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Review article

Food Losses and Waste: A Global Overview with a Focus on Near East and North Africa Region

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Abstract

Food losses refer to edible food mass decrease throughout the human food chain. Food losses occurring at consumption stage are called food waste. Food Losses and Waste (FLW) represent one of the most critical social, economic and ecological challenges facing humanity, besides being also an ethical issue. FAO data show that roughly one-third of food produced for human consumption is lost or wasted. There are no precise and accurate data regarding food waste in Near East and North Africa (NENA) region. The review paper aims at providing insights about the extent of FLW in NENA region with a special focus on Arab countries and Iran. The paper explores linkages between food waste and food security. Moreover, it analyses the economic and environmental implications of FLW. FLW vary depending on food type, country and season. Generally speaking, postharvest losses are significant in this region for most of commodity groups. It is estimated that FLW amount to 34% of food supply in NENA region. FLW undermine the very foundations of food security and amount to major depletion of resources (e.g. water, land, energy) and produce needlessly greenhouse gases. They also represent a wasted investment that reduces farmers' incomes and increase consumers' expenses. Therefore, food waste reduction is crucial for improving the sustainability of the food supply chain and achieving food and nutrition security in the region.

Keywords:
Food waste, food Losses, food security, food system, NENA region

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INTRODUCTION

The rapid growth in world population, global income and meat consumption in the last decades are major drivers behind increased demand for food. There are essentially four options available to meet this challenge (European Group on Ethics in Science and New Technologies [EGE], 2008): (i) increase the area cultivated, thus putting further pressure on the remaining land, including marginal ground and forests; (ii) increase the productivity of the land currently cultivated; (iii) rationalize distribution of agricultural products to ensure they are in the right place at the right time; and/or (iv) modify the consumption habits of those enjoying excess and redistribute. The Foresight Global Food and Farming Futures project reached similar conclusions. In fact, it highlighted that substantial changes will be required throughout the different elements of the food system and beyond if food security is to be provided for a predicted nine billion people. Action has to occur on all of the following four fronts simultaneously (Foresight, 2011a): (i) more food must be produced sustainably through the spread and implementation of existing knowledge, technology and best practice, and by investment in new science and innovation and the social infrastructure that enables food producers to benefit from all of these; (ii) demand for the most resource-intensive types of food must be contained; (iii) waste in all areas of the food system must be minimized; and (iv) the political and economic governance of the food system must be improved to increase food system productivity and sustainability.

Food waste is one of the most severe social, economic, and ecological pathologies among those facing the planet. Producing food that will never end up on a table means unnecessarily aggravating the health of the planet. At a time in history when, nearly one billion people are still dying of hunger or have to settle for inadequate nutrition it is unacceptable that over a third of the world's food remains abandoned in the fields or ends up in landfills (Barilla, 2013). From an ethical point of view, a better management and distribution of food resources could be beneficial to society's least privileged (United Kingdom's Waste and Resources Action Programme [WRAP], 2008). However, there is also a psychological and cultural issue behind food wastage; the loss of the value of food (Barilla, 2013).

Food Losses and Waste (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. According to Parfitt et al. (2010), the term "food losses" refers to the decrease in edible food mass throughout the part of the supply chain leading specifically to edible food for human consumption. Food losses take place at the production, post-harvest and processing stages in the food supply chain. Losses occurring at the end of the food chain - retail and consumption - are referred to as "food waste". In fact, food waste may be more finely classified as food loss when incurred during early phases of the food supply-chain, and as food waste within latter phases (Gustavsson et al., 2011; High Level Panel of Experts on Food Security and Nutrition [HLPE], 2014).

Food waste most commonly refers to edible food products, which are intended for the purposes of human consumption, but have instead been discarded, lost, degraded or consumed by pests. It does not include the inedible or undesirable portions of foodstuffs (FAO, 1981; Foresight, 2011; Hodges et al., 2010; Parfitt et al., 2010). This is confirmed by Gustavsson et al. (2011) as they consider that food waste or loss should be measured only for products that are intended for human consumption, i.e. feed and non-edible product parts are excluded. Food that was originally meant for human consumption but which is accidentally eliminated from the human food chain is regarded as food loss or waste even if it is then directed to a non-food use (feed, bioenergy, etc.) (Gustavsson et al., 2011; HLPE, 2014). Inedible food waste refers to fractions of discarded food that are not normally eaten or digested, such as bones, pineapple and banana skins, eggshells, etc. (BIO Intelligence Service, 2013).

Food waste can be further categorized as either avoidable or unavoidable. Avoidable food

waste consists of products that could have been eaten, such as leftovers, food left to go bad and food past its sell-by date. Unavoidable food waste consists of non-edible waste such as peels, bones, shells and coffee grounds (Schott et al., 2013).

