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Food Losses and Food Waste in China

A FIRST ESTIMATE

Gang Liu

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Abstract

FOOD LOSSES AND FOOD WASTE IN CHINA: A FIRST ESTIMATE

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Reducing food losses and food waste is attracting growing public attention at the international, regional, and national levels, and is widely acknowledged to contribute to abating interlinked sustainability challenges such as food security, climate change, and water shortage. However, the pattern and scale of food waste throughout the supply chain remains poorly understood for developing countries such as China, despite growing media coverage and public concerns in recent years. The data in the literature are either out of date or fragmented. This report presents estimates of food losses and food waste in China, based on literature data, informed estimates, and other publicly available information.

Keywords: agricultural losses, food loss, food waste, food waste reduction, grain storage, municipal solid waste, China, food value chain, data, policy information

JEL classification: Q180, Q530, Q580

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Executive Summary

Reducing food losses and food waste is attracting growing public attention at the international, regional, and national levels, and is widely acknowledged to contribute to abating interlinked sustainability challenges such as food security, climate change, and water shortage. However, the pattern and scale of food waste throughout the supply chain remains poorly understood for developing countries such as China, despite growing media coverage and public concerns in recent years. The data in the literature are either out of date or fragmented. This report presents estimates of food losses and food waste in China, based on literature data, informed estimates, and other publicly available information.

The main conclusions are as follows: (i) information on the quantity of food loss and waste along the various stages of food value chain is deficient and rarely complete, with most of the previous estimates found to be relatively limited to staple food such as rice, wheat, and maize (or *liangshi* in Chinese); (ii) storage contributes the most to postharvest losses for all types of food (e.g. 5.7-8.6% for grain, 2.5-3.7% for meats, and 10-15% for perishable food). One notable reason behind this is the dominance of small scale production; (iii) technological and infrastructural change in the past decades are likely to have reduced the postharvest food losses, while consumer food waste is expected to have ballooned due to growing affluence and rapid urbanisation; (iv) the majority of consumer food waste is found in the catering and restaurant sector rather than at the household level, which appears the opposite of that in western countries; (v) China has established a regulatory framework dealing with waste in general, however, as in other countries this framework is not specifically adapted to food loss and waste, and the relevant government ministries and agencies are currently working rather independently.

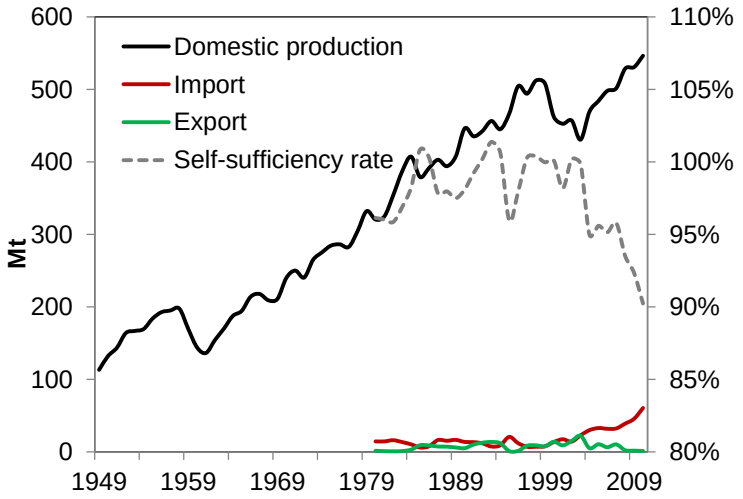
Since there are seldom official statistics, the presented data should be interpreted tentatively. However, it provides an order of magnitude estimate and may help inform the public and policy-makers of how serious the problem is and where actions are urgently needed.

1. Introduction

Food security continues to pose global challenges. While assuring sufficient agricultural production to meet a growing demand plays an important role, the reduction of losses and waste throughout the supply chain should also be taken into account if food security is to be maintained in the future (Liu et al., 2013a). The FAO has estimated that roughly one-third of the annual food production in the world (or 1.3 billion tons) does not reach the consumer (Gustavsson et al., 2011). Many other estimates have shown a similar range (Hall et al., 2009; Beretta et al., 2013; Monier et al., 2010; Fox, 2013). For example, the UK Waste and Resources Action Programme (WRAP) found that food wasted per year is 22-25% of that purchased (by weight) in the UK (WRAP, 2009).

China's food security is of particular concern for the world, with roughly 20% of the world's population but only 7% of its arable land (Brown, 1994; Smil, 1995; Larson, 2013). While the country has demonstrated a remarkable success in increasing agricultural production in the past several decades (see Figure 1) and reducing the number of its undernourished people from 21% of the population in 1990 to 12% today (OECD and FAO, 2013), demand is outpacing domestic supply (see Table 1 on Contextual indicators). According to a recent projection by the OECD and the FAO, China's agricultural growth is expected to slow down over the next decade (2013-2022), with production growing by 1.7% annually but consumption by 1.9% annually (OECD and FAO, 2013).

Figure 1. Domestic production, import, export, and self-sufficiency ratio of grain* in China, 1949-2010



Note: *including rice, wheat, maize, and soybeans in the Chinese statistics; see details in section 1.3.

Source: NBSC, 2012.

Several issues are expected to cloud China's continuous efforts to meet its growing domestic demand for food in both quantity and quality. For example, as a result of rapid urbanisation, China's arable land is edging dangerously close to the "red line" of 1.8 billion mu (about 120 million hectare) needed to ensure its grain production (Liu

et al., 2012), with a per-capita level (0.09 hectare) only about 40% of the world average in 2011 (NDRC 2009a). China's agricultural production has already been constrained by its limited and unevenly distributed land and water resources, which may continue shrinking in the face of global climate change (Liu et al., 2013b; Zhao and Huang, 2011a). Some contextual indicators of China and China's agricultural sector are summarised in Table 1.

