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Title : Food losses and wastage as a sustainability indicator of food and farming systems

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A little known topic of high interest for sustainability

A world population expected to be 9 billion humans by 2050, its growing share of urban citizens and a shift of lifestyles and diet patterns of the rising middle class in emerging economies place considerable strain on the planet's resources. According to the FAO, food production will need to grow by 70% to feed world population in 2050 (Bruinsma, 2009). Further trends like global warming, declining freshwater resources, biodiversity or loss of fertile land, interconnected and closely linked to global food security, require an integrated and innovative approach to solution-finding.

Sustainable food consumption and production is on top of political and scientific agendas (Nellemann *et al.*, 2009; World Economic Forum 2009; FAO/OECD 2011; Foresight, 2011; EU ERA-NET SUSFOOD 2012-2014). Food is one of the most important drivers, along housing and transports, of environmental pressures and resource consumption (Tukker *et al.*, 2008).

Environmental impacts occur all along the food chain including waste management. Escalating food prices of recent years have highlighted the already difficult access to food for the most vulnerable ones both in industrialized and in developing countries. In 2011, 18 million European citizens have benefit from food aid initiatives and worldwide, the share of the food insecure population is still scandalously high (FAO, 2010).

In this respect, food losses and wastage are highly unsustainable: negative impacts occur at any stage of the food system without the food to service its main purpose, that of providing nourishment to humans³. Due to a lower pressure on the already highly constrained farming sector, losses and wastage reduction offer considerable potential on the transition pathways towards sustainable food and farming systems. Furthermore, reduction strategies contribute to wider policy agendas like improving resource efficiency, mitigating climate change and preserving biodiversity. This phenomenon raises social questions. At an individual level, less food losses and wastage mean lower household expenses (estimated savings amount to around 500€ per household and per year) and lower costs, for catering services or hospitals for example. Lower costs for resources and waste management mean economic advantage for businesses. Apart from the social, environmental, economical and financial impacts resulting from food losses and wastage, whose assessment by means of sustainability analysis is a challenging task by itself, ethical considerations guide reduction strategies.

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³ WRAP considers that food losses and wastage by households alone has consumed 6% of water requirements in Great Britain and was the cause of 3% of national greenhouse gas emissions (WRAP & WWF, 2011).

We therefore suggest that the incidence of food losses and wastage throughout the food chain be one indicator for the assessment of sustainable food and farming systems.

A lack of consensus on definitions of food losses, food wastage and food waste

Significant differences in definitions of food losses, wastage and waste exist (FAO, 1981; Lundqvist *et al.*, 2008; Parfitt *et al.*, 2010). In developing countries, we often hear of post-harvest losses, that is to say losses occurring from the harvesting to distribution stages. The terms food wastage, and more frequently used food waste, however rather applies downstream of the food chain, in distribution, catering and households. How these terms are used, however, depends on a simplified conception of food systems that are far more complex in reality, as upstream losses, during the first stages of the chain, also exist in industrialized countries, but for different reasons and under different names (withdrawal, shrinkage). Strictly speaking, the term waste, governed by a European directive⁴, refers to what is thrown away without distinction of the circumstances and reasons which lead to the product discard.

Apart from their differences, the definitions question the relationship between the use of agricultural resources for human diet and for other uses. If we consider food losses and wastage to include foods that would initially have been edible to humans, but which have served a different purpose (animal feed, chemical, pharmaceutical and cosmetic industries, leather goods and textiles, energy production or compost ...), we observe very high quantities. However, if we take into account the initial purpose of foods including their by-products and then their final utilisation, we achieve a more interesting systemic typology. What humans do not directly eat is not necessarily lost or wasted.

Naturally, agricultural and livestock products are not entirely edible for humans, in any case not in normal conditions (citrus fruit zest, bones, egg shells etc.). This being said, the line between what is edible and what is not edible is sometimes fine and depends on dietary habits and food culture (consumption of bread crusts, apple or potato peel, fat on meat etc.). Therefore food processing and preparation waste contains a non-edible fraction which is neither loss nor wastage for the human diet. The absence of clarification leaves room for confusion between food wastage or waste on the one hand and biowaste on the other, confusion that the European Parliament pointed out recently⁵.

