Food loss Solutions

Version 2, July 2024

Authors: H.B. (Heike) Axmann MSc, dr. X. (Xuezhen) Guo, dr.ir. J. (Jan) Broeze, Charlotte Harbers MSc, dr. M. (Marcela) Viquez-Zamora, dr.ir. JM (Han) Soethoudt

Mitigate+: Food Loss and Waste country profile China

Estimates of Food Loss and Waste, associated GHG emissions, nutritional losses, land use and water footprints

Urgency and call for action on FLW reduction

Theoretically, the world produces enough food to nourish the growing world population. Although precise data remains scarce, according to most recent studies, globally each year possibly as much as 30 per cent of the food produced is being lost or wasted somewhere between farm and fork. This not only represents a threat to food security but also severely and negatively impacts our food systems and natural resources. Food Loss and Waste (FLW) accounts for around 8 to 10 percent of our global Greenhouse Gas Emissions (GHGEs). Approximately a quarter of all freshwater used by agriculture is associated to the lost and wasted food. 4.4 million km² of land is used to grow food which is lost or wasted (FAO, 2019; WWF, 2021; Guo et al., 2020). The Sustainable Development Goal (SDG) Target 12.3 calls to 'halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses' (Lipinski, B. 2022). With only 7 years to go, the world is far from being on track to achieve this target.

Way forward reducing FLW without baseline data

The UN and the Champions 12.3 Coalition launched the 'Target-Measure-Act approach' calling on all governments and companies to set FLW reduction targets, measure FLW, identify hotspots[1], and to take action to reduce FLW accordingly (Lipinski, 2020). However, with respect to primary data on FLW, much remains to be done. Just a

Food Loss and Waste (FLW) definition

FLW refers to all food intended for human consumption that is finally not consumed by humans. Food Loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers from the production stage in the chain, excluding retail, food service providers and consumers. Food Waste is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers (FAO, 2019). Under this definition, FLW does not include food that is consumed in excess of nutritional requirements nor food that incurs a decrease of market value due to over-supply or other market forces, and not due to reduced quality.

1 In this document hotspots are defined as food products or food (sub) categories, eventually in combination with a supply chain link, that show the highest scores with respect to a selected (sub)set of sustainability indicators: FLW, GHGEs, nutrition, land use and water footprint.
2 Mutton & Goat Meat is not considered for the land-use footprints due to the marginal land consideration.

handful of mainly western countries have taken action to systematically measure and reduce FLW. Lack of data make it particularly difficult for lower-and-middle-income countries (LMIC), including China, to specify the hotspot food products and chain stages, to define smart targets and to identity adequate interventions.

In order to contribute to this essential information we developed and used a mass flow model based on secondary data to derive the volume of FLW and the associated parameters accordingly (Guo et al., 2020). This approach allows to present an indicative country profile showing per food product category and chain stage not only the amount of FLW but also the GHGEs, the land-use and water footprints related to producing the FLW as well as induced nutrient losses. The sums differs per product and chain stage. Focusing on food products and chain stages which largely contribute to the aforementioned parameters can substantially lead to resource use efficiency and at the same time to climate mitigation action and nutrition security. This integrated approach towards FLW reduction can support policy makers and other food system actors taking informed decisions contributing to multiple sustainability objectives in parallel.

Modelling country data on FLW and FLW-associated GHGEs, land-use and water footprints and nutritional losses

FLW data was generated through a bottom-up, mass-flow model (Guo et al., 2020) that combines data on production and outputs as well as imports and exports at the country level. Estimates of losses per chain stage are derived from Porter et al. (2016) to calculate the FLW in the supply chain according to the country's production and trade. The FLW-associated GHG emissions are calculated by using the GHG emission factors derived from Porter et al. (2016) to multiply the FLW at different supply chain stages.

Furthermore, a Protein and Nutrition Database developed by WUR (built on nutritional compositions derived from databases from FAO, USDA, Denmark and Japan) was used to calculate the nutritional value of the total consumed food in each country. The nutrient intakes are compared with estimated nutrition requirements per country (which is based on the composition of the population and per capita nutrient demand, according to WHO dietary recommendations).