Today, about four billion metric tons of food are produced per annum worldwide. However, due to poor practices along the food chain (harvesting, storage and transportation), as well as market and consumer wastage, it is estimated that 1.2–2 billion tons of all food produced never reaches a human stomach (Institution of Mechanical Engineers-UK, 2013). In fact, it is commonly believed that food chain losses are in the order of 30 to 50% between farm and fork (Bloom, 2007; Giovannucci et al., 2012; Gustavsson et al., 2011; Henningsson et al., 2004; Institution of Mechanical Engineers-UK, 2013; Kader, 2005; Lundqvist et al., 2008; Meeusen and Hagelaar, 2008). The amount of food lost or wasted every year is equivalent to more than half of the world's annual cereals crop (2.3 billion tons in 2009/10) (Gustavsson et al., 2011). Global FLW amount to approximately 24% of all food calories (Lipinski et al., 2013).

There are considerable variations from one country, commodity and season to another (Lundqvist, 2010). Food losses and wastage occur in harvesting, transport, storage, packaging, processing, wholesale and retail trade, and where food is consumed (Gustavsson et al., 2011; HLPE, 2014; Institution of Mechanical Engineers-UK, 2013). Losses in the first part of the food chain - which are due to poor harvesting, transport, storage - are more important in developing countries (Lundqvist et al., 2008), while in industrialized countries most losses occur at the retail and consumer level, i.e. food is wasted (Gustavsson et al., 2011; HLPE, 2014). In developing countries 40% of losses occurs at post-harvest and processing levels while in industrialized countries more than 40% of losses happens at retail and consumer levels. At retail level, large quantities of food are wasted due to quality standards that over-emphasize appearance. Every year, consumers in rich countries waste almost as much food (222 million tons) as the entire net food production of sub-Saharan Africa (230 million tons) (FAO, 2013a).

Fruits and vegetables, plus roots and tubers have the highest wastage rates of any food. Global quantitative food losses and waste per year are roughly 30% for cereals, 40-50% for root crops, fruits and vegetables, 20% for oil seeds, meat and dairy (FAO, 2013a). As for post-harvest losses, estimates range from 8-22% of cereals lost at farm-level and post-harvest due to poor storage (Bala et al., 2010) to nearly 100% in some situations for horticultural produce (Parfitt et al., 2010). Moreover, over 40% of marine fisheries are wasted as by-catch (Davies et al., 2009).

Trends in diet composition towards a higher proportion of animal food items, fruit and vegetables tend to shorten the durability of food and could increase the risk of losses and wastage. In addition, distance to market, a more complex food chain and changes in composition and variety of food supply provide opportunities for more food wastage (Lundqvist et al., 2008).

However, there are no precise and accurate data regarding FLW in many developing countries including those of Near East & North Africa (NENA) region; where this problem exacerbates the inefficiency of the food chain thus contributing to food and nutrition insecurity among some of population groups. It is estimated that 34% of food supplies suitable for human consumption are being lost or wasted in NENA region (Gustavsson et al., 2011). A review of available literature on FLW in the NENA region developed by FAO Regional Office for the Near East (FAO/RNE) indicates a serious lack of information on FLW in several respects. Quantitative data on the magnitude, causes and stages of the supply chain where FLW occur are indispensable in taking remedial action; however, data have not been systematically collected and included in national or international databases (FAO, 2014). FLW in the NENA region are high (Capone et al., 2016; COMCEC, 2017; FAO, 2014, 2015, 2015a) and contribute to reduced food availability, aggravated water scarcity, adverse environmental impacts and increased food imports in an already highly import-dependent region (FAO, 2014, 2015a).

Therefore, the paper aims at providing insights about the extent of FLW in the NENA region. The ultimate aim is to allow scholars, practitioners and policy makers to gain insights and familiarity with the subject area and to have a common ground for future shared research and action aimed at addressing this issue in NENA countries.

