

INNOVATION FOR THE REDUCTION OF FOOD LOSSES AND WASTE

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Wasting food is an unsustainable, economically negative, environmentally wrong and morally unacceptable phenomenon. Food waste exacerbates the inefficiency of the food chain, thus contributing to food and nutrition insecurity in the Mediterranean region especially in southern and eastern Mediterranean countries (SEMCs). Food loss and waste (FLW) lead to a major squandering of resources including water, land, energy, labour and capital and needlessly produce GHG emissions. The potential that lies in the elimination of losses and waste along the food chain thus making more food available to consumers should be highly considered by Mediterranean policies and research agendas related to the agri-food sector.

FLW reduction constitutes a significant lever for broader improvements of the Mediterranean food systems that result in increased food security, food safety, quality and sustainability. It would help increase the available offer and the efficiency of the use of food. Therefore, innovation along the food chain is crucial for the reduction of both the amount and extent of FLW worldwide and particularly in the Mediterranean area. When developing FLW reduction solutions and strategies, especially technical and organisational ones, one should keep in mind that there has to be a compromise between obtaining an acceptable return on investment by an individual or the private sector, protecting the environment and fulfilling consumer demand for food safety, product quality, and a diverse variety of nutritious, flavourful, and acceptably-priced food (Buzby and Hyman, 2012).

Today, in the Mediterranean both the private and the public sectors are aware of the importance of innovation for the prevention of food losses and the reduction of food waste. Innovation represents a major issue within the European Union cooperation and development financial tools targeted towards the Mediterranean

countries. Recently, the *Innovation Union*, a strategy aiming to create an innovation-friendly environment that makes it easier for great ideas to be turned into products and services, has been set up to enhance economic growth and contribute to the creation of jobs in the EU countries. In the framework of this strategy, the European Innovation Partnerships (EIP) play an important role as a new tool fostering innovation in the agrofood sector. In its roadmap for a resource-efficient Europe, the European Commission (EC) has set the target to halve the generation of food waste by 2020.

In order to highlight the potential of innovation in reducing the amount and extent of FLW along the Mediterranean food chains, this chapter revolves around several issues: innovation models and types; innovative integrated strategies for FLW management; product and process innovations for FLW prevention and reduction along the food chain; political, organisational and social innovations for FLW prevention and reduction; and innovative solutions and good practices for FLW recycling and re-use.

Innovation models and types

It is thanks to the human ability to invent solutions and accumulate knowledge that humans succeed in adapting to change. For many years, innovation has been closely related to sustainable development and it is now high time to position it more clearly (Lacirignola, 2015). The adoption of innovations is decisive for development strategies in the Mediterranean. Traditional linear approaches have proved to be less effective; the necessity to build systems capable to put needs and solutions into perspective is widely recognised (Adinolfi *et al.*, 2015).

Innovation is a complex phenomenon, involving the production, diffusion and translation of scientific or technical knowledge into new or modified products and services as well as new production or processing techniques (Menrad and Feigl, 2007). Food innovation refers to the addition of new or unusual ingredients; new combinations of product; different processing systems or elaboration procedures (Vanhonacker *et al.*, 2010).

Different models for the innovation process can be found in scientific literature, such as the sequential or linear model and the integrative model. In the last forty years we have assisted to a shift from a concept of innovation centred on research to innovation as a result of interactions among several actors establishing diverse linkages (World Bank, 2007). Innovations can be classified under the term of object or under that of profundity. When systematising innovations under the term of object usually one distinguishes between product innovations and process innovations, but also organisational and social innovations. The OECD and Eurostat (2005) distinguish product, process, marketing and organisational innovations. *Product innovations* can be understood as the application of new production (Wegner, 1991). Important product innovation attributes include: improving useful properties of the product, increasing quality, changing of design and reducing environmental impacts. *Process innovations* are changes in the field of production that are applied within the enterprise (Hauschildt, 1997). New production techniques allowing new product

innovations, process innovations, could be seen as an investment in skills, resources and competences of a company. Process and product innovation are often closely related and the distinction between them is not always clear-cut. *Organisational innovations* improve or modernise the administrative and process organisation of a company (Pleschak and Sabisch, 1996), such as the reduction of hierarchy levels and the solution of co-operation and interface problems. *Social innovations* concern changes in the field of human resources management of companies such as the provision of specific training for employees (Eherer, 1994). Social innovations are distinct from other forms of innovation. They are defined as new ideas (products, services and models) that meet social needs (more effectively than alternatives) and create new social relationships or collaborations (Murray *et al.*, 2010).