In calculating the land use footprint of plant-based food items, FAO's 'Crops and livestock products' database is utilized by combining data on yields and harvested areas. This gives a simplified estimate of how much cropland is needed to grow the produce. Country-specific land use estimates for animal-based food items are however scarce. Therefore, global estimates as published by Poore & Nemecek (2018) are used. Applying this non-differentiated data has a drawback that it not accurately takes into account country-specific farming practices. Lastly, for the water footprint the broadly recognized datasets of Mekonnen and Hoekstra are used. These cover the Green, Blue and Grey water footprint of crops and derived crop products (Mekonnen & Hoekstra, 2011), and of animals and animal products (Mekonnen & Hoekstra, 2010).

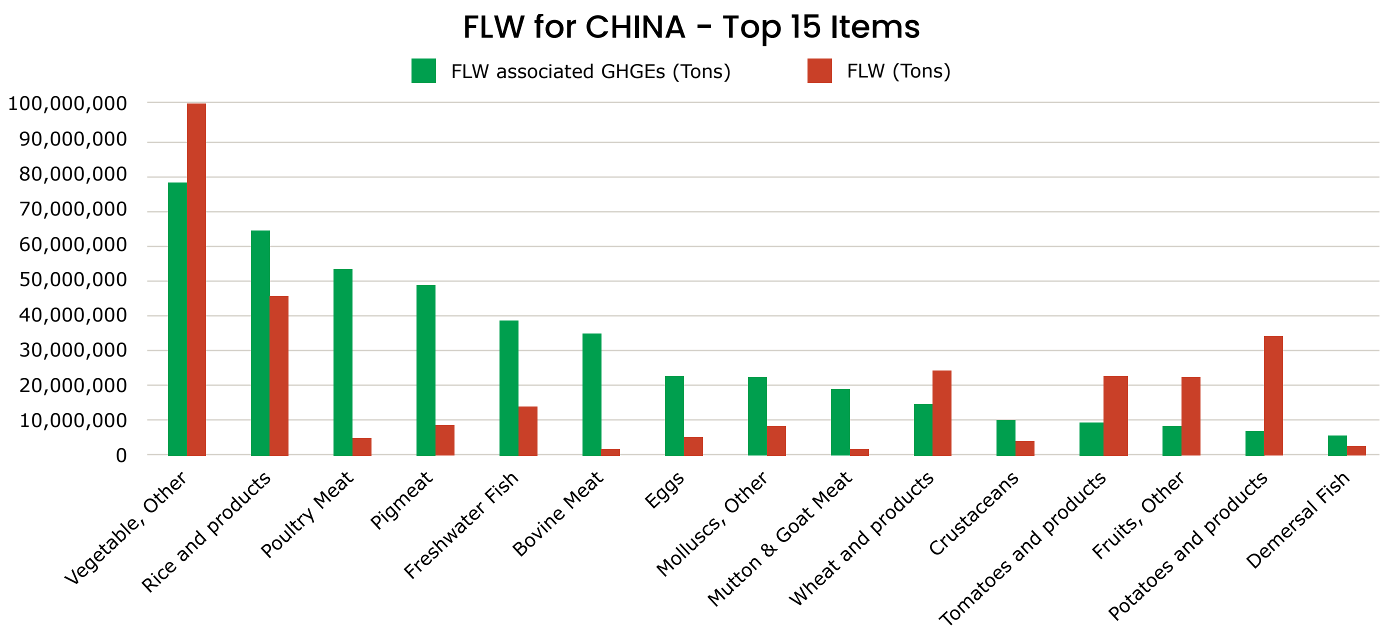

Figure 1 Top 15 hotspot categories of food loss and waste in terms of volumes and FLW-associated GHG emissions (in CO2-eq.)

