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REDUCING FOOD LOSS AND WASTE

Setting a Global Action Agenda

With support from



The
**ROCKEFELLER
FOUNDATION**

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FOREWORD

How is the world going to feed nearly 10 billion people while also advancing economic development and meeting the challenge of climate change? This has become one of the paramount questions of our time. Reducing food loss and waste is part of the answer.

Tackling the issue of food loss and waste can generate a “triple win.” Reductions can save money for farmers, companies, and households. Wasting less food means we can feed more people. And reductions can alleviate pressure on climate, as well as on water and land.

Fortunately, a modern movement around food loss and waste reduction is emerging. In 2015, nations of the world adopted the Sustainable Development Goals (SDGs)—including “Target 12.3,” which calls for halving the rate of food loss and waste by 2030. In 2016, a group of leaders came together to form the Champions 12.3 coalition to help inspire ambition and motivate action toward this SDG target. Numerous organizations, including those we lead, have launched initiatives to address this important issue. And recent landmark studies such as the World Resources Report *Creating a Sustainable Food Future* and the EAT-Lancet Commission’s *Healthy Diets from Sustainable Food Systems* make the case that halving the rate of food loss and waste is necessary if the world is to sustainably feed the planet over coming decades.

The issue is now on the minds of public and private sector leaders. Ambitions have been raised. Steps are being taken. What we need now, though, is a shared vision of what needs to happen to get the world on track to halving food loss and waste. We need a Global Action Agenda.

In this report, we offer that agenda. First, we encourage countries and companies to adopt the global SDG 12.3 target as their own, measure their food loss and waste (since what gets measured gets managed), and take action on the hotspots identified. Although simple, this “Target-Measure-Act” approach is proving effective. Second, we identify a short-list of “to do’s” for each type of actor in the food supply chain. If you don’t know which actions to take, start with this list and go from there. Third, to scale up the impact and pace of these actor-specific interventions, we recommend 10 interventions that tackle food loss and waste across the entire supply chain, target a handful of food loss and waste hotspots, and help set the enabling policy and financial conditions that are necessary for success.

We hope this report will inspire you to play a role in helping create a sustainable food future. The need is urgent—because food is a terrible thing to waste.

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CARROTS

ONIONS

Tomatoes

EXECUTIVE SUMMARY

Reducing food loss and waste can help meet the UN Sustainable Development Goals (SDGs) by 2030, contribute to the Paris Agreement on climate change, and sustainably feed the planet by 2050. This report lays out a **Global Action Agenda** that will help reduce food loss and waste and achieve SDG 12.3. This action agenda includes a Target-Measure-Act approach, an actor-specific “to-do” list, and 10 “scaling interventions” designed to take the approach and to-do list to scale.

HIGHLIGHTS

- Numerous studies find that the world experiences significant levels of food loss and waste, with losses “near the farm” predominant in lower-income regions and waste “near the plate” predominant in higher-income regions.
- Halving the rate of food loss and waste is an important “no regrets” strategy that would contribute to achieving the UN Sustainable Development Goals, meeting the goals of the Paris Agreement on climate change, and sustainably feeding the planet.
- This report, based on extensive desk-based research and input from partner organizations, proposes a **Global Action Agenda** to reduce food loss and waste. It involves three main components.
- Governments and companies should follow the “Target-Measure-Act” approach: Adopt a target to halve food loss and waste by 2030, measure how much and where food is being lost and wasted, and take action on the hotspots.
- All actors in the food supply chain should kick-start their actions by pursuing a “to-do” list tailored to their specific roles.
- Governments and business leaders should pursue 10 “scaling interventions” that have the potential to rapidly scale, accelerate, and broaden deployment of the Target-Measure-Act approach and the actor-specific interventions.

Background

Reducing food loss and waste is an important strategy to help meet the UN Sustainable Development Goals (SDGs) by 2030, contribute to the Paris Agreement on climate change, and sustainably feed the planet by 2050. SDG 12 aims to ensure “sustainable consumption and production patterns,” and one of its targets (SDG 12.3) calls for halving rates of food loss and waste. This in turn would contribute to meeting a number of other SDGs, such as those on hunger, poverty, and health. Recent modeling efforts indicate that halving food loss and waste rates would yield significant reductions in greenhouse gas (GHG) emissions because more efficient use of food would reduce the need for land conversion for additional food production and slow the rate of increase in fertilizer applications and methane emissions from food in landfills (Searchinger et al. 2018; Willett et al. 2019). Moreover, a recent World Resources Report (Searchinger et al. 2018) and a just-released report from the

EAT-Lancet Commission (Willett et al. 2019) both identify halving food loss and waste as a critical element in achieving a sustainable food future. The private sector is also making changes to tackle food loss and waste, with over 30 of the world’s largest global companies having set targets in line with SDG 12.3 (Flanagan et al. 2018). In short, reducing food loss and waste is rapidly rising on public and private sector agendas as a strategy to help fix an inefficient food system for the sake of people and the planet.

About this report

This report lays out a **Global Action Agenda** for reducing the rate of food loss and waste and thereby achieving SDG 12.3. The action agenda includes a Target-Measure-Act approach, an actor-specific “to-do” list, and 10 “scaling interventions” designed to take the approach and to-do list to scale.

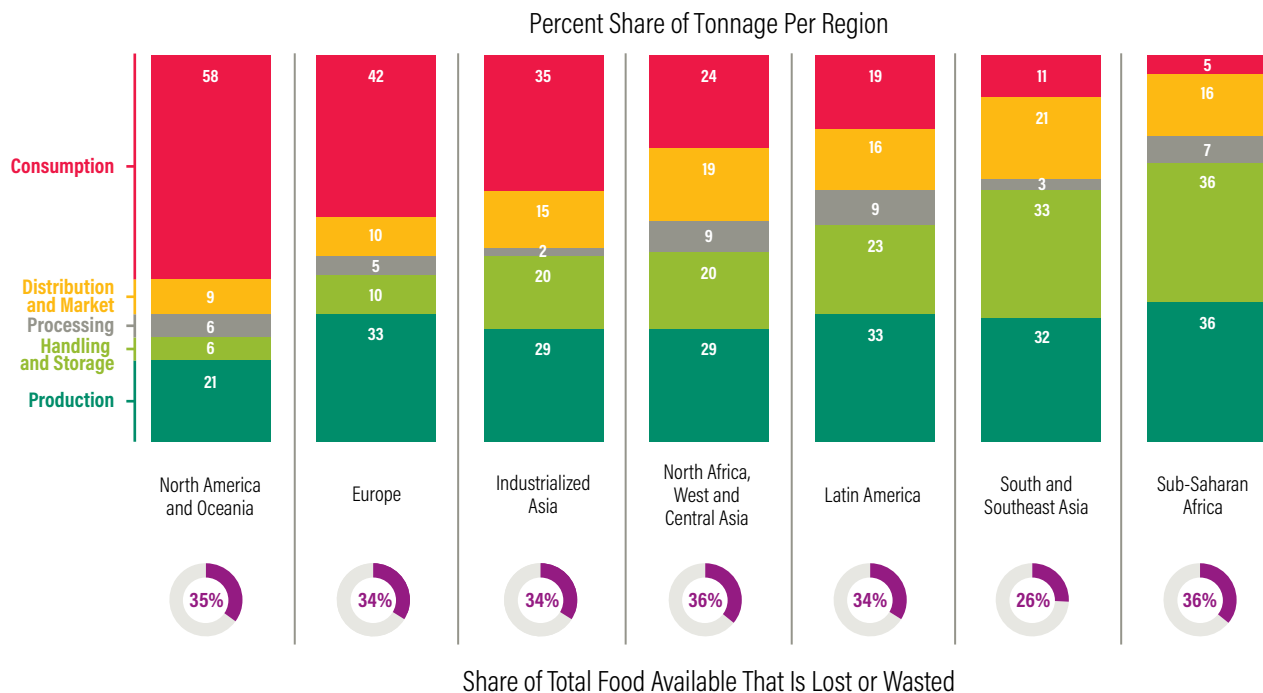
The Global Action Agenda is designed to guide businesses, governments, civil society, and other actors in the food supply chain who can play a role in tackling food loss and waste, individually and collectively.

This report was jointly prepared by WRI with support from The Rockefeller Foundation, and in collaboration with food loss and waste experts from the Consortium for Innovation in Postharvest Loss and Food Waste Reduction, Iowa State University, the University of Maryland, the Natural Resources Defense Council (NRDC), United Nations Environment Programme (UNEP), Wageningen University & Research, the Waste & Resources Action Programme (WRAP), and the World Bank.

What is the food loss and waste challenge?

A significant amount of food intended for human consumption is never eaten. In 2011, the Food and Agriculture Organization of the United Nations (FAO) launched a landmark publication, *Global Food Losses and Food Waste: Extent, Causes and Prevention* (FAO 2011), with the headline finding that one-third of all food is lost or wasted between the farm and the plate. Despite its uncertainties, this figure remains the only global estimate currently available. Our assessment of more subcontinental and commodity-specific studies conducted since then suggests that the FAO data are broadly correct.

Figure ES-1 | **Distribution of Food Loss and Waste by Region and Stage in the Food Supply Chain, 2007**



Notes: Values displayed are of food loss and waste as a percent of food supply, defined here as the sum of the "Food" and "Processing" columns of the FAO Food Balance Sheet. Numbers may not sum to 100 due to rounding.
Source: WRI analysis based on FAO (2011).

The distribution of food loss and waste across the food supply chain varies by region of the world. Food loss and waste at the point of consumption in homes and restaurants appears to be a hotspot of food loss and waste in high-income regions, whereas losses during handling and storage are a hotspot in low-income regions. On-farm production losses (i.e., during and just after harvest) are an issue in all regions (FAO 2011) (Figure ES-1).

The world is calling for halving the rate of food loss and waste. In September 2015, nations of the world formally adopted a set of 17 Sustainable Development Goals (SDGs) as part of the 2030 Agenda for Sustainable Development—global goals to end poverty and hunger, protect the planet, and ensure prosperity for all. SDG 12 seeks to “ensure sustainable consumption and production patterns.” The third target under this goal, Target 12.3, calls for halving “per capita global food waste at the retail and consumer levels and reduc[ing] food losses along production and supply chains, including post-harvest losses,” by 2030 (UN 2017).

Why does it matter?

Food loss and waste matters in terms of the environment, economy, food security, jobs, and ethics. *The environment:* The food that is lost and wasted each year accounts for an estimated 8 percent of annual GHG emissions, consumes a quarter of all water used by agriculture, and requires an agricultural area the size of China. *The economy:* The annual market value of lost and wasted food is estimated at an astounding \$940 billion globally (FAO 2015a). *Food security:* More than 1 billion metric tons of food per year is never consumed in a world where one in nine people are still undernourished (FAO et al. 2018). *Jobs:* Reducing food loss and waste could play a modest role in job creation across the supply chain, ranging from smallholder processing facilities close to the farm to technology start-up companies that help redistribute food that would otherwise be wasted. *Ethics:* Reducing food loss and waste is considered by many people as simply “the right thing to do.”

The benefits of reducing food loss and waste can be significant. For instance, reducing the current rate of food loss and waste by 50 percent by 2050 would have the following results:

- It would close the gap between food needed in 2050 and food available in 2010 by more than 20 percent (Searchinger et al. 2018).
- It would avoid the need to convert an area of natural ecosystems roughly the size of Argentina into agricultural land between 2010 and 2050 (Searchinger et al. 2018).
- It would lower GHG emissions by 1.5 gigatons of carbon dioxide equivalent (Gt CO₂e) per year by 2050, an amount more than the current energy- and industry-related emissions of Japan (Searchinger et al. 2018).

What is causing food loss and waste?

Understanding why food loss and waste occurs (whether intentionally or not) is important to successfully reducing it. The most immediate reasons food leaves the human food supply chain (the “direct causes”) tie back to concern about a food’s safety or suitability for consumption, or there being no perceived use or market for it. This may be due to deterioration or suboptimal quality, or issues such as the food’s appearance, excess supply, and seasonal production fluctuations. Leading to these direct causes are a number of “underlying drivers.” These can be technological, managerial, behavioral, or structural in nature. The technological drivers are poor infra-

structure, inadequate equipment, and suboptimal packaging. The managerial drivers are inadequate food management practices, skills, or knowledge; inflexible procurement practices; poor supply and demand forecasting and planning; and marketing strategies. The behavioral drivers are norms and attitudes, lack of awareness, and concerns about possible risks. The structural drivers are conditions in demographics, climate, policies and regulations, economics, and financing that lead to food loss and waste. These 15 underlying drivers need to be addressed if food loss and waste is to be reduced.

The underlying drivers of food loss and waste are closely interrelated. An instance of food loss or waste is often driven by more than one driver (e.g., rice losses may occur due to inadequate storage bags, which, in turn, may be caused by a grower’s lack of access to credit to purchase better bags). Moreover, while an underlying driver may affect one stage of the food supply chain, the generation of loss and waste might actually occur at a different stage. For instance, orders modified last-minute by food retailers at the distribution and market stage of the food supply chain can result in fruits and vegetables being left in the farm field, leading to losses during production.

Among the various underlying drivers, some are more relevant in certain regions. For example, lack of infrastructure is typically a more significant driver in low-income countries, whereas social norms and attitudes such as the acceptability of not eating all the food on one’s plate are often a driver in high-income countries.



Reducing food losses close to the farm (during production as well as handling and storage) can be a result of “good economic development.” As economies develop and underlying drivers shift, food loss may give way to food waste closer to the plate.

What should be done about it?

Governments and companies should pursue a simple but effective “Target-Measure-Act” approach to reducing food loss and waste:



TARGET

Set targets. Targets set ambition, and ambition motivates action. Governments and companies should therefore adopt an explicit food loss and waste reduction goal aligned with SDG 12.3—a 50 percent reduction by 2030.



MEASURE

Measure your food loss and waste. The adage “what gets measured gets managed” holds true for food loss and waste as well. Quantifying food loss and waste within borders, operations, or supply chains can help decision-makers better understand how much, where, and why food is being lost or wasted. This information provides an evidence-based foundation for prioritizing interventions to reduce food loss and waste, and helps entities monitor whether they are on track to realizing their target. Governments and companies should therefore start to measure their food loss and waste and monitor progress over time.



ACT

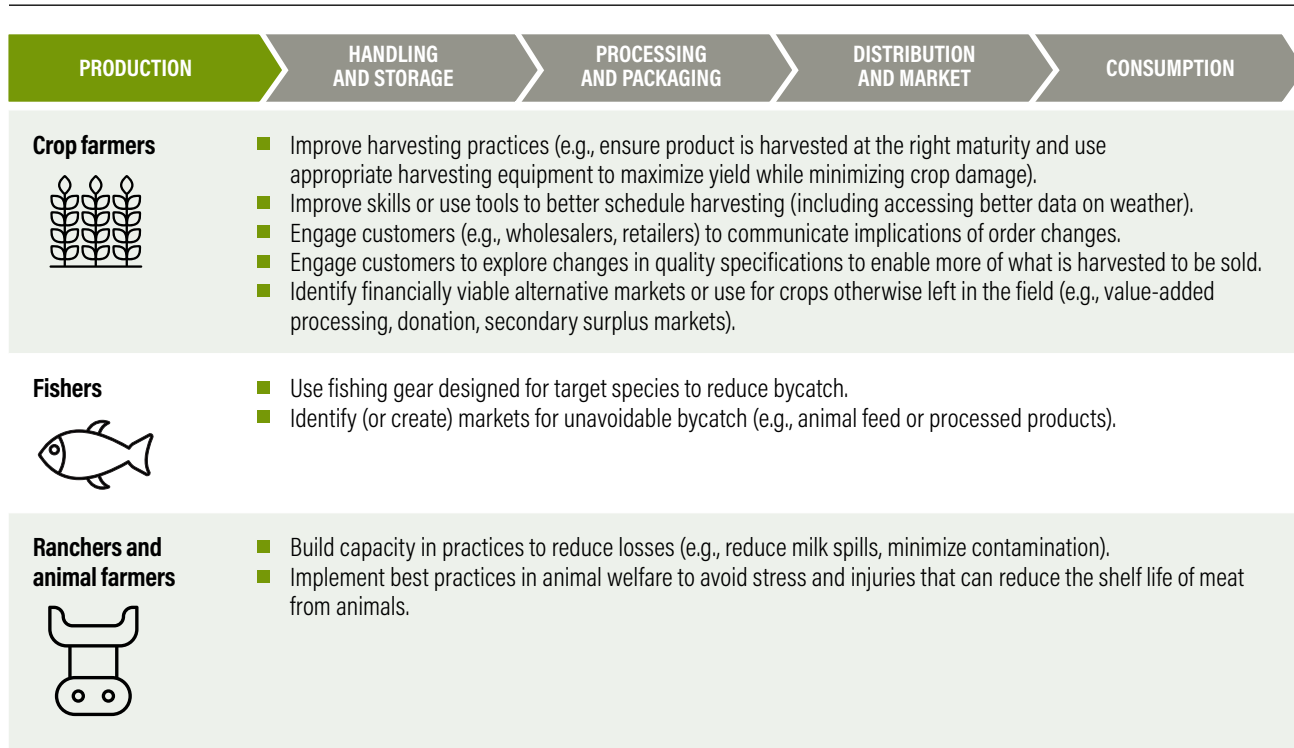
Take action. What ultimately matters is action. However, there is no proverbial “silver bullet” action for reducing food loss and waste. Rather, reducing it at scale will require numerous actors in the food supply chain to implement a variety of context-specific interventions. Figure ES-2 provides a priority to-do list for each type of actor to get started reducing food loss and waste. Governments, companies, farmers, citizens, and others should immediately get moving on implementing their respective to-do lists.

Experiences from reduction initiatives that are making progress provide a number of insights on taking action:

- Awareness is a start (but only a start).
- Make the “business case” to motivate actors (so they see reducing food loss and waste as in their self-interest).
- Recognize that there is no silver bullet (a number of interventions are typically required).
- Which interventions are relevant vary between and within countries (especially depending on the level of economic development).
- Beware of knock-on effects across the supply chain (reductions at one stage might merely trigger loss and waste elsewhere).
- Collaboration between actors is crucial (especially when pursuing a “whole supply chain” approach).



Figure ES-2 | Priority “To Dos” by Actor (Not Exhaustive)



Source: Canali et al. (2014); CEC (2017, 2018, 2019); Clowes et al. (2018a, 2018b, 2019); Food Loss and Waste Protocol (2016); Global Knowledge Initiative (2017); Gunders and Bloom (2017); Hegnsholt et al. (2018); HLPE (2014); ReFED (2016); Gooch et al. (2019); WWF-US (2018).

Figure ES-2 | Priority “To Dos” by Actor (Not Exhaustive), continued

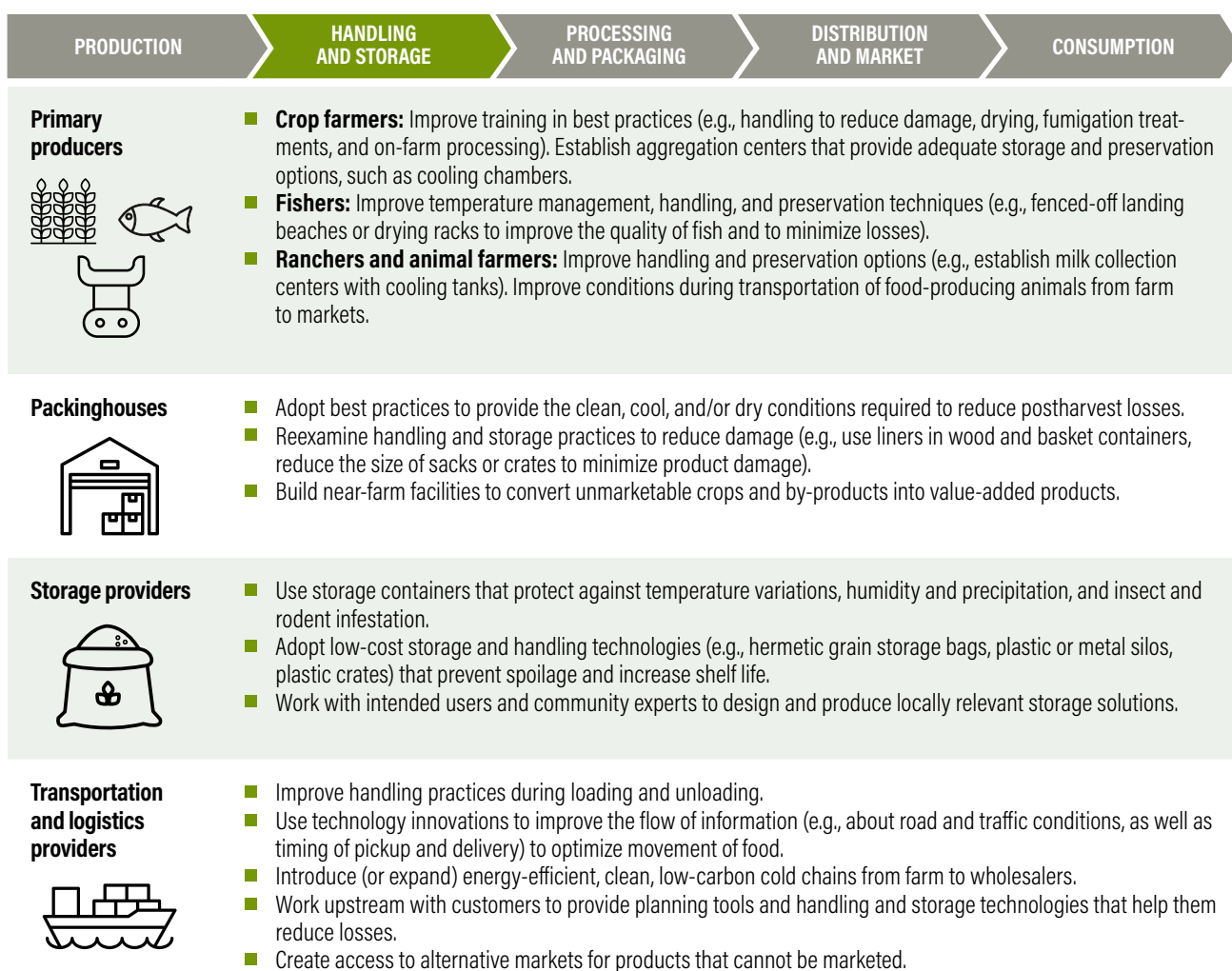


Figure ES-2 | Priority “To Dos” by Actor (Not Exhaustive), continued

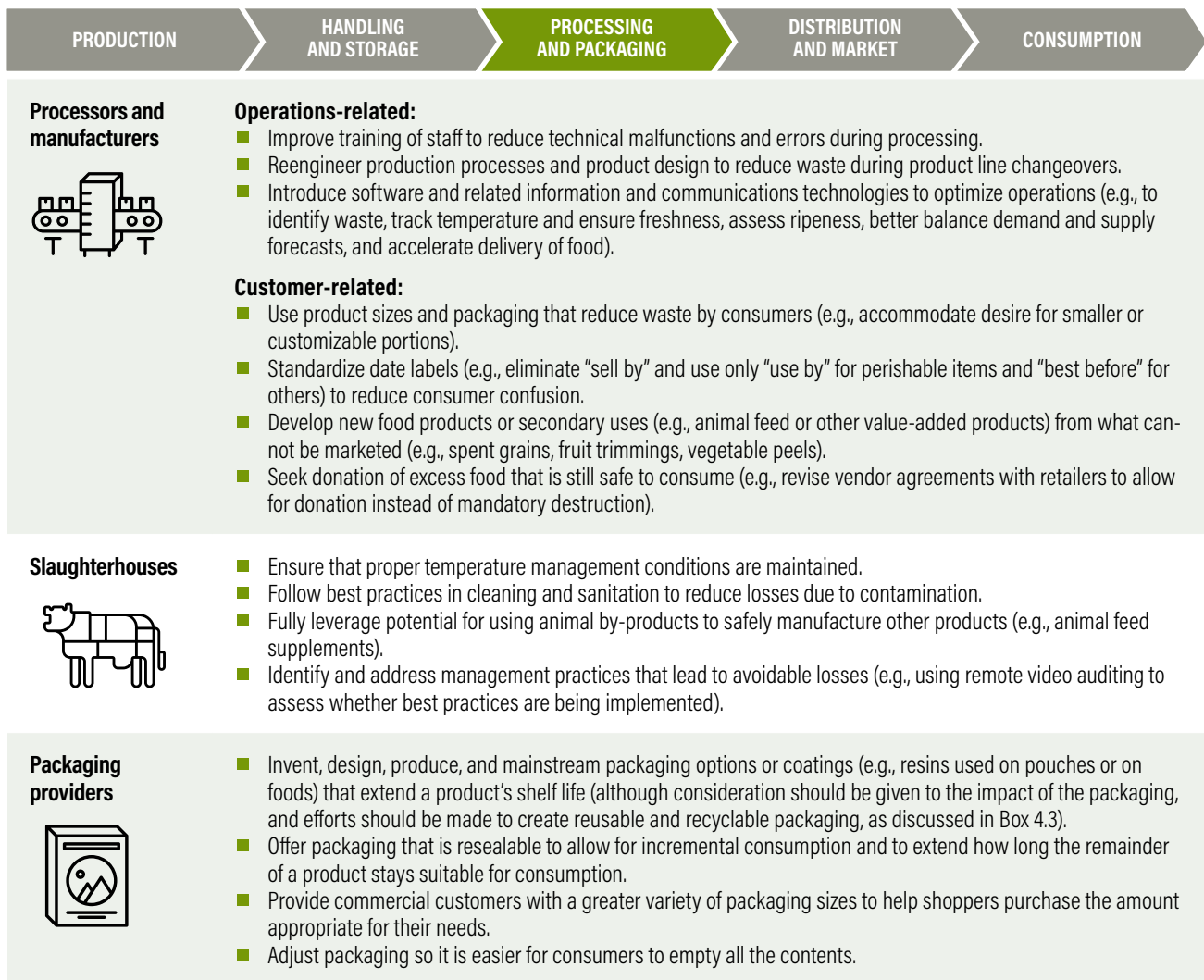


Figure ES-2 | Priority “To Dos” by Actor (Not Exhaustive), continued

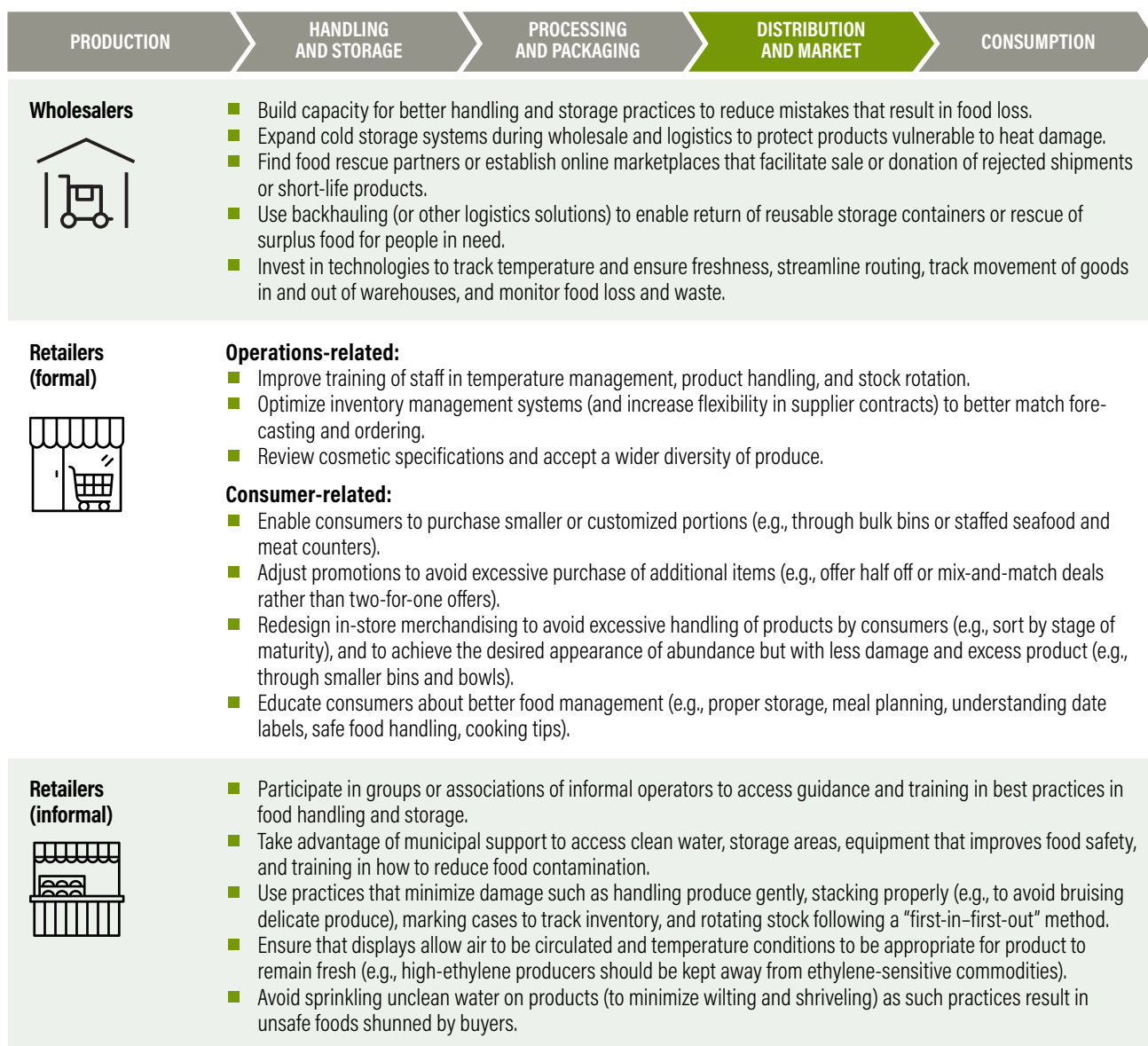


Figure ES-2 | Priority “To Dos” by Actor (Not Exhaustive), continued

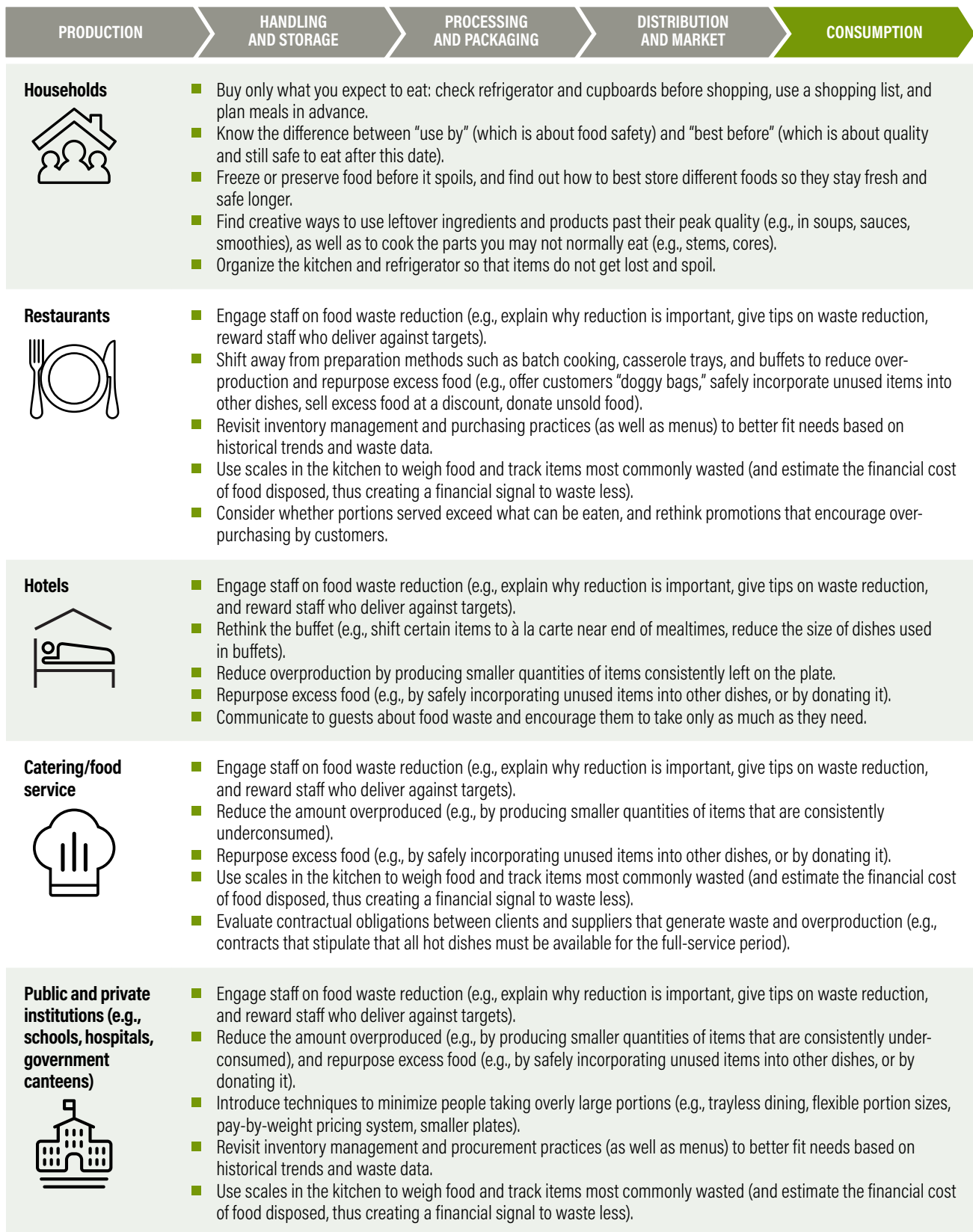


Figure ES-2 | Priority “To Dos” by Actor (Not Exhaustive), continued

	PRODUCTION	HANDLING AND STORAGE	PROCESSING AND PACKAGING	DISTRIBUTION AND MARKET	CONSUMPTION
Policymakers 	<ul style="list-style-type: none"> ■ Embed into agricultural extension services (and in farmer subsidy programs) food loss reduction awareness, technical assistance, and financial aid. ■ Develop, facilitate, promote, and/or improve climate-smart infrastructure (e.g., roads, electricity, irrigation, community storage) and access to it, especially for smallholder farmers who live far from markets. ■ Increase investment in agricultural research related to postharvest loss and provide incentives for the adoption of postharvest technologies (e.g., zero-rates tax on imported postharvest technologies, incentives for local manufacturers of postharvest technologies, subsidies for postharvest technologies). ■ Implement policies to prevent unfair trading practices (e.g., last-minute order cancellations and unilateral or retroactive changes to contracts). ■ Remove barriers to food redistribution via policies (e.g., liability limitations, tax breaks) that make it easier for food suppliers to donate safe (but unsold) food to charities or to those in need. ■ Support policies to standardize food date labeling practices to reduce confusion about product safety and quality, and improve consumer understanding of the meaning of date labels. ■ Include food waste reduction lessons in school curricula and include food waste reduction training in public procurement programs. ■ Provide municipal support for informal retailers to access clean water, storage areas, equipment that improves food safety, and training in how to reduce food contamination. ■ Make measurement and reporting of food loss and waste by large companies mandatory. 				
Financiers 	<ul style="list-style-type: none"> ■ Increase the number of philanthropic institutions funding food loss and waste prevention activities. ■ Create financing instruments and product lines (e.g., funds, bonds, loans) dedicated to reducing food loss and waste. ■ Increase start-up financing for new technologies and business models that would reduce food loss and waste, as well as financing to scale up proven technologies and models. ■ Increase development cooperation between high-income and low-income countries targeting food loss and waste. ■ Introduce “pay-as-you-go” programs to make technologies affordable for smaller operations (e.g., for solar-powered refrigeration units and mobile processing). 				
Innovators and intermediaries (e.g., brokers, consolidators, digital solution developers) 	<ul style="list-style-type: none"> ■ Develop and improve availability of processing and preservation facilities (including aggregation centers and mobile low-carbon options). ■ Develop alternative outlets during peak season through organizing export opportunities to markets with other seasonalities. ■ For unmarketable crops, improve flow of information to find alternative buyers, promote financially viable alternative markets, or develop new outlets (e.g., as processed foods, industrial products, animal feed). ■ Apply innovations to reduce delays for imported products during the point of exit and entry, which extends the shelf life of perishable products. ■ Leverage technology and digital solutions to rethink and better coordinate key processes between suppliers and customers in a more organized and informed way. 				
Researchers 	<ul style="list-style-type: none"> ■ Research new and innovative technologies to preserve food quality and extend shelf life. ■ Develop innovative products from perishable food commodities, such as fruits and vegetables, to promote whole food utilization. ■ Undertake research to fill data gaps and standardize reporting of food loss and waste data in order to better compare results, create benchmarks, and provide clearer direction for stakeholders. ■ Assess impact of interventions to improve evidence base of what works and the return on investment. ■ Develop sector-specific guidance that provides the motivation and technical information for businesses to take action (e.g., promote industry roadmaps for food loss and waste reduction). 				
Civil society 	<ul style="list-style-type: none"> ■ Raise awareness and shift social norms so that food loss and waste is considered “unacceptable” for all, including higher-income consumers. ■ Encourage public and private sector leaders to pursue the Target-Measure-Act strategy. ■ Act as a channel for the sharing and reporting of food waste data and progress. 				

