



Potential Food Waste Reduction Opportunities

Major transformations are required to create sustainable food systems, but near-term immediate actions can support longer-term, more fundamental transition to sustainability. For incremental steps to contribute to long-term changes, stakeholders should define sustainability, measure unsustainability, and understand what interests, ideas and institutions contributed to the current structures, ideas, institutions, policies, and practices. Such understanding will enable stakeholders to choose near-term actions that can lead towards sustainability.

The tables, below, are intended to provide a starting point for stakeholders who are working to build sustainable food systems and are considering a range of near-term interventions. Much additional experience and knowledge by farmers, peasants, indigenous groups and other practitioners should be consulted for a full understanding of these and additional potential interventions.

The following tables summarize mitigation opportunities, adaptation potential, and food system implications based on global literature regarding food loss, food waste, and climate change. The opportunities may not be relevant or appropriate for low- and middle-income countries.

Minimizing waste is important to decrease unnecessary emissions from agriculture, but also to help compensate for the effects of climate change on food production (e.g., lower harvest rates and greater variability in volume of harvest) (Vermeulen et al., 2012). There are a substantial number of interventions that can minimize the amount of waste throughout the food systems. It is important to consider the potential trade-offs between waste reductions and their environmental impacts (Bernstad et al., 2016).

Production. In high-income countries in particular, farmers tend to overplant and overproduce crops to ensure they meet requirements of the market despite the possibility of weather events, pest disturbance, and other factors. While more research is needed to determine the extent of food loss from pests and weeds (Bajzelj et al., 2014), coordination between farmers and other interventions can help to supplement any shortages from one farmer with surplus from another (Stuart, 2009).

Storage. Poor storage is a major contributor to waste in the food system as products may expire prior to reaching retailers or consumers. In low-income countries, technologies such as small metal silos and plastic storage bags can help preserve food longer while protecting it from pests, mold, and other toxins (Lipinski et al., 2013). Additionally, investment in grain reserves can help to preserve harvests for extended periods for use in years when weather patterns prevent sufficient harvest (Vermeulen et al., 2012).

Marketplace Changes. Increasing communication between markets and farmers and between different market actors can curb waste. Technology to communicate with farmers about market prices and demand may reduce waste while also providing better prices to farmers for their product (Dorward, 2012). Marketing cooperatives can also serve to increase efficiency of activities such as assembling produce and preparing commodities for transportation rather than working as individual actors (Kader, 2005).

Retail. Retailers can take action to decrease waste. For instance, retailers in high-income countries should consider changing quality standards to include those food products that are aesthetically different from typical products, but are similar quality in taste and nutrition (Dorward, 2012; Gustavsson et al., 2011). Food chain operators, retailers, restaurants and other food service providers have opportunities to reduce food waste (Dorward, 2012; Lipinski et al., 2013; Sheffield, 2016, Daily Table, 2015; Gustavsson et al., 2011).

Consumers. Particularly in high-income countries, consumers account for a large portion of waste (Alexander et al., 2016). There are a number of ways consumers can contribute to reducing food waste through dietary choices and other behavioral choices. Issues related to proper labelling (e.g., sell by dates) and consumer education can help (Gustavsson et al., 2011; Wilson et al. 2016; Garnett, 2011).

Disposal. Disposal of some food products is inevitable. In order to maximize use of these wasted foods, food waste can be used as animal feed; methane capture, biogas, and biomass can be used as energy sources (Schott et al., 2016); and organic food material can be used for composting (Bajzelj et al., 2014; Dorward, 2012).

Policy and Other Incentives. Governments and other key stakeholders can pursue policies to decrease waste throughout the system. Interventions include developing a food loss and waste measurement protocol (Lipinski et al., 2013), setting waste reduction targets, emissions reduction policies that require consumers to waste less in high-income countries (Dorward, 2012), landfill taxes (Dorward, 2012), increased investment in reducing postharvest losses in developing countries (Lipinski et al., 2013), and improved infrastructure of roads, energy, and markets in developing countries (Choudhury, 2006).