We therefore prefer to use the term food losses and wastage together without distinguishing them.

In order to be as accurate as possible with regard to the various constructs, Gustavson *et al.* (2011) defined as food losses or waste "the masses of food lost or wasted in the part of food

4 Directive 2008/98/EC of European Parliament and of the Council of 19 November 2008 on waste <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF>

5 <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A7-2011-0430+0+DOC+PDF+V0//EN>

chains leading to edible products going to human consumption". Only agricultural goods meant for human consumption that are not consumed, regardless of the reasons and regardless of the fate of the products (animal feed, compost, etc.), are considered to be lost or wasted according to these authors.

The lack of consensus as to the definition of the terms losses and wastage or waste is problematic as firstly, the purpose of the discussion on which public and private stakeholders pronounce themselves is neither well identified nor identical among these stakeholders, and secondly, it may partly explain the significant variations according to source between the estimated amounts lost and wasted. Substantial work is therefore necessary to harmonize definitions on food losses and wastage and to establish a common approach on system boundaries in order to quantify their extent across countries properly.

The extent of food losses and wastage

Several sources estimate global losses and wastage at around 30% of initial production intended for human consumption (Lundqvist *et al.*, 2008 ; Foresight, 2011; Gustavsson *et al.*, 2011). On the basis of literature and FAO food balance sheets, per major world region, Gustavsson *et al.* (2011) established that between 208 and 300 kg of food per capita and per year is lost or wasted throughout the food chain in European and North American countries, of which 95 to 115 kg by consumers. In sub-Saharan Africa and South and South East Asia, 120 to 170 kg of food per capita and per year is lost or wasted, of which only 6 to 11 kg by consumers.

Most importantly, food losses and wastage occur at any stage of the food and farming system. Recent international reviews though have found a dearth of robust data both for industrialized and for developing countries. Little is known on the subject in emerging economies (China, India, Brazil,...).

- In industrialized countries

In industrialized countries, food processing industries and households are supposed to generate the biggest amounts of food losses and wastage. In Great Britain, 25% of quantities purchased by households are wasted, according to data from WRAP (2009). This data reports 8.3 million tonnes, equivalent to 134 kg per person and per year, of food and beverages wasted (in particular loose or wrapped fruit and vegetables, bread, ready meals, meat, fish and milk), of which the two thirds could have perfectly well been consumed. In France, according to a study by the Environment and Energy Management Agency (Ademe, 2007) conducted on the composition of household and jointly collected waste, 7 kg of wrapped foodstuffs are thrown away per year and per head. Thirteen kilograms out of the 72 kg food waste represent meal leftovers or other foodstuffs, bringing the quantity of food wastage per capita and per year to 20 kg.

One British study (WRAP, 2010) assessed food waste in secondary processing, retailing and upstream distribution sectors (wholesale trade, warehouse activity, trading groups). Secondary processing as a whole generates the highest volumes of food waste after household

consumption, equivalent to almost 2.6 million tonnes per year, and this despite the fact that by-products used elsewhere are not included in the figures. According to occasional observations, losses and wastage in agri-food industries may represent 20% (WRAP, 2010) of processed raw materials. In much lower proportions, the bulk of food waste in the field of distribution is generated in the retail sector (362,000 tonnes per year). FareShare, the British food banks federation, declares to have rescued only 3,000 tonnes of foodstuffs in 2008 (compared to 2,000 tonnes in 2007).

Data for agriculture on losses and wastage are scarce. Amongst farming sectors, horticulture may be the sector most concerned due to the perishable character of produce and due to high labour costs. The primary processing sector for crops (notably sugars and fats, starch and flour mills) tends to put its by-products to use in animal feed (9,5 million tonnes dry matter in France, RESEDA 2005). Animal processing industries face more difficulties in using their by-products (0.55 million tonnes in France, RESEDA 2005): two thirds of this waste is incinerated since the bovine spongiform encephalopathy (BSE) epidemic. The remaining third is processed into gelatine and glues.