What progress has been made so far?

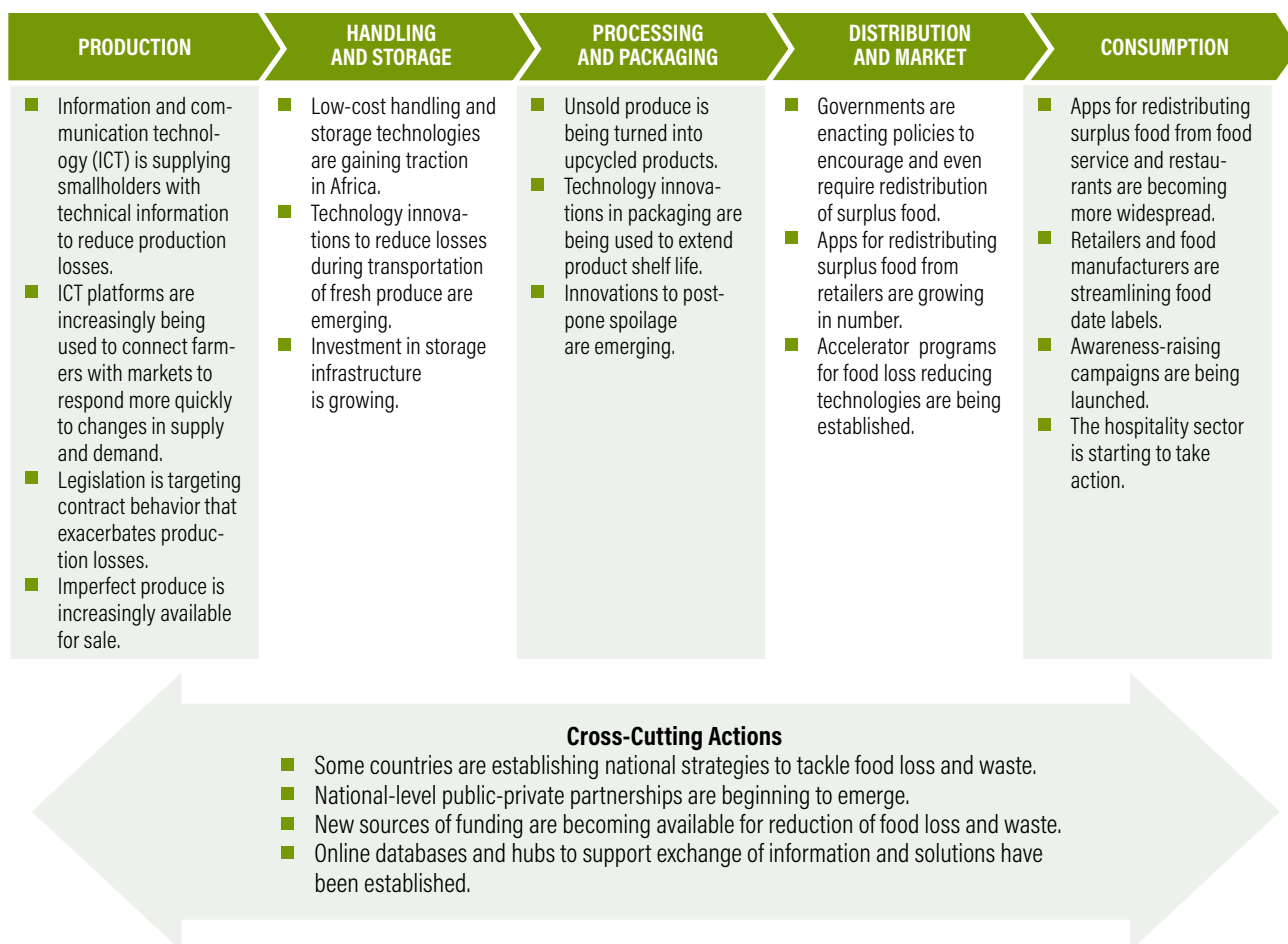
Progress has been made toward implementing some aspects of Target-Measure-Act. In terms of setting targets, 50 percent of the world’s population now lives in a country that has set an explicit, public target aligned with SDG 12.3 (Flanagan et al. 2018). In addition, 32 of the world’s 50 largest food companies (by revenue) independently have set—or participate in programs that have set—a food loss and waste reduction target consistent with SDG 12.3 (Flanagan et al. 2018). In terms of measurement, countries representing 12 percent of the world’s population measure food loss and/or waste within their borders, and more than 30 of the world’s largest companies are now measuring food loss and waste within their operations. In terms of taking action, over the past few years a number of

technologies, policies, and business practices have been designed along the food supply chain to tackle food loss and waste (Figure ES-3).

What needs to happen next?

Despite the progress to date, much more must be done and done much faster if SDG 12.3 is to be met. Most of the specific interventions on the to-do lists are already technically possible. The problem is that too few actors are deploying them. Why? In some cases, it may be lack of awareness, concern, or focus regarding food loss and waste. In others, it may be lack of ability or resources (e.g., technical, financial). And in still others, it may be lack of collaboration across a large number of actors needed to effect change. What is needed next is a series of “scaling interventions” that address these bottlenecks.

Figure ES-3 | **Emerging Developments to Reduce Food Loss and Waste across the Supply Chain**



Source: WRI analysis.

To address this, we propose 10 such scaling interventions that have the potential to accelerate and broaden deployment of the Target-Measure-Act approach and of the actor-specific interventions. Three of them take a whole supply chain approach, four of them target specific hotspots of food loss and waste, and three more enhance enabling conditions for reducing food loss and waste. They may not constitute a comprehensive set, but they are a good starting point for making progress.

Whole supply chain approaches

1. *Develop national strategies for reducing food loss and waste.* Increase the number of countries with national strategies, as these can be an important catalyst for Target-Measure-Act at the country level—aligning public policy, private sector action, and farmer-to-consumer behavior toward a shared goal.
2. *Create national public-private partnerships.* Increase the number of country-level public-private partnerships dedicated to achieving SDG 12.3.
3. *Launch a “10x20x30” supply chain initiative.* Launch a voluntary private sector campaign where at least 10 corporate “power players” commit to Target-Measure-Act themselves and then engage their own 20 largest suppliers to do the same and achieve a 50 percent reduction in food loss and waste by 2030.

Hotspot-specific approaches

4. *Invigorate efforts to strengthen value chains and reduce smallholder losses.* Invigorate efforts to help smallholder farmers reduce food losses during production and storage.
5. *Launch a “decade of storage solutions.”* Kick-start a focused collaboration among storage providers, cold chain alliances, financiers, and governments to get income-sensitive, climate-smart storage technologies into the hands of farmers and distribution networks around the world.

6. *Shift consumer social norms.* Leveraging the latest findings of behavioral science, engage grassroots campaigns, social media, religious communities, and others to make “wasting food” as unacceptable as littering now is in many countries.
7. *Go after GHG emissions reductions.* Use sector-led programs to tackle food loss and waste from beef, dairy, and rice head on, and get the reduction of food loss and waste into nationally determined contributions to the Paris Agreement on climate change.

Enabling approaches

8. *Scale up financing.* Develop funds and financing products dedicated to investing in innovation and scaling up enterprises, technologies, and programs that would reduce food loss and waste.
9. *Overcome the data deficit.* Over the next five years, a concentrated push to measure food loss and waste is needed to overcome this data deficit in time to support achievement of SDG 12.3.
10. *Advance the research agenda.* More research is still needed to answer multiple “next generation” questions that would, in turn, help refine food loss and waste reduction strategies and advance implementation of the global agenda.

A call to action

The Target-Measure-Act approach, combined with the actor-specific interventions and the 10 scaling interventions, comprise our proposed Global Action Agenda.

Momentum is growing, but the world has much more to do. Only 11 years remain to achieve the targets of the SDGs, and food loss and waste is still pervasive. Actors ranging from governments, businesses, farmers, consumers, and everyone in between can play a role in the Global Action Agenda. With worldwide participation, we just might realize a future where no food fit for consumption goes to waste.



INTRODUCTION

How can the world nutritiously feed nearly 10 billion people by the year 2050 in a manner that advances human well-being while also reducing the food system's impact on the environment, particularly on climate change? This is one of the paramount questions of the first half of this century. Successfully answering it means the world will achieve a sustainable food future. Unsuccessfully doing so means disaster for food security, the climate, and people.

The answer requires implementing a “menu of solutions” that simultaneously (a) closes the gap between the food needed by 2050 and that available today, and (b) significantly reduces greenhouse gas (GHG) emissions from agriculture and related land-use change by 2050 in order to meet the Paris Agreement on climate change. One critical menu item for achieving both is to reduce the current rate of food loss and waste by 50 percent. Recent modeling¹ found that doing so would close the food gap by more than 20 percent (Figure I.1) and reduce the food system’s projected GHG emissions by 10 percent (Figure I.2).² Thus, among the menu items, reducing food loss and waste has a sizable impact. The EAT-Lancet Commission Report (Willett et al. 2019) similarly highlighted the important role of reducing food loss and waste in achieving a sustainable food system.

Failure to act will make the challenge of achieving a sustainable food future immensely harder. If current rates continue, the amount of food loss and waste will grow from today’s 1.3 billion metric tons per year (FAO 2011) to 2.1 billion tons by 2030 (Hegnsholt et al. 2018) and even more by 2050

(Searchinger et al. 2018). In a world where one in nine people already suffer from undernourishment and 2 billion suffer from micronutrient deficiencies (FAO et al. 2018), such amounts of unconsumed food would be a travesty—and a symptom of a food system that is not performing as it could. Furthermore, the annual GHG emissions associated with all this lost and wasted food could grow from 4.4 gigatons at present to 6.2 gigatons by 2050 (Searchinger et al. 2018). This is the equivalent of adding another Brazil—the world’s sixth-largest emitter—to the world’s emissions (Carbon Brief 2018).

In some instances, some food loss and waste may be unavoidable. From farmers all the way to consumers, people will make rational decisions like plowing back into the soil diseased produce or not implementing reduction approaches where the costs outweigh the benefits. Some food loss and waste will always be with us. That said, dramatically reducing food loss and waste is possible and would generate many social, economic, and environmental benefits.

Figure I.1 | **Reducing Food Loss and Waste Can Play an Important Role in Closing the Food Gap Between 2010 and 2050 Without Expanding Cultivated Area**



Note: Includes all crops intended for direct human consumption, animal feed, industrial uses, seeds, and biofuels.
Source: Searchinger et al. (2018).

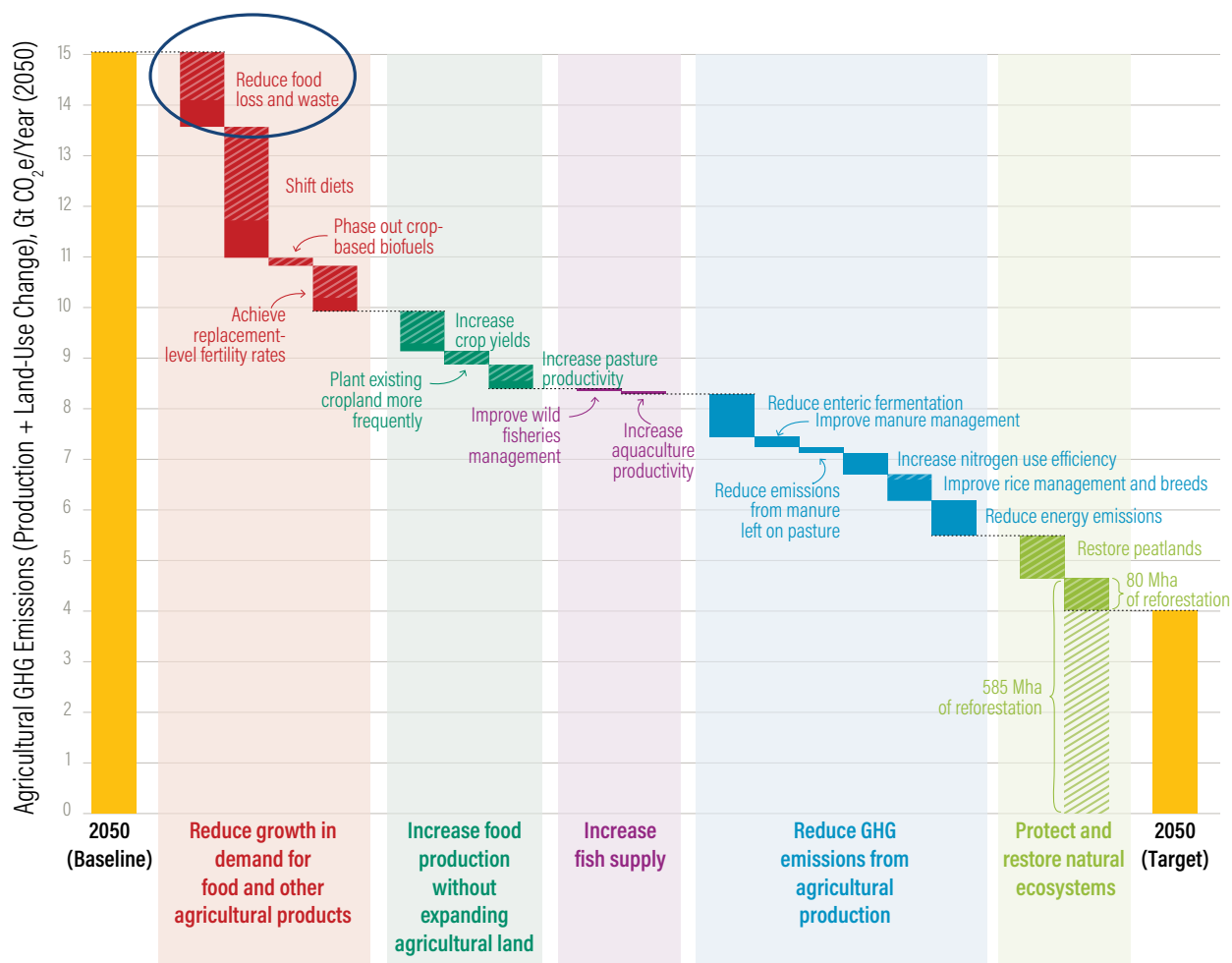
This report, *Reducing Food Loss and Waste: Setting a Global Action Agenda*, offers a suite of recommendations for how the world can cut the rate of food loss and waste in half. It elaborates on this agenda by answering the following questions:

- Chapter 1: What Is the Food Loss and Waste Challenge?
- Chapter 2: Why Does It Matter?
- Chapter 3: What Is Causing It?

- Chapter 4: What Should Be Done About It?
- Chapter 5: What Progress Has Been Made So Far?
- Chapter 6: What Needs to Happen Next?

With this report, we aspire to catalyze ambition, mobilize action, and accelerate progress toward halving the rate of food loss and waste—an aspiration critical for people and the planet.

Figure I.2 | **Reducing Food Loss and Waste Can Play an Important Role in Eliminating the Projected 15 Gt of Greenhouse Gas Emissions from Agriculture and Land-Use in 2050 (CO₂ equivalent)**



Note: Solid areas represent agricultural production emissions. Hatched areas represent emissions from land-use change.
Source: Searchinger et al. (2018).



CHAPTER I

WHAT IS THE FOOD LOSS AND WASTE CHALLENGE?

Food loss and waste is an issue of epic proportions. This chapter defines food loss and waste, summarizes what and where food is being lost and wasted, and compares recent regional quantifications with more historic global estimates.

SUMMARY POINTS

- The 2011 landmark publication by the Food and Agriculture Organization of the United Nations (FAO), *Global Food Losses and Food Waste: Extent, Causes and Prevention*, found that one-third of all food is lost or wasted between the farm and the plate. This astounding amount poses a sizable challenge to the world's food system. Despite its uncertainties, this figure remains the only global estimate currently available.
- Definitions of "food loss and waste" vary. This report recommends that "food loss and waste" be defined as food (and its associated inedible parts) that is intended for human consumption but that leaves the food supply chain somewhere between being ready for harvest or slaughter and being consumed.
- The distribution of food loss and waste across the food supply chain varies by region of the world. Food loss and waste at the point of consumption in homes and restaurants appears to be a hotspot of food loss and waste in high-income regions, whereas losses during handling and storage are a hotspot in low-income regions, and on-farm production losses (i.e., during and just after harvest) are an issue in multiple places.
- When it comes to tonnage of food loss and waste (and micronutrient losses), fruit and vegetable losses are a major hotspot, particularly close to the farm throughout Asia and sub-Saharan Africa and close to the plate in industrialized countries. Roots and tubers stand out, too, during the production and the handling and storage stages of the food supply chain in sub-Saharan Africa.
- When it comes to caloric losses, cereals are a hotspot, especially in Europe and North America (during consumption) and throughout Asia (during the production and the handling and storage stages). Roots and tubers in sub-Saharan Africa (during the production and the handling and storage stages) also appear to be a hotspot of caloric losses.
- When it comes to food-related greenhouse gas emissions, beef, dairy, and rice are the GHG hotspots of food loss and waste.
- An assessment of more subcontinental and commodity-specific studies conducted since the FAO (2011) report suggests that the FAO data may be broadly correct, and that several stages of the food supply chain are hotspots of food loss and waste, including production (just about everywhere), handling and storage (in South Asia and Africa), and consumption (in high-income countries but at a risk of increasing elsewhere, too).
- Despite all these data points, there is still a shortage of quantification of food loss and waste. A big effort to quantify and make publicly available data on food loss and waste—by country, food category, private sector supply chain, and more—is urgently needed since such data are needed for identifying hotspots of food loss and waste and for prioritizing interventions.



In 2011, the Food and Agriculture Organization of the United Nations (FAO) released a landmark publication, *Global Food Losses and Food Waste: Extent, Causes and Prevention*. This report introduced the astonishing finding that one-third of all food is lost or wasted between the farm and the fork. As the first major attempt to generate quantitative evidence on a global scale, it made headlines and brought worldwide attention to the challenge of food loss and waste.

What is really known, though, about the scale and nature of food loss and waste? Not as much as one would hope or as decision-makers need, it turns out. Although a lot has been written about food loss and waste since 2011, most of the global and continental quantitative analyses rely on the original data from the FAO 2011 study—despite the fact that it has a number of uncertainties (Box 1.1). That said, these data remain the only global figures currently available—although a number of national, corporate, and commodity-specific assessments have since been conducted. Regardless of the

accuracy of the 2011 report, the report and studies conducted since indicate there is a significant opportunity to reduce current levels of food loss and waste.

What Is Food Loss and Waste?

When it comes to understanding the nature and scale of the food loss and waste challenge, this is a common first question. For a number of reasons, no single definition of food loss and waste has been consistently used.

The landmark 2011 FAO report defined “food loss and waste” as “the edible parts of plants and animals produced or harvested for human consumption but not ultimately consumed by people. It represents a decrease in the mass, caloric, and/or nutritional value of edible food intended for human consumption at any stage in the food value chain.” Box 1.2 summarizes the specifics of what it covered. The quantitative data derived from FAO (2011) and used in this chapter are based on this definition.

BOX 1.1 | UNCERTAINTIES IN THE FAO 2011 DATA

The data presented in FAO's 2011 report provide valuable insight into estimated levels of food loss and waste and serve as a good starting point. However, they have several sources of uncertainty:

- **Inconsistent data sources.** For many food categories and geographies, directly measured food loss and waste data were not available. Rather, the report's data were based on national food balance sheets. Figures from this source are reported by government agencies. But not all governments report figures, and sometimes their quantification methods and definitions vary. The result is a summing up of tonnage across quite different data sources.
- **Extrapolation from small number of studies.** Where relevant, directly measured data were not available, the study had to use assumptions and estimations based on comparable crops, stages of the food supply chain, and even countries. For example, the figure that 25 percent of cereals are wasted during the consumption stage in Europe is based on one study conducted in the United Kingdom that measured how much bread was wasted at the household level (HLPE 2014). There were no data points on household food waste for Africa and Latin America, and only one data point on household food waste for Asia, so assumptions were made for household waste for these continents. Using studies from a small number of countries and extrapolating these results to an entire region (which includes countries quite different from each other) may mean that regional results are not representative of each country within that region.
- **Use of conversion factors.** The research used proxy conversion factors to estimate the part of an agricultural product that is typically considered for human consumption, an approach that can affect the accuracy of the figures.
- **Age of the study.** The data used in FAO (2011) are from 2007. They are thus now more than a decade old and may not accurately represent current conditions.
- **“Destinations” included.** Moreover, the study “counted” as food loss and waste food intended for human consumption that ended up as animal feed. Some more recent developments in quantification, however, do not count food diverted to animal feed as loss or waste.

Thus, as the report itself cautioned, the data are imperfect and the results should be treated accordingly (Gustavsson et al. 2013).

BOX 1.2 | WHAT THE 2011 FAO REPORT AND DATA COVER

The 2011 FAO report includes food but not associated inedible parts (e.g., pits, rinds). The quantitative figures using this definition cover the following seven basic commodities and their derived products: (1) cereals; (2) roots and tubers; (3) fruits and vegetables; (4) oilseeds, pulses, and nuts; (5) meat; (6) fish and seafood; and (7) milk and eggs. Food loss and waste apply to food products in the supply chain starting from the moment that crops are ready for harvest in the field, plantation, or orchard; animals are on the farm—in the field, sty, pen, shed, or coop—ready for slaughter; milk has been drawn from the udder; aquaculture fish are mature in the pond; and wild fish have been caught in the net. Thus, losses or unrealized yields while the crop or animal was growing are not included. The supply chain ends at the moment food products are consumed by people, discarded, or otherwise removed from the food chain intended for direct human consumption.

For the 2011 report, food that was originally meant for human consumption but is removed from the food chain is considered food loss or waste, even if it is then used as animal feed or bioenergy. The data do not include by-products (“inedible parts”) such as bones, organs, skins, seeds, peels, hulls, or bran; surplus food that is redirected to food banks and subsequently eaten by people; food grown intentionally for animal feed, seed, or industrial use; and overconsumption beyond recommended caloric needs.

The FAO 2011 data did not assess where the food went when it exited the food supply chain. By inference, then, it includes all possible destinations: animal feed; bio-based materials and biochemical processing; codigestion and anaerobic digestion; composting and other aerobic processes; controlled combustion; land application; landfill; crops not harvested or plowed in; refuse, discards, and litter; and sewer and wastewater treatment.

The FAO 2011 data did not quantify qualitative losses (e.g., nutritional value), either.

Source: FAO (2011).

Variations on the definition of food loss and waste diverge along several dimensions:

- **Material type.** Some definitions include only the portion of plants, animals, and fungi typically eaten by people. Others include the associated inedible parts, such as pits or stones, rinds, and bones. Whereas the former keeps the focus on “food” intended for consumption, the latter recognizes that “inedible parts” also have value, and parts considered inedible by some people (e.g., chicken feet, blood, fruit rinds, eggshells) may be considered food by others. Including “associated inedible parts” also has the practical benefit of simplifying quantification of food loss and waste, since the associated inedible parts do not need to be separated from the food during measurement.
- **Destinations.** A “destination” is where the food ends up if it is not eaten by people. (See Appendix A for definitions of all 10 possible destinations.) Some definitions include food that ends up being fed to animals, converted into energy, and/or other end uses that still create some sort of value. Other definitions only include destinations that do not generate any human value (e.g., landfill, sewer).
- **Quantity versus quality.** Some definitions of food loss and waste consider only the quantity (measured in kilograms or U.S. tons) of food that leaves the supply chain. Other definitions include losses in quality, such as the loss of nutritional or economic value. Such qualitative features, however, have been difficult to quantify in a systematic way.
- **Preharvest versus postharvest.** Some definitions of food loss and waste include losses that occur “preharvest,” before the crop has been harvested or the animal slaughtered. This includes unrealized yields due to weather, pests, or suboptimal management while the crops or livestock were growing. Not meeting full yield potential, however, is a food *production* issue, not an issue of maximizing the consumption of food already grown. Some definitions count only losses that occur “post-harvest,” after harvest or slaughter. This does

not include losses occurring during the harvesting process. Other definitions, including the one used by FAO (2011), count food loss from the point when the crop is ready to harvest or the animal is ready for slaughter. This includes losses during the process of harvesting (e.g., grains not captured by harvesting equipment).

- **Loss versus waste.** Some definitions make a distinction between “food loss” and “food waste.” One distinction is premised on intentionality (Fabi and English 2018). “Food loss” occurs when food unintentionally leaves the supply chain (e.g., it spills, it is eaten by pests); it is a technology, infrastructure, or environmental issue. “Food waste,” on the other hand, occurs due to the intentional act of a person (e.g., negligence or conscious decision to throw away food); it is a human behavior issue. This distinction may be relevant for informing reduction strategies because the interventions to address technology gaps will be different from those to address consumer behaviors. Intentionality, however, can be difficult to discern when conducting quantification. The other distinction is premised on where in the supply chain food exits. In this case, “food loss” occurs from the farm up to but not including the retail store, while “food waste” occurs at the retail store all the way to the household, restaurant, or other point of consumption (FAO 2011). This distinction is easier to identify when quantifying than discerning intentionality.

For practical purposes and for tracking progress toward reducing food loss and waste, this report considers food loss and waste to be food (and its associated inedible parts) that is intended for human consumption but that leaves the food supply chain somewhere between being ready for harvest or slaughter (herein referred to as the “production” stage of the food supply chain) and being consumed. As in FAO (2011), the “production” stage includes losses that occur during the process of harvesting or slaughtering, but does not include preharvest losses.³ Quantification should focus first on weight, but one could include more qualitative factors if and when feasible. All possible destinations should count, except food and associated inedible parts diverted to animal feed or biomaterials (which is a common end use of inedible parts).⁴

There appears to be a convergence toward this definition. For instance, the forthcoming Food Loss Index (led by FAO), the Food Waste Index (led by UNEP), and the European Union Commission definition of “food loss and waste” include all destinations except for food that ends up as animal feed, gets converted into biomaterials, or is not harvested (or plowed into the soil) (Fabi and English 2018; European Commission 2019). All three include food and associated inedible parts (Figure 1.1). One reason they do not include “not harvested” is that government agencies currently tend to collect data at the farm gate, which by definition excludes any crops left in the field. But companies and research institutions are starting to gather this pre-farm gate information, so this data gap should be reduced over time.

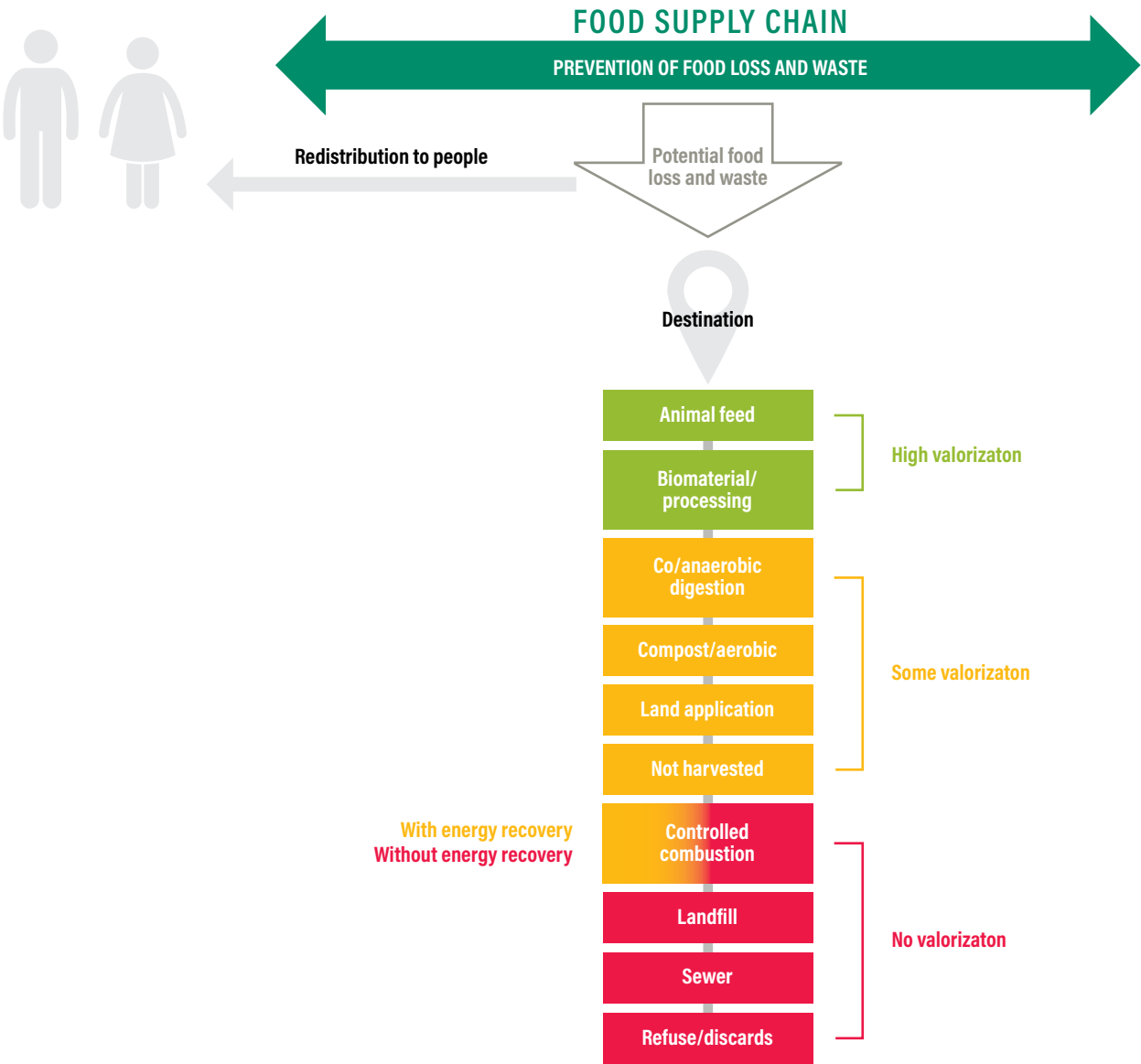
Some may argue that any food (and associated inedible parts) converted into something of value to people—typically energy or a soil amendment—should not be considered loss or waste. There are several counterpoints, however, to this perspective. First, because converting food into energy or into a soil amendment is not the original intended use of food, it represents a reduction in food supply relative to food demand. More food therefore needs to be grown—in a world already facing land and greenhouse gas emissions constraints. Second, such nonfood destinations are a relatively inefficient use of the resources already expended. Clearing land, applying fertilizers and water, harvesting crops, and processing it into food is not the most resource-efficient means of generating energy or a soil amendment; there are more direct and efficient ways to do so. Third, a global target to reduce food loss and waste (see Chapter 2) falls under a global goal about resource-use efficiency (i.e., “sustainable consumption and production”). Considerations of resource-use efficiency are therefore relevant when defining food loss and waste. Of course, generating some value out of food loss and waste is better than generating no value at all. Thus, there has emerged a general consensus toward a hierarchy of destinations or alternative uses of food that leaves the human food supply chain (Figure 1.2).

Figure 1.1 | “Material Types” and “Destinations”: FAO (2011) versus Recommendation versus EU/FLI/FWI



Source: WRI analysis.

Figure 1.2 | A Hierarchy of Destinations



Source: WRI analysis.

What Is Being Lost and Wasted?

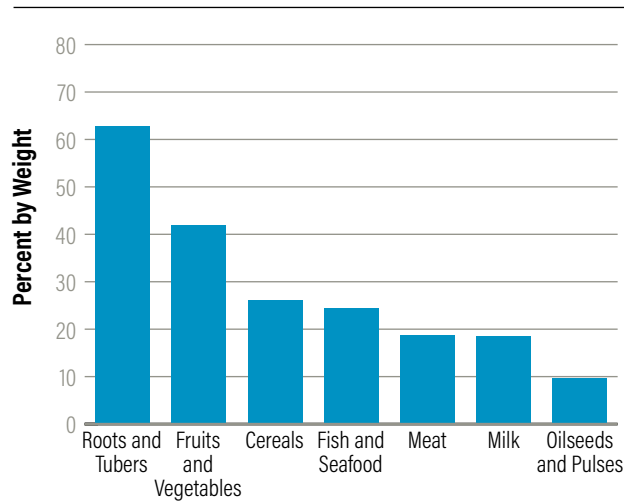
Once we recognize their uncertainties, what do the data in the 2011 FAO report appear to tell us about the nature, scale, and distribution of food loss and waste around the world?