In terms of profundity and degree of novelty, radical innovations and incremental innovations can be generally distinguished. Usually, innovations only bring about many small improvements in a continuous upgrading process and involve a combination of technical, institutional and other sorts of changes (Poun and Essegbey, 2008). *Radical innovations* are characterised by a high degree of novelty. Product innovation is considered radical if it leads to the creation of a new market and if the innovator manages to gain a monopoly position at least temporarily. This kind of innovation often means complex changes in different fields of the innovating company, high financial expenditures and a high market risk (Kotler and Bliemel, 1999; Wittkopp, 2004). *Incremental innovations* do not create a monopoly position and have only a low degree of novelty. They are often characterised by an improved benefit-cost ratio or improvements in the utility pattern for consumers (Bessau and Lenk, 1999; Pleschak and Sabisch, 1996). For incremental innovations less technical application is needed which means there is a lower risk in product development than for radical innovations. Accordingly, incremental innovations may be produced faster and with lower financial expenditures. Incremental innovations rather target on success for a short period, while radical innovations are expected to provide success for longer periods.

Innovation arises in a particular socio-economic, political and institutional context and is shaped by the environment (either enabling or disabling) in which it can thrive (IICA, 2014). *Political and institutional innovations* are important drivers of the agri-food system with implications also in terms of food losses and waste. Political innovation is the development of new political systems and public policies and is often strongly linked to institutional innovation processes. Institutional innovations entail a change of policies, standards, regulations, processes, institutional practices or relationships with other organisations, so as to create a more dynamic environment that encourages improvements in the performance of an institution or system (IICA, 2014; OECD, 2011).

Innovative integrated strategies for FLW management

The High Level Panel of Experts on Food Security and Nutrition (HLPE, 2014) distinguished three levels of FLW causes: micro-, meso- and macro-levels. The importance of meso- and macro-causes stems from the fact that quite often, causes of FLW of a physical, technical or behavioural nature are induced by broader economic, social and institutional causes. A wide range of causes organised in different levels calls for a wide range of solutions, also organised in different levels, which concern investments, good practices, behavioural change, coordination within food chains, valorisation of food and by-products or coordination of policies and actions. Post-harvest solutions range from improved practices in crop and animal production and investment in storage to the adoption of technical innovations in transport, processing and packaging. Technical and behaviour-driven solutions to reduce consumer waste include food service solutions in the hospitality sector (hotels, restaurants, canteens, catering, etc.) and household-level solutions.

Integrating FLW concerns in policies can take two complementary forms: (1) integrate FLW concerns in all policies which can have an impact on them; (2) devise a specific FLW reduction policy to address the interdependencies of actions that end up creating FLW (HLPE, 2014). In OECD countries (2014), existing legal frameworks with a FLW component are mostly focused on waste management and environmental concerns in general, aspects of prevention and improved re-use of waste, all waste taken into account, the food parts within the waste being only one aspect of the problem.

Policies are aimed at setting priorities or coordinating actions of various actors or sectors. One of the important dimensions of such priorities is to give clear directions among the “competing” uses of food waste. Specialised publications have presented many “*food use hierarchies*” (HLPE, 2014). These include the *Food Waste Pyramid for London*, presenting a hierarchy of approaches to tackle food waste, in order of priority, the *Food Recovery Hierarchy* developed by the US Environmental Protection Agency (US-EPA), the Netherlands’ *Ladder of Moerman*, the *Food Waste Hierarchy* of the Public Waste Agency of Flanders (OVAM), FoodDrinkEurope’s *Food Waste Hierarchy* (FoodDrinkEurope, 2013). These food waste management hierarchies or “pyramids” prioritise reduction of FLW at source and present a list of preference for use, re-use, recycling and waste treatment.

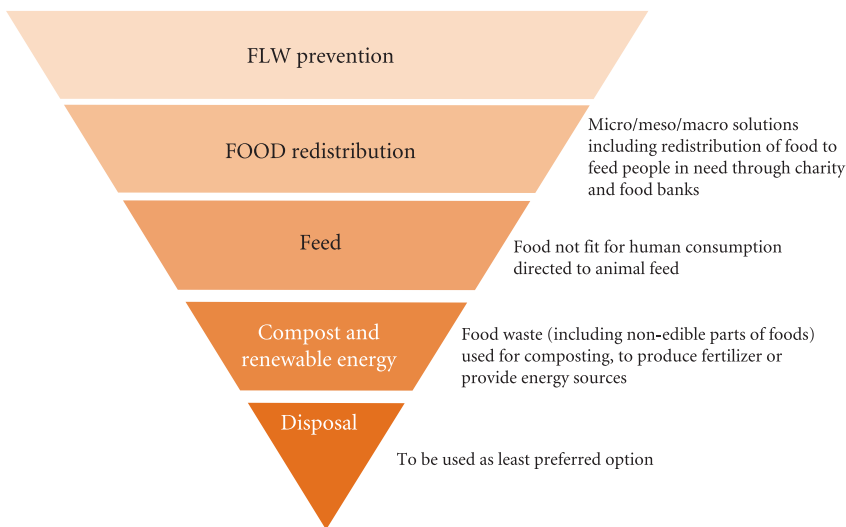
In line with an overall pattern of waste management, all these pyramids more or less follow the same structure (see Figure 1): 1) support FLW prevention; 2) facilitate the distribution of still edible but not marketable food such as by means of food banks or other institutions; 3) use residual food as animal feed; 4) use what is left as compost and/or energy. Using disposal in landfills is the least preferred option (HLPE, 2014).