Table 1. Contextual indicators of China and China's agriculture sector, 1995, 2011*

	1995	2011*
Economic context		
GDP (USD billion)	726	7,296
Population (million)	1,211	1,348
Land area (thousand km^2)	9,327	9,327
Population density (inhabitants/km2)	129	144
GDP per capita, PPP (USD)	1,513	8,387
Trade as % of GDP	19.3	25.0
Agriculture in the economy		
Agriculture in GDP (%)	20.0	10.1
Agriculture share in employment (%)	52.2	34.8
Agro-food exports (% of total exports)	7.7	2.3
Agro-food imports (% of total imports)	8.7	5.1
Characteristics of the agricultural sector		
Agro-food trade balance (USD million)	-54	-45,911
Crop in total agricultural production (%)	66	62
Livestock in total agricultural production (%)	34	38
Agricultural area (AA) (thousand ha)	532,716	524,321
Share of arable land in AA (%)	23	21
Share of irrigated land in AA (%)	9	12
Share of agriculture in water consumption (%)	70	61
Nitrogen Balance, Kg/ha	..	..

* or latest available year.

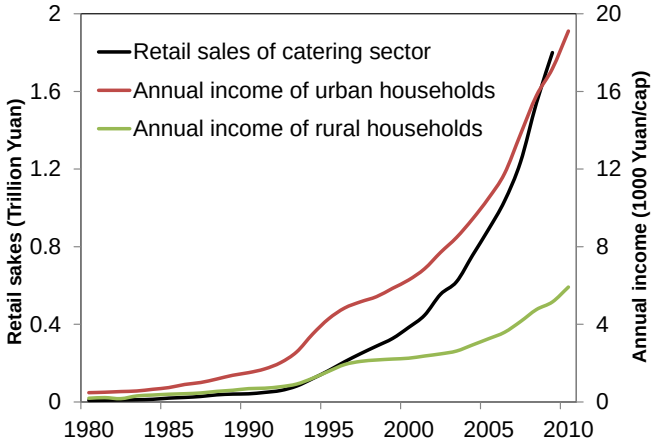
Source: OECD statistical databases, UN COMTRADE, World Development Indicators and national data.

China is also no exception to the fact that a significant amount of food ends up not consumed along the value chain. The agricultural production system in China has long been based on small-scale production, with currently about 250 million small farmers (Zhao and Huang, 2011b). This farm structure coincides with low efficiency in production and postharvest handling, leading especially to postharvest food losses due to inadequate infrastructure, lack of adequate storage facilities, and lack of knowledge and technology (Gustavsson et al., 2011; Parfitt et al., 2010; FAO, 2012; UNEP, 2012; Hodges et al., 2011; Liu et al., 2013a).

The increasing affluence and booming catering sector in China go hand in hand with increased food waste at the consumer stage. The annual income of Chinese urban and rural residents has substantially increased (about 30-fold for rural household net income

and 40-fold for urban household disposable income over the 1980-2010 period), and the retail sales of the catering sector have ballooned from CNY 8 billion in 1980 to CNY 1.8 trillion in 2009 (Figure 2). According to the National Bureau of Statistics data, during the five years from 2007 to 2011, at the height of the global financial crisis, the revenue of the catering industry has maintained a steady annual growth of about 14% (Deloitte, 2012). Changing life styles of increasingly prosperous consumers include eating more and more meals away from home (Bai et al., 2010), and food waste generated in the restaurant and catering sector has consequently sharply increased.

Figure 2. Retail sales of the catering sector (trillion CNY) and per capita annual income (1000 CNY) of urban and rural households in China, 1980-2010



Note: Numbers are in nominal terms.

Source: NBSC, 2012.

In China, municipal solid waste (MSW) generation has shown an 8% to 10% increase in recent years and reached 352 Mt (or 440 kg/cap) in 2010. Food waste takes up a high share in MSW in almost all cities (Table 2), roughly ranging from 50% to 70% (Tai et al., 2011). Most of it is mixed with other solid waste in MSW and eventually incinerated and landfilled (for example, on a national average 56.6% was landfilled in 2009) (Hu et al., 2012). This exerts growing pressure on waste management and leads to negative environmental impacts, such as water pollution, soil degradation and emission of greenhouse gases.

Table 2. Quantity of food remnants and the share in MSW in the eight pilot cities in 2008

	Food remnants (tonnes/day)	Share in municipal solid waste (%)
Beijing	725.84	66.19
Shanghai	588.33	71.14
Guangzhou	268.79	52.00
Shenzhen	300.26	51.10
Hangzhou	129.85	53.00
Nanjing	137.65	70.59
Xiamen	74.33	74.63
Guilin	15.20	61.31

Source: Tai et al., 2011.

Food losses and food waste have potential environmental consequences in two ways: (i) environmental effects related to the use of upstream resource inputs, such as water (Ridoutt et al., 2010; Lundqvist et al., 2008), land (Kummu et al., 2012), and energy and GHG emissions (Cuéllar and Webber, 2010); and (ii) environmental impacts downstream, related to waste disposal and its environmental impacts (Dorward, 2012; Garnett, 2011; Kim et al., 2013).

Therefore, reducing food losses and food waste can potentially increase the final consumption of agricultural products used as food, feed or as commercially viable byproducts, and at the same time offers an opportunity to mitigate various environmental impacts. Finding those opportunities, however, requires an understanding of the pattern and scale of food waste throughout the supply chain and the relevant policy and regulatory framework (Fox, 2013). This information remains poorly understood for China, despite growing media coverage and public concerns in recent years (Liu et al., 2013a). The data in the literature are either out of date and fragmented as for many other developing countries (Parfitt et al., 2010), or not country specific.[1] This report aims at providing an overview and systematic estimate of food losses and food waste in China, based on data published in the literature, informed estimates, and other publicly available information.

2. Food value chain and definition of food waste

A food value chain is described in Figure 3. Food losses and food waste occur at various stages of the chain, and can be defined and measured in different ways and units (Table 3). The definitions of food loss or food waste vary greatly depending on the country and the research angle, and there is no universal consensus yet on the definitions and measurements of food waste. According to the FAO, food losses refer to "the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption" and "food losses occurring at the end of the food chain are rather called food waste" (Gustavsson et al., 2011; Parfitt et al., 2010).