By food category

Each major food group is subject to food loss and waste (Figure 1.3). According to the FAO (2011) data, roots and tubers (which include potatoes, sweet potatoes, cassava, yams, and other root-based foods) and fruits and vegetables experience the highest rates of loss and waste. When viewed as a proportion of the 1.3 billion metric tons estimated to be lost and wasted globally (Figure 1.4), fruits and vegetables are the commodity group that makes up the largest share of total annual food loss and waste. When analyzed in terms of caloric content, however, cereals (which include grains and bread) comprise the largest share. This variance results

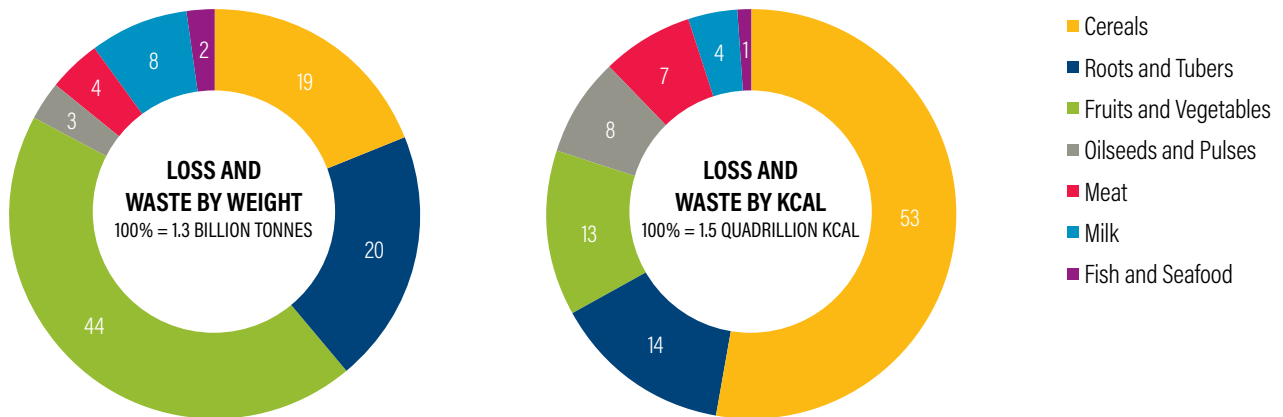
from differences in intrinsic water and caloric content. A significant share of the weight in fruits and vegetables is water, whereas cereals are drier and more energy-dense than fruits and vegetables.

Figure 1.3 | **Share of Food Group Lost or Wasted (2007)**



Source: WRI analysis based on FAO (2011).

Figure 1.4 | **Share of Global Food Loss and Waste by Commodity (2007)**

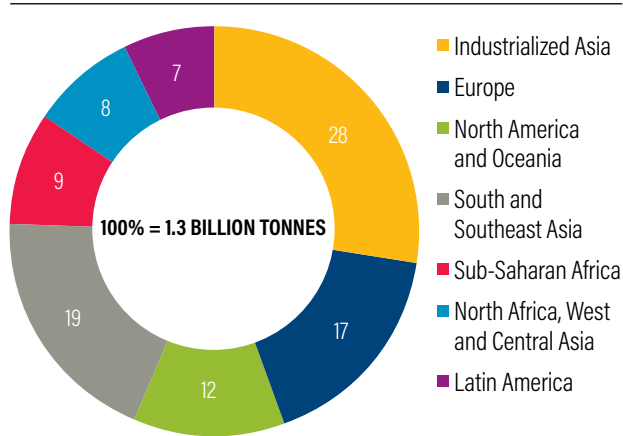


Source: WRI analysis based on FAO (2011).

By geography

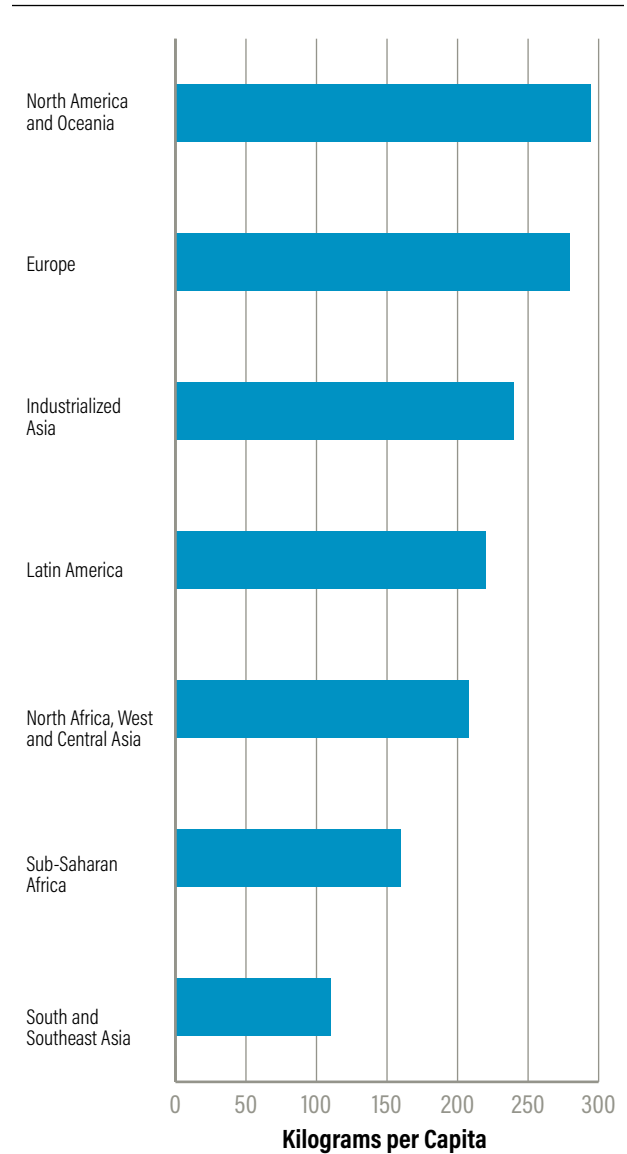
FAO (2011) estimated that just over half of total food loss and waste (by weight) occurs in the developed world—North America and Oceania,⁵ Europe, and the industrialized Asian nations of China, Japan, and South Korea. Low- and other middle-income countries account for 43 percent of the loss (Figure 1.5). On a per capita basis, North America, Oceania, and Europe stand out (Figure 1.6). South and Southeast Asia are responsible for the least amount of food loss and waste (by weight) on a per capita basis, although detailed data are missing at the consumption stage.

Figure 1.5 | **Share of Global Food Loss and Waste by Region (2007)**



Source: WRI analysis based on FAO (2011).

Figure 1.6 | **Per Capita Food Loss and Waste by Region (2007)**



Source: WRI analysis based on FAO (2011).

By stage in the food supply chain

As Table 1.1 describes, food loss and waste can occur at any stage of the food supply chain, albeit in different manners.

FAO (2011) estimated that globally, 30 percent of all food loss and waste (by weight) occurs during the production stage. Another 21 percent occurs

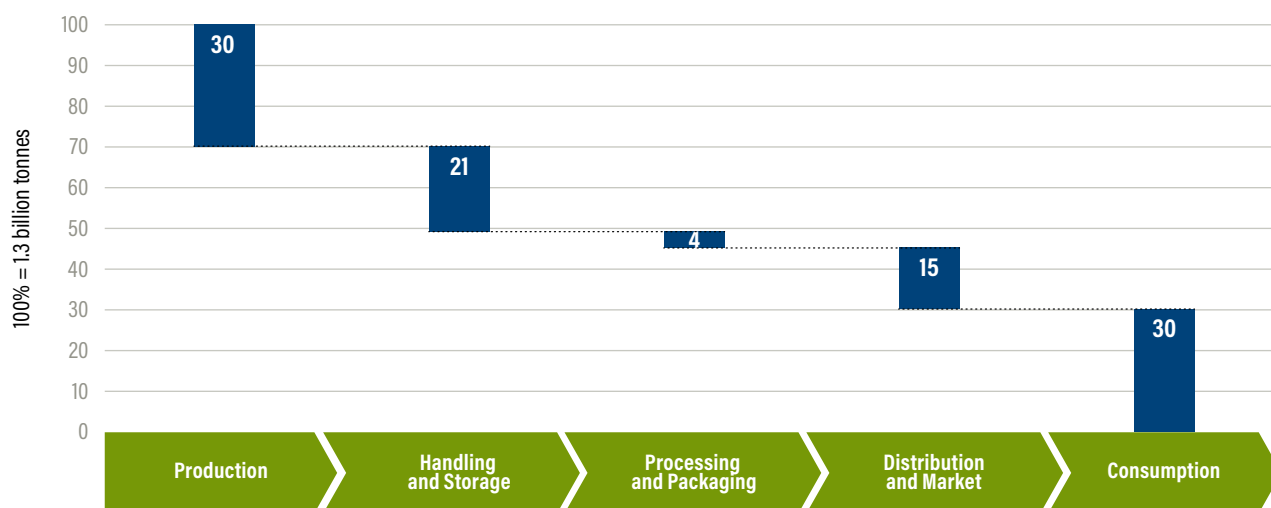
during handling and storage. Very little, 4 percent, occurs during processing and packaging. Around 15 percent occurs during distribution and market. A sizeable 30 percent occurs during consumption—at a restaurant, food service environment, or the home (Figure 1.7).

Table 1.1 | **Examples of Food Loss and Waste along the Food Supply Chain (Not Exhaustive)**

PRODUCTION	HANDLING AND STORAGE	PROCESSING AND PACKAGING	DISTRIBUTION AND MARKET	CONSUMPTION
<i>During or immediately after harvesting on the farm</i>	<i>After leaving the farm for handling, storage, and transportation</i>	<i>During industrial or domestic processing and/or packaging</i>	<i>During distribution to markets, including at wholesale and retail markets</i>	<i>In the home or business of the consumer, including restaurants and caterers</i>
<ul style="list-style-type: none"> Fruits discarded due to bruising during picking Crops sorted out post-harvest for not meeting cosmetic standards Crops left behind in fields due to poor mechanical harvesting or drops in prices Fish discarded during fishing operations 	<ul style="list-style-type: none"> Harvested food eaten by pests Harvested food degraded by fungus or disease Fish that are spilled or degraded after landing 	<ul style="list-style-type: none"> Milk spilled during pasteurization and processing Food sorted out as not suitable for processing Livestock trimming during slaughtering and industrial processing Fish spilled or damaged during canning or smoking 	<ul style="list-style-type: none"> Food sorted out due to quality Safe food disposed because of going past sell-by date before being purchased Food spilled or damaged in market 	<ul style="list-style-type: none"> Food sorted out due to quality Food purchased but not eaten Food cooked but not eaten

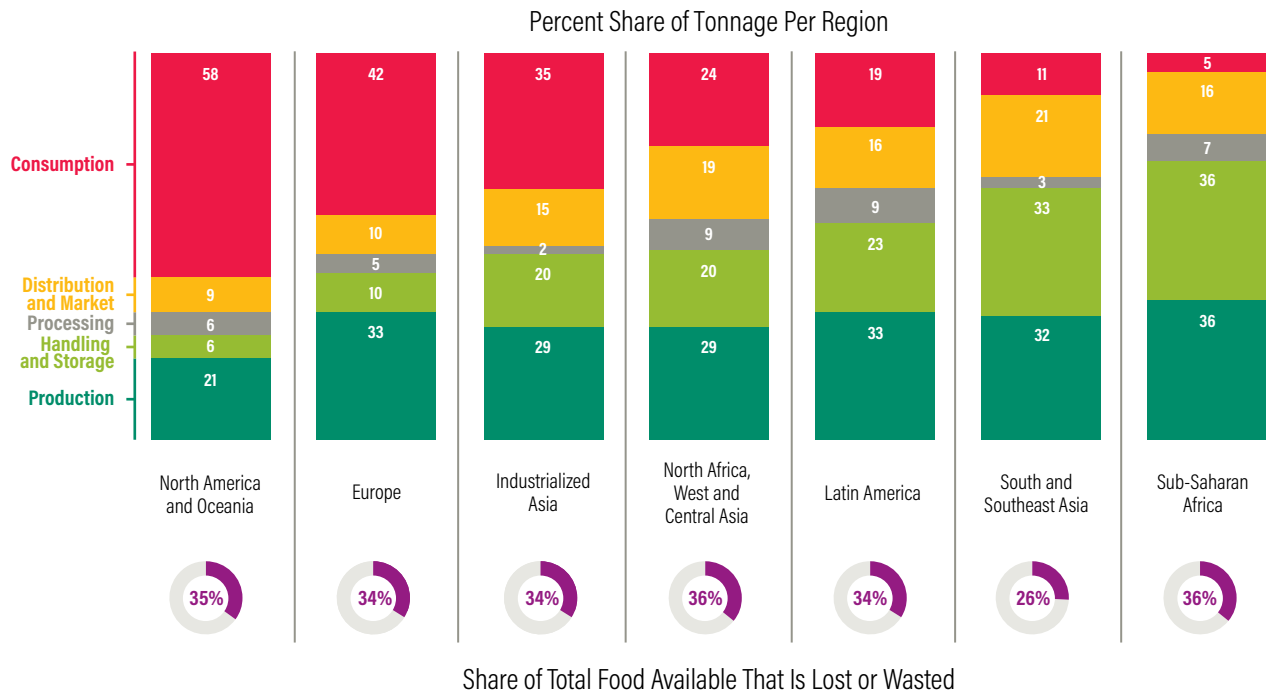
Source: WRI analysis based on FAO (2011).

Figure 1.7 | **Distribution of Total Global Food Loss and Waste across the Food Supply Chain (2007)**



Source: WRI analysis based on FAO (2011).

Figure 1.8 | Distribution of Food Loss and Waste by Region and Stage in the Food Supply Chain, 2007



Notes: Values displayed are of food loss and waste as a percent of food supply, defined here as the sum of the "Food" and "Processing" columns of the FAO Food Balance Sheet. Numbers may not sum to 100 due to rounding.
Source: WRI analysis based on FAO (2011).

The distribution of food loss and waste across the food supply chain, however, varies by region of the world and indicates possible “hotspots” (Figure 1.8). The two stages with the greatest variance between regions are consumption and the handling and storage stage. High-income regions appear to have a relatively high share of food loss and waste occurring at the consumption stage. In fact, there is a 10-fold difference in share of loss and waste at this stage between North America and sub-Saharan Africa. In contrast, low-income regions appear to have a higher share of loss and waste during the handling and storage stage, with a sixfold difference in share of food loss and waste at this stage between sub-Saharan Africa and North America. The share of food loss and waste that occurs at the start of the food supply chain, the production stage, is quite similar among regions, between 29 and 36 percent, with the exception of North America and Oceania. More recent studies also appear to confirm that losses during production are not restricted to low-income countries. In

Canada, for example, 24 percent of all food that is lost and wasted is lost during production, compared with 14 percent in the home (Gooch et al. 2019). Consumption, therefore, appears to be a hotspot in high-income regions, storage a hotspot in low-income regions, and production losses an issue just about everywhere.

By objective

In terms of selected objectives of food loss and waste reduction, several hotspots seem to exist (Figure 1.9).⁶

Tonnage (SDG Target and micronutrients):

When it comes to reducing the absolute tonnage of food loss and waste, FAO (2011) data suggest fruit and vegetable losses are a major hotspot, particularly close to the farm (i.e., production as well as handling and storage) throughout Asia and sub-Saharan Africa and close to the plate (i.e., market, consumption) in industrialized countries.

Roots and tubers stand out, too, during the production and storage stages in sub-Saharan Africa. Tonnage is important because the SDG 12.3 target metric⁷ is based on mass (per capita)—to meet the target, reductions in tonnage are needed. Moreover, tonnage arguably could be considered a proxy for loss of micronutrients,⁸ given that those food categories with high tonnage losses—fruits and vegetables as well as roots and tubers (see Figure 1.4)—tend to be those that are high in vitamins and minerals. Efforts to improve micronutrient availability might therefore consider prioritizing the tonnage hotspots of food loss and waste. Reducing the loss and waste of fruits and vegetables will become even more important over the coming decades if recommendations to increase dietary intake of fruits and vegetables for the sake of improving human health (Willett et al. 2019) are heeded. Otherwise the quest to improve health might lead to an increase in food loss and waste.

Calories: When it comes to reducing the loss of calories (an important macronutrient), the global data suggest that cereals are a hotspot. This makes intuitive sense given the relatively high energy density of grains and their derivative products like bread and pasta versus other food categories. High caloric loss and waste hotspots appear to be cereals in Europe (during consumption), industrialized Asia (during production and storage), North America (during consumption), and South and Southeast Asia (during production and storage). Roots and tubers close to the farm in sub-Saharan Africa also appear to be a hotspot of caloric losses.⁹

Climate: When it comes to reducing food-related greenhouse gas emissions, meat (in particular ruminant meat such as beef) has by far the highest greenhouse gas footprint per kilogram of food, followed by dairy (Ranganathan et al. 2016). This is because nearly 50 percent of direct agricultural production emissions are caused by ruminants (i.e., cattle, goats, sheep) via enteric fermentation (i.e., methane generated in their stomachs) and their manure (Figure 1.10). Additional emissions are associated with land-use change to create pastures for beef cattle and dairy cows. Among plant-based foods, rice has a high footprint, given the methane released from paddies. In fact, about 17 percent of all direct agricultural production

emissions come from growing rice (Searchinger et al. 2018). These hotspots of greenhouse gas emissions translate into being hotspots for emissions associated with food loss and waste (Figure 1.10). Therefore, it is not surprising that FAO’s categories of “meat” (which includes beef) and “cereals” (which includes rice) are the greenhouse gas hotspots of food loss and waste (Figure 1.9), even though meat and dairy constituted only an estimated 4 percent and 8 percent, respectively, of food loss and waste globally by tonnage.

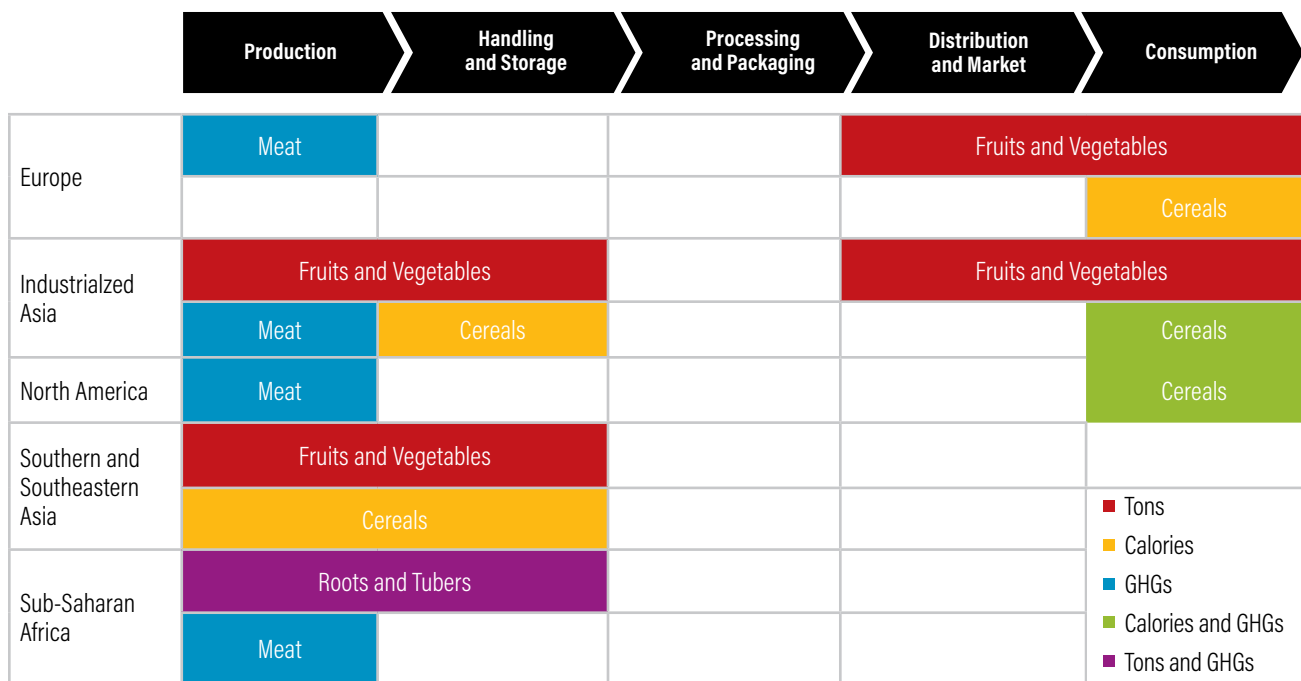
Some combinations of geography, stage in the supply chain, and food category hit more than one objective. In particular, cereals at the consumption stage in industrialized Asia and North America appear to be hotspots for both caloric losses and greenhouse gas emissions. Roots and tubers in sub-Saharan Africa appear to be a hotspot for both caloric losses and tonnage (and thus micronutrients as well).

When it comes to reducing inefficient use of water for agriculture, fruits and vegetables on average will be a hotspot given their water-intensity per metric ton. However, because the data used for Figure 1.9 come only at the near-continental scale, one cannot draw conclusions about water hotspots. For example, abundant extraction of water in one part of Latin America (e.g., a portion of Brazil) may not lead to water resource constraints since the agricultural region may have plenty of rainfall, whereas abundant extraction of water in another area of the continent (e.g., a portion of Chile) may lead to water resource constraints. More local data are needed. Whereas greenhouse gas emissions have local causes but global consequences, water extraction has local causes and local consequences.

What Do More Recent Data Suggest?

The quantifications above are primarily based on the 2011 FAO report. Recognizing its limitations, we looked at more subcontinental and commodity-specific studies conducted since then to identify to what degree they corroborate or deviate from the patterns first identified by FAO in 2011 on quantitative loss and waste.¹⁰ A wide but noncomprehensive review of published studies¹¹ suggests several insights:

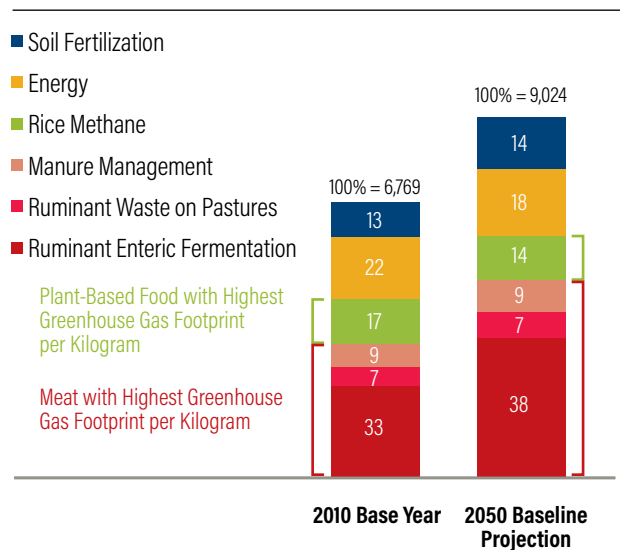
Figure 1.9 | Hotspots of Food Loss and Waste per Objective



Note: Not all regions had hotspots that crossed our threshold of scale.
 Source: WRI analysis based on FAO (2011).

■ **The numbers are wide ranging but “in the ballpark.”** Some of the more recent data sources indicate food loss and waste figures that are lower than those in FAO (2011) for similar combinations of food category, geography, and stage in the value chain. The share of total food produced that is lost during production in Europe is an example. Some studies indicate figures that are higher, such as cereal losses during processing in sub-Saharan Africa. Quite a few indicate figures where FAO (2011) is within the range of these other studies (Figure 1.11). But when taken as a whole, these more recent studies arguably indicate that the FAO (2011) figures are “in the ballpark.”

Figure 1.10 | Annual Agricultural Production Emissions (Percent), Million Metric Tons CO₂e



Note: The 2050 baseline projection contains a number of assumptions, which are listed in the source. Numbers may not sum to 100 due to rounding.
 Source: Searchinger et al.

Figure 1.11 | Results of Multiple Food Loss and Waste Quantification Studies since FAO (2011)



Note: Each letter represents a study that estimates food loss or waste at a particular stage of the supply chain. The same letter repeated represents different estimates contained within the same study. The list of studies cited in this chart can be found in Appendix B.
 Source: WRI analysis of various studies.

■ **Production is a hotspot.** A survey of more than 30 recent studies prepared since 2011 (the majority of which focus on country and commodity combinations from sub-Saharan Africa) found that losses during harvesting are a common point across crop commodities. Data from the African Postharvest Losses Information System (APHLIS), for instance, show that food loss for maize is concentrated at production (e.g., harvesting) and storage,

for rice at harvesting, and for sorghum at harvesting and handling (APHLIS 2016). A study by the International Food Policy Research Group (IFPRI) across several crops and five low- and middle-income countries found that the majority of food losses—between 59 and 86 percent—happen on the farm (the study included preharvest losses) (Delgado et al. 2017). Some recent studies indicate that high losses during the production stage may

not be restricted to low-income countries. In Australia's recently published national baseline, for instance, production was responsible for 31 percent of the country's total food loss and waste (Arcadis 2019). In the United Kingdom, a recent study found that around 1.6 million metric tons of food is wasted during production, which is more than the amount of food wasted in the hospitality and food service and retail sectors combined (WRAP 2019b). The drivers of on-farm losses likely differ, however, with lack of technologies and lack of appropriate harvesting techniques being drivers in low-income countries and lack of economically viable labor supplies or market demand being drivers in high-income countries.

- **Handling and storage is a hotspot.** Data sources beyond FAO (2011) indicate that storage is often a hotspot of food losses. For example, an assessment of 45 different crops over 100 regions of India found that poor storage was the hotspot of losses for cereals, pulses, oilseeds, fruits, vegetables, and poultry (Jha et al. 2015). In particular, the main driver of these storage losses was lack of cold chain infrastructure, including lack of low-cost cold storage facilities for villages. APHLIS indicates that, for nine cereal crops across eight countries in sub-Saharan Africa, handling and storage was the stage with the highest share of losses in 2016 (8 percent of total crop produced). This figure matches the FAO (2011) estimate of 8 percent for cereals in sub-Saharan Africa. While other meta-analyses affirm that grains and cereals suffer higher losses during handling and storage, they also show that fresh produce suffers higher losses during processing and packaging (Sheahan and Barrett 2017). It is therefore important to keep in mind the crop and local context when assessing the hotspots of loss.
- **Consumption is important, too.** Data about food waste during the consumption stage (e.g., at the home or restaurant, or in a food service environment) from high-income countries appear to confirm relatively high rates at this stage. For instance, Australia recently reported that 41 percent of the country's food loss and waste occurs at the consumption stage (Arcadis 2019). For the United Kingdom, of all food lost

and wasted from the farm gate to the home, 79 percent is wasted during the consumption stage (WRAP 2017a). Although FAO (2011) indicated much lower rates of food waste during consumption in low-income countries, that analysis relied upon very few, and in some regions zero, data points. Therefore, one cannot necessarily conclude that food waste at consumption is only a problem in high-income countries. It might be an issue in some low-income regions, or a growing one as these countries urbanize and develop. There is a risk that as countries develop, their overall rate of food loss and waste (as a share of total food produced) may stay the same but *where* the loss and waste occurs will shift from "close to the farm" to "close to the plate" (as Figure 1.8 would suggest). More quantification of food waste at the consumption stage is needed in these markets.

- **Big push on data needed.** Despite all these data points, there is still insufficient quantification of food loss and waste based on solid methods. Without more such data, it will be difficult to drive action and target interventions toward hotspots where the most food is lost and wasted. In late 2019, FAO will publish updated global and regional estimates of food loss. However, these numbers will not be comparable to the 2011 FAO estimates because the scopes (in terms of stages of the food supply chain and destinations of food loss and waste) are different.¹² Of the various studies currently available, many use different scopes, which makes results difficult to compare. Moreover, too few use direct measurement. A meta-analysis of postharvest loss studies from around the world from 2006 to 2017 found that the methods used to measure quantitative losses included surveys via interviews and questionnaires (41 percent) and mixed methods (37 percent), while only 7 percent were direct measurements alone (Kitinoja et al. 2018). Sheahan and Barrett (2017), likewise, found that only 20 percent of food loss and waste studies they evaluated used empirical field data. A big effort to quantify and make publicly available data on food loss and waste—per country, food category, private sector entity (and its supply chain)—is urgently needed.



CHAPTER 2

WHY DOES IT MATTER?

Reducing food loss and waste can generate a range of benefits for people and the planet. This chapter explores these benefits.

SUMMARY POINTS

- Food loss and waste matters in terms of the environment, economy, food security, jobs, and ethics, and reducing it helps address multiple Sustainable Development Goals (SDGs).
- In terms of the **environment**, food loss and waste is responsible for an estimated 8 percent of annual greenhouse gas emissions, consumes a quarter of all water used by agriculture each year, and requires agricultural area the size of China to grow food that ultimately is not eaten by people.
- In terms of the **economy**, at a global level, the annual market value of food that is lost and wasted is estimated to be an astounding \$940 billion.
- In terms of **food security**, more than 1 billion metric tons of food is lost and wasted per year in a world where one in nine people is still undernourished.
- In terms of **jobs**, reducing food loss and waste might play a modest role in job creation across the supply chain, ranging from jobs for smallholders in processing close to the farm to jobs in technology start-up companies.
- In terms of **ethics**, reducing food loss and waste is considered by many people as simply “the right thing to do.”
- In terms of the **SDGs**, reducing food loss and waste can help meet various globally agreed aspirations, including SDG 1 (no poverty), SDG 2 (zero hunger), SDG 12 (sustainable consumption and production), and SDG 13 (climate action), among others.
- The **benefits** of reducing food loss and waste can be significant. For instance, reducing the current rate of food loss and waste by 50 percent by 2050 would achieve the following goals:
 - Close the gap between food needed in 2050 and food available in 2010 by more than 20 percent.
 - Avoid the demand to convert an area of natural ecosystems roughly the size of Argentina into agricultural land between 2010 and 2050.
 - Lower greenhouse gas emissions by 1.5 gigatons of carbon dioxide equivalent (Gt CO₂e) per year by 2050, an amount more than the current energy- and industry-related emissions of Japan.

The huge scale of food loss and waste around the world matters because of its impact on the environment, economy, and food security. Likewise, addressing food loss and waste is important because of its potential to support jobs, meet a moral imperative for some, and contribute to achieving multiple Sustainable Development Goals (SDGs).

Environment

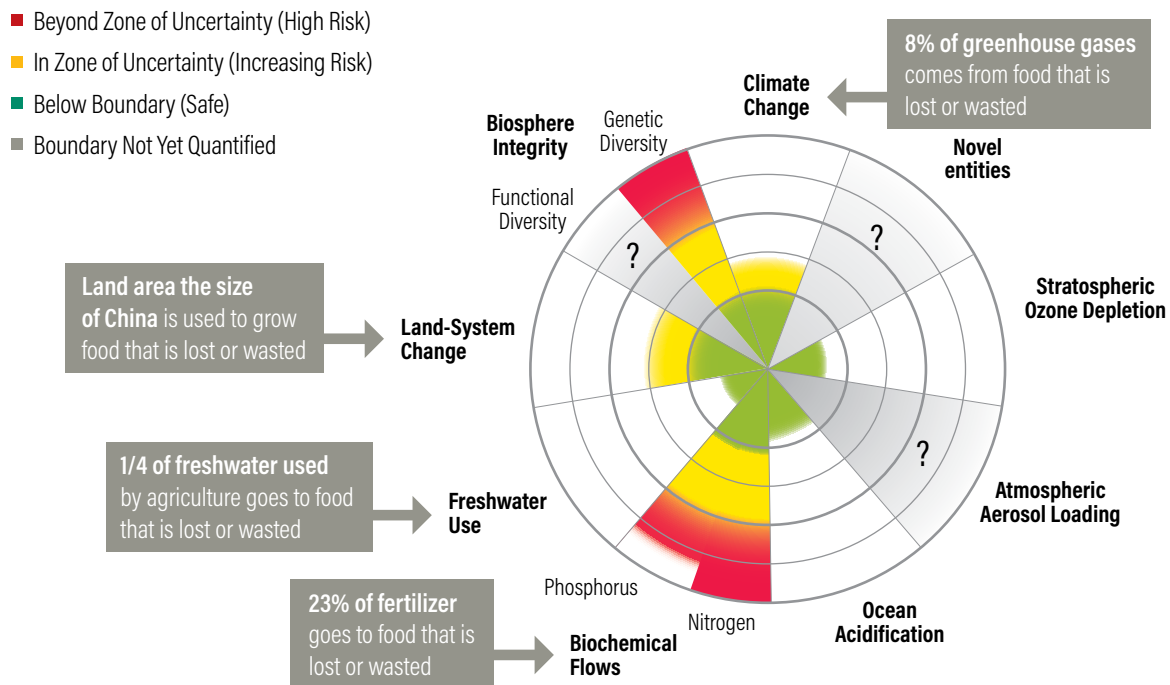
Food loss and waste has huge impacts on the environment, putting pressure on a number of planetary boundaries (Figure 2.1):

- It generates about 8 percent of global greenhouse gas emissions annually (FAO 2015a). This includes the carbon dioxide and nitrous oxide emissions arising from the land-use change, fertilizer applications, and energy use associated with growing food that is lost and wasted, as well as the methane emissions released when food decays in landfills and elsewhere. If food loss and waste were a country, it would be the third-largest emitter after China and the United States.

- It consumes about one-quarter of all water used by agriculture each year (Kummu et al. 2012). In water-stressed areas, this inefficient use can exacerbate the pressure (although in areas with an abundant supply of water, impacts of food loss and waste on water may hardly be felt).
- It requires land area the size of China to be grown (FAO 2013).
- It accounts for 23 percent of total global fertilizer use. This is an issue not only because fertilizers are an expense to farmers but also because fertilizers contain finite natural resources (e.g., phosphorous) and can have a negative impact on the environment (e.g., on water quality) (Kummu et al. 2012).

Reducing food loss and waste would lower these environmental impacts by essentially reducing the amount of food otherwise needed to be produced to adequately feed a growing human population. This means using fewer natural resources such as water and land, applying less fertilizer, and emitting

Figure 2.1 | **Where Food Loss and Waste Pushes against Planetary Boundaries**



Note: Novel entities are defined as new substances, new forms of existing substances, and modified life forms that have the potential for unwanted geophysical and/or biological effects. Functional and genetic diversity refers to all living species on Earth, not just those species used for food. Sources: Steffen et al. (2015); FAO (2015a, 2013); Kummu et al. (2012).

smaller amounts of greenhouse gases. Reducing food loss and waste can therefore support a number of environmental goals. For example, reducing food loss and waste can be an important—albeit currently underutilized—contributor to meeting the Paris Agreement on climate change. Just a dozen countries currently include the reduction of food loss and waste in their nationally determined contributions (Climate Watch 2019); more should do so. Reducing food loss and waste also can help countries conserve freshwater resources and lower water pollution caused by excess fertilizer runoff. The EAT-Lancet Commission (Willett et al. 2019) estimates that halving food loss and waste by 2050 could reduce freshwater use by about 13 percent.

Reducing current rates of food loss and waste by 50 percent also would have significant benefits for climate, land, and biodiversity. Relative to the 2050

business-as-usual scenario identified by WRI, the World Bank, UNEP, and others in *Creating a Sustainable Food Future* (Searchinger et al. 2018), such a halving would reduce greenhouse gas emissions by 1.5 Gt CO₂e per year by 2050.¹³ This amount is more than recent energy and industry emissions from Japan.¹⁴ Such a halving also would avoid the conversion of 278 million hectares of natural ecosystems into agricultural land between 2010 and 2050. This is an area roughly the size of Argentina.¹⁵ Since habitat conversion is the number one cause of biodiversity loss (Millennium Ecosystem Assessment 2005), halving food loss and waste can be a strategy for addressing the current biodiversity crisis. The EAT-Lancet Commission (Willett et al. 2019) estimates that doing so could reduce projected biodiversity losses by up to 33 percent relative to its business-as-usual scenario.