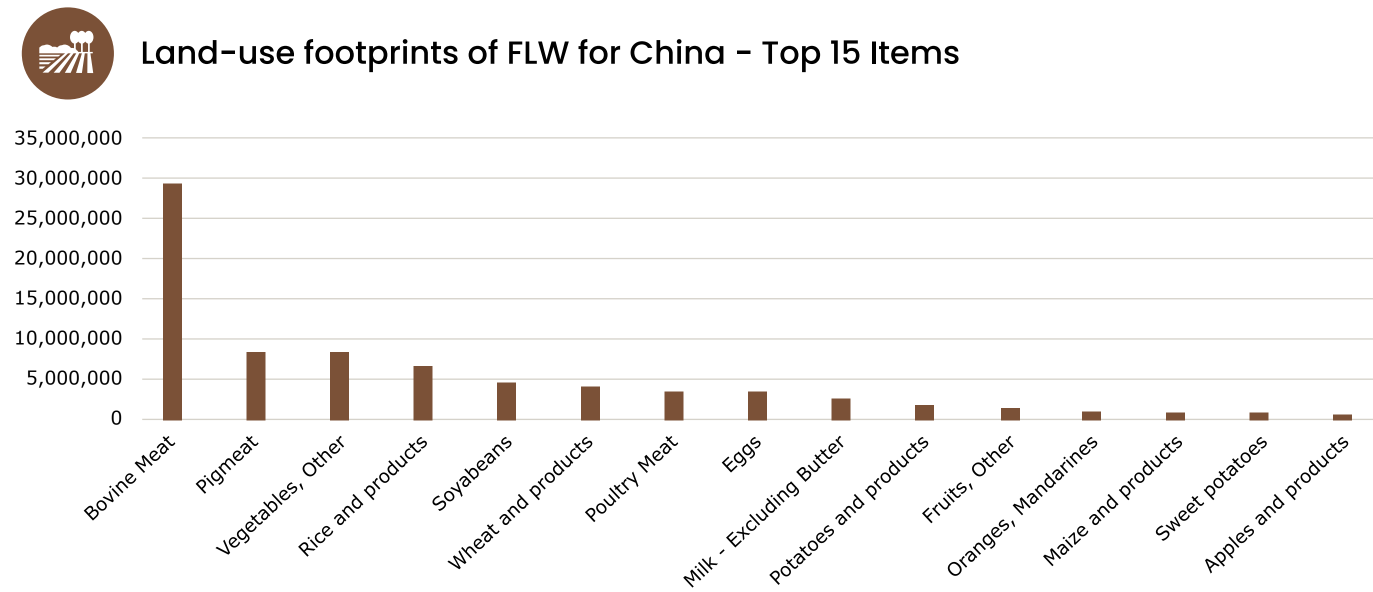

Figure 2 Top 15 hotspot categories of the land-use footprints of FLW (in ha)

FLW, GHGEs, nutrition, land use and water footprint country profile China

Based on the country data modelling, estimates on FLW-associated GHGEs were retrieved for China and plotted with the FLW total tonnage to visualize the two components (Figure 1). Food categories were ranked according to the production of FLW-associated GHGEs. For FLW, vegetables, rice, potatoes, wheat and tomatoes are the hotspots. The five hotspot products for FLW-associated GHGEs are: vegetables, rice, poultry meat, pig meat and freshwater fish. The category 'vegetables, others' has by far the highest FLW in weight as well as associated GHGEs, 100,000 and 79,000 tons respectively. For rice 46 million FLW tons induce 64 million tons CO2-eq. GHGEs.

Figure 2 presents the top 15 items with the largest land-use footprints of FLW. Bovine meat, pig meat, vegetables, rice, and soybeans rank the top five. Note that land use footprints do not apply for aquatic products.

With respect to the water footprints of the FLW, vegetables, rice and pigmeat are the top 3 contributors followed by wheat and soybeans (Figure 3). Here also, the indicator 'water footprint' does not apply to aquatic products.

From another perspective, taking the percentages of FLW in relation to production percentages, potatoes and the four aquatic products are identified as the main hotspots showing average losses of 45% and 44% respectively along the chains (Figure 4).