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 fertiliser, either directly or through compost. In urban areas, organic waste can be also an

important source of methane. Sorting, composting and methane valorisation could reduce the environmental impact of FLW (HLPE, 2014).

In a study commissioned by the European Commission (Directorate General for Environment – DG ENV), the Bio Intelligence Service identified a wide range of food waste prevention initiatives that can be applied at different scales (Monier *et al.*, 2011): awareness campaigns; informational tools (e.g. sector specific prevention guidelines and handbooks); training programmes about FLW prevention (e.g. for food service staff or consumers *via* waste-free cooking workshops); logistical improvements (e.g. stock management improvements for retailers, reservation requirements for cafeterias, ordering flexibility of meals in hospitals); regulatory measures (such as separate collection of food waste); unused food redistribution programmes (to charitable groups).

Figure 1 - A food-use-not-waste hierarchy of actions to minimise FLW along the food chain



Source: Adapted from the Food Waste Pyramid for London (www.feeding5k.org) by HLPE (2014).

Since the causes of FLW are not the same in all countries, potential solutions to food waste and loss reduction are also quite different across countries and even across different socio-economic groups in the same country. Improving food supply chain efficiency such as improving production techniques and infrastructures seems to be the key for developing countries (Kader, 2004), while developed countries should improve their management of the downstream food supply chain by conducting consumer education campaigns, and facilitating increased donation of abundant food (to food banks) (Monier *et al.*, 2011).

Product and process innovations for FLW prevention and reduction along the food chain

Food losses at post-harvest and processing stages are high especially in developing countries (Gustavsson *et al.*, 2011). When appropriately applied, good agricultural practices and good veterinary practices can protect food at the primary stages of production. 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. A key intervention all along food chains is to improve storage conditions. Various solutions and post-harvest technologies exist for this purpose (HLPE, 2014).

Reducing FLW would require substantial additional investments in the limited storage capacity of SEMCs. Dry storage in general and capacity to handle cereals in particular are at the heart of this problem. In several countries of the region the majority of farmers still store their grains using traditional methods, with rodents, insects and birds being responsible for the bulk of cereal losses. For instance, Egypt loses between 13% and 15% of the available cereals between harvesting and final consumption (FAO, 2015).

Post-harvest losses can be reduced with the adoption of innovative techniques and practices in refrigeration, manufacturing and transport technologies. Waste is minimised by modifying packaging and through other approaches that either prolong the shelf life of foods or help consumers reduce food waste in other ways (WRAP, 2012). According to Foresight (2011), reducing post-harvest losses and waste can be achieved through: deployment of existing knowledge and technology in storage and transport infrastructure; investment in new, appropriate technology; and infrastructure, financial and market reforms.

Technical solutions in transport, processing and packaging need to be adapted to local situations, including the availability of infrastructures, economic and human resources, as well as operating conditions of the rest of the food chain. The development of food processing requires appropriate processing technologies and infrastructure in a concerted food chain approach (as for example in atmosphere packaging) (HLPE, 2014). At almost every stage of the food chain, FLW may be reduced by using appropriate packaging, as a key element of a set of technologies and processes to protect food (Olsmats and Wallteg, 2009). Therefore, the packaging industry has indeed a key role to play in addressing food losses. Packaging solutions should take into account the need to reduce waste in general and be adapted to local producers/packagers as well as to consumers' needs (FAO, 2011b). Including information on the packaging on how food should be best conserved and stored also leads to FLW reduction (HLPE, 2014). Preservation processes such as canning, pasteurisation and sterilisation, and packaging technologies contribute to increasing the shelf life of products, thereby reducing FLW in the food chain (Langelaan *et al.*, 2013).

According to the International Institute of Refrigeration (IIR), 23% of perishable foods are lost in developing countries due to the lack of use of refrigeration (IIR, 2009). Therefore, appropriate temperature is a key element for the reduction of FLW. Cold chain management often depends on broad interventions involving actors all along the food chain with the support of public authorities (HLPE, 2014; Albisu, 2014). In perishable foods supply chains, effective cold chain management starts with pre-cooling, cold storage, refrigerated transport and refrigerated display during marketing. Strategies to reduce food losses could also start with interventions by public authorities and development partners to improve the cold chain infrastructure in developing countries. In Tunisia, the food security strategy includes a national plan for the cold chain, which includes investments and incentives with a particular focus on fruits and vegetables, mainly for export (HLPE, 2014).

Very often, and this is particularly true in the Mediterranean area, FLW are a result of inadequate infrastructure and connections. The latest *Mediterra* report of the CIHEAM (2014c) clearly shows that the development of Mediterranean infrastructure and logistics (ports, corridors, multimodal platforms, cold chain, etc.) related to the agri-food sector is important not only to foster exchanges and trade in the Mediterranean but also to address issues related to food system sustainability such as the struggle against FLW. In fact, the optimisation of the transport of agri-food products can significantly contribute to reducing losses and waste.