Economy

Food loss and waste has significant economic impacts. At a global level, the annual market value of food that is lost and wasted is estimated to be an astounding \$940 billion (FAO 2015a).¹⁶ National impacts have been calculated, too. In Mexico, for instance, food loss and waste is estimated to cost \$25 billion, or around 2.5 percent of the country's gross domestic product (GDP) (World Bank Mexico 2019). In India, one study estimated that food loss results in economic losses of \$15 billion, or around 6.2 percent of India's GDP for the agriculture sector for 2012–13 (Jha et al. 2015, in FAO 2017a). The economic costs of wasting food are also felt by households. An average family of four in the United States spends \$1,800 per year on food that is wasted (Gunders and Bloom 2017). In Canada, the annual cost of avoidable food waste amounts to just over CD\$1,700 per household (Gooch et al. 2019).

Similarly, businesses can lose money when food is wasted. For example, if a food manufacturer procures milk from dairies but some of that milk spoils or spills during processing, then the manufacturer will not earn a market return on that portion of its purchased raw milk. If the bakery in a supermarket bakes bread vastly in excess of demand and it remains unsold, then the retailer does not capture a financial return on the ingredients, energy, and staff time spent baking that bread (Hanson and Mitchell 2017). Data on economic impacts by sector are thin. One quantification, however, found that food wasted in the hospitality and food service sectors in the United Kingdom alone to be £2.5 billion per year (WRAP 2013). Because of these economic impacts, there can be a financial case for governments and companies to take steps to reduce their food loss and waste (Box 2.1). Interviews with store managers by Hanson and Mitchell (2017) suggest that some businesses believe such measures may bring both financial and more indirect benefits to their operations (Box 2.2).



BOX 2.1 | A FINANCIAL CASE FOR REDUCING FOOD LOSS AND WASTE

Since significant financial resources are used to grow, harvest, store, process, transport, market, and purchase food, it seems obvious that when food is lost and wasted, some entity (or several entities) along the food supply chain is losing out and not recouping a return on some investment it has made. One might therefore wonder why many businesses do not work to reduce their food loss and waste.

One reason is that the costs of food loss and waste are often hidden within operational budgets, are spread out along the supply chain between different actors, or are accepted as “the cost of doing business” (Hanson and Mitchell 2017). Another reason is that reducing food loss and waste often requires up-front expenditures. It takes money to conduct a food loss and waste inventory to identify where and how much food is being lost and wasted, to determine what actions to take, and to implement those actions. These costs can include expenditures on staff, consultants, new equipment, process redesigns, or other activities. Furthermore, measures to reduce food loss and waste may incur additional operational costs, such as changing packaging material, packaging foods into smaller portions, or increasing the frequency of ordering and of distribution transportation (Tromp et al. 2016). Another concern among some business managers may be that encouraging customers to waste less food may result in a decline in sales. Thus, some business managers may believe or conclude that the costs of taking action outweigh the benefits (Hanson and Mitchell 2017).

An emerging body of data indicates, however, possible financial benefits to farmers, companies, city governments, and national governments in reducing food loss

and waste. For example, an analysis of 1,200 sites of 700 food companies in 17 countries found that 99 percent of sites had a positive return on their investment in food loss and waste reduction efforts, and half of the sites yielded at least a \$14 return for every \$1 invested (Hanson and Mitchell 2017). Companies included in this analysis represented a range of sectors across the food value chain, including food manufacturing, retail, hospitality, and food service.

There also is some evidence that national and city governments can save money through reducing food loss and waste. In 2007, for example, the UK government launched a nationwide initiative to reduce household food waste, a cornerstone of which was the “Love Food, Hate Waste” awareness-raising and behavior change campaign run by the Waste & Resources Action Programme (WRAP). By 2012—just five years later—it had achieved a 21 percent reduction in household food waste relative to 2007 levels, although reductions leveled off after 2012 (WRAP 2012).¹⁷ Over the five-year period, the total cost of implementing initiative-related activities was £26 million, while the total financial benefits to the government and citizens attributable to the initiative was £6.6 billion. The resulting benefit-cost ratio was 250 to 1, a very substantial return on the investment made (Hanson and Mitchell 2017).

WRAP also implemented a variety of measures, similar to those used nationally, in six boroughs in London in 2012 over the course of six months. Activities included awareness-raising, outreach to residents, and practical tips on food management. These initiatives resulted in a 15 percent decrease in household food waste (Quested and Ingle 2013). The total cost of

implementing these activities was £168,500. The resulting financial benefits were £1.3 million for the city government from avoided waste disposal costs and £14.2 million in prevented food purchase costs for local residents, bringing the total financial benefits to the city and its residents to £15.5 million. This means that for every £1 the city government invested, it saved £8. When including the benefits to households, every £1 invested by the government generated £92 in benefit to the city and the residents of participating boroughs (Hanson and Mitchell 2017).¹⁸

Looking further upstream, analyses are indicating some financial returns of investing in technologies and practices to reduce food losses near the farm. For instance, one study in Kenya found that farmers who used metal silos to prevent grain losses saved an average of 150–200 kg of grain, worth approximately US\$130 (Gitonga et al. 2013). Adopters of metal silos also spent less on insecticides and were able to store maize for an average of nine weeks longer than nonadopters, meaning they were able to sell their surplus maize when prices were higher as opposed to selling directly after harvest, when prices tend to be low (Gitonga et al. 2013). In West and Central Africa, hermetic storage bags generated a 29 percent internal rate of return over a five-year period (Sonka et al. 2015). A modeling study in Nigeria concluded that scaling use of plastic crates to protect tomatoes during transportation could result in a 36 percent reduction in tomato losses. The investment would have a four-month payback period and an internal rate of return of 34 percent after three years (Gromko and Abdurasalova 2018).

BOX 2.2 | FOOD RETAILER AND MANUFACTURER MOTIVATIONS FOR PARTICIPATING IN FOOD WASTE REDUCTION PROGRAMS

Some food manufacturers and businesses may be concerned that helping customers reduce their food waste may result in customers buying less food overall, which could result in less food sales and falling revenues. If so, then why do food retailers and manufacturers participate in food loss and waste reduction programs?

First, according to interviews, store managers indicated that such programs help them extend product shelf life (for instance, through improved packaging) and reduce product losses, both in stores and along their supply chains, which results in financial benefits to the stores.

Second, an econometric study indicated that a reduction in food sales at UK retailers during a 2007–12 study period did not necessarily translate into a one-to-one reduction in revenue. Rather, consumers plowed approximately 50 percent of their savings back into retail purchases, often on higher-value food items (referred to as “trading up”) or on other nonfood items (WRAP 2014).

Third, interviewees cited several nonfinancial benefits to engaging in food waste reduction programs. These included increasing employee pride, fulfilling a sense of ethical responsibility, and strengthening customer relationships. Hegnholt et al. (2018) noted that companies that are effective at addressing societal challenges tend to be rewarded with customer loyalty. Likewise, donating surplus food to charities can strengthen a company’s brand, public reputation, and employees’ pride in where they work.

Source: Hanson and Mitchell (2017).

Food Security and Nutrition

Food loss and waste is important in relation to food security and nutrition. More than 820 million people are undernourished today (FAO et al. 2018), yet more than 1 billion metric tons of food intended for human consumption never gets consumed (FAO 2017b). Of course, not all of the food that is lost or wasted would likely reach those in need. For instance, it would be difficult and expensive to transport perishable surplus food sufficiently in time or across long distances—such as from a wasteful consumer in a high-income country to a hungry person in a faraway low-income country. How reduced food loss and waste might translate into improved food security is complex. That said, reductions can help increase the amount of food that remains available for human consumption, meaning that more people could be fed from a given level of agricultural output.

At the global level, one modeling study (Searchinger et al. 2018) found that reducing the rate of food loss and waste by 50 percent by 2050 would close the gap between food available in 2010 and that needed in 2050 by more than 20 percent. This is a substantial amount. Curtailing food loss and waste also would have long-term benefits for global food security by relieving pressure on the natural resources on which future food production ultimately depends (HLPE 2014).

At a local level, reducing food loss and waste can improve the local availability of food. For example, improving storage facilities can reduce food losses and increase the amount of food available for farmers to consume or to sell at market. For instance, one study found that the use of hermetic storage technologies for grains in two regions in Tanzania led to a 33 percent reduction in the number of food-insecure households during the lean season, and that hunger levels dropped by one-third immediately after farmers began using the improved storage technologies (WFP 2019). Reducing food losses on the farm and during handling and storage also can increase incomes, which could be used by farmers to support paying for family needs such as food, education, and health care (HLPE 2014). In India, interventions that provided precooling and cold storage facilities to banana growers reduced losses by 20 percent and resulted in farmers receiving three times higher

value for their produce (Danfoss 2019). In high-income countries and urban areas, redistributing surplus food from restaurants and retailers to food banks can support those in need. It is important to note, however, that redistributing surplus food provides little incentive to change the practices that often lead to the generation of surplus food, or to improve long-term food access for households and communities (Box 2.3).

The link between food loss and waste, on the one hand, and food security, on the other, is about not only hunger but also food safety. Human health can be impacted when food contamination and spoilage go undetected. For example, aflatoxin—a toxin produced by certain fungi that are found on crops such as maize—is one of the most naturally occurring carcinogenic substances found and can lead to slow-developing esophageal and liver cancers (WFP 2019). Aflatoxin poisoning can occur when people consume poorly stored crops. One study estimated that 4.5 billion people in low-income countries are at risk of exposure to aflatoxins (Villers 2014). The World Bank estimates that unsafe food costs low-income countries around \$110 billion each year due to medical expenses and losses in productivity—costs that could be reduced by improving the handling of food across the supply chain (Jaffee et al. 2018). The risk of contamination increases significantly when farmers dry their crops on the ground. Implementing practices such as drying crops on tarps instead is a low-cost approach to reducing this risk, and reduces food losses (WFP 2019).

One aspect of food security that warrants more attention is the impact of food loss and waste on nutrition (HLPE 2014). Food loss and waste is often measured in weight and therefore does not account for the nutritional content of different foods. Foods such as fish and seafood, for instance, represent a small portion of food loss and waste by weight but provide essential protein and micronutrients for the hundreds of millions of people for whom seafood is the primary source of protein. Furthermore, nutritious foods such as fruits, vegetables, and dairy products are highly perishable—unless suitably preserved or processed—and thus are disproportionately vulnerable to food loss and waste.

BOX 2.3 | REDISTRIBUTION OF SURPLUS FOOD AND FOOD SECURITY

Donating surplus food to charity—instead of disposing of it—can help people in need. For instance, a study by the Natural Resources Defense Council in Nashville, Denver, and New York City found that the surplus food from the grocery, retail, restaurant, and food service sectors in these three cities could provide an additional 68 million meals annually to those in need. The study found that food donation at this scale could enable Denver and Nashville to meet an additional 46 and 48 percent, respectively, of their meals gap (Berkenkamp and Phillips 2017).

Redistribution of surplus food presents a way to feed people and use food that would otherwise be wasted. However, although redistribution represents a short-term solution to hunger, it does not address hunger's root causes or provide a long-term solution to food insecurity. Likewise, redistribution does not encourage a shift in practices that led to the surplus in the first place.

Research suggests that significant amounts of nutrients are lost when such food is lost or wasted. One study in the United States found that food wasted at the retail and consumption stages on an average day in 2012 contained the recommended daily allowance of dietary fiber for 74 million adult women (Spiker et al. 2017). In the United Kingdom, the typical food waste created by one person in one year could provide the nutrients and energy required for six weeks of the year for the average adult woman (Cooper et al. 2018). The Global Panel on Agriculture and Food Systems for Nutrition (2018) reports that if rates of food loss and waste increase by around one-third by 2030 (due to rising incomes, urbanization, and failure to take decisive steps to reduce food loss and waste), significant nutrient “disappearance” would occur. In particular, as a percentage of nutrients available, between 18 percent and 41 percent of vitamins and minerals such as vitamin A, folate, calcium, and iron would no longer be available for human consumption (Global Panel 2018).

Reducing food loss and waste therefore can be a lever in creating a more nutrition-sensitive food system and can increase the availability of nutrients essential for a healthy life. For example, in the Kano region of Nigeria, where 42 percent of children are vitamin A deficient, a 35 percent reduction in postharvest loss of tomatoes would result in additional availability of Vitamin A for up to 1.1 million Nigerian children per day (GAIN Health n.d.).

Jobs

Reducing food loss and waste might play a modest role in creating jobs. For example, ReFED's *Roadmap to Reduce U.S. Food Waste* (ReFED 2016) estimates that, if the roadmap's 27 solutions were implemented, an additional 15,000 jobs would be created and sustained in the United States. The majority of these jobs would be created in the recycling sector, due to opening of more composting and anaerobic digestion facilities to process increased amounts of food scraps. The donation and storage sector, which includes food recovery organizations, has the next highest potential to create jobs, followed by food donation transportation. Australia's Fight Food Waste Cooperative Research Centre estimates that reducing food waste in Australia by 30 million metric tons could directly and indirectly generate up to 5,200 jobs, mostly in rural areas (Fight Food Waste CRC 2018).

Start-up companies that tackle food loss and waste upstream in the food supply chain can be a source of job creation, too. For example, Protix, a company that uses food waste to feed insects, which in turn are processed into high-value protein for animal

feed, now operates in 12 countries and expects to employ over 100 people by the end of 2019 (Protix 2019).

Evidence is also emerging from low-income countries. For example, qualitative data from The Rockefeller Foundation's YieldWise Initiative found that a number of individuals employed by nongovernmental organization (NGO) implementers have successfully transitioned into working for companies that provide technologies and technical assistance to the smallholder farmers they previously trained and advised (Rockefeller Foundation 2019). As well as creating jobs, activities that reduce food loss and waste can also add value to food products along the value chain, which can create additional income for workers. For example, Psaltry, a cassava processing company based in Nigeria, provides locally sourced cassava products and starch for the industrial sector to create products as diverse as confectionary and building materials. The company reduces postharvest losses by strategically placing its processing facility, which employs over 300 people, close to smallholder farms. The company sources material directly from smallholder farmers, encouraging farmers to commercialize their cassava production and earning farmers additional income (Psaltry 2019).

That said, the impact of reducing food loss and waste on the net number of jobs is an under-researched area. Data on job creation often does not consider how many jobs may be lost if food loss and waste were reduced. For example, if on-farm losses are substantially reduced through



mechanization, less labor may be needed. More quantitative research is needed on the relationship between the reduction of food loss and waste, on the one hand, and job creation, on the other.

Ethics

For many people, food loss and waste matters because it is an ethical or moral issue. Some people were raised by their parents to “eat everything on your plate because there are people in the world who are starving.” The fact that so much food is lost or wasted while so many people are undernourished is considered by many to be an ethical travesty. It is only in relatively recent human history that significant numbers of people have been able to afford to waste food. This may go some way to explaining why, in a number of high-income countries, senior citizens waste significantly less food than other age groups (Quested et al. 2013). In a number of countries—such as Bangladesh, Ethiopia, India, and Pakistan—the cultural memory of when food was scarce is still quite strong (Gjerris and Gaiani 2014).

The importance of not wasting food is also hinted at by several of the world’s major religions. The Qur’an states this most explicitly: “Do not waste. He does not love the wasteful” (Qur’an 6:141). The Bible also contains a few references to food waste. For example, after the Feeding of the 5,000, Jesus told his disciples, “Collect the pieces that are left over so that nothing is wasted” (John 6:12). The importance of preventing food waste has also been expressed in ethical terms by Pope Francis, whose *Laudato Si’*, an encyclical on the environment,

states that “whenever food is thrown out it is as if it were stolen from the table of the poor” (Francis 2015). Judaism condemns wastefulness in principles such as *bal tashchit* (“Do not destroy”), which essentially prohibits any wasteful negative effects on the natural environment. At many Buddhist retreats, Buddhists follow the practice of eating meals “orioki” style, taking “just enough” food. Hinduism teaches that no one should be hungry and that people should help those who are hungry; Mahatma Gandhi once said that “God comes to the poor in the form of food” (Food Waste Weekend 2018).

Ethical considerations regarding food loss and waste appear to resonate with the business community as well. Interviews with business leaders found that reducing food loss and waste is often framed in ethical terms, and that reducing food loss and waste is simply “the right thing to do” (Hanson and Mitchell 2017). Tesco’s CEO, Dave Lewis, illustrated this point in a speech to The Consumer Goods Forum in mid-2016: “Why wouldn’t we want to have a look at this [reducing food loss and waste]? We can look at it through commercial sensibility, because waste ultimately has to be paid for, so if we eradicate it we can lower our costs. We might even be able to improve the margins if that’s the thing that really drives us. But there’s also a bigger goal which is how we might make a contribution to that massive inequality that exists already in terms of those who have food and those that don’t. Both of them, I think, are enough for us as an industry to motivate ourselves, engage ourselves, and innovate against this need” (Lewis 2016).



SDGs

Food loss and waste is an important issue for the Sustainable Development Goals (SDGs) (Figure 2.2). In September 2015, countries of the world formally adopted a set of 17 SDGs as part of the 2030 Agenda for Sustainable Development—global goals to end poverty and hunger, protect the planet, and ensure prosperity for all populations and generations (UN 2017). Most directly, reducing food loss and increasing waste reduction can help achieve SDG 12, which seeks to “ensure sustainable consumption and production patterns.” The third target under this goal, Target 12.3, calls for halving “per capita global food waste at the retail and

consumer levels and reduc[ing] food losses along production and supply chains, including post-harvest losses,” by 2030 (UN 2017).

Reducing food loss and waste can help meet other goals, too, albeit sometimes in a more indirect manner. For instance, reducing on-farm food losses can improve incomes for farmers and thereby tackle poverty (SDGs 1 and 8). Diverting to those in need food that otherwise would have been wasted can help address hunger (SDG 2). Reducing food waste going to landfills can help cities become more sustainable (SDG 11). Reducing food loss and waste can help address climate goals by reducing emissions from landfills and all the emissions

Figure 2.2 | Reducing Food Loss and Waste Can Help Achieve Multiple SDGs (Not Exhaustive)



Source: WRI analysis.

associated with clearing land and growing food that is ultimately not consumed (SDG 13). Moreover, reducing food loss and waste can play a role in protecting biodiversity by reducing pressure to convert natural land-based ecosystems into farmland (SDG 15) and by reducing bycatch (SDG 14).

In short, reducing food loss and waste is one of a handful of strategies that can hit numerous SDGs at the same time. As such, it should be considered a “no regrets” move for farmers, consumers, businesses, and governments.





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CHAPTER 3

WHAT IS CAUSING IT?

Understanding the causes of food loss and waste is a prerequisite for identifying appropriate solutions. This chapter identifies the direct causes and underlying drivers of food loss and waste.

SUMMARY POINTS

- Understanding why food loss and waste occurs (whether intentionally or not) is important to successfully reducing it.
- The most immediate reasons food leaves the human food supply chain (the “direct causes”) tie back to concern about a food’s safety or suitability for consumption, or there being no perceived use or market for it. This may be due to deterioration or suboptimal quality, or issues such as the food’s appearance, excess supply, and seasonal production fluctuations.
- Leading to these direct causes are a number of “underlying drivers.” These can be categorized as technological, managerial, behavioral, or structural. The technological drivers are poor infrastructure, inadequate equipment, and suboptimal packaging. The managerial drivers are inadequate food management practices, skills, or knowledge; inflexible procurement practices; poor supply and demand forecasting and planning; and marketing strategies. The behavioral drivers are norms and attitudes, lack of awareness, and concerns about possible risks. The structural drivers are conditions in demographics, climate, policies and regulations, economics, and financing that lead to food loss and waste. These 15 underlying drivers need to be addressed for food loss and waste to be reduced.
- The underlying drivers of food loss and waste are closely interrelated. An instance of food loss and waste often has more than one driver (e.g., rice losses may occur due to inadequate storage bags, which, in turn, may be caused by a grower’s lack of access to credit to purchase better bags). Moreover, while an underlying driver may occur during one stage of the food supply chain, the generation of loss and waste might actually occur at a different stage. For instance, orders modified last-minute by food retailers at the distribution and market stage of the food supply chain can result in fruits and vegetables being left in the farm field, leading to losses during the production stage.
- Among the various drivers, some are more relevant in certain regions. For example, lack of infrastructure is typically a more significant driver in low-income countries, whereas social norms and attitudes such as the acceptability of not eating all the food on one’s plate are often a driver in high-income countries. Reducing food losses close to the farm (during production as well as handling and storage) can be a result of “good economic development.” But as economies develop and underlying drivers shift, food loss may give way to food waste closer to the plate.

Food leaves the human food supply chain—intentionally and unintentionally—as a result of a range of interrelated factors. Understanding these factors, and identifying which are relevant per circumstance, is important if public and private sector actors are to successfully prevent and reduce food loss and waste.

Direct Causes

The most immediate reasons food leaves the human food supply chain relate to concerns about a food’s safety or suitability for consumption, or to there being no perceived use or market. There are four primary “direct causes”:

- **Deterioration.** The food item’s quality has been compromised. For example, it may be bruised, spoiled, spilled, diseased, eaten by pests, or cooked improperly.
- **Suboptimal quality.** The food item is below desired quality in terms of taste, nutritional content, or other salient feature. This may also include parts considered “trim” or inedible in the particular cultural context, such as bones and rinds, or because the food is not at the ideal stage of maturity (either immature or too ripe) for consumption or for the intended market.
- **Appearance.** The food item has cosmetic defects, such as blemishes, scars, or scratches, which affect its perceived value. Or the food item has attributes that are not accepted by the market such as undesirable size, shape, weight, color, or mislabeled packaging.
- **Lack of a buyer/user.** This includes too much of a food product grown relative to current market demand, inadequate access to markets, inability to get food to market, non-targeted animal or seafood species caught, too much food prepared, and food left on the plate.

Direct causes can occur at any stage of the food supply chain. For example, a farmer may leave potatoes in the field that were damaged during harvesting (i.e., deterioration) or that are too small to meet the buyer’s specifications (i.e., appearance). A food processor may discard chicken that fell on the floor (i.e., deterioration), or it may have surplus chicken without an identified use when a customer

cancels its order (i.e., lack of a buyer). An individual may discard a perishable product that is past its date label (i.e., suboptimal quality), or dispose of uneaten food on the plate after a meal (i.e., lack of a user).

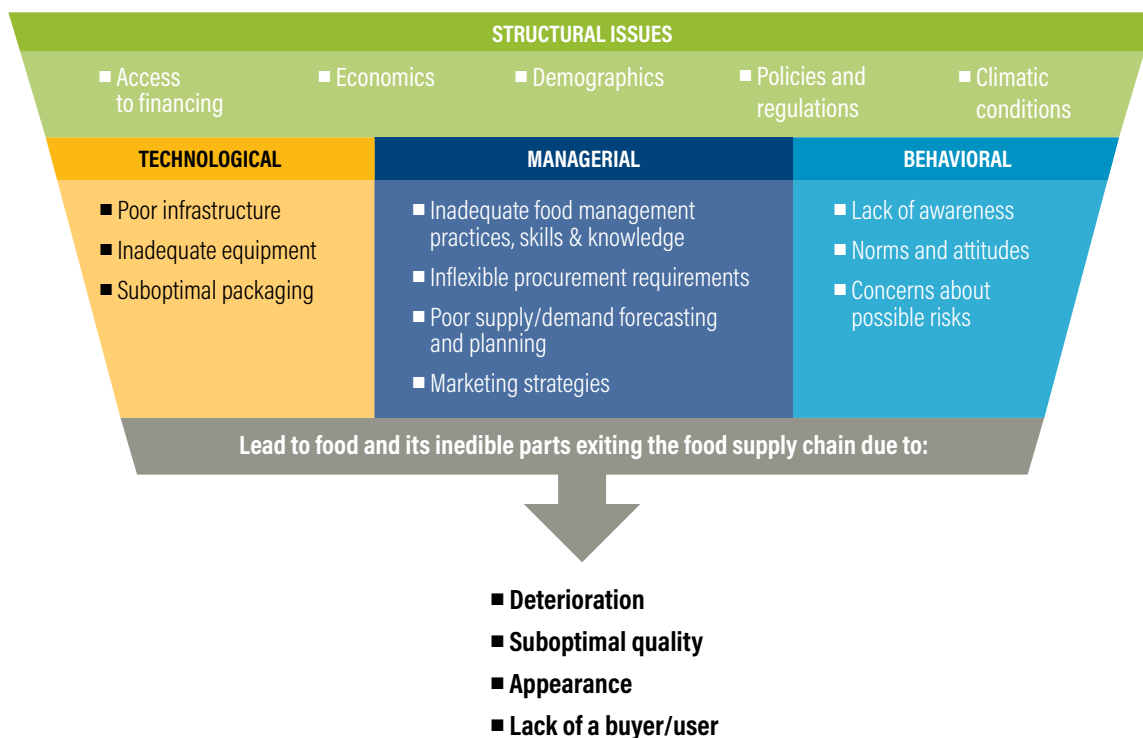
Underlying Drivers

Developing strategies to prevent and reduce food loss and waste, however, needs to be informed by more than an awareness that a food product is declining in either quality or value. One needs to understand what underpins such declines. We call these the “underlying drivers” of food loss and waste. In other words, the underlying drivers are those factors that give rise to the direct causes. It is these underlying drivers that food loss and waste reduction strategies need to address. One does not develop a strategy to tackle the deterioration of food per se. Rather, one develops a strategy to tackle what is causing that deterioration.

While diverse and interrelated, underlying drivers fall into four generic categories. First are those that are considered technological, including physical infrastructure such as roads and processing facilities, as well as equipment and packaging. Second are those related to management approaches, including skills and knowledge (or lack thereof). Third are those related to social dynamics and individual attitudes. Fourth are those that are more structural in nature, related to the demographic, climatic, economic, and policy context of the food system. Across these four categories, there are at least 15 kinds of specific underlying drivers (Figure 3.1).¹⁹

Table 3.1 defines these underlying drivers and highlights at which stage of the food supply chain food loss and waste can occur due to that driver. This table is a new framing and synthesis of the reasons for food loss and waste, building upon a number of previous studies that also categorized the causes and drivers of food loss and waste.²⁰

Figure 3.1 | **Why Food Is Lost or Wasted Is Due to Multiple Underlying Drivers**



Source: WRI analysis.

Table 3.1 | **Underlying Drivers of Food Loss and Waste and Where in the Supply Chain Loss and Waste Occurs (Not Exhaustive)**

CATEGORY	UNDERLYING DRIVER	DESCRIPTION
Technological	Poor infrastructure	Lack of or poor-quality infrastructure (public or private) along the food supply chain. Public infrastructure includes reliable power supplies, reliable communication, usable roads, and access to markets. Private infrastructure includes storage facilities, cold chains, processing facilities, and distribution- or market-related logistics (e.g., handling facilities).
	Inadequate equipment	Lack of or suboptimal equipment along the food supply chain. This includes equipment used during harvesting (e.g., combines), storage (e.g., bags), distribution (e.g., pallet jacks), merchandising (e.g., displays), and food preparation (e.g., stoves, refrigeration).
	Suboptimal packaging	Suboptimal pack sizes, and insufficient packaging to protect products after harvest from deterioration and damage.
Managerial	Inadequate food management practices, skills, and knowledge	Lack of or inadequate management practices or use of equipment due to a lack of knowledge, skills, or incentives. Among producers, this could include poor use of mechanical harvesters, improper use of fishing gear, and inadequate animal care practices. Among households this includes a lack of knowledge about planning and preparing meals, as well as how to assess product freshness and interpret date labels.
	Inflexible procurement requirements	Contractual practices (e.g., last-minute order changes, take-back clauses) or quality and cosmetic standards (e.g., undesired attributes) that result in food leaving the supply chain. While some procurement requirements may reduce the amount of unusable food that is sent further down the supply chain, other requirements may result in nutritious, edible food exiting the human food supply chain.
	Poor supply and demand forecasting and planning	Poor forecasting and information flow between buyer and supplier. At the farm, this includes suboptimal crop scheduling and forecasting. In the middle of the supply chain, this includes suboptimal inventory management. At the consumption stage, this includes buying and preparing more food than will be consumed.
	Marketing strategies	Promotions, merchandising displays, or other marketing strategies that increase the likelihood of product damage, surplus, or overpurchasing by consumers.
Behavioral	Norms and attitudes	Norms and attitudes that influence food production and consumption behaviors and cause products to be removed from the food chain at any stage. These include what types of foods are considered appealing (e.g., whether certain parts of an animal are typically eaten), the preferred appearance of products (e.g., no blemishes), showing off "abundance" to indicate wealth or hospitality, attitudes about food generally (e.g., dislike of leftovers, desire for variety, preference for "fresh"), and social values that accept resource waste and its impacts.
	Lack of awareness	Lack of awareness that food loss and waste happens and has an impact, and how one contributes to the problem. Farmers, business managers, and consumers often do not think they lose or waste food, but measurement suggests otherwise. Lack of awareness also can include a limited understanding of how reducing food loss and waste can provide direct (personal or business) benefits (e.g., enhanced product freshness, reduced costs).
	Concerns about possible risks	Actual or perceived risks related to food safety (including food labeling), reputation, and liability. This includes concerns about safe food consumption, or fear about liability linked to food donation.

Table 3.1 | **Underlying Drivers of Food Loss and Waste and Where in the Supply Chain Loss and Waste Occurs (Not Exhaustive), continued**

CATEGORY	UNDERLYING DRIVER	FOOD SUPPLY CHAIN STAGES				
		PRODUCTION	HANDLING AND STORAGE	PROCESSING AND PACKAGING	DISTRIBUTION AND MARKET	CONSUMPTION
Technological	Poor infrastructure	X	X	X	X	X
	Inadequate equipment	X	X	X	X	X
	Suboptimal packaging		X	X	X	X
Managerial	Inadequate food management practices, skills, and knowledge	X	X	X	X	X
	Inflexible procurement requirements	X	X	X	X	
	Poor supply and demand forecasting and planning	X	X	X	X	X
	Marketing strategies			X	X	X
Behavioral	Norms and attitudes	X	X	X	X	X
	Lack of awareness	X	X	X	X	X
	Concerns about possible risks	X	X	X	X	X

Table 3.1 | **Underlying Drivers of Food Loss and Waste and Where in the Supply Chain Loss and Waste Occurs (Not Exhaustive), continued**

CATEGORY	UNDERLYING DRIVER	DESCRIPTION
Structural	Demographics	Household size, urbanization, and growth in the middle class (which is linked to higher disposable income) impact food production and consumption. This includes reduced availability of labor to harvest food in the production stage, which can increase food losses. The rise of the middle class can change how people acquire, eat, and manage food (e.g., portion sizes, shopping habits, preference for "fresh"), which can increase the likelihood of food waste.
	Climatic conditions	Weather (e.g., rain, snow, ice, wind, cold, heat) and impacts from a changing climate affect growing conditions, which can result in damage to crops or surplus product. These conditions also affect other factors such as the degree of damage by pests and diseases, and the ability to get a product to market (e.g., disruptions in transportation networks).
	Policies and regulations	Policies and regulations may be barriers, be poorly coordinated, or be absent, resulting in food leaving the food supply chain. Policy barriers may relate to food safety, food quality, labeling, packaging, trade and customs, tax incentives, agricultural extension services, and use of unsold food for animal feed or energy.
	Economics	Costs of avoiding or reducing food loss and waste are (or are perceived to be) high in comparison to the benefits that would be obtained. Growers, especially smallholders, may not invest in loss reduction practices or technologies due to poverty. Growers may harvest crops prematurely (increasing the risk of food losses) because they need cash or because market prices are currently high. Conversely, growers may not harvest crops where the cost to do so exceeds the market price, and if alternative markets for second-grade products are not profitable. A food processor may accept food loss and waste as the "cost of doing business" or because disposal costs are low. In many countries, food comprises only a small share of household expenditures, lowering the cost of waste and the perceived value of conserving food.
	Access to Financing	Inability to access sufficient financing (e.g., investment, loans, grants) to purchase, implement, or scale technologies, capacity-building programs, and/or enterprises that would reduce food loss and waste.

Sources: WRI analysis based on Canali et al. (2014); CEC (2017, 2018, 2019); Clowes et al. (2018a, 2018b, 2019); Food Loss and Waste Protocol (2016); Global Knowledge Initiative (2017); Gunders and Bloom (2017); Hegnholt et al. (2018); HLPE (2014); ReFED (2016); Gooch et al. (2019); and WWF-US (2018).

Table 3.1 | **Underlying Drivers of Food Loss and Waste and Where in the Supply Chain Loss and Waste Occurs (Not Exhaustive), continued**

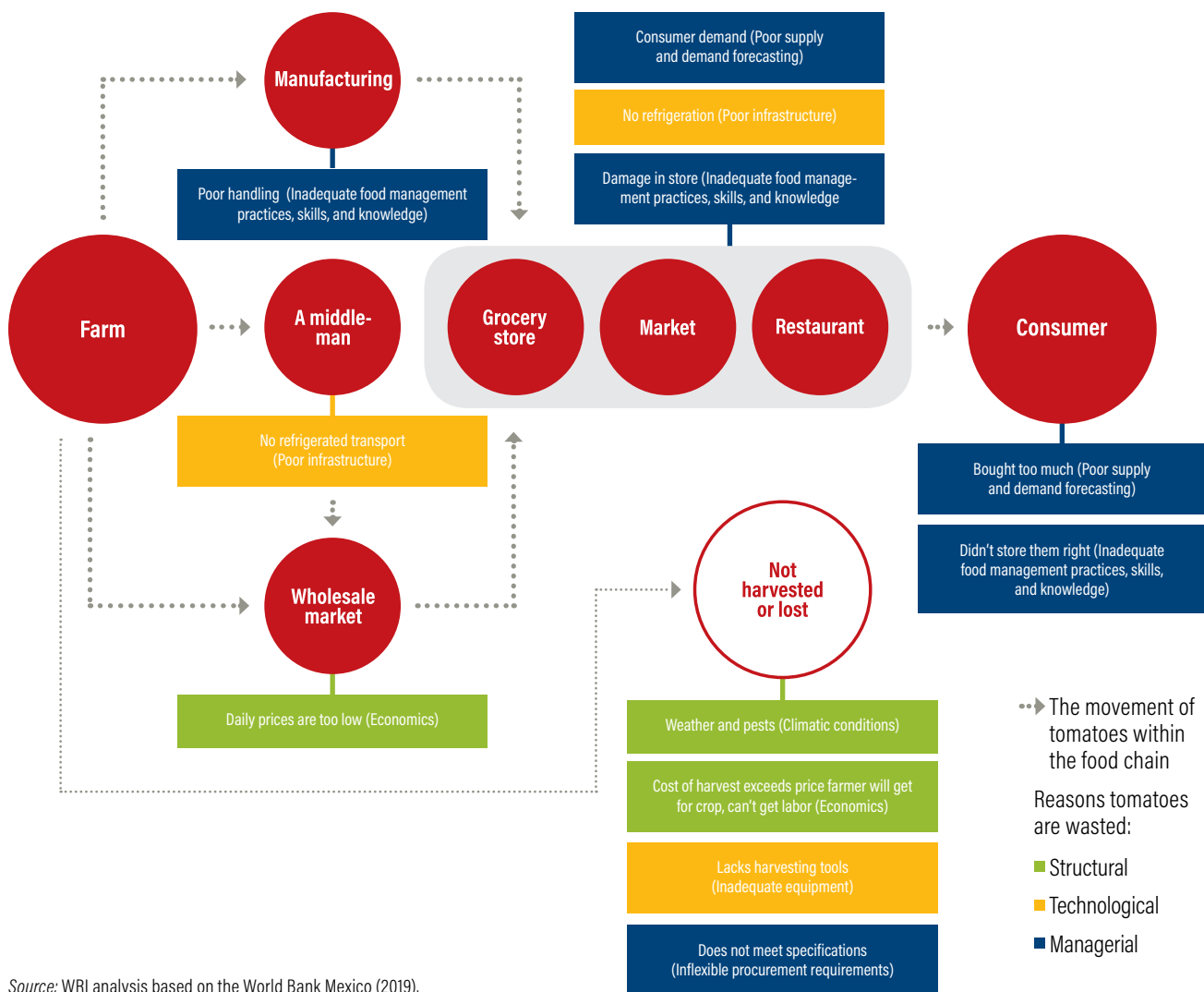
CATEGORY	UNDERLYING DRIVER	FOOD SUPPLY CHAIN STAGES				
		PRODUCTION	HANDLING AND STORAGE	PROCESSING AND PACKAGING	DISTRIBUTION AND MARKET	CONSUMPTION
Structural	Demographics	X				X
	Climatic conditions	X	X	X	X	X
	Policies and regulations	X	X	X	X	X
	Economics	X	X	X	X	X
	Access to Financing	X	X	X	X	X

We make several observations about these underlying drivers of food loss and waste:

- Underlying drivers can occur at multiple stages.** All the underlying drivers can occur at more than one stage of the food supply chain (e.g., loss and waste can be generated by poor infrastructure at every stage in the chain), even though the actors involved may differ by stage (e.g., farmer during the production stage, household during the consumption stage) (Figure 3.2).