Opportunities Table: Food Waste Opportunities

Opportunity	Mitigation Potential	Adaptation Potential	Co-benefits	Challenges	Food System Implications
	Qualitative description plus quantitative if available (range of possible emission reductions?)	Qualitative description plus quantitative if available			Potential feedbacks and interactions
Institutional programs	School Breakfast Program waste mitigation: "saving food for later, actively encouraging children's consumption, smaller portion sizes, composting and donating uneaten food" (Blondin 2015)	Unknown	May provide benefits for reduced energy intake with health benefits for some	Pre-packaged foods (e.g. cartons of milk) would need to be repackaged or redesigned. Programs that require participants to take certain foods would need to be reconsidered.	Given the size of institutional programs in many countries, small shifts in these programs could have significant impacts for supply. Since these programs also often take excess food commodities, this might require a shift in where those commodities may go.
Improve system and understanding of sell-by dates	Improve system and understanding of sell-by dates that discourage use of food that is likely edible, promote recipes that use leftover food (Dorward 2012)	May result in changes in amounts of food being refrigerated and/or stored (unknown direction)	Saves consumers money if they are not throwing away still edible food	At least in the US, there is a complex system of sell-by, best-by, etc. dates. These are variable at the state level with no federal oversight.	Would require consistent printing of dates at the processing level and education at the retail and consumer level. May reduce the need for some levels of production.
Education on food waste	Education on food waste and how consumers contribute via schools and political initiatives are starting points to change people's attitudes and understanding (FAO)	Unknown	Food waste reductions can save money	Public education campaigns have limited levels of success.	Would require education across the food system at all levels to have impacts. Consumer driven campaigns could help minimize household food waste, but would largely not address other losses in the system.
Alternative uses	Use of food waste for composting or animal feed can help repurpose food waste and prevent it from further contributing to GHGs in landfills. These strategies will not prevent the generation of emissions throughout the food system, but can minimize food system emissions in disposal, and potentially provide a useful outcome of a waste product.	Use in compost could help with soil health and farm resilience.	Can result in viable industries in composting, animal feeds, and energy generation. Can provide a low cost food option for livestock producers, and an input for farmers as an alternative to synthetic fertilizers.	Generating a market for food waste doesn't prevent food waste, it repurposes it. These markets also result in new infrastructure and transportation/distribution. Ultimately, creating a demand for food waste may prevent strategies to minimize food waste in the first place.	Some recent research suggests that people will waste more food when they know it is being composted. Some of these alternative "end of life" uses may prevent food from being wasted earlier in the supply chain and ultimately reducing total emissions. Thus, efforts to create markets and infrastructure for food waste should consider its potential to shift, if food wastes are reduced earlier in the food system. Food waste inputs into livestock and compost systems should also consider other environmental, economic and social impacts.
Use waste as sources of energy	Use of methane capture in landfills, biogas, and biomass from waste as sources of energy (Schott et al 2016)	Unknown	Production of energy	Expensive implementation	If food waste is diverted from landfills or digesters, it will cause an overall reduction in landfill sizes and production of methane gas, so there should be a balance of energy generation via food-waste landfills and digesters. Ultimately, greater GHG emission reductions are made by not generating waste in the first place, rather than repurposing it at the end of the supply chain.
Landfill taxes (Dorward 2012)	Landfill taxes (Dorward 2012)				
Develop a food loss and waste measurement protocol	Develop a food loss and waste measurement protocol (WRI reducing...)				

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Set food loss and waste reduction targets	Set food loss and waste reduction targets (WRI reducing...)				
Emissions reduction policies	Emissions reduction policies requiring consumers to waste less in high income countries (Dorward 2012)				
Increase investment in reducing postharvest losses	Increase investment in reducing postharvest losses in developing countries (WRI reducing...)				
Create entities devoted to reducing food waste	Create entities devoted to reducing food waste in developed countries (WRI reducing...)				
Infrastructure for roads, energy, and markets	"Governments should improve the infrastructure for roads, energy, and markets in developing countries. Private sector investments can improve storage and cold chain facilities as well as transportation" (Choudhury, 2006) via FAO	May help provide greater ease of transport for future climate shocks. Cold-chain expansion will help minimize future food safety threats from increased temperatures.	Provides market opportunities, income and access to services for those living in rural areas.	Significant cost and undertaking in many rural areas. Cold-chain expansion could result in increased GHG emissions, especially if not done with best available technologies.	Greater connectivity and refrigeration for rural households, especially in low-income countries could provide significant economic benefits, but also have many other implications. It could increase rural migration and urbanization. It can also increase availability of goods-including Westernized foods and diets into rural areas.
Improved market institutions and infrastructure	Improved market institutions and infrastructure such as technology to communicate with farmers on prices for their goods (Dorward 2012)				
Marketing cooperatives	Marketing cooperatives are organizations providing a central point for assembling produce from small farmers and preparing commodities for transportation to markets. The marketing cooperatives should be able to reduce food losses by increasing the efficiency of these activities." (Kader, 2005) via FAO				
Packaging to extend product lifespans and decrease waste	Packaging to reduce food waste through use of ethylene inhibitors, absorber packaging, cooling and venting, shading (Blanke et al. 2015; Hanssen 2017).	May help safeguard foods from future climate change impacts including extreme temperatures or events that could disrupt food distribution	May help enable produce and other healthy foods to be transported longer distances	Could increase resource use and GHG emissions associated with packaging.	Packaging of foods would increase natural resource use potentially, but likely reduce overall emissions if preventing food waste. It could require additional manufacturing or processing. Need to ensure consumer acceptance of processing and packaging technologies.
Plastic Crates	Using plastic crates during storage and handling to prevent produce from being damaged. Use in developing countries to substitute for sacks and bags that can damage produce (WRI)	May withstand future climate impacts better	Keeps produce and goods in better form	Costs, production and distribution of plastic crates as well as system to take them from market back to farm level	May require different modes of transporting food to markets (bags and sacks could be transported via animal, bicycle, etc.) Plastic crates may require trucks and other transportation forms that could increase GHG emissions. System of distribution for crates to ensure maintenance and repair and not single use is critical to minimize resource use and GHGs.