Political, organisational and social innovations for FLW prevention and reduction

The possibility of reducing food waste depends on several institutional (legislation and policy) initiatives¹: improvements in current legislation and policy; new non-regulatory initiatives undertaken by governments; new initiatives voluntarily undertaken by stakeholders. It is therefore essential to change the legislation in order to: stimulate the utilisation of food products presently destined for disposal; increase tax on waste disposal and improve separate waste collection; limit by-catches in fisheries; and sanction unfair deals of big retailers with suppliers. These institutional (legislation and policies) actions can have a realistic effect on behaviours affecting food waste (see Table 1).

Mediterranean countries have now begun to take into account these institutional priorities and to act consequently to encourage FLW reduction at different levels. The Regional Programme, established by the FAO in Egypt, Lebanon and Jordan, aimed at building capacities for food loss reduction in the Near East region (2014-2016), also includes institutional and legislative aspects. The 32nd edition of the FAO Regional Conference (Rome, 24-28 February 2014) for the Near East on Reducing FLW in the Near East & North Africa Region endorsed the “*Strategic framework for the reduction of Food Losses and Waste in the Near East and North Africa*” whose objective is the reduction of FLW in the region by 50% during the next 10 years.

1 - EU-Fusions, August 2014 (www.eu-fusions.org).

Many global and regional initiatives aiming to reduce FLW have already been launched. One of the most important ones, the SAVE FOOD initiative (Global Initiative on Food Loss and Waste Reduction) led by the FAO and *Messe Düsseldorf* (Germany), has many objectives (FAO, 2013): awareness raising on the impact of FLW and solutions for reducing them; collaboration and coordination of world-wide initiatives on FLW reduction by establishing a global partnership of public and private sector organisations and companies; policy, strategy and programme development for FLW reduction; and support to investment programmes and projects.

Table 1 - Drivers of food waste generation, increase and reduction related to the institutional and policy context category

Food supply chain segments	Drivers of current food waste generation	Drivers of threats of increase	Drivers of possibilities of reduction
Primary production	<ul style="list-style-type: none"> – Grading & overproduction – Market conditions/price – Tax policy 	<ul style="list-style-type: none"> – Fishery policies – Public policy on bio-fuel production – Contracts between supplier and retailers 	<ul style="list-style-type: none"> – Fishing policy reform – Information / awareness – Farm to shop cooperation – Selling by weight not by piece (fruit and vegetables)
Processing of farm staples	<ul style="list-style-type: none"> – Profitability – Access to finance 	<ul style="list-style-type: none"> – Public policy on bio-fuel production 	<ul style="list-style-type: none"> – Use of by-products (for animal feed production)
Food processing and packaging	<ul style="list-style-type: none"> – Legislative measures – Taxation policies 	<ul style="list-style-type: none"> – Legislative and taxation measures – Public policy on bio-fuel production 	<ul style="list-style-type: none"> – Policies for resale/use of sub-standard⁷ products – Food standards related to safety
Wholesale and logistics	<ul style="list-style-type: none"> – Specific marketing standards – Legal restrictions with respect to best before/consumption dates – Blemish of packaging – Low cost for discarding food 	<ul style="list-style-type: none"> – Disposal costs – Decrease of financial support non-profit distribution – Blockages in alternative use chains 	<ul style="list-style-type: none"> – Disposal costs (landfill tax increase) – Tax incentive for donations – Improving distribution logistics – Encouraging research into advanced packaging – Encourage the development of new business models around imperfect produce

<p>Retail and markets</p>	<ul style="list-style-type: none"> – Marketing standards – Dates for preservation labelling – Measurement and pricing of food waste – Rejection of delivery/returns – Lack of policies to encourage redistribution 	<ul style="list-style-type: none"> – Food safety standards – Redistribution (hindrances related to health risks and new fiscal policies) – Cost of food waste – Ending of voluntary agreements (related to food waste prevention/reduction) 	<ul style="list-style-type: none"> – Food redistribution programmes – Reduce prices according to sell before/best before date of products – Raising-awareness initiatives – Alternative use of products – Encourage closer contact between farm production and consumers – Limits to price promotions with discounts on volumes (by retailers' initiatives) – Eco-labelling of stores – Improved packaging
<p>Food services</p>	<ul style="list-style-type: none"> – Ban on feeding animal by-products (ABP) and catering waste to animals – Expiry dates 	<ul style="list-style-type: none"> – Contracts – Public procurement laws (which do not take care of food waste concerns) 	<ul style="list-style-type: none"> – Encourage separate collection of food waste and quantification – Encourage consumption of leftovers and use of doggie bags (voluntary initiatives)
<p>Households</p>	<ul style="list-style-type: none"> – Price of food/proportion of income spent on food – Waste collection infrastructure – Dietary guidance 	<ul style="list-style-type: none"> – Public funding – Food skills and diet guidance (related to public education policy and public health campaigning) 	<ul style="list-style-type: none"> – Application of date marks (new regulation on food information for consumers) – Waste collection infrastructure (improving waste separation) – Dietary guidance (education programmes)

Source: Adapted from Canali *et al.* (2014).