- Loss and waste can be driven by multiple underlying drivers at once.** A given instance of food loss and waste may involve more than one driver. For example, loss of rice due to poor storage may be a result of inadequate storage containers (*inadequate equipment*) which, in turn, was caused by the farmer not having access to credit to purchase better storage containers (*access to financing*).

Figure 3.2 | Example of Underlying Drivers in Tomato Supply Chain (Mexico)



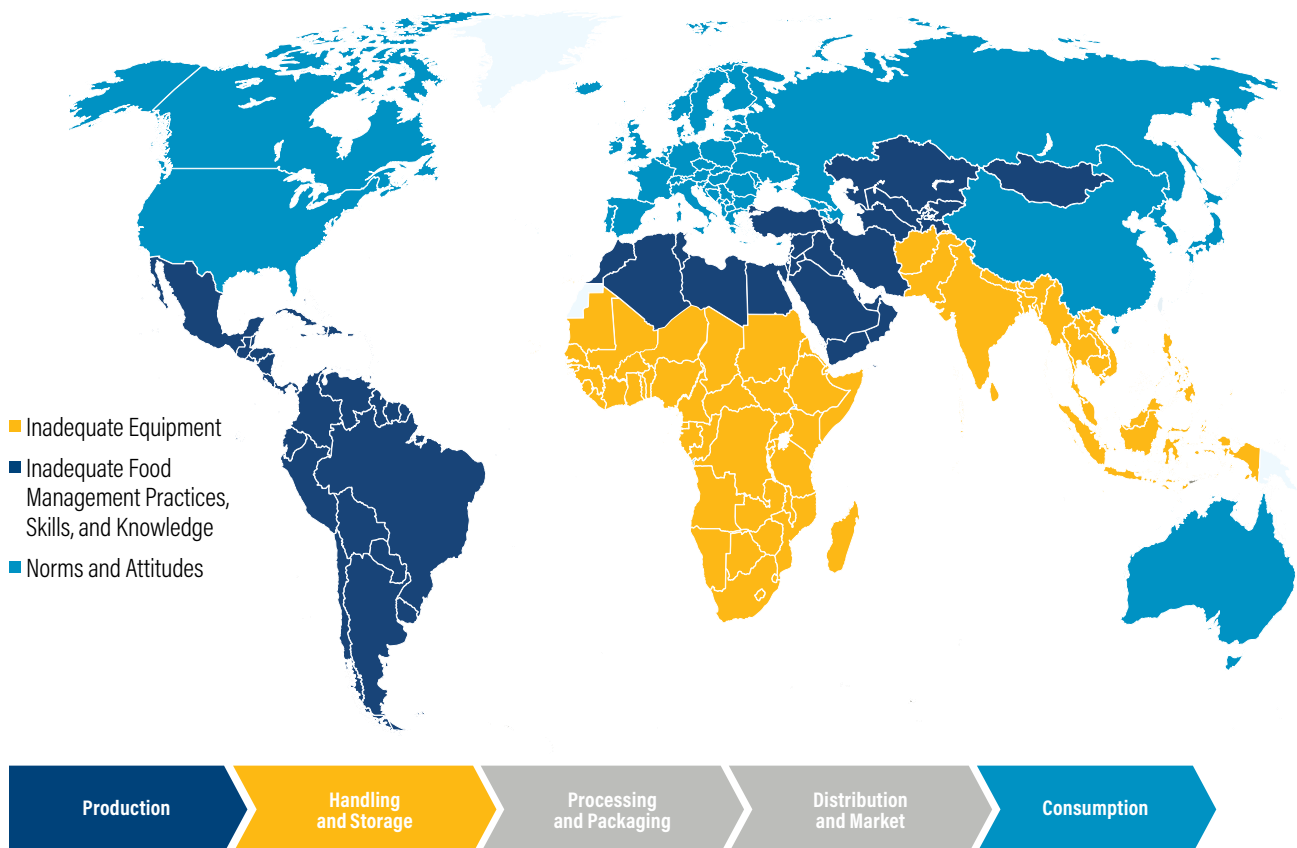
Source: WRI analysis based on the World Bank Mexico (2019).

- **Some drivers are more relevant in certain regions.** Inadequate equipment, as well as inadequate food management practices and skills, are arguably more prevalent in low- and middle-income countries, whereas social norms that do not encourage food efficiency (e.g., overpurchasing of food) in the home are arguably more prevalent in high-income countries (Figure 3.3).
- **An underlying driver occurring during one stage of the food supply chain may result in the actual food loss and waste occurring at a different stage.** The food supply chain is a complex system where actions at one stage in the chain can affect food

when it is at another stage. For example, rough handling of fruit (*inadequate food management practices*) during the production or handling stages of the food supply chain can reduce the fruit's shelf life at the market or consumption stage, thereby increasing food waste at these latter stages. The impacts can go the other direction, too. For instance, orders canceled by retailers (*inflexible procurement requirements*) at the market stage can result in food being lost or wasted at the processing site or all the way back at the farm.

Understanding the underlying drivers at play for a given instance of food loss and waste is a prerequisite for developing an effective food loss and waste reduction strategy for that instance.

Figure 3.3 | **Leading Underlying Drivers and Supply Chain Stage of Food Loss and Waste per Region**



Note: The map highlights by geographic region the leading underlying driver of food loss and waste for the supply chain stage that is estimated to account for the largest share of food loss and waste in that region. Countries are grouped in the same regions as given in FAO (2011). Which food supply chain stage accounts for the highest share of food loss and waste per region is based on FAO (2011). The leading driver of food loss and waste draws upon a review of HLPE (2014).

Source: WRI analysis based on FAO (2011) and HLPE (2014).



CHAPTER 4

WHAT SHOULD BE DONE ABOUT IT?

A simple three-step approach can set anyone on the path toward reducing food loss and waste. This chapter explains that approach and introduces a “to do” list for the principal types of actors in the food supply chain.

SUMMARY POINTS

- The three-step approach Target-Measure-Act is a useful framework being used by governments and companies to guide food loss and waste reduction strategies.
 - **Target:** Setting a reduction target increases decision-maker attention to the issue of food loss and waste—and attention is a prerequisite for taking action.
 - **Measure:** Measuring and analyzing how much and where food is being lost or wasted enables identification of the largest opportunities for reduction. Measurement is important for developing the evidence base for prioritizing food loss and waste reduction interventions and for tracking progress over time.
 - **Act:** Taking action consists of identifying the specific interventions that one should implement to reduce food loss and waste, and then implementing them. These interventions include technologies, practices, programs, investments, and/or behavior changes that aim to reduce food loss and waste at one or more stages of the food supply chain.
- There is a role for everyone in the food system, from farmers all the way to consumers, in reducing food loss and waste. We propose a short list of priority **“to dos”** for each kind of actor that will help them implement the “Act” portion of the Target-Measure-Act framework.
- Experiences from reduction initiatives that are making progress provide **insights** relevant to the action agenda:
 - Awareness is a start (but only a start).
 - Make the “business case” to motivate actors (so they see reducing food loss and waste as in their self-interest).
 - Recognize that there is no silver bullet (a number of interventions are typically required).
 - Which interventions are relevant varies from country to country and within countries (especially depending on the level of economic development).
 - Beware of knock-on effects across the supply chain (reductions at one stage might merely trigger loss and waste later).
 - Collaboration among actors is crucial (especially when one is pursuing a “whole supply chain” approach).

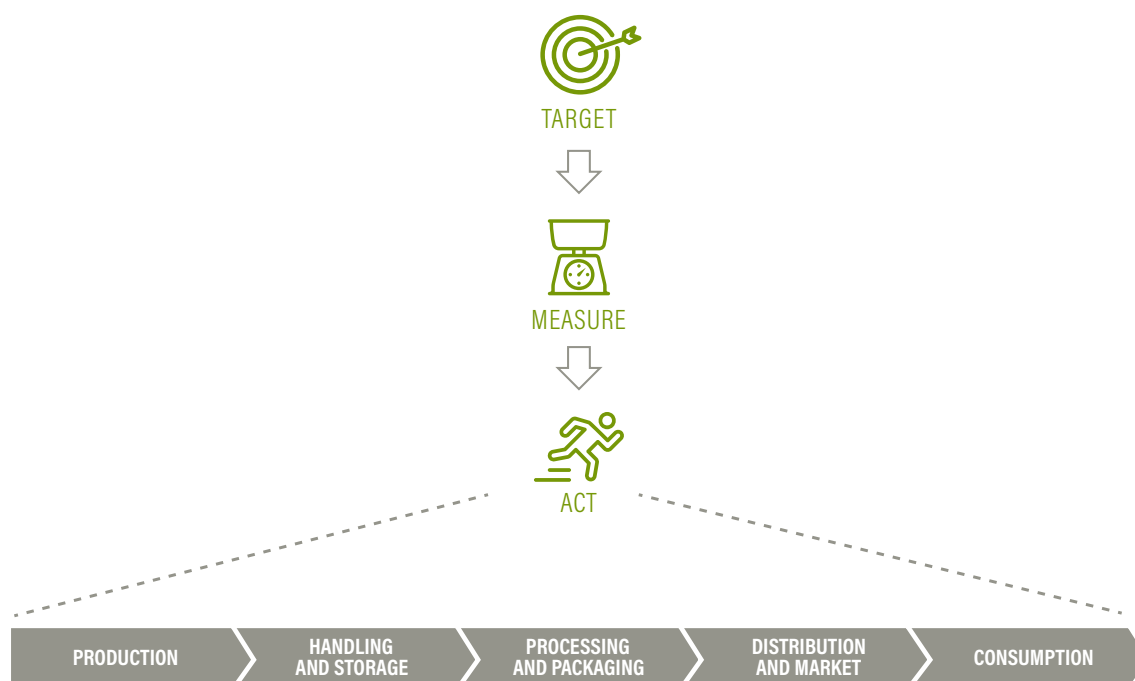
In light of the variety of underlying drivers, what should governments, companies, farmers, households, and others do to prevent and reduce food loss and waste? Although there may be multiple ways to frame it, we recommend a three-step approach: (1) Target, (2) Measure, and (3) Act (Figure 4.1). Although this framing could be considered “generic,” it has been derived from studying what appears to be working in the realm of food loss and waste reduction efforts. The authors have observed that the entities which have made progress on reducing food loss and waste within the past decade have followed this approach, either explicitly or implicitly. Examples include the United Kingdom (the nation that has made the most known progress in reducing food loss and waste since the mid-2000s), London (the first major city to have achieved reductions in food waste), and a number of major food businesses (e.g., Kellogg Company, Nestlé, Olam, Sodexo, Tesco, Walmart). Moreover, Target-Measure-Act is now the approach being pursued by additional countries and political blocs (e.g., the European Union’s strategy for fulfilling SDG 12.3 essentially follows this approach) and by numerous companies, including some of the largest food companies (by sales) in the world (e.g., members of The Consumer Goods Forum, members of the Global Agribusiness Alliance). (We elaborate on these developments in Chapter 5.)

Target

Targets set ambition, and ambition motivates action. Setting a reduction target is a deliberate way of raising decision-maker attention to the issue of food loss and waste—and attention is a typical prerequisite for taking action.

The most straightforward target to adopt—and most aligned with the global agenda—is SDG 12.3: Reduce food waste by 50 percent and reduce food loss along the supply chain by 2030. Moreover, a 50 percent reduction target is increasingly being proposed by studies modeling what it will take to achieve a sustainable food future (see Searchinger et al. 2018; and Willet et al. 2019). For some entities, adopting this target simply consists of “internalizing” the already-accepted SDGs. In theory, this should apply to every national government since all nations signed on to the SDGs. But because the SDGs have 169 targets, Target 12.3

Figure 4.1 | A Strategy for Tackling Food Loss and Waste



Source: WRI analysis.

could get “lost” and not receive sufficient attention. Therefore, we recommend that governments explicitly and publicly articulate a 50 percent food loss and waste reduction target in order to emphasize attention and commitment to the issue. Moreover, although not necessarily bound by the SDGs, companies should set similar targets to reduce food loss and waste by 50 percent.

When setting a target, it is important for the entity to define the scope of the target.²¹ The scope includes several parameters:

- **Time period:** The start date is often 2015 (year of SDG formulation) or a more recent year, and the end date is typically 2030.
- **Geographic boundary:** For nations this would be the country itself (unless subnational states or cities want to set their own targets). For businesses, this could be operations within one country or all global operations.
- **Food category:** The most complete target would cover all food categories. Some targets, however, cover certain dominant crop or food

categories most important to the well-being of the country or performance of the company.

- **Lifecycle stage:** The most complete target would cover all stages in the food supply chain, from production to consumption. But some targets may cover just those stages of the food supply chain where the business operates (e.g., for a food manufacturer this might be the “processing” stage).

Measure

The old adage “what gets measured gets managed” holds true for food loss and waste as well. Quantifying food loss and waste within borders, operations, or supply chains can help decision-makers better understand how much and where food is being lost or wasted. Doing so enables identification of “hotspots” that may provide the largest opportunities for (and thus benefits of) reduction. Such information provides the evidence base for developing and prioritizing reduction strategies and interventions. Measurement also is necessary if entities are to know whether or not they are on track to realizing their target. When

BOX 4.1 | RESOURCES TO GET STARTED WITH MEASUREMENT AND PRIORITIZATION

Various resources are available to help companies, governments, and others measure food loss and waste. Developed by the Food Loss and Waste Protocol (2016), the *Food Loss and Waste Accounting and Reporting Standard* provides globally applicable guidance on developing a food loss and waste inventory. It helps define the scope of measurement, gives guidance on 10 common quantification methods (offering a tool to identify which of the 10 are appropriate for one's circumstances), and recommends how to report results.

Developed by FAO, the Food Loss Analysis Case Study Methodology helps one understand the amount of losses and underlying drivers for a particular commodity at critical loss points in a given country (FAO 2019a). Additional resources on measurement can be found through online platforms including the Technical Platform on the Measurement and Reduction of Food Loss and Waste (FAO 2019b), the REFRESH Community of Experts (2019), and *Further with Food* (2019). Various studies and data points focused on quantifying field-level losses and understanding the drivers of loss during primary production (and beyond) have been produced by organizations including Wageningen University (Canali et al. 2014), World Wildlife Fund (WWF-US 2018), the African Postharvest Losses Information System (APHLIS 2019), the International Food Policy Research Institute (Delgado et al. 2017), GIZ (Ostermann et al. 2015), YieldWise (Rockefeller Foundation 2019), and the Global Strategy to Improve Agricultural and Rural Statistics (GSARS 2018).

Other guides on measurement include *Why and How to Measure Food Loss and Waste: A Practical Guide*, produced by the Commission for Environmental Cooperation (focused on Mexico, Canada, and the United States) (CEC 2019); *Food Waste Reduction Roadmap and Toolkit*, published by WRAP (focused on the food processing, retail, hospitality, and food service sectors) (WRAP 2018a); *A Food Loss and Waste Quantification Handbook* (aimed at providing guidance for the 21 member economies of the Asia-Pacific Economic Cooperation group) (Chang and Hsu 2019a); and *Food Waste Quantification Manual to Monitor Food Waste Amounts and Progression*, developed through the EU FUSIONS project (focused on EU member states) (Tostivint et al. 2016).

conducted periodically, measurement enables monitoring of progress over time—identifying when and where interventions are having an impact and when and where corrective measures are needed. Therefore, every government and company should start to measure its food loss and waste, and monitor progress and trends over time.

Some might suggest that one should measure first and set a reduction target based on this afterward. However, because of SDG 12.3, the increasingly generally accepted target for reducing food loss and waste has already been set. Moreover, it is important to not let “the perfect become the enemy of the good.” One does not necessarily need complete or precise quantification in order to take steps to minimize food loss and waste. One should balance the costs and time of conducting food loss and waste measurement with the level of detail needed—although many experiences indicate that the benefits of measurement can greatly outweigh the costs (see Box 2.1). Box 4.1 outlines resources available to help start the measurement process and understand where to prioritize interventions.

Act

Setting targets and measuring food loss and waste are important. But what ultimately matters is action. “Act” consists of identifying the specific interventions that entities should implement to reduce food loss and waste, and then implementing them. These interventions include technologies, practices, programs, investments, and/or behavior changes that explicitly aim to reduce food loss and waste at one or more stages of the food supply chain. Act is where the proverbial “rubber hits the road.”

When it comes to taking action, many proven interventions exist. Figuring out which to employ should be informed by the results of measurement and an understanding of the underlying drivers. In other words, “measurement” ideally should inform “action.” An action for all companies is to quantify food loss and waste in their own operations, map their supply chain, determine hotspots, develop food loss reduction policies, set targets and workplans, and ideally make public commitments to monitor, measure, and reduce. By knowing *where* and *how much* food is being lost and wasted, one

can identify the hotspots and prioritize those. By knowing *why* food is being lost and wasted, one can identify interventions that address the specific underlying driver(s). Appendix C summarizes some promising, albeit not exhaustive, interventions per driver. It also highlights which drivers tend to be more salient in low-income versus middle- and high-income countries. These interventions were identified from a variety of sources (Box 4.2).

Because food loss and waste is so pervasive, there is a role for everyone in the food system when it comes to taking action to reduce it. Figure 4.2 highlights many of the important actors per stage of the food supply chain, as well as actors whose actions cut across the stages. Although there are a number of interventions any particular actor could pursue (depending on their circumstances and available resources), the following identifies a priority to-do list each type of actor could pursue first in order to kick-start reductions in food loss and waste.

BOX 4.2 | DATA SOURCES FOR INTERVENTIONS

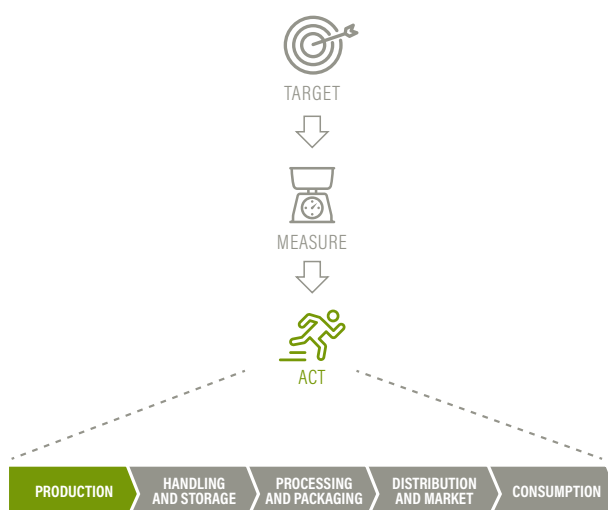
The interventions in Appendix C and in the rest of this chapter were drawn from a review of academic literature, recommendations found in synthesis reports on food loss and waste, experiences from reduction efforts, as well as input from this report's partner organizations. Literature sources include Canali et al. (2014); CEC (2017, 2018, 2019); Clowes et al. (2018a, 2018b, 2019); FAO (1989); Food Loss and Waste Protocol (2016); Global Knowledge Initiative (2017); Gunders and Bloom (2017); Hegnholt et al. (2018); HLPE (2014); ReFED (2016); Gooch et al. (2019); and WWF-US (2018). Field experience sources include the Courtauld Commitment, a variety of FAO field studies, a number of business projects, and YieldWise project results.



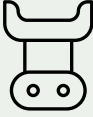
Figure 4.2 | **Key Actors for Reducing Food Loss and Waste (Not Exhaustive)**



Production

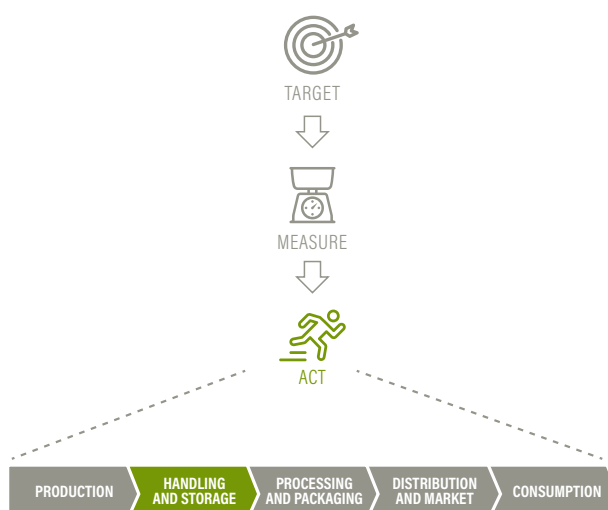
Food losses during harvesting can result from any number of factors, including damage incurred during harvest, failure of harvesting methods to capture all of the available crop, high production (e.g., labor) costs relative to market prices, and lack of an economically viable market for surplus food (e.g., food does not meet cosmetic requirements or is in excess if an order has been canceled), among others. Relevant interventions tend to be those that address the underlying drivers of inadequate infrastructure, lack of equipment, insufficient skills and knowledge, economic factors, and climatic conditions.

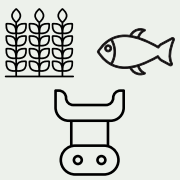


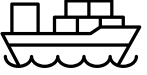


ACTOR	KEY "TO DO"
<p>Crop farmers</p> 	<ul style="list-style-type: none"> ■ Improve harvesting practices (e.g., ensure product is harvested at the right maturity and use appropriate harvesting equipment to maximize yield while minimizing crop damage). ■ Improve skills or use tools to better schedule harvesting (including accessing better data on weather). ■ Engage customers (e.g., wholesalers, retailers) to communicate implications of order changes. ■ Engage customers to explore changes in quality specifications to enable more of what is harvested to be sold. ■ Identify financially viable alternative markets or use for crops otherwise left in the field (e.g., value-added processing, donation, secondary surplus markets).
<p>Fishers</p> 	<ul style="list-style-type: none"> ■ Use fishing gear designed for target species to reduce bycatch. ■ Identify (or create) markets for unavoidable bycatch (e.g., animal feed or processed products).
<p>Ranchers and animal farmers</p> 	<ul style="list-style-type: none"> ■ Build capacity in practices to reduce losses (e.g., reduce milk spills, minimize contamination). ■ Implement best practices in animal welfare to avoid stress and injuries that can reduce the shelf life of meat from animals.

Handling and storage

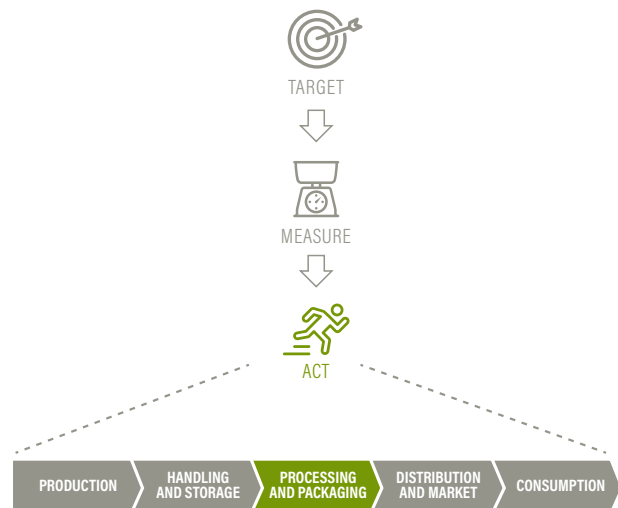
Food losses during handling and storage can result from any number of factors, including careless handling, pests, inadequate reduction of heat and moisture during storage, vibration of vehicles on bad roads, lack of cold chain infrastructure, delays at border crossings, and disruptions due to weather, among others. Relevant interventions tend to be those that address the underlying drivers of poor infrastructure, inadequate equipment, inadequate implementation of practices, insufficient skills and knowledge, procurement requirements, and climatic conditions.


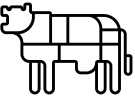



ACTOR	KEY "TO DO"
<p>Primary producers</p> 	<ul style="list-style-type: none"> ■ Crop farmers: Improve training in best practices (e.g., handling to reduce damage, drying, fumigation treatments, and on-farm processing). Establish aggregation centers that provide adequate storage and preservation options, such as cooling chambers. ■ Fishers: Improve temperature management, handling, and preservation techniques (e.g., fenced-off landing beaches or drying racks to improve the quality of fish and to minimize losses). ■ Ranchers and animal farmers: Improve handling and preservation options (e.g., establish milk collection centers with cooling tanks). Improve conditions during transportation of food-producing animals from farm to markets.
<p>Packinghouses</p> 	<ul style="list-style-type: none"> ■ Adopt best practices to provide the clean, cool, and/or dry conditions required to reduce postharvest losses. ■ Reexamine handling and storage practices to reduce damage (e.g., use liners in wood and basket containers, reduce the size of sacks or crates to minimize product damage). ■ Build near-farm facilities to convert unmarketable crops and by-products into value-added products.
<p>Storage providers</p> 	<ul style="list-style-type: none"> ■ Use storage containers that protect against temperature variations, humidity and precipitation, and insect and rodent infestation. ■ Adopt low-cost storage and handling technologies (e.g., hermetic grain storage bags, plastic or metal silos, plastic crates) that prevent spoilage and increase shelf life. ■ Work with intended users and community experts to design and produce locally relevant storage solutions.
<p>Transportation and logistics providers</p> 	<ul style="list-style-type: none"> ■ Improve handling practices during loading and unloading. ■ Use technology innovations to improve the flow of information (e.g., about road and traffic conditions, as well as timing of pickup and delivery) to optimize movement of food. ■ Introduce (or expand) energy-efficient, clean, low-carbon cold chains from farm to wholesalers. ■ Work upstream with customers to provide planning tools and handling and storage technologies that help them reduce losses. ■ Create access to alternative markets for products that cannot be marketed.

Processing and packaging

Food loss and waste during processing and packaging can result from factors including poor management of inventory, inaccurate forecasts, human errors and interruptions during food processing, residual food not used during product line changeovers, and product or package defects. Relevant interventions to reduce food loss and waste at processing facilities tend to be those that address the underlying drivers of inadequate implementation of management practices, skills, and knowledge, and poor supply and demand forecasting. Interventions by processing facilities that can reduce loss and waste later in the food supply chain (after food leaves the processing facility) tend to involve improving packaging, adjusting marketing strategies, and exploring economically viable markets for food by-products.



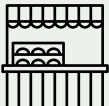


ACTOR	KEY "TO DO"
<p>Processors and manufacturers</p> 	<p>Operations-related:</p> <ul style="list-style-type: none"> ■ Improve training of staff to reduce technical malfunctions and errors during processing. ■ Reengineer production processes and product design to reduce waste during product line changeovers. ■ Introduce software and related information and communications technologies to optimize operations (e.g., to identify waste, track temperature and ensure freshness, assess ripeness, better balance demand and supply forecasts, and accelerate delivery of food). <p>Customer-related:</p> <ul style="list-style-type: none"> ■ Use product sizes and packaging that reduce waste by consumers (e.g., accommodate desire for smaller or customizable portions). ■ Standardize date labels (e.g., eliminate "sell by" and use only "use by" for perishable items and "best before" for others) to reduce consumer confusion. ■ Develop new food products or secondary uses (e.g., animal feed or other value-added products) from what cannot be marketed (e.g., spent grains, fruit trimmings, vegetable peels). ■ Seek donation of excess food that is still safe to consume (e.g., revise vendor agreements with retailers to allow for donation instead of mandatory destruction).
<p>Slaughterhouses</p> 	<ul style="list-style-type: none"> ■ Ensure that proper temperature management conditions are maintained. ■ Follow best practices in cleaning and sanitation to reduce losses due to contamination. ■ Fully leverage potential for using animal by-products to safely manufacture other products (e.g., animal feed supplements). ■ Identify and address management practices that lead to avoidable losses (e.g., using remote video auditing to assess whether best practices are being implemented).
<p>Packaging providers</p> 	<ul style="list-style-type: none"> ■ Invent, design, produce, and mainstream packaging options or coatings (e.g., resins used on pouches or on foods) that extend a product's shelf life (although consideration should be given to the impact of the packaging, and efforts should be made to create reusable and recyclable packaging, as discussed in Box 4.3). ■ Offer packaging that is resealable to allow for incremental consumption and to extend how long the remainder of a product stays suitable for consumption. ■ Provide commercial customers with a greater variety of packaging sizes to help shoppers purchase the amount appropriate for their needs. ■ Adjust packaging so it is easier for consumers to empty all the contents.

Distribution and market

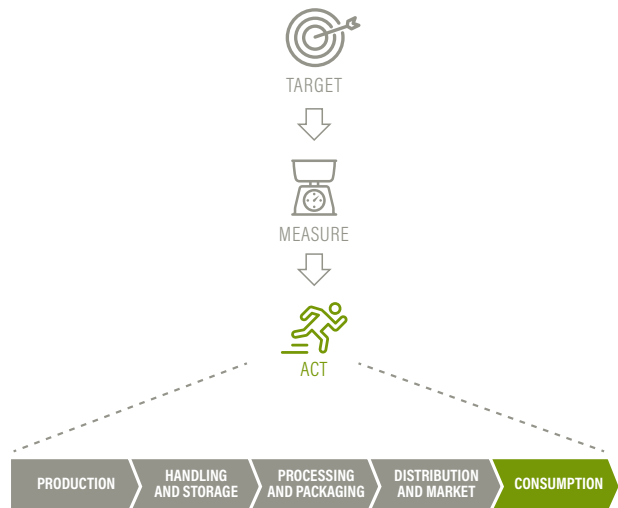
Food loss and waste during wholesale and retail can result from factors including poor handling, not storing or transporting product at the right temperature, equipment malfunctions, overstocking due to an inadequate assessment of supply and demand (or fear of empty shelves), and disposing of unsold food, among others. Relevant interventions tend to be those that address the underlying drivers of inadequate skills and knowledge, poor supply and demand forecasting, suboptimal packaging, inadequate equipment, concerns about possible risks, inflexible procurement requirements, and marketing strategies.





ACTOR	KEY "TO DO"
<p>Wholesalers</p> 	<ul style="list-style-type: none"> ■ Build capacity for better handling and storage practices to reduce mistakes that result in food loss. ■ Expand cold storage systems during wholesale and logistics to protect products vulnerable to heat damage. ■ Find food rescue partners or establish online marketplaces that facilitate sale or donation of rejected shipments or short-life products. ■ Use backhauling (or other logistics solutions) to enable return of reusable storage containers or rescue of surplus food for people in need. ■ Invest in technologies to track temperature and ensure freshness, streamline routing, track movement of goods in and out of warehouses, and monitor food loss and waste.
<p>Retailers (formal)</p> 	<p>Operations-related:</p> <ul style="list-style-type: none"> ■ Improve training of staff in temperature management, product handling, and stock rotation. ■ Optimize inventory management systems (and increase flexibility in supplier contracts) to better match forecasting and ordering. ■ Review cosmetic specifications and accept a wider diversity of produce. <p>Consumer-related:</p> <ul style="list-style-type: none"> ■ Enable consumers to purchase smaller or customized portions (e.g., through bulk bins or staffed seafood and meat counters). ■ Adjust promotions to avoid excessive purchase of additional items (e.g., offer half off or mix-and-match deals rather than two-for-one offers). ■ Redesign in-store merchandising to avoid excessive handling of products by consumers (e.g., sort by stage of maturity), and to achieve the desired appearance of abundance but with less damage and excess product (e.g., through smaller bins and bowls). ■ Educate consumers about better food management (e.g., proper storage, meal planning, understanding date labels, safe food handling, cooking tips).
<p>Retailers (informal)</p> 	<ul style="list-style-type: none"> ■ Participate in groups or associations of informal operators to access guidance and training in best practices in food handling and storage. ■ Take advantage of municipal support to access clean water, storage areas, equipment that improves food safety, and training in how to reduce food contamination. ■ Use practices that minimize damage such as handling produce gently, stacking properly (e.g., to avoid bruising delicate produce), marking cases to track inventory, and rotating stock following a "first-in-first-out" method. ■ Ensure that displays allow air to be circulated and temperature conditions to be appropriate for product to remain fresh (e.g., high-ethylene producers should be kept away from ethylene-sensitive commodities). ■ Avoid sprinkling unclean water on products (to minimize wilting and shriveling) as such practices result in unsafe foods shunned by buyers.

Consumption

Food loss and waste during consumption, whether from a company’s or consumer’s perspective, can result from inaccurately planning what will be consumed, portion sizes that are too large, mistakes during preparation, fears related to food safety, and improper handling and storage, among other factors. Relevant interventions tend to be those that address the underlying drivers of inadequate implementation of practices, inadequate skills and knowledge, cultural norms and attitudes, concerns about possible risks, lack of awareness, suboptimal packaging, and marketing strategies.





ACTOR	KEY "TO DO"
<p>Households</p> 	<ul style="list-style-type: none"> ■ Buy only what you expect to eat: check refrigerator and cupboards before shopping, use a shopping list, and plan meals in advance. ■ Know the difference between “use by” (which is about food safety) and “best before” (which is about quality and still safe to eat after this date). ■ Freeze or preserve food before it spoils, and find out how to best store different foods so they stay fresh and safe longer. ■ Find creative ways to use leftover ingredients and products past their peak quality (e.g., in soups, sauces, smoothies), as well as to cook the parts you may not normally eat (e.g., stems, cores). ■ Organize the kitchen and refrigerator so that items do not get lost and spoil.
<p>Restaurants</p> 	<ul style="list-style-type: none"> ■ Engage staff on food waste reduction (e.g., explain why reduction is important, give tips on waste reduction, reward staff who deliver against targets). ■ Shift away from preparation methods such as batch cooking, casserole trays, and buffets to reduce overproduction and repurpose excess food (e.g., offer customers “doggy bags,” safely incorporate unused items into other dishes, sell excess food at a discount, donate unsold food). ■ Revisit inventory management and purchasing practices (as well as menus) to better fit needs based on historical trends and waste data. ■ Use scales in the kitchen to weigh food and track items most commonly wasted (and estimate the financial cost of food disposed, thus creating a financial signal to waste less). ■ Consider whether portions served exceed what can be eaten, and rethink promotions that encourage over-purchasing by customers.
<p>Hotels</p> 	<ul style="list-style-type: none"> ■ Engage staff on food waste reduction (e.g., explain why reduction is important, give tips on waste reduction, and reward staff who deliver against targets). ■ Rethink the buffet (e.g., shift certain items to à la carte near end of mealtimes, reduce the size of dishes used in buffets). ■ Reduce overproduction by producing smaller quantities of items consistently left on the plate. ■ Repurpose excess food (e.g., by safely incorporating unused items into other dishes, or by donating it). ■ Communicate to guests about food waste and encourage them to take only as much as they need.

