Food Losses and Waste of Food

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Contributor: Daniel Durán Sandoval

In recent times the issue of food losses and waste of food (FLW) has received increased academic and political attention. Although the definition of FLW is not clear, the truth is that globally roughly one-third of food is not consumed and is wasted, equivalent to 1.3. billion tonnes per year. The reasons for FLW differ between countries. In developed countries, most FLW occurs at the retail, foodservice and, home stages of the food supply chain for a variety of reasons. For instance, food not used in time, burning, spoilage, personal preferences or, leftover waste. While in developing countries FLW is mainly due to the absence of infrastructure, lack of knowledge and, investment in storage technologies.

Keywords: food losses ; waste of food ; food supply chain ; sustainable development goal ; food security ; food sustainability

1. Introduction

In recent times the issue of food losses and waste of food (FLW) has received increased academic and political attention. Although the definition of FLW is not clear, the truth is that globally roughly one-third of food is not consumed and is wasted, equivalent to 1.3. billion tonnes per year [1]. The reasons for FLW differ between countries. In developed countries, most FLW occurs at the retail, foodservice and, home stages of the food supply chain for a variety of reasons [2][3]. For instance, food not used in time, burning, spoilage, personal preferences or, leftover waste [4][5]. While in developing countries FLW is mainly due to the absence of infrastructure, lack of knowledge and, investment in storage technologies [1][6].

To end hunger, achieve food security, improve nutrition and food waste is the aim of Sustainable Development Goal 2 (SDG2), one of the 17 SDGs adopted by United Nations Members States in 2015. This goal is reinforced by target 12.3 focus on Zero Hunger and food waste. Specifically, it indicates to “end hunger, achieve food security and improved nutrition and promote sustainable agriculture” and “to halve global food waste at retail and consumer levels, as well as to reduce food loss during production and supply” [7]. However, despite these key objectives, about 820 million people in the world are undernourished and 2 billion people have moderate or severe food insecurity [8]. One of the most striking cases is that of China, which has 22% of the world’s population and whose economy was ranked in 2018 as the second largest in the world with a GDP of 13.6 trillion US dollars [9]. Furthermore, GDP per capita growth between 1980–2018 was 8.5% annual average, with an income increase from 347 US dollars in 1980 to 7753 US dollars in 2018 [9]. Such economic growth brings an improvement in living standards, including an increase in food consumption. For instance, the domestic supply quantity of the two most consumed food groups in China, namely, vegetables and cereals, has increased from 204 to 572 kg per capita per year between 1980 to 2017, which represents an increase of 280% [10].

Along with this, China has progressed in reducing undernourishment. From 2000–2002 to 2016–2018, China has reduced the number of undernourished people from 209 to 122 million people, equivalent to a reduction of 41% [10]. For instance, the rate of stunting and underweight in children under five years felt by half from 2002 to 2013 [11]. However, the number of people that experience undernourishment is still considerable and the amount of FLW is quite alarming and is increasing dramatically [12][13].

In recent years the Chinese government is concerned to address FLW as a tool to improve food security and reduce environmental problems [12]. Further improving per unit area yield will be hard in the context of limited cultivated land resources, water scarcity, land competition due to industrialization, urbanization, infrastructure development and, ongoing soil erosion and desertification [14]. In addition, the U.S.A-China trade war is having economic effects around the world, particularly in agricultural markets, such as soybeans, pork, fruit, and nuts, due to the endurance of the tariffs [15]. This situation may affect China’s food security, especially considering that it imports about 87% of its consumption of soybean, which is equivalent to 60% of the world’s transactions for this food [15]. In addition, it is important to consider that the Covid-19 pandemic has been the main concern and challenge for humanity and will probably continue to be so for a long time [16]. The pandemic has accelerated some trends that were already emerging for consumer goods companies.