In January 2012, the EU Parliament adopted a non-legislative resolution calling upon the European Commission (EC) and Member States to take “radical measures” to reduce waste from farm to fork by 50% by 2025. It is estimated that up to 50% of edible food is wasted in EU households, supermarkets, restaurants and along the food supply chain each year (BIO Intelligence Service, 2013; Segrè, 2013). The EP therefore called on the commission to implement a coordinated strategy combining EU-wide and national measures to improve the efficiency of the food supply and consumption chains sector by sector, and to tackle food waste as a matter of urgency². The resolution identified areas that need to be addressed by such a strategy.

European Union launches landing obligation to drive greater selectivity and reduced waste in the fisheries sector

In fishing, discards refer to the unwanted catch returned to the water due to size, species, appearance (blemished or damaged catch) or vessels having achieved their quotas (Clucas, 1997). In the European Union, fishing discards have been a contentious concern, with calls for stronger regulations to combat this waste being echoed across the region. The large-scale food waste is largely untracked and affects Europe’s ability to assess the impact of fishing on the marine environment and populations of different species. To make up for this lack of evaluation, in January 2014, the European Union’s new Common Fisheries Policy (CFP) introduced a landing obligation, commonly referred to as a “discard ban”. This new regulation requires that all catch is kept on the vessel, landed and then counted according to quotas. This regulation is intended to encourage higher selectivity among fishing vessels and provide more reliable catch data. This data is then used to estimate the state of specific fish stocks. Moreover, through modelling, the data is studied to determine the health of the stock and how much can be caught sustainably in the following year (European Commission, 2015b). To ensure the smooth applicability of the new regulation, it is being implemented gradually between 2015 and 2019. The European Commission adopted five discard plans in October 2014 (applicable from 2015), which affect pelagic and industrial fisheries in all Union waters, and fisheries for cod in the Baltic (European Commission, 2015b).

The Waste Framework Directive requires Member States to establish National Waste Prevention Programmes and to determine concrete objectives by December 2013. France has already announced its 50% reduction goal of the volume of food waste by 2025 and, furthermore, proposed a national pact against food waste to be signed by a wide range of leading stakeholders to signal their shared commitment (BIO Intelligence Service, 2013). In 2013, Spain also set up food losses and reduction targets.

2 - www.waste-management-world.com/articles/print/volume-13/issue-1/regulars/news/european-parliament-aims-to-resolve-food-waste.html

“More food, less waste” initiative in Spain

Following the request by the European Parliament for its Member States to develop action plans against food waste, the Spanish Ministry of Agriculture, Food and Environment has developed the “*More food, less waste*” initiative that is based on recommendations, voluntary agreements and self-regulation. It aims to decrease the amount of waste and encourage dialogue and coordination between stakeholders within the food chain and public authorities. The ambitious programme includes several actions: carrying out studies on FLW; reporting and promoting good practices and actions to raise awareness among wholesale, retail distributors and consumers; establishing administrative rules in order to improve quality standards and by-products management for non-food use; promoting voluntary collaboration among agri-food agents between the public and private sector including food banks to gather useful food that could be distributed among the needy; and developing new technologies for FLW reduction. In addition, the strategy supports the “*What can I do?*” campaign that provides all actors within the food chain with advice on how to reduce food waste. Under the same framework, the Ministry of Agriculture organised between 4-10 November 2013 the “*Waste Reduction Week*” during which there were seminars and activities targeting, among others, food service professionals, catering schools, primary schools and consumers.

Source: MAGRAMA (2012); Vay (2014).

The Italian Ministry of Environment has also set up a task force for the reduction of food waste. On the occasion of the national day against food waste (5 February 2014), the task force met to develop a national plan for waste prevention (Last Minute Market, 2014). Cities play a key role in the generation, management and prevention of food waste and are in a strategic position to work with citizens, schools, restaurants and food businesses to promote and support food waste reduction. Their activities could focus on awareness raising and communication, education and training and separate collection of food waste for energy recovery and composting³. Over five hundred Italian municipalities have signed the “*Charter for a network of local and regional authorities with zero waste*”, promoted by Last Minute Market, thus pledging to reduce waste and losses along the food supply chain. Following this initiative, the “*National Network of Municipalities against Waste*” (Association Sprecozero.net) coordinated by the city of Sasso Marconi (province of Bologna) was created in December 2013 (Last Minute Market, 2014).