- In developing countries

In developing countries, post-harvest losses remain little quantified to date, even though the international community became aware of the extent of the phenomenon in the 1970s. At the time, they were only related to storage and were synonymous with "damages caused by insects". Various deciding factors such as storage method, choice of variety, technical equipment, and finally know-how and culture-based decisions remained underestimated. Taking the example of corn, weight losses may vary from 3% for traditional varieties to more than 20% for hybrid varieties (Schulten, 1982). For some years now, the FAO and its research and development partners have been investing in the compilation of databases on post-harvest losses⁶ putting emphasis on providing representative and quality data which take into account climatic, bio-physical and technical conditions of the situations studied.

For rice for example, the second most frequently consumed cereal by humans and of which losses have been widely studied, global losses are estimated at 15% (Grolleaud 2002, Liang *et al.* 1993), but variability between countries, climatic zones and practices and in data reliability is significant. During storage, often studied specifically, losses range from less than 1% in a study conducted in Malawi (Singano *et al.*, 2008 a,b) to 12-13% in Bangladesh (World Bank, cited by Grolleaud, 2002) through a bracket of 3-6% in China (IDRC, cited by Grolleaud, 2002) or in Malaysia (FAO, 2007).

⁶ The Aphlis www.phlosses.net database, backed by the European Commission's Joint Research Centre and the Natural Resources Institute (NRI); the INPhO database <http://www.fao.org/inpho>, backed by the FAO, the Cirad and the GTZ.

In sub-Saharan Africa, cereal post-harvest and pre-processing losses are estimated at 10-20% in Aphlis, representing 4 billion dollars. Such losses represent 13.5% of the total value of cereal production in these countries (World Bank, 2011).

For perishable products (root vegetables, tubers, fruit, etc.), there is even fewer representative data available. Losses of cassava in Africa in traditional systems may reach 45% (Jeon and Halos, 1991) and yam up to 50% (Osunde, 2008). As for fruit, post-harvest losses are considered to represent between 15 and 50% in developing countries in general (Subrahmanyam, 1986; Jeffries and Jeger, 1990; Coursey and Booth, 1972). In the Philippines for example they may range from 15 to 35% (from 30 to 60% for fruit such as papaya).

Even if accurate data on food losses and wastage is lacking in most countries in the world, these estimations suggest there is sizeable potential for reducing them.

Reasons for food losses and wastage and barriers to a more efficient food use

A number of reasons lead to losses or wastage at all stages in food systems, as much in industrialized as in developing countries. Table 1 gives a non-exhaustive view of these reasons.

Table 1: Reasons for food losses and wastage and stages of occurrence in food systems in industrialized and developing countries

Stage in the food system	Industrialized countries	Developing countries
- at harvest	Non-harvest, market withdrawals and destruction (fruits and vegetables)	Tools, accidents, pests, limited access to the field
- at storage (at farm, warehouse etc.)	Temperature, humidity, dehydration, market withdrawals	Pests, lacking cold chain, recipients and packaging
- at transport (at several stages)	Packaging, temperature, handling	Accidents, road blocks, lacking infrastructure, vehicles
- at processing (primary, secondary etc.)	Shrinking, process-related losses, standardization	Tools, accidents
- at distribution (markets, shops etc.)	Refusals and returns, nearing use-by date, damage, mis-storage	Marketing standards of supermarkets and export markets ?
- at consumption (at home, out of home)	Confusion between use-by date and best-before date, poor household management and knowledge, unsuitable portions, hygiene	Changing household practices of wealthy households towards those in industrialized countries?

Source: compilation by authors

In industrialized countries, various technical, legal, fiscal and organizational barriers refrain from using food more efficiently. For example, some hygiene rules within European, private and public regulations have been identified as a major reason for throwing away food in the catering industry due to very wide safety margins that companies apply (Waarst *et al.*, 2011). In many cases, high labour costs are a major obstacle, for example in grocery stores when throwing away the whole plastic bag of apples costs less than opening the bag, sorting out the damaged one and selling the remaining apples unpacked. High level of standardization in processing or transports play a

role. Currently, processing equipment only operates with standard fruit and vegetables, and the logistics are less efficient for those of different shapes and sizes which cannot be packed easily. Eventually, the question comes up which stakeholder interests go against a reduction of losses and wastage. Money is earned with food at all supply-chain stages prior to throwing it away. Which negative effects may be associated with reducing wastage, and to what extent (employment at supply-chain stages related to wasted food, economic value of waste management)?