This report follows this approach and refers pre-consumer stage losses as "food losses" and consumer stage loss as "food waste". It differentiates three main life cycle stages: the agricultural production stage (on-farm losses before harvesting begins), the postharvest stage (between harvesting and human consumption, including harvesting, storage, processing, and distribution), and the consumer stage (both at the household level and for meals away from home). Non-food use that gets out of the food chain has also been identified and quantified to the extent possible. Note that this is only a conceptual visualisation of the food production and consumption system. Therefore it may not represent a strict step-by-step flow of food and there are overlaps between different processes. For example, storage may occur at processing and distribution stages as well and transportation occurs at almost each stage. In addition, imports and exports are not captured in this conceptualisation.

There are few data on food waste from official governmental statistics in China. The estimates in this report are therefore based on two "unofficial" sources: (i) data from several first-hand field surveys, and (ii) data from peer-reviewed publications, expert

1. For example, in the FAO report (Gustavsson et al., 2011), China has been aggregated together with Japan and South Korea in the "Industrialized Asia".

interviews, and grey literature (e.g. reports published by industry groups and non-governmental organisations). The data cover a wide range both over space (mainly different provinces within China) and through time (from early 1990s to 2012). Where possible, national averages are calculated. This means that the data represent only a "best estimate snapshot" for the current food waste situation in China, and should be cautiously interpreted for any temporal or interregional comparisons.

Whenever possible, a distinction is made between different types of food, for example cereals, roots and tubers, oil crops and pulses, fruits and vegetables, meats, and aquatic products. It is important to mention that the definition of food commodities is slightly different in China: "*Liangshi"* in the Chinese statistics, which can be roughly translated as "staple food", includes not only "cereals" as in the FAO statistics or "grain" as in the USDA statistics (i.e. wheat, rice, maize), but also potatoes (as "roots and tubers" in the FAO statistics) and soybeans (as "oilseeds and pulses" in the FAO statistics). Since the data often cannot be disaggregated, *liangshi* is kept as a separate type.

Figure 3. Food losses and food waste along the different stages of the food value chain

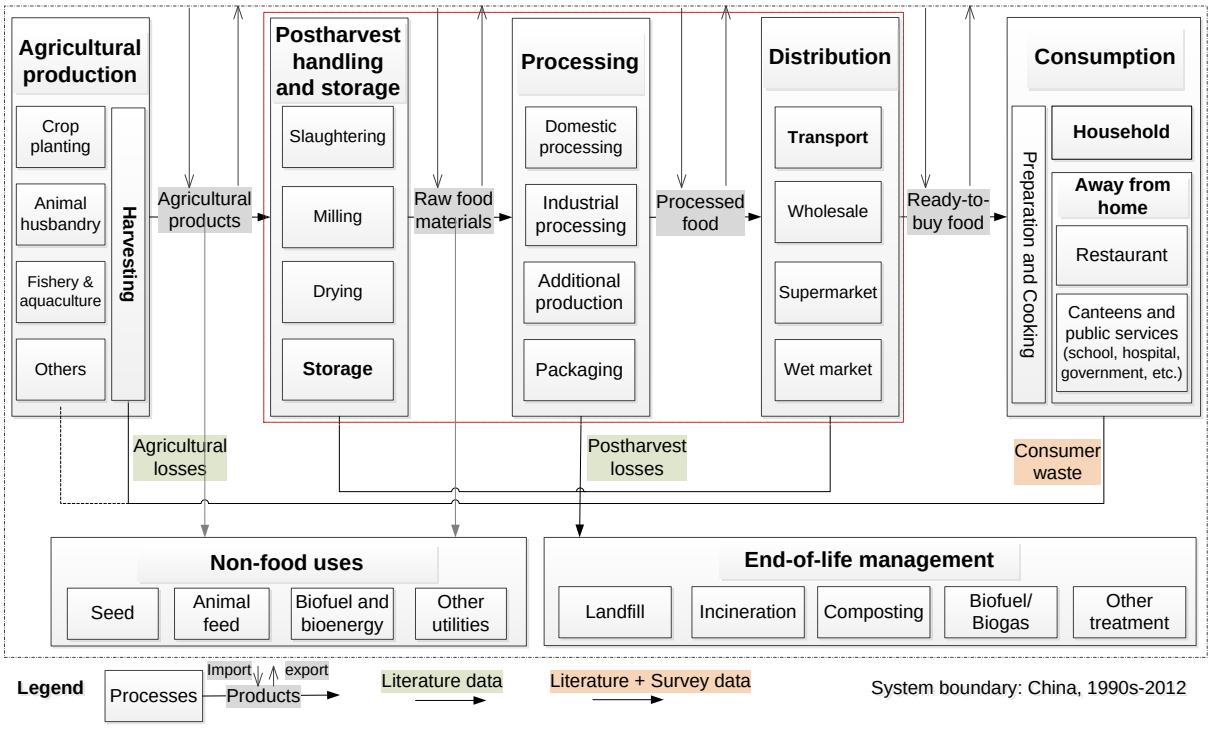


Table 3. Definition, measurement unit, and determining approach of food losses and food waste

	Sub-type	Note	Example
Definition	Life cycle perspective	"food losses" (pre-consumer stage) vs. "food waste" (consumer stage)	(Parfitt et al. 2010)
	Moral perspective	"human consumption" vs. "non-food use (animal feed, bioenergy, etc.)"	(Gustavsson et al. 2011)
	Functional perspective	"avoidable" (edible) vs. "possibly avoidable" (can be eaten) vs. "unavoidable" (not edible under normal circumstances)	(WRAP 2011)
Measurement unit	By weight	kg (absolute or percentage)	
	By calorific or nutritional value	joule/calorie (absolute or percentage)	
	By monetary value	dollar (absolute or percentage)	
Determining approach	Bottom-up	average or scale-up based on survey	
	Top-down	total food supply minus calculated food consumption	(Hall et al. 2009)

3. Collection and verification of statistical data on food loss and waste in China

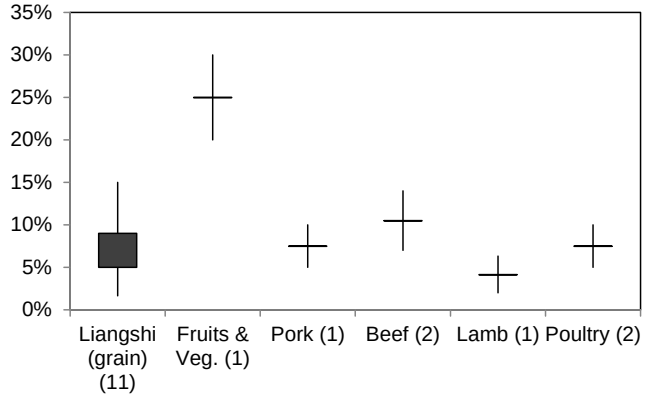
3.1. Preharvest farm-level losses

Losses of agricultural products occur already at the initial stage on the farm. Agricultural losses of vegetable commodities and products are mainly caused by diseases, insects, weeds, and rodents, severe weather during planting and inefficient seeding. Agricultural losses of livestock products refer mainly to death and sickness before first-stage processing, such as animal death during breeding for bovine, pork, and poultry meat, discards during fishing for fish, and decreased milk production due to dairy cow sickness (mastitis) for milk.