The other Mediterranean countries, including SEMCs, can adopt similar food waste prevention and reduction programmes and strategies. The final declaration of the 10th meeting of the Ministers of Agriculture of the thirteen Mediterranean Member Countries of the CIHEAM dedicated to “*Sustainable food security in the Mediterranean: situation and outlook*” that was held in Algiers on the 6 February 2014, proposed the CIHEAM to strengthen instruments and networks and to encourage regional initiatives that addressed the issue of food waste (CIHEAM, 2014a).

The efficiency of FLW reduction often depends on broader interventions involving private actors all along the food chain and/or public actors. Collective storage, which can include the mutualisation of risks of post-harvest losses, is also a solution for

3 - European Union, Report from the Second Meeting of the Working Group on Food Waste, February 2013.

food losses reduction. Its effectiveness depends on the local institutional context (existence of local institutions, cooperatives or producer organisations) (HLPE, 2014). Producer organisations such as cooperatives and associations as well as their federations can play an important role in reducing losses of their members' produce through organisational and management innovations, by supporting collective activities mainly for production planning, sorting, grading and logistics (Kelly, 2012). The FAO has been working closely with various forms of producer organisations and cooperatives to develop different mechanisms and tools for reducing losses early in the supply chain (FAO, IFAD and WFP, 2012). The warehouse receipt system is a good example of the role of producer organisations and cooperatives. The system ensures that food is stored properly so that losses are reduced. This model should therefore also be promoted in the Mediterranean region.

There is great concern among food chain actors (e.g. industries, retailers, etc.) to apply better norms to reduce FLW and to incorporate them as part of their social corporate responsibility. This is for instance the case of food services in Algeria or food and beverage firms in Turkey (CIHEAM, 2014b). In this regard, the inclusion in annual corporate businesses reports of a section on the environmental impacts resulting from their activities could be useful to reduce FLW. Businesses can commit and report on the monitoring of FLW and indicate how they intend to reduce them in their activities or support activities that lead to the reduction of FLW outside this framework (with their suppliers, at consumer level or elsewhere) (HLPE, 2014).

Moreover, the reduction of FLW implies the governance and organisation of new supply chains. The development of closed-loop models (WEF, 2010 and 2014) is meant to coordinate all actors for concerted actions. Losses or waste of all forms are fed to the extent possible back into the value chain. Food graded as lower quality by retailers or manufacturers for cosmetic reasons and food that is surplus would be made available through alternative routes (as cheaper alternatives), while food waste would be utilised as a by-product (HLPE, 2014).

Several studies (such as Qusted *et al.*, 2013) have detailed measures that consumers could implement to reduce their own food waste:

- Better planning of purchases to avoid buying more than is needed;
- Avoid impulsive or advance purchasing of food that is not required immediately;
- Better understanding of the distinction between “best before” and “use by” dates;
- Better storage practices and stock management in the home;
- Better evaluation of the portions that need to be prepared;
- Better knowledge on how to use the leftovers on other recipes instead of discarding.

The Egyptian government has started to implement several reforms and strategies for both food and fuel subsidies in order to reduce losses and budget deficit. A new smart card system, which replaces the ration card system, can record data on the household head's monthly quota of subsidised goods and other household information as well (Ramadan, 2014). Such reform would enable the government to reduce wastage and leakage and reduce corruption (World Bank, 2010).

The Egyptian social smartcard

Egypt currently imports twice as much wheat than the whole of the EU to produce subsidised bread that unfortunately is often wasted or fed to animals. The Egyptian government has taken many measures to cut down on massive waste and in April 2015 it has introduced a smartcard system that aims to modernise the country's long-established tradition of bread subsidies. Around 70 million of Egypt's 90 million inhabitants are eligible for the smartcard system, which entitles each family member to receive five rolls of bread a day. If cardholders opt not to claim all of their daily allowance, they gain tradable points that can then be used to purchase other staples or non-foodstuffs in government registered stores. According to the Ministry of Supply, this point system provides poor Egyptians with an additional supplement for food purchases of between 40-50 Egyptian pounds a month (5-6 euros). Meanwhile, the demand of bread has reportedly dropped by between 15% and 20% as the population started to rationalise their consumption. Other countries in the region, such as Jordan, are interested in adopting a similar approach.

Source: The Guardian, "Bread Rationing and Smartcards: Egypt Takes Radical Steps to Tackle Food Waste", 20 March 2015 (www.theguardian.com).

Food banks are among the most important social and organisational innovations for food waste prevention. They acquire donated food, a large part of which would otherwise be wasted, from farms, manufacturers, distributors, retail stores, consumers, and other sources. They then make it available to those in need through a network of community agencies (school feeding programmes, food pantries, soup kitchens, hospices, substance abuse clinics, after-school programmes and other non-profit programmes).