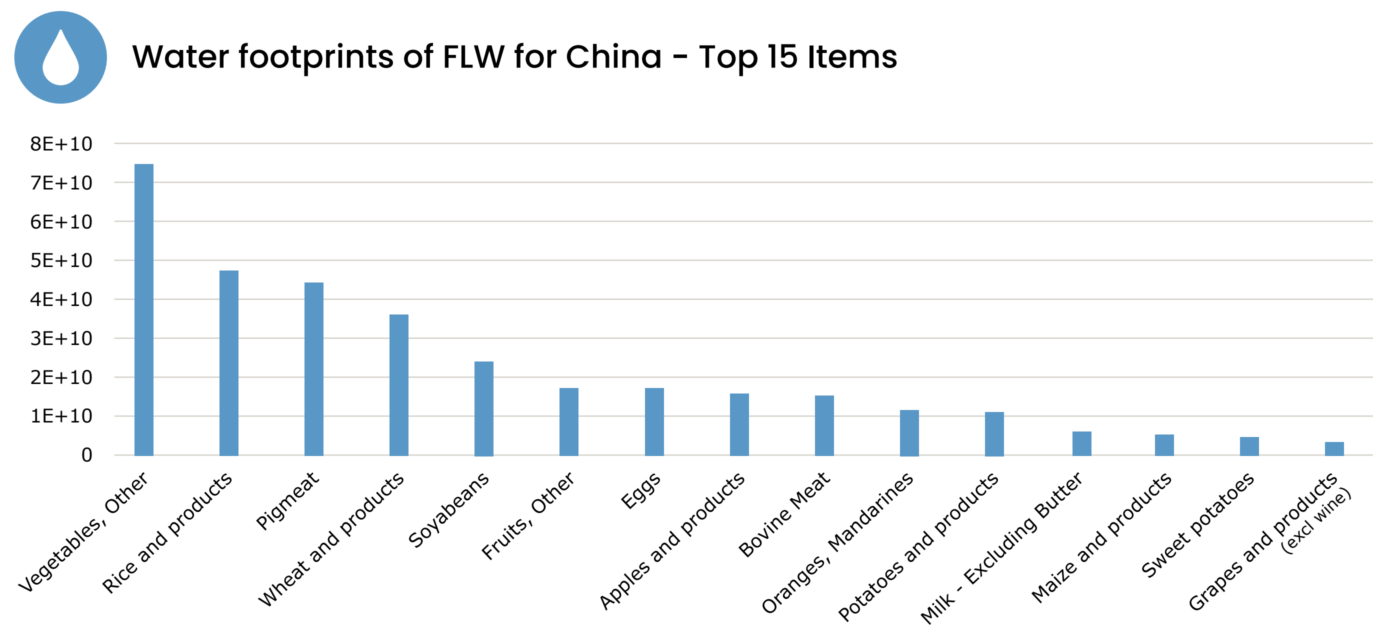

Figure 3 Top 15 hotspot categories of the water footprints of FLW (in m3)

