Committee on World Food Security

High Level Panel of Experts on Food Security and Nutrition

Food Losses And Waste In The Context Of Sustainable Food Systems V0 DRAFT

A zero-draft consultation paper 23 December 2013

Submitted by the HLPE
to open electronic consultation

This V0 draft has been produced by the HLPE Project Team under guidance and oversight of the HLPE Steering Committee.

HLPE Project Team:
Vishweshwaraiah Prakash (Team Leader)
Jane Ambuko
Walter Belik
Jikun Huang
Toine Timmermans

This V0 draft issubmitted for open e-consultation on our dedicated platform http://www.fao.org/fsnforum/cfs-hlpe/food-losses-waste-v0 as part of the HLPE report elaboration process, for public and expert feedback and comments.

Please read the cover letter to this electronic consultation, page 2.

Comments can be sent by e-mail to: cfs-hlpe@fao.org or to fsn-moderator@fao.org.

This consultation will be used by the HLPE to further elaborate the report, which will then be submitted to peer review, before its finalization and approval by the HLPE Steering Committee.

The final report is expected to be ready for publication in end May / early June 2014.

This V0 draft may be thoroughly corrected, modified, expanded and revised after the present consultation.

For this reason we invite you not cite or quote elements from this V0.

Please only refer to the final publication for quotations.

COVER Letter from the HLPE to this V0 Consultation

In November 2012, the UN Committee on World Food Security (CFS) requested the High Level Panel of Experts on Food Security and Nutrition (HLPE) to conduct a study on Food Losses and Waste in the Context of Sustainable Food Systems. Final findings of the study will feed into CFS 41 Plenary session on policy convergence (October 2014).

As part of the process of elaboration of its reports, the HLPE now seeks inputs, suggestions, comments on the present V0 draft (link). This e-consultation will be used by the HLPE to further elaborate the report, which will then be submitted to external expert review, before finalization and approval by the HLPE Steering Committee.

HLPE V0 drafts are deliberately presented – with their range of imperfections – early enough in the process, at a work-in-progress stage when sufficient time remains to give proper consideration to the feedback received so that it can be really useful and play a real role in the elaboration of the report. It is a key part of the scientific dialogue between the HLPE Project Team and Steering Committee and the rest of the knowledge community. In that respect, the present draft identifies areas for recommendations at a very initial stage, and the HLPE would welcome any related evidence-based suggestions or proposals.

In order to strengthen the related parts of the report, the HLPE would welcome submission of material, suggestions, references, examples, on the following important aspects:

1. How to measure Food Losses and Waste (FLW)? FLW can be measured from different perspectives (weight, caloric and nutrition value, monetary value…) with different approaches presenting pros and cons, and methodological issues. Do you think that the V0 draft covers properly the aspects of FLW measurements, including nutrient losses? Is there additional evidence about estimates of past and current food losses and waste, which would deserve to be mentioned?
2. What are the key policy aspects to reduce food losses and waste in order to improve the sustainability of food systems, in different countries and contexts? Is there evidence about the potential of economic incentives, and which ones (taxes, etc.)? What margins for policies in the context of food safety laws and regulations, such as expiration dates?
3. Can respondents submit concrete initiatives or successful interventions having reduced food losses and waste, currently taking place, conducted by governments, stakeholders, private sector, civil society?
4. What is the cost-benefit potential (and barrier to adoption) of different options, including technologies, to reduce and prevent food losses and waste at different stage of the food chain?
5. Cold chains and cold storage (including adaptable low-cost technologies for cold storage such as evaporative cooling, charcoal coolers, zeer pots, etc): what could be cost-effective and adapted solutions to reduce food losses and waste and to improve the sustainability of food systems, given the diversity of national contexts?
6. Systemic approaches and solutions to reduce food losses and waste: Reducing food losses and waste is a matter which concerns the coordinated joint action (and change) by many actors, producers, retailers, consumers, private sector, governments. Which systemic solutions/approaches would be the most effective to reduce FLW, towards more sustainable food systems? At that systemic level, which drivers would create leverage for radical change?

We thank in advance all the contributors for being kind enough to read and comment and suggest inputs on this early version of the report.

the HLPE reminds that this V0 draft may be thoroughly corrected, modified, expanded and revised after the present consultation, and building on it. Please do cite or quote only the final version of the report, expected for end May / early June 2014

We look forward for a rich and fruitful consultation,

The HLPE, 23 December 2013

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INTRODUCTION

The Committee on World Food Security, in its thirty-ninth Session (October 2012) requested the High Level Panel of Experts on Food Security and Nutrition, to undertake a study on 'Food losses and waste in the context of sustainable food systems' to be presented to the CFS Plenary in 2014.

The issue of food losses and waste has recently received much attention and has been given high visibility: According to FAO (2011), almost one-third of food produced for human consumption — approximately 1.3 billion tonnes per year is either lost or wasted globally: their reduction is now presented as essential to improve food security (HLPE, 2011, FAO, 2012ab) and to reduce the environmental footprint of food systems (HLPE, 2012, FAO, 2012a;b, UNEP, 2012a;b).

The issue was prominent on the agenda towards the preparation of the Rio+20 Conference, which linked the reduction of food losses and waste to the issue of more sustainable food systems, linking consumption and production and recognizing that production is driven by consumption, and that the environmental impacts of food systems have to be assessed all along food chains. The Zero Hunger Challenge launched by the Secretary General of the United Nations in Rio de Janeiro during the conference integrates a zero-food-loss-and-waste challenge and a 100%-sustainable-food-systems challenge.

The formulation of the request by the CFS seeks to understand the reasons for food losses and waste, and the means to reduce them, and to do this from a sustainability perspective, including the three dimensions of sustainability: environmental, social and economic.

It requires defining what "food losses and waste" means, to consider their extent and the means to reduce them. It also implies adopting an integrated view of food production, commercialization and consumption.

By requesting the HLPE to examine the issue of food losses and waste *in the context of sustainable food systems*, the CFS invites the HLPE to investigate how the reduction of food losses and waste could improve the sustainability of food systems, as well as how unsustainable food systems contribute to food losses and waste[1].

This in turn requires considering the very notion of sustainable food systems, which includes their contribution to the four dimensions of food security, now, and in the future.Efficient, well-managed and sustainable food systems are essential to end hunger and malnutrition as well as protect the environment. "*The key to better nutrition, and ultimately to ensuring each person's right to food, lies in better food systems – smarter approaches, policies and investments encompassing the environment, people, institutions and processes by which agricultural products are produced, processed and brought to consumers in a sustainable manner*" Secretary-General Ban Ki-moon said in his message for the World Food Day on 16 October 2013 (UN, 2013a).

Such an amount of food losses and waste is even more appalling in a time when systems are already under stress and required to produce more with less to meet the growing demand for food. The loss and waste of food translates into a loss or waste of resources in food production, and the unnecessary production of greenhouse gas emissions. Resources used in food production are used in vain, and greenhouse gas emissions caused by production of food that gets lost or wasted are also emissions in vain.

It is also appalling in a time when regions of the world are still suffering from chronic food insecurity: is it reasonable, and what rationale can be found to the current situation where consumers in rich countries waste every year almost as much food (222 million tonnes) as the entire net food production of sub-Saharan Africa (230 million tonnes)? Industrialized and developing countries dissipate roughly the same quantities of food – respectively 670 and 630 million tonnes, but overall, on a per-capita basis, much more food is *wasted*in the industrialized world (the biggest share of it at the consumption stage), than*lost* in developing countries (mainly at the production, harvest, post-harvest and processing phase). It is estimated that the per capita food waste by consumers in

[1] Food systems encompass the ecosystem and all activities that relate to the production, processing, distribution, preparation and consumption of food. A food system also includes the inputs needed and outputs generated by each of these activities as well as their outcomes, insofar as they contribute to food and nutrition security.

Europe and North-America is 95-115 kg/year, while this figure in Sub-Saharan Africa and South/Southeast Asia is only 6-11 kg/year.

What is the real extent of food losses and waste, and what can be the contribution of a reduction in food losses and waste to improve food and nutrition security in the context of sustainable food systems?

To address this question, the report adopts the following approach.

First, it clarifies the acceptation (definition) used for food losses and waste, as well as for sustainable food systems. It summarizes available data on the extent of food losses and waste, recognizing that they are very much dependent on the specific conditions and local situation in a given country.

Second, it depicts the impacts of FLW on sustainable food systems and food security.

It then reviews the range of causes to FLW, which depend on production, storage and processing choices, patterns and technologies, internal infrastructure and capacity, marketing chains and channels for distribution, consumer purchasing, and food use practices, etc. In doing so, a distinction is made between primary, secondary, and systemic causes.

Finally it aims at depicting the solutions to reduce FLW and their potential, looking at the present state of public polices when they exist. In doing so, the report tries to sort out the roles for governments, consumers, social actors and private sector.

Recommendations are derived from the analysis.

1 FOOD LOSS AND WASTE AND SUSTAINABLE FOOD SYSTEMS: DEFINITION, EXTENT AND IMPACTS

The importance of FLW and their impact on the various dimensions of the sustainability of food security and on food security is of growing concern. There is general agreement that FLW are important. However figures differ often widely. These differences are due to differences on definitions -and thus on calculation methods- and to difference on available data. A better understanding of FLW requires improving the comparability of methodologies and data.

1.1 What are FLW along food chains and how to measure them?

1.1.1 What are the existing concepts and definitions[2]?

What are Food Losses and Waste? There can be various approaches to the "definition". Several definitions co-existed in the past, depending on the main angle of attack to the problem of FLW. One first divide in terms of approaches is the one between looking at the problem with the lens of food and food security, versus looking at the problem with the lens of waste or environmental impacts. Looking from supply chain efficiency and economic driven value chain perspectives also puts more emphasis onspecific aspects of FLW.

Approaching FLW from a food security perspective invites to consider only edible foods or parts of food which are edible for human consumption. Under this approach, strictly speaking, FLW exists only with respect to food meant to be eaten by humans, i.e. edible foods, which brings the issue of food safety and quality, as well as the cultural dimension of "*edibility*". Other studies have adopted a "caloric" approach, by which "calorie loss" is estimated in the food system, i.e the difference between (i) the potential of the food system to produce edible calories and (ii) daily calorie requirements. This last approach triggers immediately two issues, and one question. First, the relation between food losses and waste and over nutrition, as consumption over the daily requirements can be then assimilated as waste. Second, the issue of the "caloric" efficiency of the food system itself in terms of how it transforms plant calories into human food. Both issues lead to a questioning on how to account for the nutritional dimensions, as calories are not the only dimension of nutrition, and a food system less performing in "caloric terms" may perform better in terms of diet (proteins, micronutrients).

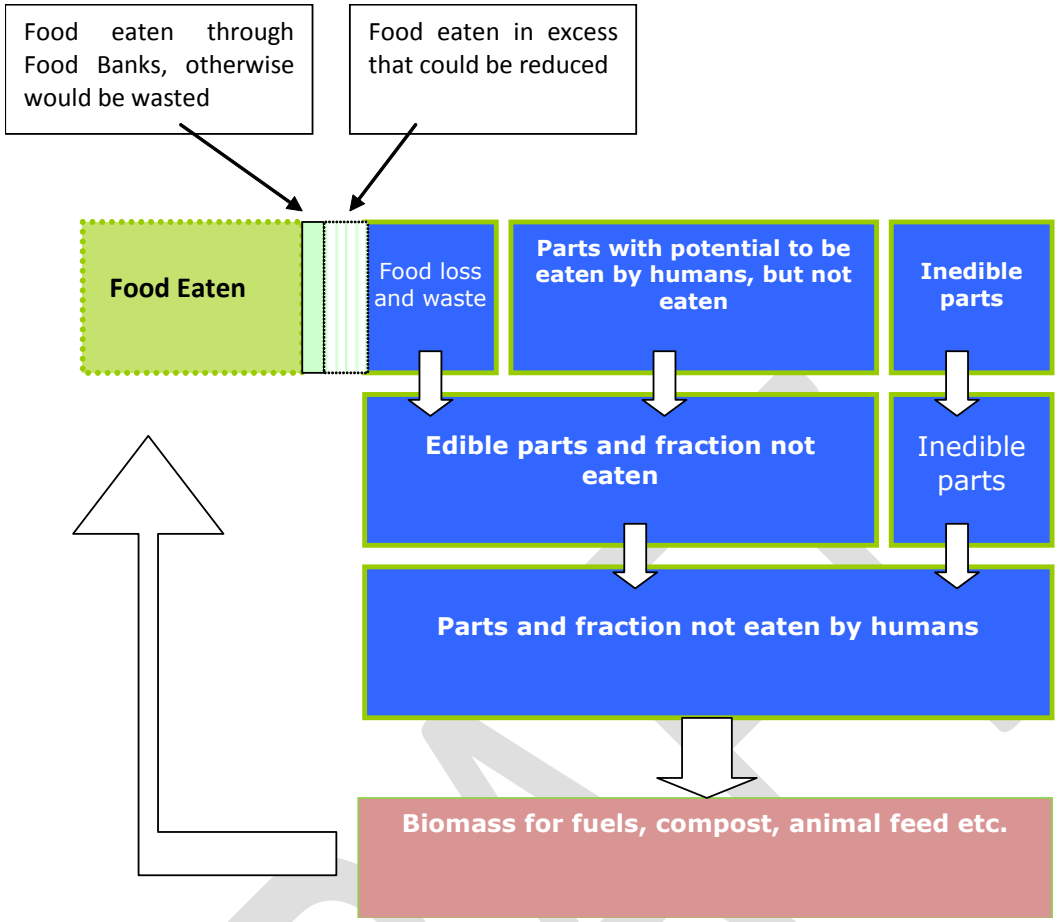
Athird approach toassessing FLW would bebased on monetary value.Food losses and waste translate also in economic losses and waste.

Approaching food losses and waste from a "waste" perspective leads to consider all food related waste, edible or not. In such approaches, some distinguish "non avoidable waste" (non edible parts of food), and "avoidable waste" which is food waste. Such approaches also call to consider "what happens with the waste", either as feed, recycling, energy production, as compost to return nutrients to the soil, incineration or landfill. An approach from a value chain perspective is based on the balance between supply and demand and the roles and behavior of different actors in the supply chain. (See Figure 1).

The debates on such approaches to FLW is not only a question of finding a common definition. It has implications in terms of measurements, and interpretation of figures. All figures on FLW are determined by the scope and the approach. These different perspectives generate different definitions and measurements making comparisons between studies often difficult. It makes comparison of figures difficult, and dangerous if not accompanied with a clear explanation from what perspective, and how they have been calculated. It has also implications in terms of defining and understanding "what needs to be done", policies and objectives, etc. This is why there is now a strong movement for a harmonization of definitions and measurement (FAO, OECD, EC, FUSIONS, WRI, UNEP).

[2] Taking into account for quantities and quality of food lost and wasted; other uses of food (livestock, energy); "overuse" of food (natural resources and over-nutrition/obesity); actual uses of food losses and waste as feed for livestock and feedstock for energy production; food losses and waste circulating through informal circuits, food banks or food charity.

Figure 1 Food uses and non-edible parts of food destination



<u>To be able to allow for a consistent interpretation of the definitions of FLW, the context and terminologies used need to be described.</u>

<u>In this report the following definitions will be used</u>

- food means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be eaten by humans.

- A food supply chain encompasses all those activities that help ensure the delivery of finished products to the consumer from the primary producer. Such activities can include processing, storage, transport and distribution, manufacturing,wholesale, retail and consumption.

- A Food system encompass the ecosystem and all activities that relate to the production, processing, distribution, preparation and consumption of food. A food system also includes the inputs needed and outputs generated by each of these activities as well as their outcomes, insofar as they contribute to food and nutrition security.

- **Food loss** refers to a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption.
- **Food waste** refers to food appropriate for human consumption being discarded, whether or not after it has beenkept beyond its expiry date or left to spoil.
- FLW occur between the moment when a product is ready to be harvested or harvested, and the moment when it is consumed or removed from the food supply chain.

The following examples of inefficiencies or fraction are not considered as FLW:

- Inedible fractions removed from the food supply chain (e.g. side streams)

- Over nutrition
- Less food being produced compared to a more optimal production system (e.g. yield gap)
- Conversion from plant based resources to meat production or animal products

1.1.2 How to measure FLW,what are the data available and how reliable are they?

At global level the study Global food Losses and food waste of FAO, executed by SIK, has been the most quoted and used reference in the recent years. The study highlights losses and waste occurring along the entire food chain, and makes assessments of their magnitude. The study revealed that there are major data gaps in the knowledge of global food loss and waste (Gustavsson, 2011). The available statistics are based on very limited data (Parfitt, 2013), based on point-estimates, with no assessment ofthe margin of error or uncertainty.

Box 1 The methodology of the FAO study: "Global Food Losses and Food Waste - extent, causes and prevention"- FAO, 2011

The production volumes presented were collected from FAO Statistical Yearbook 2009. Waste percentages of losses and waste for different regions of the world; different commodity groups and different steps of the supply chain were collected from an extensive literature search and by expert consultation. Where there are gaps of knowledge, assumptions and estimations were made, based on food losses and waste levels in comparable regions, commodity groups and/or steps of the food supply chain. For quantifying losses and waste, national and regional Food Balance Sheets from the year 2007 were used, mapping out the regional food supplies. Different calculation models were applied for each commodity group: cereals; roots & tubers; oilseeds & pulses; fruit & vegetables; meat; fish & seafood and milk & eggs. The methodology of the study is challenged by major data gaps for both waste percentages of losses and waste and the causes of losses and waste. The results must therefore be taken with great caution (Gustavsson, 2013b).

1.1.3 Need for harmonized methodologies and protocols to describe and measure FLW

There is a pressing need to have more reliable and valid data available to assess the extent of FLW and compare diverse practices and systems. This requires both harmonized monitoring methodologies, preferably from a global perspective, but also the commitment of stakeholder groups to be transparent on reporting losses and waste in food supply chain practice

Developing global protocols for the measurement of FLW is highly complex, having to account for a large number of variables , often different from country to country. While most of the data on post harvest losses in the Food Supply Chain in developing countries is not available or recorded, there is no recorded data on food waste at the consumer end in the developed countries.

Hence it is felt that there is an urgent need for harmonized methodologies and protocols to describe and measure FLW. The main points for developing a methodology for harmonized protocols are

- A global definition for Food, Food Supply Chain, Food Loss and Food Waste
- Data on existing food supply chains world over with special emphasis on concentrating the early stages of food supply chain in developing countries and later stages of food supply chain in developed countries from secondary sources of information (external and internal)
- To standardize methods for collection of data
- Evaluation of data using statistical tools

- Mapping of global food supply chain to describe and to measure the FLW

Such a methodology should be devised in such a way to allow for local and product-specific adaptations as appropriate.

1.2 Food losses and waste and sustainable food systems

The increasing concern about FLW is often framed in the broader objective of improving the sustainability of food systems.

1.2.1 What are sustainable food systems (in all dimensions of sustainability)? Definitions?

A food system is generally defined as all the elements linked to food production and consumption (Ericsen 2008, Ingram 2011). Itencompass (i) activities related to the production, processing, distribution, preparation and consumption of food; and (ii) the outcomes of these activities contributing to food security, food availability, food access and food utilization. Food systems also contribute to a range of other socioeconomic (e.g. wealth) and environmental (e.g. greenhouse gas emissions) issues.A food system is made up of the environment, people, institutions and processes by which agricultural products are produced, processed and brought to consumers.

There are many different views as to what constitutes a 'sustainable' food system, and what falls within the scope of the term 'sustainability'. Strictly speaking sustainability implies the use of resources at rates that do not exceed the capacity of the Earth to replace them. For food, a sustainable system might be seen as encompassing a range of issues such as security of the supply of food, health, safety, affordability, quality, job supply and environment concerns:climate change, biodiversity, water and soil quality, etc.

The notion of sustainability introduces a time dimension which invites to consider the notion of food systems from a functional, teleological point of view.

Thus intended a *food system* could be defined by its function: ensuring food production and consumption of food and a *sustainable food system* (SFS) would be one that ensures production and consumption of adequate food (in quantity and quality) for all and ultimately food security and nutrition in such a way that the economic, social and environmental basis to generate food security and nutrition of future generations are not compromised.

Therefore the understanding of what a sustainable food system entails requires to consider how the three dimensions of sustainability (economic, social and environmental) interact with the four dimensions of food security (availability, access, utilization and stability).

Food security refers to the availability of food and one's access to it. A household is considered food-secure when its occupants do not live in hunger or fear of starvation. Food security is a central element for the economic and social stability of any nation. The World Health Organization defines three facets of food security: food availability, food access, and food use. Food availability is having sufficient quantities of food on a consistent basis. Food access is having sufficient resources, both economic and physicalto obtain appropriate foods for a nutritious diet. Food systems contribute to food security in its 4 dimensions by providing food, but also livelihoods and income... Food use is the appropriate use of food resources based on knowledge of basic nutrition and care. It is a function of safe drinking water, environmental hygiene, primary health care and education.
The FAO adds a fourth facet: the stability of the first three dimensions of food security over time. Among others, sustainable food security requires a stable supply of food with robust agricultural growth and properly functioning agricultural markets.Every aspect of the food system has an effect on the final availability and accessibility of diverse, nutritious foods – and therefore on consumers' ability to choose healthy diets.

How to assess a FS with respect to sustainability, what are the most important criteria, including by consideration of specificities and priorities? Given the function of food systems, food security shall be the priority, but that entails in turn numerous issues, with different geographical and time scales. Priorities will thus depend on context (scarcity of resources, importance of agriculture as an income provider, etc.)

Use of resources is one of the key dimensions to assess the sustainability of food systems. Overuse of resource, at the system level, generally undermines the environmental, but also economic and social basis of food security (with possible impacts in all the dimensions of food security). Trade-offs can take place between the different dimensions of sustainability, and these trade-offs can manifest themselves differently at different scales.

One example of those trade-offs is the issue of livestock. The importance of livestock for both developed and developing economies is paramount but livestock production has different relations to food security in these two worlds. Livestock enable to produce food from coarse resources and in difficult conditions. In developing countries, livestock can be particularly important to fight poverty and to provide more nutritiousfood. Livestock has a relevant role in small proprieties in developing countries not only as production of food, but also as a capital, as a guarantee in order to leverage more credit (Randolph *et al.*, 2007). It is also useful in the food system in so far as it provides manure. It also gives status and power to peasants. However, while some livestock systems are integrated into cropping systems and provide an essential component of those, other livestock systems, in addition to impacting the environment dimension of sustainability[3], create a competition in the use of grains between food and feed[4]. Therefore meat consumption, everything being equal, reduces the availabilities of calories, and adds pressure on natural resource use.

As some components of food systems do not perform equally in terms of sustainability and food security, food losses and waste of the related produce will also not be of equal concerns in terms of their impact on sustainability and food security.A loss or waste of meat measured by mass is therefore not equivalent, from a sustainable food system perspective (given the above definition) to the same mass of grain loss or waste: the impact on availability of calories is different (meat having a multiplier effect), and the economic impact is different, for operators along the food chain and especially for the consumers.

Box 2 Example: export of chicken

Theexport andimportofless ediblefoodslikechicken wingsis demandbasedconsumerpreferences fromtheimporting countries.World poultry trade reveals that the order of preference of poultry parts in western countries is chicken breast, leg quarters and chicken wings; while eastern countries (except Japan) prefer chicken feet, chicken wings, legs, offal and leg quarters. Russia is the largest importer of poultry meat in the world, followed by Hong Kong/China. While Russia's imports are mostly chicken leg quarters, Hong Kong's top imports are chicken feet. Hong Kong is the leading importer of chicken feet, legs, wings, and offal, making it the second largest importer of US chicken, trailing only Russia. Such movements are based on (and reveal) profound income and cultural differences between countries.

Sustainable food systems can be contemplated at different scales, including regional scales. How food losses and waste ultimately impact the sustainability of food systems (and how solutions can be found) is to be looked within scales, but also across scales, including regional ones. For cultural or for economic reasons, some systems generate "waste" which for another system is useful resources or food. This is typically the case for some parts of chicken which are considered "less edible" in some regions than others (see Box 2). Enabling the transfers of those foods from regions where they are considered not edible to regions where they are considered edible might be seen as a contribution to the reduction of food losses and waste across geographic scales, as well as a contribution to food and nutrition security of poorer people. However its impact on other dimensions

[3] According to FAO (2006a) livestock is responsible for 18% of greenhouse gases emissions. Compared to rice, for example, each kg of beef produces 10 times more CO_2. The water consumption in production process also is bigger comparing to other alimentation. Taking into account the nutritional value: 0.5 m^3 of water is necessary to produce 1000 kcal of vegetables whilst producing the same 1000 kcal of beef needs 4 m^3 of water, in annual basis (Lundqvist & Molden, 2008).

[4] According to calculations of UNEP assuming that all non-food use is for food-producing animals, and that 3 kg of cereals are used per kilogram of animal product and also that each kilogram of animal product contains half the calories found in kg of cereals (roughly 1,500 kcal per kg of meat), this means that each kilogram of cereals used for feed give 500 kcal for human consumption. Thus, taking the energy value of the meat produced into consideration, the loss of calories by feeding the cereals to animals instead of using the cereals directly as human food represents the annual calorie need for more than 3.5 billion people".See Nellemann *et al*. (eds.) (2009).

of sustainability, as well as on equity, are discussed, as the gains have to be weighed against the impacts on the producers in the importing countries, as well as food safety considerations (which should be harmonized) and probably also nutrition, as the controversies on turkey tail international trade which leads to a concentration of the consumption of very fat parts in some countries attest.

1.2.2 How the reduction of food losses and waste could improve the sustainability of food systems? As well as how unsustainable food systems contribute to food losses and waste?[5]

Food wasted while people go hungry is first of all sign of a global food system which does not fulfil its function; whatever the reason. It is a sign and symbol of inefficiency and inequity.

The production of food, which is finally not eaten, whether it is lost during the production and transformation processes, or wasted at the consumption stage, entails the use of resources in vain. Therefore, reducing food losses and waste would also reduce the pressure on natural resources. Reducing food losses and waste appears thus as emblematic of better resource efficiency, a key dimension of more sustainable food systems. Food waste at the consumer level in developed (and in some cases developing) countries is also emblematic of non-sustainable consumption patterns. As such, reducing food waste appears as a way to raise awareness more generally on sustainable consumption as a driver of sustainable food systems.

1.2.3 What is the potential to reduce FLW?

Regional differences in food losses and waste, both in extent and in stages where they happen have led several authors to identify margins of improvement (Gustavsson *et al.,* 2011). Some authors (Kummu *et al.*, 2012) have gone further, in calculating a global potential for improvement by applying to the whole production the lowest loss and waste percentage achieved in any region in each step of food chains. They conclude that approximately half of food losses and waste could be prevented compared to the current situation.

According to this analysis (Kummu *et al.*, 2012), the largest global potential for improvement is in agricultural losses and in consumption waste. Global agricultural losses could be reduced by 47% and global consumption waste by 86%. They note that the global potential for improvement is largest in regions where there is lowest need for extra food supply.

The UK Government Office for Science considers in its indicative conclusions that halving global food waste by 2050 is a realistic target, in view of the evidence reviewed by their report (Foresight, 2010).

There is not much evidence on the reduction of FLW at national level, partly because of lack of consistent methodologies and data to assess, partly because most of national policies are recent. Some countries (UK, South Korea, Japan)have made the reduction of FLW a high priority topic in early 21th century and some first evidence of their impacts is available (see section 4). These last years, in mainly Western countries, a growing number of multinational companies, especially in retail, catering and food processing report transparently about progress in the reduction of FLW within their businesses.