In developing countries, loss reduction is hampered by a general lack of basic storage and transport infrastructure and of market access. Education and financial services are lacking in particular for smallholder farmers in rural areas.

Action levers for optimised food use

A better understanding as to perceptions of food losses and wastage by different stakeholders and patterns of causes is necessary in order to identify and explore innovative solutions for optimised food use. In industrialized countries, changes underway indicate a transformation in the representations and strategies of stakeholders, along with awareness of the need to address what is increasingly becoming a genuine "public concern". The agricultural sector and certain agri-food industries for example are already exploring ways to reduce costs and minimize losses. A possible use of by-products for human food instead of animal feed is currently the subject of applied research. The agri-food industry is about to reinstate the principle of closed-loop supply chains, according to which the waste disposed of by one group serves as raw materials for another group.

According to recent studies and reports, action levers for reduction and prevention of food losses and wastage are expected to lie in different fields of public and private intervention and to require levers of different nature.

In industrialized countries

- Technical levers

In terms of technical innovations, significant progress has been made in the fields of production, logistics and storage. Production equipments allowing higher output have emerged, such as curd-cutting machines which save 3% matter. It is also a question of improving process outputs using a wider variety of raw materials. At the interface between agri-food industries and distributors, production strategies, stock management and business practices must be further coordinated. Charities and waste collection professionals are beginning to set up networks for the redistribution and use of unsold goods. Packaging can also be improved: packaging and portion size, sealing systems, reclosure systems to prevent products drying out, hardening or spilling. Innovations can be expected in this area (Conseil national de l'emballage, 2011) and this as

much as two thirds of packaging is used for foodstuffs. Rapid, accurate and little costly detection tests also need to be developed with respect to product safety to ensure that waste prevention does not damage consumer health.

- Fiscal levers

Including donations in the calculation of the tax base of companies in France, recently authorised by law⁷, has encouraged distribution to food banks. In the same way, increasing the charges on effluents loaded with organic matter has caused companies to question their practices. A syrup-making company admitted saving 20% matter after having recalculated its water treatment charges upon renewal of its contract (colloquium Reseda 2009). As part of the Grenelle II law, the announcement for 2012 of compulsory separate collection of bio-waste for large producers is already a driving force for innovation. In these sectors, we observe that it is often indirectly related decisions that initiate reduction of losses and wastage.

- Normative or regulatory levers

Expiry dates, for example, are often misunderstood and confounded. Whereas the use-by date applies to fresh products and refers to microbiological quality, the best before date applies to preserved or frozen products and to groceries and only refers to preservation of organoleptic properties and vitamin content. The debate on removing such dates has begun in the United Kingdom and how they are used is currently being discussed at European level. Generally, sanitary legislation, the “zero risk” approach and penal responsibility for products are often brought up, notably in catering and supermarket distribution, as being major causes of losses and wastage. In Australia, an association which collects unsold goods, managed to obtain a regulatory text relieving supermarkets of all penal responsibility in the case of food intoxication caused by donated food, provided that associations ensure to maintain the cold chain.

Inseparable from food safety concerns, image and consumer satisfaction are never sacrificed to concessions by companies. On the contrary, companies even have a tendency to establish increasingly wide safety margins, sometimes even more stringent than regulatory standards, as found out in the case of phytosanitary product residues (Waarst *et al.*, 2011). This is why relaxing regulatory constraints does not necessarily lead to a change in practices. In a similar way, lifting of the EU restrictions (size and shape for example) for 26 out of 36 fruits and vegetables, in July 2009, visibly has not led to marketing of differently appearing products so far (Waarts *et al.*, 2011)

7 <http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022521587&dateTexte=&categorieLien=id>

: the sector continues to rely on former standards as in-house quality standards. This means that entire sectors must adjust to relaxing regulations. Processing, logistics and marketing solutions must therefore be developed for the entire sector in order to create a market offer in compliance with the new standard.