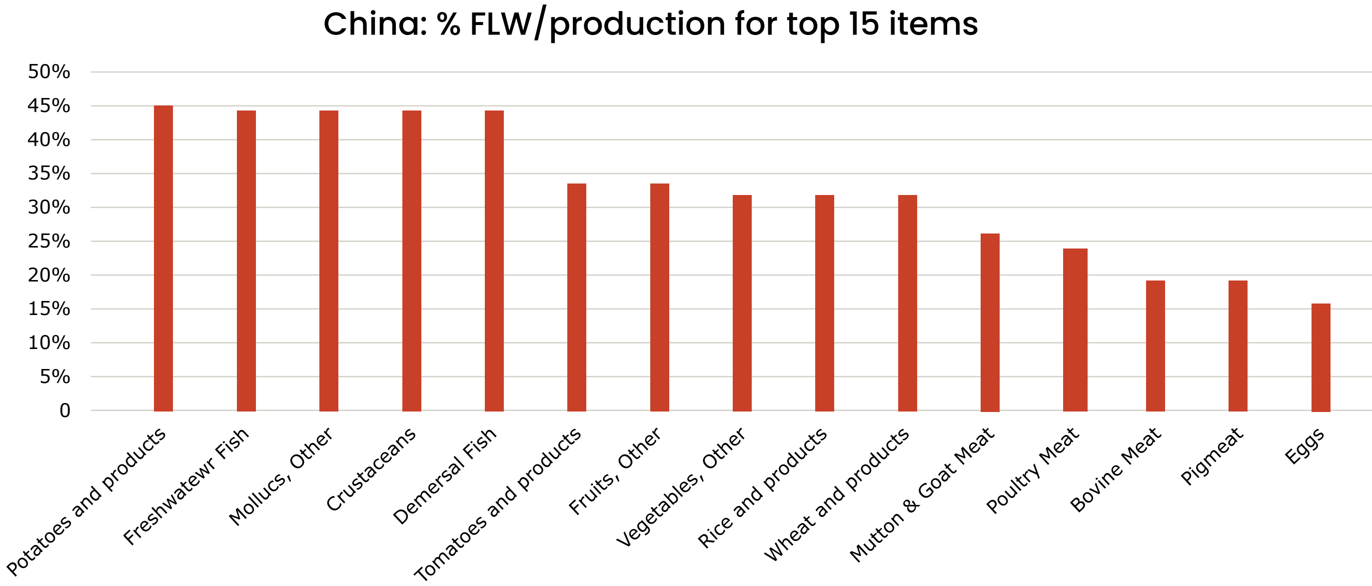

Figure 4 Percentages of FLW per product category

Further insights in hotspots are derived from estimated distribution of the FLW along supply chains for the two hotspot product categories in the region (Figure 5). These data suggest that for potatoes, the agricultural production and the processing and packaging stages are the hotspots for FLW. The agricultural production, postharvest handling and storage supply chain stages of aquatic products present FLW supply chain hotspots. These are focus points for more detailed data collection and analysis of causes to address potential interventions. Smart interventions in such 'hotspots' in food supply chains can substantially contribute to GHG emission mitigation of food systems. Analysis of specificities of such chains (e.g. comparing informal and formal supply chains, and urban and rural settings) including comparison with supply chains for similar product categories may reveal promising interventions. Interventions may combine hardware (packaging, cooling, etc.), orgware (e.g. arrangements in chains) and software (knowledge, information) elements.

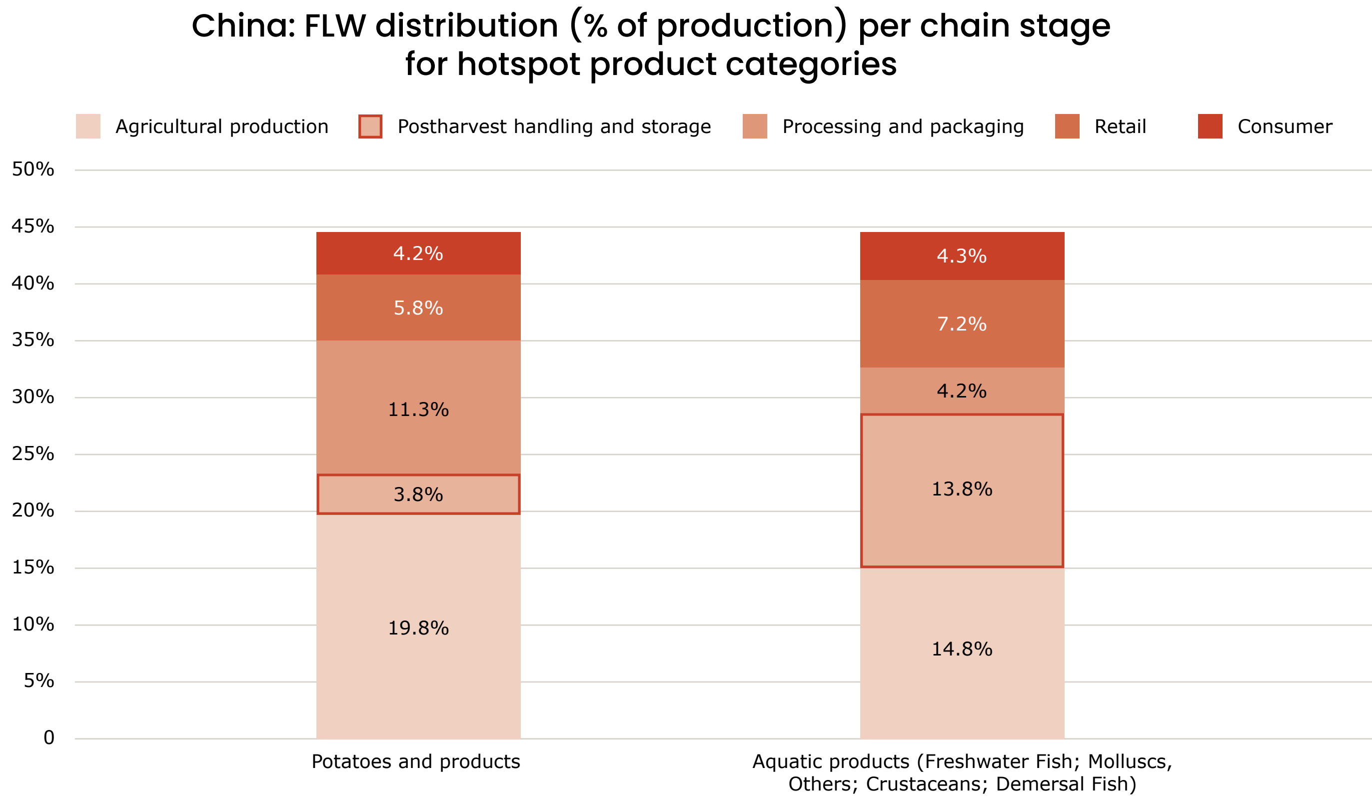

Figure 5 Percentages of FLW per stage in the supply chain for the top 2 hotspot product categories
Remark: Agricultural production does not include any potential yield gaps and focuses on actual production and harvest losses.