Food banking in Italy

The world's first Food Bank was founded in 1967 in Phoenix, Arizona. John Van Hengel, known as the "Father of Food Banking", was volunteering in a soup kitchen when a mother with ten children gave him the idea of a place where surplus food could be stored and made available to the poor. Food Banks were then developed in Canada and Europe. Today, they operate worldwide. The *Fondazione Banco Alimentare Onlus* was established in Italy in 1989 and since 1990 it is a member of the European Federation of Food Banks. With the help of a network of 21 Food Banks across Italy, it collects and distributes surplus food from the food chain to 8,669 charitable organisations that help 1,909,986 poor people every year, raises awareness on food waste and food poverty and advocates for policies that sustain food poverty. Its daily activity contributes to food security, improves the sustainability of food systems and reduces the impact of food waste on the environment. The initiative was presented as a best practice entitled "Food is a Resource to Secure Tangible Assistance and Inclusion to the Deprived" in the framework of the call for best practices of Expo Milan 2015.

Source: www.feedingknowledge.net/02-search/-/bsd/6204/en_GB

In Lebanon, important initiatives tackling food waste have been launched by civil society organisations. Among them, those of the Lebanese Food Bank are worth mentioning.

Initiatives of the Lebanese Food Bank against food waste

The Lebanese Food Bank (LFB) is a non-profit organisation created in 2011 by a group of businessmen, and officially launched in May 2013. It can be considered among the most important organisations operating against food waste thanks to the scale of its actions, its continuity in time, its size and the advertising of its work through media campaigns. It is a member of the Arab Food Banking Regional Network. The organisation's main objective is to eliminate hunger from Lebanon by 2020 by building strong partnerships in the public and private sectors as well as strengthening cooperation and increasing donations of food or money from individuals. The LFB has more than thirty partners (banks, hotels, bakeries, etc.) and its actions are divided into four main axes: the feeding programmes aimed at feeding the needy; the development programmes which aim to develop the capacities of the needy; encouraging volunteering to provide various services thanks to many different and specialised talents and skills; the awareness programme "*Not To Waste Food*". The awareness campaigns target hotels, restaurants, catering companies, food factories and individuals. Awareness is being also raised in schools and universities. Instead of throwing away excess food, the LFB distributes it to orphanages, nursing homes and NGOs. The LFB supports more than thirty NGOs.

Source: Oneissi (2014).

Food banks have also proliferated in Spain after the economic crisis. There are nearly 54 across Spain and they gather around 100 million tonnes of food per year. They usually collect uncooked food that is not used or given on purpose to be distributed among poor people (Albisu, 2014). New communication initiatives can also serve as social innovations for food waste prevention. Innovative communication tools to raise awareness among consumers on FLW are increasingly necessary as a complementary device to support educational initiatives at policy level. An example is the one created with the participation of the CIHEAM-Bari.

"Once upon a time: food waste": an educational conference-drama on food waste in Italy

On the basis of the paradoxes of our times related to food and nutrition, in collaboration with Massimo Melpignano and Antonio Cajelli, the group of researchers from the CIHEAM-Bari, created a conference show entitled "*C'era una volta il... UEIST (Food)*" (Once upon a time there was... UEIST [Food]), an original training and dissemination path that aims to guide the audience – consumers – through a reflection on topics related to food production and consumption (health, ethical, political, cultural, moral and financial aspects). These issues were identified through a real "construction site of ideas" where the CIHEAM-Bari experts played a leading role with the authors of the play, civil society and local institutions representatives. Massimo Melpignano (lawyer and financial adviser), who for several years

was committed to defend citizens' and consumers' rights and Antonio Cajelli (independent financial educator) represent the Articolo 47 – Liberi dal debito (Article 47 – Free from debt), a social association involved in creating awareness pathways on the issues of financial education, food waste and related social phenomena.

Innovative solutions and good practices for food waste recycling and re-use

Food waste can be recycled as animal feed, or used for the production of compost or renewable energy. Within the food-processing sector, substantial parts of the raw materials that enter the factory are ultimately traded as by-products. Utilisation of these streams for food would require alternative processing to the chains' primary product. Hence, a large part of these side streams is only poorly valorised: for animal feed, technical applications and fertiliser production (through composting) (HLPE, 2014).

The NOSHAN Project – Turning food waste into animal feed

Food waste is characterised for its nutritional potential. It can therefore contribute to the production of functional feed ingredients (additives). Nevertheless, this production would require appropriate technologies that stabilise and convert the waste into suitable raw materials for bulk feed. The main aim of the NOSHAN project (Seventh Framework Programme for Research and Technological Development of the European Union, grant agreement No. 312140) with partners from 4 Mediterranean countries (France, Italy, Spain and Turkey) is to address the process and technologies needed to use food waste for feed and feed additives production at low cost, low energy consumption with maximal valorisation of waste materials. The project includes two different groups of activities: the replacement of bulk feed ingredients with starting waste materials to cope with part of the huge amounts of food waste generated in Europe; and the valorisation of active ingredients in food waste to convert them into more valuable feed additives. Forty-two food waste streams have been analysed to identify those that have the potential to be transformed in high quality feed or to be used to obtain feed additives. Drying, extraction and acidification were chosen as best solutions for the stabilisation of selected starting materials. Cost-effective as well as environmental friendly technologies will be scaled-up.