1.2.4 Distinction between types of food systems

There have been various attempts to typologies of food systems. Many of them are constructed on a historical perspective, from “traditional” to “industrialized” systems. Most of them resort to criteria related to the relations between production and consumption: distinction between producers and consumers, part of consumption produced "internally", distance from which food is coming. Scale is of course key here. To a certain extent most if not all food systems are linked to a global food system.

[5] Food systems encompass the ecosystem and all activities that relate to the production, processing, distribution, preparation and consumption of food. A food system also includes the inputs needed and outputs generated by each of these activities as well as their outcomes, insofar as they contribute to food and nutrition security.

Some authors oppose “local” systems to “industrialized” systems, part of global system; generally to insist on the fact that “local” systems are more sustainable (Carroll, 2010; Link and Ling, 2007).This is a very controversial issue, debated between those who consider that global trade is the more efficient from an economic and also environmental point of view and those who consider that “local systems” are the most sustainable. This position is often summarized by the notion of food miles, expressing the distance from which food is transported. It has often been presented as being closely linked to the carbon footprint of food. Such a presentation is wrong, given the fact that transport represents, on average, only 11% of the emissions generated by food production, half of which being due to the consumers when they shop (Weber 2008).Advocates of local systems also pretend that they generate less FLW. There again it very much depends, on products and contexts.

In fact the biggest contribution of local systems to sustainability is probably that they reestablish proximity and contact between food production and consumption thus often giving more value to food, both economic and symbolic, with numerous direct and indirect benefits: more value for producers, better recognition of sustainable practices, indirect incentives to protect farm land against urban spread, and also, especially for fresh products, less need for conservation and transport, thus less energy consumption, and, if well managed (including at consumption level) better nutritional quality.

On the other hand broader systems enable to better benefit from geographic comparative advantages, particularly important for agricultural production, dependent as it is on natural resources and climatic conditions. Detailed life cycle analysis have shown that global efficiency is more important than transport and that, for fresh products, and from a strictly carbon perspective “seasonal” is much more important than “local”. Trade can compensate for local scarcities of resources and enable a country to spare its resources and manage them more sustainably. It is in that perspective that the concept of water foot print has been forged, with the idea that water scarce countries could import water rich products and export less water intense products. Various studies show that it is true in some cases(Green P. S. 2012, 2013).- Other factors than comparative natural resources endowment play a major role here, including diverse economic and financial resources. Most importantly, for markets to really play their role would require prices to integrate all externalities, positive and negative, giving for instance to water its real “value”.

1.2.5 What are the trends / evolutions of food systems, and related drivers?

The global food system is highly complex and is driven by many economic, cultural and environmental factors. Moreover food systems are profoundly changing.Better understanding these drivers and changes and how they interact is indispensable to improve public policies.

Important global trends and factors are changing both consumption, production, and their interrelations.

Global population is projected to increase to nearly eight billion by 2030 and more than 9 billion by 2050, with an even faster growing middle-class, creating demand for more varied, high-quality diet requiring additional resource to be produced. At the same time, a significant share of the world's population is suffering from under-nutrition or malnutrition. According to FAO food demand will increase by 60% towards 2050, driven by population and income growth. This projected increase, higher than population growth, estimated at 30% is driven by income growth and changing consumption patterns towards more livestock products, following recent evolutions. Diets are expected to include a growing part of fresh products, including fruits and vegetables, most of which are more fragile than “staple food” as well as for other. perishable products such as fish and sea food. These trends, as well as other trends such as resource constraints, biofuels and climate change are expected to drive higher and volatile prices (HLPE, 2011; 2013).

At the same time growing urbanization and further globalizations of food markets, with increasing distances travelled by food (including fragile perishables) will make these changes particularly challenging for the sustainability of food systems, with an increasing importance of cold chains & post harvest technology in developing countries, and corresponding challenges in terms of affordability, as well as effectiveness of solutions appropriate to local conditions and resources.

Over recent decades the food system has changed from one that is predominantly supply-driven, to one that is more demand driven - our agro-economic model is generally focused now on providing food at the lowest possible prices. There has also been a shift in power in the supply chain, with bargaining power more concentrated in the retail sector than before, with primary producers taking on a subordinate economic role.

The food system is in transition and there are several trends, many of them contradictory, that are leading to changes in how to produce and consume food. Since the '70 of last century several technical innovations and new production processes were introduced and these things reduced the size of the world in terms of distances. The process of globalization, so called, involved not only the dispersion of production and expansion of financial relations among people and countries as well as changes in cultural habits.

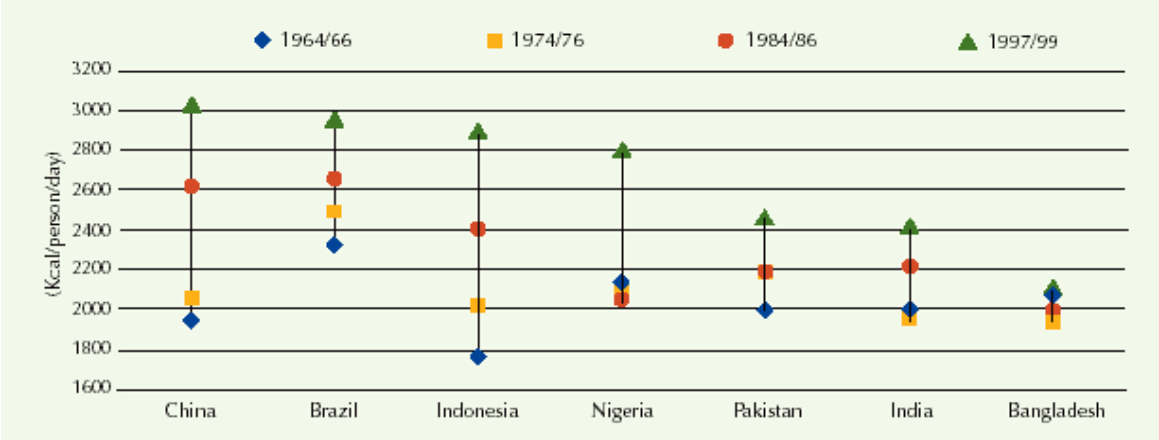
Taking only the last two decades, marked by the period corresponding to the commitments of the Millennium, it is observed that although the world has experienced a troubled period in the past five years, the population in poverty has been reduced and approached the Millennium goal.In 20 years, developing countries managed to reduce by 700 million people living with less than $ 1.25 a day, but still persists 1.2 billion people under these conditions. Schooling also increased with 90% of school-aged children attending schools and with almost full parity of genres (UN, 2013a).The close distances, improving income, better health and education made the habits of food consumption become increasingly homogeneous. It is worth saying that the search for differences and the valuation of specificities also found their space in this changing world.

The world population is aging as the fertility rate has been reducing, of the current 2.9 children per woman to 2.2 children per woman in 2050 and the mortality rate also comes down with an increase in the average life expectancy of 66 years (current) for 76 years old in 2050 (UN, 2001). In 2050 the number of people above 60 should overcome the children and adolescents up to the age of 15. The world population growth in urban areas is also striking. Between 1990 and 2011 the population of urban areas grew by 1.6billion people, and just this year 52% of the world population now live in urban areas and 40% of the total population lived in cities with more than 1 million inhabitants (World Bank, 2013). This will drive profound changes in the way food supply and its stability is ensured.

In addition to these social and demographic changes the countries are increasingly close in commercial terms. Trade barriers are reduced and the exchange between them is increasing. The exports of all countries in the world have multiplied by three times between 1990 and 2010, even considering the crisis of 2008.

In summary, despite the enormous differences that persist between developed and developing regions with regard to the economic characteristics, there is a clear pattern of life approach that facilitated by the exchange of goods, promotes consumer habits very close.This movement of convergence of eating habits, also called westernization (Kearney, 2010), is increasing the caloric consumption in developing countries, as seen in the chart below, improving the diet at the same time that promotes the consumption of obesogenicfood and increases waste.

Figure 2 Per capita consumption in developing countries with more than 100 million inhabitants 1979/99



Source: FAO, 2006c

The increase in the consumption of meat is the biggest change introduced by new western diet. In China between 1978 and 1997 the average per capita intake of meat increased by30 % (Kearney, 2010: 2028). Estimates by FAO (2006) show that the consumption of meat has increased by 50% in China in the last 30 years and that this growth should slow down. Still, for all the developing countries, the consumption of meat will double by 2050 (FAO, 2006: 6).

Western consumption habits are not limited only to the intake of food, but the whole process of acquisition, processing and consumption, reproducing the effects downstream of waste in supermarkets, packaging and portions, without regarding the distances covered for transporting food from the outside of the producing regions. Much of these new consumers in developing countries receive their products already in a state of deterioration after long road trips in precarious regions. In certain localities electricity does not arrive or arrives intermittently and the house does not have refrigerators or conservation equipment that can prolong the life of these foods.

For these reasons, trends point to an increase in the proportion of wasted food in developing regions. Even if we can reduce the losses in agricultural production and processing in developing countries, the growth of income and the change in consumption habits will impact negatively on waste.

1.3 Extent and Impacts of food losses and waste on the sustainability of food systems including food security

The global extent and impacts of FLW have recently been object of several publications, using available data and methodologies.

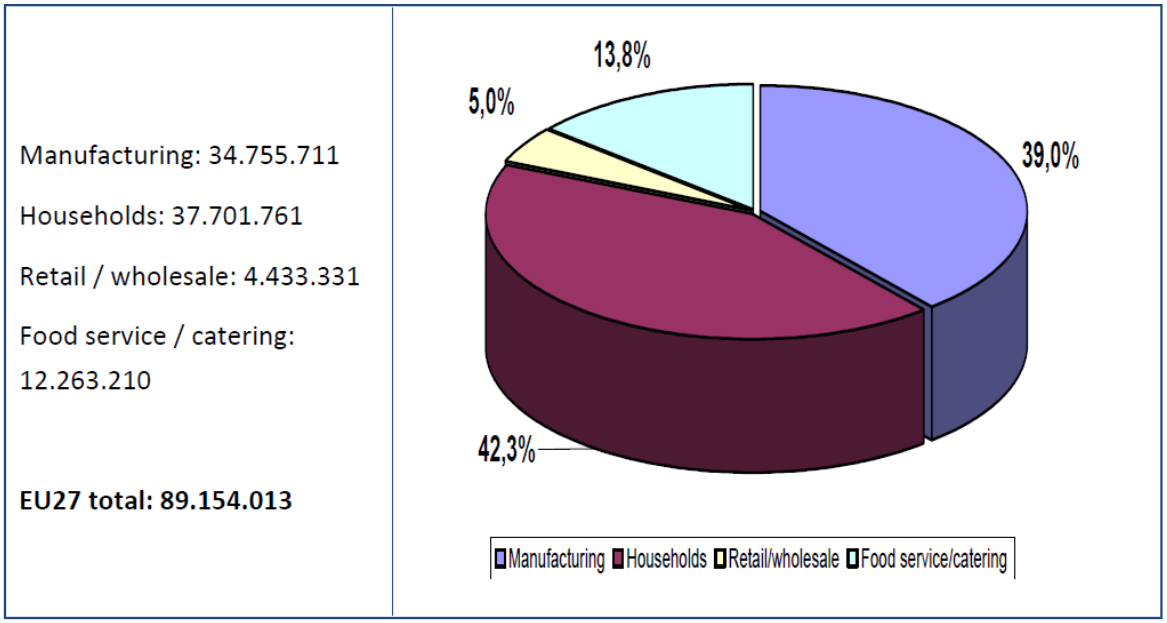
1.3.1 Extent of food losses and waste

As stated above and given the diversity of approaches and reliability and availability of data it is impossible to give a precise estimation of food lost and wasted.

At global level most recent studies use the figures from the FAO 2011 Global Food Losses and Food Waste report (Gustavsson*et al.,* 2011). FAO estimates that roughly one-third of all edible food produced for human consumption is wasted or otherwise lost from the food supply per year, or about 1.3 billion metric tonnes. The FAO estimates that the per capita food waste by consumers in Europe and North America is 95-115 kg/year, while this figure in Sub-Sahara Africa and South/Southeast Asia is only 6-11 kg/year (Gustavsson*et al.,* 2011).Inspired and merely based on the methodologies and outcomes of this study several new studies have been published. Globally around a quarter of the produced food in terms of kcal is lost in the food supply chain (Kummu, 2012). Without accounting for GHG emissions from land use change, the carbon footprint of food produced and not eaten is estimated at 3.3 Gt of CO_2 equivalent. The direct economic cost, based on producer prices only, is about USD 750 billion (FAO, 2013b).

In Eastern and Southern Africa alone, based on APHLIS estimates, the FLW of grains are valued at US$1.6 billion per year, or about 13.5 percent of the total value of grain production. According to a food waste study for the European Commission, food waste generated in the EU27 totaled around 89 million tonnes in 2006,179 kg of food waste per, of which about 76 kg/capita, is produced by households (Monier, 2011), see Figure 3. There are more detailed studies at country level, amongst others UK (WRAP, 2013a; 2013b), Germany (Kranert, 2012), the Netherlands (Soethoudt and Timmermans, 2013) and Switzerland (Berretta, 2013), etc. Total food waste at the retail and consumer levels in the US was estimated at $165.6 billion in 2008 at retail prizes, per capita 188 kg/year. Per capita loss at the consumer level was $390/year (Buzby, 2012).The FLW rate of grains in the entire supply chain is 19.0% ± 5.8% in China, with the consumer segment having the single largest portion of food waste of 7.3% ± 4.8% (Liu, 2013). An overview of recent studies on food waste generation on national, European and global level is described in (Priefer, 2013). While Japan's domestic food supply accounts for 39% of its total food consumption, the amount of food wasted accounts for 40% of national food production (Marra, 2013).

Figure 3 Breakdown of food waste across EU 27 (t/year)



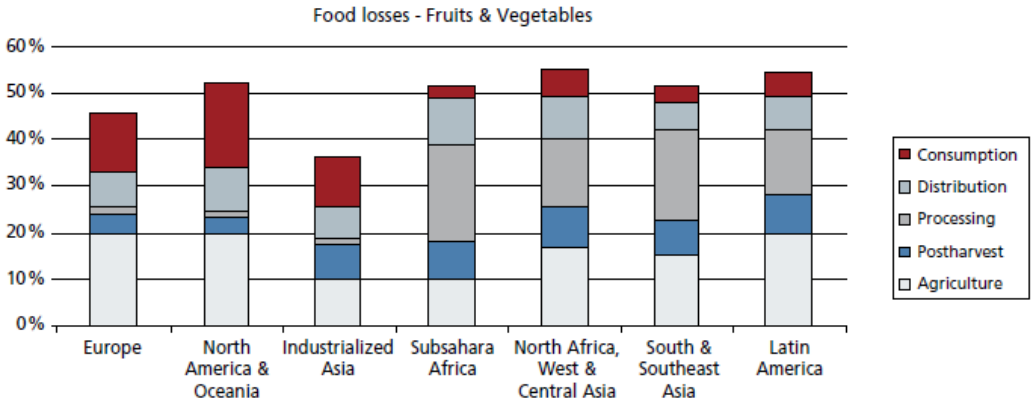
Source: Monier, 2010

Some detailed studies give more precise and accurate perspectives on specific parts of food supply chains. There are sector studies published in scientific literature including among others for production of farm staples, processing, wholesale and logistics, retail, markets, redistribution, food services and households (Møller, 2013). A detailed and comprehensive overview of different sectors (excluding primary production)has been gathered for UK (WRAP, 2011a, 2011b, 2011c).

The extent of Post Harvest Lossesin developing countries is relatively unknown and mostly guesstimates derived from questionnaires rather than actual measurements. For example, of the 40 supply chain stages estimates for south and south-east Asia in the FAO report (Gustavsson*et al.,* 2011), over 70% were based on assumptions, generic data or estimates from other regions.Demands for simplified loss figures can lead to, for example, single national figures for maize PHLs representing many years. It is therefore important not only to work with figures that are good estimates at the time and in the situation they are taken, but also to be aware that at other times and situations the figures will differ (Hodges*et al.,* 2010). In developing countries the losses at the production stage are significantly higher than in industrialized countries. This distinction is at first order pertinent but is not enough if the perspective is SFS and their evolution. Looking at e.g. the estimated FLW of fruits in vegetables in different regions indicates clearly difference in the parts of FSC where the losses occur (Gustavsson*et al.,* 2011). In developed countries also, the losses recorded at the agricultural stage (due to sizing and aesthetic standards, product quality regulations, production surpluses, or economic factors) are not negligible. For example, in Italy in 2009, 17.7 million tons of agricultural produce was left in the fields, representing 3.25% of total production (Segrè, 2011)

In sub-Saharan Africa, quantitative losses in cereal grains (the main staples) range from 5 to 40% of the total production with an average of 13.5%. In monetary terms, these losses amount to 4 billion USD, which exceeds the total value of food aid received by SSA in the decade between 1998 – 2008. These grain losses could meet the calorific needs of at least 48 million people (World Bank, 2011). In fruits and vegetables, which are highly perishable, postharvest losses range between 30 to 40% in SSA. The extentof losses vary depending on region, season, commodity. Recent studies conducted in Rwanda, Ghana, Benin and India showed losses ranging from 30 to 80% in different commodities (Kitinoja *et al.,* 2011).

Figure 4 Part of the initial production lost or wasted at different stages of the FSC for fruits and vegetables in different regions



Source: Gustavsson *et al.,* 2011

1.3.2 Impact of food losses and waste on the sustainability of food systems

Food losses have various impacts on the sustainability of food systems and food security. For a better understanding of these impacts, they could be divided in three important fields: economic, social and environmental. Besides, these impacts could be described atthree levels, namely: at the level of the society, more general (macrolevel); at the level of the production chain (mesolevel) and at the level of households and individuals (microlevel). Table 1 below presents a summary of these results.

Table 1 Impact of losses and waste

Level\field	Economic	Social	Environmental
Macro	• Unrealized economic effort; • Unproductive public investment in infrastructure and education; • Additional resource mobilization with pressure on the financial market; • Subsidies and pressures on the budgets of the Governments.	• Reduction in financial resources for investment in other areas; • Higher level of food prices and difficulties in access to food; • Larger number of poor people.	• Pressure on natural resources: water and soil; • Emission of greenhouse gases; • Occupation of forests and conservation areas; • Depletion of fishery resources; • Pressure on wildlife; • Greater spending on non-renewable energy.
Meso	• Imbalance in production flows and need for more investments in intermediate stocks; • Construction of silos and warehouses for intermediate stocks.	• Low labour productivity; • Profit reduction or loss; • Difficulties for companies to make their planning.	• management ofsupply chain; • Improvement in Corporate social Responsibility; • Costs of disposal and treatment of waste.
Micro	• Businesses and consumers spend a larger portion of theirbudget on foods that will not be sold or consumed.	• Lower wages; • Consumers with fewer resources for purchase; • Lack of products.	• amount of garbage and waste; • Contamination of individuals in rural and urban areas.

As stressed in Table 1, the losses and waste of 1/3 of the food produced annually bring negative effects in the economic sphere with enormous costs for the entire production system. Estimates show that this sunk cost reaches 750 billion dollars per year (FAO, 2013c). However this impact is differentiated according to the level of analysis adopted and the position of the agent in the production structure. Depending on their market power and their position and capacity of coordination of the production chain some agents may push the costs of inefficiency to other agents in a situation of inferiority. In non-competitive markets, most likely it is the consumer who pays for inefficiency and losses in the production process. Then in markets where there is greater competition, losses are assumed by subaltern agents that under contract must submit to the standards imposed by the "chain coordinator". This position of "chain coordinator" can be performed by a major supermarket company, a trader or even a processing industry. It's good to remember that, even where there is competition, consumers are paying a higher price for food due to inefficiency of the system as a whole. Moreover, considering the high degree of waste in the household, observed primarily in developed countries, the consumer is paying twice a higher price for food.

In developing countries, where food costs represent a significant portion of the domestic budget, the impact of losses in food production is devastating. There is an obvious relationship between the participation of expenditures on food in the household budget and the income of these families. This is clear when we compare countries or different social classes in the same country, outlining the famous Engel curve (Seale, Regmi, Bernstein, 2003; Hicks, 2013). In richer countries, spending on food does not exceed 15% of the income of households, with approximately half of theseexpenses occurring through food consumption outside the home. In these countries, economic losses with wasted foods do not affect the finances of families in a relevant way and neither families would feel responsible of the waste that occurs in restaurants and school cafeterias that make up their food spending away from home.

Complete opposite situations occur in low-income countries where the weight of food comes to represent more than 70% of the household expenditure, as is in Myanmar,53% in rural India or 54% in Azerbaijan.[6] As the waste is very small in these low-income households, positive impacts resulting from the reduction of losses would only be significant in those countries at production and distribution stages. However, as the structures of those markets are also poor and archaic, often dominated by intermediaries (middlemen), the price transmission mechanism does not work as in microeconomics textbooks and eventually gains from this reduction in losses would be concentrated in a few agents with no benefit to the entire population.

Another controversy seen in the economic field is about the effects of a reduction in losses that could be achieved in the initial stages of the production chain onthe other stages and in a system as a whole. Some studies point out that a greater supply of food due to the reduction of losses atproduction stage could simply raise the waste downstream in the food system. That is, without having changed the consumption pattern, the new consumers – attracted by a greater offer of products and a possible drop in prices, would have access to more food but also would produce more waste. At the same time the old consumers would continue on their path of waste if nothing is done to avoid it (Rutten, 2013; Godfray *et al.,* 2013). In other words, these authors argue that without a general change of mentality and given the incentives createdby falling prices little may be done to reduce food losses and waste[7]. This distortion can be better understood when we examine meso-level relations in the Food Supply Chain.

In the social sphere the impact of large amount of Food losses and waste leads to an enormous waste of public resources to productive programs for agriculture, capacity building, training and subsidies. In poor countries the competition for public resources and food aid is huge. In Africa for example, the low level of governmental investment in agricultural production prompted the adoption of the Comprehensive Africa Agriculture Development Programme (CAADP) within the framework of the 2003 Maputo Declaration in which the signatories commit themselves to "allocating at least 10 percent of national budgetary resources for their implementation within five years". However, an assessment released in 2009 by the New Partnership for Africa's Development (NEPAD), organism in charge of monitoring the implementation of the agreement showed that most countries that

[6] Data from ILO LABORSTA. The expenditures in Myanmar are from the year 2001, rural India and Azerbaijan from 2003.

[7] According to Rutten (2013) "The overall welfare impacts in the market of the foodcommodity in which waste is reduced and other marketscombined thus depends on consumer preferences".

reported their position had regressed in terms of resource allocation for agriculture. At that time 50% of the countries were investing less than 5% in agriculture and only 22% of the countries (8 countries among those who responded to the survey) had reached the goal.

More recently, on the occasion of the meeting held in Addis Ababa[8] it was found that there were certain progresswith ten of the 54 (18%) AU Member States having reached the target of allocating at least 10% of public investment toagriculture.[9] These difficulties show that the public investment in agriculture is a fundamental element for the progress of agriculture and the lack of resources is structural and in some cases the Government has no financial flexibility, spending basically on salaries and administrative payments (Kolavalli *et al.,* 2010).

The high volume of losses in agriculture in developing countries ends up reflecting also on labour productivity. Given that the revenue per employee is low, wages are also low without leading to sale prices more affordable to the population. This paradox prevents expansion of the consumer market which in turn could boost the producers for the acquisition of new technologies. From the social point of view, this vicious cycle reduces the availability of resources in the hands of producers and consumers, demanding an increasing effort for change.

Food losses and waste can be translated into direct environmental impacts. The footprint resulting from losses and waste can be represented by the emission of 3.3 billion tonnes of greenhouse gases released into the atmosphere, the use of 1.4 billion hectares of arable land and the useless consumption of 250 km^3 of blue water (FAO, 2013d). All the world effort for slowing the pace of climate change is based on international commitments regarding the reduction in the emission of gases and desintensification of the use of natural resources. The reduction of losses and waste could be a shortcut to achieve these goals. Indirectly, the unnecessary expense of natural resources also causes externalities as the need to correct the water pollution caused by the intensive use of nitrogenous fertilizers in agriculture and the requirement to build more landfills in large cities.

At the level of the supply chain, the impacts of the intensive use of natural resources should be computed from the beginning of production to the sale of the final product in orderthat the Corporate Social Responsibility (CSR) be shared by all stakeholders. In developed countries, corporate annual reports have a section with the environmental and social impacts of their activities to the stakeholders and many stock markets around the world negotiate papers from companies certified as "green". In these cases, which are increasingly comprehensive and frequent, the intrinsic value of the company is linked to its ability to be sustainable. It appears then that the power of business organization positioned as "chain coordinator", which have the role of coordinating the productive effort in a particular industry is not negligible and, extrapolating national boundaries, may play a key role in reducing losses and waste.

1.3.3 Impacts on food security

The impact of food losses on local availability of food and thus on food security is an old topic.

What is new is the importance given to global food losses and waste as a food security issue. It has been raised first from an environmental point of view, as part of growing concerns on the capacity of the global food system to be able to satisfy a growing demand (see infra). It is also increasingly mentioned as a sign of an unsustainable and inefficient food system to have enough food being produced globally with at the same time one third of it lost or wasted and hundreds of millions of persons being hungry. And to a great extent it shows that food is not distributed according to needs but to wealth. If we agree that the very aim of sustainable food systems is to ensure food security then it is the sign that the system is not sustainable. Goal should be that systems should be self-sustainable.

Impacts on availability

Analyzing the impacts arising from losses and waste according to the four dimensions of food safety and nutrition we can mention:

[8] Renewed Partnership for a Unified Approach to end Hunger in Africa by 2025 within the CAADP Framework in July 2013

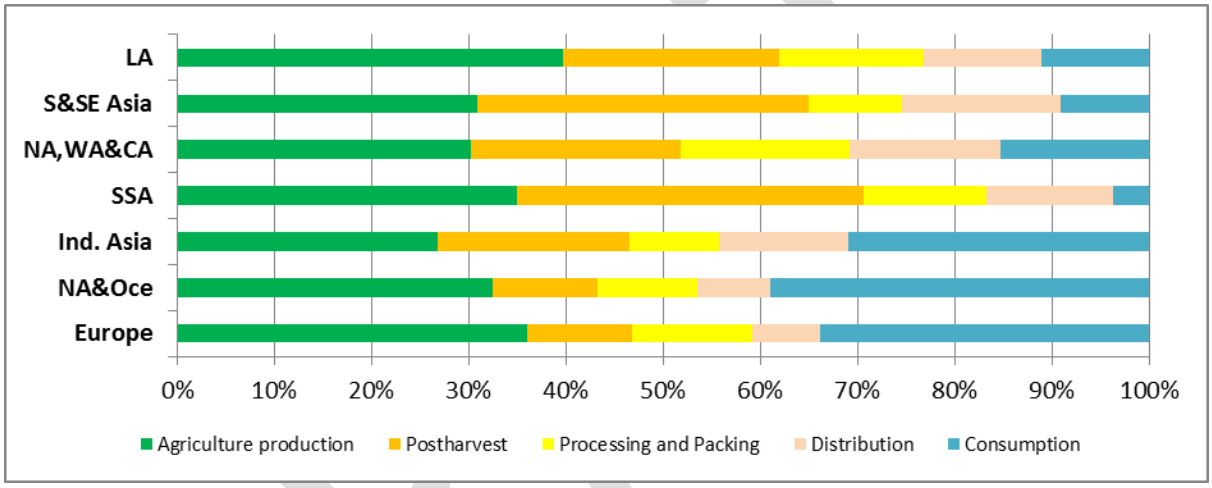
[9] See http://www.fao.org/news/story/en/item/179303/icode/

The impact of FLW on **availability** is the most mentioned when analyzing the problem because from the calculation of 1.3 billion tonnes of food lost annually it would be possible to feed the 842 million people (12% of world population) that were estimated to be suffering from chronic hunger in 2011-13 (FAO, 2013e).