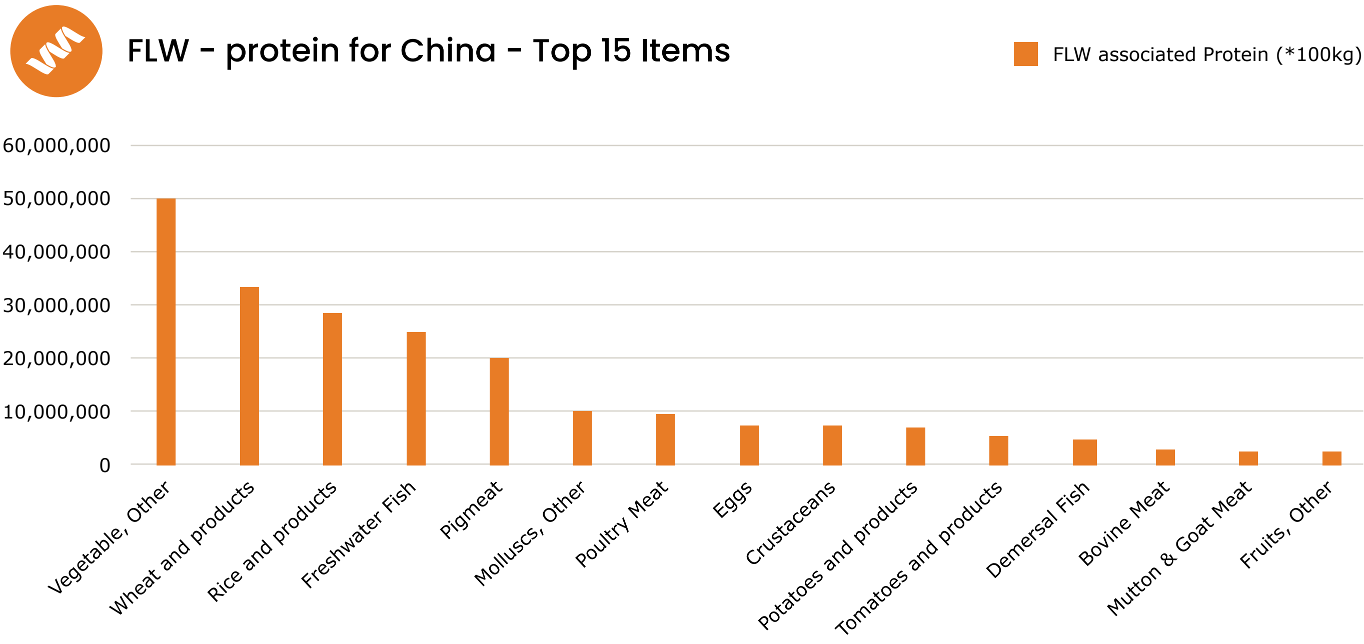

Figure 6 Top 15 hotspot categories of loss of proteins associated with FLW

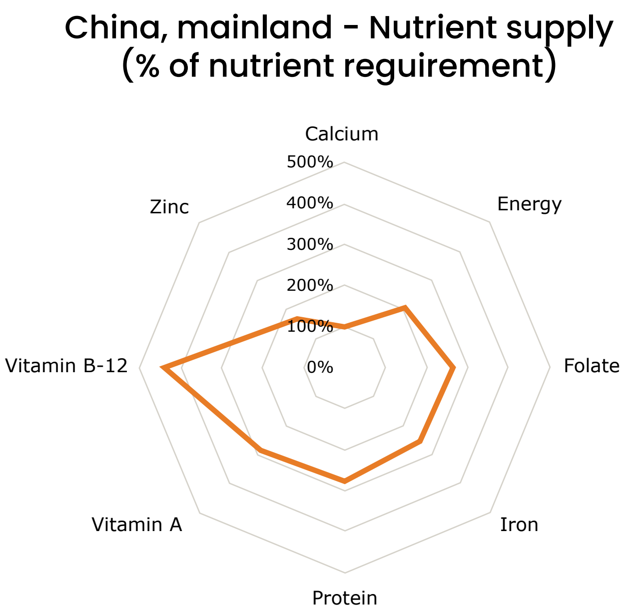

Figure 7 Average provision of nutrients per capita relative to WHO dietary recommendations
Remark: because of uneven distribution of food over the population, parts of the population will suffer more insufficiencies than this diagram implies.