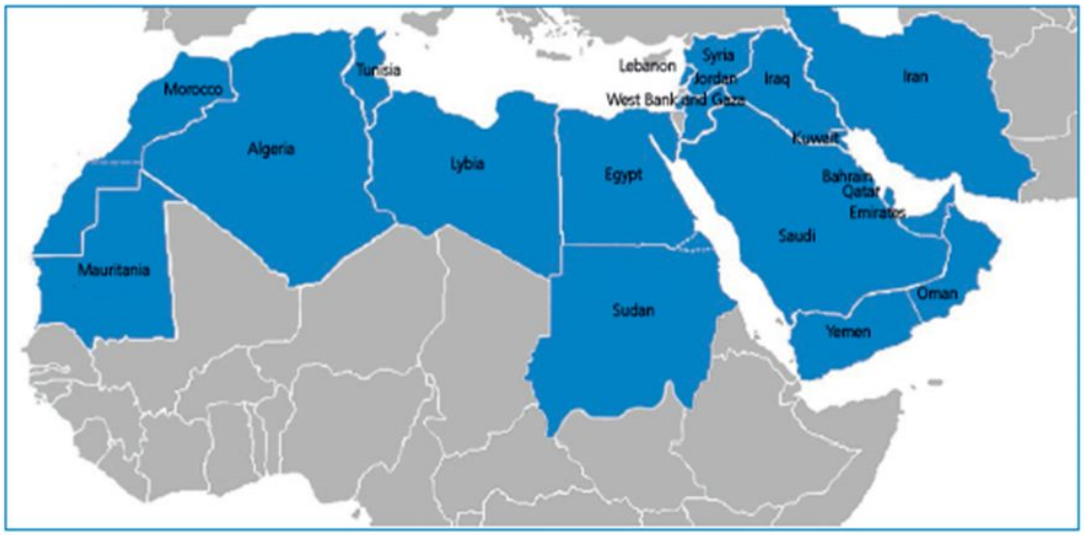
MATERIAL AND METHODS

The methodological approach adopted in this paper is at the same time explorative, descriptive and analytical. The work is exploratory as, to our knowledge, this is one of few times that the issue of FLW is addressed taking into consideration the whole NENA region, and there are few earlier exhaustive and region-wide studies to which one can refer for information about this issue. The exploratory character of the present research is also due to the lack and scarcity of data. The research is descriptive as the literature review aims also at describing the extent of the problem in the NENA countries taking into consideration the available data. It is also analytical as it investigates relationships between food waste, environmental footprints and household food spending. Doing so it goes beyond describing the state-of-the-art regarding FLW in the NENA region to analyzing their environmental and economic implications.

The geographical coverage of this study include countries that are under FAO Regional Office for NENA region (Figure 1).

The paper is mainly based on an extended critical literature review. The main secondary data sources include: Barilla Centre for Food and Nutrition (Barilla Center for Food & Nutrition, 2012); BIO Intelligence Service (2013); European Group on Ethics in Science and New Technologies to the European Commission (EGE, 2008); Institution of Mechanical Engineers-UK (2013); FAO (2011, 2012b, 2013c, 2013d, 2014, 2015, 2015a, 2017); High Level Panel of Experts on Food Security and Nutrition (HLPE, 2014); International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) (e.g. Capone et al., 2016; Di Terlizzi et al., 2016); Iranian Islamic Parliament Research Center (e.g. Tootyaii & Soleimani, 2009); Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC, 2017); United Kingdom's Waste and Resources Action Program (WRAP, 2008); United Nations Environment Program (United Nations Environment Programme [UNEP], 2012a, 2012b); World Resources Institute (e.g. Lipinski et al., 2013; Searchinger et al., 2013).

The paper analyses the extent of food losses and food waste in the NENA region focusing on the main food groups: meat and meat products, cereals and bakery products, fruits and vegetables, roots and tubers, and milk and dairy products (Table 1). The analysis was based on the global



Countries of the NENA region: Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi, Sudan, Syria, Tunisia, Emirates, Yemen, West Bank and Gaza.

Figure 1. NENA region. Source: Aw-Dahir (2015).

Table 1
Seven Food Commodity Groups Considered in FAO's Study on Global Food Losses and Waste

Food commodity group	Food products
Cereals	Wheat, rice, barley, maize, rye, oats, millet, sorghum, other cereals.
Roots and tubers	Potatoes, sweet potatoes, cassava, yams, other roots.
Oilseeds and pulses	Soybeans, groundnuts, sunflower seeds, rape and mustard seed, cottonseed, coconuts, sesame seed, palm kernels, olives, other oil crops.
Fruit and vegetables	Oranges and mandarins, lemons and limes, grapefruit, bananas, plantains, apples, pineapples, dates, grapes, tomatoes, onions, other citrus, fruit and vegetables.
Meat	Bovine meat, mutton/goat meat, poultry meat, other meat, offals.
Fish and seafood	Freshwater fish, demersal fish, pelagic fish, crustaceans, cephalopods, aquatic mammal meat, aquatic plants, other fish and aquatic animals/products.
Dairy products	Milk

Source: Gustavsson et al. (2011).

data as well as some national case studies (e.g. Abouabdillah et al., 2015; Ali Arous et al., 2017; Charbel et al., 2016; COMCEC, 2017; Elmenofi et al., 2015; FAO, 2012b, 2013c, 2014, 2015, 2015a; Sassi et al., 2016; Tootyaii & Soleimani, 2009). Then, it explores linkages between food waste and food security by providing estimates of wasted calories worldwide and in some NENA countries. Moreover, the paper analyses the economic (monetary value of food wasted) as well as environmental implications of FLW especially in terms of GHG emissions, water consumption and nitrogen footprint.