Losses and waste are not evenly distributed around the world. Producer countries and net food exporters have a proportionately higher losses volume and high-income countries, which consume more food, have a high proportion of food wasted.

FAO (2011) shows that losses and waste in rich countries like in Europe and North America are in the range of 280–300 kg/capita/year with waste representing something around 35% of food produced. In Sub Saharan Africa and South/Southeast Asia the food losses and waste are 120–170kg/year and the waste itself represents only 5% of food produced. The figure below shows the distribution of the FLW along the Food Chain for the various regions of the world, noting that the treatment to be given to the reduction of losses and waste must be differentiated by regions.

Figure 5 Food losses and waste in the food supply chain



Source: elaborated from Gustavson et al. 2011

It is worth mentioning also that the reduction of losses of major producingcountries like Brazil, Russia, Australia and others will not be reflected directly in increased supply in countries with large numbers of malnourished. Similarly, a rationalization in food consumption in rich countries as the United States would not be transformed in a higher availability in poor countries. To reduce losses and waste is a challenge in global terms, but to increase the food supply in deficit countries requiresa regional treatment.

Kummu *et al.,* (2012) estimate that the average human consumption of 3,326 kcal/cap/day is divided into 87% for plant products and 17% for animal products. Considering that the Dietary energy requirement (DER)[10] for an adult with vigorously active lifestyle is at least 2,250 kcal/day (FAO, 2001) or even considering worldwide averages projected by FAO for the year 2015, of the order of 2940 kcal/Day (FAO, 2003b) there would be a big difference between supply and demand, generating a caloric availability not seized. The loss and waste estimated by Kummu *et al.,* (2013) only for vegetable products is 614 kcal/cap/Day, this loss corresponds to 24% in terms of energy from what is produced for human consumption and 16% of all that is produced in these cultures, since more than ¼ from that crop production is directed to feed. It's worth mentioning that according to FAO calculations from the Food balance Sheets, 43% of the kilocalories intended for animal feed return tor human consumption.

Overall this greater availability can be checked when comparing the maps of Average dietary energy supply adequacy released by FAO(2013e).In all regions the average dietary adequacy is positive and has been rising compared to the base year of 1990-92. Even in "Low-income food-

[10] The amount of dietary energy required by an individual to maintain body functions, health and normal activities.

deficit countries" the adequacy calculated rate to 2013 is at 110%, which shows that the availability is increasing over the last two decades.

Impacts on access

A very controversial issue is to what extent food waste in rich countries have an incidence on poor consumers or to what extent reducing food waste would improve food security. The answer to such a question, rather than by considering material transfers (or rather often reduction of material transfers) could be analysed through effect on prices and income (accessibility). What are the socio-economic impacts/consequences of FLW? What are the relations between the price of food and the amount of food lost and wasted? Can policies to reduce food losses and waste, everything else being equal, lead to a reduction of the overall effective demand, and thus to less pressure on the price system? With what consequences for producers and consumers? What consequence on non-food agro-resources and their price?

Analyses of economic impact of food losses and waste should consider the different actors along the food chain. It would also allow to better understand who would gain or loose to reduce them, which is key to design appropriate policies and incentives. At global level some analysis have highlighted the fact that losses and waste contribute to higher demand and thus to higher prices (HLPE, 2011). Theeffect of prices is itself very much dependent on being net seller or net buyer (see analysis in HLPE 2013 on biofuels and food security).

Two major barriers can limit access to food: physical and economic.

We consider as physical barriers the wars and conflicts that prevent certain populations to have access to food, even if it is deteriorating and it is being thrown awayby producers or by merchants.In some parts of the world, local chiefs or ethnicities still impose theirpower by preventing that the rival groups could feed themselves. This leads to increasing difficulties for humanitarian agencies or United Nations agencies such as Unicef, UNHCR and World Food Program that distribute food to refugees.

Physical barriers can also be natural barriers, difficulty of transport or even natural disasters-preventing access to entire regions having surpluses (UN Millennium Project, 2005).There may also be cultural barriers that prevent certain groups(e.g.women) having access to food donations. In such cases, the fact that there is a surplus about to be discarded in another part of the world or even in their own region has no practical consequence. According to Brinkman and Hendrix (2011) in the last 20 years, all humanitarian crisis caused by lack of food occurred in countries self-sufficient in terms of food. Crises in these countries often promote a vicious circle in which the lack of food for certain groups amplifies conflicts preventing a solution.

Economic barriers are raised by exogenous events, such as high international prices but also by problems arising from economic policy. Common occurrence that preceded the recent riots that occurred from 2010 in several Arab countries, which became known as the "Arab spring" was the rise in food prices. Brinkman & Hendrix (2011) point out to a correlation between high food prices and conflict inrecent decades. Lagi, Bertrand and Bar-Yam (2011) listed 29 conflicts that occurred in the North Africa and Middle East since 2004 and which originate from high food prices (Lagi, Bertrand and Bar-Yam, 2011).These conflicts known as "food riots" arosefrom the impossibility of the local political system to cope with rising prices.

There are several policies triggered by Governments to deal with the volatility and price spikes which occur since the mid-decade. In a recent publication, the HLPE presented a set of national policy options to deal with volatility (HLPE, 2011a). The programs developed from these policies aim to stabilize prices and reduce the impact of volatility on incomes and purchasing power. The HLPE (2011) features five classes of instruments that can act on reduction of short-term rates at the same time promoting the improvement of production and distribution structures, taking into account the specificities of each country. It is worth remembering, however, that the impact of each of the programmes for food security overall is differentiated. Raising barriers to exports food producing countries, action taken by various countries with the goal of keeping the local supply from the middle of the last decade, can prove to be a problem because, besides discouraging local growers, it reduces the international offer and puts more pressure on prices. Similarly, trade barriers to imports of food fromproducing countries can keep home prices high witch discourages competition and the introduction of innovations with the potential of cost reduction. Both the barriers to exports as barriers to imports – direct and indirect, in the form of subsidies to producers, are problematic from the point of view of food security. That means a reduction in losses in production, processing

and distribution of food in the exporting countries may not represent consumers direct access in countries affected by food shortage or high prices to a better diet.

Materne *et al.,* (2011) show that after the rise in agricultural prices in the middle of the last decade, an important group of countries imposed/ raised import barriers or even established quotas for the importation of some products. This is the case of the Philippines, Vietnam, Gambia, Rwanda, Kenya, Nigeria, Ghana, Mauritania, Argentina among others (Maetz *et al.,* 2011).Another important group of countries has placed barriers or imposed quotas on exports (see Figure 6).

Not infrequently, several countries practiced the two policies. On the other hand cash transfer and food assistance programs to consumers grew, as compensatory measures – which in many cases have become permanent, to most vulnerable populations, including in developed countries.

In a recent study the WTO examined the correlation between the high European unemployment rates and the imposition of trade barriers. A survey by Euro barometer 2012 shows that the higher the unemployment and economy's vulnerability to population would be willing to support the imposition of barriers to imports. In the case of food, the body points out that the biggest motivation in favour of raising barriers is foodsafety problems (WTO, 2013).

Figure 6 International food prices and export restrictions

Source: Giordani, Rocha and Ruta, 2012

Impacts on nutrition – food, health and nutrition security

A key issue, often underestimated, is the loss of nutritional quality. A recent report by the World Resources Institute (Lipinski *et al.,*2013) transformed FAO figures into calories. Such an analysisfails to take into account the contributions of fish, fruits and vegetables to overcoming hidden hunger caused by the deficiency of micronutrients like Vitamin A, Vitamin B12, iron, zinc. Iodine, etc.

Fruits and vegetables are sources of important micronutrients and bioactive components with a proven role in preventing lifestyle chronic diseases. Fruits and vegetables account for highest quantitative food losses. Avoiding and minimizing waste of fruits and vegetables would result in utilizing all the valuable constitutes present in them for prevention of micronutrient deficiencies and their disease preventing role.

One third of world population suffersfromiron deficiency anemia. One of the causes of iron deficiency anemia is low iron intake and poor bioavailability of iron form in the diets. Cereal grains, legumes, green leafy vegetables and animal foods are important sources of iron in the diet and

contribute various proportions depending upon the amount eaten. Fruits and vegetable are also rich in organic acids and vitamin C which promote iron absorption.

During refining of foods many healthful components are removed which otherwise would account for preventing diseases thus compromising the health security of population. The byproducts from these refinement systems are often wasted and need value addition. Making higher quantities of natural foods valuable to masses would ensure health security by providing foods with a higher density of nutrients and phytochemicals.

Nutrient density of foods decrease with spoilage [insect infestation of grains] or long duration storage [vitamins in fruits and vegetables]. For best use of available resources, foods need to be stored well, and for a shorter duration, wherever possible.

For instance, ascorbic acid begins to degrade immediately after harvest and degrades steadily during storage. Some experiments on fresh spinach showed a 100% loss in four days. (eg. Lee and Kader, 2000).Refrigeration can slow the process but it continues to degrade during prolonged storage of frozen products. On the other hand, ascorbic acid losses during storage of canned goods tend to be small.

Such considerations call for an extension of the mere notion of “Quantity” of loss towards integrating quality aspects in the measure and in the problem of reduction of food losses and waste.

And this is of particular importance as consumption of fruits and vegetables products is increasing particularly rapidly and especially as fresh. It has also to be considered with changing modes of buying food, less often. It calls also for considering food losses and waste, and their reduction, in a holistic way, all along food chains, and inside food systems, from production to consumption.

1.3.4 Environmental impacts (which can also have long term impacts on future food security)

Food losses and waste have two major environmental impacts, as waste of the resources used to produce the food lost and wasted and at disposal as a major source of negative impacts including emissions of methane, a potent greenhouse gas (GHG).

Waste of resources

Recent studies have attempted to quantify the amount of resources wasted when food is lost or wasted. Most of them use estimations of the average consumption or impact of production and apply it to the amount estimated to be lost. Such global analysis are useful to raise awareness on the issue but would need to be refined as the amount of resources used is different according to the way and place of production and also, especially, to the stage where the loss occur (especially for energy).

Most studies take a quite comprehensive approach and estimate so-called footprints that measure the various ways resources are used or needed or external impacts generated throughout the lifecycle in terms of a single unit of measure. Examples are the carbon footprint in terms of emissions, the ecological footprint in terms of land surface implied and the water footprint reflecting virtual water content (BCFN, 2012).

Scientific studies on environmental impact usually address categories such as climate change/Greenhouse Gas emissions/carbon footprint (Garnett, 2011), water footprint (Ridoutt, 2010; Chapagain, 2013; Vanham, 2013), nitrogen (Grizetti, 2013) and land use (Wirsenius, 2010). More commonly are Life Cycle Analysis studies, comparing or analyzing different treatment systems of food waste (end-of-life technology), including composting, digestion and landfill of household and/or industrial food/organic waste (including Lundie, 2005; Lee, 2007; Roy 2009; Kim, 2010; Garnett, 2011; Mena, 2011; Bernstadt, 2012; Kummu, 2012; Herrero, 2013; Rigamonti, 2013; Vanham, 2013).

In order to estimate the environmental impact of a wasted food, it is necessary to consider its entire “life cycle” (or in other words, work through all the stages of the food supply chain), calculating the indicators commonly used, such as the carbon footprint (CO_2 equivalent), the ecological footprint (m^2 equivalent), and the water footprint (m^3 of virtual water) (Barilla, 2012).

However, these general data might hide important particularities that differentiate production systems. For example, a cow of 600 kg weightproducing 35 liters of milk per dayin Europe

consumes 26.8 liters ofwater per day (at a temperature of 35 degrees Celsius). Another cow of 200 kg weightproducing only 2 litres of milk per day in Africa, consumes 28.7 litres of water per day in the same temperature (FAO, 2006). In other words the water foot print of a liter of milk produced in Africa is higher, making even more important to reduce losses.

The most recent global study on the environmental impact of food losses andwaste has been published by the FAO (2013). It estimates losses and waste to be 1.6 Gtonnes of "primary product equivalents", with edible part of food at 1.3 Gtonnes. This amount can be weighed against total agricultural production (for food and non-food uses), which is about 6 Gtonnes.

Energy / GHG / Climate change

Without accounting for GHG emissions from land use change, the carbon footprint of food produced and not eaten is estimated to 3.3 Gtonnes of CO_2 equivalent: as such, food waste ranks as the third top emitter after USA and China (FAO, 2013); And, if roughly one third of food produced for human consumption that is lost or wasted globally every year (FAO, 2011) is estimated to be equivalent to 6 to 10 per cent of human-generated greenhouse gas emissions (Vermeulen *et al.,* 2012). Consumer waste is more water and energy intensive than postharvest waste due to energy used in transport, packaging, processing, distribution, and preparation at home. On average consumer waste consumes 8 times more energy than postharvest waste (Dobbs*et al.,* 2011).

Water Footprint

Lundqvist, de Fraiture and Molden (2008) states that food waste is also water waste, as large quantities of water are used to produce the lost food. From the environmental perspective food waste accounts for more than one quarter of the total consumptive use of finite and vulnerable fresh water and more than 300 million barrels of oil per year. Estimates for the US, for example, suggest that food waste corresponds to 40 trillion litres of irrigation water, enough water to meet the household needs of 500 million. Globally, the blue water footprint (i.e. the consumption of surface and groundwater resources) of food wastage is about 250 km3, which is equivalent to the annual water discharge of the Volga river, or three times the volume of lake Geneva (FAO, 2013); Kessova (2013) compares this volume to half of that of Lake Victoria. In arid and semi arid countries, water is already a limiting factor in agricultural production. About1.2 billion people, one-fifth of the world's population, live in basins where water is running out.

Land Use

Land use is increasingly drawing more attention in scientific and public studies. The Institute of Mechanical Engineers (2013) recalls that global food production currently utilizes approximately 4.9Gha of the 14.8Gha of land surface area on the planet, though only about 10Gha of the latter is capable of supporting productive biomass (i.e. not desert, tundra, mountains etc.) for agriculture. Thus some 50% of the available suitable land is already appropriated. Given current trends in both dietary preferences and production efficiency, it is conceivable that something closer to a high meat consumption/high production efficiency outcome may emerge and in that case the land-use figure for food production would, following a 2025 peak of 5.26Gha, fall back to around present levels at 4.82Gha in 2050. In the context of a productive land resource of about 10Gha, such an outcome might appear reasonable. However, adding the land-use demands that will emerge from current aspirations around the world to increase biomass production for energy sourcing, potentially up to 30% of global primary energy by 2030 compared with about 10% today (Barilla, 2012), competing needs for food and energy are likely to define the key land-use tensions in the coming decades. In an elaborated study on global resource productivity practices by the McKinsey Global Institute (MGI), reducing food waste was ranked in the top-3 of measures that will contribute to improved productivity of resources. MGI calculated, amongst other aspects, that by reducing food waste at the point of consumption in developed countries by 30%, this would save roughly 40 million hectares of cropland. According to FAO (2013) produced but uneaten food vainly occupies almost 1.4 billion hectares of land; this represents close to 30 per cent of the world's agricultural land area.

Biodiversity

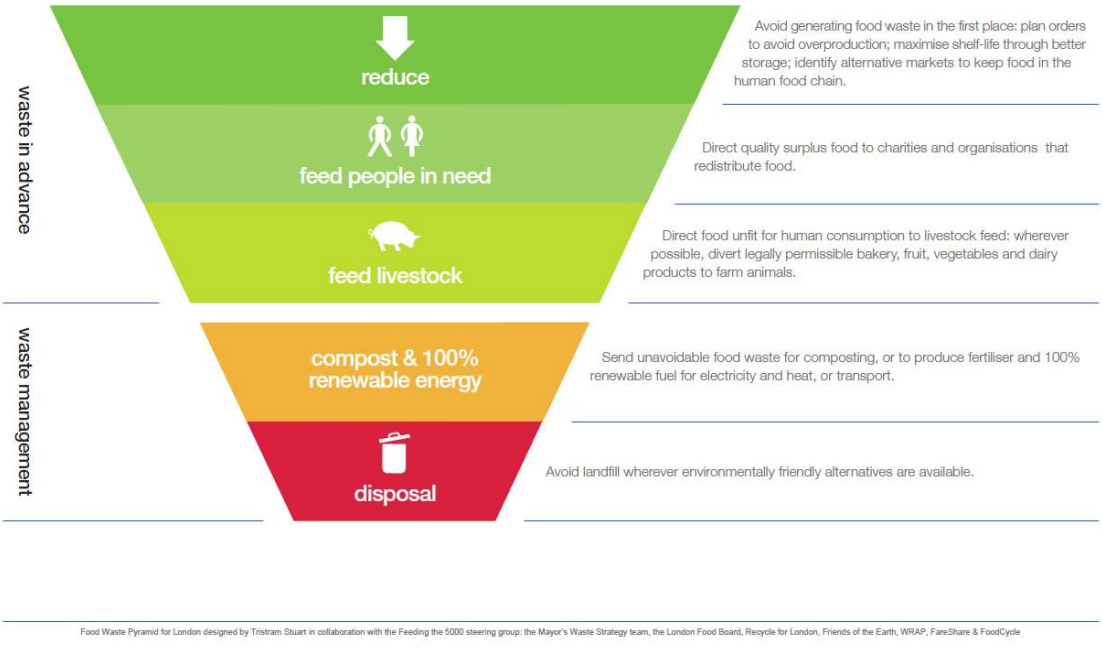
While it is difficult to estimate impacts on biodiversity at a global level, food losses and wasteunduly compound is the negative externalities that mono-cropping and agriculture expansion into wild areas create on biodiversity loss, including mammals, birds, fish and amphibians (FAO, 2013).

Waste management

Food related waste (including edible and non-edible parts) represents an important proportion of waste. In rural areas it can be used easily as feed or organic fertilizer, either directly or through compost. In urban areas it is often not valorized and constitutes an important part of waste which is a growing concern. Organic waste is also an important source of methane when sent to landfill. Sorting, composting and methane valorization could reduce this part of environmental impact.

A hierarchy for food waste prevention has been developed by the US Environmental Protection Agency. Other examples are the Netherlands Ladder of Moerman, Food Waste Pyramid for London (figure x), OVAM (Public Waste Agency of Flanders)'s food waste hierarchy, Food Drink Europe's food waste hierarchy (Food Drink Europe, 2013).It prioritizes reduction at source and presents a list of preference for use, re-use, recycling and waste treatment. The US EPA and London hierarchy do not differentiate between waste treatment options; anaerobic digestion is likely to be environmentally preferable to composting, incineration and land filling (BIOIS, 2010).

Figure 7 The inverted food waste pyramid



Source: http://www.feeding5k.org

The Food Waste Pyramid shows the steps that businesses can take to tackle food waste, in order of priority.

2 CAUSES AND DRIVERS OF FOOD LOSSES / FOOD WASTE

Losses along the food supply chain result from interrelated actions right from harvest. Some of the losses can be traced to actions (or non-actions) at the production stage. Looking at the food supply chain as a system of interrelated steps is key to identification of the critical control points in clearly identifying the causes of FLW and interventions to reduce them. Just as in a conveyor belt, actions at one stage in the chain can affect the whole chain. Therefore emphasizing or optimizing an individual step does not necessarily translate into efficiency of the whole system nor better final quality.

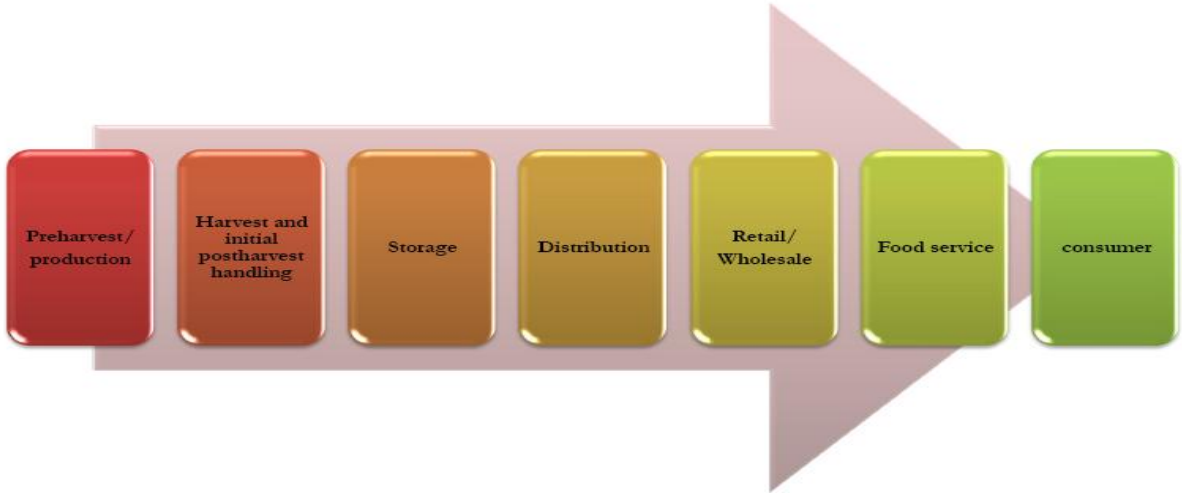
In this chapter the causes and drivers of FLW will be addressed from a supply chain perspective in each case highlighting actions and factors that have a significant contribution to the overall FLW. Particular attention is given to pre harvest factors and postharvest handling practices that contribute to postharvest quality, consumer acceptability and overall FLW.

The causes and drivers of food losses can be either direct or indirect but are interrelated. Direct causes of food losses could be biological, microbial, chemical, biochemical, mechanical, physical, physiological or psychological. These causes render the produce unacceptable for consumption or processing hence discarded. The direct causes result from or are aggravated by indirect factors, which could be regarded as systemic – arising from dysfunctional systems.

2.1 Direct causes of food losses at various stages of the supply chain

The direct causes vary in extent and impact for the different stages of the supply chain from production, harvest, postharvest, storage, transformation, distribution, retail and consumption.

Figure 8 Supply chain



2.1.1 Preharvest/production stage

Although the focus of the report is on the losses happening after harvest, it is noteworthy that conditions and actions in the field before harvest greatly influence quality and shelf life after harvest. The genetic potential of a crop variety, growing conditions, and cultural practices all have a significant effect on quality at harvest, transport (shipping) and storage stability (Florkowski *et al.,* 2009).

The preharvest factors affecting quality of the produce can be divided into four groups; choice of crop variety, cultural practices, biological factors and environmental factors. Obviously, losses due to these factors vary depending on different types of cultivation, the seasons, and different production areas. Significant differences exist at this stage between developed and developing

countries. Differences in production/agronomic practices result in completely different quality, representing the first step of cause of loss.

Most studies on pre harvest loss factors have focused on crop losses due to biological/biotic factors (weeds, insect pests and diseases). According to Oerke (2006), the losses attributed to pests are estimated to be 26 – 29% in soybean, wheat and cotton, 31% in maize, 37% in rice and 40% in potatoes. There are other pre harvest factors driving postharvest food losses (qualitative and quantitative) including; poor choice of crop varieties for the location and for the target market; poor agronomic and cultural practices including fertilization/nutrient management, water management, pest/disease management, pruning, staking, bagging. These factors either lead to reduced crop performance resulting in lost yield potential or failure to attain desirable quality attributes leading to high percentage of rejects/culls.

Choice of the right variety that is suitable or well adapted for a given location (production site) and one that meets the requirements of the target market in terms of quality specifications and time to maturity is an important consideration at the production stage (Kader, 2002). Wrong choices made at this stage result in produce of inferior quality leading to high losses from culls. On the other hand, if the crop matures when the demand is low due to glut or alternatives, some producers opt to leave the crop in the field as the returns do not justify the cost of harvesting and transport. In other cereals such as maize, wheat and sorghum, choice of varieties that are prone to lodging for regions where winds are prevalent is a contributor to high losses. An equally important cause of food losses in cereals is planting poorly adapted varieties for a given location e.g. those that may mature during the rainy season predisposing them to fungal infection.

In fruits and vegetables poor agronomic practices during the production phase greatly contribute to the product quality (visual and nutritional). Preharvest pest infestation is known to be a major contributor to postharvest losses in fruits because some of the latent infestations only manifest themselvesin postharvest continuum (Thomson, 2003). On the other hand, poor water and nutrient management contributes to poor produce quality resulting in a high percentage of culls during grading. Some of the low quality produce is left unharvested because of failure to meet certain quality standards dictated by the consumers or target markets. Unfavorable environmental conditions such as heavy precipitation result in high disease incidents, brittle vegetables, fruits with low brix among other defects. On the other hand, high temperatures have been reported to cause physiological disorders such as solar yellowing in sweet paper and cauliflower (Postharvest Hub, 2008), sunscald in apples (USDA, 2011) and mango. In grain crops, temperature extremes are reported to predispose aflatoxin contamination rendering food unsafe and therefore discarded.

Producers sometimes overproduce to hedge against uncertainties of weather, pest attacks and to ensure adherence to contractual obligations with the buyers. Often the excess produce is left un-harvested or is sold to processors or feed industries which pay relatively lower prices (FAO, 2011).

2.1.2 Harvesting and initial handling stage

Poor harvest scheduling/timing and rough (careless) handling of the produce are key contributors to food losses. In grain crops such as maize, sorghum and groundnuts, over maturity and delayed harvesting are major factors reported to contribute to aflatoxin contamination (El-din and Farag, 2008, Lewis *et al.,* 2005). In some developing countries, farmers habitually leave the cereals such as maize in the field upon maturity to dry because they lack facilities for drying. However, when harvest season coincides with the second rains as isthe case in some countries, there is increased rotting and aflatoxin contamination, a major cause of food losses in cereals (Alakonya *et al.,* 2008). On the other hand, in highly perishable fruits and vegetables, maturity at harvest is a major determinant of quality and shelf life of the produce. Some farmers are driven to harvest their crops prematurely due to poverty or urgent need for food and cash. Some farmers harvest crops such as banana prematurely because of fear of theft. Immature fruits are more prone to mechanical damage and shriveling and have inferior eating qualities when ripened. Conversely, over mature fruits have a short shelf life and are often mealy with insipid flavor (Sivakumar, 2011). In both cases (immature and over mature) the fruits are highly susceptible to physiological disorders.Premature harvesting leads to reduced nutritional and economic value (FAO, 2012c).Sometimes the commodity may be totally wasted as it may not be suitable for consumption (FAO, 2013).

Harvesting techniques can also contribute to the losses. Unlike in developed countries where harvesting is mechanized with minimal handling, in developing countries harvesting is mostly

manual with repeated handling. Multiple handling increases damage especially in highly perishable commodities such as fruits and vegetables (FAO, 2013).In fruits, vegetables, root and tuber cropsmechanical damage during harvesting is a major factor contributing to losses. The injured spots not only serve as entry points for pathogens but also aggravate water loss from the produce. Respiration and wound ethylene production significantly increases in the injured tissues further aggravating the losses.In most cases the farmers lack proper containers to pack the harvested produce for the market or storage.