The results of agricultural preharvest farm-level losses for main vegetable and animal commodities and products in China are presented as a "candle stick" stock chart in Figure 4. Note that all the detailed information for references are documented in the Appendix (as is the case for Figure 6). The eleven case studies for *liangshi* (grain) suggest approximately an average agricultural loss of 5-9%, with the highest estimate as 15% and the lowest estimate as 1.7%. Preharvest infections (e.g. pests) and natural disasters (e.g. drought) contribute the most to such losses. For example, according to China Agriculture Statistical Report, 21.6 Mt of grain (or about 4% of the output) was lost due to diseases, insects, weeds, and rodents in 2010. Additionally, the low efficiency of seeding has also resulted in a certain loss: about 20 Mt of grain is used for seeding each year in China, which is about 40% above the level observed in industrialised countries (Tang, 1998).

Very few estimates (Figure 4) are available for fruits and vegetables and animal commodities and products. It is estimated that 20-30% of fruits and vegetables are lost at the agricultural stage. For different types of meat, a loss of 5-10% can be observed.

Figure 4. Agricultural losses of main vegetable and livestock products in China



Note: The candle sticks represent the maximum, the average, and the minimum. The numbers in brackets indicate the number of case studies found in the literature.

Source: Data sources are detailed in the Appendix.

3.2. Postharvest food losses

Postharvest losses refer to food damage and degradation during different postharvest handling and processing stages from the beginning and completion of harvesting to the moment of final consumption. They include harvesting losses, such as when grain is threshed, winnowed, and dried or when animals are transported to the slaughterhouse, as well as losses along the chain during transportation, storage, and processing. Those stages are aggregated into four sub-stages, postharvest handling (i.e. harvesting, threshing, and milling, and drying), storage, processing, and distribution, and are presented for different food commodities and products in Figure 5.

By food commodity and product

Because China's food supply depends largely on staple foods such as rice, wheat, and maize, most of the previous estimates for postharvest food losses concentrate on *liangshi* (grain). The majority of grain losses, as shown in Figure 5(a), are found in postharvest handling (4-6% on average) and storage (5.7-8.6% on average). In processing and distribution, the average loss of grain is 2.2%-3.3% and 1-1.5%, respectively.

There are fewer studies for postharvest losses of meats (Figure 5(b)). The loss rate at postharvest handling, storage, processing, and distribution stages of meats can be approximated as 1.4%-2.1%, 2.5%-3.7%, 1.1%, and 3%, respectively. One study also estimates that about 2%, 4%, and 3.2% of fish and aquatic products are lost at the harvesting, storage, and distribution stages, respectively (Xu, 2007).

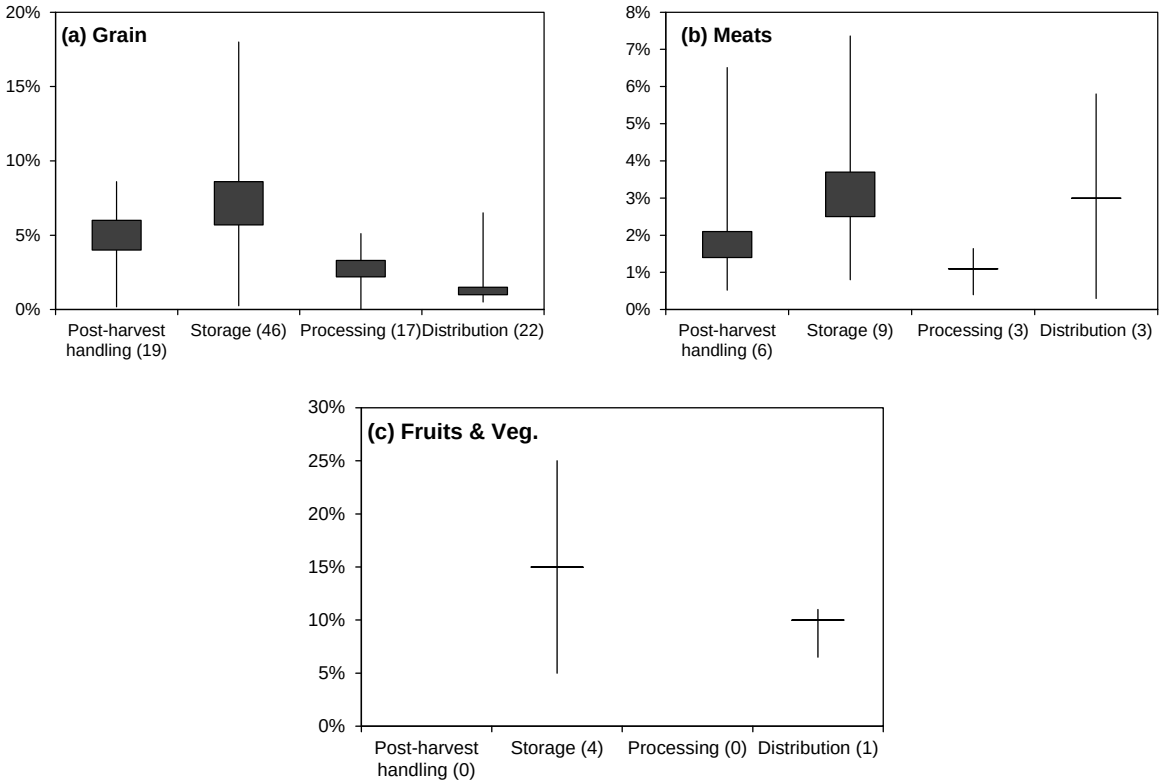
Perishable food such as fruits and vegetables show a high postharvest loss (Figure 5c). In storage and distribution, the average loss of fruits and vegetables is estimated as 15% and 10%, respectively.