- Information and awareness-raising levers

Initiatives of this type abound across Europe⁸. One of the leading expertise body on food waste in Europe is The Waste and Resources Action Programme (WRAP), a UK non-profit organization for the reduction of waste, efficient use of resources, and development of sustainable products. WRAP works with partners from major businesses, trade bodies and local authorities and focuses on developing strategies of food waste prevention at consumer level, business and public sectors. The French Environment and Energy Management Agency (ADEME) sets up the Optigède⁹ website in June 2011, which offers an exchange platform for those in charge of waste prevention and management and provides information on best practices. Consumers are a prime target of information and awareness-raising initiatives¹⁰, but other sectors become involved as well. School teaching and higher education would be an appropriate means to introduce the subject of losses and wastage, as it covers a wide range of individual theoretical and practical educational subjects (hygiene, domestic management, agri-food management, environmental assessment).

In developing countries

In developing countries, forty years after the initial efforts undertaken by the FAO and its partners, post-harvest losses are still highly relevant. Technical innovations have been tacked on to traditional practices and local conditions. As little compatible, they were the cause of losses at several post-harvest stages: choice of hybrid varieties vulnerable to pest attack, implementation of production seasons under less favourable meteorological conditions, too frequent and uncontrolled opening of storage containers for grains under modified atmospheres. Taking local context into account and involvement of the population within a participative approach, are decisive factors for the success of crop protection measures. Action plans for reducing post-harvest losses lie in two main areas: technical innovations and organisational innovations (FAO, World Bank, 2010).

- Technical innovations

These are necessary at all stages in post-harvest systems. Among which:

⁸ For example the Danish movement Stop Wasting Food <http://www.stopspildafmad.dk/inenglish.html>, the British Love Food Hate Waste http://www.lovefoodhatewaste.com/about_food_waste; a website of the French federation of associations for the protection of the environment (FNE) <http://www.fne.asso.fr/fr/nos-dossiers/dechets/gaspillage-alimentaire.html>

⁹ www.optigede.ademe.fr

¹⁰ After several years mass awareness campaigns by the WRAP, food wasted by the British households, in particular edible foods, had indeed dropped by 18% (WRAP, 2011).

- equipment for stabilising raw products (drying, salting, sweetening, smoking, fermentation, heat treatment), while aiming for technical efficiency in terms of yield, energy (renewable ideally) and environment, and while concentrating on the nutritional and sanitary qualities of products. Such treatments may create added value and open perspectives to access new markets, for export for example. This equipment often requires little investment, and is accessible to small businesses and women's groups, which are priority targets.

- techniques and equipment both in households and on a communal level (FAO, 2008) in order to ensure airtight storage and transport, improvement in conditioning and packaging, in particular of perishable products (Manalili *et al.*, 2011), a cold chain based on traditional systems (underground cellars etc.), storage methods based on the use of bio-insecticides that are little harmful to human health and financially accessible, or based on integrated control, and this along with training in how to use the products.

- infrastructure for transport and packaging, vehicles, logistics resources.

- communication infrastructures (notably mobile telephones) for access to market information and for commercial operations.

On-farm storage is important for household food security as it prevents farmers, in default of efficient stocking equipment, from selling crops at low prices and buying them back dearly at a later date for their own consumption. Increasing storage capacity is therefore directly related to rural household food consumption, as much from a qualitative as a quantitative point of view. Family-sized metal silos, manufactured on-site and maintained by local tinsmiths, have proved beneficial individually on a household level as well as collectively (job creation, stabilisation of market prices, reduction of poverty, improvement in population living conditions), since their progressive introduction to some Central American countries as part of a rural development strategy PostCosecha¹¹ (Herrmann, 1991). The FAO has been successfully promoting the metal silo since (FAO, 2008). A similar initiative has been launched in some African countries with a locally manufactured cowpea triple bagging system (Baributsa *et al.*, 2010) provided with an airtight sealing system.