Initial cooling of perishable foods such as fruits, vegetables, milk, meat, mushrooms destined for distant markets (domestic or export) is critical for maintenance of quality. Therefore storage in cold rooms or under shade immediately after harvest makes a significant difference in shelf life of the produce. Most growers in developing countries lack on-farm cold storage facilities or shades. As a result the perishable produce is left in the open or kept under ambient room conditions. Temperature management is key tomaintenance of perishable produce quality as it is central to other deteriorative processes such as microbial growth, softening, water loss leading to shriveling. Failure to maintain low temperature of produce immediately after harvest is a major contributor to spoilage and losses at the subsequent stages of the value chain. Time of day when the produce is harvested has implications on the product temperature and efforts needed to lower it. Some producers harvest their produce during hot hours of the day. Such produce is not only difficult to cool during storage but is more prone to faster deterioration (Kader, 2002). For some root, bulbs and tuber crops such as potato, sweet potato and onions, curing isknown to extend the shelf life. However, most growers rush to market their produce immediately after maturity or harvest. Delays in marketing uncured crops result in high losses due to water loss and decay (Kader, 2002).

Some of the crops grown in the fields are actually never harvested, significantly contributing to the FLW.In the United States alone, it is estimated that on average, 7% of planted fields are not harvested each year. A significant amount of food that is harvested is left in the fields for failing to meet high appearance quality standards (shape, size, weight) of the target market (Stuart, 2009). Often the rejects/culls end up in processing/feed industries, hence not totally lost. However the high appearance standards may divert food that is perfect for human consumption into other less profitable uses (Stuart, 2009). Sometimes failure to harvest is for economic reasons; low market price at the time of harvest, high labor cost. Conversely, some growers plant more acreage to hedge against uncertainties of weather and pests or to speculate on high prices. Often the extra produce contributes to over supply leading to low prices, which in turns results in more of the produce left in the fields as the returns do not justify the cost of harvesting and transport. Although this losses could be considering food that haven't met the consumer needs, they are not completely useless considering thefarmers uses for biofertilization or feeding animals.

2.1.3 Storage Stage

Within the postharvest handling system, food items can be stored from a few hours to several months depending on the commodity and storage conditions. Storage serves as means of delaying marketing and subsequent consumption of the produce. This can only be realized if the storage conditions are optimized, otherwise significant food losses characterize this stage of the supply chain. It should be noted however, that even with the best storage conditions, the shelf life is dependent on the initial quality and storage stability resulting from decisions made at the earlier stages of the supply chain.

In developed countries storage facilities are well established right from the production stage and throughout the supply chain. Cold storage coupled with advancedcomplementary postharvest technologies (such as controlled atmosphere, 1-MCP) enables the supply chain actors to significantly extend the shelf-life and marketing period for perishable foods including fruits, vegetables, meat, fish and seafood and dairy products. In this case, losses during storage could arise from breakdown of the refrigeration systems, temperature abuse resulting in freezing or chilling injury. Overall, poor management of conditions (temperature, gas composition, relative humidity) may lead to deterioration or contamination of stored products, just as over storage periods, due to lack of transportation and other infrastructure requirements.

On the contrary, in developing countries, lack of proper storage facilities is a major cause of postharvest losses (FAO, 2011a). Cold storage facilities are non-existent or inaccessible to the majority of small holder farmers in Sub-Saharan Africa. Highly perishable commodities such as fruits, vegetables, meat, fish and diary products require adequate storage facilities with well-

maintained conditions (mainly temperature, relative humidity and gas composition). Such perishables commodities spoil within hours of 'harvesting' (includes fishing, milking, slaughtering) due to lack of or poor infrastructure for initial storage, transportation, cooling and market (Rolle, 2006; Stuart, 2009).

Due to lack of storage facilities, growers/producers sell their produce at low prices or leave the produce un-harvested. Delayed collection of harvested perishables results in total loss due to lack of storage facilities. Some growers who may have contracts with wholesale or retail stores often lose the produce when the transporters delay to collect the harvested produce. At the wholesale/retail markets, cold storage facilities are rare and where they exist, produce with different temperature requirements are often mixed in the same store, resulting in temperature abuse. Other factors that contribute to losses during storage include poor ventilation resulting in ethylene accumulation which aggravates deterioration of perishable fruits and vegetables. Poor sanitation in storage areas results in contamination of stored products which become unsafe for human consumption. Losses during storage also arise from consumption by rodents, birds, monkeys and other large animals. Additionally, excreta, hair, feathers, frass, webbing of the animals, birds and insects contaminate the food rendering it unfit for human consumption.

Suboptimal storage conditions often favor chemical and biochemical reactions that result in undesirable changes in color, flavor, texture and nutritional value. Poor storage conditions also favor microbial growth and rotting of stored products which are eventually discarded. In root and tuber crops poor storage conditions result in greening and sprouting both of which lower the quality and nutritional value of the crop (Stuart, 2011).

There are several chemicals or treatments which are used before or during storage to enhance the shelf life of fruits and vegetables. Some of these treatments (e.g. sodium hypochlorite, acetic acid, irradiation, hot air/water immersion) are used to sanitize the produce and therefore reduce microbial damage, while others (e.g. 1-MCP) inhibit the effects of agents of deterioration such as ethylene.However, injudicious use of these treatments result in damage to the products or residues that render the products unsafe. In some cases, unregulated chemicals have been used to enhance the shelf life of perishables, thereby posing a health hazard. In many open air markets in developing countries, the traders sprinkle unclean water onto perishable commodities such as vegetables and fruits to minimize wilting and shriveling under the hot sun. Such practices which are aimed at slowing down deterioration result in unsafe foods which are shunned by buyers and may end up being discarded. For other perishables such as milk, there are acceptable chemical methods such as the lacto peroxidase system (LP-system) for milk preservation, especially in rural areas where refrigeration facilities are non-existent (Dambi *et al.,* 2008). However, unscrupulous traders often resort to use of other chemicals such as hydrogen peroxide and formalin which may extend the shelf life of the milk but are harmful to users. Often such milk is impounded by public health officers resulting in high wastage.

Shelf stable foods such as grains can be stored for long periods if the storage conditions are optimized. However some of the storage structures used in the developing countries are rudimentary or poorly designed/constructed. Most farmers in SSA still use traditional grain stores made of grass, wood and mud. These structures cannot guarantee protection against major storage pests such as rodents, insects, birds and fungal infection (Yusuf and He, 2011;Kankolongo *et al.,* 2009). In some cases, there are no storage facilities and farmers simply store the grains inside the houses they live in (Bett and Nguyo, 2007).

Proper drying of the grains to a low moisture content (<13%) is critical for proper storage. However due to factors such as poor weather and lack of knowledge by the farmers, the grains are improperly dried. Such grains are predisposed to pest damage and fungal growth (IFPRI, 2010). For example in maize, losses attributed to postharvest pests are estimated to be 30%. The major pests in this case are common weevil (*Sitophilus zeamis*) and the larger grain borer (*Prostephanus truncatus*) reported to cause 10 – 20% and 30 – 90% losses respectively (Bett and Nguyo, 2007). The damage caused by these pests results in low nutritional value, percentage germination (for seed grains), reduced weight and low market value (Yusuf and He, 2011).Due to lack of good storage facilities, many farmers are forced to sell their produce immediately after harvest when the prices are low. This is a disincentive as the farmers are not encouraged to produce more in subsequent seasons, contributing to a vicious cycle of poverty.

There are a number of postharvest technologies developed to protect stored grains from pests and other loss agents including actellic super, super grain bags and metal silos (Kimenju *et al.,* 2010).

Although these technologies have been shown to effectively reduce pest damage during storage many small-holder farmers have not adopted them due to cost and lack of information on how to use them.

2.1.4 Processing (transformation) stage

Food losses at this stage are mainly due to technical malfunctions and inefficiencies of the systems which lead to loss, damage (including contamination) to the food. Errors during processing often lead to defects in the end product such as wrong size, weight, shape, appearance or damaged package. Although these defects have no bearing on the safety or quality of the product, it is discarded as it does not adhere to set standards. Forhighly perishable foods such as milk, fish, meat, seafood, contamination during processing is a major cause of losses. The contamination may be from the processing unit not properly cleaned and sanitized from previous operations or even from part of the produce which contaminates the whole unit. The contaminated products are discarded leading to losses. Another source of loss especially in horticultural commodities is excessive trimming to attain a certain shape or size. Such trimmings, although perfectly fit and safe for human consumption, are usually discarded.

In most developing countries, there is a general lack or inadequacy of processing facilities. The processing industries often lack capacity to process the volumes delivered. The situation is aggravated by seasonality of some of the processed products. A good example is mango which is seasonal for most tropical countries. In Kenya, the processors are overwhelmed during the peak season (December to March) when there is oversupply of mango fruits. As a result high volumes of mangos delivered to the processors go to waste due to the limited capacity of the processing plants. Consequently the farmers or traders who deliver the fruits to these factories incur high losses from transporting the fruits to the factories only for the fruits to be discarded or bought at very low prices.

Forother perishable commodities such as milk, the situation is similar as milk production is ‘seasonal’ with high volumes during the wet season when there is abundance of livestock forage crops. During the high season when there is oversupply of milk, much of it is wasted because the processors can only handle limited volumes.

In recent years, there has been a dramatic growth in fresh cut produce stimulated by consumer demand for fresh, healthy, convenient foods which are safe and nutritious (FAO, 2010). The fresh-cut products are prone to discoloration, rotting and dehydration due to damaged and exposed tissues and lack of protective skin. Deterioration of the fresh-cut produce is aggravated by poor packaging and temperature management.In developing countries the fresh-cut industry has grown exponentially without concurrent development in packaging and cold chain to ensure fresh quality maintenance. This has contributed to significantly high losses as the poor packaged and handled produce deteriorate fast. Even in the developed countries, where the proper packaging and cold chain maintenance are ensured, the losses in fresh-cut products are significantly high.

In some developing countries, there has been a massive campaign to promote fruit and vegetable processing into dried/dehydrated products, juices, concentrates, jams, purees as a measure to reduce postharvest losses especially during the high season or bumper harvest. However some of the processors do so without proper process management and set standards to ensure food safety and quality. As a result, some of the processed products are unsafe and nutritionally poor. Forsome fruits and vegetables, blanching is done prior to drying or freezing to arrest enzymatic activity. Failure to blanch often results in off-flavors and discoloration of the processed products which may be discarded. However failure to optimize the blanching conditions (such as duration and temperature) often results in products of inferior aesthetic and nutritional quality, which may be rejected by the consumers.

2.1.5 Distribution stage

Horticultural crops, fish, meat and dairy products are highly perishable due to high nutrient and water content (FAO, 2013). In developed countries, transportation of the perishable foods in refrigerated tracks is standard practice. Loading and offloading from the trucks is mechanized and well-coordinated to reduce losses from inefficiencies.In this case, losses occur when the cooling

systems malfunction during transport, the trucks breakdown or are involved in accidents. Sometimes losses occur when there are delays in loading docks where no cooling is provided. Imported products are also subjected to testing at the point of exit or entry to adhere to phyto sanitary regulations. This testing process often delays shipment and considerably reduces the shelf life of the perishable products. In some cases, perishable shipments are rejected on account of failing to meet phyto sanitary requirements or other market standards set by the target markets. In such instances, the whole shipment is dumped/destroyed if an alternative buyer cannot be found in time.

Conversely, in developing countries, lack of proper transportation vehicles, poor roads, poor/inefficient logistical management hinder proper conservation of perishable commodities during transport (Rolle, 2006).It is not uncommon to find highly perishable produce being transported in open, unrefrigerated trucks. Additionally, loading and off-loading of fruits and vegetables from the tracks is done manually by casual laborers who handle the products roughly causing extensive mechanical injury. Usually the fragile products are stuffed into the truck to accommodate more volumes without paying much attention to mechanical damage caused to the products or pre disposure to deteriorative processes (Kader, 2002). In most cases these products are poorly packed/packaged for transport. Some transporters use sacks, polythene bags or simply load the 'naked' products directly onto the trucks leading to compression damage during transport.The poor state of roads especially in rural areas where most of the production occurs further aggravates the losses during transportation. The status of the roads worsens during the rainy season and it is common to see trucks ferrying perishable products breaking down of getting stuck in the mud for days. In such instances the perishable products get spoiled and never get to the destination. In developing countries, it is estimated that postharvest losses of fruits and vegetables can range from 35 – 50% annually due to poor infrastructure (IME, 2013).

In Latin America, South and Southeast Asia approximately 25% of fish and seafood products are lost due to logistics related problems, because high levels of deterioration occur during distribution of fresh fish and seafood. Similarly, the logistics related loss in dairy products is significant (more than 10%) in developing countries. Inability to market milk products during the rainy season, lack of proper transportation and cold chain during hot season, erratic power supply to milk processors and coolers are some of the causes of losses in dairy products.

The logistics related risks also occur in the transportation of food producing animals. Transport of livestock is known to be stressful and injurious, which leads to production loss and poor animal welfare. For example, in the USA about 80,000 pigs die per year during transport (Greger, 2007). A case study in Ghana indicated that more than 16% of expected income is lost due to occurrence of death and sickness or injuries of cattle during transport from farm to cattle market and abattoir (Frimpong *et al.,* 2012). A similar case study in central Ethiopia (Bulitta *et al.,* 2012) indicated that during cattle transport from farm to central market over 45% of animals were affected (either stolen, died or injured).

A larger problem that occurs at the distribution stage is that of rejected shipments. Rejected perishable shipments can be dumped if another buyer cannot be found in time. If these perishables do make it to a store, they have a shorter shelf life by the time they get there. Sometimes they are brought to food banks if the food banks have the capacity to take them. Even food banks sometimes reject these loads because they cannot use them in the quantities being shipped, for instance a truckload of beets. Distribution centers can also find themselves with surplus product when individual stores don't require what they had forecasted.

2.2 Causes of nutritional losses

In addition to quantitative losses, food products can also face a deterioration of quality, leading to a loss of economic and nutritional value. In the assessment of losses, the focus is often limited to quantitative and less on qualitative losses.

The World Resources Institute has estimated that 1.5 Quadrillion kcal energy is being lost every year due to food losses and waste. Cereals comprise the largest share of global food loss and waste by caloric content—53 percent, Fish and seafood is a relatively small share—1percent. Whereas cereals comprise the most food loss and waste relative to other food commodities on a caloric basis, fruits and vegetables are the largest source of loss and waste on a weight basis . This variance primarily results from differences in water content; much of the lost and wasted weight in

fruits and vegetables is water. Nonetheless, reducing the loss and waste of fruits and vegetables is clearly important since these foods provide people with many essential vitamins and minerals such as vitamin A, vitamin C, and potassium needed for leading healthy lives. In terms of percentage of kcal lost or wasted for each food commodity, Roots and tubers experience the greatest amount of loss and waste—63 percent on a caloric basis. Forty-two percent is the rate for fruits and vegetables, and about a quarter of cereals and seafood produced are lost or wasted on a caloric basis.

Basically the nutritional losses are directly related to the food losses.

Inadequate care of food after harvest, improper handling and storage conditions and faulty processing techniques can accelerate the nutrient losses. Nutrient density of fresh foods, (soon after harvest) is highest, especially in fruits and vegetables and continually declines during storage. Adequate storage and handling can reducethe rate of destruction thus protecting the nutrient and making more amount of nutrient available for physiological use.

While conversion of food to processed forms may be essential or desirable from the convenience point of view, processing / refining, such as polishing of rice and removal of bran in wheat, removes many essential nutrients from the food amounting to significant losses of nutrients. Processing techniques also fractionate food into different components, for example, extraction of juice from fruits resulting in loss of nutrient and bioactive components in non-utilized leftover residue. These are either discarded as waste or are channeled into non-food use. In dried fruit and vegetables, significant amount of nutrients especially vitamins are lost during drying and other pre-drying processes such as blanching. As a result, even though the food is preserved for later use, itsnutritive value is lower.

Cultural practices or taboos or availability of alternate produce may either result in use of precious food commodities for ritualistic non-food uses or underutilization of locally produced indigenous foods, which could be nutritionally superior.All these would amount to loss of the nutrients associated with such foods.

Indiscriminate practices in food trade such as food adulteration can lower the quality of food due to dilution of nutrient density or destruction of nutrient. It can be due to incorporation of edible / inedible material, non-permitted additives, excessive additives, or abstraction of a component.

2.3 “Systemic” causes of food losses: economic development/ regional

The systemic causes of food losses and waste differ in low-income and medium/high-income countries. In low-income countries they are mainly linked to financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in adverse climatic conditions, infrastructure, packaging and marketing systems. In medium/high income countries they mainly relate to consumer behavior as well as to a lack of coordination between different actors in the supply chain. We discuss the different causes in countries at different stages of development in the following categories:

2.3.1 Lack of infrastructure

In many low-income countries, there is considerable food loss due to lack of storage capacity and poor storage conditions as well as lack of capacity to transport the produce to processing plants or markets immediately after harvesting. There are also too few wholesale, supermarket and retail facilities providing suitable storage and sales conditions for food products. Wholesale and retail markets in developing countries are often small, overcrowded, unsanitary and lacking cooling equipment (Kader, 2005).

Availability and efficient use of the cold chain significantly affect FLW. Temperature control is the single most important factor in food preservation, especially for perishable commodities such as fruits and vegetables. It is estimated that the rate of deterioration of perishables increases two to three-fold with every 10 °C increase in temperature within the commodity’s physiological temperature range. Therefore maintaining low produce temperature right from harvest to retail (cold chain) is of paramount importance in quality preservation. Cold chain maintenance from production to retail is possible and is achievable by most supply chain actors in developed countries, which

have a well-developed and functional cold chain infrastructure. On the contrary, in most developing countries, the cold chain infrastructure including on-farm cold rooms, reliable power supply, refrigerated transport facilities are non-existent, inaccessible, poorly maintained or utilized. Cost of providing the cold chain per ton of produce depends on energy costs plus utilization efficiency of the facilities throughout the year. Mittal (2007) reported that about 30% of the fruits and vegetables grown in India get wasted annually due to gaps in the cold chain. Fonseca and Njie (2009) found that the lack of capacity of cold chain is the main reason for the postharvest loss in Latin America and Caribbean countries. As economies grow, the need forcold chain grows rapidly, but most consumers lack the awareness of the importance of the cold chain and many companies cannot bear the huge investment, it makes the gap of the resources of cold chain logistics large and cannot meet the normal need of cold chain logistics in Beijing (Lan *et al.,* 2013).

In India the fruit and vegetable production has dramatically increased but with the infrastructure still needed to bridge the gap such as cool and cold chambers, cold transportation chain and Value addition for both fresh and preservation techniques. Increased production can therefore come with - more than proportional- increase of losses.

2.3.2 Lack of credit market/institutions

In rural areas of developing countries, credit constraint is one of the primary bottlenecks in investment and adoption of technology to reduce food loss in whole food chain (HLPE, 2013b).

2.3.3 Lack of transformation and packing industries

In many situations the food processing industry doesn't have the capacity to process and preserve fresh farm produce to be able to meet the demand. Part of the problem stems from the seasonality of production and the cost of investing in processing facilities that will not be used year-round (Gustavsson *et al.,* 2011). Choudhury (2006) highlights high loss rates associated with a lack of packing houses in India, with FFVs generally packed in the field and some even transported without transit packaging.

2.3.4 Lack of good practices: conservation and logistics

Logistics related food loss is high in low income countries. Injuries from punctures (due to inappropriate containers and packaging), impacts (due to bad roads and driving behavior), compression (due to overfilling of containers and inappropriate loading), and vibration (due to rough roads and bad driving behavior) as well as exposure to high or low temperature, moisture, chemical contaminants and insects are main causes of logistics related damages to fruits and vegetable produces. Poor management in conservation also causes food losses in low-income countries. In large-scale storage facilities in SSA, standards of fumigation treatment to destroy insect infestation are generally too poor to kill all insects, which encourage insect resistance to the fumigant. Although the incidence of resistance has not been investigated extensively in SSA, it is known from Morocco (Benhalima*et al.,* 2004). In some instances due to technical limitations, decisions aimed at preserving quality result in the opposite of the desired goal. For example, while cold storage is recommended to preserve quality, storing chilling sensitive products at very low temperatures results in chilling injury, ultimately leading to loss of the produce. On the other hand mixing products such as fruits, vegetables, milk, meat in a single cold room as is typical of most wholesale and retail outlets in developing countries may have negative effect due to contamination or accelerated deterioration.

2.3.5 Lack of integrated food chain approaches and management

Without a well-functioningintegrated food chain, food losses are exacerbated especially in low-income countries. One reason for losses in the food chain is theincreasing distance between the places where food is produced and where it is consumed. Apart from farmers, transporters, store keepers, food processing industry, shopkeepers, supermarkets, among others, are involved. We therefore need to look at the stakeholders and drivers in various segments of the food chain and to what extent interests either coincide or are at odds across major groups. Enhancing efficiency in

one part of the chain, e.g. in production, can be nullified if losses and wastage occur, or increase, in other parts of the chain.

A small number of large retailers in the UK exercise market power over the 7000 suppliers within the sector. To avoid being 'de-listed', food manufacturers will often over-produce in case extra quantities are required at short notice. For manufacturers of super- markets' own brands, packaged surplus production cannot be sold elsewhere and becomes waste; however, the sector is adept at reusing the majority of food waste generated (C-Tech, 2004).

Similarly in developing countries where small holder farmers are contracted to produce for domestic or export market, lack of horizontal and vertical linkages contribute to inefficiencies in the supply chain leading to losses. If the small holder farmers were organized into associations (or farmer groups), they would be able to access credit to finance production and postharvest handling facilities such as cold rooms, drying equipment, processing units etc. Additionally with such groups in place, training on good harvest and postharvest handling practices to reduce losses can be actualized. On the marketing side, such groups would be better placed to meet targeted volumes – those who produce excess volumes would compensate the under-producers thereby meeting contractual volumes and maintaining their market access

Lack of effective communication infrastructure and information flow also causes logistics risks in the food supply chain.

2.3.6 Unsustainable social and economic practices

Parfitt*et al.* (2010) found that in low-income countries, many of the issues identified, including related to contractual practices, are no different from supply chain issues in developed economies in the following aspects:

a. payment terms discouraging small growers;
b. retailer product quality standards deterring small- holders from supplying produce to the market;
c. high contractual penalties for partial or total non- delivery of orders by suppliers;
d. product take-back clauses in supplier contracts allowing retailers to return product to suppliers once a residual shelf-life has been reached;
e. often poor demand forecasting and replenishment systems and a lack of FSC transparency; and
f. difficulties inherent in transitioning from trading systems previously driven by spot market prices towards long-term contracts.

2.3.7 Food safety aspects

Food losses out of food safety concerns are important in medium/high-income countries. In Europe, private regulations have been identified as major reasons for throwing away food in the catering business due to strict hygiene rules and wide safety margins (Waarst *et al.,* 2001). Food regulations can be applied in ways that remove food that is still safe for human consumption from the food supply chain(FAO, 2012).

Goodwin *et al.* (2002) examine the implementation of the so-called "Mega-Reg" by USDA Food Safety and Inspection Service (USDA FSIS) authorizing establishment of regulatory hazard analysis and critical control point (HACCP) procedures. Results show average welfare losses up to 35 million a year for the broiler industry as well as substantial losses to consumers resulting from the new regulation. Fonseca and Njie (2009) reports that the rejection of fruit and vegetables from Latin America and Caribbean countries to the US is mainly out of food safety concerns.

2.3.8 Identification of ultimate causes in the food chain

It is important not to confuse where a specific loss is occurring with its cause. Losses at one stage of the food chain can have their cause at another stage. For instance lack of care in the manipulation of fruits in the very early stages, harvest, packaging, can reduce their shelf life and

cause their waste at retailer or consumer level. Conversely fruits can be left to rot in the field because of a retailer's decision to lower its buying price or interrupt a contract. Reducing FLW thus requires to identify their ultimate cause (s). For instance lack of care in harvesting can be due to poor conditions of work of laborers in the field.

2.4 Causes of food waste

Food is now being treated in rich countries as consumer goods, of a commodity of use, hence respect for food as an essential item of use is declining. Hence a large quantity of food is purchased, which is not needed, and wasted because it is never used. This is true for fresh foods (discarded because it is spoilt at household level), processed and packaged foods (discarded because of expiry date], and restaurant foods (because huge portion size or large quantity of food purchased), which could not be used.

Food waste occurs mainly in the latest stages of Supply Food chain. In poor countries waste is reduced, because consumption is smaller, and because consumers have a lower income and therefore, any waste weighs enough in their pockets. The distribution system itself found in poor countries makes losses smaller. In poor countries the street fairs predominate in the commercialization of fresh products. In countries with a large proportion of rural population fairs are local and in these places it is possible to observe that very little is thrown away voluntarily or negligently. In urban areas of poor countries the fairs have an important role and modern self-service retail has a presence still stumbling. In these countries, the big supermarket chains are not yet consolidated while their growth have been explosive since the 1990s (Reardon and Berdegué, 2002; Reardon, Timmer and Berdegue, 2006). The participation of large supermarket chains in developing countries is still lower, with some exceptions (Chile and Argentina in Latin America, for example), than the high concentrations found in developed countries where only three networks can concentrate more than 80% of sales.

In distribution of food through street fairs or mom & pop stores the waste level is lower because when the manipulated merchandise turns into lower quality products would be sold for lower prices. As the sales amounts are smaller, there is no room for stocks and also the owners already know the habits of the customers and very little is thrown away.On the other hand, in large establishments, there is a dictatorship of quality, which – in most cases- does not reflect the quality of the product but other attributes such as shape and color. In large supermarket chains the procurement system is centralized, it searches the specialization of the transport and wholesale, it favours suppliers and it has its own classification of products (Reardon, Timmer and Berdegue, 2006) making that large quantities of food are wasted. Research of the Institution of Mechanical Engineers (2012) shows that, because of physical appearance criteria, 30% of UK vegetable crops are never harvested[11].

The disposal of food at marketing stage occurs in greater proportion in the case of fresh than in processed items. It is estimated that the food processing has a rate of waste around only 20% in comparison with the fresh food (Kummu *et al.,* 2013: 481). Even if we consider the minimum processing as the separation and packaging in small containers, or cutting or cleaning of parts, the shelf life of the food can be extended, although the residue discarded (shells, parts with bruising and wilting) will eventually increase in supermarkets.

Lipinski *et al.,* (2013) highlights that the food waste at the consumption stage costs on average of USD 1,600 per year for a family of four in United States. Calculations performed with FAO data (FAO, 2011) show that 39% of waste by weight, at the stage of consumption is concentrated in three countries of Industrialized Asia: Japan, China and Korea and the three developed regions contribute with 79% of the waste in households (See Figure 5)

2.4.1 Losses in retail outlets

The ultimate destination of most food products is the retail market, where the consumer is king – hecan choose to accept or reject the product. The retailers influence the activities of supply chains

[11] Institution of Mechanical Engineers GLOBAL FOOD: WASTE NOT,WANT NOT.2013, p.18.

as they dictate the quality of the produce to be supplied and displayed in their outlets. The retail stage is the most visible stage of the entire process because it is the only stage in the whole chain that the consumer/buyer sees. It is the stage where the fate of the food product is determined in terms of price or whether it will be discarded based on the perceived quality. Conditions within the retail outlet (temperature, relative humidity, lighting, gas composition etc) and handling practices have an effect on quality, shelf life and acceptability of the product.

High losses at the retail stage occur in perishable commodities such as fruits and vegetables, fish and seafood, meat, dairy products, baked foods, cooked foods. In the US alone, it was estimated that the in-store food losses was 10% of the total food supply. This is in spite of measures put in place by the retailers to keep the products fresh such as protective packaging, temperature control, maintaining high humidity around the produce through misting, proper organization of produce on the display to minimize handling by buyers. The losses at the retail stage are even higher in developing countries where these measures are not in place.