RESULTS AND DISCUSSION

Extent of food losses and food waste in the NENA region

According to FAO (2013c), causes of FLW in NENA region are lack of appropriate policy and regulatory framework, institutional weaknesses, and inadequate and weak infrastructural base. FAO (2015a) points out that the causes of FLW are attributed to poor farming systems, deficient infrastructure and inadequate post-harvest practices (e.g. handling practices, drying techniques, cold storage). The region has also a deficient market mainly due to inefficient marketing systems and inadequate market structure. NENA region suffers from very low cold chain capacity, especially due to its hot climate. Refrigerated storage capacity in Egypt was 0.0144 m3/capita, in comparison to 0.141 m^3/capita in France, indicating that it is very low although the hot climate in the region requires a much higher capacity. The lack of and unreliability of power supply is a key challenge to establishing the cold chain in the region. Poor maintenance and management practices are another major factor concerning the infrastructure in the region. Other types of infrastructure face similar major constraints. Wholesale and retail markets in the region are often small, overcrowded, unsanitary and lacking cooling equipment, and adequate facilities for loading, unloading, ripening, consumer packaging and temporary storage (FAO, 2013c).

Per capita food loss (including food waste) is 280 kg/year in Europe, about 215 kg/year in North Africa, West & Central Asia (NAWCA), about 130 kg/year in South and Southeast Asia and around 166 kg/year in Sub-Saharan Africa (Table 2). Overall, on a per-capita basis, much more food is wasted in the industrialized world than in developing countries: 95-115 kg/capita/year in Europe and only 6-11 kg/capita/year Sub-Saharan Africa (Gustavsson et al., 2011). Generally speaking, it is estimated that only 32% of FLW in North Africa and West and Central Asia (cf. NENA region) occurs at the consumption stage (mostly in urban centres), while up to 68% of FLW occur during production, handling, processing and distribution. Significant waste takes place also during social events (e.g. wedding ceremonies, family gatherings) and religious occasions such as the fasting month of Ramadan (FAO, 2015a).

The percentage of FLW of the edible parts of

Table 2
Food Losses (Pre-Consumptions Stages) and Food Waste (Consumption Stage) in North Africa, West & Central Asia, Europe and South and Southeast Asia regions (kg/capita/year).

Region	Food losses	Food waste	Food losses and food waste
Europe	190	90	280
North Africa, West & Central Asia*	180	35	215
South and Southeast Asia**	115	15	130
Sub-Saharan Africa** *	160	6	166

Source: Adapted from Gustavsson et al., 2011.
* NENA countries included in this group are Algeria, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Yemen.
** This group includes Iran.
*** NENA countries included in this group are Mauritania and Sudan.

the seven food commodity groups in the NENA countries are shown in Table 3. Generally speaking, postharvest losses are higher than waste at consumption stage in North Africa, West & Central Asia as well as in South and Southeast Asia.

Quantitative FLW in NENA region are estimated to be 45% of fruits and vegetables, 28% of fish and seafood, 26% of roots and tubers, 18% of dairy products, 16% of oilseeds and pulses, 14 to 19% of grains and 13% of meats. For fruits and vegetables, which have the highest proportion of losses and waste, country-specific data indicates a substantial part (as high as 29% for fresh vegetables in Egypt) of these losses occur at the post-harvest stage (FAO, 2014; 2015a).

Qualitative food losses are also very high in NENA region and exacerbated by deficient market infrastructure (e.g. poor transportation in non-refrigerated vehicles, lack of cold chain infrastructure, open air markets where food is exposed to sunlight) that speeds up food degradation and may create health hazards (FAO, 2015a).

Losses and waste severely affect the availability of food in the NENA region. It is estimated that

Table 3
Weight Percentages of FLW (in Percentage of What Enters Each Step of the Food Supply Chain) in NENA Countries

World region	Commodity groups	Steps of the food supply chain				
		Agricultural production (%)	Postharvest handling and storage (%)	Processing and packaging (%)	Distribution: Supermarket retail (%)	Consumption (%)
North Africa, West and Central Asia	Cereals	6	8	2.7	4	12
	Roots & tubers	6	10	12	4	6
	Oilseeds & pulses	15	6	8	2	2
	Fruits & vegetables	17	10	20	15	12
	Meat	6.6	0.2	5	5	8
	Fish & seafood	6.6	5	9	10	4
	Milk	3.5	6	2	8	2
South and Southeast Asia	Cereals	6	7	3.5	2	3
	Roots & tubers	6	19	10	11	3
	Oilseeds & pulses	7	12	8	2	1
	Fruits & vegetables	15	9	25	10	7
	Meat	5.1	0.3	5	7	4
	Fish & seafood	8.2	6	9	15	2
	Milk	3.5	6	2	10	1

Source: Adapted from Gustavsson et al., 2011.