Consumers are becoming more mature and demanding, business models have diversified, and competition is increasingly fierce. Despite all the post-pandemic uncertainty, Zipser and Poh [17] point out that the Chinese economy will continue to be the engine driving global consumption growth. According to Laborde et al. [18], the pandemic has affected all the four pillars of food security, especially access to food. Hence, working toward the reduction of FLW, especially in the post-consumer segment, will be critical to future food security [19].

2. Food Loss and Waste

The FAO definition of FLW refers to the decline in mass or quality attributes of food intended for human consumption that are produced throughout the Food Supply Chain (FSC), from initial production down to final domestic consumption [20]. However, there are many different definitions of FLW and they are often controversial [21]. According to Chaboud and Daviron [22] differences in the definition of FLW occur in terms of scope (intended or not for human consumption), timing (pre-harvest, ready for harvest, post-harvest), criteria (use, edibility or nutrition), perspective (environmental, social, food security), and type (qualitative or quantitative).

Also, there were some nuances between the term food loss and food waste. The first term refers to the decrease in the mass of edible food that takes place from production to processing stages in the FSC [23][24]. The second term refers to good quality food suitable for human consumption but not consumed because it is discarded at the end of the FSC, in distribution, retail, and consumption [24][25].

To operationalize the previous definition of FLW other concepts were considered such as food loss and waste rate (FLWR), allocation factors, and conversion factors. The FLWR is defined as the ratio of food loss and waste to the total amount of food production. The allocation factors determine the proportion of food that is destined for human consumption. The conversion factors determine the proportion of food that is edible.

3. Food Security and SDG2 Zero Hunger

Firstly, it is important to define the concept of food security. The World Food Summit in 1996 defined food security as “The situation when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” [26]. This widely accepted definition reinforces the multidimensional nature of food security considering its four dimensions, availability, access, use, and stability [27].

Today, FSC has become more globalized, specialized, and complex due to advances in technology and transportation, and the reduction of trade barriers [28]. In globalized food systems, there are a large number of actors that are horizontally and vertically connected. This evolution from traditional agriculture to globalized agriculture has increased the distance between the places where food is produced and consumed [29]. This situation can lead to an increase in the probability of FLW due to a long time between post-harvest and consumption and the large number of transactions involved between the different FSC actors. However, it can also lead to improvements in food security due to the possibility of connecting food producers with populations that suffer from food insecurity. In this sense, the Chinese case is particularly relevant because since 2019 China has been the world’s largest agricultural importer [30].

The commitment to achieve food security was assumed by SDG 2 Zero Hunger, which is specified in eight targets. The first two targets address the problems of micro and macro-nutrient deficiencies. However, they do not face the problems of excessive consumption or consumption of food that are high in salt, fat, and sugar and their subsequent health consequences. SDG targets 2.3 and 2.4 are related to food production, specifically productivity and incomes of small food producers and sustainable food production. The last 4 targets address implementation issues that contribute to the achievement of the first 4 targets, namely genetic diversity, infrastructure and technology, and agricultural trades and markets (**Figure 1**).

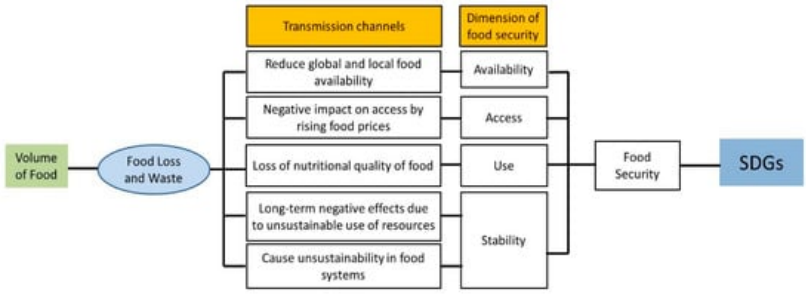

Figure 1. Impacts of FLW on food security and SDG 2.