Figure 6 shows the protein losses associated with FLW where vegetables, wheat, rice, freshwater fish and pig meat are the top five items. Finally, the food supply and FLW data were used to assess nutrient supply per capita in the Chinese population in relation to recommended nutrient intake (Figure 7). These are average numbers, and it is not likely that nutrients are evenly distributed across China. Hence, there will be parts of the population that suffer insufficiencies of calcium, iron and energy (carbohydrates, fat).
From nutrition security perspective, efforts for mitigating FLW in soybeans, wheat, fish and rice chains would contribute the most to population nutrient gains (Table 1).

Table 1 Food product categories for which the FLW have highest share for the most critical nutrients.

Critical nutrients	FLW categories with highest loss of the nutrient (highest first)
Calcium	Soybeans, wheat, fish
Energy	Rice, wheat
Iron	Rice, wheat, soybeans

Value loss

Money is an important driver for change. Hence, converting the FLW weight to Chinese currency may trigger stakeholders to invest in FLW reduction interventions. According to Li,Y., et al. (2019) food worth over 200 billion RMB (29 billion USD) was thrown away in 2016. However this seems an underestimate since our data show that 80% of FLW fruits and vegetables are vegetables, and they have an average wholesale price of 4 RMB/kg. The weight of FLW for fruits and vegetables is 215 Mt (see table 2), implying a value loss of 80% x 215 x 109 x 4 = 688 billion RMB for vegetables only. And even if the farm price is less than half the 200 billion Yuan turns out to be too low.
Similar calculations can be made for e.g. fruit (5.5 RMB/kg) and meat (between 15 and 20 RMB/kg).
Even if farm prices would be plugged in for the calculations the conclusion turns out to be the same.

Validation

The data used in Porter are not sufficiently granular to apply separate country commodity-stage-loss factors. Hence, the mass flow model described here might show data that don't match reality for the specific country at hand: China. In that context a literature review was carried out to check whether the derived data are more or less in line with research related to China itself. From the UN Food System Summit in 2021 it is known that national FLW data are scarce and difficult to obtain. Countries have been invited by the UN to take action on national level and develop policies laid down in a 'national pathway' document.

One article was found on FLW in China as a whole. In Xue, L., et al (2021) the total annual food production between 2014-2018 was about 1293 Mt, and 349 Mt was lost or wasted (27%). In this study FLW is compared to food supply (including import and export) and FLW was 486 Mt of 1872 Mt of production (FLW=26%). Both studies take import/export into account. Between 2014-2018 export weight of agricultural products was 520 Mt, whereas the import weight was much lower with 175 Mt average, leading to a net food supply of 1638 Mt average. In this study trade data from 2020 are export 67 Mt and import 232 Mt resulting in a net supply of 1707 Mt. Results for main food categories are:

Table 2 FLW weight (MTons) validation

Food category	FLW (here)	FLW (2014-2018)
Fruits & vegetables	287	215
Roots and tubers	5.1	7.2
Cereals	82	31
Meat	16	59
Dairy	3.2	3.6

Clearly there are large differences for meat and cereals and in Xue, L., et al (2021) this difference is explained by the fact that FAO FLW coefficients are not China specific but derived from industrialized Asia, including South Korea and Japan. Moreover, they do not distinguish food waste rates for different cereal types either (maize, wheat and rice). These countries are very modern and show different consumption patterns and waste figures.
Note that the major FLW food categories remain fruits and vegetables, cereals and meat.