By life cycle stage

Storage. Figure 5 clearly demonstrates that storage contributes the most to postharvest losses. One notable reason behind this is the fragmented and small scale

farm structure in China. According to the "Special Programme for Construction of Scientific Grain Storage in Rural Households in the 12th Five Year (2011-2015) Plan" of the State Administration of Grain, there are currently about 250 million rural households in China, in which over 85% is involved in grain production (SAG and NDRC 2011).

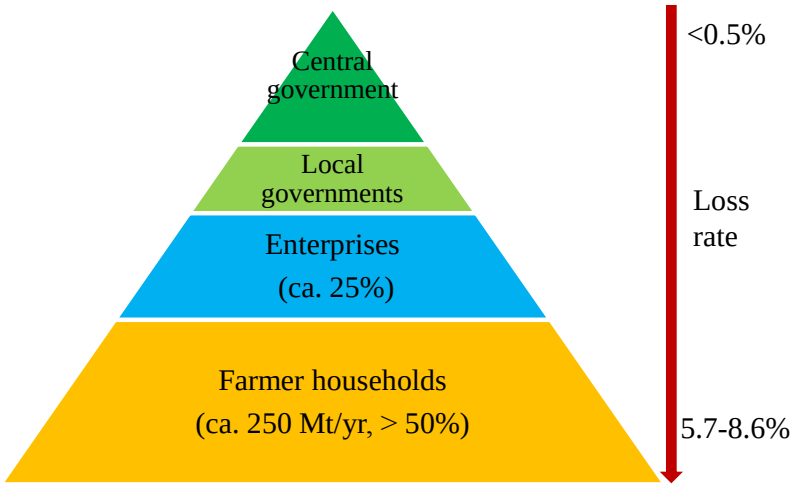
Figure 5. Postharvest losses of liangshi (a), meats (b), and fruits and vegetables (c) in China at different stages



Source: Data sources are detailed in the Appendix.

China's grain storage appears as a pyramid structure (Figure 6): over 50% of grain is stored by farm households (which represents a decrease from 70-80% in the 1990s), 25% by commercial enterprises, and the remaining 25% by local and central governments (Wu, 2012). While the governmental granaries report a low loss rate (less than 0.5%, close to the level in industrialised countries), high storage losses are found at farm households when the grain is being stored for own consumption (normally half a year to a year) or while the farmer awaits a selling opportunity.

Figure 6. The pyramid structure of grain storage and associated loss rate in China



Source: Data sources are detailed in the Appendix.

For family farms, grain losses during storage are mainly caused by insects, fungi, and rodents because of insufficient awareness, knowledge, and infrastructure. In a survey funded by the Ministry of Agriculture in 2011, 58.6%, 32.3%, and 55.2% of over 700 sample households across China have reported cereal storage losses resulting from insect infestations, mold damage, and rat infestations, respectively (Zhao et al., 2011). On average, it was estimated that 49%, 30%, and 21% of China's grain loss is caused by rodents, fungi, and insects, respectively (SAG and NDRC 2011).

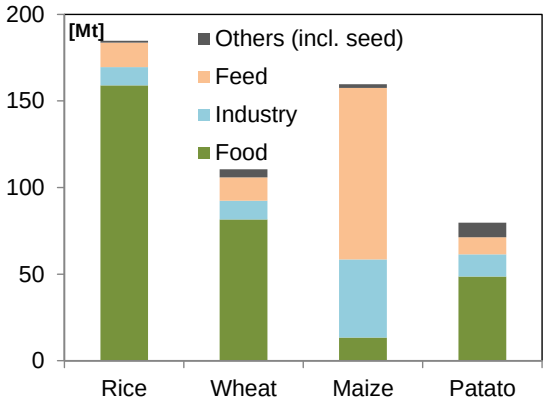
Although there are no official statistics on the amount of food losses during storage, our estimates above appear in the same range as recently quoted by two governmental officers, Mr. Ren Zhengxiao, Director of the State Administration of Grain, China (Ren 2013) and Mr. Zhang Tianzuo, Director of the Bureau of Agricultural Products Processing, Ministry of Agriculture, China (Zhang 2012) (see Mr. Zhang's estimates for the percentage and volume of food loss at storage in Table 4).

Table 4. Food losses at the storage stage in China

Food type	Percentage of loss	Volume of loss in 2011
Liangshi	7%-10%	15-22.5 Mt
Vegetables	15%-20%	100 Mt
Fruits	10%-15%	14 Mt
Potatoes	15-25%	16 Mt

Source: Estimated by Zhang Tianzuo, Director of the Bureau of Agricultural Products Processing, Ministry of Agriculture (Zhang, 2012).

Figure 7. Structure of use of main grain crops in China in 2010



Source: Jiang (2012); Jin (2012).

Processing. Currently only a small fraction of food in China is industrially processed (see structure of use of main grain crops in Figure 7). Meanwhile, the resource efficiency of food processing and retailing is still very low (Ren, 2013), resulting in a considerable loss of food. For example, as high as 69% of China's potatoes is consumed as fresh (not processed) potatoes (Reardon et al., 2012). In comparison, the fresh consumption ratio of potatoes is only 22% in industrialised countries such as Canada (Lupescu and Gray, 2012).

Distribution. Losses in transportation and distribution occur mainly because mechanised bulk handling is not yet widespread in China. For example, over 80% of grain is still loaded and unloaded in bags during transportation and manually transported jute sacks are still widely used across China (Xi, 2010).

Geographical and temporal variation

Since these sparse literature data cover a wide range of years and geographic locations it is difficult to generate statistically meaningful temporal trends or geographical comparisons. However, there are some general tendencies which can be observed, despite the information gaps and uncertainties.

