, in particular, food can be lost as a result of premature harvesting: due to food shortages or desperate need for money, farmers are sometimes forced to harvest crops too early, affecting not only market value but also nutritional value, resulting in food that is unfit for consumption being wasted <sup>[29]</sup>. However, food losses can also occur following a delay in harvest, as products left in the field after reaching maturity are susceptible to attack by pests, rodents and fungi. This results in an increase in decay and a consequent decrease in quality as well as increased susceptibility to damage during transport <sup>[25]</sup>. Knowing when to produce and harvest different crops is of crucial importance as these are affected by weather conditions, which are often unpredictable. Indeed, high temperatures can compromise the proper formation of flowers and fruit and they can be sunburned. Moreover, not only high temperatures, but also colder climates can cause increased action by insects and fungi, increasing the likelihood of disease and forcing farmers to use pesticides <sup>[15]</sup>. Losses can affect not only field products, but also meat as a result of diseases that can affect animals due to poor herd management, temperatures and access to water, increasing overall mortality <sup>[30]</sup>.

### **2.3. Food Loss during Post-Harvest**

The largest post-harvest losses take place in the storage stage and are easier to estimate and prevent <sup>[4]</sup>. As previously mentioned, the causes of food losses vary across the world and between the same types of commodities. For example, low-income countries cause loss of fresh fruit and vegetables mostly as a result of inadequate infrastructure or lack of cold storage compared to industrialised countries. As a result, products are consequently destined for disposal due to a shorter shelf life and thus a higher perishability and will <sup>[31]</sup>. This can also happen if the crop remains in a pile waiting to be transported and thus also exposed to heat and direct sunlight due to too long a period of waiting between the different stages of the FSC <sup>[15]</sup>.

During post-harvest, increased losses can be linked not only to the use of inadequate equipment, but also to the use of unsuitable packaging for a particular fruit and vegetable product, causing physical damage that decreases the shelf life of the harvest. In fact, interviews carried out with operators of some farms have confirmed the fact that post-harvest losses also occur as a result of human errors deriving mostly from a lack of knowledge in the correct handling of different products <sup>[11]</sup>. Many foods, especially fruit and vegetables, have to follow standards of size, shape and quality to meet the demands of the end consumer, and these are often not respected as a result of processing errors or damaged packaging. This leads to the throwing away of food that is still viable because these errors are not necessarily synonymous with a decrease in taste, nutritional value or food safety <sup>[14]</sup>. However, these products with shape or “cosmetic” defects not usable for the fresh market could be canned or frozen or, if broken, crushed or seriously damaged, diverted to the industry for processing (for juice or puree) or treatment (fresh-cut). Furthermore, waste can be avoided by allowing volunteers to collect residual streams of products that, due to shape or cosmetic problems, cannot be appropriately wrapped and packed and to distribute them through food banks <sup>[32]</sup>.

Stuart <sup>[33]</sup> studies were based on understanding the influence of standards on food loss levels. In particular, on one British farm Stuart found that large quantities of carrots were being used for animal feed production as they were slightly declining <sup>[33]</sup>. The finished products, before being packaged, pass through machines that search for aesthetic defects (colour, size, shape) so that the products in the packages are all uniform, which is important for consumer satisfaction.

The processing of different products requires quality standards that must be respected especially for those foods intended for human consumption. So, for example, cleaning the line for the production of two different products can be important to prevent residues from the previous processing from affecting the quality of the subsequent foodstuffs and therefore to avoid the production of waste <sup>[14]</sup>. In many developing countries, however, it is often not cost-effective to invest in storage or processing facilities because the seasonality of produce means that it is not used all year round. Thus, the lack of infrastructure to store fresh food to meet demand means that food losses increase <sup>[34]</sup>.

In order to maintain the required standards, products in damaged or incorrectly sealed packaging are lost, as these errors could lead to a decrease in the quality of the foodstuffs with consequent damage to the processors who would be rejected by the buyers <sup>[14]</sup>.

## 2.4. Food Loss and Waste during Distribution, Retail and Consumption

During transport, losses can occur due to damage to packaging, which makes products more susceptible to spoilage, but also due to the long distances often present between the place of production and the place of sale. This leads not only to higher transport costs, but also to the possibility of higher losses due to bad roads or unsuitable means of transportation [15].

At the retail stage, it is important to make demand forecasts in order to avoid products remaining unsold before the recommended use-by date. This is complicated, however, as demand depends on the seasonality of the products, promotions offered by supermarkets or the time of year [11].

In developed countries, supermarkets offer a large number of goods of different types and brands to meet consumer demands. However, this increases the likelihood that products will not be sold before their use-by date, leading to higher levels of waste [35].

Correct storage and display methods at retail level are also important, and this is why retail staff must be trained. This is mostly the case in both developed and non-industrialised countries: food wastage occurs mostly due to the poor hygienic conditions of markets which also lack the necessary facilities for cooling and thus proper preservation of food [11]. In these countries, however, poverty means that levels of wastage are very minimal, so they hardly ever occur at household level [15]. In contrast, in rich countries the consumer can “afford” to waste food, not only because of the higher income, but also because there is a high amount of food available from retail shops and restaurants [36]. Restaurants offer buffets where you can take as much food as you want at a fixed price, which encourages consumers to take more food than they actually need; retail shops offer cheap deals that encourage over-purchasing or offer ready-to-eat food in too large a portion [37].

In addition to waste due to poor planning of (over)purchases, consumers often confuse labels regarding “use by” or “best before” and do not pay attention to storage instructions on the packaging. As a result, food is often thrown away both because it is not consumed before it has passed its “best by” date and also because many goods in retail shops remain unsold since consumers prefer to buy food with a longer shelf life [38].

Underlying all of this is a lack of complete knowledge about levels of waste and its impact in both economic and environmental terms [11].

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