ACTOR	KEY "TO DO"
<p>Catering/food service</p> 	<ul style="list-style-type: none"> ■ Engage staff on food waste reduction (e.g., explain why reduction is important, give tips on waste reduction, and reward staff who deliver against targets). ■ Reduce the amount overproduced (e.g., by producing smaller quantities of items that are consistently underconsumed). ■ Repurpose excess food (e.g., by safely incorporating unused items into other dishes, or by donating it). ■ Use scales in the kitchen to weigh food and track items most commonly wasted (and estimate the financial cost of food disposed, thus creating a financial signal to waste less). ■ Evaluate contractual obligations between clients and suppliers that generate waste and overproduction (e.g., contracts that stipulate that all hot dishes must be available for the full-service period).
<p>Public and private institutions (e.g., schools, hospitals, government canteens)</p> 	<ul style="list-style-type: none"> ■ Engage staff on food waste reduction (e.g., explain why reduction is important, give tips on waste reduction, and reward staff who deliver against targets). ■ Reduce the amount overproduced (e.g., by producing smaller quantities of items that are consistently underconsumed), and repurpose excess food (e.g., by safely incorporating unused items into other dishes, or by donating it). ■ Introduce techniques to minimize people taking overly large portions (e.g., trayless dining, flexible portion sizes, pay-by-weight pricing system, smaller plates). ■ Revisit inventory management and procurement practices (as well as menus) to better fit needs based on historical trends and waste data. ■ Use scales in the kitchen to weigh food and track items most commonly wasted (and estimate the financial cost of food disposed, thus creating a financial signal to waste less).

Across the supply chain

Food loss and waste across multiple stages of the food supply chain can result from any number of factors that broadly affect the food system, including demographic shifts that influence consumption habits, poorly coordinated policies and regulations on issues such as food safety, difficulty accessing financing to invest in equipment that reduces loss and waste, a lack of markets, or insufficient motivation for action, among others. Relevant interventions that can be undertaken by actors such as policymakers, financiers, intermediaries, innovators, researchers, and civil society tend to be those that address the underlying drivers of poor infrastructure, policies and regulations, access to financing, demographic shifts, economic conditions, as well as norms and attitudes.



ACTOR	KEY "TO DO"
<p>Policymakers</p> 	<ul style="list-style-type: none"> ■ Embed into agricultural extension services (and in farmer subsidy programs) food loss reduction awareness, technical assistance, and financial aid. ■ Develop, facilitate, promote, and/or improve climate-smart infrastructure (e.g., roads, electricity, irrigation, community storage) and access to it, especially for smallholder farmers who live far from markets. ■ Increase investment in agricultural research related to postharvest loss and provide incentives for the adoption of postharvest technologies (e.g., zero-rates tax on imported postharvest technologies, incentives for local manufacturers of postharvest technologies, subsidies for postharvest technologies). ■ Implement policies to prevent unfair trading practices (e.g., last-minute order cancellations and unilateral or retroactive changes to contracts). ■ Remove barriers to food redistribution via policies (e.g., liability limitations, tax breaks) that make it easier for food suppliers to donate safe (but unsold) food to charities or to those in need. ■ Support policies to standardize food date labeling practices to reduce confusion about product safety and quality, and improve consumer understanding of the meaning of date labels. ■ Include food waste reduction lessons in school curricula and include food waste reduction training in public procurement programs. ■ Provide municipal support for informal retailers to access clean water, storage areas, equipment that improves food safety, and training in how to reduce food contamination. ■ Make measurement and reporting of food loss and waste by large companies mandatory.
<p>Financiers</p> 	<ul style="list-style-type: none"> ■ Increase the number of philanthropic institutions funding food loss and waste prevention activities. ■ Create financing instruments and product lines (e.g., funds, bonds, loans) dedicated to reducing food loss and waste. ■ Increase start-up financing for new technologies and business models that would reduce food loss and waste, as well as financing to scale up proven technologies and models. ■ Increase development cooperation between high-income and low-income countries targeting food loss and waste. ■ Introduce "pay-as-you-go" programs to make technologies affordable for smaller operations (e.g., for solar-powered refrigeration units and mobile processing).

ACTOR	KEY "TO DO"
<p>Innovators and intermediaries (e.g., brokers, consolidators, digital solution developers)</p> 	<ul style="list-style-type: none"> ■ Develop and improve availability of processing and preservation facilities (including aggregation centers and mobile low-carbon options). ■ Develop alternative outlets during peak season through organizing export opportunities to markets with other seasonalities. ■ For unmarketable crops, improve flow of information to find alternative buyers, promote financially viable alternative markets, or develop new outlets (e.g., as processed foods, industrial products, animal feed). ■ Apply innovations to reduce delays for imported products during the point of exit and entry, which extends the shelf life of perishable products. ■ Leverage technology and digital solutions to rethink and better coordinate key processes between suppliers and customers in a more organized and informed way.
<p>Researchers</p> 	<ul style="list-style-type: none"> ■ Research new and innovative technologies to preserve food quality and extend shelf life. ■ Develop innovative products from perishable food commodities, such as fruits and vegetables, to promote whole food utilization. ■ Undertake research to fill data gaps and standardize reporting of food loss and waste data in order to better compare results, create benchmarks, and provide clearer direction for stakeholders. ■ Assess impact of interventions to improve evidence base of what works and the return on investment. ■ Develop sector-specific guidance that provides the motivation and technical information for businesses to take action (e.g., promote industry roadmaps for food loss and waste reduction).
<p>Civil society</p> 	<ul style="list-style-type: none"> ■ Raise awareness and shift social norms so that food loss and waste is considered "unacceptable" for all, including higher-income consumers. ■ Encourage public and private sector leaders to pursue the Target-Measure-Act strategy. ■ Act as a channel for the sharing and reporting of food waste data and progress.

Source: Canali et al. (2014); CEC (2017, 2018, 2019); Clowes et al. (2018a, 2018b, 2019); Food Loss and Waste Protocol (2016); Global Knowledge Initiative (2017); Gunders and Bloom (2017); Hegnholt et al. (2018); HLPE (2014); ReFED (2016); Gooch et al. (2019); WWF-US (2018).

Insights to Consider

Experiences of reduction initiatives that are making progress have yielded several insights that are important for any of these actors to consider when launching a food loss and waste reduction effort:

- **Awareness is a start.** Raising awareness that there is a food loss and waste challenge is a start. In some cases, key actors were not aware that they were experiencing food loss and waste, or denied that they were. Subsequent measurement found otherwise.²² But awareness alone does not guarantee action.
- **Make the “business case.”** Actors are more likely to take action on food loss and waste if they see an economic or other benefit in doing so. Identifying and communicating that “business case” (including how the benefits of action justify the costs of taking action) can therefore help motivate actors. The benefits that resonate with the target audience, however, may vary from audience to audience. For some, the business case is economic and financial. For others, it may be rooted in food security or natural resource conservation.
- **There is no silver bullet.** No single intervention will solve the food loss and waste challenge. Rather, it will require a multitude of different interventions, implemented at different stages of the food supply chain, and by different actors.
- **Which interventions are relevant vary by geography.** The hotspots and underlying drivers of food loss and waste vary from country to country, and within each of them, for a number of reasons, particularly related to a country’s level of economic development. In low-income countries, most food loss occurs during production as well as on- and off-farm handling and storage (see Figure 1.8). Thus, better infrastructure, low-cost technologies,

and improved technical know-how with respect to harvesting as well as handling and storage will be important interventions. In high-income countries, much of the food waste occurs at the consumption stage of the food supply chain. Thus, steps to shift consumer behavior will be important.

- **Beware of knock-on effects across the supply chain.** Successfully implementing an intervention at one stage of the food supply chain may reduce food loss and waste there but merely shift it to some other portion of the chain. For example, if excess product by producers or distributors is pushed into retail, this may lead to losses in stores that cannot sell the product or do not have sufficient time to arrange for the product to be diverted to those in need before it spoils. To avoid this, one should consider an intervention’s impact across the chain and find complementary interventions to prevent such a shift.
- **Collaboration is crucial.** In most cases, implementing a “whole supply chain” approach requires working with other entities, including suppliers, technical experts, and government authorities. No single entity has a broad enough reach to make a strategy for reducing food loss and waste realize its potential. Thus, companies collaborating with their suppliers, suppliers with their farmers, governments with the private sector, and NGOs bringing actors from across the supply chain together, are promising approaches in the fight against food loss and waste. Such collaboration includes voluntary agreements and supply relationships across the value chain that rethink contractual elements to support pragmatic solutions. Leveraging the power of data can help promote collaboration since a deeper understanding can be gained about how actions taken in one part of the value chain can increase or reduce food loss and waste up or down the chain.

BOX 4.3 | THE RELATIONSHIP BETWEEN PLASTIC PACKAGING AND FOOD WASTE

Plastics can play an important role in preventing food loss and waste across the food supply chain. In low-income countries, where high losses can occur during handling as well as transport and storage as a result of the use of inappropriate containers that cause damage to produce (Lipinski et al. 2013), reusable plastic crates can reduce losses by 25 percent (Kitinoja 2013). Hermetic storage bags, typically made from multiple layers of plastic, have also been shown to significantly reduce postharvest losses. In high-income countries, consumer behavior is a leading underlying driver of food waste, and the top reason for food wastage in the home is that it is not eaten in time (WRAP 2012). Plastic packaging can extend the storage life of food, with plastic packaging extending the shelf life of cucumbers, for example, by 11 days (Maddox 2018). Increasing the amount of fresh produce that is plastic-packed has therefore been proposed as a means of reducing food waste (AMERIPEN 2018).

However, the proliferation of plastic packaging and the impact plastics can have on the marine environment when plastic enters the ocean has emerged as a high-profile environmental issue in recent years. The disposal of plastics can also have a negative impact on the terrestrial and groundwater ecosystems. A recent study tested over 150 samples of tap water from countries including Germany, India, and the United States and found that 81 percent of the samples contained microplastics (Kosuth et al. 2018). Public concern about plastic waste, in particular single-use plastics, is at an all-time high, with one survey of 2,000 people

finding that 62 percent of people were concerned about plastic packaging (ThoughtWorks 2018).

In what situations does the use of plastic to reduce food loss and waste have a net benefit? This question is difficult to answer because many plastics break down into unrecognizable pieces relatively quickly, making it difficult to determine what ends up in the ocean (Hooper and Cerededa 2018). The evidence available suggests that the majority of marine plastic originates on land as mismanaged waste (Jambeck et al. 2015), and a U.S. analysis of plastic waste found food wrappers and containers to be the most common items (5 Gyres et al. 2017). This evidence suggests that consumer waste is more at risk of entering the marine environment than plastic-based technologies that prevent food losses close to the farm, such as plastic crates and hermetic storage bags. Furthermore, plastic crates have a significantly smaller carbon footprint than corrugated cardboard alternatives, and, being reusable, are less damaging to marine environments than single or limited-use plastic alternatives (Singh et al. 2006). Therefore, the use of plastic early in the food supply chain appears to have a net positive impact on food and the environment. Thus, public policies, such as the ban on plastic bags introduced in Kenya, that take a blanket approach to curtailing plastics—impacting such upstream applications—can be detrimental (Jerving 2017).

The matter is less straightforward when considering the increased use of single-use plastic packaging that extends storage life to reduce food

waste at the consumer level. Although plastic packaging can extend storage life, its impact is product-specific, and some studies suggest that the benefits of plastic packaging can be overstated (Schweitzer et al. 2018), with adequate refrigeration playing a more important role (WRAP 2018b). Over one-quarter of avoidable food waste in the United Kingdom is thrown away in its packaging (Ventour 2008), and increasing storage life will not necessarily reduce the food waste of overstuffed households (Canali et al. 2014). Packaging materials such as glass, metal, and bio-based packaging could provide alternatives to plastic packaging. However, the environmental impact of producing these materials can be higher than that of plastics, so merely replacing plastic packaging with other materials is not straightforward (Bertolucci et al. 2014).

An upcoming study suggests that buying loose, individual products opposed to prepackaged produce can result in lower household food waste because consumers then tend to buy only what they need (WRAP forthcoming). The study also suggests that by altering their commercial practices, retailers can mitigate food waste associated with loose produce both in-store and earlier in the supply chain. This evidence suggests that although plastic packaging can play a role in extending the shelf life of products, the root causes of why food is wasted in the home, such as a lack of planning and overbuying, need to be tackled if food waste is to be significantly reduced.



CHAPTER 5

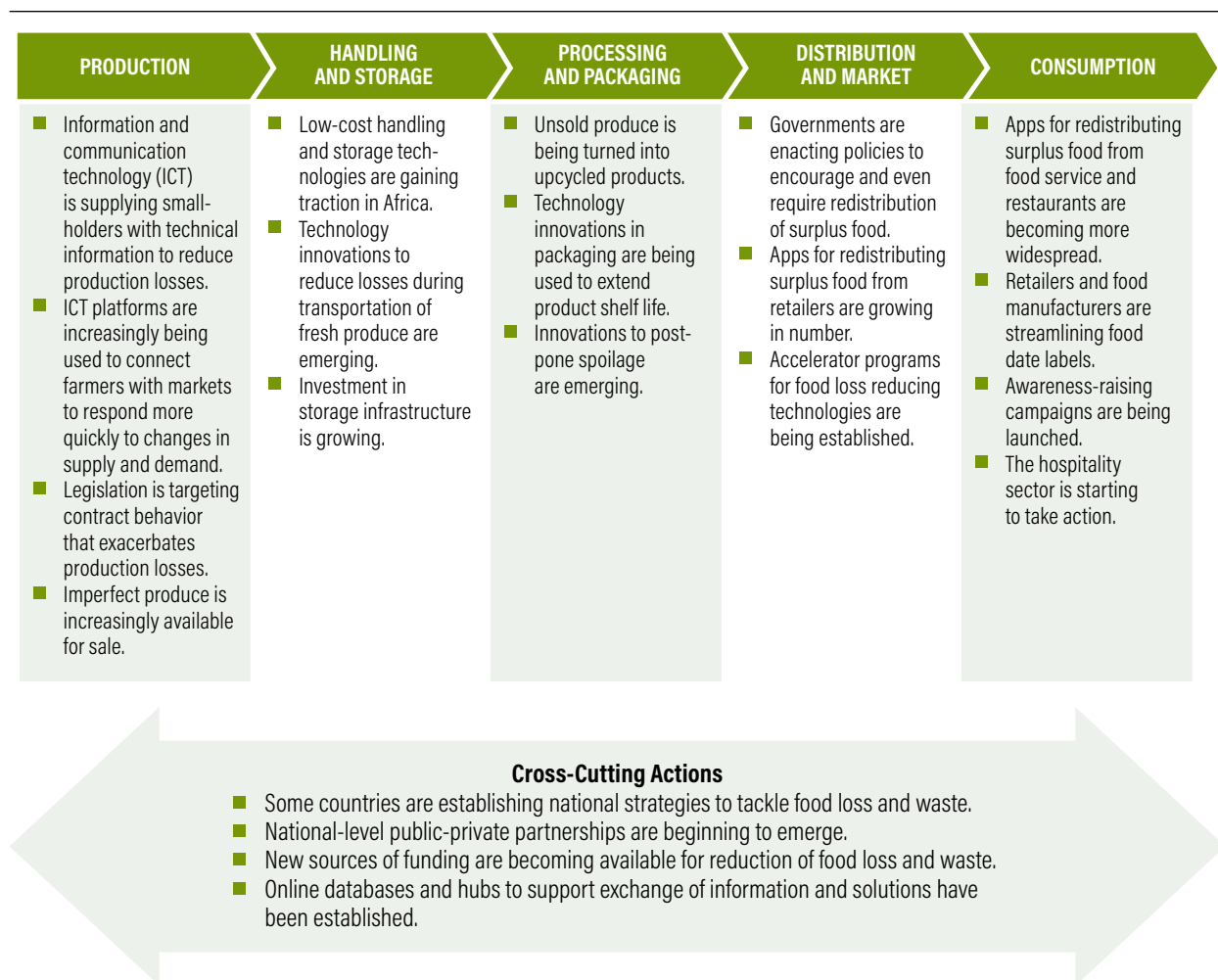
WHAT PROGRESS HAS BEEN MADE SO FAR?

The world has been making some progress with the Target-Measure-Act approach. This chapter summarizes salient developments in tackling food loss and waste since the advent of the SDGs in 2015.

SUMMARY POINTS

- Progress has been made toward implementing a global agenda for reducing food loss and waste.
 - More than 30 of the world's largest companies are now measuring food loss and waste within their operations.
- In terms of setting **targets**:
 - 50 percent of the world's population lives in a country that has set an explicit, public target aligned with SDG 12.3.
 - 32 of the world's 50 largest food companies (by revenue) independently have set, or participate in
- In terms of **measurement**:
 - Countries representing 12 percent of the world's population measure food loss and/or waste within their borders.
- In terms of taking **action**, a number of emerging developments along the food supply chain over the past few years indicate an increased focus by decision-makers on food loss and waste reduction (Figure 5.1).

Figure 5.1 | **Emerging Developments to Reduce Food Loss and Waste across the Supply Chain**



Source: WRI analysis.

Progress has been made toward implementing some of the strategies described in Chapter 4. This chapter highlights—using the Target-Measure-Act framework—some of the more salient developments since the announcement of the SDGs in 2015 (Box 5.1). These developments both give reason to hope that progress can be made and highlight the need to dramatically accelerate efforts if SDG 12.3 is to be achieved.

Target

Since the launch of the SDGs, an increasing number of governments and companies have set food loss and waste reduction targets for the first time.

Governments

The major development regarding targets has been the adoption, in September 2015, by governments around the world of the SDGs. The SDGs include Target 12.3, which calls for halving “per capita global food waste at the retail and consumer levels and reduc[ing] food losses along production and supply chains, including post-harvest losses,” by 2030 (UN 2017). This was the first-ever global commitment to reducing food loss *and waste* with a numeric target—although the United Nations had set a food loss reduction target in 1975 (Box 5.2).

A number of government bodies have internalized SDG 12.3 by publicly setting food loss and/or waste reduction targets consistent with it. Australia, the European Union, Japan, Norway, the United Arab Emirates, and the United States have done so (Figure 5.2). In 2014, as part of the Malabo Declaration, the African Union set a target of reducing postharvest losses—which is currently more of an issue in Africa than food waste—by 50 percent by 2025. Vietnam has a target to reduce postharvest losses of agricultural and fishery products by 50 percent by 2020. China has a national strategy for how to achieve each of the 169 SDG targets and, in its 2016–20 Five-Year Plan, set a quantitative target of reducing food losses by about 37 percent by 2020 (a rate consistent with achieving a 50 percent reduction in losses by 2030).

Thus, as of early 2019, countries comprising 50 percent of the world’s population have set an explicit food loss and/or waste reduction target that complements the more blanket adoption of SDG 12.3. (Figure 5.2).

BOX 5.1 | DATA SOURCES FOR THIS CHAPTER

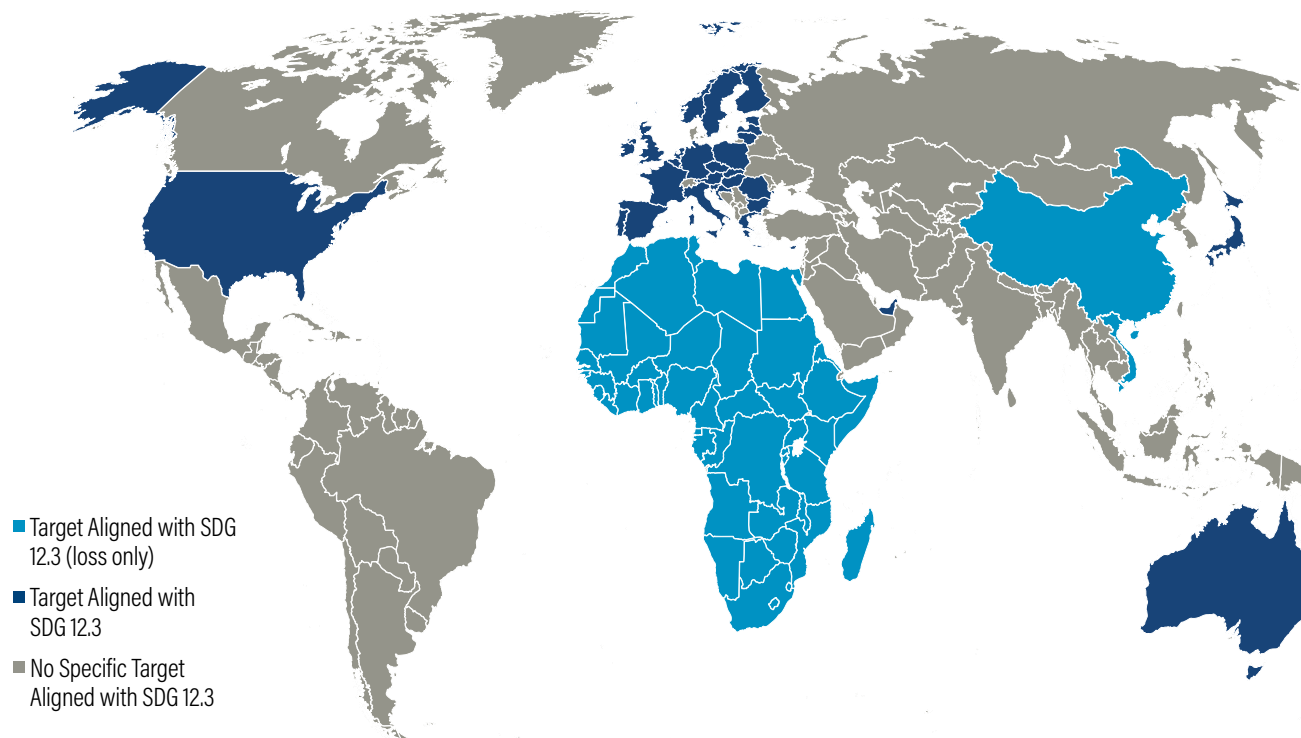
Examples of progress to date were found through a literature review and internet searches in the English language. Information also was gathered from interviews with more than a dozen global experts. Restricting searches to the English language may have impacted the geographic spread of examples, so specific effort was made to gather input from experts working in low- and middle-income countries, as these regions tend to be underreported when compared with efforts in high-income countries. Despite all this input, the following summary is not intended to be exhaustive. This chapter charts progress since the announcement of the SDGs in 2015. We chose this date because from that point onward the international community had a specific food loss and waste reduction target.

BOX 5.2 | DATA SOURCES FOR THIS CHAPTER

In 1975, during its seventh session, the UN General Assembly set a goal of reducing postharvest losses by 50 percent by 1985. This target focused only on losses (near the farm), not food waste (near the plate). In 1976, FAO’s Special Action Programme identified three constraints on postharvest loss prevention in developing countries: lack of information about the size and causes of the losses, lack of infrastructure for implementing prevention measures, and lack of investment. By 1985, the target was not met, and the constraints remain to this day.

Source: FAO (2018).

Figure 5.2 | National and Regional Governments with Specific Food Loss and Waste Reduction Targets Aligned with SDG 12.3 (as of early 2019)



Source: WRI analysis.

Subnational governments are also setting goals in line with SDG 12.3. In 2018, London committed to a target of 50 percent food waste reduction by 2030 (Greater London Authority 2018). In 2017, Dubai expanded its work on food waste by launching a zero-tolerance approach to food waste (Saseendran 2017). In 2015, New York City set a goal of reducing the amount of waste, including food waste, disposed of by households by 90 percent by 2030 (#OneNYC 2018). In 2018, the Pacific Coast Collaborative—consisting of British Columbia, California, Oregon, and Washington, as well as the cities of Oakland, Portland, San Francisco, Seattle, and Vancouver, Canada—committed to halving food waste by 2030 (Pacific Coast Collaborative 2018). In 2018, 23 cities and regions representing 150 million citizens—including Auckland; Catalonia; Paris; Philadelphia; San Jose, California; Sydney; Tel Aviv; and Vancouver, Canada—signed the “Advancing towards Zero Waste Declaration,” through which they commit to reducing the amount of waste sent to landfills and incineration by at least 50 percent by 2030 (C40 2018).

Companies

The private sector also has been adopting targets aligned with SDG 12.3:

- In 2015, The Consumer Goods Forum (CGF) announced a “Food Waste Resolution,” which calls for members to halve food waste within their individual retail and manufacturing operations by 2025. The CGF is a network of over 400 retailers, manufacturers, service providers, and other stakeholders and represents combined annual sales of \$2.8 trillion (Consumer Goods Forum 2015). We estimate that CGF members are responsible for at least 25 percent of all food sold in commercial markets around the world.²³
- In 2016, the U.S. Department of Agriculture and U.S. Environmental Protection Agency announced the formation of the group “U.S. Food Loss and Waste 2030 Champions.” The coali-

tion is currently comprised of 23 U.S.-based companies that have made a public commitment to halve food loss and waste within their own operations by 2030. Members include some of the largest food retailers in the United States, such as Kroger, Walmart, and Wegmans, food manufacturers such as Campbell Soup Company, Kellogg Company, PepsiCo, and Unilever, as well as restaurants and food service providers including Aramark, Bon Appétit, Hilton, Sodexo, and Yum! brands (USDA 2018).

- In 2017, the Global Agri-business Alliance (GAA) announced a “Food and Agricultural Product Loss Resolution,” which calls for members to halve food losses within their operations (and pursue reductions in their supply chains) by 2030. The GAA is a collaboration of nearly 20 companies involved in food and agricultural production, commodity trading, and processing. Membership includes some of the world’s largest food producers, such as Olam, and numerous companies with operations throughout Asia and Africa (WBCSD 2017).
- In 2018, a coalition of 17 Danish food retailers, food manufacturers, and the nonprofit organization Stop Wasting Food formed “Denmark against Food Waste,” wherein the companies committed to halving their food waste by 2030 and to measuring and publishing their food loss and waste data every year. The commitment includes Denmark’s largest retailer, Salling Group, as well as Danish operations of Arla, Nestlé, and Unilever, among others (Askew 2018).
- In 2019, eight food manufacturers and retailers committed to reduce food waste in their Canadian operations by 50 percent by 2025. The companies include Kraft Heinz Canada, Loblaw Companies Ltd., Maple Leaf Foods, Metro Inc., Save-on-Foods, Sobeys Inc., Unilever Canada, and Walmart Canada (National Zero Waste Council 2019).

These commitments mean that 32 of the world’s 50 largest food companies (by revenue) across the food supply chain independently have set, or participate in programs that have set, a food loss and waste reduction target consistent with SDG

12.3 (Flanagan et al. 2018). This number of companies setting targets since 2015 is an indication of growing momentum within the private sector on the food loss and waste agenda. However, the majority of companies doing so have been food retailers and manufacturers with headquarters in Europe or North America. For Target 12.3’s ambitions to be achieved, companies from across the entire food supply chain and from around the world will need to set food loss and waste reduction targets.

Measure

FAO’s *Global Food Losses and Food Waste* (2011) report estimated food loss and waste throughout the food supply chain, dividing the world into seven near-continental regions. Much government action to achieve SDG 12.3, however, will need to occur at the country or even subnational level. Measurement, therefore, will be needed at that scale to be actionable. Likewise, action by companies will need to be informed by company-level or supply-chain-level quantification.

Governments

Several developments since 2015 have advanced, or are advancing, progress on government measurement of food loss and waste:

- To assist governments with monitoring progress toward SDG 12.3, UN agencies have been developing national-level estimates of food loss and food waste. FAO has been leading the development of a “Food Loss Index” that will estimate food losses occurring within a country from farm gate up to, but not including, the retail level. The estimate for a country is based at a minimum on data about losses among 10 key food commodities produced in that country. In late 2018, the Food Loss Index was approved by the Inter-agency and Expert Group (IAEG) on SDG Indicators to be an official indicator for UN SDG monitoring. In complementary fashion, UNEP has been leading the development of a “Food Waste Index.” This index will be used by governments to estimate food waste within their country from its manufacturing, retail, hospitality, food service, and consumer sectors. The Food Waste Index will go before the IAEG for approval in 2019.

■ The European Union has issued estimates for food loss and waste levels across its member states—publishing its first baseline report in 2010 (Monier et al. 2010) while providing a more comprehensive estimate in 2016 (Stenmarck et al. 2016). In 2019, the European Commission adopted a common definition and measurement methodology to support member states in quantifying food waste across the food supply chain. Based on a common definition of food waste, the methodology is expected to enter into force in late 2019 following scrutiny by co-legislators, and will ensure coherent monitoring of food waste levels across the European Union. Member states will monitor their food waste levels from 2020 onward using this agreed methodology, with the first published results expected by mid-2022 (European Commission 2019).

■ A number of individual high-income countries have taken steps to start or improve their measurement of food loss and waste. The United Kingdom has been a leader in this regard, having countrywide estimates of food waste for 2007, 2010, 2014, 2015, and 2018 (WRAP 2018c). Japan has been collecting post-farm gate food loss and waste data since 2001 (Lipinski 2017). Since 2015, the United States has been estimating food loss and waste—both per capita and in absolute amounts (U.S. EPA 2016). In 2018, Denmark updated its food waste statistics for households (The Local 2018). New Zealand also published estimates of its domestic household food waste (Yates 2018). In 2019, Canada published its first estimate (Gooch et al. 2019) and Australia announced its first nationwide baseline assessment of food loss and waste (Arcadis 2019).

■ A number of middle-income countries are starting to measure, too. Argentina, for instance, started work to measure its food loss and waste—finding that up to 45 percent of fruits and vegetables are lost after harvesting (Postharvest Network 2017). In 2019, the Saudi Grains Organization and the Saudi Ministry of Environment, Water, and Agriculture found food loss and waste levels of approximately 33 percent throughout the food supply chain, primarily at the production and consumption stages (SAGO 2019). In 2018, the government

of Mexico established a base-year estimate for food loss and waste for the country. In Mexico, at least 20 million metric tons of food per year is lost or wasted from the farm gate to the retail stage, with an additional 11 million tons per year from households and small businesses (World Bank Mexico 2019). In 2019, the Asia-Pacific Economic Cooperation Forum, which comprises 21 member economies, published handbooks on how to conduct food loss and waste quantification, as well as how to establish public-private partnerships that support the reduction of food loss and waste along the supply chain (Chang and Hsu 2019a, 2019b).

■ In 2018, four African nations—Kenya, Tanzania, Zambia, and Zimbabwe—completed the first step of quantification of food loss and waste for single commodities. Kenya focused on maize, Tanzania on tomatoes, and Zambia and Zimbabwe on milk. The analysis covered from the point of harvest to the point of (but not including) processing. In 2018, the African Union Commission published its first Biennial Review Report, which tracks progress toward achieving the Malabo goals. The report shows that five countries are on track to achieve the postharvest loss reduction target by 2025: Malawi, Mauritania, Rwanda, Togo, and Uganda (African Union 2018).

As of early 2019, a number of countries were measuring food loss and/or waste within their borders. These include Australia, Canada, Denmark, Estonia, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Saudi Arabia, Slovenia, Spain, the United Kingdom, and the United States—nations that are home to 12 percent of the world's population.

Measurement by cities appears to be much less advanced. Examples of those measuring include Vancouver, Canada, which conducted baseline research in 2015 into the amount of food waste generated by households (Metro Vancouver 2015). In 2017, the Natural Resources Defense Council (NRDC), with support from The Rockefeller Foundation, estimated the amounts, sources, and types of food going to waste in three U.S. cities: New York City, Nashville, and Denver (Hoover 2017). UNEP and WRAP have been supporting quantification of household food waste in Jeddah, Saudi Arabia, since 2017 (Savola Negaderha 2019).

Companies

Companies have been making progress on measuring their food loss and waste. In 2015, only a handful of companies were measuring, but by early 2019 at least 30 companies in the Forbes Global 2000 were measuring their food loss and waste. Not all companies, however, are publicly reporting the results of their food loss and waste inventories.²⁴ Lack of public reporting hinders efforts to track industry progress over time, fill data gaps in national inventories, share best practices, and motivate other companies to measure.

The rise in corporate measurement of food loss and waste over the past few years began with companies focusing solely internally. Such business-level data are valuable for identifying hot spots of food loss and waste within one's own operations, as well as for starting to understand the underlying drivers. But some companies are now pushing measurement up their supply chains, recognizing the need for a "whole chain approach." For example, in 2017 Tesco announced partnership agreements with 27 of its largest food suppliers wherein the suppliers would measure food waste within their own operations and publish the resulting inventories by September 2018 (Tesco 2017). Similarly, Nestlé has been quantifying upstream food loss and waste, working with suppliers to quantify losses from farm to factory on a commodity basis (Box 5.3). However, to achieve the scale of reductions called for by SDG 12.3, many more companies will need to follow suit and actively work with their suppliers to measure food loss and waste.

Cross-cutting

Since the launch of the SDGs, there have been several efforts to improve measurement to benefit both governments and companies:

- **The Food Loss and Waste Accounting and Reporting Standard (FLW Standard).** Launched in 2016, the FLW Standard provides global requirements and guidance for quantifying and reporting on the weight of food and/or associated inedible parts removed from the food supply chain (Food Loss and Waste Protocol 2016).²⁵

BOX 5.3 | GLOBAL COMPANIES MEASURE AND MANAGE LOSSES

From 2017 to 2018, Nestlé reduced its rejection of maize at its facilities in Nigeria from 17 percent to 4 percent due primarily to improvements in postharvest management practices. In 2017, workers hired by Nestlé's suppliers to manually clean and sort grains at warehouses were unable to sufficiently sort moldy grains (for mycotoxins) and clear dust (for aluminum phosphide residue). This resulted in a high rejection rate due to contamination. In 2018, Nestlé rolled out a program to ensure that suppliers fully implemented its standard operating procedures for warehouse grains management. Increased compliance resulted in the rejection rate falling by more than 75 percent.

In 2018, Olam, in partnership with Wageningen University & Research and the Sustainable Food Lab, measured how much rice was lost across smallholder rice farms. Following a participatory workshop and field trials, they calculated postharvest losses to be 35 percent, equivalent to a loss of US\$520 per hectare for the farmer and 97 million servings of rice, based on the volumes procured by Olam in 2017 (Olam International 2018). Good agricultural practice training is now being developed to emphasize harvesting and handling techniques to reduce losses. At its oil palm plantations, Olam identified approximately 9 percent losses, which were primarily associated with manual harvesting and collection of palm fruit bunches. To tackle these losses, Olam has developed and is piloting Agripal, a mobile app designed to reduce crop losses by recording real-time data on harvested, collected, and uncollected bunches with a geotagging functionality traced back to individual harvesters and exact locations.

Sources: J. Charad, Nestlé, personal communication, 2019; and C. Brown, Olam, personal communication, 2019.