Geographically, northern China tends to show a higher postharvest storage loss than southern China. According to a survey by the State Administration of Grain (SAG and NDRC, 2011), the average household grain storage loss in northeastern provinces, northwestern provinces, the middle and lower reaches of the Yangze River, and the Yellow-Huaihe-Haihe Plain is 10.2%, 8.8%, 7.4%, and 5% respectively. This geographical variation may be explained by, among other factors, the climatic condition and planting structure. With regard to different crops, the national average household storage loss of maize is 11%, much higher than 6.5% for rice and 4.7% for wheat.

Technological and infrastructural change in the past decades, for example the improvement of cold storage and road infrastructure and the spread of mobile phones, are likely to have reduced the postharvest wastage over time. For example, a recent survey by the Asian Development Bank (Reardon et al., 2012) found the postharvest physical wastage of potatoes to be only about 7% and that of rice to be only about 1-2% in some provinces of China, which strongly contradicts with previous assertions of a

level of over 20% (Gustavsson et al., 2011). This may suggest that China's food supply chains have become more efficient and affirm a point reiterated in an earlier review that there is a tendency to overstate losses in relation to traditional agricultural systems in developing countries (e.g. due to the use of out-of-date data) (Parfitt et al., 2010).

3.3. Consumer food waste

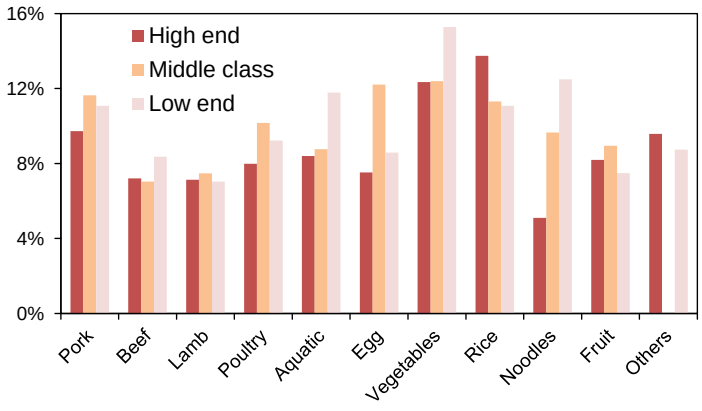
Food waste at the consumer stage occurs both at the household level and during meals away from home. According to the FAO, much less food is wasted at the consumer level in low-income countries than in medium- and high-income countries (Gustavsson et al., 2011). As the world's largest emerging economy, China is already experiencing higher levels of wastage of food at final consumer stage, especially in urban areas and in the catering and restaurant sector.

There is little information about food wastage in Chinese households. A crude expert estimation for China's household food waste equates to about 5.5 Mt of grain every year (Zheng, 2011; Liu et al., 2013a), or roughly 2.5% of China's annual grain output. This is still low on a per capita level nationally (4-5 kg/yr), but the overall amount is already approaching the level of the United Kingdom (WRAP, 2011). Surveys in large cities in China, for example Beijing, also show a much higher level than this national average (25.6 kg/cap/yr) (Zhang and Fu, 2010).

Food waste during away-from-home meals is higher. As a 2011 survey conducted by China Agricultural University shows, 28.3% of canteen food ends up in rubbish bins on campuses nationwide (Wang, 2013).

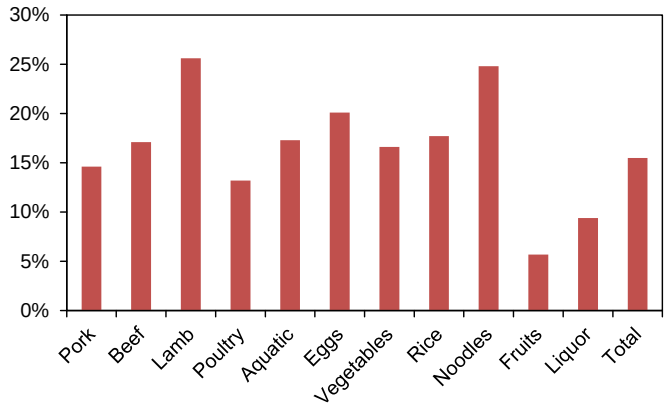
Two field surveys in Beijing in 2005 (Xu, 2005) and in Lhasa in 2011 (Wang et al., 2013) in the catering and restaurant sector showed that food wasted is about 11-17% of that ordered (by weight; varying by food type and class of restaurant, see Figures 8 and 9). This share is higher than the normally assumed national average, or 10% (Wang, 2013), although a lack of clarity over the definition of food waste among different studies and a lack of larger scale surveys across China makes this comparison fragile.

Figure 8. Catering food waste in Beijing by food type and class of restaurant



Source: survey conducted in 2005 for 2211 tables in selected restaurants across Beijing (Xu, 2005).

Figure 9. Catering food waste in Lhasa by food type



Source: survey conducted in 2011 and 2012 for 443 tables in selected restaurants across Lhasa (Wang et al., 2013).

It was estimated that in total over 50 Mt of grain is wasted annually at the consumer stage in China (Zheng, 2011), higher than that lost at pre-consumer stages (35 Mt, excluding the agricultural stage) (Ren, 2013). The majority of consumer food waste is found in mid- to high-end restaurants and public service canteens (together about 90%) (Zheng, 2011). This pattern is notably different from that in western countries, where households produce the largest fraction of food waste. For example, in the EU27, the share of private households in food waste is estimated at 42% (38Mt), while the food service sector produces 14% (12.3 Mt) of that waste (Monier et al., 2010).

Consumer food wastage in China is expected to continue to increase in the coming years, due to the growing affluence, continuing urbanisation, and the elevated level of food waste in the catering and restaurant sector. For example, a survey in the early 1990s (Zhan, 1995) showed that the average wastage of rice and wheat in restaurants was only 1.8-3.3% and 2.5-6.5% (varying by type of restaurant), respectively; these two ratios have risen to 9.2-22.4% and 10.8-24.7% (varying by type of restaurant), respectively, according to a recent survey in 2008 (Zhang and Yao, 2009). This is consistent with the majority of previous studies which show that as the proportion of income spent on food declines, food wastage increases (Parfitt et al., 2010; Gustavsson et al., 2011).[2]

4. Policy information on food loss and waste in China

Recent regulations, policies, and official plans (issued after the year 2007) relevant to food losses and food waste in China are summarised in Table 5. Several features can be identified from this:

2. Note that the above numbers do not include a significant amount of production that is not used for direct human consumption purposes. These non-food uses are mainly for wine production and animal feed in China (see the structure of use of rice, wheat, maize, and potato in Figure 7). For example, the production of alcoholic drinks made from grain consumes over 20 Mt of grain a year in China, a number that is growing in recent years.