10-15% of non-perishables (e.g. grains) and up to 60% of perishables are lost during the whole production chain in the Near East region. In addition, post-cooking losses are also significant. The very significant post-harvest losses are due to many reasons, inter alia, extreme environmental conditions, inadequate storage, transport and packaging infrastructure, etc. (FAO, 2011).

Not only food losses but also food waste, including household food waste, is a critical issue in NENA countries. In fact, the results of an online exploratory survey - carried out in Algeria (Ali Arous et al., 2017), Egypt (Elmenofi et al., 2015), Lebanon (Charbel et al., 2016), Morocco (Abouabdillah et al., 2015) and Tunisia (Sassi et al., 2016) - show that household planning and shopping activities are important predictors of FW. On the other hand, data showed that food waste increases during the fasting month of Ramadan and according to the category of food (most wasted product groups are cereals and bakery products, fruits and vegetables). FW is widespread in Morocco as only 3.3% of respondents declared that they do not waste any food compared to 13.8% in Egypt. About 41% in both countries declared that their households throw away at least 250 g of still consumable food each week.

As in other states in South and South East Asia, most of food waste in Iran occurs in the supply hand (Gustavsson et al., 2011; Rastegary, 2015). In 2009, a Ministerial statement indicated an average figure of 18.85% in agricultural products. The most wasted products are fruits and orchard products, and fish and seafood are the least wasted products in national level (Tootyaii & Soleimani, 2009). Food waste has been increasing in the following years and the waste figures are no better than regional levels: 30% waste in bread, 25-30% waste in fruits and vegetables, 10% waste in rice, 25% waste in date (Ayaronline, 2014; E'tedaal, 2012; Iranian Labor News Agency, 2014; Salamat, 2015; Taamol, 2014). The amount of food waste in Iran is being affected by some defects in supply chains and culture. Firstly, loss of quality in supply chains of many agro-products and foods is reflected in food waste on consumption hand. In this sense, a big portion of food waste in consumption phase is rooted in the former stages of supply chains, and should be considered essentially as food loss. Moreover, some harmful consumption patterns have been growing in Iranian society. One of these is the consumerist attitude and behavior towards food. This behavior can be exacerbated with a raise in general purchase power in the post-sanction era (Rastegary, 2015). One major concern in this area is absence of food policy in Iran. The state is in need of an all-encompassing food policy, rather than several independent agricultural, industrial, health, environmental and social policies (Tootyaii & Soleimani, 2009).

Some important constraints have hindered so far effective actions in reducing FLW in NENA region. These include, among others, lack of awareness and technical capacity among food supply chain actors; inadequate data on commodity and location-specific losses and waste; non-existent or inappropriate policies, regulations and incentives; institutional and coordination gaps; and insufficient investment (e.g. cold chain infrastructure, processing, transportation) (FAO, 2015a).

Food waste and food security

FLW undermine the very foundations of food and nutrition security. In fact, it affects all the four components of sustainable food security i.e. availability, access, utilization and stability. Therefore, the reduction of the amount of food lost or wasted globally is now presented as essential to improve food security (FAO, 2012, 2012a, 2012b, 2017; HLPE, 2011). This is particularly true and relevant as some authors identified margins of improvement. In fact, Kummu et al. (2012) pointed out that approximately half of FLW could be prevented compared to the current situation. According to them, 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%.

The amount of food produced on farmers' fields is much more than is necessary for a healthy, productive and active life for the global population. Nevertheless, losses of food between

the farmer field and the dinner table are huge (Lundqvist et al., 2008). When converted into calories, global FLW amount to approximately 24% of all food produced. Essentially, one out of every four food calories intended for people is not ultimately consumed by them (Kummu et al., 2012; Lipinski et al., 2013; Searchinger et al., 2013). Although high, that figure is lower than the commonly cited figure of one-third, which measures losses by weight (Searchinger et al., 2013). Food waste alone corresponds to about 10% of the world's total caloric energy consumption (Gustavsson et al., 2011). According to Kummu et al. (2012) only vegetable products loss and waste correspond to 614 kcal/cap/day so 24% in terms of energy from what is produced for human consumption. However, the above-mentioned caloric estimates of FLW fail to capture the nutritional quality loss that's to say the amount of micronutrients (e.g. vitamin A, iron, zinc, iodine) that is associated to food lost or wasted or because of poor cooking and food preparation practices and methods.