- Organisational innovation

Diffusion of knowledge and access to capital, to equipment investments, information and markets, which are important for reducing losses depend among other things on the way in which postharvest operators and support services are organised. Producer organisations or cooperatives are therefore useful: joint specifications and standards may encourage adoption of good practices and increase the added value of products in a collective approach (Murthy *et al.*, 2009). Costly investments, such as a refrigeration system, can be shared (Spore, 2011). Access to a market, whether domestic or export, is an essential element to enabling operators to maximize their efforts. The Purchase for Progress (P4P) programme in the World Food

11 <http://www.postcosecha.net>

Programme (WFP) (2010), for example, provides the most vulnerable farmers with access to markets and enables them to make durable investments, by offering them various ways of selling their crops (direct contracts or contracts with local traders, three-year periods) (Davies and Salvagnol 2010).

Another essential element is access to capital for investment which is often a delicate problem for small operators in rural areas. There are different schemes, such as microfinance, warehouse receipting and inventory credits (Coulter, 2010). A loss reduction strategy must be analyzed from a standpoint of finances and longevity. This involves taking post-harvest system innovations into consideration with respect to the value chain as a whole, and with this in mind, of identifying the long-term economic benefits and return on investment (Kitinoja *et al.*, 2011, World Bank 2011).

Conclusions and outlook

Reducing food losses and wastage is not only a moral obligation towards people who do not have the means to eat properly. It would also reduce pressure on ecosystems and on consumer purchasing power and should increase income of producers. Faced with the challenge of feeding an estimated 9 billion human beings in 2050, this approach deserves to be considered a priority as, to date, no new agricultural techniques are likely to rapidly increase production by 30%. In contrast, cutting by half losses and wastage along the food chain would appear to be absolutely possible (Foresight, 2011).

The previous chapter has illustrated different action levers which can be effective for the reduction of food losses and wastage. As our examples have shown, due to food system's complexity characterized by strong interaction of an important number of actors, life cycle thinking is essential in policy making for loss and wastage reduction and prevention. Going beyond farming systems, all stages as processing, storage, transport, distribution, food preparation need to be managed as a whole in order to avoid impact transfer from one stage to another stage. In this respect, the use for non-food purposes (animal feed, energy, compost etc.) of organic waste related to food losses and wastage fully justifies a systems approach to analyse the production and usage of agricultural biomass as a whole.

Having apparent solutions within grasp, we should keep in mind that it is labour that is costly in industrialized countries. Whereas the means to reduce losses and wastage exist, it is often not profitable to implement them in the current food system structure or under current marketing and technical conditions. Not labour, but the product is expensive in developing countries. They often do not have the means (financial and organisational, etc.) to invest in wrapping and packaging, in equipment, infrastructure and training.

Stakeholders may easily identify specific gains to be achieved when reducing losses and wastage, and be it first and foremost an image gain, especially since the topic has recently

benefited from massive public awareness raising. Cost management (expected long-term high level of prices and price volatility on commodity markets), public relations and consideration of societal expectations towards their environmental performances (corporate sustainability responsibility and for example in France, environmental labelling regulations following the *Grenelle de l'Environnement* discussions) should actually be motivation. But the role of indirect financial incentives for waste reduction should not be neglected besides direct campaigns. When anticipating regulations in a context of overall tightened environmental and waste policies, companies often take the first steps in favour of reduction strategies. As for consumers, information on environmental and social impacts of food waste prevention and on the effect on the personal moneybag may contribute, but is probably not enough to induce significant behaviour change.

In conclusion, multidisciplinary research, innovation and purposeful policies are needed to overcome barriers to food losses and wastage reduction and prevention (Redlingshöfer, Soyeux 2011). What is beginning to be perceived as a genuine aberration in both our modern and traditional food systems, must become a *leitmotiv* in all strategies leading to more sustainable food systems. A multi-stakeholder platform would be relevant to discuss cross-sector relevant problems (consumer behaviour change, regulation, food labelling etc.) and prepare recommendations to be addressed to decision-makers. Only joint efforts of all stakeholders involved will make progress on more efficient food use possible. Will they enable a change of paradigm in food systems which puts food back in its rightful place?

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