To achieve food security and SDG 2, all FSC is critical, that is, from sustainable food production to responsible consumption. Monitoring FLW can directly contribute to the achievement of the SDGs in different ways. First, control of FLW increases food availability [31], which could improve food security. Second, sustainable food systems with less FLWs could lower the cost of food. According to FAO [1] given the large magnitude of FLW, investments to reduce them could be a way to reduce the cost of food. For example, Lemaire and Limbourg [31] state that reduction of FLW or the donation of food before becoming FLW can lead to a reduction in the cost of food if the cost of that action is lower than the cost of disposal of FLW. Reducing FLW and the cost of food production increase the availability of food in the food market reducing food prices, resulting in improved access to food for vulnerable people [32].

In addition, reducing FLW at the FSC consumption stage could lead to an increase in the consumer's food budget, improving consumer access to food. In fact, at the household level, Schanes, Doberning and Gözet [33] point out that saving money is the predominant intention behind reducing FLW, before environmental concerns. However, these links between FLW and food prices are not yet well investigated, especially at the quantitative level [32]. Third, the control of FLW implies an increase in the availability of food of high nutritional quality, reducing hunger problems not only with an increase in the availability of food but also by providing food with better nutritional qualities [32]. Fourth, sustainable food systems with fewer FLWs can reduce investment risk for businesses. Thus, it can reduce the volatility of food prices, increasing the stability of the food supply. Markets are currently characterized by low transparency and high volatility in food prices, leading to the exclusion of vulnerable people from food systems [20].

Furthermore, FLW has negative effects on the environment through the waste of water and land, CO_2, N_2O, and CH_4 emissions that cause climate change and damage to biodiversity [34][35]. The deterioration of the environment in turn has negative effects on agriculture, generating a vicious circle [15]. For example, climate change affects the vulnerability of food insecurity due to its biophysical effects on crops, livestock, and the productivity of the agricultural system [36]. In addition, intensive land use causes acidification and degradation of the soil, which reduces the yield of agricultural production.

4. Patterns and Scale of Food Loss and Waste in China

Ma et al., [37] pointed out three main general factors to explain FLW in China. First, economic growth and increased income and purchasing power. China's economy was ranked in 2018 as the second-largest economy in the world. Existing data indicate that per capita food waste in households increases with an increase in GDP per capita [38]. Economic growth implies an increase in the disposable income of households, which makes disposable income-producing that the share of income spent on food is low compared to the available budget of households. Therefore, it could lead to careless behaviours of people related to FLW. Second, the development of agriculture in recent decades. China's agricultural sector developed significantly in recent decades. For example, in the period from 1980 to 2017, cereal production increased from 232 to 620 million tonnes [10]. Besides, in 2017 China ranked first in the world in meat production, 88 million tonnes, almost double that of the second-largest producer, the United States [10].

Additionally, an industrialization process is underway in Chinese food production, from small domestic animal production to large, industrialized production. According to Wang et al., [39], before 1980, less than 5% of food animals were produced in concentrated animal feeding operations, but in 2010 more than 50% of the animals were raised under these conditions. An increase in food production will eventually increase FLW if the factors that cause FLW are held constant. For example, if a country increases grain production, but storage technology is inefficient and remains constant, FLW will also increase. Third, public policies related to agriculture and food waste. The Chinese government considers cereal production a national priority due to its large population. To meet this objective, the government has promoted a set of public policies to encourage grain production. For instance, the government heavily subsidizes cereal production, provides specialized seeds (elite cultivars) and agricultural machinery to farmers, and provides incentives for surplus agricultural production [37]. Most of these public policies are carried out based on the consumption of inputs. Examples of these public policies are the Comprehensive Subsidy on Agricultural Inputs established in 2006 and the Subsidy for the Purchase of Agricultural Machinery. The previous public policy compensates grain producers for increases in the price of inputs. To this end, the Chinese government budgeted 12 billion yuan in 2006, while this budget increased to 71.6 billion yuan in 2010 [40]. This last public policy aims to help farmers to buy agricultural machinery, subsidizing between 20–30% of the sale price. For this purpose, the Chinese government provided 2 billion yuan in 2007, increasing the budget to 15.5 billion yuan in 2010 [40]. Initially, most public policies related to agricultural production focused on increasing production rather than controlling FLW in the process or promoting sustainable consumption. Therefore, the increase in production caused a concurrent increase in the absolute volume of FLW.