Perhaps part of these losses could be attributed to stolen food by employees and consumers in retail. Supermarkets don't present the figures of stolen food mixing this cause with the regular losses. The economic crisis worsened these habits and more and more consumers think that it is not immoral to steal food or eat fruits during their shopping time (Forbes Magazine, 2012).

Some of the factors (drivers) seen to contribute significantly to the high losses at the retail stage include:

Wasteful product display

In most retail outlets, piles of fresh-looking produce on display is seen as a means to attract buyers, who then have the luxury to choose by rummaging through the pile. This has two effects that contribute to high losses at this stage; as the buyers rummage through the piles, they injure the other produce; on the other hand, the produce at the bottom of the pile is damaged by the weight of the produce on top. In some cases the products such as fruits at different ripening stages are piled together to give the buyer a choice. From a physiological perspective, piling products such as fruits of different ripening stages shortens the shelf life of the produce that would otherwise have a longer shelf life because of the different ethylene production and respiration rates. Besides, the products of advanced ripening stages are more delicate and when they are piled together with the raw (less ripe) products, they suffer more mechanical injury due to the weight and excessive handling by the buyers.

The store owners seek to maintain a variety of products displayed in large volumes which are replenished regularly to fill the shelves for the consumer's satisfaction. Often food products close to expiry dates are ignored by the consumers who prefer the 'fresher/newer' products (SEPA, 2008).

Pressure to meet expectations of customers

The consumer demand for perfect products (in terms of color, shape, size, freedom from blemishes) has led to most retailers setting high standards for products delivered to their stores. Failure to adhere to these standards by the producers result in rejection at delivery or culling of the displayed products. Often times in countries where there are no strict controls on food safety standards, some retailers use unregulated chemicals or overuse regulated chemicals to maintain freshness of the produce to attract consumers. Injudicious use of such chemicals on foods which may be impounded by public health officers contribute to food losses. Conversely when such practices go unnoticed, there are serious food safety concerns.

Efforts to increase convenience for the consumers

Most retailers have ventured into fresh-cut (fruits and vegetables), ready-made meals food items such as chicken, potato, beef, fish etc. While this is meeting the demandof the consumers, high losses result because the processed products are more prone to spoilage. Store managers feel compelled to display only freshly cut or cooked foods and hence large volumes of the foods that remain unsold at the end of the day are discarded. The figures on discarded ready-made or processed foods are scanty, especially in developing countries where this culture isjust picking up. However, it is estimated that convenience stores in US discard approximately 25% of their food products (Jones, 2005). This situation is aggravated by confusion about the 'sell-by' dates. Most retailers often remove and discard edible food simply because it is near the sell-by date. This is often prompted by the store managers' desire to protect the reputation of their stores.

The generalization of the sale of fresh cuts in supermarkets since the eighties brings diverse effects on losses and waste. The chain of production of fresh fruits, vegetables and root cutsconsists of several steps that can be technologically complex depending on the level of capitalization of the producers and the market to be served. The production process starts in the field with a choice of high quality products and the removal of parts considered inedible or of lesser value. Then the process goes through the following phases: pre -cooling, washing and disinfection, peeling, trimming, deseeding, cutting to specific sizes, sorting defects, dipping, drying, and storage, packaging and labeling and distribution (James & Nagramsak, 2011). It is estimated that by maintaining the right conditions and with proper packaging, this product would get a shelf life longer and allow a safer use in meals made at home.

These attributes and the time saving in the preparation of meals have led to a rapid expansionof the fresh cuts marketcovering from low quality products produced in cottage industries and distributed by street vendors to the sophisticated products distributed to restaurants and canteens. With regard to waste, the introduction of fresh cuts would be exchanging the generation of waste at residences by a large amount of unused product and considered inedible waste on farms and packing sheds. Although the generation of losses is very large in the whole process, with the generalization of this fresh cuts, these spillagewould be concentrated in rural areas.This concentration of losses and waste could reduce transportation costs of goods that would not be consumed. There is also a reduction in the pressure on landfills of big cities at the same time that the increased organic mass could be available for the feeding of animals and bio fertilization. There are also reports of these leftovers channeled to the production of juices and jams (Verghese *et al.,* 2013).

As negative point there is a clear increase in spending of packagingconsumption, more energy is wasted and more greenhouse gases could be produced. Additionally as the life of the product is being prolonged, it is likely that the radius of supply for these products would be increased.

The growth in sales of fresh cuts is probably impacting on the decrease of Fruits and vegetables leftover in American supermarkets. Research published in the 2009, Economic Research Service (USDA) reports that "... average food estimated loss for fruit at the supermarket level decreased 2.3 percentage points from 10.7 percent in 2005 to 8.4 percent in 2006. One possible theory for this decreased loss could be the popularity of fresh - cut fruit " (Buzby *et al.*, 2009:7). It is noted, however, that not all of the fresh cuts product that sold in bags for consumer convenience are effectively consumed. Reports presenting results of a survey prepared by supermarket chain Tesco (UK), in the first half of 2013, have showed that 68 % of salad sold in bags have been thrown out - 35 % of it in the home. The causes for this waste are linked to the package size and the need of the consumer mix products from different packages to assemble their salads (The Guardian, 2013).

Large pack sizes

Some consumers who wish to buy just small quantities of a produce are forced to buy more than they need because of the package size. In the case of new products in the market which the consumer only wishes to test, when the product is only offered in large packs and the consumer does not like it upon testing, the extra volume is wasted.

Out-of-store losses driven by retailers

On the upstream end of the supply chain, retail stores impose strict contract conditions on the growers such as quantity and quality guarantees. This sometimes prompts the growers to overplant beyond their contracts, just to ensure that they fulfill the contract conditions. The extra produce is often discarded or sold for a lower price to alternative buyers. Sometimes, the stores make last minute changes in the orders (often reducing the quantities) resulting in wastage of the extra produce. Downstream, store managers seek to influence the consumers purchasing appetite. Impulse buying by consumers is prompted by product promotions, bulk discounts. Consumers in turn buy quantities of products that end up in garbage bins.

2.4.2 Drivers of losses at the consumption stage

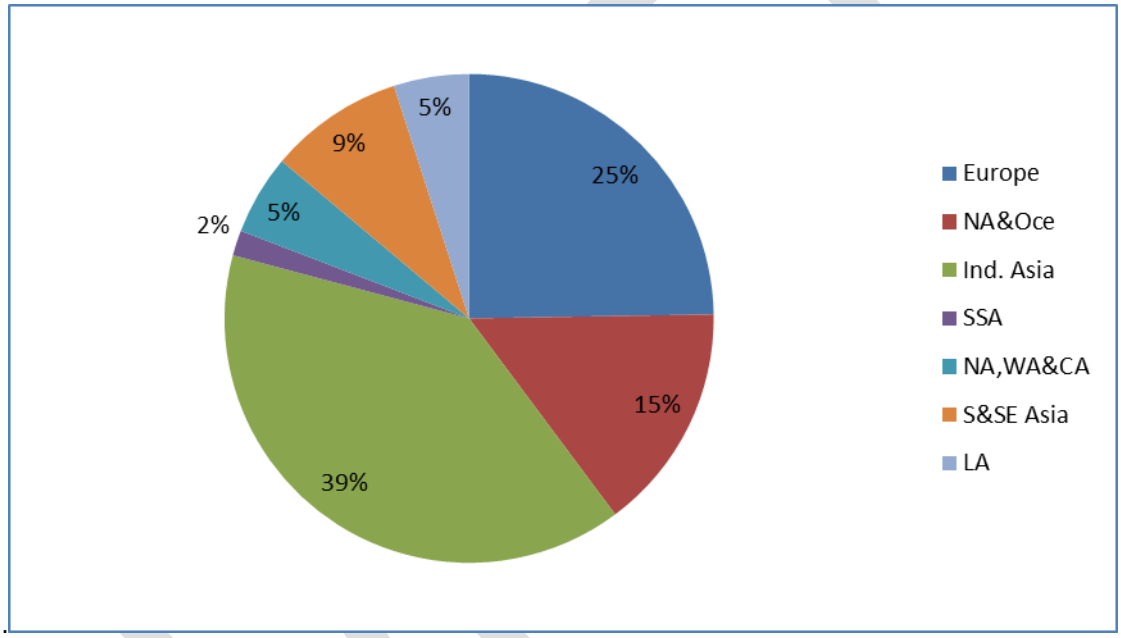
Affluence and consumer attitudes; most consumers in developed countries can afford to waste food.

Among causes often mentioned figure:

- Poor planning of purchases often leading to buying more than is needed – impulsive or advance purchasing of food that is not required immediately.
- Poor storage or stock management in the home.
- Excess portions prepared. And not eaten
- Poor food preparation techniques often leading to less food being eaten, nutritional losses due to the preparation method.
- Discarding food due to confusion over 'best before' and 'use by' dates.
- Lack of knowledge on how to consume/use food more efficiently e.g. use of the left overs on other recipes instead of than discarding.

Food is also used as a symbol of prosperity, hence more quantity of food is used by people from higher socio-economic group to provide variety and show prodigality. Food losses can also be significant in official events. The recent "Empty Plate" campaign in China draws attention to the food waste in banquets offered to or provided by government officials (BBC, May 8, 2013). Surveys in other developing countries confirm it (Fox and Fimeche, 2013).

Figure 9 Waste at consumption stage



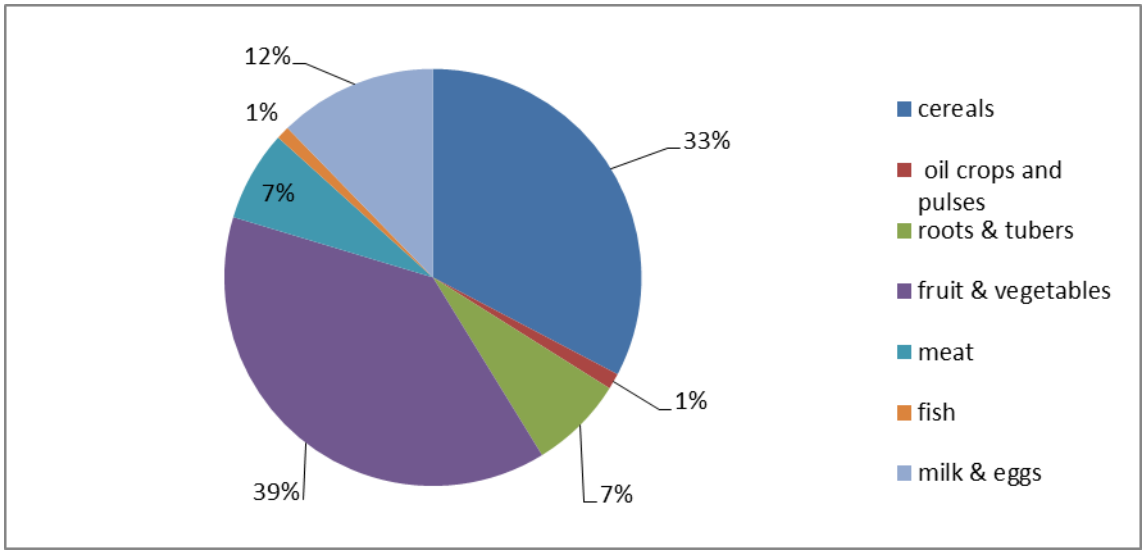
Source: FAO, 2011

Among the seven product categories surveyed, most of the waste at household level is fruits and vegetables (39%) followed by cereals (33%) as presented in Figure 10.

According to a survey conducted in 2009 by WRAP (2009) for households in UK 41% of the waste occurs because the meals were cooked or served too much and 54% of waste is because the food was not used in time. It is estimated that from the prices of autumn 2007 and spring 2008, the total cost of waste was £12 billion per year or £480 per household per year. In terms of cost "waste represents 15% of expenditure on food and drink brought into the home"(p.28).

There is a methodological problem in measuring the waste of fruits and vegetables and cereals, because the calculations generalize the information about the edible portion of these foods and there are cultural and regional differences in the way in which they are consumed. Anyway, there is a high level of waste by the lack of knowledge in the form of preparation of these foods – with low utilization of the edibles parties, conservation problems in poor regions (where houses don't have refrigerators) and families do not use preservation techniques.

Figure 10 Participation of various food categories in total consumer waste



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Source: FAO, 2011

Four criteria are often identified as having an impact on the level of waste in households in developed countries: Household size and composition, Household income, Household demographics, Households Culture (Parfitt, Barthel and Macnaughton, 2010).Households with fewer residents waste more because the parts purchased and prepared are typically larger than the consumption capacity, households whose income is higher waste more - consistent with their greater food consumption. It turns out also that there is larger waste in households with greater presence of adolescents and young people and, finally, there is an influence of the cultural environment on the level of waste. Parfitt, Barthel and Macaughton (2010) mention that in the United States, the households with Hispanics have a level of waste 25% less than non-Hispanic households (p. 30).

Another element that probably plays an important role, although less studied, is buying habits.Buying less often and in greater quantities, as is done in rich countries, could increase waste as the possibility of products loose their validity on the basis of their expiration date is greater than in countries where consumer habits or financial constraints lead to purchase of supplies for the same day or smaller periods of time.

This consumer behaviour is induced largely by the confusing system adopted in some countries forthe expiration date of the products. Many studies have called the attention to inconsistencies that exists in the labelling of products which cause many products to bediscarded for this reason. In the United States, federal law requires the manufacturers of processed products to use three different dates on the packaging: "sell-by" or "best if used by" and "use-by" being that the first establishes what is the deadline for the product to remain on the supermarket shelf, the second sets the best date for consumption and the third recommends the deadline from the point of view of food safety. These different dates makevery common the disposal in households of products in perfect condition for consumption. Considering also that as the product nears its sell by date supermarkets tend to put it on sale and their cost for disposal or for donation - where the legislation favours, is reduced so that the damage in financial terms is not as high as it may seem.

From the point of view of the consumer, the use of expiration dates as limitation and disposal guidance imply a subjective assessment of the condition of the product. In fact, it is not clear to the consumer, after opening the product, how long the product will retain its nutritional properties and how soon it will deteriorate, kept in a refrigerated environment (in which temperature?) or not. Another problem linked to the disposal of products in the residences is large packaging of the products, even for fresh food. Advertising campaigns "3 for 2" or "economic packages" on sale in supermarkets induce to waste because, once opened, the tendency is that they damage before being consumed.

In school canteens and restaurants the existence of fixed price buffet (eat as much you can), supersize portions and refill soft drinks promote obesity and waste (Lipinski*et al.,* 2013).The activist Tristan Stuart (2009) estimates that “24 to 35% of school lunches end up in the bin” in UK. In US recent research conducted by Cohen et al (2013) with middle School students of Boston

demonstrated that in terms of calories”on average, students discarded roughly 19% of their entrées, 47% of their fruit, 25% of their milk and 73% of their vegetables”. The waste is very high even in developing countries as in Brazil that has a gigantic public school meal program. Longo-Silva *et al.,* (2013) investigated the consumption of food in the nurseries of seven public day care centers with children aged 12 to 36 months in São Paulo. Considering the waste in weight the mean was 34% for 9 food and preparations.

3 REDUCING FOOD LOSSES AND WASTE FOR SUSTAINABLE FOOD SYSTEMS AND FOOD SECURITY

As shown above causes of food losses and waste are quite different along the food supply chain, including production, storage, processing, distribution, and consumption. They are also very different depending on the nature of different products and on local conditions. Even when causes of FLW are physical and technical, they are generally due to broader systemic causes, economic, social and institutional. Solutions at micro levels, to be implemented directly by single actors, from farmers to consumers, often involve (or require) changes all along the food chain, and, even when of a technical nature, generally require macro solutions, often economic and/or institutional.

3.1 A framework for solutions to reducing FLW

Solutions to reduce food losses and waste can be classified according to the stages where they are to be applied, to the stake holders having to implement them, to their scale, to their nature (technical, economical, regulatory,…). Solutions to reduce food levels at one stage often involve actors upstream or downstream the food chain. Implementing them thus often requires relations between various actors. They can also require the involvement of other actors, often public.

Micro-level solutions usually refer to physical and technical solutions to be adopted by individual agents like producers and consumers, while macro-level solutions include broader measures, often economic, institutional or social.

Solutions to reduce FLW often involve different stakeholders: Not only private sectors (e.g. farmers, consumers, processing agents, and retailers) and public sectors (e.g. government, research institutes) but also social organizations (e.g. non-profit organizations) can be involved in reducing food losses and waste.

As discussed in Section 3, developing countries have a large amount of post-harvest losses in the early stages of the supply chain, mostly because of the financial and structural limitations in techniques, storage and transport infrastructures, while in developed countries food losses and waste are usually associated with consumers. Therefore, the solutions to reduction of food wastes and loss are quite different across countries. In brief, improving the efficiency of food supply chain is the key for developing countries, such as improving the production techniques and infrastructures (Kader, 2004), while developed countries should improve their management of the downstream of the supply chain, conducting consumer education campaigns, and facilitating increased donation of abundant food (Monier, 2011).

3.2 Technical solutions to reduce food losses

At each stage of the food chain technical solutions can be implemented to address specific causes of losses (see annex 1 and 2). Often very simple and sustainable solutions can be adopted to reduce the high level of losses in developing countries (UN Millennium Project, 2005; Gustavsson *et al.,* 2011) as the installation of small milk coolers near the farms, plastic crates for fruits and vegetables, cell phones for following thefluctuation of market prices and even vans for transporting food. On the latter, it is worth mentioning that in developed countries the truck transporters havetrailer with food refrigerator with up to seven temperatures that are monitored directly by the driver. However to rural areas of developing countries would suffice a tarp over the truck to transport grain, vents in the transport of fresh food, protection against heatstroke and, in both cases , transportation preferably in the evening hours to avoid that the load may deteriorate rapidly (Foscaches *et al.,* 2012).

Box 3 ACIAR Initiative: two-stage drying technology in Southeast Asia

The Australian Centre for International Agricultural Research (ACIAR) set up R&D programs in Vietnam, Thailand, Malaysia and Philippines to overcome wastage and quality problems associated with drying grains in humid, tropical climates, with a focus on the rice industry. In Southeast Asia, especially big rice exporter like Vietnam, a lack of drying technology is the main reason for grain loss and decrease in rice quality. The traditional drying technics such as sun-drying were unlikely to reduce the moisture content to 14%, the safety level for long-term storage. In wet seasons, the moisture content could go above 30% and it is difficult to find enough room and labour to dry the grains properly.

Concepts and Impacts

The two-stage grain-drying technology was developed, based on the use of a flash dryer or a fluidised-bed dryer in the first stage, for grain with high moisture content (>18%), followed by slower, in-store drying to reduce the grain moisture content to a safe storage level.

The ACIAR program was successful to develop a drying technology that delivers a marked improvement in the proportion of rice meeting Grade 1 standards. The technology has been widely adopted in Thailand and there is growing interest in it in Vietnam and China (Pearce and Davis, 2008).

Problems

There has been no adoption in the Philippines of the two-stage process as a whole or of either of its components. Economic analyses suggest that two-stage drying technology, while more costly, has a positive impact on profit, largely from quality improvement (Chupungco, Dumayas and John, 2008). In recent years, the increase in energy prices has made the technology less attractive than when it was first developed. In many parts of Southeast Asia, rice-trading sectors are still characterized by small traders turning over small volumes of rice within a short amount of time. The two-stage technology requires significant initial investment in drying facilities (often including shed space), which means an increasing return to scales. Large bulks of rice handling are required, which asks for structural change in the rice industry with small-volume trading.

Source: Chupungco, Dumayas, and John,2008; Pearce and Davis, 2004

Several experiments have been developed to improve packaging for fruits and vegetables. An interesting experiment developed in Brazil is the system of Plastic Food Containers Bank run by the Public Terminals in some cities. In this system, the producer - or even the intermediate, rents boxes of diverse sizes adapted to the product to be transported, which are taken to the rural area already cleaned and sanitized. At product delivery in the Food Terminal, the producer receives the same amount of empty boxes for holding the next transport. At the same time, the boxes which are emptied in the marketing process are subjected to cleaning and sanitizing. According to the boxes' manufacturers, the loss can be reduced by 30% with this system[12] but so far there is no evidence to establish the exact percentage of loss reduction. The difficulties in measuring this gain arise from the fact that the system was not well received by producers and intermediaries. That's because the old system, based on standard wood boxes was cheaper for the farmer and allowed the intermediary to still make a profit by trading boxes. In the new system, in addition to revenue losses from the sale of boxes the producer or the middleman would have to pay a fee to the Food Terminal for the use of plastic boxes. Moreover, the simplification of the activities of loading and transshipment threaten a large number of workers whose livelihood depend on these activities.

This case demonstrates that the feasibility of operations for FLW reduction in the medium and long term have increasingly to rely on an institutional effort involving all actors in the chain, including private actors. For the purpose of this study we understand institutions as institutional arrangements or governance, which is the space in which the actors interact and build their strategies. In this sense, we can say that the markets as institutions are not given, but *constructed* by social actors.

The lack of infrastructure in many developing countries and poor harvesting/growing techniques are likely to remain major elements in the generation of food losses and waste. Less than 5 per cent of the funding for agricultural research is allocated to post-harvest systems and yet reduction of these losses is recognized as an important component of improved food security. Irrespective of global

[12] See odebricht informa online- PetrochemicalsIII. More hygieniclesslosses text by Lucian Maglia

region, there is a need for successful introduction of culture-specific innovations and technologies across the Food SupplyChain to reduce losses.

Innovative technology throughout the Food Supply Chain, in both developed and developing worlds, particularly in packaging, contributes to improving shelf life for perishable foods and semi-prepared meals. Continued developments in packaging, e.g. utilizing materials science, have the potential to further increase shelf life.

In the case of archaic practices that lead to a high volume of losses, especially in developing countries, what prevails is the institutional inertia in which all possibility of change is rejected because it can break the tenuous social and economic balance between actors. The change in the institutional arrangement is driven by exogenous factors such as changes in relative prices, technological or organizational change, consumer preferences etc. but also by endogenous factors that are gestated in a longer period such as demographic changes, shifts in the labor market, technological trajectories among other factors. But even considering these exogenous and endogenous determinants, it is possible to say that changes in institutional arrangements can also be induced.

Indeed, governments and public authorities can induce these changes by changing relative prices through taxation or subsidy policies of products, financing of new technologies and capacity building. If these changes are made in the direction and at such a pace that they find support along most of the stakeholders, there is a great possibility we close a virtuous circle of development in this area.

3.3 Infrastructure needsto reducefood losses at various stages of the supply chain: the example of cold chains

Often the efficiency of FLW reduction depends on broader interventions involving private actors all along the food chain and/or public actors. It is particularly the case when the main solutions reside in improvement of logistics. Cold chain management in perishable foods supply chains offers a very good example of potential solutions and what is needed to implement them.

Temperature control is the single most important factor in food preservation, especially for perishables. It is estimated that the rate of deterioration of perishables increases two to three-fold with every 10 °C increase in temperature (Kader, 2005). Controlling product temperature and reducing the amount of time that a product is at sub-optimal temperature is key to maintaining the quality, improving shelf life and extending marketing period and ultimately reducing postharvest losses.

A cold chain refers to an uninterrupted series of activities which maintain a given temperature range from the production point to the consumer (Ilic and Vukosavljevic, 2010). Effective cold chain management starts with pre-cooling, cold storage, refrigerated transport and refrigerated display during marketing. In developed countries which are technologically advanced, cold chain management is standard practice and temperature abuse would only occur when an established system breaks down or malfunctions.

In the developing countries, there has been significant increase in cold chain infrastructure; it more than doubled in India, increased by 60% in Brazil and 20% in China (Jemlic and Ilić, 2012). The increasing capacity is driven by reliance on the cold chain to meet the growing trade and consumption of better quality products both in domestic and export markets. Despite the growing importance of cold chain management in the trade of perishable commodities, in many other developing countries especially in Africa, there is little development of the cold chain infrastructure. The majority of the small holder farmers cannot afford on-farm cold storage facilities and therefore harvested perishables products are often stored at ambient field or room conditions which could be very high in the tropics. For farmers who produce for export or high end domestic markets, the produce is often collected and transported in refrigerated trucks to the destination. However it is important to note that cold chain management must start at harvest – time of day when the crops are harvested, initial shading before collection or removal of field heat prior to cold storage or refrigerated transport. Temperature abuse right from the farm predisposes the produce to faster deterioration in subsequent postharvest handling stages. Harvesting at the time of day when it is hot and failure to provide shading for the harvested produce are practices that contribute significantly to subsequent deterioration. This applies even if the produce is transported in

refrigerated trucks or stored under optimal cold storage conditions at later stages of the supply chain. Affordability and efficiency of cold chain solutions to reduce losses and waste is also a matter of concern.

For small holder farmers, lack of on-farm cold storage means that they cannot harvest and store the perishable products (fruits, vegetables, mushrooms, fish, milk etc) for later collection or marketing. Once harvested, if the perishable products are not consumed or sold, they will start to deteriorate and go to waste within hours. At the retail stage, failure to maintain the cold chain for displayed products negates any efforts at the earlier stages of the supply chain. In most retail outlets in developed countries, there are efforts to maintain the cold chain for displayed products including, fruits and vegetables (whole and fresh-cut), meats, fish, milk etc. However in many countries in the developing world, there is rampant temperature abuse for displayed perishables leading to very high food losses at the retail stage.At the consumer stage, most urban families have access to refrigerators and could maintain the cold chain for the purchased products. However, losses occur because of storage at unsafe temperatures for some products such as tropical fruits and vegetables which are prone to chilling injury. On the other hand most families/households (especially in rural areas) do not have refrigerators and therefore even the perishable foods are stored at ambient room conditions leading to fast deterioration and high losses, if the foods are not consumed soon after harvest or purchase.

Refrigerated cold stores are the best option for preservation of quality of harvested perishable foods. However, these are expensive to buy and run and therefore out of reach for the majority of small holder farmers. Additionally lack of connection to electricity grid for most rural farmers complicates introduction of electricity-powered cold rooms. This calls for alternative low-cost, electricity independent options. Evaporative coolers offer one such alternative and there have been efforts to promote them in many developing countries. There are various designs and size based on the use and scale of operation. There are pot designs (such as Janita pot in India, Zeer pot in Sudan), Charcoal coolers, Statistic cooling chambers, Naya cellar (in Nepal) among others. Although these are simple, effective and cheaper alternatives which can be adapted to local conditions and scale of production, they have not been widely adopted by small holder farmers. This is partly because of lack of awareness and incentives to make the farmers realize the potential benefits of these cooling options.

Current interventions by governments and development partners to improve the cold chain infrastructure in developing countries is the introduction of group cold-storage facilities. This is meant to cater for a group of farmers with common interests. In Kenya, the Japan International Cooperation Agency (JICA) working with the Horticultural Crops Development Authority (HCDA) introduced conventional cold rooms in strategic locations to cater small holder farmers almost 10 years ago. Unfortunately these facilities have not benefitted the intended target users (small holder farmers). Instead middlemen (brokers) are the ones who have been operating these cold rooms. Another initiative seeking to support smallholder farmers in groups is the promotion of ‘Cool bot’ cold storage facilities on pilot scale. Cool bot cold rooms are simple and cheaper alternative to conventional cold rooms where a gadget (Cool bot) is attached to a standard AC fitted room which in tricks the AC to work extra thereby cooling the room to below set temperature for standard AC (18 $^{\circ}$C). Although this technology is on pilot scale in countries such as Kenya, Tanzania, Rwanda and Uganda, it has been widely adopted in some countries such as India, USA, and Bangladesh.

Box 4 Cold chain intervention in India

India has roughly 5 300 cold storages with a capacity of 23 million metric tonnes, over 90 percent of which are suitable for storing potatoes only. With average capacity utilization in the cold chain sector between30 percent to 75 percent, the profits of a cold storage facility depend largely on investment in technology, infrastructure and service standards.