Even if just one-fourth of the food currently lost or wasted globally could be saved, it would be enough to feed 870 million hungry people in the world (FAO, 2013a). The world's nearly one billion hungry people could be fed on less than a quarter of the food that is wasted in the US and Europe (Stuart, 2009). Losses in cereal grains in Sub-Saharan Africa alone could meet the calorific needs of at least 48 million people (World Bank, 2011). According to the results of a report of the World Resources Institute, cutting global FLW in half by 2050 would reduce the food gap by roughly 20% (Searchinger et al., 2013). According to Clay (2011), if we could eliminate current waste levels, we would halve the amount of extra food needed by 2050, thus allowing rethinking the argument for more intense production methods. In fact, food loss reduction can help containing the need for future additional food production (Aulakh & Regmi, 2013; FAO, 2004; Kader, 2005). Obesity and consequent overconsumption is also considered as a kind of food waste. Reducing the consumption of excess calories would reduce the 2050 calorie gap by 6% (Searchinger et al., 2013).

Research carried out by Smil (2004), provides a global overview of losses and waste that take place along the entire food chain: on average, only 43% of the products cultivated for food are actually consumed. Global farmers are able to produce food that is equivalent to 4600 kcal/capita/day. However, 600 kcal/capita/day are lost because of inefficiencies in the harvesting, transportation, storage, and processing stages. Moreover, the conversion of food production (mainly grains) into feed for livestock causes a further net decrease of 1200 kcal/capita/day. While not really food waste per se, allocating food to animals raises many questions among food security scholars. Finally, food retail distribution causes additional waste (equal to 800 kcal/capita/day), leading to an average usable per capita daily dietary energy of just 2,000 kcal.

The relation between FLW and food security is particularly relevant in the Near East and North Africa region. In fact, NENA region still experiences a food deficit and relies on food imports to meet over 50% of its total food requirements. Therefore, it is unacceptable that the region loses or wastes up to 250 kg of food per person each year, a figure that is higher than the global average (FAO, 2014, 2015a). According to some reports, 35% of 100 million tons/year of national agricultural production in Iran is wasted, which is sufficient to sustain 15 million people (Izadi & Haiati, 2013 in Rastegary, 2015).

Economic implications of food waste

Economically avoidable food losses have a direct and negative impact on farmer and consumer incomes (Gustavsson et al., 2011; HLPE, 2014). Food waste implies a considerable loss of money for both producers and consumers (WRAP, 2008). In fact, FLW represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses (Lipinski et al., 2013) as food losses during harvest and in storage translate into lost income for farmers and into higher food prices for consumers (FAO, 2013a, 2017; HLPE, 2014). FLW imply that consumers are paying a higher price for food due to inefficiency and/or inequity of the food system as a whole. In general, with a reduction in FLW, the overall food

supply would increase, which would drive down food prices and benefit consumers. The direct economic cost of FLW, based on producer prices only, is about US$ 750 billion (FAO, 2013b). According to FAO (2013), FLW amount to roughly US$ 680 billion in industrialized countries and US$ 310 billion in developing countries.

According to a report of the Islamic Parliament Research Center (Tootyaii & Soleimani, 2009) the value of wasted agro-products in Iran is approximately equal to 25% of national revenue from oil exports in 2009. Some controversial reports also indicate the economic losses of the tremendous food wastage. For instance, in January 2015 the research center of the Islamic Parliament estimated that the annual waste of bread incurs a 2.857 billion USD cost to the state (Talebi, 2014). The Agricultural Commission in the Islamic Parliament urged that the value of food waste in Iran in 2014 has been approximately equal to aggregate figure of staples and agro-products imports of the state in the same year (Salamat, 2015). Wasted food also depletes an immense sum of funds that are allocated to sustain and support national food security. Indeed, the state spends billions of dollars of subsidies in terms of low-priced lands, water, agricultural inputs (e.g. seeds, fertilizers, and pesticides), farming equipment, and supplementary services (Iran Economy News, 2015; Alef, 2015). The outcomes are very disappointing as Iran is expected to lose and/or waste one-third of forecasted 47.3 billion USD agricultural production in 2015 (Business Monitor International, 2015).