- First, there are not so many waste regulations or policies in place. Moreover, many of them cover waste or municipal solid waste in general but not specifically adapted to food waste and losses.

- Second, national policies and regulations relevant to food losses and food waste can be categorised in two groups: those that address food waste generation (Table 5a) and those that deal with food waste treatment (Table 5b). Quite a few of them focus on postharvest losses (especially at storage), but there are not so many on consumer food waste. Food waste management systems are often operated under the responsibility of local governments and municipalities.

- Third, several government ministries and agencies in China have been identified as being relevant for policy making in food waste reduction and treatment (e.g. NDRC and MOA in Table 5a); however, they are currently working rather independently. For example, while the collection and transportation of food waste is regulated by the Ministry of Housing and Urban-Rural Development, its treatment is regulated by the Ministry of Environmental Protection. There seems to be scope for closer coordination and improved policy coherence (for example, by a high-level committee under the State Council).

Table 5. Recent regulations, policies, and official plans addressing food losses and food waste reduction (5a) and treatment (5b) in China

5 (a) Regulations, policies, and plans for food waste reduction	Main content	Issuing date	Issuing division
Outline of the Programme for Mid- and Long-term National Grain Security (2008-2020)	Major targets and countermeasures to enhance the storage, processing, and retailing system of grain	2008/11/13	SC
Planning for 50 Mt New Production Capacity of Grain (2009-2020)	Countermeasures and targets to reduce both agricultural losses (1-2% reduction of insect infestations by 2020) and postharvest losses	2009/11/3	NDRC
Administrative Rules on Storage and Warehousing in Grain and Oil Industry	Detailed measures and reporting regulations on grain storage	2009/12/29	NDRC
Outline of the Programme for National Pig Slaughtering Industry (2010-2015)	Major targets for improving efficiency in slaughtering, processing, and retailing and market concentration of the slaughtering industry	2009/12/31	MOC
State Council Circular to Further Enhance Grain Saving and Food Waste Reduction	Detailed countermeasures on organizing, educating, supervising, and inspecting the work on food waste reduction in China	2010/1/18	SC
Special Programme for Construction of Scientific Grain Storage in Rural Households in the 12th Five-Year (2011-2015) Plan	To hand out standard storage instruments for 8 million households and reduce their storage loss to 2%; to construct 1000 pilot steel granaries (capacity over 100 ton) in major grain producing areas; to establish technical guidance and service systems for farmers	2011/03	NDRC and SAG
Development Plan (2011-2020) for a Grain-Saving Animal Husbandry Industry	Short term and mid- and long-term targets for non-grain fodder production	2011/12/21	MOA
Development Plan (2011-2020) for the Vegetables Industry	Countermeasures for reducing postharvest losses of vegetables	2012/1/16	NDRC and MOA

5 (a) Regulations, policies, and plans for food waste reduction	Main content	Issuing date	Issuing division
China's 12th Five-Year Plan (2011-2015) for Construction and Development of National Grain Market System	Measures to improve the efficiency of trade, retailing, wholesale of grain	2012/1/21	SAG
China's 12th Five-Year Plan (2011-2015) for the Meet Industry	Measures to improve the efficiency of processing and retailing of meat	2012/2/24	MIIT
Eight Rules on Improving Style of Work and Enhancing Close Ties With the People	A campaign against official extravagance and governmental reception meals at public expenses	2012/12/4	Politburo
Plan of Action for Implementation of Resource Saving and Loss Reduction in the Grain Production Sector	Specific technical standard and code for design for grain loss reduction	To be issued soon	SAG
5 (b) Regulations, policies, and plans for food waste treatment	**Main content**	**Issuing date**	**Issuing division**
Administrative Rules on Municipal Solid Waste	Detailed regulations on municipal food waste clearance	2007/04/28	MHURD
Food Security Law	Regulations on safety issues of food waste treatment (e.g. clause 28: recycled food waste not allowed for food production)	2009/2/28	NPC
China's 12th Five-Year Plan (2011-2015) for Environmental Protection	Detailed plan for household waste collection and treatment (a safe treatment rate of 80% in urban areas by 2015)	2011/12/15	MEP
Grain Law	Specific clauses (clause 33 in the draft) to promote grain saving and combat food waste	Draft for comment promulgated on 2012/02/21	NPC

Note: The policies are ordered by chronological sequence.

NDRC (National Development and Reform Committee), SAG (State Administration of Grain), SC (State Council), NPC (The National People's Congress), Politburo (the Political Bureau of the Central Committee of the Communist Party of China), MOA (Ministry of Agriculture), MHURD (Ministry of Housing and Urban-Rural Development), MOC (Ministry of Commerce), MIIT (Ministry of Industry and Information Technology), MEP (Ministry of Environmental Protection).

Appendix

Metadata for references used in this report

References	Unit	Food commodity	Lifecycle coverage	Method of estimation	Year of estimation	Geographical and sample coverage
Zhan, 1995	kg + %	Grain (wheat, rice, maize, and others)	HS, P, D, C	S	1992	1400 samples (in 574 counties and 22 provinces)
Xu, 2005	kg + %	Pork, beef, lamb, poultry, aquatic products, eggs, vegetables, rice, wheat, fruits, others	C_{afh}	S	2005	2211 catering tables in Beijing
Zhang and Yao, 2009	%	Grain (wheat, rice, and others)	C_{afh}	S	2008	216 restaurants in 159 counties in Henan province
Deng et al., 2002	%	Grain	HS	S	1992-1993	Chongyang county, Hubei province
Lan et al., 2006	%	Grain	HS	S	1984 and 2004	17 counties in 8 provinces
Guo and Sun, 2006	%	Grain (maize)	D	Ns		Northeastern China
Xu, 2007	kg + %	Grain, meats, aquatic products, fruits, vegetables	HS, P, D, C	Ns	2007	National average
Zhang et al., 2009	kg + %	Grain	Postharvest, C	Ns	ns	National average
Wang, 2009	%	Grain	HS	S	2008	40 national storehouse in Henan province
Zhang et al., 1998	kg + %	Grain	AP, HS, P, D, C	L	1998	National average
Zhou et al., 2005	%	Maize and rice	HS	S	2005	Over 70 households in 15 counties in Liaoning province
Gao et al., 2008	%	Maize	HS	L	2008	Liaoning province, northeastern China
Wu and Tan, 1998	kg + %	Grain	HS	L	1992	National average
Zheng, 1994	kg + %	Grain	AP	L	1950-1990	National average
Ping, 2005	kg + %	Grain	HS, D	L	2004	National average
Ying et al., 2005	%	Rice	HS, P, D	S	2004	27 households in 9 villages in Zhejiang Province
Ren, 2013	kg + JYP + %	Grain	HS, D, P, C	L	2011	National average
Zhang, 2012	kg + JYP + %	Grain, fruits, potatoes, vegetables	HS	L	2011	National average