Overall conclusions and suggestions for the next steps

Figure 8 displays a comprehensive ranking of hotspot food products based on five criteria. While there are ten hotspot food products identified, a closer examination reveals notable variations in the ranking of them across the five criteria. Vegetables and rice emerge as extremely critical products serving as a hotspot for all five categories. Pig meat follows closely, positioned as a hotspot for four categories and also falls into the category of extremely critical products. In the next tier of hotspot products, wheat is classified as very critical hotspot product. Fresh waterfish and soybean are identified as hotspots for two product categories and are classified as moderately critical. Bovine meat, poultry, potato and tomato being identified among the top five products in one of the categories but not any of the other four categories and are therefore classified as slightly critical products.

It is suggested to develop FLW reduction actions, with synergy on GHGEs mitigation, nutrition, land-use and water footprints. The above analysis underlines that, if one considers sustainability in the context of these five indicators the greatest impact can be achieved by concentrating efforts on vegetables, rice, pig meat, and wheat compared to focusing on other food products.

Since the results are not on product level, it is not immediately clear, where to start your intervention. Our suggestion is to develop FLW reduction actions, with synergy on GHGEs mitigation, nutrition, land-use and water footprints, is to implement monitoring or/and gather primary data for hotspot-supply chains of the country. The results in this document guide stakeholders by focusing on the top five food (sub) categories in combination with the indicative results on FLW per supply chain link. To research interventions, it is necessary to go to product level, which can be based on production or trade data in the country. The next step is to identify business cases for FLW reduction. For this purpose, WUR's EFFICIENT protocol[2] and FLW cause and intervention tool[3] can be used.

2 https://edepot.wur.nl/556214 and https://sites.google.com/iastate.edu/phlfwreduction/home/efficient-food-loss-waste-protocol

3 The FLW cause & intervention tool (the-efficient-protocol.azurewebsites.net)

China: Hotspot food products evaluated across five criteria

	FLW tons	GHGEs	Land-use footprints	Water footprints	Protein Losses	Conclusions
Vegetables	1	1	3	1	1	Extremely critical
Rice	2	2	4	2	3	Extremely critical
Pigmeat		4	2	3	5	Very critical
Wheat	4			4	2	Very critical
Fresh waterfish		5	○	○	4	Moderatley critical
Soybean			5	5		Moderatley critical
Bovine meat			1			Slightly critical
Poultry		3				Slightly critical
Potatoe	3					Slightly critical
Tomato	5					Slightly critical

● Extremely critical ● Very critical ● Critical ● Moderately critical ● Slightly critical ○ Not applicable

Figure 8 Ranking of hotspot product across five criteria

References

FAO. 2019. The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome. Licence: CC BY-NC-SA 3.0 IGO.

FAO, I., UNICEF, WFP and WHO., In Brief to The State of Food Security and Nutrition in the World 2021 - Transforming food systems for food security, improved nutrition and affordable healthy diets for all. 2021: p. 40.

Guo, X.; Broeze, J.; Groot, J.J.; Axmann, H.; Vollebregt, M. 2020. A Worldwide Hotspot Analysis on Food Loss and Waste, Associated Greenhouse Gas Emissions, and Protein Losses. *Sustainability* , 12, 7488.

Lipinski, B., Champions 12.3: SDG Target 12.3 on food loss and waste: 2022 progress report. 2022: p. 12.

Mekonnen, M., & Hoekstra, A. Y. (2010). The green, blue and grey water footprint of animals and animal products. (Value of water research report 48; No. 48).

Mekonnen, M. M., & Hoekstra, A. Y. (2011). The green, blue and grey water footprint of crops and derived crop products. Hydrology and Earth System Sciences, 15(5), 1577-1600.

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.

Porter, S. D., Reay, D. S., Higgins, P., & Bomberg, E. 2016. A half-century of production-phase greenhouse gas emissions from food loss & waste in the global food supply chain. *Science of the Total Environment*, 571, 721-729.

WWF, Driven to waste: The global impact of food loss and waste on farms. 2021: p. 24.

Colophon

Project number
623923390

Carried out by
The research that is documented in this study reports on work carried out by Wageningen Food & Biobased Research under Mitigate+ in 2022-2024. It was conducted in an objective way by the researchers.

Authors
Authors are researchers at Wageningen Food and Biobased Research, Wageningen, The Netherlands. Corresponding author: heike.axmann@wur.nl.

Acknowledgment
Support for this study was provided through Mitigate+: Initiative for Low-Emission Food Systems. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund.

Version
July 2024

WAGENINGEN UNIVERSITY & RESEARCH

CGIAR INITIATIVE ON Low-Emission Food Systems