- **The Food Waste Atlas.** Launched in 2018, the atlas is a global repository of quantified food loss and waste data through which users can search by combinations of location, food category, and stage in the supply chain (Flanagan et al. 2018).²⁶
- **The FLW Value Calculator.** Launched in 2018, this online calculator enables companies,

governments, and other entities to estimate the environmental impacts (on greenhouse gas emissions, water usage, etc.) and nutritional impacts (macronutrients, micronutrients, etc.) of food loss and waste by geography and by food commodity (Flanagan et al. 2018).²⁷

- **Multiple quantification methods.** For instance, FAO prepared its Food Loss Analysis Case Study Methodology, designed to help analysts quantify losses, loss points, and causes in specific food supply chains in a country. In 2018, IFPRI and the Consultative Group on International Agricultural Research (CGIAR) developed a food loss methodology (including valuation of economic losses) involving self-reported surveys for commodities in specific countries.

Act

The public and private sector commitments to set targets and measure suggest a growing momentum to address food loss and waste. At present, many of these commitments are collective expressions of intent. However, intent needs to be translated into action and results if significant reductions in food loss and waste are to be achieved.

Efforts to address food loss and waste are not new, and activity in many places has been ongoing for some time. The highlights below are organized according to the stage in the food supply chain where food loss and waste otherwise would have occurred. They are not exhaustive—and examples from member countries of the Organisation for Economic Co-operation and Development tend to dominate what can be discovered in publicly available data—but rather are intended to give an indication of some early-stage “trends” across a range of geographies that have gained traction since the launch of the SDGs.

Production

- **Information and communication technology (ICT) is supplying smallholders with technical information to reduce production losses.** In 2018, Farm Radio International, with the support of The Rockefeller Foundation, launched a consortium of local radio stations and nonprofits to deliver

technical advice on postharvest loss reduction. Interactive radio, television programs, and mobile videos provide farmers in Kenya, Nigeria, and Tanzania with the information they need and connect them with input suppliers (Farm Radio International 2018). Scientific Animators without Borders provides extension information via animated videos that are available in a number of languages on topics such as how to build a solar grain dryer and how to hermetically seal produce using locally available containers (SAWBO 2019).

- **ICT platforms are increasingly being used to connect farmers with markets to respond more quickly to changes in supply and demand.** For example, since 2015, the business-to-business e-commerce platform Freshdeal, operating in Europe, pairs fresh produce sellers with buyers, enabling buyers with emergency shortages of fresh produce to quickly purchase stocks from farmers with unexpected surplus (Freshdeal 2019). Twiga Foods, based in Kenya, also provides a mobile platform that links smallholder farmers to informal food vendors in urban areas. The company operates a central packhouse with cold storage facilities and a fleet of vans that allow for quick collection of produce, resulting in postharvest losses of only 5 percent, compared to around 30 percent at informal markets. Twiga Foods works with over 13,000 farmers and 6,000 vendors across Kenya (Twiga Foods 2018).
- **Legislation is targeting contract behavior that exacerbates production losses.** In 2018, the European Commission set new rules on unfair trading practices, prohibiting, for example, late payment for perishable food products, last-minute order cancellations, and retroactive changes to contracts (European Commission 2018).
- **Imperfect produce is increasingly available for sale.** Retailers, particularly larger retailers that typically stock higher-grade produce, are increasingly selling, often at a discount, fruits and vegetables as “wonky” or “imperfect” food. Previously, this produce would have failed to meet retailer cosmetic

standards due to blemishes or nonstandard shapes, and thus would have been discarded by farmers. Imperfect food labels are now available in a number of countries, including Brazil, Denmark, France, the United Kingdom, and the United States. Likewise, some retailers are committing to “whole crop” purchases.

Handling and storage

- **Low-cost handling and storage technologies are gaining traction in Africa.** For decades there has been an interest in introducing storage technologies for smallholders in Africa. Over the past few years, some of these technologies have gained traction. For example, by 2017 Purdue Improved Crop Storage (PICS) bags—a form of hermetically sealed, large, three-ply plastic storage bags for cowpeas and other crops—had been distributed to more than 12.5 million farmers (Purdue University 2018). The Postharvest Loss Alliance for Nutrition in Nigeria (PLAN-N) has started working with the Lagos government and the Nigerian Ministry of Agriculture to promote the use of plastic crates for postharvest handling to reduce tomato losses. More than 80,000 of these crates have been purchased that together can hold 1.6 million kg of fresh tomatoes that are now more likely to reach the consumer (Gain Health n.d.).
- **Technology innovations to reduce losses during transportation of fresh produce are emerging.** The mobile app Cheetah, for instance, allows food value chain players such as growers and transporters to share information on shortcomings within the food value chain, including delays and unforeseen costs such as the breakdown of vehicles due to poor road conditions. This information can then be used to demand improvements to infrastructure, show traders the fastest route to market, and provide more accurate data on postharvest losses during handling and transportation (Cheetah 2018). In Uganda, the Fruti-Cycle Project provides biogas-powered tricycles with cold storage units able to carry 300 kg (Global Knowledge Initiative 2017). According to its designers, the tricycle will provide more than a 15 percent return on investment in the second year of use (Bayer Foundations 2017).

- **Investment in storage infrastructure is growing.** For example, in 2018, the government of India and the National Cold Chain Development Board provided funding support for developing more than 2,000 fruit and vegetable packinghouses by 2021 (Kulkarni 2017). In 2018, the “One District, One Warehouse” project was launched by the government of Ghana. The initiative aims to build 50 units of 1,000-metric-ton warehouses in selected districts that will provide storage for farmers and their produce (GhanaWeb 2018). AgResults, which uses “pay-for-results” competitions to incentivize the private sector to invest in agricultural innovations, worked in Kenya to incentivize the private sector to develop and sell on-farm storage devices. By 2018, it had reached nearly 329,000 smallholder farmers and sold over 1 million improved storage devices, resulting in approximately 413,000 metric tons of improved storage capacity (AgResults 2018).

Processing and packaging

- **Unsold produce is being turned into upcycled products.** A growing number of start-ups are turning leftover produce into juices, soups, sauces, and other “upcycled” food products. For instance, Unilever’s Hellman’s Red and Green Tomato Ketchup is saving an estimated 2.5 million tomatoes every year that would have otherwise been discarded during processing for not being “red enough” (Unilever 2018). In Kenya, a new smallholder aggregation and processing center for mangoes has been established. The facility is equipped with low-cost storage technologies that enable farmers to aggregate their produce and negotiate better prices, as well as juice processing and drying facilities that allow farmers to transform fresh mangoes into value-added products such as pulp, juices, and dried chips—which fetch a better price at market (Ambuko 2019).
- **Technology innovations in packaging are being used to extend product shelf life.** Mitsubishi, for example, has developed NutraSave, a resin that can be layered onto flexible packaging such as pouches and films to reduce oxygen absorption, thereby preserving

food longer—even potentially doubling the shelf life of some products (Packaging Strategies 2017). Royal DSM has created “Pack-Age,” a product for the cheese industry that allows cheese to mature without developing a rind that has to be thrown away, meaning the whole cheese can be used (DSM 2018).

- **Innovations to postpone spoilage are emerging.** For example, Apeel Sciences has developed a range of invisible, edible, all-natural coatings that are applied to fresh produce to extend shelf life. This coating acts as a physical barrier that slows down the rate of water loss, oxidation, and microbial activity (Apeel Sciences 2019). Companies such as Nanology, FreshPaper, and Bluapple have started manufacturing discs and pods that go inside refrigerators or fruit bowls and absorb the gases that accelerate ripening, keeping fresh produce fresher for longer (Goodwin 2019).

Distribution and market

- **Governments are enacting policies to encourage and even require redistribution of surplus food.** Since 2015, countries including Argentina, France, Ghana, and Italy have passed legislative measures and tax incentive schemes that make redistributing surplus food easier (Flanagan et al. 2018; Lemos 2018; Zero Waste Europe 2016; Michail 2019).²⁸ In the United States, several states, including Arizona, Colorado, Kentucky, Oregon, and Virginia (as well as the District of Columbia), now have tax incentives to encourage food donation (Gunders and Bloom 2017). The Czech Republic and France have adopted legislation that requires large supermarkets to donate unsold yet still safe and wholesome food to charities (Prague.tv 2017; Durandsmet 2018).²⁹
- **Apps for redistributing surplus food from retailers are growing in number.** Mobile apps such as FoodCloud and Food Rescue Hero are now helping accelerate the redistribution of unsold food by connecting retailers with surplus food with those in need, with Food Rescue Hero even coordinating transport of the surplus and tracking the impact of this redistribution on hunger and the environment (412 Food Rescue 2018).
- **Accelerator programs for food loss reducing technologies are being established.** Maersk Growth has partnered with Rockstart, a start-up accelerator, to create FoodTrack by Maersk, an accelerator program for start-ups that are trying to reduce food loss. Graduates from the first program include Tsenso, a technology that monitors the temperatures at which a product was stored along the whole supply chain to provide a more accurate shelf life indicator for food (Gunders 2018).

Consumption

- **Apps for redistributing surplus food from food service and restaurants are becoming more widespread.** Apps that connect restaurants and food service companies with unsold or leftover food to customers who want it are emerging across the globe. No Food Waste, operating in India, rescues food from weddings, parties, and other functions and redistributes this food to the needy (No Food Waste 2019). Apps 11th Hour, operating in Singapore, and Too Good To Go, operating in nine European countries, enable customers to pick up meals that are near their expiry from restaurants and food stalls at a discount.
- **Retailers and food manufacturers are streamlining food date labels.** Consumer confusion about date labels can be an underlying driver of household food waste.³⁰ Recognizing this, the CGF announced in 2017 a worldwide “Call to Action” to standardize food date labeling by 2020, calling for food manufacturer and retailer CGF members to use only one food date label per product—either one communicating food quality for nonperishable items or one communicating food safety for perishable items (Lipinski et al. 2017).
- **Awareness raising campaigns are being launched.** The “Love Food, Hate Waste” campaign created by WRAP for the UK market in 2007 has been adapted and introduced in other countries, including Australia, Canada, New Zealand, and Saudi Arabia (WRAP 2019a). Since launching in the United States in 2016,

the NRDC and Ad Council “Save the Food” campaign has raised awareness of food waste as an issue from 32 percent in 2016 to 47 percent by 2018 (Ipsos Public Affairs 2019). Several other countries, including Brazil (Sem Desperdicio 2019), Germany (BMEL 2015), and Mauritius (University of Mauritius 2018), as well as cities including Buenos Aires (Jaegerfelt 2018) and Dubai (Saseendran 2017), have launched public awareness campaigns, too.

- **The hospitality sector is starting to take action.** For example, the AccorHotels chain has partnered with the redistribution app Too Good to Go since 2016, saving over 32,000 meals (Mullan 2018). In 2018, 130 chefs from 38 countries launched the “Chef’s Manifesto” action plan, which provides practical guidance for chefs to reduce food waste in commercial kitchens (SDG2 Advocacy Hub 2018).

Across the supply chain

- **Some countries are establishing national strategies to tackle food loss and waste.** In 2018, the African Union Commission announced its “Continental Post Harvest Management Strategy,” designed to help member states develop policies and strategies to address postharvest food losses across the food supply chain. Four African nations recently completed their complementary national postharvest food loss reduction strategies: Ethiopia, Kenya, Zambia, and Zimbabwe. Tanzania’s is in process of being prepared. Between 2017 and early 2019, Australia, Croatia, Germany, Portugal, and the United Kingdom announced national strategies to tackle food loss and waste. In 2019, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), and the U.S. Food and Drug Administration (FDA) announced a joint strategy to reduce food waste. The strategy will focus on consumer education, improving guidance on measurement, clarifying food date labels, and leveraging public-private partnerships (U.S. EPA 2019).
- **National-level public-private partnerships are beginning to emerge.** An increasing number of national-level public-private partnerships focused on reducing food loss and waste have been inspired by the first such partnership—the Courtauld Commitment—launched in the United Kingdom more than a decade ago. In 2016, the USDA and EPA formed the Food Loss and Waste 2030 Champions group (USDA 2018). The Netherlands came next, launching in early 2017 United against Food Waste, a public-private partnership that is part of the Dutch national agenda to halve food waste by 2030 (REFRESH 2018). In 2018, four EU REFRESH pilot countries—Germany, Hungary, Spain, and China—launched voluntary partnerships or national platforms that aim to reduce food loss and waste (REFRESH and WRAP Global 2019). This was followed by a coalition of companies, government agencies, and non-governmental organizations recently launching the “Food Loss and Waste Action Partnership—Indonesia,” which is dedicated to reducing food loss and waste within the country (Flanagan et al. 2018). In 2018, the Australian government launched the 10-year Fight Food Waste Cooperative Research Centre, a public-private partnership that involves 46 industry and 10 research partners to investigate methods to increase food donation as well as develop household and business behavior change programs (Fight Food Waste CRC 2018).
- **New sources of funding are becoming available for reducing food loss and waste.** In 2019, the World Bank launched the first Sustainable Development Bond. Swedish insurance and pensions group Folksam is investing US\$300 million in the three-year bond (World Bank 2019). In 2016, The Rockefeller Foundation launched YieldWise, a \$130 million investment, to demonstrate practical approaches to halving food loss and waste by 2030. The program focuses on reducing food loss in Kenya, Nigeria, and Tanzania, as well as food waste in Europe and North America (Rockefeller Foundation 2019). Early results for reductions in food losses are promising (Box 5.4). Public sector funding can also play a role in supporting solutions to food loss and waste. For example, in 2019, the Foundation for Food and Agriculture Research (FFAR), a grant-making body established by the U.S. govern-

ment, funded the Consortium for Innovation in Post-harvest Loss and Food Waste Reduction, which aims to develop a scalable approach for adoption of the YieldWise model (FFAR 2019a). The FFAR also provided funding to Cornell University to develop a way to convert agricultural waste into snacks (FFAR 2019b).

- **Online databases and hubs to support exchange of information and solutions have been established.** In response to a G20 recommendation, FAO and IFPRI launched the Technical Platform on the Measurement and Reduction of Food Loss and Waste in 2015 to facilitate information-sharing on practices and solutions. In 2017 alone, the USDA, EPA, and a number of NGO and industry partners launched *Further with Food*; Rethink Food Waste through Economics and Data (ReFED) launched online the Innovator Database and the Policy Finder (ReFED 2018); and Wageningen University & Research launched the REFRESH Community of Experts (2019). In 2018, the IVL Swedish Environmental Research Institute established the platform Reducing Food Waste, which compiles news and information with the aim of encouraging stakeholders in China to reduce food waste.³¹

Evidence of Impact

In light of the above, evidence is emerging of actual reductions in the amount of food that is lost and wasted.

Governments

Data are available on the reduction of food loss and waste for a small subset of efforts at the national or city level. Often these reductions are a result of efforts by governments working in collaboration with NGOs and/or businesses. There have been several notable examples of progress:

- Between 2007 and 2012, the United Kingdom implemented a targeted effort to reduce food waste in the home, restaurant, and food retail (the market and consumption stages of the food supply chain). This effort resulted in a reduction in avoidable post-farm gate food waste of 19 percent in the United Kingdom (measured in kilograms per person) between 2007 and

2015, the largest known decline in food loss or food waste at the national level in the world in recent history (WRAP 2018c).

- Between 2010 and 2015, food waste in Norway across industry, wholesale, retail, and households was reduced by 12 percent on a kilogram per person basis. This reduction followed the launch of the From Waste to Resources program, which implemented a number of strategies to reduce food waste, including simplifying date labels and educating consumers about date labels, meal planning, and proper storage (Stensgård and Hanssen 2016).
- Between 2011 and 2017, Danish households reduced avoidable food waste by an average of 8 percent per capita (The Local 2018).
- New Zealand ran a “Love Food, Hate Waste” campaign between 2015 and 2018. The campaign specifically targeted demographic groups with high levels of food waste, such as young people and families with young children, rather than the general population. Following the campaign, a garbage bin audit showed that 27 percent less food waste was sent to landfill by households aware of the campaign (Waste-MINZ 2018).
- Redistribution of surplus food to charities and others grew by 50 percent between 2015 and 2017 in the United Kingdom. The combined increase totaled 14,500 metric tons, the equivalent of an extra 35 million meals per year (WRAP 2018d).
- Seoul, South Korea, implemented a pay-as-you-throw policy in 2013 that requires Seoul’s 10 million residents to pay for the food they waste by weight. Between 2013 and 2017, Seoul’s overall food waste decreased by 10 percent. The scheme is being rolled out to 16 other cities and provinces across the country (PBS *News Hour* 2017).

Companies

A body of data is starting to emerge about the impact of recent business efforts to reduce food loss and waste, with a number of examples:

- In 2015, Walmart started implementing a food waste reduction program in its Canadian stores. Steps implemented included introducing process improvements (e.g., improved ordering and forecasting), creating an “antiwaste” culture in stores, and increasing redistribution efforts. In-store food waste was reduced by 23 percent by year-end 2017 (Probert 2018).
- Unilever reduced food waste in its manufacturing operations by 37 percent between 2016 and 2017, with less than 1 percent of wasted food now going to landfill (Unilever 2019).
- Between 2017–18 and 2019, Tesco halved the amount of food safe for human consumption going to energy recovery. Overall, this led to the amount of food going to waste in Tesco’s UK operations in 2019 falling by 17 percent (0.45 percent sales), compared to the previous year (Tesco 2019).
- A 2018 study of food waste reduction programs of 86 food service sites across six countries found that food service providers³² achieved on average a 36 percent reduction of food waste (measured by weight) over a 12-month time frame, and over three years the average site reduced food waste by 44 percent (Clowes et al. 2018a). Steps leading to such reductions included introducing scales in kitchens that weigh and estimate the monetary value of food just before it is thrown into the garbage bin, training chefs and staff, reducing menu items that are consistently underconsumed, and repurposing leftovers for use in other menu items (Clowes et al. 2018a).
- A 2017 study of food waste reduction programs among 42 hotel sites across 15 countries found that, on average, hotels achieved a 21 percent reduction of food waste (measured by weight) during the first 12 months of the programs (Clowes et al. 2018b). A key action identified to reduce waste in hotels was rethinking the buffet, which tends to be the source of a significant amount of waste within the hotel industry. Strategies to reduce waste in buffets include providing individual servings rather than pans of food, displaying messaging about food waste near the buffet, and selling leftovers from the buffet later in the day (Clowes et al. 2018b).
- For a number of years, the Kellogg Company has implemented food loss and waste reduction activities, including working with TechnoServe to reduce losses at the farm and simplifying date labels. In 2017, Kellogg’s manufacturing operations achieved an overall reduction in food waste of roughly 5 percent compared to the year before (Kellogg Company 2019).
- Between 2016 and 2017, Danone reduced unrecovered food waste³³ by nearly 11 percent globally. Reductions were achieved by providing training to farmers to reduce milk losses, training staff on best practices to reduce waste in company operations, and creating a food donation program (Danone 2017).
- Between 2015 and 2017, AMT Fruit, one of the United Kingdom’s largest citrus specialists, reduced overall operation food waste by 27 percent. This reduction was achieved by broadening product specifications, introducing new product lines that feature food produce that previously would have fallen outside of specifications, such as “giant” varieties, and developing partnerships with food charities that redistribute unsold food (AMT Fruit 2018).
- In 2017, cruise ship operator Costa Cruises implemented a program to reduce food waste in ship kitchens, the buffet, and customer plates by 50 percent by 2020 across its entire fleet of ships. Steps taken to reduce food waste included using scales to quantify the amount, type, and monetary value of food waste generated in kitchens, as well as launching a communication initiative to encourage responsible consumption in buffets. By 2018, the company was already over halfway toward achieving its target (Klupacs 2018).
- In 2017, IKEA launched its Food Is Precious initiative to reduce kitchen food waste in its in-store restaurants. The company implemented a number of steps across more than 100 sites, including setting a clear goal to reduce food waste by half, using smart scales to measure the type of food thrown away and the reason behind the waste, and engaging coworkers by appointing a Food Waste Champion in each store. Just 12 weeks into implementation,

IKEA had seen an average waste reduction of 20 percent, and some sites experienced a

reduction as high as 54 percent after six months (IKEA 2019).

BOX 5.4 | EVIDENCE OF ON-FARM LOSS REDUCTION FROM THE YIELDWISE INITIATIVE IN KENYA, NIGERIA, AND TANZANIA

The YieldWise Initiative in partnership with the private sector and government has supported more than 200,000 farmers in Kenya, Nigeria, and Tanzania to improve in the following areas:

1. Access to appropriate loss-reducing technologies.
2. Access to finance by collaborating with financial institutions to develop credit products that can be accessed by farmers and farmer-based organizations.
3. Aggregation and training of farmers and other supply chain actors in postharvest management and facilitation of development of local aggregation centers.
4. Access to markets by stimulating demand, engaging actors across the diverse ecosystem of buyers.

The early results are encouraging, with catalytic demonstrations for maize, mangoes, and tomatoes indicating loss reduction of between 20 and 30 percent, while more farmers are being connected to market channels and have been provided with assured markets for their produce.

Early evaluations of the three YieldWise initiatives have shown that the projects have significantly advanced the use of postharvest loss reduction technologies and practices, while case study examples show a link between YieldWise activities and enhanced well-being of individual smallholder farmers.

Mangoes in Kenya

While long a feature of Kenyan agriculture, mango farming has expanded considerably in recent years, with production increasing by 36 percent between 2012 and 2016. This rise in production has been accompanied by a 91 percent rise in gross revenues, over the same period, with 2016 revenues of nearly 12,000 million Kenyan shillings (KES) (approximately \$120 million). The rate of postharvest loss for mangoes in Kenya is high, with estimates ranging from around 40 to 50 percent of production (Ambuko 2016).

The YieldWise Initiative focused on expanding the effective use of the loss-reducing technologies and practices, including fruit fly traps, tarps, crates, and cold storage units. By mid-2018, nearly 21,000 smallholder farmers had received training, and individual loss-reducing technologies were used over 70,000 times by these smallholder farmers. On average, a farmer who adopted one YieldWise technology had a yield of approximately 90 more mangoes, an increase of approximately 35 percent. For each additional practice adopted, more than 45 additional mangoes per tree made it to market.

Case studies have documented the qualitative impact of the YieldWise Initiative on individual smallholder farmers in three of Kenya's counties. In Meru County, a female farmer who has been farming for 30 years was trained by the YieldWise program to control destructive pests that had previously caused losses in thousands of her mangoes. Using

fruit fly traps, she started to have successful harvests of good quality mangoes and now generates a net income of approximately KES 300,000 (about \$3,000) per harvest.

The YieldWise Initiative has also benefited the families of smallholder farmers. As a result of increased mango production and higher earnings, program beneficiaries were better able to support their families, for example, by paying school fees and university tuition for their children, accessing health care services, and improving their homes. Farmers reported that they have improved their homes by plastering them and connecting to the electric grid where available or placing solar panels on their roofs. Farmers also noted an increase in their social standing and influence on their communities because of the respect they gained by having become more successful in the production of mangoes and other crops they produce on their farms.

A number of YieldWise program farmers have become leaders of farmer groups that meet on a regular basis to exchange knowledge and experiences, explore additional entrepreneurial activities, and further improve the livelihoods of their families. The quantitative data show that participation in these groups was associated with better farming outcomes. For example, one group of mango farmers is currently pooling their resources to invest in placing a 40-foot container on the property of the lead farmer to aggregate their mangoes and precool them for a buyer with whom they

BOX 5.4 | EVIDENCE OF ON-FARM LOSS REDUCTION FROM THE YIELDWISE INITIATIVE IN KENYA, NIGERIA, AND TANZANIA (CONTINUED)

have a multiseason contract. They are sharing expenses, with farmers paying 70 percent and the buyer 30 percent. The farmer group will own the container 100 percent and is equipping it with solar panels to power the precooling system. In addition to mangoes, they intend to use the container to aggregate other produce they grow on their farms, including high-value crops such as avocados. This highlights the scalability of the YieldWise program and its whole-farm impact on the other crops smallholder farmers grow.

Maize in Tanzania

Maize is a food staple of major importance for Tanzania's economy, cultivated by most farmers both to ensure household food sufficiency and for commercial purposes. This importance is illustrated by the fact that maize occupies 45 percent of the country's cultivated land, making Tanzania East Africa's largest maize producer.

Starting in 2016, the YieldWise Initiative introduced smallholder farmers to a series of postharvest loss reduction technologies, including mechanized dehusking, mechanized threshing, tarp use, and improved storage practices. By the end of 2016, more than 25,000 smallholder farmers had been trained in the use of at least one of these technologies. The use of mechanical dehusking

almost doubled to 24 percent among beneficiary farmers, and the use of tarps for sun drying increased to 88 percent. Over the project's duration, postharvest losses were substantially reduced. For example, while the beneficiary farmer group reported losses of 19 percent, losses in the control farmer group exceeded 39 percent, meaning that the YieldWise beneficiary farmers lost approximately half less than the control group. Beyond these benefits, farmers who adopted improved storage technologies such as hermetic bags and plastic silos reported improvement in the quality of maize stored for consumption, with maize remaining free from pesticides, aflatoxin, and damage by pests (WFP 2019).

Tomatoes in Nigeria

Nigeria is the second-largest producer of tomatoes in Africa, with approximately 1.8 million metric tons of fresh tomato fruits produced for domestic consumption annually. Tomatoes are a major food component used by every household, contributing to the national food security program. They have the added advantage of being an annual crop with high yield—making it a crop of high economic potential to farmers. However, the national demand of about 2–3 million metric tons annually results in a demand gap of about 500,000 metric tons for tomatoes

grown domestically. The demand gap is primarily addressed with imported processed tomato products.

YieldWise has delivered training in loss-reducing practices that fosters value addition, improved agronomic practices, and created market access. About 86 percent of farmers who participated in these programs reported that they apply what they learned from this training, and 61 percent of farmers strongly agree that postharvest loss has been reduced as a result of the training provided. The group of farmers who received training had significantly higher yields than did those in the control group, as well as suffering fewer losses during transportation thanks to a modest increase in the use of plastic crates and sales to aggregation centers, which reduced transportation distance. Of participating farmers, 56 percent strongly agreed that their profits improved as a result of YieldWise training. Furthermore, intervention farmers also saw a significant decrease in postharvest losses. In 2016, 37 percent of the tomatoes harvested were lost at postharvest, while in 2017 that number dropped to 17 percent—meaning losses were reduced by 54 percent.

Sources: Genesis Analytics (2018); Ipsos Tanzania (2017); Pyxera Global (2019); Vandercasteelen (2019).

A Critical Caveat

The dearth of examples is evidence that too few governments and businesses have yet completed both a base-year quantification of food loss and waste and a follow-up quantification (i.e., a “before” and “after” measurement). This is somewhat understandable given the novelty of the modern food loss and waste movement; most countries and companies are just starting.

More concerning, though, is the proverbial ticking clock when it comes to the SDGs. With just 11 years to go, no one is yet able to determine by how much *the world overall* has reduced food loss and waste since the advent of the SDGs. This is because global base-year data (for example, food loss and waste in 2015) have not yet been reported and no follow-up quantification of global food loss and waste levels has been conducted since FAO’s 2011 report. This data gap is serious and needs to be addressed.

Over time, as more and more countries conduct national food loss and waste inventories, a global picture should emerge. Moreover, as discussed earlier, FAO and UNEP are working to develop national-level estimates for both food loss and food

waste (i.e., the Food Loss Index and the Food Waste Index). But it is important to note that the first figures of the Food Loss Index, to be released in late 2019, will not be comparable to the earlier FAO (2011) figures because the scope of what is being estimated (in terms of stages of the food supply chain, commodities, destinations of food loss and waste, and the calculation method used) is different.³⁴ Likewise, member states of the European Union will start reporting their national food loss and waste figures by the end of 2022. Once these measurements are under way, base-year figures are completed, and a subsequent measurement occurs, the world should start to have an indication of national and global progress in reducing food loss and waste. However, significant effort is still needed, and civil society and NGOs working on food loss and waste can play an important role in encouraging companies and governments to set targets and measure food loss and waste, holding them accountable to these commitments. As more and more companies quantify their food loss and waste, the private sector will be better able to identify whether the sum of their actions is also adding up to meaningful reductions of food loss and waste. But all this measurement is not a foregone conclusion. A concentrated effort is still needed.





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CHAPTER 6

WHAT NEEDS TO HAPPEN NEXT?

If SDG 12.3 is to be achieved, much more needs to be done to scale efforts to reduce food loss and waste. This chapter introduces 10 scaling interventions that could accelerate and broaden deployment of solutions.

SUMMARY POINTS

- This report introduces a **Global Action Agenda** as a promising approach to accelerate the reduction of food loss and waste at scale.
- One component of this agenda is the Target-Measure-Act approach, as outlined in Chapter 4.
- A second component of this agenda is the suite of to-do lists of specific interventions for each of the major actors in the food supply chain, as also outlined in Chapter 4.
- A third component of this agenda is a set of 10 scaling interventions designed to ramp up across multiple actors and geographies deployment of Target-Measure-Act and the to-do list of specific interventions. Some of these engage supply chains, some target specific hotspots identified in Chapter 1, and others support enabling conditions for reducing food loss and waste.

Whole supply chain approaches

1. *Develop national strategies for reducing food loss and waste.* Increase the number of countries with national strategies, as these can be an important catalyst for Target-Measure-Act at the country level—aligning public policy, private sector action, and farmer-to-consumer behavior toward a shared goal.
2. *Create national public-private partnerships.* Increase the number of country-level public-private partnerships dedicated to achieving SDG 12.3.

3. *Launch a “10x20x30” supply chain initiative.* Launch a voluntary private sector campaign where at least 10 corporate “power players” commit to Target-Measure-Act themselves and then engage their own 20 largest suppliers to do the same, with a shared goal of halving their food loss and waste by 2030.

Hotspot-specific approaches

4. *Invalidate efforts to strengthen value chains and reduce smallholder losses.* Invalidate efforts to help smallholder farmers reduce food losses during production and storage.
5. *Launch a “decade of storage solutions.”* Kick-start a focused collaboration among storage providers, cold chain alliances, financiers, and governments to get income-sensitive, climate-smart storage technologies into the hands of farmers and distribution networks around the world.
6. *Shift social norms.* Leverage the latest findings of behavioral science, engage grassroots campaigns, social media, religious communities, and others to make “wasting food” as unacceptable as littering now is in many countries.

7. *Go after greenhouse gas emissions reductions.* Use sector-led programs to tackle food loss and waste from beef, dairy, and rice head on, and get the reduction of food loss and waste into nationally determined contributions to the Paris Agreement on climate change.

Enabling approaches

8. *Scale up financing.* Develop funds and financing products dedicated to investing in enterprises, technologies, and programs designed to reduce food loss and waste.
 9. *Overcome the data deficit.* Over the next five years, launch a concentrated push to measure food loss and waste and overcome this data deficit in time to support achievement of SDG 12.3.
 10. *Advance the research agenda.* Target research on multiple “next generation” questions that would, in turn, help refine food loss and waste reduction strategies and advance implementation of the global agenda.
- Actors ranging from governments, businesses, farmers, consumers, and everyone in between can play a role in the **Global Action Agenda**. With worldwide participation we just might realize a future where no food fit for consumption goes to waste.

Food loss and waste is a major global challenge (Chapter 1) that must be addressed for a range of reasons (Chapter 2). It has a variety of causes and underlying drivers (Chapter 3). Fortunately, many interventions exist for reducing food loss and waste; there is a to-do list for each major type of actor in the food supply chain (Chapter 4). Some governments and businesses are already making progress at implementing some of these interventions (Chapter 5). However, the evidence and practitioner

interviews suggest that the world still has a long way to go. More must be done, and done much faster, if SDG 12.3 is going to be met.

The solutions to food loss and waste will vary depending on the specific context. This report suggests a **Global Action Agenda** as one possible strategy to help accelerate progress toward achieving SDG 12.3. Chapter 4 introduces two components of this agenda. One is the simple yet widely applicable request for entities to Target-Measure-Act. A second component is the suite of

to-do lists of high-impact interventions for each major actor in the food supply chain. These are specific interventions that actors can take to kick-start immediate progress in reducing food loss and waste. But a third component is also needed: a suite of scaling interventions designed to ramp up implementation of these specific ones.

Most of the specific interventions on the to-do lists already exist; the issue is that too few are deploying them. Why? In some cases, it may be lack of awareness, concern, or focus regarding food loss and waste. In others, it may be a lack of ability or resources (e.g., technical, financial). And in still others, it may be lack of collaboration across a large number of actors to effect the needed change. The scaling interventions seek to address these bottlenecks.

With input from interviews of representatives from the private sector, governments, and research institutions, we have identified 10 possible scaling interventions that have the potential to accelerate and broaden deployment of the Target-Measure-Act approach and deployment of the needed actor-specific interventions. Three of them take a whole supply chain approach, four of them target specific hotspots of food loss and waste, and three more enhance some of the enabling conditions for reducing food loss and waste. They may not constitute a comprehensive set, but they are a start.

Whole supply chain approaches

- 1. Develop national strategies for reducing food loss and waste.** Increase the number of countries with national strategies, as these can be an important catalyst for Target-Measure-Act at the country level—aligning public policy, private sector action, and farmer-to-consumer behavior toward a shared goal.
- 2. Create national public-private partnerships.** Increase the number of country-level public-private partnerships dedicated to achieving SDG 12.3.
- 3. Launch a “10x20x30” supply chain initiative.** Launch a voluntary private sector campaign where at least 10 corporate “power

players” commit to Target-Measure-Act themselves and then engage their own 20 largest suppliers to do the same.

Hotspot-specific approaches

- 4. Invigorate efforts to strengthen value chains and reduce smallholder losses.** Invigorate efforts to help smallholder farmers reduce food losses during production and storage.
- 5. Launch a “decade of storage solutions.”** Kick-start a focused collaboration among storage providers, cold chain alliances, financiers, and governments to get income-sensitive, climate-smart storage technologies into the hands of farmers and distribution networks around the world.
- 6. Shift consumer social norms.** Leveraging the latest findings of behavioral science, engage grassroots campaigns, social media, religious communities, and others to make “wasting food” as unacceptable as littering now is in many countries.
- 7. Go after greenhouse gas emissions reductions.** Use sector-led programs to tackle food loss and waste from beef, dairy, and rice head on, and get the reduction of food loss and waste into nationally determined contributions to the Paris Agreement on climate change.

Enabling approaches

- 8. Scale up financing.** Develop funds and financing products dedicated to investing in innovating and scaling up enterprises, technologies, and programs designed to reduce food loss and waste.
- 9. Overcome the data deficit.** Over the next five years, a concentrated push to measure food loss and waste is needed to overcome this data deficit in time to support achievement of SDG 12.3.
- 10. Advance the research agenda.** More research is still needed to answer multiple “next generation” questions that would, in

turn, help refine food loss and waste reduction strategies and advance implementation of the global agenda.

Not all countries, companies, and other entities need to pursue all 10 interventions. For some entities, lack of resources and capacity may be a constraint. For others, not every intervention may be relevant to their context. Rather, each entity can take this list of scaling interventions as a starting point for inspiration.

Whole Supply Chain Approaches

The following set of scaling interventions aims to get large portions of the food supply chain actively engaged in, and collaborating on, the Target-Measure-Act approach. As discussed in Chapter 4, achieving SDG 12.3 will necessitate involvement of a lot of actors. No single institution can achieve change alone. The following three scaling interventions have the potential for impact in their own right, yet they also could be combined—with scaling interventions 2 and 3 contributing to scaling intervention 1.