The gap between demand and supply of cold storage facilities in India, the world's second largest producer of fruit and vegetables, was 36.832 million tonnes (mt) in 2010, according to a Yes Bank study.Cold storage facilities are available for only 10% of the produce, resulting in 18-40% of the produce being lost,"In the present scenario, India is able to store only 2% of its farm produce in temperature-controlled environment as against 8% for the Asia-Pacific sector and 85% for Europe and North America," the study said.

The government of India, on the basis of various industry recommendations, established an autonomous body: the National Centre for Cold Chain Development (NCCD) in July 2012 to promote and develop integrated cold chain in India for perishable agriculture and horticulture produce including perishable from allied sectors. The main objectives of the centre are to recommend standards and protocols for cold chain infrastructure, suggest guidelines for human resource development and to recommend appropriate policy frame-work for development of cold chain.NCCD is intended to serve as the nodal agency for India's cold chain development, the centre piece for all future support interventions to this sector. As the nodal body, the NCCD is to recommend policy interventions, take on capacity building and skill development initiatives, recommend standards and certifications and basically act as guide & mentor to the cold chain industry. Besidesthe Governmenthad also constituted a Committee on Supply Chain & Logistics (focusing on Post Harvest marketing).

The National Horticultural Boardan autonomous society under theDepartment of Agriculture & Co-operation, Ministry of Agriculture, Govt. of India. hastaken a big step in creating technical standards for cold chain projects.Govt. agencies like the National Horticultural Board, the National Horticultural Mission &the Ministry of Food Processing Industries, offerfinancial incentives for the new projects as well as for expansion of existing units. However, these projects have to be, essentially, based on modern & efficient technology in tune with the technical standards.

Pre cooling of Fruits & Vegetables

The concept of pre-cooling of grapes was introduced in the '80s primarily in the state of Maharashtra,which is the leading grape growing state in India. This helped the farmers to export grapes to Europe, Gulf countries etc. Later this technology was adopted for other fruits like mango, pomegranate,oranges and other fruits.

Controlled Atmosphere storage

With the onset of the 21st century, the need was realized to set up controlled atmosphere following the trends in Europe, America & other countries. A number of CA stores have already been established in the northern part of the country at locations which have proximity to apple growing regions. The capacities generally ranged between 1000 MT to 12000 MT.

A few units of smaller capacities have also been established in the west and south regions ofthe country.

Ripening Chambers

There has been considerable interest in scientific ripening and storage of food like banana, mango etc. in recent years and the units are being established at a number of places. A good development in this direction can be seen in southern India andinthestates ofGujarat & Maharashtra.

Evaporative Cool (EC) Storage

Evaporative Cool (EC) Storage System maintains 10-15o C lower temperature compared to field temperature, and maintains around 90% RH. The shelf-life of fruits and vegetables can be extended by 3 to 90 days depending on the commodity. Since EC storage system does not require energy input for maintenance, it is therefore known as Zero energy storage and is suitable for remote rural areas with extensive applications for storage of commodities like potato, yam, cassava, apple, orange, lime, tomato, etc. Research institutes, like the Central Food Technological Research Institute (CFTRI) and Indian Agricultural Research Institute (IARI)have developed a number of these rural scale designs.

Source: http://agriexchange.apeda.gov.in; Report oncold chain management ofIndia –YesBank 2012

3.4 Reduction of food losses through capacity building, education, training and extension services

Capacity development in the form of education, training and extension services for farmers and all actors along the food chains is a key tool for reducing food losses. Besides capacitybuildingin the transfer of existing technologies and the spread of good practice, allied to market-led investment, have the greatest potential to reduce food losses and waste across the Food Supply Chain inthe developingworld.

Governments, relevant international organizations private sector and thestakeholders downthe FoodSupplyChain are urged both to continue and to increase their contribution to capacity-building and the transfer of appropriate technology, in particular environmentally sound technology, to developing countries and countries with economies in transition, as well as to promote partnerships for fostering sustainable agriculture and food andnutrition security and promoting rural development. A multi-stakeholder platform would be relevant to discuss cross-sector relevant problems (consumer behaviour change, regulation, food labeling 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.

Box 5 Centre of Excellence Post Harvest Food Losses

The Centre of Excellence Post Harvest Food Losses (CoE) is a public-private cooperation model aiming todevelop the post-harvest knowledge of perishable food products in emerging and developing countries. With the ambition to contribute to the reduction of food losses and improve food supply chains in developing economies. Characteristics of the CoE are:

Improving access to knowledge on postharvest issues and supply chain efficiency for chain actors and stakeholders, and capitalise on public and private organisational excellence in developed countries. Joint profiling on post-harvest development and food loss reduction. Demand-driven approach: initiate action upon articulated post-harvest questions from chain actors. Link with (inter-)national networks (active) in developing growth markets, incl. knowledge institutes, extension service providers, chain actors, NGO's, a.o. Building a network of capacities with regional applied research institutions and sharing of frameworks, toolboxes, methodologies and best practices is an important activity.

The NoE will be launched in 2014, with a selection of 10 countries for proactive approach with an initial focus on Africa. The government of the Netherlands is donor in this initiative.

PHL areas of knowledge:

- The commodity
- Varieties /species: chemical, physical, biological and microbial composition
- Environmental conditions (weather):
- RH, temperature, rainfall, climatic changes
- Storage requirements, techniques & technologies
- Processing techniques, -treatments & technologies
- Packaging requirements, materials, techniques, technologies
- Best practices: low tech - intermediate - high tech (costs)
- Physiologists, engineers, food scientists, microbiologists, economists
- PH-pest control, production factors, harvesting tools,
- Supply Chain Management: transport, logistics, food regulations
- Consumer preferences; nutritional aspects
- Quality assurance : food safety systems
- Markets & market requirements:both domestic & export

Source: Wageningen UR (the Netherlands) CoE Post-Harvest Food Losses

3.4.1 Prevention of food losses by good practices in crop and animal production

When appropriately applied, GAPs and GVPs can protect food at the primary stage of production from contamination by extraneous materials (filth, putrid or decomposed materials, rocks, dirt and sand); toxic chemicals and contaminants from the environment (heavy metals, environmental pollution and industrial chemicals); excessive or unsafe levels of agricultural chemical residues (pesticides, fertilizers, veterinary drugs and other chemicals); contamination or damage by pests, insects and vermin; and biological contamination by mould, pathogenic bacteria or viruses - any of which can cause spoilage, crop damage and food borne illness or chronic health consequences in humans. Increased human health risks may also result from consumption of animal products if animals have been fed contaminated feedstuffs which carry over into edible meat products. Once a product is declared as unfit for human consumption, the entire production batch is lost.

Box 6 Two sides in the loss prevention in Latin America

Latin America relies on exports to drive the local economy and generate jobs. In some countries the exportation of agricultural products is the main sector of the economy. Accordingly, yield loss due to post-harvest problems, inefficiencies in transport and packaging unsuitable represent loss to the farmers. When the product shipped did not meet determinations of compliance or is not in accordance with the certification imposed by private trading companies or supermarket chains from developed countries, there is no recovery possible and the cargo is simply destroyed.

Recently, the Inter-American Institute for Cooperation on Agriculture (IICA) conducted a survey on the main focuses of losses in agricultural production in order to direct their work in the region. High losses were identified in important products for domestic consumption suchas 40% in potatoes in the Andean region and 35 % in vegetables in Haiti. The spoilage is high also for export crops such as bananas in Ecuador or pumpkin in the Caribbean countries. The causes are all too familiar: lack of cold chain devices; inappropriate handling and packaging and the lack of market and climate information to producers that make them take wrong decisions about what, where and when to plant . The remedies are also known: investments in training, equipment and market information. Tthe IICA initiative brings partnership agreements between American universities and local organizations and the possibility of bringing international donations for these projects. (IICA, 2013)

On the other hand, from the same diagnosis butfollowing the botton up sense therootsorganizations in Latin America are boosting theexchange of informations between producers. Movements such as the Campesino a Campesino (CaC) or Farmer- to- Farmer Programme, havebeen spreading since the late '80s through Central America, although theiroriginmight be attributed to the organization of peasants during post-revolutionary period in Cuba in the '60s. The effort consists in promoting the technical exchange between producers and farmer's visits and training. The CaChas no scientific basis - using only the ancestral knowledge of the peasants producing immediate results in the application of simple technologies (IFAD, 2010) . Likewise and with the same philosophy the peasants knowledge transmissionis supported and disseminatedby international organizations such as Food First Institute. Other important organizations as La Via Campesina and Action Aid are supporting similar initiatives rejecting the system of international donations and transfer technologies based on technological packages.

The quality and safety of food intended for manufacturing or processing can be ensured by applying good manufacturing practices (GMPs) and good hygienic practices (GHPs) to food processing. When properly applied, these measures ensure quality and safety for all the processing or manufacturing steps from the receipt of the raw materials (primary products and other ingredients) to the shipping and marketing of the final products to the consumers. Implementation of GHPs entails the use of appropriate sanitary measures to prevent microbial contamination and assurance of optimum sanitary conditions for processing food products.

3.4.2 Prevention of food losses by Food Safety control procedures

The manufacture of safe food is the responsibility of everyone in the food chain, and food factory, from the operative on the conveyor belt to the higher management. The production of safe food requires the following:

- Control at source
- Product design and process control
- Good hygienic practices during production. processing, handling and distribution, storage, sale, preparation and use
- Preventatives approach because effectiveness of microbial end-product testing is limited.

The above has to be implemented in conjunction with the application of the Hazard Analysis Critical Control Point (HACCP) system. This preventative system offers more control than end-product testing, because the effectiveness of microbiological examination in assessing the safety of food is limited. Implementing such systems can be particularly challenging for small producers.

The rapid globalization of food production and trade has increased the potential likelihood of international incidents involving contaminated food. Food safety authorities all over the world have acknowledged that ensuring food safety must not only be tackled at the national level but also through closer linkages among food safety authorities at the international level.

In some countries, there is a need to update and revise the existing legal framework regarding food quality and safety. Regulations governing food standards are often lacking or outdated. Food control infrastructure may be non-existent, poorly organized or inadequately supported because of the lack of sufficient financial resources. In many countries, different government ministries or agencies are involved in food regulation and control, but their failure to coordinate their activities results in a waste of resources because of overlapping and redundant work efforts. There is generally a need for improved regulatory food inspection and laboratory services, development of food control enforcement programmes and the administration and coordination of food control activities in developing countries. Training in technical areas of food control is nearly always needed in such countries.

The recognition of the standards, guidelines and recommendations of the Codex Alimentarius Commission as the benchmark standards for international food trade has created an exceptional interest among developed and developing countries in the use of Codex recommendations in resolving food control issues. Some importing countries are imposing specific sanitary measures that are difficult for developing countries to meet, such as the required use of HACCP-based systems for exported products. Consequently, exporting countries, especially developing countries that rely on the food export trade for foreign exchange, have a particular interest in strengthening national food control systems, harmonizing national food regulations with international standards and establishing import and export food inspection and certification systems to ensure conformity with the SPS and TBT agreements.

3.5 Reduce food waste

As mentioned above, drivers offood waste at consumer level are often behavioral, mainly resulting from the abundance of food.

3.5.1 Social aspects

Social norms, traditions and even food culture may limit the potential to reduce generating FLW. Generally, these factors cannot be changed easily. For example, most western consumers do not eat animal's head, stomachs, feet that are usually edible. Convincing consumers to change the eating habit to act like Chinese people who enjoy eating nearly every part of animal would be difficult. Complacent food culture hinders reducing food waste (FAO, 2013b), which should be taken into account when estimating the actual FLW that could be reduced.

Consumer preferences also vary greatly among countries and cultures. For example, elimination of defects from a given commodity before marketing is much less rigorous in low-income countries than in medium/high-income countries. On the other hand, appearance quality is often over-emphasized in developed countries (Kader, 2004). Shopping habits of affluent consumers who have “throw-away mindsets”, and buy more food than their families can possibly eat, also contribute to food waste in high/medium income countries.

3.5.2 Action towards consumers

There are clearly fundamental factors affecting post- consumer food waste worldwide, some of which may require solutions that involve direct communication and awareness rising among consumers onthe importance of reducing food waste. Others require government interventions and the support and cooperation of the food industry itself, such as improving the clarity of food date labeling and advice on food storage or ensuring that an appropriate range of pack or portion sizes is available that meets the needs of different households (Parfitt, Barthel and Macnaughton, l2010; Kessova, 2013). Reducing developed-country food waste is particularly challenging, as it is so closely linked to individual behaviour and cultural attitudes towards food. Waste may be reduced by alerting consumers onthe scale of the issue as well as ondomestic strategies for reducing food loss. Advocacy, education, and possibly legislation may also reduce waste in the food service and retail sectors. Legislation such as that on sell-by dates and swill that has inadvertently increased food waste should be re-examined within a more inclusive competing-risks framework (Godfray*et al.,* 2010).

There has been empirical case study evidence from food waste prevention and mitigation strategies focusing on prevention/behavioural change studies. Example are most commonly found in the canteens and catering sector, parallel to the case quantification studies available from these sectors, including Getlinger (1996) on elementary schools;Li (2003) on in-flight catering, McCaffree (2009) and Thiagarajah (2012) and Cohen (2013) on comparisons of service systems, and Whitehair (2013) on the influence of written messages catering customers behaviour.Other mitigating strategies references include Food donation / food banks (Alexander, 2008; Williams, 2012; Schneider 2013), Hospital / elderly care catering (Nichols, 2002; Williams, 2011), hotels eco-initiatives (Kallbekken ,2013; Wyngaard, 2013), household recycling behaviour (Bernstadt, 2013) and food waste into livestock (De Boer, 1980; Wilson 1981; Yang 2006, Kato, 2012). The Waste and Resource Action Programme (WRAP) in the United Kingdom achieved a 13 percent reduction in household food waste from 2007 to 2010 (WRAP, 2012)

Box 7 Apotential strategy for decreasing food waste

USA carried out a work on impact on plate waste, switching from a tray to a tray-less delivery system in a university dining hall and employee response to the switch.

The objective of this 2010 study was to compare the impact of using a tray vs a tray-less system on plate waste and on employees' attitudes. To test the hypothesis that going tray-less would reduce waste, liquid and solid plate waste were measured for 1 week with the then-existing tray system and again after a new tray less system was implemented in a buffet-style university dining hall serving roughly 1,000 meals a day. Food service staff were invited to participate in a focus group about the impact on their jobs. The investigators calculated plate waste per patron under the two systems and used an independent sample test to examine the significance of the difference. Comments from the focus group were analyzed for themes. A significant decrease in solid waste per patron (0.81 oz; P=0.001) was observed in switching from the tray to the tray less system (4.39 ± 0.24 oz vs 3.58 ± 0.08 oz per patron). A non-significant reduction was observed with liquid waste (49.77 ± 2.62 mL vs 46.36 ± 4.51 mL; P=0.18). Most of the employees preferred the tray-less system as long as it did reduce waste, but felt that increased breakage of dishware and increased need to wipe down tables were possible concerns resulting from the switch. This study demonstrates that tray-less dining can reduce plate waste, and that employees can be supportive of the change.

Source: Apotential strategy for decreasing food waste in food service operations is tray less dining.Thiagarajah K, Getty VM of the department of applied health science, Indiana university, Bloomington, IN47405.

Box 8 UK household food and drink waste

Research shows that annual UK household food and drink waste has fallen by 1.1 million tonnes (13%) over a three year period from 8.3 million tonnes to an estimated 7.2 million tonnes. WRAP commissioned Resource Futures to determine an updated estimate for local authority collected household food waste, based on the most recent compositional studies and Waste Data Flow data, and to estimate the change since 2006/7. WRAP has used this as a basis for updating the estimate for the overall levels of household food and drink waste in the UK. The reduction in annual UK household food and drink waste between 2006/7 and 2010 was around 1.1 million tonnes, or around 13%. The new estimate is 7.2 million tonnes annually, or equivalent to around a fifth of all food and drink purchased. Avoidable household food and drink waste (i.e. food and drink that could have been eaten) has reduced by 950 000 tonnes, or 18%, from 5.3 to 4.4 million tonnes annually.

Although all these studies describe a positive effect on reducing food waste, it has become clear that it is very difficult to establish true relational causes between instrument and effectiveness food waste reduction, since this is influenced by many interlinked factors. However, the evidence is promising that by using a combination of strategies, food waste reduction and prevention is possible. The following steps in research should focus on detailing more effects in pilot experiments and studying up scaling towards the general public and food supply chain actors.

3.5.3 Campaigns against food waste in Southeast Asia

FLW in Asian countries in general are lower than in Europe and the US. In recent years, many countries have put more attention on reducing FLW through raising consumers' awareness and improving ways of preserving food.

The recent "Empty Plate" campaign in China draws people's attention to the food waste caused by government officials. In fact, the campaign has reached beyond government officials and has an impact on ordinary people. Anecdotal evidence suggests that since the start of the campaign in January, there has been a significant reduction in restaurant food waste.[13]

We also see similar campaign in South Korea, the "Half-bowl" campaign, which encourages people to order half a bowl of rice to reduce food waste in restaurants. It was expected to reduce restaurant FLW by 20% by the end of the year. Some companies invented a new kind of food container, which adds an extra layer inside to exclude air and moist to slow down the rotting process.[14]

In April 2011, Japan's Consumer Affairs Agency (CAA) revised Volume 2 of the Q & A book in order to clarify theissues of "use by date" and "best before date" which are often misunderstood by consumers. CAA also defined the "one third rule" (see box 15) as a voluntary business practice and stated that abolishing this rule could help reduce food waste.

The Q & A book is used as an operational guideline and serves as a reference for processed foods manufacturesand importers.As there was no regulatory change due to these revisions, U.S. importers of processed foodsmay continue to use current labels anduse the Q & A book as a source of information when creating a new label. The revision document clarifies the definition of ''use by '' and ''best before'' dates and the voluntary nature of the ''one third rule''. It also promotes listing of the information for storage conditions and other best practices to facilitate consumer's understanding of the food labels.[15]

From these studies and examples, a general outline towards actions/instruments can be categorized in three levels

- Awareness: Instruments thatfocus on principles of knowledge transfer (information/education) andagenda setting(advocacy, lobbying, policy development)
- Innovation: Instrumentsthatfocus on the developmentof new technologies andchanges in the contextual environment inwhich industry & consumer behavior takes place, including market, social, institutional changes and game changing pilot practice.

[13] http://www.bbc.co.uk/news/world-asia-china-21711928

[14] http://e-jen.net/html/newpage.html?code=1

[15] http://intl.ce.cn/sjjj/qy/201307/15/t20130715_566223.shtml

- Cooperation: Instruments that focus on up scalinginnovativepractices anddevelopmentof integrated (system) solutionsona large scale. Successful implementation ofinstruments or measuresforthe reduction offoodwaste in supplychain will require co-operation between different stakeholders and agents in the chain. The need for a system or integrative approach originates from the complexity of causes of food waste.
- Social innovation is a combination of all the above approaches. Social innovations are new ideas(products, services and models) that simultaneously meet social needs(more effectively than alternatives) and create new social relationships or collaborations.

Box 9 Using the whole nutrition properties from fruits and vegetables

The full use of fruits and vegetables can extract all the nutritional benefits of these foods, reduce waste and save money for families and institutions that serve meals. Several programs around the world teach how to take advantage of stems of vegetables and fruit peels for the preparation of sauces, spices and juices. Some of the most renowned chefs in TV programs have sought to pass information to the general public by demonstrating that what was thrown away and the leftovers from other meals may turn into a delicious and nutritious repast. The British chef Jamie Oliver has also used the argument of the need to save on his preaching by full use of food. Encouraged by his Foundation were instituted various programs of school gardens and full use of food in many parts of the world. According to a recent research developed in Italy, due to economic crisis, 57% ofItaliansreduced their food waste and among the different strategies to save, 24% of respondents declare that they are using the leftovers for new meals (Barilla, 2012:20).

An initiative that deserves attention and is being supported by FAO is a program developed by SESI - an organization that gathers the Brazilian industry stakeholders, named Kitchen Brazil. The purpose of this program is to teach notions of the full use of the food to poor families in Brazil and also tocooks in workers' and students' cafeterias everywhere. The Kitchen Brazil started its activities in 2008 and has a fleet of 33 trucks equipped with experimental kitchen, nutritionists and a classroom where courses are given to the general public and for food security agents. The trucks have traveled to isolated rural areas and poor neighborhoods of large cities, and stay at these locations for 4 or 5 days teaching recipes like papaya juice with orange peel, pink risotto (beet stems, stalks and peels of carrots), pizza with leftover rice , macaroni pie and other delights. Through exchange and training, the Kitchen Brazil has implemented similar projects in Uruguay, Guatemala, Honduras, El Salvador and Mozambique.

3.6 The crucial role of women to reduce FLW

In most rural communities, women comprise two thirds of the agricultural labor force and up to 80% of the total food production (Humera et al. 2009). The women play a key role in postharvest handling mainly drying, threshing, dehusking, shelling, grading, cleaning, initial processing and storage of food grains (Sidhu, 2007). These are drudgery prone tasks and it is recorded that high losses occur during these postharvest activities.Apart from the grain crops (staples), women in many developing countries are responsible for growing and processing highly perishable crops such as fruits, vegetables and tubers. They are also the ones charged with preservation and storage of foods such as milk, meat, fish etc. Despite the key role they play from production to food processing, women in developing countries experiment barriers in the postharvest handling practices. Most of them lack knowledge and access to good processing practices and efficient processing tools. Additionally, when there are opportunities for training in the skills required such as postharvest handling practices including processing, they are often excluded because most producer organizations through which such capacity building efforts are conducted, are usually dominated by men.As a result, women farmers end up with inferior processed products which cannot meet market standards and are therefore discarded or sold to alternative markets for lower prices.

There are initiatives from government and development partners in developing countries to improve the livelihoods of women farmers through value addition and marketing of perishables food crops such as fruits and vegetables. These initiatives have two-thronged benefits – economic empowerment of rural women and reduction of postharvest losses in the perishable commodities. In Kenya, initiatives by GIZ and the government through the ministry of agriculture has seen farmers

(especially women) trained in solar drying of fruits and vegetables, making of products such as juices, pulp, jams and chutneys.

Box 10 Success story in Kenya: Ukambani women reaping profits by processing fruits

Mango is one of the major fruit produced in the Eastern Province of Kenya. The mango season in this province is from December to March. During this peak season, there is a glut and limited market for the fruits leading to high losses.The farmers sell four mangoes at 10 shillings (0.1 USD) to traders who transport them to urban markets and sell at 20 shillings (0.25 USD) a piece. This is a scenario that recurs every year and has left the mango farmers impoverished. To reverse the trend, the Arid Lands Resource Management Project (ALRMP), in collaboration with the European Union, has come up with a project to initiate value addition to products seen to have low value in the area.The initiative was meant to empower the community to maximize profits from the fruits and reduce the losses by processing the fruits. With the support from ALRMP, women have taken the lead and embraced value addition to maximize profit margins. The fruit growers have realized that mangoes and paw paws which used to rot in farms would not go to waste again. One of the groups that have taken advantage of this opportunity is a local NGO, Kithethesyo Women Self Help Group in Migwani division. After getting intensive training, 40 members decided that value addition was the best way to go. The ALRMP advanced the group 315,000 shillings (4,200 US dollars) to buy a fruit processor. This was a turning point for the group members who have lived to maximize the new invention to improve their levels of income. “The machine can squeeze 100 liters of juice from mangoes and paw paw jam in less than an hour”, said the group chairlady Phoebe Kasee. She explained that the juice was then blended with preservatives, hot water and citric acid to produce a rich and tantalizing natural juice that can compete with other products in the market. “The shelve life of mango juice is 18 months while that of the paw paw jam is 36 months”, said Kasee. She acknowledged that the members have greatly improved their income as mango juice goes at 80 shillings (1 USD) per litre while the same quantity of pawpaw jam sells at between 120-150 shillings (1-2 USD). “I personally have been able to build a decent house and educate my children from the juice products”, said Kasee, asserting that in the past it was difficult for one to get 2,000 shillings (about 30 USD) from their harvest of mango and pawpaw.

Loss in nutritional quality of foods as a result of poor cooking/preparation practices is often ignored. Food preparation/cooking methods including those that expose the food to high levels of heat, light, oxygen result in loss of nutrients. Nutrients are also washed out of the foods by the fluids which are used to cook. This calls for proper or optimized preparation and cooking methods that ensure retention of nutritional qualities. Women who are the ones mostly involved in food preparation should be educated on proper food preparation and cooking methods to preserve foods’ nutritional qualities.

3.7 Socio-economic aspects of food losses and waste reduction

Technically we have the potential to reduce a large amount of FLW annually, socio-economic constraints may limit the amount we can actually reduce. In often cases the problem is not only the availability of technologies or measures, but also the economic cost of proposed solutions to reduce FLW. In addition to the economic cost, actions to reduce FLW shall also concern sanitary issues and impacts on the environment. Moreover, there could be both winners and losers due to changes inthe quantity and price of available food in the market.

3.7.1 Economic aspects

The economic benefits of reducing food loss and waste are large. With a reduction in FLW, the overall food supply will increase, which will generate a downward pressure for food prices and benefit consumers.

While the motive for reducing FLW is obvious, it is not economically rational to say that the solutions or measures to reduce FLW presented in the previous sections are feasible and can be successfully implemented. Society will have to accept some level of food loss (Stuart, 2009). It is unrealistic to think that we will ever totally eliminate FLW. When marginal benefit exceeds marginal cost, reducing FLW further is no longer economically viable. Moreover, there has to be a compromise between obtaining an acceptable return on investment by individual or private sector and protecting the environment as well as fulfilling consumer demand for food safety, product

quality, and a diverse variety of nutritious, flavorful, and acceptably-priced food (Buzby and Hyman, 2012).

Whatever measures are taken to reduce FLW, economic cost will occur, and economic return to investment becomes a critical factor affecting individual or any agent's decision on whether to take an action to reduce FLW. Many measures to reduce FLW involve investments (e.g., infrastructures, establishing markets, cold chains and other facilities). From a strictly economic perspective, if information and knowledge are well provided, any producer or consumer decides not to take an action to reduce FLW implies that the cost of taking the action is higher than the benefit expected.

From the economic point of view, the efforts should be focused on how to lower the costs of measures used to reduce FLW or increase amount of FLW reduction given the same level of costs.However, there is little empirical study in FLW literature that has addressed the above issues.A recent paper analyzing the impacts of reducing food losses and/or waste based on economic theory (Rutten, 2013) also pointed out that empirical studies are important to policy formulation. Without scientific data and information on the cost and benefit of any intervention on FLW reduction, policy recommendation could be misleading.

A cost and benefit analysis should be rigorously conducted on the various measures to be implemented. Such an analysis should consider not only the direct investment cost and benefit of any measure taken to reduce FLW, but also indirect impacts on the producer/consumer prices due to reduced FLW and change in food supply in the market. Moreover, any food product price change further affects producer's income and consumer's purchasing power as well as the production and demand of this food product. Changing price of one food product can also affect the productions and consumptions of other food products due to the substitution effect of either production or consumption.

Rational economic decisions on whether or not to reduce FLW are often subjected to information and knowledge on the measures to reduce FLW. The lack of information and knowledge can increase the cost of adopting measures to reduce FLW as they affect ability to access to technology and other measures. The government, public and private institutions could play important roles in providing immediate market and other information and affecting individual's decision making.