Besides the previous general causes of FLW, there are also specific causes at each particular stage of FSC. In China, 51% of starchy root and 28% of vegetable FLW were produced at the agricultural production stage. The reason is mainly due to diseases, insects, weeds, rodents, severe climatic conditions during planting, and inefficient seeding [41]. Likewise, at this stage, around 38% of fish and seafood, dairy products, and eggs are discarded. During the agricultural production stage, the main causes of FLW from livestock products are death and diseases, such as the death of an animal during breeding for bovine, pork, and poultry meat, discards during the fishing of fish, and the decrease in milk production due to dairy cow diseases such as mastitis [41].

In China, 35% of cereal FLW was produced at the post-harvest and storage stage. The main reason is the fragmented and small-scale structure of the farms [41]. According to Ma et al. [37] in China, 70% of storage is done on small farms. Government grain storage facilities are more efficient and have lower FLW rates than small farms [12]. The main reason for this difference is that small farmers store grain for their self-consumption or even a sales opportunity without the proper facilities or technology. In this sense, SAG and NDRC [42] estimated that on average 49%, 30%, and 21% of Chinese grain waste during storage was caused by rodents, fungi, and insects, respectively.

The economic growth of the last four decades has improved the standards of living of the Chinese population, and now people can buy more food and with better nutritional qualities. Consumption of animal products has also increased, creating more unavoidable waste, for example, animal bones and organs [37]. Increasing population prosperity and the associated changes in consumption trends have increased FLW at the FSC consumption stage. At the same time, according to Liu et al. [12], the traditional Chinese culture of “cherishing food” is fading, which has further contributed to the rise in FLW. Furthermore, some researchers, such as [14][43], state that FLW in restaurants is higher than in canteens and homes. Although several factors could explain this phenomenon, Chinese consumption psychology and other cultural factors have a significant impact [44]. At home and in canteens Chinese people worry more about FLW because of the price of the food they pay. However, in restaurants, consumers often invite their guests, friends, or family and order large quantities of food as an act of “save face” or “mianzi”, resulting in a high level of FLW [14]. For example, at dinners, the host prepares as much food as possible for guests and they should eat as much as possible. According to the Chinese culture of hospitality or “mianzi”, the host will be ashamed if a guest does not have enough to eat [43]. In the consumption stage, a higher level of education leads to a decrease in FLW but also leads to a higher amount of food consumption [45].

Several studies have been developed on the patterns and scale of FLW in China. For example, Liu et al. [12] estimated that in China the maximum total amount of FLW in grains, vegetables, and fruit was 248 million tonnes in 2010. Liu [41] concluded that storage is the largest contributor to post-harvest FLW, specifically on 8.6%, 3.7%, and 15% for grain, meats, and perishable food, respectively. Song et al. [45] stated that an average person wastes 16 kg of food at home annually (consumption is approximately 415 kg). Porter et al. [46] pointed out that in China FLW was 411 million tonnes in 2011. Sun et al. [13] estimated that, at the consumption stage, FLW of cereals and vegetables were 29 and 20.63 million tonnes in 2010, while those of pork and poultry were 1.9 and 0.78 million tonnes. Qi, Lai and Roe [47] reported an annual per capita household food waste of 14.9 kg in 2009. Finally, Li et al. [48] estimated that the average generation of food waste in the rural household is 8.74 g per capita per meal (g/pc/meal).

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