The analysis of the supply and demand economic theory shows that FLW reduction may improve food security due to lower food prices and increased food consumption. Consumers may increase spending from savings on previously wasted food. However, some trade-offs may also arise over time between food system actors, countries and markets. Consumers are generally better off while producers may be worse off. Reducing food waste may diminish producers' revenues. In the short-run producers may have to incur also food losses reduction costs. Meanwhile, consumers may delay spending savings on previously wasted foods (Rutten, 2013). Some studies point out that a greater supply of food due to the reduction of losses at production stage, without changes in consumption patterns, could simply raise waste downstream in the food system. In fact, some consumers, especially in developed countries, would have access to more food at even lower prices so could produce more food waste. Meanwhile, other consumers would continue on their path of waste if nothing is done to avoid it (Godfray et al., 2010; Rutten, 2013a). All in all, the economic outcomes of FLW reduction actions and strategies depend on, amongst others, the extent to which losses and/or waste are avoidable, the costs involved, the causes of FLW (Rutten, 2013). Anyway, society will have to accept some level of food loss (Stuart, 2009) when reducing FLW further becomes no longer economically viable.

Environmental implications of food losses and waste

FLW reduction is now considered as essential to reduce the environmental footprint of food systems (Bellù, 2016; FAO, 2012, 2012a, 2013a; HLPE, 2011; UNEP, 2012a, 2012b). In fact, this is presented as crucial for reducing the emission of greenhouse gases (GHG), thus slowing the pace of climate change, and des-intensifying natural resources use.

The long food products journey involves consumption of resources, labor, and, consequently, of GHG emissions. So, when considering a foodstuff throughout its life cycle, one must also take into account the water, energy, and resources consumed, and, therefore, wasted when this food becomes refuse (Barilla, 2013). Food and drink wastage involves major environmental consequences at global and local levels. Food loss and wastage amounts to major squandering of resources, including water, land, energy, labor and capital, and needlessly produce GHG emissions (Bellù, 2016; FAO, 2013a; Gustavsson et al., 2011). Wasting food means losing not only life-supporting nutrition but also precious resources. FLW imply that large amounts of land, energy, fertilizers and water have also been lost in the production of foodstuffs which simply end up as waste (Gustavsson et al., 2011; Institution of

Mechanical Engineers-UK, 2013).

FLW inflict a host of impacts, including unnecessary GHG emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide (Lipinski et al., 2013). FLW can be translated into direct and indirect environmental impacts. FLW have two major direct environmental impacts: waste of the resources used to produce the food lost and wasted and major source of negative impacts including emissions of GHG at disposal. Indirect environmental externalities include unnecessary surface and ground water pollution caused by the intensive use of nitrogenous fertilizers in agriculture. FLW negative externalities include also those that mono-cropping and agriculture expansion into wild areas create in terms of biodiversity loss (FAO, 2013d).

Many recent scientific studies have attempted to analyze environmental impacts of FLW usually addressing categories such as greenhouse gas emissions (carbon footprint) (e.g. Garnett, 2011), water footprint (e.g. Chapagain & James, 2013; Ridoutt et al., 2010; Vanham & Bidoglio, 2013), nitrogen (e.g. Grizetti, 2013) and land use (ecological footprint) (e.g. Wirsenius et al., 2010). The direct environmental footprint resulting from losses and waste of food at global level can be represented by the emission of 3.3 billion tons of greenhouse gases released into the atmosphere and the use of 1.4 billion hectares of arable land (FAO, 2013d, 2013e). In fact, without accounting for GHG emissions from land use change, the carbon footprint of food produced and not eaten is estimated at 3.3 gigatons of CO_2 equivalent (FAO, 2013b, 2013d). The roughly one third of food produced for human consumption that is lost or wasted globally every year (Gustavsson et al., 2011; HLPE, 2014) is estimated to be equivalent to 6 to 10% of human-generated greenhouse gas emissions (Vermeulen et al., 2012).

Organic waste, including food waste, is an important source of methane when sent to landfill. Decomposition of organic material is a major contributor to greenhouse gas (GHG) emissions, which cause global warming (WRAP, 2008). It is well known that every product generates CO_2 throughout its life cycle and, therefore, has a carbon footprint that weighs heavily on climate change.

Food waste is also a wastage of land resources (FAO, 2013d; Wirsenius et al., 2010). The McKinsey Global Institute ranked reducing food waste in the top-3 of measures that will contribute to improved productivity of global resources. It pointed out that reducing food waste in developed countries by 30% would save roughly 40 million hectares of cropland. As a matter of fact, it is estimated that produced but uneaten food vainly occupies close to 30% of the world's agricultural land area i.e. almost 1.4 billion hectares of land (FAO, 2013d).

FLW account for more than one quarter of the total consumptive use of finite and vulnerable freshwater resources and more than 300 million barrels of oil per year (Hall et al., 2009; Lundqvist et al., 2008). Globally, the blue water footprint (i.e. the consumption of surface and groundwater resources) of food wastage is about 250 km^3 (FAO, 2013d, 2013e). Minimizing waste can reduce demand for water; a 50% decrease in FLW at the global level would save 1,350 km^3 a year (FAO, 2012).