Improving the managerial skills, particularly for small farmers in low-income countries could reduce the economic cost greatly. Much of the FLW is also associated with management in storage, transportation, cold chain, packaging and a lack of integrated supply chain. Formal and informal trainings to producers are necessary to reduce such costs.

Low-income countries usually face the problems of missing well functioningmarkets. For example, farmers, food industry and retailers often lack access to the credit market, which could pose serious constraints for making rational and necessary decisions on their investments to reduce FLW. Improving road and marketing infrastructure can also significantly reduce the cost of taking many measures to reduce FLW.

When weighing economic costs and benefits, sanitary concerns and the impact on the environment should also be considered. It makes economic sense at the small scale, by lowering household food bills and at the large scale by reducing disposal costs for restaurants, processors and farmers. Developing cold chains in low-income countries isimportant for sanitation though they are costly to set up and manage and consume more energy. Reducing losses for fresh products could also have environmental impacts as they often require either refrigeration or quicker means of transport, or both.

3.7.2 Food losses and waste reduction: winners and losers

When there is a solution or measure taken by any decision maker to reduce FLW, the costs and benefits are often borne not only by the decision maker but also other stakeholders along the food chain and the other sectors related to the food markets. Any analysis should thus consider potential winners and losers in the whole food system. It should also consider how FLW was used (e.g., used as feed for animal) or disposed.In particular the analysis should consider whether the poor producers and consumers gain from FLW reduction. It should consider all the impacts of the proposed change to reduce FLW. See above the example of Plastic Food Containers in Brazil.

In general, reducing FLW increases food supply and drives down the food price, which has different implications to various stakeholders in the whole food system. The stakeholders who taken

economic viable measures to reduce FLW in either harvest or storage or transportation or processing or marketing benefit not only themselves, but also make consumers benefit , particularly the poorer consumers, due to lower food prices. However, all the other stakeholders in the same stream of the food chain can be losers. For example, if the harvest losses could be significantly reduced by the large-scale and wealthy farmers in a country, while most of the stakeholders downstream thefood chain would be beneficiaries, the small-scale and the poor farmers in the same county who would not be able to reduce their harvest losses but receive the lower farm-gate prices would end upas losers.

Winners and losers from FLW reduction also differ by the type of foods. The poor generally consume more staple food (e.g., cereal, cassava and sweet potato) and less meat and other high-value products than the rich consumer, they benefit more from FLW reduction in staple food. While the efforts to reduce FLW for high-value products benefit all consumers, the poor gain relatively less than the rich. It is worth to note that many small-scale and poor farmers are both food producers and consumers, they could either be winners and losers from overall FLW reduction in the market depending on how much losses of agricultural products could be reduced by them, the prices received, and price changes of other foods purchased from the market.

The effect of reducing FLW also depends on the means taken. For example, if the FLW reduction is done through improved technology and infrastructure, both consumers and producers could be winners. If the reduction of FLW is achieved with high investment cost after farm-gate and raise food price in the market (e.g., passed the investment to the downstream), both consumers and producers are losers. The producers become losers because the farm-gate price does not change and market demand for agricultural products fall as the food price increases.

Box 11 Saving money through waste reduction

Many companies are making money by reducing food waste in processing and services in North America and Europe. The advertisers in the yellow pages providing solutions for the reduction of losses, inventory controls and even use of leftovers is huge. Creative solutions designed through the use of computer technology allow huge savings.

This is the case of systems that make monitoring of all operations in the production of meals, photographing the leftovers and weighing the quantities discarded. In the modern systems it is possible to calculatethe cash values that were being lostby informing the type of food being discardedand itsweight, using a scale attached to the computer.

A similar system but public domain was developed by EPA - Environmental Protection Agency of the United States and consists of a series of Excel spreadsheets that do all the calculations for companies that manage industrial kitchens, restaurants convenience stores , hotels and hospitals etc. . Each type of wasted food is selected and valued according to a standard cost. At the same time, the system calculates rebates owed by allocating the leftovers depending of their destination (rescue , animal feed and composting) and the total emission of greenhouse gases generated by waste. Based on these worksheets it's easyto devise a policy to reduce losses to the horizon 1-10 years (see http://www.epa.gov/foodrecovery/tools/index.htm) .

It is worth to stress that, in the case of unrecoverable losses, likewise there are a large number of companies offering anaerobic digesters that allow the generation of combustible gases that could reduce food production costs.

3.7.3 Utilization of surplus food that is saved

While it is important to reduce FLW from the perspective of food security and alleviating poverty, how to distribute the saved food poses a difficult question to all participants in the food market. Surplus food redistribution has been promoted as a way of reducing FLW. Past studies have focused on the use of surplus food as if it is beyond the market mechanisms. This is challenged by recent research which says the practices are never independent of their market attachment, environmental and social relations. Based on a case study in England, Midgley (2013) concluded that unless we distinguish between genuine waste to be recovered and surplus to be redistributed for community benefit, surplus food as a resource is unlikely to be fully utilized; inequalities in market powers along the redistribution chain, property rights and other legal issues related to surplus food will affect the efficiency and fairness of the redistribution.

In some cases, reducing FLW has obvious benefits when the effort to save is not too costly and the use of redistribution of saved food is easy. For example, in a small agricultural economy based on small household farming, the saved food from production and postharvest processing could be saved in the households' warehouse and used by the household later at low cost. This type of saving food could help alleviating hunger and poverty. For consumers, not ordering too much food in the restaurant and having more considerate purchasing budget also generates the right signals to producers as to what the "real" demand is in the market. At the same time, consumers will have additional budget for other products.

In other cases, efforts to redistribute the saved food could pose new risks regarding food quality, cost of transport and preserve, and a potential impact on local food prices. Redistribution food requires additional labor, storage, examining and monitoring. If the saved food is too scattered, hard to identify the quality, or difficult to be transported to people in need, then the effort to save should be carefully evaluated.

Box 12 India's Food and Nutrition Security Act 2013

India faces a unique development paradox of being in the front ranks of fast growing global economies, with about 25 percent of the world's hungry poor. Although the country grows enough food for its people, pockets of hunger remain. According to some figures, around 40 per cent of children under the age of five years are malnourished and nearly half of all pregnant women aged between 15 and 49 years suffer from anemia. Nutrition is crucial for fulfillment of basic human rights and forms the foundation for meaningful human existence with decreased susceptibility to infection, related morbidity, disability and mortality, better learning capacities and adult productivity.Agricultural growth is crucial for our economic development and Food security. Over the years due to concerted efforts of government, India has emerged as a leading producer of some cereals and animal products. Government of India has also launched several schemes to further increase the growth in agriculture and boost farm production to establish sustained food systems in the country.Further in order to provide food and nutritional security to the people by ensuring availability of food at affordable prices, Government has enacted National Food Security Act, recently. The National Food Security Act is a historic initiative for ensuring food and nutritional security to the people. It gives right to the people to receive adequate quantity of food grains at affordable prices.(National Food Security Bill 2013, The Gazette of India)

TheNational FoodSecurity Act to provide for food and nutritional security in human life cycle approach, by ensuring access to adequate quantity of quality food at affordable prices to people to live a life with dignity and for matters connected therewith or incidental thereto. The Act covers Provision for Food Security, entitlements for the eligible households, pregnant women and lactating mothers, Children up to the age of 4 years fortheir nutritional needs, provide meals, free of charge, to children who suffer from malnutrition, so as to meet the nutritional standards, provisionfor foodsecurity allowance, undertaking reforms in TargetedPublicDistributionSystem, Women Empowerment, Grievance Redressal Mechanism, Obligations of Central, State Governmentsand Local Authorities, Transparency and Accountability, The Actalso provides ProvisionsforAdvancingFoodSecurity- give special focus to the needs of the vulnerable groups especially in remote areas and other areas which are difficult to access, hilly and tribal areas for ensuring their food security.

Source: Provisions for advancing food security; National FoodSecurity Bill 2013 - The Gazette of India, Ministry ofLaw and Justice, Government of India, DFID. Sustainable Livelihood Guidance Note.

The Strategic role of food banks

Almost fifty years ago in Phoenix, Arizona (US), a group of volunteers lead by John Van Hengel started to collect food donations to feed the poor from the parish of St Mary. That was the initial step for the inauguration of the first structure known as a Food Bank. Today the Food Bank movement gathers thousands of organizations and millions of volunteers around the world.

Most of the donations received by Food Banks come from processors, wholesalers and supermarkets. These firms donate food that has little commercial value but is good and healthy for consumption. Sometimes food processors face problems in packaging, labeling or cancellation from buyers and the products can't be delivered. Difficult situations are also very common in the distribution stage of the food supply chain, such as: expiring merchandise; unmarketable bruised fruit and vegetables or changes in the consumer motivation due to weather or other concerns. Instead of dumping or burning this food, which would cost not only in financial terms but also in bad publicity for these companies, the local Food Bank could pick up and distribute where needed.

Initially implemented in developed countries where the scale of waste is proportional to the abundance, this concept was later adopted and disseminated throughout the world. Emerging as community initiatives, food banks in developing countries are basically non-governmental initiatives. The role of national governments is essentially to guarantee an institutional environment that favors donations, with respect to tax incentives and to encourage civil responsibility ("Good Samaritan" laws).The creation of national food bank networks contribute to reinforcethese incentives.

In order to give incentives and facilitate the donations President Clinton proclaimed the Bill of Good Samaritan in 1996, that exempts donor companies from taxes and penal responsibilities. This act was a watershed and boosted the movement of Food Banks.After that many other countries have followed suit but there are deep differences in terms of taxes and liability.In Canada, for instance, the Canadian Association of Food Banks within their 1,927 food programs has helped 872 thousand people (2,54% of the national population assisted). In 2012 companies and citizens donated 38 million Canadian dollars and morethan 8 thousand tons of food without any tax incentives. Mexico is another country that has an active and important Food Bank Association (65 Food Banks associated) and collected 1.7 thousand tons of food in 2012, but in this case, companies have incentives in their income tax to donate food. Moreover, firms have to communicate to the fiscal authorities about the food destruction and offer this food to donation through government tax office webpage 30 days in advance.Both Canada and Mexico are participants and founders of the Global FoodBanking Network, an organization that is present in 23 countries and is projected to reach the goal of 418,000 tons of food in 2013. Feeding America is the largest world network and has a huge program of donations to institutions working with 200 food banks in every state of the country. In the US,food donation is eligible for an enhanced tax deduction and the money donated can be considered for income tax reduction purposes. According to the Feeding America Annual report, the organization collected the impressive quantity of 1.3 million tons in 2012 to be distributed through mobile pantries, hot meals in cafeterias, food baskets and used food banks to seek beneficiaries of SNAP (Supplemental Nutrition Assistance Program – formerly Food Stamps Program).

On the European continent the food banking movement is also strong. The first food bank was created in 1984 in Paris, and two years later, the European Federation of Food Banks (FEBA) was founded. This organization gathers 253 Food banks in 21 countries and collected 388.000 tons of food donations in 2012. In addition to the tax benefits provided to businesses (Good Samaritan laws), 13 European Member States allow VAT exemption on donated food. In Europe the FEBA, Red Cross and other humanitarian organizations could receive for free products directly from the State Intervention Stocks, which is an important component of the Common Agricultural Policy.

Since 2009 the European Agricultural Policy is reducing its interference in the food commodity market redirecting the budgetary amount used to support remunerative prices guaranteed throughthe government procurement todirect aid to farmers. On the other hand the need of food for donation has increased in order to face the food security problems of those affected by the recession.As these publicstocks were shrinkingand considering the outbreak of economic crisis with millions of citizens in deprivation, the agricultural authorities have decided to complement these stocks with food purchased in regular market. Recently the Court of Justice of the European Union has determined the end of these acquisitions and the replacement of the interventions stocks but the European Parliament, in turn, decided to maintain this policy under a new regulation but reducing the amounts that would be transferred to this market acquisitions.

In such cases, it is important to emphasize that, although the food banks are acting to meet the demands for food from a population in need, they use here a surplus arising from the European agricultural overproduction. The use of food banks for the allocation of government procurement carriyingout a policy in agriculture is widespread. In some countries, even the food banks are public and act as a tool for agricultural policy and income generation for certain segments in the countryside. The government of Brazil and other Latin American countries have programs to encourage the production of farmers with a commitment to purchase these provisions for distribution through food banks. The same is happening in India where the central government company (FCI – Food Corporation of India) apart from selling its products directly to the population by Public Distribution System, donate grains to Food banks and other Welfare institutions.

The World Food Program is a major buyer of rice and wheat from India public stocks. According to WFP 2012 Food Procurement Annual Report the organization acquired 2 million tons of food (roughly US$1.1billion) in 2012 out of which 318,275 tons in India. WFP is expanding its purchases of food directly from smallholders to be distributed on the premises under the program P4P (Purchase for Progress)The organization no longer accepts donations of food surpluses from

developed countries and the developed countries must contribute in cash. The transportation in long distances between the place of food procurement and the receiving regions only happens in catastrophes when the emergency requires that the affected populations should be assisted quickly.

Local Food Banks also have an important role in case of emergencies. In Japan, where the organization Second Harvest was created in 2000 to assist the growing number of poor peopleits participation in the relief to disaster victims was crucial.In 2012 the donations reached the level of 3,500 tonnes, driven by the emergence of disasters like the 2011 tsunami. In the U.S., Canada and several European countries, the food distribution programs are essentially non-governmental havingbeen created to reduce food waste, promote volunteerism and benefit poor families who depend on others to survive. Thus, the origins of the food banks are associated with local philanthropic initiatives, many of them of a religious nature, founded on principles of solidarity, community help and cooperation with a strong interest in reducing waste, now identified with environmental causes and rational consumption. In general we might say that the food banks have emerged and prospered as a non-governmental initiative in countries characterized by abundance and a strong culture of community resulting from shortages in times of war, intolerance of waste and solidarity.

Different types of products - from the most perishable, to processed and industrialized, make the food banks operations very complex. There are institutions that collect food from the neighborhood to serve the local public and they are called primary Banks, but it's alsopossible to identify Food Banks in a secondary and tertiary level.Tertiary Banks must receive food from others Banks and deliver these goods very fast to catastrophe victims or needy people, sometimes onthe other side of the country. The most efficient food banks have only a small food storage capacitybecause the donations should be delivered to their destination very fast for food safety reasons.

Recently, Russia inaugurated a new phase in the technology of food banking. From Moscow a small staff commands virtually all the operations of the FoodBankRus covering the vast Russian territory, collecting food in one part, mobilizing transportation and sending this food to the social institutions wherever they are. The virtual procedures allow the bank to collect donations in a country where the philanthropy concept is new to make them reach the beneficiaries very fast.

Food Banks' operations depend directly on the will of food chain companies, to receiving and sharing information about foods that are losing their commercial value or agricultural products that are ripe and ready for harvesting but whose market prices do not cover production costs. The operations need also the voluntary involvement of other specialties that have a secondary role in the food chain, such as logistics, information technology and legal services. The close collaboration between the food banks and private business demonstrates that it is possible to build a new sustainable economic framework in order to avoid losses and waste. A good example of these joint projects is the campaign " Every Crumb Counts " signed by the European Federation of Food Banks and the European retail sector promoting four types of actions to reduce losses and waste, as follows: prevention, redirection of food waste to feed people, animals and the recovery of soil and energy production from food residues.

Box 13 Honouring food to prevent food waste -the Indian context of heritage

The UN's theme: Think. Eat. Save: Reducing Food Print, puts the spotlight squarely on the imperative need to eliminate the wastage of food all over the world. In this context, perhaps the West has much to learn from the East, which has traditionally seen food as sacred. Thatbeing so, the culture has strongly emphasized thevital need to respect food and toreceive it as an offering from the Divine. There is so much more to food than just a medium to stanch hunger or whet the taste bud. Most of us sense this instinctively, but the Upanishads (Philosophical texts of Hindu religion) actually puts it down in black and white.

From these guidelines has arisen much of Indian cuisine. Since freshness was considered imperative, food was cooked and consumed almost instantly. Each meal was freshly prepared, with very little carry/leftover. To ensure that there was no wastage, the amount of food required for the household was measured and made judiciously. Leftovers were however ingeniously reused, for waste was considered sacrilege. Even today many of these practices still prevail, though the widespread use of refrigeration and the convenience of cooking in large quantities have come in the way of eating fresh food.

Source: www.lifepositive.com

3.8 Food Laws for preventing food losses and waste – What is the present state of public policies?

Disclaimer: this section will be completed using the ongoing work of OECD, Fusions etc., and the results of the e-consultation. Suggestions for inputs are particularly welcome

In the developing world, transfer of existing technologies and the spread of good practices, allied to market-led investment, have the greatest potential to reduce food waste across the FSC. It is of key importance, however, that practical developments address the problems of local farmers, using indigenous knowledge where that has been shown to be sustainable. Without participation of local farmers, such knowledge transfer is unlikely to succeed.

While attempts to shift consumer behaviour *may*result in reduction in food waste in developed countries, changes in legislation and business behaviour towards more sustainable food production and consumption will be necessary to reduce waste from its current high levels. An example might be through the development of closed-loop supply chain models (WEF, 2010). In such models, waste of all forms would be fed back into the value chain (such as packaging waste being re-used), food graded as lower quality for cosmetic reasons and food that is surplus to retailer or manufacturers, to be made available through alternative routes (as cheaper alternatives), while unavoidable food waste would be utilized as a by-product, e.g. in providing energy from waste using the appropriate technology.

European Union policy goals reduce food wastes

The European Commission wants to help consumers cut food waste by making 'best before' and 'use by' dates clearer on the packaging. With almost 80 million European citizens living beneath the poverty line and 16 million depending on food aid, the European Parliament has launched a crusade against food waste.[16]

Up to 50% of edible and healthy food is wasted in EU households, supermarkets, restaurants and along the food supply chain each year, the Parliament said, calling for urgent measures to address the issue.

In a resolution adopted in January 2013,[17] legislators called on the European Commission to halve food waste by 2025, by adopting a comprehensive range of measures.

European Commission looking at clearer labelling rules for consumers. On the consumer side, labelling is often misinterpreted due to the lack of understanding on the distinction between the 'best before' date (quality criteria) and the 'use by' date (safety issue).

At EU level, the European Commission is considering to adopt a carbon dioxide labelling scheme for commercial products that could include a grading system for food and other products similar to the well-known energy consumption labels seen on fridges and washing-machines.[18]

FAO and Messe Düsseldorf lead the SAVE FOOD - Global Initiative on Food Loss and Waste Reduction

FAO and Messe Düsseldorf are collaborating with donors, bi- and multi-lateral agencies and financial institutions and private sector partners (the food packaging industry and others) to develop and implement a programme on food loss and waste reduction.

The start-up plan for this global initiative rests on four main pillars:

1) **Awareness raising** on the impact of, and solutions for food loss and waste. This will be achieved by a global *communication and media campaign*, the *dissemination* of Save Food programme findings and results, and the organization of*Regional SAVE FOOD Congresses*.

[16] http://www.euractiv.com/cap/parliament-pushes-slash-food-was-news-510225

[17] http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P7-TA-2012-0014&language=EN&ring=A7-2011-0430

[18] http://www.euractiv.com/specialreport-prods-green-planet/eu-wants-carbon-labels-tin-news-513629

Important goals are increased knowledge and changed behaviour of actors and consumers in the food chains, and promotion of the SAVE FOOD initiative to attract partners.

2) **Collaboration** and coordinationof world-wide initiatives on food loss and waste reduction.SAVE FOOD is establishing a global *partnership* of public and private sector organizations and companies, that are active in the fight against food loss and waste. In order to develop, plan and implement interventions and use resources most efficiently, it is essential that all these initiatives are being coordinated well, so that everybody knows what is happening world-wide, that information, problems and solutions can be shared, and that methodologies, strategies and approaches will be harmonised.

3) **Policy, strategy and programme development** for food loss and waste reduction. This includes a series of field studies on a national-regional basis, combining a food chain approach to loss assessments with cost-benefit analyses to determine which food loss reduction interventions provide the best returns on investment. Further, the Initiative undertakes studies on the socio-economic impacts of food loss and waste, and the political and regulatory framework that affects food loss and waste.

4) Support to **investment programmes and projects**, implemented by private and public sectors. This includes technical and managerial support for, as well as capacity building (training) of food supply chain actors and organizations involved in food loss and waste reduction, either at the food subsector level or policy level.

Although food losses and waste occur at all stages of the food supply chain, the causes and their impact around the world differ. In developing countries, food losses affect small farmers the hardest. Almost 65% of food losses happen at the production, post-harvest, and processing stage. In industrialized countries, food waste often occurs at the retail and consumer level due to a “throw-away” mindset.

It is this difference that the SAVE FOOD initiative is targeting by focusing its efforts in strengthening food supply chains in developing countries beginning in Kenya and at the same time raising awareness of food waste in industrialized countries.

The studies will cover seven (7) countries including Cameroon, India, Myanmar, Senegal, Thailand, Uganda, and Viet Nam and will examine the following commodity groups: cereals, fruits and vegetables, roots and tubers, milk, meat and fish.

Policy information on food loss and waste in China

Food losses and waste is attracting growing concerns from Chinese government. The efforts to reduce food losses have been made mainly in government’s food storage in the past three decades and farmer’s grain storage through experimenting Food Bank (see Box 14) and storage infrastructure subsidy program in recent years. This subsidy program has been piloted in three major grain production provinces in 2007 and planned to expand to 24 provinces in 2016. The program is targeted to cover eight million farmers and estimated 5.5 million tons of farmers’ grain storage . The Development Plan for the Vegetables Industry by the National Development and Reform Commission and Ministry of Agriculture has also planned to significantly reduce postharvest losses of vegetables in 2011-2020.

The efforts to reduce food waste have also attracted great attention by government in recent years. For example, almost in every other year since early 2000s, the Legislation Affairs Office of State Council made a leadership campaign on food waste reduction by reducing government and public institution’s spending on official and business meals, particularly food banquets and receptions. In recent years, each government organization has to publicize its annual food expenditure along with total expenditure. At the end of 2012, a more strict campaign against government food waste is launched under the new central government leadership. The effect of this campaign is remarkable. According to the Xinhua News Agency report, the sales of high-end restaurants in Beijing and Shanghai have declined by over 35% and 20%, respectively, in the spring festival of 2013 comparing to last year.

Public media has contributed to campaign against food waste by both government officials and regular consumers. Since the beginning of 2013, CCTV, the national level and state-run TV station, and a number of TV stations at provincial level have launched a series of public advertisements for food waste reduction campaign (see Box 15).

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Box 14 Warrant experiment in China: a financial innovation to reduce postharvest food loss

A survey from the State Grain Bureau of China in 2009 showed that the average loss of grains stored by rural households reached more than 8%. The loss was mainly due to the poor storage infrastructure. Among various efforts to reduce postharvest loss, one noteworthy effort is the experiment of Warrants (also called "food bank" in China). It is a quasi-financial arrangement that allows farmers to "save" grains in a grain trading company and farmers have the ownership of the grain while the company has the use right. Then the company earns profits by trading grains and part of that profit is returned to farmers as "interest".

An experiment of warrant was initiated in 1980s in Guangrao County in Shandong Province. The Guangrao county court started a business called "liangdaiyihuan" in which the court would preserve, process and exchange grains for the farmers. In 2007, the first official Food Bank was set up in Taicang County in Jiangsu Province. This system has the advantage of drying, processing and storage for rural households and thus reduce the food loss.

The system has expanded in recent years. Major grain production provinces such as Heilongjiang, Henan, Sichuan and Hubei have all started the experiments on warrants. In 2011, Taicang County in Jiangsu Province estimated that Warrants had saved 3900 tons of grains for the county every year.

However, such an expansion is facing challenge. For example, in Changle County in Shandong, more than 90% of warrants suffered a loss due to the large fluctuation in grain prices. The National Development and Reform Commission has attempted to advocate for the warrant as a new arrangement to preserve grains and increase flexibility in the agricultural food market. However, due to the experimental nature of the system, many legal and financial issues are not clarified.

Source: http://www.gdcct.gov.cn/market/feature/food_banks; http://www.ebdoing.com/Html/News26.htm; Liu and He, 2012.

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Box 15 Campaigns against food waste in China, South Korea and Japan

Food waste in Asian countries in general is lower than in Europe and the US. In recent years, many countries have put more attention on reducing FLW through raising consumers' awareness, improving ways of preserving food and adjusting retailing practices.

China: "Empty Plate" Campaign

The recent "Empty Plate" campaign in China draws people's attention to the food waste. The campaign was initially targeted on public food consumption and reception and banquets. In fact, the campaign has reached beyond government officials and has also significant impact on ordinary people. Anecdotal evidence suggests that since the start of the campaign in January 2013, there has been a significant reduction in restaurant food wastage.

South Korea: "Half-bowl" Campaign and a New Container

In South Korea, a similar campaign, the "Half-bowl" campaign, encourages people to order half a bowl of rice to reduce food waste in restaurants. It was expected to reduce restaurant FLW by 20% by the end of the year. Some companies invented a new kind of food container, which adds an extra layer inside to exclude air and moist to slow down the rotten process.

Japan: Delivery Date Extension Experiment

Japan experimented on extending the delivery date to reduce FLW. Customs in the Japanese food industries requires a "1/3 rule" which says food products that exceeds one third of the expiration time cannot be delivered to retailers. Participating companies will extend the food delivery date to ½ expiration time from 1/3 expiration time.

Source: http://www.bbc.co.uk/news/world-asia-china-21711928; http://e-jen.net/html/newpage.html?code=1; http://intl.ce.cn/sjjj/qy/201307/15/t20130715_566223.shtml

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3.9 Reducing FLW: towards more sustainable food systems

Reducing food losses and waste is essential to improve the sustainability of food systems. As such it can be part of broader systemic changes. Such changes towards better efficiency and sustainability can also involve actions to improve the valorization of co products and of food related waste.

Some countries have started to define strategies and targets, most of these actions have not been assessed. Countries that have set official governments targets to reduce FLW are: UK (2000), South Korea (2008), Japan (Food Recycling Law in 2001), the Netherlands (2009), France (2013, Spain (2013), Austria (2012). A majority of these are European countries. The European Commission (2011) has set a target to reduce FLW by50% in 2020 as part of the Flagship resource-efficient Europe, initiative under the Europe 2020 Strategy (EC, 2011).The 2008 Waste Framework Directive requires Member States to establish National Waste Prevention Programmes and objectives by December 2013. The European Commission should by the end of 2014 also set waste prevention and decoupling objectives for 2020 based on best practices. Member States have been encouraged to include food waste prevention policies and targets in their National Waste Prevention Programmes. More realistic ambitions and targets from the EC can be expected as part of the Communication on Sustainable production (early 2014).

Box 16 Courtauld Commitment (UK)

Results of Phase 1 were reported end 2012 (reduction 13% of food waste). Results of Phase 2 are expected to be reported end 2013. Phase 3 has been launched Q1 2013. Courtauld is a voluntary agreement, high urgency because of environmental drivers (avoid landfill). Source of information: WRAP.

South Korea achievements: A total of EUR 581 million was provided by the South Korean government to save 14,452 tonnes of food waste per day in 2008. This means that a total of 5,274,980 tonnes of food waste were saved in 2008. The expected outcome of the food waste policy is a 20 per cent reduction in the volume of food waste by 2012 compared to that of year 2010.From: DG ENV, Economic Analysis of Resource Efficiency Policies, August 2011.

3.9.1 Valorisation of by-products and side streams

Within the food processing sector, substantial parts of the raw materials that enter the factory are ultimately traded as by-products (see Table 2). Direct utilizationof these streams for food would require alternative (and generally technically more complex) processing than the chains' primary product.