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Communication and cooperation between farmers to reduce overproduction	"Communication and cooperation between farmers to reduce risk of overproduction by allowing surplus crops from one farm to solve a shortage of crops on another" (Stuart 2009 via FAO Global...)				
Increase food processing facilities	"Lack of processing facilities causes high food loss in developing countries when seasonality of production and the cost of investing in processing facilities that will not be used year-round result in insufficient capacity to process and preserve produce. Governments should create a better enabling environment and investment climate to stimulate the private sector to invest in the food industry and to work more closely with farmers to address supply issues." FAO		Can increase local consumption of foods, especially in low-income countries	Processing of foods with addition of sugar, salt, fats or other additives could have negative public health impacts.	Increase in processing facilities in low-income countries could create jobs (outside of agriculture) and potentially shift food systems towards more industrialized and processed foods. However, processing can result in healthy foods, so this is not universal. Increased local supply of foods may shift trade demands.
Reducing portion sizes served at restaurants and other food service providers	Reducing portion sizes served at restaurants and other food service providers can help to reduce food waste from leftover food and cost to providers (WRI reducing...)		May reduce energy intake, which could provide health benefits for some	Consumer expectations about costs versus food amounts could prevent this action. Potential for restaurants to reduce costs, commensurate with portion size reductions, but could influence profitability	With an increasing amount of meals eaten outside the home, shifts in restaurant portions could have a notable change on dietary emissions from food waste and public health benefits. It could influence restaurant profitability, so further research could assist with strategies that don't compromise economic viability.
Replace all you can eat campus cafeteria options with a la carte and/or remove cafeteria trays	Replace all you can eat campus cafeteria options with a la carte to deter excess food production and take (Costello et al 2016).	Unknown	May reduce energy intake, which could provide health benefits for some	Convenience factor for many to have a tray. Cost perceptions of consumers may be challenging. Economic viability should be considered.	With an increasing amount of meals eaten outside the home at cafeteria, shifts could have a notable change on dietary emissions from food waste and public health benefits. It could influence cafeteria profitability, so further research could assist with strategies that don't compromise economic viability.
Decrease storage temperature for meat	Decrease storage temperature for meat product to prolong shelf life (Eriksson et al 2016). Meat is not a significant portion of food waste; however, given its high GHG impact, it results in a significant proportion of food waste emissions (Costello et al. 2016; Heller and Keoleian 2015)	Could be challenging with increased future temperatures and lack of cold-chain		May increase GHG emissions from energy- best available technologies should be used to minimize GHG emissions.	Must be accompanied by expansion of cold chain refrigeration to be scalable and with technology changes to minimize GHG emissions from refrigerants.
Encourage supermarkets to sell heterogeneous produce	"Supermarkets seem convinced that consumers will not buy food which has the 'wrong' weight, size, or appearance. Surveys do however show that consumers are willing to buy heterogeneous produce as long as the taste is not affected (Stuart 2009). Consumers have the power to influence quality standards. This could be done by questioning them and offering them a broader quality range of products in retail stores." (FAO) (Dorward, 2012)		May enable retail stores to sell more produce and increase profitability	Consumer acceptance- public education campaigns have been successful in France and cheaper options have been successful in U.S.	If sold at a lower cost may result in increased purchasing of products, which could potentially be wasted at the household level rather than the retail level (just pushing the waste into a different sector).
Time and Temperature Labels	Time and Temperature Labels (Dorward 2012)				

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Renewed investment in systems of grain reserves	Renewed investment in systems of grain reserves (AR 131)				
Storage bags, metal silos, and other appropriate storage devices	Storage bags, small metal silos, and other storage devices allow for airtight storage of crops by smallholder farmers to prevent pest contamination, mold growth, and toxins				