References	Unit	Food commodity	Lifecycle coverage	Method of estimation	Year of estimation	Geographical and sample coverage
SAG, 2009	kg + JYP + %	Grain	HS	L	2006	National average
SAG and NDRC, 2011	kg + %	Grain (maize, rice, and wheat)	HS	S	2009	National average
Zhu et al., 2006	%	Rice	HS	S	2004-2006	Three counties in Hunan and Jiangxi provinces
Cao and Jiang, 1999	%	Grain	HS, P, D, C	S	1989-1991, 1993-1994	342 households in three counties in Jiangsu province
Chen, 1998	%	Grain (rice, maize, soybeans) and peanuts	HS	S	1997	100 households in 17 counties in Jiangxi province
Ma and Chu, 2007	%	Grain	AP	L	2004	National average
Tang, 2007	%	Grain	HS	S	2006	National average
Tang, 1998	%	Grain	AP, HS, P, D, C	L	1997	National average
Peng, 1992	%	Grain	HS, P, D, C	L	1990	National average
Li, 2008	%	Grain	HS	S	2007	Qingyuan county, Liaoning province
Chen et al., 2012	%	Wheat	HS	S	2011	154 households in 12 counties, Shandong province
Zhu et al., 2009	%	Rice	HS	S	2007	16 households in Taicang city, Jiangsu province
Jin and Lan, 2004	%	Grain	AP	L	ns	National average
Zheng, 2000	kg + %	Rice	HS	S	1999	357 households in 17 counties, Jiangxi province
Cai, 2012	%	Grain	HS	S	2006	Ningxia province
Li et al., 2010	kg + %	Grain	AP	L	1990-2005	National average
Zheng and Zhao, 2007	kg + %	Grain	HS	L	2005	National average
NDRC, 2009a	%	Grain	AP	L	2007	National average
Zhang et al., 2012	kg + %	Grain	HS	S	2011	15 villages in Ningxia province
Jiang et al., 2008	%	Grain	HS	L	2007	National average
Wang et al., 2005	%	Grain	HS	L	2004	National average
Xinhua News, 2005	kg + %	Grain, fruits, vegetables	AP	L	2004	National average
Xi, 2010	%	Grain	HS, D, C	L	2008	National average
Zheng, 2002	kg	Grain	AP, HS, P, D, C	L	1998	National average

References	Unit	Food commodity	Lifecycle coverage	Method of estimation	Year of estimation	Geographical and sample coverage
Zheng, 2011	kg + CNY	Grain	C_h, C_{afh}	L	2010	National average
Peng, 1997	kg + %	Grain	AP, HS, P, D, C	L	1996	National average
SAG, 2008	%	Grain	HS	S	2008	8 counties in Chongqing
Wu, 2013	%	Rice, maize, wheat	HS, P, D	L	2010	Henan province and national average
Reardon et al., 2012	%	Rice, potato	HS, P, D	S	2010	Jiamusi in Heilongjiang province and 320 households in 2 counties in Gansu province
Parfitt et al., 2010	%	Rice	HS	S	ns	Zhejiang province
Yao, 2009	%	Pork	AP	L	2008	National average
Shen, 2008	%	Poultry (chicken)	AP	L	2007	National average
Huang, 2011	%	Pork	D	L	ns	National average
Chen, 2005	%	Pork	HS	L	ns	National average
Zhou, 1988	%	Pork	HS	S	1985	A slaughterhouse in Taizhou, Jiangsu province
Liu, 1990	%	Pork	HS	L	1990	National average
Shao and Liu, 1995	%	Pork	HS	S	1994	Guizhou province
Zhang and Chang, 2009	kg + CNY + %	Pork	HS, D	S	2007	Beijing
Du et al., 2009	%	Beef	HS	S	2008	A typical slaughterhouse
Xia et al., 2007	%	Meat	HS	L	2006	National average
Jiang et al., 2004	%	Beef	HS, P	S	2003	A slaughterhouse in Dongying, Shandong province
Luan, 2009	%	Pork	P	L	2008	National average
Wang and Meng, 2009	%	Beef	AP	L	2008	National average
Lu et al., 2010	%	Pork	HS	L	ns	National average
Zhang and Xu, 1994	%	Beef	HS	S	1992	34 samples
Sun, 2012	%	Pork	HS	S	2010	Zizhong county, Sichuan province
Wang, 1987	kg	Pork	HS	S	1985	124 samples
Zhu et al., 2008	%	Pork	HS	S	2008	1500-1700 samples in Kaiyuan, Liaoning province

References	Unit	Food commodity	Lifecycle coverage	Method of estimation	Year of estimation	Geographical and sample coverage
Gu and Wang, 2007	%	Poultry	AP	L	2007	National average
NDRC, 2009b	kg + CNY	Beef and lamb	AP	S	2008	National average

Note: (1) Measurement unit: "%" = percentage of waste in total input; "kg" = physical value; "CNY" = monetary value; (2) Lifecycle coverage: Agricultural production (AP), postharvest handling and storage (HS), Processing (P), Distribution (D), Consumption (C; including household consumption: C_h, and away-from-home consumption: C_{afh}); (3) Method of estimation: s = First-hand field survey or questionnaire survey; l = Literature data, model simulation, or informed estimates; ns = not specified.

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