Hence, a large part of these side streams is only poorly valorized: for animal feed, technical applications and fertilizer production (through composting).

Waste stream valorization: Alternative sourcing of gelatin

Confidence in traditional sources of gelatin (amongst others bovine hides and bones) was seriously damaged by BSE breakout. Increase of gelatin prices has been a trailblazer for alternative production processes. A successful example is the Dutch company Ten Kate Vetten; their production process (primarily aiming at extracting fats from pig slaughter by-products) was innovated so that high-quality gelatin can be isolated from their processing water. The (mild) fat extraction process furthermore enabled valorization of other protein products in pet feed. Key success factor: development of a patented innovative process that enabled valorization of high quality gelatin. External factor: market-demand for gelatin from a safe source due to BSE breakout.

Table 2 Food processing side streams (mass-% of crop)

Type of food	Production process	% of input
Fish	Canning	30-65%
	Filetting + smoking	50-75%
Meat	Beef slaughtering	40-52%
	Pig slaughtering	30-40%
	Poultry slaughtering	30-40%
Dairy products	Milk, butter cream	0%
	Yoghurt production	2-6%
	Cheese production	85-90%
Fruits & vegetables	Juice production	30-50%
	Vegetable oil	40-70%
Commodities	Corn starch	40-45%
	Potato starch	80%
	Wheat starch	50%
	Beet sugar production	86%

Source: European Parliament (2013)

Waste stream valorization: production of potato protein from potato processing waste water

Recently the Dutch potato starch processing company AVEBE started recovering proteins from what was previously considered waste water (in a new company called Solanic). Based on the average annual throughput (2.5 million tons potatoes, grown on 55,000 hectares, delivering 700,000 tons starch) the AVEBE/Solanic production potential is estimated at 25 to 30,000 tons high quality potato proteins (FoodChain, 2009). This new, by-product based, source can replace 15,000 protein crop cultivation (average protein productivity is about 2 tons/hectares (Vereijken and Linnemann, 2006).

Box 17 Rice bran utilization in india

India is a leading producer of rice and a large quantity of rice bran is produced in hullers and traditional rice mills butthe quality of rice bran produced was poor due to high fatty acids. The rice bran produced was not pure and mixed with rice husk particles and was used mainly for boiler feeds and for soap making industry. R & D work carried outin national laboratories and other institutions to stabilize rice bran in order to recover valuable rice bran oil rich in antioxidants which could be used for edible purposes. The process of recovery of edible oil from rice bran is by solvent extraction process and during this process a large number of valuable by products are obtained. This has boosted the value addition to rice bran utilization in the country and presently a major part of rice bran which is produced in rice mills goes for extractionpurposes. Ediblegrade rice bran oil is presently used as cooking oil and also being marketing as ‘health oil’’ in combination with other edible oils.

This is a typical example of intervention of high science and technology which is instrumental in reducing the losses in the rice mill value chain and high by products value addition.

4 CONCLUSION AND POTENTIAL AREAS FOR RECOMMENDATIONS

Despite data gaps and lack of available data on food wastage in many countries (for example, data on post-harvest losses does not exist for certain developing nations, whereas retail and household level food waste data is available only in very few developed countries), the magnitude of food losses have been assessed, and most of the causes of food losses have been identified.

In most food systems, FLW are important, and have a direct and direct incidence on food security and on the sustainability of food systems -and therefore potential long term impacts on food security.

Reducing FLW can provide an important contribution to improving the sustainability of food systems and food security. It would also be the sign of improvement in the broader area of resource efficiency.

To a great extent understanding and preventing food losses and waste requires a deep understanding of food systems (Ericsen 2008, Ingram 2011) as a whole, including their context and specificities. This is because causes of FLW go all along from production to consumption, because they are driven by technological, economic, social, institutional, cultural and behavioural causes, because they are very diverse and most of the time driven by systemic causes.

The exact causes of food losses and waste vary throughout the world and are very much dependent on the specific conditions and local situation in a given country. Currently, the assessments are extremely rough, and still unknown are the attribution of food losses per specific driver/cause, making it difficult to prioritize actions and decide on quantitatively most effective interventions.

In this context, reducing FLW often requires not only direct -often technical- solutions, but also to understand and address systemic causes. This calls for a more holistic approach of FLW as part of a broader improvement of food systems towards food security and sustainability, as FLW are potential resources that can be used for food security. As such reducing FLW can improve sustainability not only directly but also indirectly, by the actions needed, including better cooperation between actors.

There are a wide range of approaches towardsreducing food losses and wastes. Technical, policy tools, information etc., taking into account regional and product specificities, as well as actions at different levels of Food Supply Chain (FSC). There is a potential for better valorization of food waste and food related waste, including modifications of food systems in place. Appropriate programmes and instruments need to be looked into for reducing food losses and food waste. Factors like the role of governments, consumers, social actors and other stakeholders, private sector and social responsibilities are also vital in reducing food losses and waste.

There is a need to take a holistic approach right from the farmer (production stage) till the food reaches the consumer (consumption stage) in the domestic and international market. A range of approaches are possible across the various stages of Food Supply Chain (FSC). Some interventions such as cold chain and evaporative cool storage for storage of food directly affect FLW, while other approaches like consumer awareness, education, campaigns, training on food loss and waste prevention, skills, the concept of healthy diet, indirectly affect FLW by influencing consumer behavior.

The role played by women in the prevention of food losses and waste need immediate attention. Womenplay a key role in reducing food losses in developing countries and the challenges faced by poor women in food loss reduction should be analyzed and documented.

An assessment of existing food supply chain (FSC) and logistics of food products in developing countries is to be viewed with a multidisciplinary and integrated approach. The target of the proposed integrated approach to supply chain design and management is the simultaneous control of quality, safety, sustainability and logistics efficiency of food products and processes along the whole FSC “from farm to fork”: Improving food losses and waste is one of the way to improve the sustainability of food systems. However it shall not hide all other ways and issues to address in order to make food systems more sustainable, ways which lead to improve their efficiency, as well as ways which improve their resilience. And there is a long list of actions which ranges from

addressing agro-ecosystem stresses like soil degradation, adapting to climate change, to consumer related issues such as changing diets, biofuels, food consumption trends and fight against obesity. Some of these solutions to render food systems more sustainable will have the side effect to also reduce FLW, creating a positive sustainability loop.

From above angles, it is imperative to reiterate that the problem of addressing food loss and waste is highly complex. Just as soil degradation drives poor nutrition, unhealthy consumer preferences for cheap fast foods also send wrong signals back down the food value chain and into homes and soils of farmers across the world. It is like an integrated food web with various cross linkages with not only physical strands but also cognitive and behavioral patterns.

It is important to note that many technical solutions can be effective only when other parts of the Food Supply Chain (FSC) are effective. Can we look forward for a zero food loss and waste food supply chain locally ? globally? A big question mark! But the losses and wastes can be minimized with an integrated supply chain approach, with multiple cross linkages.

By 2050, the world will need about 60 percent more calories per year in order to feed 9 billion people.[19] Cutting current food loss and waste levels in half would shrink the size of this food gap by 22 percent.[20] The world faced an analogous situation in the 1970s with the energy crisis. In the face of record oil prices and growing demand, several industrialized nations essentially declared war on energy wastefulness, significantly improving their energy efficiency. A “war on waste” has yet to be waged when it comes to food. Given that food prices have hit historic highs and global demand continues to rise, now is the time to start slashing food waste and loss.[21] A sense of urgency is essential for real commitments, so that the problem and possible solutions are taken up with the seriousness and timeliness they deserve.

4.1 Possible areas for recommendations

(Work in progress - D R A F T)

1. A first recommendation could be to better integrate food chains and food systems perspectives in any food security and nutrition and agricultural strategy or action.

- Reduction of FLW shall be systematically considered and assessed as a potential mean to improve agricultural and food systems efficiency towards improved FS. It requires to analyze direct and indirect causes of FLW in a given system and to identify hotspots where it would be most efficient to act.
- Methodologies and tools should be prepared to enable all actors to conduct suchanalyzes. FAO could undertake this work, building upon its experience, and with partners.

2. A second recommendation is to consider and assess potential solutions to reduce FLW taking into account constraints (including systemic constraints), costs and potential direct and indirect impacts. This requires identifying the actors who will be directly implementing solutions, the costs they will be bearing, potential benefits and who will benefit. It also requires to identify constraints and what would enable to overcome them (technologies, infrastructures, changes of organization in the food chain/system, training, capacity building, policies and institutions). A methodological tool or guidance usable by the various actors would be of use here.

3. Most of the causes of food losses are driven by one or more main causes: lack of adequate technologies, inappropriate practices, lack of infrastructures, lack of organization (of governance?) in the food chain/system. After the initial stage of awareness and identification of hotspots, potential solutions should be integrated in a broader perspective; including in investment strategies for smallholder agriculture for instance.

[19] http://www.wri.org/blog/great-balancing-act-3-needs-sustainable-food-future

[20] http://www.wri.org/publication/creating-sustainable-food-future-installment-two

[21] *Ibid.*

4. FLW often reveals a lack of relations inside the food chain/system: lack of communication, lack of valorization/recognition of efforts needed/made at one stage to reduce FLW at another stage (downstream or even upstream). This calls for improving governance inside food chains, involving all actors (including public and private ones) and to organize collective understanding and action. It requires to appropriately share efforts/benefits of FLW reduction.

5. Importantly FLW could often be an entry point to broader improvements of food systems towards food security, food safety, quality and sustainability. This calls for a holistic food chain approach, with adequate research and extension services, including towards small transport, transformation and distribution enterprises.It can also call for the development of closed loop supply chains.

6. Addressing food waste at consumer level calls for a variety of approaches, linked to the concept of sustainable consumption and production. It should be given a priority in policies (since businesses have insufficient focus on this) and linked to broader policies such as dietary guidelines and waste valorization. It requires dedicated efforts in research, training, communication and capacity building oriented towards consumers.

7. Finally, there is a need for a coherence of policies across sectors and objectives: sustainable food consumption, food safety, bioenergy, waste.

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APPENDICES

A1 Causes of FLW by stages in the food chain

Primary causes of FLW can be very diverse: Agromomic, Biological, Chemical, Mechanical, Physiological, Psychological, etc.

The causes below could be designated as “secondary” causes, in so far as they directly encourage a primary cause of loss.

In addition one could identify systemic causes, which can drive/encourage secondary causes.

Pre-harvest

- Poor choice of varieties for location and target market
- Poor agronomic and cultural practices (water/nutrient/pest management, pruning, staking/propping…)
- General lack of information of good production, harvest and postharvest handling practices due to poor agricultural extension services for small holder
- Poor market access
- Poor organization among farmers into groups/cooperatives/associations to access services and facilities; to pool their produce for better market access, meet contractual obligations
- Lack of accessing to processing facilities in the production areas forcing the farmers to transport their produce to distant processors
- Lack of schemes that promote or facilitate utilization of unmarketable foods e.g. donation, cottage processing industries in production areas, farmers markets

Harvest and initial handling stage

- Premature or delayed harvesting; due to poverty, fear of theft, lack of information on maturity indices, labor shortages
- Poor harvesting techniques leading to spillage, mechanical injuries, heat injury
- Poor choice of containers, packaging materials appropriate for the harvested commodities
- Poor sanitation and hygiene standards especially of containers used to pack and transport the produce
- Improper drying for grains resulting in fungal infection during storage
- Improper use of agro-chemicals such as postharvest treatments leading to damage to the produce or unsafe residues; lack of enforcement of existing laws/regulations on safe use of agro-chemicals
- Lack of knowledge and capacity on good postharvest handling practices and applicable technologies among the value chain actors (growers, traders, transporters)
- Poor infrastructure for roads, energy and markets

Storage

- Lack of proper storage facilities for shelf-stable foods such as grains resulting losses from pest damage, fungal infection including aflatoxin contamination and theft
- Lack of cold storage facilities for highly perishable commodities such as fruits, vegetables, fish, meats, diary products

- Failure to use postharvest treatments/pesticides/dressing that would prevent against damage from storage pests
- Poor storage conditions; poor ventilation, poor sanitation, gas composition, lighting, mixed produce all of which favor deterioration and/or contamination of stored produce
- Lack of curing for root and tuber crops
- Poor storage conditions for root and tuber crops leading to greening and sprouting
- Failure to use applicable postharvest technologies that slow down deteriorative processes during storage

Processing

- Errors during processing resulting in defects
- Trimming to achieve desired shape and size
- Contamination along the processing line
- Lack of processing facilities; lack of capacity for existing processing units
- Seasonality of commodities such as mango, milk

Distribution

- Rough handling of produce during packing and loading/off-loading to transport tracks
- Use of inappropriate containers/packages such as sacks, polythene bags during transport
- Poor ventilation during transport
- Poor transport infrastructure; roads, refrigerated tracks
- Delays at the off-loading docks where no cooling facilities are provided
- Delays at port of entry for imported productsdue to inspection for phytosanitary compliance

Retail outlets

- Pressure to stock/display ‘perfect’ and fresh products; food that is fit for consumption is discarded
- Injudicious use of regulated chemicals to maintain fresh appearance leading to unsafe residue levels
- Wasteful displays: large piles, mixed produced, regular replenishing of stocks – those that are close to expiry risk being discarded
- Ready/processed food ventures among retailers
- Large pack sizes which force some consumers to buy what they may not use
- Product promotions and bulk discounts that lure consumers to buy produce they may not use

Consumption

- Lack of awareness, lack of shopping planning, confusion about "best before" and" use by" date labels, lack of knowledge on how to cook with leftovers (households);
- Standard portion sizes, difficulty to anticipate the number of clients (catering);
- Stock management inefficiencies, marketing strategies (2 for 1, buy 1 get 1 free), aesthetic issues (retail);
- Overproduction, product & packaging damage (farmers and food manufacturing);

- Inadequate storage (whole food chain);
- Inadequate packaging.

A2 Solutions at different stages of the food chain

Often action is more relevant to address a secondary cause than primary cause. The same holds for the systemic causes in relation to a specific secondary cause.

Preharvest/Production stage

- Choice of right varieties for location (to achieve best quality) and target market (to mature when there is demand in the market)
- Backward integration-disease resistant varieties of crops
- Proper agronomic and cultural practices to ensure high quality products – reduce losses from culls
- Proper harvest timing and scheduling for target markets
- Good harvest practices; training farmers on proper maturity indices and their importance to nutritional and economic value
- Horizontal integration (farmer organizations/cooperatives) which can receive credit/advance payment on their produce rather than harvest prematurely due to poverty
- Diversification to hedge against poverty which sometimes forces the farmer to harvest their produce prematurely
- Proper sorting/grading after harvest; separate based on size, injury and diseased/pest-infestation, different ripeness for fruits to facilitate packaging for delivery to different markets or for different uses
- Improve storagefacilities for perishablesatthe farm level
- Use of clean and appropriate containers for the commodities; raise awareness on the importance of maintaining high sanitary standards by regular cleaning of the containers
- Improve availability of agricultural extension services for small holder farmers to disseminate information requisite for good production and postharvest handling
- Improve market access; encourage and support formation farmer groups/cooperatives/associations and link them to markets, encourage contractual farming and longterm contractual agreements between growersand processors
- Facilitate utilization of unmarketable foods e.g. donation, cottage processing industries in production areas
- Improve linkages (vertical and horizontal integration) among value chain actors to improve efficiency; reduce risk of overproduction by one farmers to hedge against failure to meet contractual volumes
- Create alternative markets for the rejects/culls e.g. regular farmer markets/shops where strict quality standards are not required and are close to the consumers
- Strengthening (including through capacity building) primary producer organizations/Farmers AssociationsinGoodAgricultural Practices, GoodHarvest Practices, GoodStoragePractices, Good Manufacturing Practices and food loss prevention etc
- Organization ofsmall farmers forup scalingoftheirproduction andmarketing likeSmall Farmers Agri business Consortium in India

Handling and storage stage

- Slow down postharvest deterioration by managing contributing factors (temperature abuse, ethylene, microbial load, solanization, sprouting, contaminants)
- Improve access to low-cost handling and storage technologies (e.g. evaporative coolers, storage bags, metal silos, crates)
- Adapt applicable low-cost postharvest technologies to local conditions and promote their use among chain actors
- Train growers, traders, transporters on good postharvest handling practices applicable technologies
- Training chain actors on good storage practices such as ethylene and microbial management
- Ensure pest control protocols are followed along the foodvaluechain
- Improve infrastructure for roads, energy and markets especially in rural areas where most of the production occurs
- Public-private partnerships to improve storage facilities (including cold rooms, silos, warehouses) and transportation facilities such as refrigerated tracks for perishables
- Promote joint/group storage facilities for small holder farmers who cannot afford the facilities as individuals
- Promote innovative storage options such as the warehouse receipting system (WRS) for maize in Kenya
- Train or create awareness on food safety practices, proper use of postharvest treatments and general hygienic practices by all supply chain operators to ensure consumer protection and minimize losses from discarding unsafe foods
- Enforce existing laws/regulations on safe use of agro-chemicals

Processing and packaging

- Promote and support cottage industries in production locations to reduce the cost of transport and losses incurred in long-distance transport to far off processors
- Develop and/or strengthen linkages between farmers and processors e.g. through contracts (See above)
- Encourage staggered production of non-seasonal crops; introduce technologies for off-season production of seasonal crops (such as mango) to ensure year-round supply of raw materials to the processors
- Create an enabling environment for processors to encourage more private sector investment in processing
- Remove taxes on imported processing equipment, low taxes on local products, high taxes on imported processed products…
- Encourage and support fabrication of locally suited processing units
- Re-engineer manufacturing processes to ensure
- Improve supply chain management
- Improve packaging to keep food fresher for longer. Designinggoodpackagingto improveshelf lifeforfoodcommoditiesand processedfoods
- Develop and/or ensure processors adherence to set standards of processed foods to ensure high quality and safe foods for the consumers and reduce FLW from sub-standard products which may be pulled off the shelves
- AdaptingFoodsafetyManagement System Protocols for Technological Innovationsto reduce loss/wastesduring processing

- Better inventory management , waste audits and measurements
- Packaging, labeling and types of packs asper buyer's requirements, consumer needs of importing countries.
- Development of Cheap reusable and/or degradable packaging for developing countries.

Transport, distribution and market

- Logistics of refrigeratedcargo for shipping for overseas markets
- Develop efficient market systems especially for perishables
- link the producers with the markets by promoting horizontal and vertical integration along the supply chain
- promote commodity associations/organization/cooperativesto improve market access and efficiency of their operations
- Develop good storage facilities in wholesale/retail markets and supermarkets
- Promote proper organization and display of produce in the retail outlets (avoid mixing and piling of produce, temperature abuse by mixing produce with different temperature requirements in one common cold room etc)
- Change food date labeling practices to avoid misunderstanding by consumers
- Change in-store promotions that encourage impulse/wasteful purchases
- Provide guidance on food storage and preparation to consumers
- Improve in-store inventory Better inventory management , waste audits and measurements
- Develop markets for substandard products
- Facilitate increased donation of unsold foods

Consumption

- To encourageseasonal consumption
- Facilitate increased donation of unsold goods from restaurants and caterers
- Distribution of excessfood to charitablegroups
- Effective use ofleftovers and food products after expiry dates
- Conduct consumer education on meal planning, good storage practices, food preparation, reuse of left overs in recipes, proper interpretation of 'sell-by, best before' dates
- Reduce portion sizes
- Ensure home economics taught in schools, colleges and communities to enhance better utilization of food
- Advertisement- corporate messages about foodwaste prevention , recyclingof wasteandpackagingmaterials
- Explorationof alternate usesoffoodwastes, composting
- Food service organizations like hotels, restaurants ,cateringestablishmentsto relookat serving sizes as per customer/consumer demand and requirements adhering to Food Safety norms
- Businessesand Institutionslike schools, colleges, educational institutions , hospitals and other business organizations to create awareness on prevention of food wastes,Food Wastage Footprint, green concept
- Consumerstobeeducatedto fightagainstthepractices and messages which revalorize food: 3 for the value of 2,free item added to a menu

- Educating housewives/women on producing zero waste or food waste minimization in kitchen and othercook/workplaces , trainingand skill development
- Food consumersin urban areas to relooktheir buyinghabits on foods,foodproducts(buyonly after you consume).
- Consumer organizations to educate public/consumers on label dates/expiry dates on food packages, nutrition facts and the concept of healthy diets.
- Educating the consumer and households for properuse ofhousehold gadgets such as refrigerators, freezers etc. to store and preservefoodsto avoidwastes.
- Education on food waste, if possible integrated in a broader perspective on food use and nutrition.

Cross-cutting measures

- Training, building capacity of all supply chain actors in good practices.
- Building capacity (human and infrastructural) of institutions in developing countries for research; so as to develop appropriate (local) solutions to postharvest constraints.
- Build capacity of extension agents (in postharvest handling) and facilitate their access to small holder farmers.
- Develop capacity of all supply chain actors to identify critical control points for FLW reduction.
- Professional education and formation in good practices and food safety. Education on food waste, if possible integrated in a broader perspective on food use and nutrition.

Systemic solutions

Putting all actors together

- Creationof national/regional food lossprevention platform inassociation with farmers organization, industry associations
- Identify critical points for losses in the supply chains ofthe different commodities and institute requisite controls or interventions to check the losses
- Respectivenational governments in developing countries to awareness raising on the impact of, and solutions for food loss and waste, Collaboration and coordinationof world-wide initiatives on food loss and waste reduction, Policy, strategy and programme development for food loss and waste reduction, Support to investment programmes and projects, implemented by private and public sectors involved in food loss and waste reduction
- Respectivenational governments in developing countries to facilitate value chain finance to small holders and other actors/stakeholders inthe chainRespectivenational governments in developing countries to facilitate mapping of food value chain/foodsupply chain in order to have a clear understandingonstructure of chain, key playersandtheir roles, productand services, marketing channels etc.
- National governments to bring FoodWaste Prevention Guidelines, FoodLoss Prevention Protocols
- CFS in collaboration /partnership with respective national governmentsshould consider taking a leading role in the global harmonization of measurement protocols, frameworks and organizing a global network to manage the coordinated effort to collect primary measurements and data. Highest priority should be on developing and emerging regions.

Quality/standards dimension

- Market development formulti graded commodities/products
- Adherence ofquality standards forperishable like horticultural crops, meat, fish and poultry

- The National governments to relookattheirprevailing Food Lawsand Standards, inorder to plug loopholes and fill gaps with respect to food loss andwaste to facilitate prevention andreduction of FLW

Food chain efficiency

- To focus on production efficiency in food manufacturing units in both unorganized and organized sectors and better turnout ofinput: output ratio.
- Adopting a food chain perspective in agriculture development projects (where is the produce going to be consumed, how is it going to be transported, transformed, ...)
- Organization andManagement innovationson production planning, sorting, gradinglogistics.
- Adherence toInternational standards, foodstandards of theimportingcountries , Sanitaryandphyto sanitary measures for export of food items/products.
- Practice ofGood Inventory Management (e.g First In First Out)bythe food producersand food processorsandotheractors in production/ manufacturing activity inthe food chain.

Valorize waste or by products at all levels

- Development of method/systems to valorize food waste and food related waste, including modifications of systems in place,
- Promotion/encouragement of technological innovations in utilization of by products in food supply chain for food and non-food uses.
- Selective waste collection

Cold Chains

- Development ofcold chain for perishables
- Creating enabling environment and investment climate by the respective national governments in developing countries to stimulate the private sector to invest in cold chain logistics.

Promote short circuits and local solutions

- Localsourcingofrawmaterials
- Promotion oftraditional/local technology innovations for prevention of foodlosses

Building evidence for policy making

- Respectivenational governmentsin developing countries (which have no data) to supportresearch projects to quantify food loss and wastes to provide abasis for policy making.
- Cost benefit analysis for proposed interventions/solutions for FLW reduction

A3 Sources and data

(This Appendice to be expanded to cover other regions and other sources than FUSIONS)

Within Europe a comprehensive Preparatory Study on Food Waste across the EU27 has been executed, investigating causes, quantities, environmental impacts, best practices, forecasts and policy development (Monier, 2010). Both official Eurostat data and national estimates have been used. Limitations in the reliability of Eurostat data, due to a lack of clarity on the definition and methodology, may be significant. Additionally, data is missing for some sectors in some EU Member States. It was not possible to confirm that by-products were not included in some instances in manufacturing sector data. These issues have been ameliorated using national studies, plausibility checks and informed assumptions as far as possible in an effort to present the best available data; however, these limitations nevertheless present an important issue for data reliability (Monier, 2010).Within the FUSIONS project further evaluation of the Eurostat system has shown that there are currently formaland methodological elements that make it difficult to use the statistics for generating reliable food waste statistics to be used for creating reliable time series (Hanssen,2013).

A recent upsurge of interest in PHLs of cereals led to the development of the African Postharvest Losses Information System (APHLIS – www.aphlis.net), which includes a network of local experts, a loss calculatorand a free access database of key information (Hodges et al. 2010). The foresight review on global food and farming futures of Hodges et al, compares and contrasts PHLs and waste in developed countries (especially the USA and the UK) with those in less developed countries (LDCs), especially the case of cereals in sub-Saharan Africa (Hodges, 2011).

Because of the intensification of discussions on the definitional and methodological frameworks in the last couple of year, advancements have been made towards a more common understanding how to define and measure FLW. More recent studies at national level give more accurate and reliable insights in the amounts of FLW for e.g. UK and the Netherlands (WRAP, 2010, 2013; Soethoudt, 2013).

As part of the FUSIONS project in 2013 a thorough literature review has been executed to give a characterization of the most relevant food waste studies identified, according to e.g. data originality, methodological approach, time scale etc. (Møller, 2013). With a goal to provide state-of-the art knowledge by giving an overview of the different methods and data sources used for each step of the supply chain. And to identify the main data gaps. Figure X presents the number of references (from the FUSIONS database with over 300 classified articles and reports) which have been considered and numbers of studies relevant.

The majority of the studies covers a national level of a sector or a step in the food chain representing one of the countries (67%).These studies have either used national statistics or extrapolated data from waste compositional analysis, weighing or other semi-quantitative methods. A limited number of studies are available at the EU-level (8%), except in “retail and market” and “redistribution”. USA/Australia/Asia level is represented in “production”, “retail and markets”, “food service” and “households”, covering in average 14 % of the studies reviewed. The global level is represented in 9 % of the studies, in total 14 studies.

The methodological approach used can be based on mass data, economic data, surveys, combination of mass data and surveys or other approaches. On average, most studies used mass data (59 %), but for “retail and markets” and “redistribution” the proportion was significantly lower. For “retail and market” economic data (19 %) and interviews/surveys (50 %) are used more often than in other steps of the supply chain. Some of the studies (19 %) used combined methods or other methods (Møller, 2013).The major data gap is considered to be in the area of at farm losses, both for developing and develop countries. There are also significant gaps in understanding food waste at consumer level in different parts of the world. Collection of food waste data requires experienced in-country expertise and a commitment over many years (Parfitt, 2013).

Companies are important sources for data on FLW. There is limited transparency about FLW and these organizations are reticent to share data. With some exemptions, e.g. the organizations that have signed up with the Courtauld agreement report their FLW data (UK), in Norway as part of the Format project (Norgesgruppen), in the Netherlands (Ahold, 2011), and recently Tesco in the UK (Tesco, 2013). Also some more data about the catering sector in the Netherlands (Soethoudt, 2012)

and hospitality sector (WRAP, 2013 tbc) have become available. In a growing number of developed countries data of post consumer level food waste are consistently measured to monitor trends, based on household waste analysis (e.g. Schneider, 2009;WRAP 2010, 2013; Van Westerhoven, 2010, 2013).