Most of the Water Footprint (WF) of consumption in the NENA countries is due to the consumption of agricultural products. The share of the water footprint of agricultural products consumption in the total water footprint of consumption ranges from 84% in United Arab Emirates to 98% in Morocco, Sudan, Tunisia and Yemen. The average value is approximately 93.8% of the total WF of consumption (Mekonnen & Hoekstra, 2011). Taking into account the WF of agricultural products consumption (Mekonnen & Hoekstra, 2011), considering the conservative FLW percentage of 30% (cf. Gustavsson et al., 2011) and assuming that the same amount of water is wasted whenever food is lost and/or wasted, it can be realized that from 265 (Yemen) to 790 m^3/capita/year (United Arab Emirates) of water are lost or wasted by NENA people (Table 4).

In February 2015, the Iranian Ministry of Agriculture announced that food waste in the state accounts for wastage of 15 billion cubic meters of

Table 4
Estimates of Water Losses and Wastage in NENA Countries

Countries*	WF of consumption (m^3/capita/year)	WF of agricultural products consumption (%)	Water losses and wastage due to food losses and waste (m^3/capita/year)
Algeria	1589	97	463
Egypt	1341	90	364
Iran	1866	94	526
Jordan	1678	95	478
Kuwait	2072	88	547
Lebanon	2112	94	593
Libya	2038	93	571
Mauritania	2565	97	746
Morocco	1725	98	505
Palestine	1055	93	294
Saudi Arabia	1849	92	510
Sudan	1736	98	510
Syria	2107	95	600
Tunisia	2217	98	650
Turkey	1642	92	453
United Arab Emirates	3136	84	790
Yemen	901	98	265

*No data found for: Bahrain, Iraq, Oman and Qatar.
Source: Authors' calculation based on data from Mekonnen and Hoekstra (2011).

freshwater resources per annum (Kayhan, 2015).

The environmental impacts of food production mean that minimizing food waste is a high priority. Reducing the amount of food required by reducing waste could mitigate the negative effects of land use change and CO^2 emissions from agriculture (Schott et al., 2013). Making the food chain more efficient through waste reduction measures (e.g. Di Terlizzi et al., 2016) will reduce pressure on resources required for food production and lower greenhouse gas emissions (Foresight, 2011a). Reducing the amount of food wasted throughout the food chain in the entire NENA area would help improving food and nutrition security and contribute to easing pressure on natural resources especially water. Moreover, reducing waste across the whole food system will increase the amount of food available for human consumption for the given level of inputs, thereby improving input use efficiency (Ingram, 2011). Reducing food loss and wastage reduces water needs in agriculture (Lundqvist et al., 2008) as well as environmental impacts (Lundqvist et al., 2008; Nellemann et al., 2009). Interventions to reduce food chain waste will likely have as great or even greater impact on freshwater resource availability as other water use efficiency measures in agriculture and food production (Ridoutt et al., 2009).

CONCLUSIONS

Moving towards sustainable food consumption and production means addressing systemically the consumptive demand as well as productive supply elements by fostering smarter, efficient and appropriate food production and consumption patterns. Curbing the amount of FLW is a tangible starting point. FLW have a direct and indirect incidence on both food security and food systems sustainability. Wasting food is unsustainable, economically negative, environmentally wrong, and morally unacceptable. Food waste exacerbates the inefficiency of the food chain thus contributing to food and nutrition insecurity in the NENA region. FLW also amount to a major squandering of resources, including water, land, energy, labor and capital and needlessly produce greenhouse gas emissions, contributing to climate change. Therefore, adoption of more sustainable food consumption patterns and production systems and the reduction of FLW can help reducing pressure on natural resources, especially water, in the NENA region. Reducing waste across the whole food system

will increase input use efficiency. Trends in production, consumption and trade of food suggest an increasing dependence of the NENA region on external sources for its basic food supplies. Therefore, the potential to make more food available by simply eliminating losses, while simultaneously freeing up land, energy, water resources for other uses, is an opportunity that should not be ignored and should be put high on the research and policy agenda of NENA region. FLW reduction is a good entry point to broader improvements of NENA food systems towards food security, food safety, quality and sustainability. A recommended action to reduce food waste is the introduction of targeted awareness-raising and information campaigns and education programs. The improvement of the management and governance of the whole food system is also crucial. Research results should help designing adequate policies and guidelines for the main actors in the NENA food system. The role of governments, consumers, social actors and other food system stakeholders as well as the private sector are vital in reducing FLW. Given the entity of the problem, NENA countries should urgently adopt food waste prevention and reduction strategies.

Conflict of interest

Authors have no conflict of interest to declare.

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