Source: Projet NOSHAN (<http://noshan.eu/index.php/en>).

After being selected and processed, food-related waste can be valorised differently according to where it is generated. In rural areas, it can be easily used as feed or organic fertiliser, either directly or through compost. In urban areas, organic waste can also represent an important source of methane. In both cases, this valorisation reduces the environmental impact of FLW with economic gains (HLPE, 2014). Technical innovations can enable the processing of fruits, vegetables and root by-products into juices and jams (Verghese *et al.*, 2013), feed, bioenergy and/or compost, especially in rural areas (HLPE, 2014). Food waste side streams could also be used to feed insects having a potential for nutritious feed or food (Van Huis, 2013).

Using eggshells as biocatalyst for biodiesel production

Biodiesel is being more frequently used and considered as an alternative fuel to replace the existing petroleum-based diesel. The advantages of biodiesel are good combustion efficiency, high lubricity, biodegradability and low toxicity. Conventional ways of biodiesel production use homogeneous catalysts⁴, which create environmental problems since they imply large amounts of water waste. Environmental-friendly and effective methods of biodiesel production use the heterogeneous catalyst. Heterogeneous catalyst can be extracted from biowaste such as eggshell. By introducing the heterogeneous catalyst base, such as calcium oxide made from waste material, chicken eggshell, quail eggshell or ostrich eggshell, the excessive washing problem to remove excessive reactants and glycerol is solved. Biodiesel production is cheap and environmentally convenient. It requires no mechanical change of the standard diesel engine. It is also an environmental-friendly way of recycling waste eggshells.

Source: El-Gendy and Deriase (2015) and www.researchgate.net/publication/275042850

The livestock sector could use more of the industrial and catering reflux of foods that cannot be redirected to human consumption through redistribution and food banks. Such foods include for instance bread, broken biscuits, products safe to eat but with an appearance default, incorrectly packed products and food leftovers of big events (HLPE, 2014). Virtuous examples of innovative solutions and good practices for FLW recycling and re-use exist in many countries especially developed ones. In Japan, a law for the promotion of recycling and related activities for the treatment of cyclical food resources aims at preventing food waste and at promoting recycling of food waste into animal feed and fertilisers as well as energy recovery. In Ireland, a household food waste regulation promotes the segregation and recovery of household food waste, directing separated food waste to composting, and imposing obligations on waste collectors as well as on households. Furthermore, the catering sector has obligations in terms of segregation and processing of food waste (OECD, 2014).

Conclusion

It is clear that the reduction of FLW is necessary to generate multifaceted long-term benefits in terms of food and nutrition security and food system sustainability required by the Mediterranean to ensure its sustainable development. Innovations are therefore highly needed and several cross-cutting strategies must be developed. Food waste reduction is a collective and social imperative requiring the commitment of government agencies, NGOs, producer organisations/cooperatives, the private sector, and the food and drinks industry to engage with consumers. Solutions to reduce food waste at one stage often involve actors upstream or downstream the food chain. Thus, implementing them often requires relations between various actors including farmers and their organisations, consumers, processors, retailers, public organisations, research institutes, and civil society organisations. The feasibility,

⁴ - Catalysts can be divided into heterogeneous and homogeneous. In a heterogeneous reaction, the catalyst is in a different phase from the reactants (e.g. catalyst is solid and reactant is liquid). In a homogeneous reaction, the catalyst is in the same phase as the reactants.

efficiency and sustainability of operations for FLW reduction in the medium and long term therefore depend on an institutional effort involving all actors in the food supply chain.

Mediterranean researchers and policy makers should devote more attention to FLW. Addressing this multifaceted problem requires a comprehensive regional research and innovation agenda supported by integrated and multi-sectoral policy interventions and instruments. FLW can only be reduced with an integrated, holistic and systemic food supply chain approach that takes into account the multiple and multidimensional linkages and relations between the different food chain actors. The role of governments, consumers, social actors and other food system stakeholders as well as private sector social responsibility are vital in reducing FLW.

Through the introduction of appropriate technical and soft (organisational/social) innovations, the improvement of the management and governance of the whole food system is crucial for the reduction of food waste. Given the extent of the problem, Mediterranean countries should urgently adopt food waste prevention and reduction strategies. Research results should help design adequate policies, guidelines and recommendations for the main actors of the Mediterranean food system. Regulatory, economic/fiscal, informational/communication and behavioural and technological instruments should be combined to mutually strengthen their effects and emphasise policy coherence. Research, innovation and policy activities must be well coordinated if sustainable qualitative and quantitative results are to be achieved.

In order to effectively and efficiently address the issue of FLW it is vital to bridge the current knowledge gap. The CIHEAM and the FAO are joining efforts to meet this objective. This work stream specifically aims to improve knowledge on FLW in the Mediterranean (extent, causes, proven solutions in order to identify knowledge gaps, priorities for research and action) and support countries in designing their own strategies and plans of action by providing them with available knowledge, good practices and innovative solutions.

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