1. Develop and implement national strategies for reducing food loss and waste

National governments are the ones that approved the SDGs. Thus, it is only rational that national governments should have strategies for achieving the various SDG targets. National strategies have the potential to align public policies, private sector actions, farmer practices, and consumer behavior toward a shared goal—all at scale. If adequately supported and monitored for follow through (and not just a document sitting on a shelf), a national strategy can be an important cross-cutting catalyst for Target-Measure-Act at the country level.

A robust national strategy should affirm commitment to SDG 12.3, outline a roadmap for achieving the target, identify supporting policy frameworks and incentives (both existing and new), define who needs to do what, allocate adequate financial resources, set milestones, and establish a mechanism by which progress can be monitored and corrective action taken. In particular, it should articulate which of the actor-specific interventions described in Chapter 4 are to be prioritized,

supported, and realized in the country. As such, national strategies are able to engage nearly all relevant actors within a nation.

To date, some nations have publicly reaffirmed their commitment to SDG 12.3 (see Figure 5.2). But only a subset of these have developed national strategies to reduce food loss and waste. For example, the United Kingdom’s “Food Waste Reduction Roadmap” lays out activities, milestones, and guidance for the private sector to Target-Measure-Act on food waste, complemented by government policy support. The Netherlands is also building a national strategy. If many more nations were to create national strategies, allocate adequate finances, and pursue implementation, progress toward SDG 12.3 would be accelerated.

Africa provides an immediate opportunity for progress. The African Union’s new Continental Post Harvest Management Strategy (see Chapter 5) serves as a framework under which member states can develop their own national strategies to address postharvest food losses. And the African Union Commission is encouraging member states to do so. Thus far, five member states—Ethiopia, Kenya, Tanzania, Zambia, and Zimbabwe—have taken steps to create national strategies. These national strategies endorse the Malabo Declaration food loss reduction target, include baseline measurement of losses in priority crops, and recommend a suite of interventions tailored to addressing the hotspots per country. Yet this leaves 50 African countries without national postharvest loss strategies. Many of these governments need technical and financial assistance to develop national strategies. Getting each African nation to have its own government-endorsed, expert-informed, multistakeholder-developed, national postharvest food loss reduction strategy would be an important step forward for the continent.

2. Create national-level public-private partnerships

One promising way of implementing Target-Measure-Act at scale—and for supporting national strategies—is to establish national-level public-private partnerships dedicated to halving food loss and waste. Such partnerships could involve the national agriculture and environment agencies, food businesses (e.g., producers, manufacturers, retailers, restaurants, and hospitality companies)

active in the country, NGOs that tackle food loss and waste, and research institutions that bring topical expertise. Partnerships are important because reducing food loss and waste requires actions from actors across the entire food supply chain (from farm to plate), as well as supportive public policies. No single institution can drive a 50 percent economy-wide reduction on its own.

National-level public-private partnerships help address hotspots of food loss and waste by engaging actors in a manner that enables generic interventions (e.g., increase adoption of low-cost storage technologies) to be tailored to the national context and hotspots. In other words, a public-private partnership need not “begin with the answers.” Rather, the partnership implements a process by which members jointly figure out the interventions that are most appropriate for their national hotspots. Partnership participants voluntarily commit to SDG 12.3, conduct food loss and waste measurement inventories (publicly reporting results over time), and take action to address the hotspots. Public reporting is important for communicating progress and identifying shared hotspots (and thus possibilities for collective action). Participants share the ambition, jointly learn how to measure, and collaborate on strategy development and implementation.

Public-private partnerships are a promising approach for a number of reasons:

- They are demonstrating success. For example, the United Kingdom’s partnership is a major reason why the country has reduced its avoidable post-farm gate food waste by 19 percent on a per capita basis since 2007 (WRAP 2018a).
- They bring the private sector on board, which is critical in markets where the private sector is a major player in food production, distribution, and sales. Food loss and waste reduction targets will not be met in those markets without engaging the private sector, both incumbent large players and disruptive start-up companies.
- They bring the public sector on board, which is critical in that public policies, infrastructure, incentives, and data often are required to catalyze the systemic change needed to achieve large-scale reduction of food loss and waste.

- They are capable of reaching all the way “up” the supply chain to farmers (e.g., food manufacturers and retailers engaging their food suppliers) and all the way “down” the supply chain to consumers (e.g., retailers and government agencies engaging households).
- They popularize the Target-Measure-Act approach. Partnerships that have emerged to date have adopted SDG 12.3, started to measure, and started identifying actions to take.
- They enable sharing of best practices and common messaging throughout the national food supply chain on the importance of tackling food loss and waste.

The countries most likely to establish such public-private partnerships may be those with domestic operations of some members of the CGF and/or the Global Agribusiness Alliance. As described in Chapter 5, these business associations already have global food loss and waste reduction targets aligned with SDG 12.3, and many members have already started measurement and action in at least some of their operations. Therefore, the domestic operations should (in theory) already have corporate headquarter support for engagement in a national public-private partnership.

Public-private partnerships have an emerging track record. As discussed in Chapter 5, a handful of countries have launched such initiatives already (e.g., the Netherlands, United Kingdom, United States). This early movement can be built upon. Many more such partnerships could follow suit. If public-private partnerships emerged in the following additional countries, then 20 of the world’s largest agriculture exporters would be covered, representing 45 percent of the world’s population: Argentina, Belgium, Brazil, China, France, India, Italy, Malaysia, Mexico, New Zealand, Poland, Thailand, and Turkey (FAO 2018).

3. Launch a “10x20x30” supply chain initiative

One of the hotspots identified in Chapter 1 is food losses during production (in many countries) as well as during handling and storage (especially in low-income countries). One way of motivating action among food producers and of bringing

financial and capacity-building resources to them is for their downstream direct and indirect buyers to be engaged in a supply chain program focusing on food loss reduction. To this end, we propose a “10x20x30” supply chain initiative as one potential approach.

10x20x30 would involve at least 10 of the world’s largest food companies committing to implement the Target-Measure-Act approach, with each engaging at least 20 of their largest suppliers to do the same—with a shared goal of halving their food loss and waste by 2030. Besides taking action themselves, the 10 would provide awareness-raising, technical assistance, and a sharing platform for their suppliers to help them succeed. Such an initiative could have widespread impact. Having the 10 come from a variety of geographic markets would reduce overlap in supply chains. Thus, for the first time, a wide range of suppliers from around the world would be aggressively reducing on-farm and near-farm food losses. Up to 200 more companies would embark on the path to tackling food loss and waste.

This approach leverages the relative market concentration and power of a few companies to catalyze change “up” the supply chain and across geographies. These power players are among the largest companies in the food and agriculture sector. They occupy market positions where they are the “pinch point” in the supply chain—having many suppliers yet relatively few competitors. This concentrated position gives them market power. In many markets the power players will be food retailers, while in others they might be branded food manufacturers.

This approach essentially is a scaling up of what Tesco pioneered in 2017 when it secured the commitment of 27 of its major suppliers to Target-Measure-Act. The fact that all suppliers completed and reported their base-year food loss and waste inventories within one year of the start of the program indicates that the market power of the entity requesting the commitment, and the training provided to the suppliers, can lead to follow through. Such supply chain commitments that “flow up” to suppliers have precedence in other

sustainability agendas, such as efforts to eliminate deforestation from soft-commodity supply chains (e.g., the Tropical Forest Alliance 2020 initiative).

Hotspot-Specific Approaches

A second set of scaling interventions targets some of the key hotspots of food loss and waste identified in Chapter 1. Three hotspots are stages in the food supply chain that have high rates of food loss and waste in various geographies: production (particularly smallholders in low-income countries), handling and storage (especially in low-income countries), and consumption (particularly in high-income countries). Another hotspot is food categories that contribute the most to climate change.

4. Invigorate efforts to strengthen value chains and reduce smallholder losses

As Chapter 1 identifies, losses during production and on-farm storage are a hotspot. A dedicated effort is therefore needed to help reduce on-farm food losses, especially reaching smallholders in regions such as sub-Saharan Africa and South Asia.

One need is improved knowledge and skills in harvesting and storage. This can be delivered, for instance, via public or private sector-led outreach, local in-person training programs, and/or access to ICT-delivered knowledge and training. Another need is access to low-cost technologies such as improved harvesting equipment, storage units (e.g., hermetically sealed bags, storage bins), cold or dry storage, and low-tech food processing units. A third need is access to small-scale financing to support use of these technologies. And a fourth need is market incentives that encourage farmers to adopt practices and technologies that reduce loss.

Efforts to assist smallholders with productivity and efficiency improvements are not new. But if SDG 12.3 is to be achieved, these efforts need to be invigorated. Several possible approaches can be followed:

- Embed training in reducing harvesting and on-farm storage losses into existing smallholder capacity-building programs that are focused on improving smallholder profitability and livelihoods. Current programs may not give food loss the attention it deserves, and

extension agents may need additional training and retooling. Embedding it into existing programs circumvents the need to create something “new.”

- Prepare information about how to address on-farm and storage food losses (as well as other information of farmer interest such as market prices and how to access markets) and deliver this information to smallholders via apps, text messages, radio, extension officers, farmer-to-farmer demonstration programs, or other appropriate routes.
- In places where smallholders are generating crop surpluses, increase investments in value chain infrastructure (e.g., storage, processing) and value chain efficiency (e.g., data and analytics, transport). Such investments enable smallholders to access more formal markets and start to transition from the subsistence to the market economy. With this transition can come increased profitability, access to resources, and ability to invest in food loss reduction.
- Aggregate smallholders when delivering the items above. When farmers form groups, it is easier and less expensive for them to access training, technologies, financing, and markets than this would be for them as individuals.

5. Launch a “decade of storage solutions”

Although hotspots of food loss and waste will vary between countries and commodities, global estimates of food loss and waste (see Figure 1.9) show that handling and storage is a hotspot of food loss and waste, particularly in low-income countries. Practices and technologies exist to improve handling and storage. The key is to make these technologies available, affordable, and climate-friendly (e.g., not powered by coal-fired electricity), and to ensure people have the know-how to use them.

Efforts to improve storage and handling have been ongoing for decades. But given that this is such a hotspot and given the urgency of meeting SDG 12.3, a concentrated effort to ensure all have adequate storage is needed. Thus, we suggest that the 2020s become a “decade for storage solutions.”

This entails a collaboration among storage solution providers, the Global Food Cold Chain Council, financiers, and governments to get income-sensitive, climate-smart storage technologies into the hands of farmers and distribution networks (as well as households) around the world.

Informed by experiences of the YieldWise Initiative and other efforts, we suggest the following steps for making this a reality:

- Raise awareness about what storage technologies and practices are available and are appropriate for what conditions via media, public and private sector-led outreach programs, and other avenues.
- Build capacity or “know-how” for using these technologies via aggregated smallholder farmer training.
- Stimulate private sector investment in solutions, akin to the prize competitions of AgResults.
- Improve financial access to storage solutions via approaches like special credit rates, government subsidies for storage technologies, and “lease-to-own” programs for villages and other communities.
- Link anchor buyers to smallholder farmers, which can facilitate each of the four approaches above.

6. Shift consumer social norms

Although the scaling interventions above would reach many actors in the food supply chain, few of them would directly engage consumers. Yet as countries develop and urbanize, food loss and waste appears to “shift” downstream toward the consumption stage of the food supply chain, meaning that food waste in the home, office, and restaurants will likely become a bigger problem in the future.³⁵ A common theory as to why this is the case is that the “value of food” has declined and food is no longer considered scarce, at least in many high-income countries (Parfitt et al. 2010). There the amount households spend on food has been in decline; the average household in the United States, for example, spent 43 percent of its income on

food in 1945 but just 9 percent in 2015 (USDA ERS 2019). It is therefore no surprise, according to this theory, that food waste in the household is so high in the United States, because wasting food is now relatively cheap. By contrast, in Cameroon—a country with estimated low rates of waste at consumption—food comprises 46 percent of total household expenditures (USDA ERS 2019).

Apart from raising the price of food (which would have negative impacts for the poor and which few, if any, politicians would support), what can be done to address food waste at the consumption stage?

One approach is to raise awareness of the issue, ringing the proverbial “alarm bell” about the amount consumers waste and communicating the financial costs to households (and wider environmental and food security impacts). However, behavioral science indicates that, while education campaigns may raise awareness of an issue, increasing knowledge by itself does not necessarily translate into changed behavior (Samson 2015). Other factors play a role in shifting behavior and social norms, including (but not limited to) how easy or difficult it is to adopt the desired new behavior, how the person thinks peers will perceive him or her, and who the messenger is (Samson 2015). Accordingly, behavior change may require a range of different steps, like publicizing attractive role models or making individual food waste more publicly visible to others, providing people with tools to make preplanning food purchasing easier, or giving people tips on how to properly store food.

These insights indicate that more needs to be done to translate increased awareness into long-term changes in consumer behavior and ultimately social norms. The aspiration should be that norms in high-income countries (and increasingly in growing urban populations everywhere) are shifted so that wasting food becomes considered “unacceptable.” Among others, five approaches to advancing this are worth further exploration:

- **Adopt insights from behavioral science.** The growing field of behavioral science, which includes behavioral economics and “nudge theory,” is being applied to influence human behavior on a growing range of issues, including

shifting to more healthy and sustainable diets. However, too few food waste reduction interventions apply lessons from behavioral science.

- **Identify and cultivate influential messengers.** One lesson from behavioral science is that people tend to model their behavior on that of people they identify closely with or hold in esteem. Therefore, those seeking to reduce consumer food waste should carefully consider the appropriate messengers (who will likely differ from market to market).
- **Scale up grassroots movements.** In a number of countries, bottom-up, domestic-led campaigns by civil society organizations such as Feedback and Stop Wasting Food (Denmark) have raised public awareness of food loss and waste and developed “spokespeople” whom the public respects or listens to (e.g., celebrity chefs) in an effort to start shifting behavior. Going forward, more grassroots movements like these are needed in more countries, and they need to know which interventions are most effective at changing behavior (e.g., messages, messengers, tactics). One way to achieve this would be to support a network of national civil society organizations wherein participants from 100+ countries receive training from already established campaigns. In this manner, transferring practices and messages can be done at scale and can be tailored to local conditions.
- **Engage the “next generation” through social media.** Social media has emerged as a vehicle for rapidly raising societal problems to the forefront of public consciousness and discourse, illustrated by movements that started on social media, such as the #MeToo movement and the #ALSIceBucketChallenge. The cause of food waste reduction could leverage this vehicle, as well, particularly as a means of engaging the younger generation(s) most tuned in to social media. Perhaps their behavioral patterns could be influenced now such that, as they mature, “not wasting food” is considered the mainstream norm.
- **Engage religious communities.** As discussed in Chapter 2, there is an ethical case for reducing food loss and waste, and the

importance of not wasting food is highlighted by several of the world’s major religions. With 84 percent of the global population identified as “religious” (Hackett et al. 2015), there is a currently untapped opportunity for faith leaders to engage on this issue—urging the faith community to reduce food loss and waste on ethical and religious grounds. It is no surprise that many food rescue organizations have roots in the faith community. However, engagement needs to go beyond food redistribution, with faith leaders more proactively integrating “waste no food” messages into their teachings and communication with members. One “big idea” would be to organize an interfaith campaign on reducing consumer food waste among the world’s largest religions. Such an interfaith effort could reach billions of people.

7. Go after greenhouse gas emissions reductions

Chapter 1 (see Figure 1.9) identifies a number of hotspots of food loss and waste in terms of greenhouse gas emissions. These hotspots include meat (especially beef), dairy, and rice. One focused way to go after these emissions is to have the industry sectors for these specific food categories embark on initiatives to reduce food loss and waste from farm to plate. For example, the Global Dairy Platform—the association of dairy suppliers around the world—could commit to SDG 12.3 and start a program that engages dairies and processors with awareness-raising, loss measurement tools, guidance on which interventions to implement, case examples, a loss and waste reduction reporting platform, and periodic assessments of progress. The Sustainable Rice Platform could do the same for rice. For beef, a natural convener of an SDG 12.3 program could be the Global Roundtable for Sustainable Beef or a coalition of a handful of the world’s largest beef processors.

Another approach to go after greenhouse gas emissions is to get the reduction of food loss and waste incorporated into national climate strategies, particularly in a country’s nationally determined contribution (NDC) to the Paris Agreement on climate change. An NDC consists of the pledges a country made to the Paris Agreement to reduce its national greenhouse gas emissions. These pledges include an articulation (with varying degrees of specificity) of measures to be pursued by that

BOX 6.1 | COUNTRIES WITH FOOD LOSS AND WASTE REDUCTION IN THEIR NDCS (AS OF EARLY 2019)

Belize: Reduce postharvest losses and improve crop and livestock husbandry practices.

Bhutan: Promote climate-resilient agriculture and achieve food and nutrition security through establishing, among other things, cold-storage facilities at the subnational level.

Burkina Faso: Improve food processing and preservation methods.

Chad: Develop storage and conservation units to limit high postharvest losses as a cross-cutting priority to adapt to climate change.

Côte d’Ivoire: Develop efficient mechanization of agriculture and improvement of packaging, harvesting, and conservation infrastructure. Develop storage and conservation units to limit high post-harvest losses.

Egypt: Establish logistics centers for grain trade and storage to help achieve food security.

Ethiopia: Improve traditional methods that prevent deterioration of food and feed in storage facilities in order to ensure a secure food supply in case of extreme weather events.

Ghana: Promote innovations in postharvest storage and food processing and forest products in 43 (out of 216) administrative districts.

Honduras: Improve storage, processing, and preservation systems of agricultural production.

Maldives: Establish food storage facilities and distribution centers to increase accessibility and reduce the risk of food shortages during extreme events.

Rwanda: Set a target to provide all farmers with access to postharvest treatment and storage, and to reduce postharvest losses to 1 percent by 2030 from 10.4 percent, 27.4 percent and 8.3 percent in 2014 for maize, beans, and rice, respectively.

Uganda: Expand postharvest handling and storage facilities and access to markets.

Sources: Nationally determined contribution of each of the above countries (2016, 2017), accessed via Climate Watch (2019).

country and actors within it. NDCs are important because they help set a country's priorities when it comes to its national climate change strategy, policies, and investments.

As of February 2019, just a dozen countries had included some form of food loss and waste reduction in their NDCs (Box 6.1). There is significant scope for more countries to do the same. Priority countries include major beef and dairy producers (e.g., Argentina, Australia, Brazil, EU members, the United States), major rice producers and consumers (e.g., China, India, much of Southeast Asia), and countries in sub-Saharan Africa that produce a lot of root-based foods. All countries with large GHG emissions from organic material (much of it food) in landfills could add “reducing organic material in landfills” to their NDCs, too.

A push from government agencies and civil society organizations could encourage more governments to add food loss and waste to their respective NDCs. For instance, those involved in the NDC Partnership could make a concentrated effort to do this during 2019 and 2020. Countries can add targets and interventions to their NDCs at any time. The year 2020, however, is a Paris Agreement milestone year (five years after the agreement) and thus an important political window for raising NDC ambitions.

Enabling Approaches

A third set of scaling interventions aims to enhance several enabling conditions for reducing food loss and waste: finance, measurement, and research.

8. Scale up financing

Many of the interventions that target the hotspots of food loss and waste need more financing. For example, innovations in food storage technologies in Africa and rollout of food waste reduction technologies in Europe need more financial support. This increase in financing will need to come in a variety of forms. Some solutions are very early in development and thus need grant, de-risked, or venture capital investment. Other solutions have been successfully piloted but now need more commercial-oriented capital to go to scale. Of

course, the types of needed investments will vary in low-, middle-, and high-income countries. For example, investments in technologies to reduce food loss and waste in low- and middle-income countries should be sensitive to the needs of small-holder farmers. Table 6.1 lists possible investable innovations that would help reduce food loss, with many of the solutions also benefiting smallholders.

More financing is needed that is dedicated to innovating and scaling promising technologies, enterprises, and programs that target the reduction of food loss and waste. The amount of public, private, and philanthropic investment in reducing food loss and waste currently does not match the scale of the challenge or the ambition of SDG 12.3. Moreover, matching the scale of the food loss and waste challenge will require a shift in funding priorities. To date, much funding that affects food loss and waste arguably is primarily focused on broader goals (e.g., rural infrastructure, electrification) that in turn may have a knock-on positive effect on reducing food loss and waste. More could be achieved, however, if more investments directly targeted food loss and waste.

Here are some suggestions for dramatically increasing such financial investment:

- **Private philanthropy should increase its grantmaking to food loss and waste initiatives.** Despite all the social and environmental benefits of reducing food loss and waste, surprisingly few foundations invest in this thematic area. More philanthropies should add the reduction of food loss and waste to their portfolios, supporting civil society organizations, research institutions, and early-stage entrepreneurs in their efforts. Reducing food loss and waste could appeal to foundations targeting issues such as tackling climate change, food insecurity, rural economic development, water use efficiency, and related themes.
- **Development banks should launch financial instruments dedicated to reducing food loss and waste** and incorporate the reduction of food loss and waste into their investment portfolio objectives.

Table 6.1 | A Range of Investable Solutions to Postharvest Loss That Also Benefit Smallholders



Note: PHL = postharvest losses; SMEs = small and medium-sized enterprises.
 Source: Adapted from Global Knowledge Network (2017).

The World Bank's recent launch of a \$300 million Sustainable Development Bond focused on reducing food loss and waste is a novel example (World Bank 2019).

- **Financial institutions should launch one or more major blended finance funds dedicated to food loss and waste.** These funds would be a pool of capital that invests in technologies, entrepreneurs, and programs that reduce food loss and waste or convert it into value-added products. The funds could involve development banks, commercial banks, and philanthropic institutions.
- **Private financial institutions should launch “investment roundtables” or competitions** that bring together financiers and innovators in an efficient process to match investments with promising technologies and enterprises. For example, in 2018, Rabobank hosted “Food Loss Challenge—Asia,” an investment competition for start-up enterprises focused on food loss reduction (Rabobank 2018). These types of investment roundtables should be scaled up.
- **Financial institutions should support project preparation facilities.** Increased support is needed for making projects investment-ready. Interviews with financial institutions indicate that ideas that cross prospective financiers' desks may be promising but too often lack a credible approach to convert them into a viable business case or investment. In other words, there is a shortage of “bankable” projects. Project preparation facilities could address this problem—identifying candidate food loss and waste investments, screening the candidates, and helping prepare a subset to become “investment-ready.”

9. Overcome the data deficit

As discussed in Chapters 1 and 5, the amount of quantified data on food loss and waste remains insufficient. This shortcoming risks hindering efforts to refine hotspot identification, hone reduction strategies, and monitor progress. Over the next five years, a concentrated push to measure

(food loss and waste quantity and, where possible, quality) is needed to overcome this data deficit in time to support achievement of SDG 12.3.

This concentrated push should consist of at least four components:

- **Roll out the Food Loss Index and Food Waste Index.** Country-level estimates of food loss and waste using both indices need to take place. This would provide a harmonized baseline, a midperiod check-in, and an end-of-period assessment. Only through this approach will the world know whether or not the SDG 12.3 target has been reached. It would be a travesty if all the interventions in this report are implemented but the world is still unable to determine whether or not the target has been met.
- **Get more than 200 companies reporting.** More than 200 of the world's largest companies in the food sector need to be measuring and reporting their food loss and waste within their own operations, and over time up their supply chains. Only at this scale can one say measurement has started to be mainstreamed in the private sector.
- **Report completed inventories.** As all of these countries and companies measure their food loss and waste, they should make the results publicly available and easily accessible (e.g., on the internet). Doing so would enable identification of success stories, benchmarking against peers and sectors, and better understanding of one's supply chains. Posting completed inventories on the Food Waste Atlas (see Chapter 5) is a straightforward way to do this in a consistent and transparent manner.
- **Incentivize measurement.** More entities will measure if they are incentivized to do it. For instance, development cooperation could provide financial and technical support to low-income countries to conduct their measurements. Lending institutions could make “before and after” measurement of food loss and waste a requirement for farmers, businesses, and

Table 6.2 | **Important Questions for Reducing Food Loss and Waste (Not Exhaustive)**

Technology: Food Loss	<ul style="list-style-type: none"> ■ What technologies offer the biggest promise (in terms of impact, scale, and market readiness) for food loss reduction at the “production” and “storage” stages of the food supply chain? ■ How does one accelerate their scaling?
Technology: Food Waste	<ul style="list-style-type: none"> ■ What technologies offer the biggest promise (in terms of impact, scale, and market readiness) for food waste reduction at the “market” and “consumption” stages of the food supply chain? ■ How does one accelerate their scaling?
Cold chains	<ul style="list-style-type: none"> ■ How can the world accelerate deployment of climate-smart cold chains in low-income countries?
Economics	<ul style="list-style-type: none"> ■ What pricing signals and incentive structures (or lack thereof) are driving the economics of food loss and waste? ■ What interventions to reduce food loss and waste would provide (or are providing) the biggest return on investment?
Finance	<ul style="list-style-type: none"> ■ What types of financing are needed to scale up adoption of leading food loss and waste reduction practices and technologies?
Public policy	<ul style="list-style-type: none"> ■ What inclusive, cost-effective public policies (e.g., regulations, incentives) hold the most promise for reducing food losses in low-income countries? ■ What inclusive, cost-effective public policies (e.g., regulations, incentives) hold the most promise for reducing food waste in middle- and high-income countries?
Smallholders	<ul style="list-style-type: none"> ■ What specific types of infrastructure, technical assistance, and/or financial assistance do farmers in low-income countries need (or are already working) to implement practices that would dramatically reduce on-farm and near-farm losses? ■ How does one effectively build capacity for smallholders to implement food loss reduction practices?
Consumers	<ul style="list-style-type: none"> ■ What can the latest insights from behavioral science tell us about how to shift social norms and long-term behavior of consumers when it comes to food waste?
Other actors	<ul style="list-style-type: none"> ■ What role can cities and civil society play in reducing food loss and waste?
Measurement	<ul style="list-style-type: none"> ■ What do the new quantifications of food loss and waste (e.g., by companies, by countries) that are becoming public tell us about the hotspots and trends in food loss and waste? ■ How are qualitative losses, such as micronutrient losses, and the impact of these losses on food security and food safety best measured?

governments receiving financing for agriculture-related projects. Governments could mandate that all companies in the food sector above a certain size measure and report their food loss and waste. Retailers and manufacturers could provide technical (and financial) support to their suppliers on what to measure and how to measure it.

10. Advance the research agenda

Despite the body of knowledge that already exists on food loss and waste, more research is still needed to support overall achievement of SDG 12.3. This is an important role for public and private research institutions to play over the coming decade, and these institutions need support in this effort. Answering the nonexhaustive list of

questions in Table 6.2 would help refine strategies for reducing food loss and waste and help advance implementation of the global agenda.

A Call to Action

SDG 12.3 is a historic opportunity for the world to curtail food loss and waste at scale and reap numerous food security, economic, and environmental benefits. These benefits will contribute to many other SDGs and the Paris Agreement on climate change.

This report introduces a Global Action Agenda to accelerate the reduction of food loss and waste across actors and geographies. This agenda involves

a Target-Measure-Act approach, actor-specific to-do lists, and a suite of scaling interventions. Combined, these hit priority hotspots and articulate who needs to do what.

Momentum is growing, but the world has much more to do. Only 11 years remain to achieve the targets of the SDGs, and food loss and waste is still pervasive. Actors ranging from governments, businesses, farmers, consumers, and everyone in between can play a role in the Global Action Agenda. With worldwide participation, we just might realize a future where no food fit for consumption goes to waste.



APPENDIX A. DEFINITIONS OF “DESTINATIONS”

“Destination” refers to where food and/or the associated inedible parts go when removed from the food supply chain. There are 10 possible destinations according to the FLW Standard:

- **Animal Feed.** Diverting material from the food supply chain (directly or after processing) to animals. (This excludes crops intentionally grown for bioenergy, animal feed, seed, or industrial use.)
- **Bio-based Materials/Biochemical Processing.** Converting material into industrial products. Examples include creating fibers for packaging material, creating bioplastics (e.g., polylactic acid), making “traditional” materials such as leather or feathers (e.g., for pillows), and rendering fat, oil, or grease into a raw material to make products such as soaps, biodiesel, or cosmetics. Biochemical processing does not refer to anaerobic digestion or production of bioethanol through fermentation.
- **Codigestion/anaerobic digestion.** Breaking down material via bacteria in the absence of oxygen. This process generates biogas and nutrient-rich matter. Codigestion refers to the simultaneous anaerobic digestion of food loss and waste and other organic material in one digester. This destination includes fermentation (converting carbohydrates—such as glucose, fructose, and sucrose—via microbes into alcohols in the absence of oxygen to create products such as biofuels).
- **Composting/aerobic processes.** Breaking down material via bacteria in oxygen-rich environments. Composting refers to the production of organic material (via aerobic processes) that can be used as a soil amendment.
- **Controlled combustion.** Sending material to a facility that is specifically designed for combustion in a controlled manner, which may include some form of energy recovery (this may also be referred to as incineration).
- **Land Application.** Spreading, spraying, injecting, or incorporating organic material onto or below the surface of the land to enhance soil quality.
- **Landfill.** Sending material to an area of land or an excavated site that is specifically designed and built to receive wastes.
- **Not harvested/plowed in.** Leaving crops that were ready for harvest in the field or tilling them into the soil.
- **Refuse/discards/litter.** Abandoning material on land or disposing of it in the sea. This includes open dumps (i.e., uncovered, unlined), open burn (i.e., not in a controlled facility), the portion of harvested crops eaten by pests, and fish discards (the portion of total catch that is thrown away or slipped).
- **Sewer/wastewater treatment.** Sending material down the sewer (with or without prior treatment), including material that may go to a facility designed to treat wastewater.

APPENDIX B. LIST OF SOURCES IN FIGURE 1.11

EXAMPLE	FOOD TYPE / GEOGRAPHY	SOURCE
STAGE OF FOOD SUPPLY CHAIN: PRIMARY PRODUCTION		
A	Tomatoes, peaches, romaine lettuce, processing potatoes / Arizona, Florida, Idaho, New Jersey (United States)	World Wildlife Fund-US (2018)
B	Vegetables and berries / Vermont (United States)	Neff et al. (2018)
C	Cabbage, yellow squash, zucchini, green peppers, cucumbers, eggplants / North Carolina (United States)	Johnson et al. (2018)
D	Lettuce, strawberries / United Kingdom	WRAP (2017b)
E	Salads, mushrooms, other vegetables / United Kingdom, Spain, Poland, Czech Republic, Senegal	G's Fresh (2018)
F	Direct measurement of carrots, onions, wheat, rye, green peas, field peas, and farmed rainbow trout or char. Surveys and literature reviews to estimate losses of over 30 other food and animal products. Data point shows average losses across Finland, Sweden, Norway, and Denmark.	Franke et al. (2016)
G	Potatoes, chorizo / United Kingdom	Branston (2018)
H	Maize, rice, sorghum, millet, wheat, barley, fonio, oats, teff / Botswana, Burkina Faso, Ethiopia, Malawi, Senegal, Sierra Leone, Swaziland, Uganda Data point represents the average losses across all crops and countries.	APHLIS (2016)
I	Maize / Uganda	FAO (2017c)
J	Maize / Nigeria	Oguntade (2013)
K	Maize and sorghum / Burkina Faso	FAO (2017d)
L	Maize / Malawi	Ambler et al. (2018)
M	Maize / Kenya	FAO (2014)
N	Tomatoes / Nigeria, Rwanda	Kitinoja et al. (2019)
O	Tomatoes / Kenya	Owino et al. (2015)
P	Mangoes and tomatoes / Guyana, St. Lucia, Trinidad and Tobago Data point shows average losses for each crop across the three countries.	FAO (2015b)
Q	Potatoes / Ecuador and Peru Beans / Guatemala and Honduras Maize / Guatemala and Honduras Data points show average losses per crop.	Delgado et al. (2017)

APPENDIX B. LIST OF SOURCES IN FIGURE 1.11 (CONTINUED)

EXAMPLE	FOOD TYPE / GEOGRAPHY	SOURCE
STAGE OF FOOD SUPPLY CHAIN: HANDLING AND STORAGE		
R	Maize / Malawi, Tanzania, Uganda	Kaminski and Christiaensen (2014)
S	Maize, rice, sorghum, millet, wheat, barley, fonio, oats, teff / Botswana, Burkina Faso, Ethiopia, Malawi, Senegal, Sierra Leone, Swaziland, Uganda Data point represents the average losses across all crops and countries.	APHLIS (2016)
T	Maize / Nigeria	Oguntade (2013)
U	Rice / Kenya	Mutungi et al. (2012)
V	Maize / Uganda	FAO (2017c)
W	Maize, rice / Democratic Republic of Congo	FAO (2017e)
X	Teff / Ethiopia	Minten et al. (2016)
Y	Maize / Kenya	FAO (2014)
Z	Potatoes / Ecuador and Peru Beans / Guatemala and Honduras Maize / Guatemala and Honduras Data points show average losses per crop.	Delgado et al. (2017)
STAGE OF FOOD SUPPLY CHAIN: PROCESSING AND PACKAGING		
A1	Pearl millet, maize, sorghum / Tanzania	Abass et al. (2014)
B1	Rice / Kenya	Mutungi et al. (2012)
C1	Rice / Burkina Faso	FAO (2017d)
D1	Potatoes / Ecuador and Peru Beans / Guatemala and Honduras Maize / Guatemala and Honduras Data points show average losses per crop.	Delgado et al. (2017)
E1	Mangoes / Guyana, St. Lucia, Trinidad and Tobago, Tomatoes / Guyana, St. Lucia, Trinidad and Tobago Data point shows average losses for each crop across the three countries.	FAO (2015b)

APPENDIX B. LIST OF SOURCES IN FIGURE 1.11 (CONTINUED)

EXAMPLE	FOOD TYPE / GEOGRAPHY	SOURCE
STAGE OF FOOD SUPPLY CHAIN: PROCESSING AND PACKAGING		
F1	Tomatoes, peaches, processing potatoes / Arizona, Florida, Idaho, New Jersey (United States)	World Wildlife Fund-US (2018)
STAGE OF FOOD SUPPLY CHAIN: DISTRIBUTION AND MARKET		
G1	Maize, rice, sorghum, millet, wheat, barley, fonio, oats, teff / Botswana, Burkina Faso, Ethiopia, Malawi, Senegal, Sierra Leone, Swaziland, Uganda Data point represents the average losses across all crops and countries.	APHLIS (2016)
H1	Maize, rice / Democratic Republic of Congo	FAO (2017e)
I1	Maize / Nigeria	Oguntade (2013)
J1	Teff / Ethiopia	Minten et al. (2016)
K1	Dessert bananas, plantains / Kenya	FAO (2014)
L1	Tomatoes / Nigeria and Rwanda	Kitinoja et al. (2019)
M1	Tomatoes / Kenya	Owino et al. (2015)
N1	Cabbage, tomatoes, carrots / Tanzania	Dome and Prusty (2017)
O1	Mangoes / St. Lucia, Tomatoes / Guyana, St. Lucia, and Trinidad and Tobago Data point shows average losses per crop.	FAO (2015b)
STAGE OF FOOD SUPPLY CHAIN: CONSUMPTION		
A	Approximately 58 percent of commodities entering the Canadian food system / Canada Data point represents total of household food waste, food service, and hospitality as a percentage of total food lost and wasted from primary production up to and including the household.	Gooch et al. (2019)
B	All food categories / Australia Data point represents total of household food waste, food service, and hospitality as a percentage of total food lost and wasted from primary production up to and including the household.	Arcadis (2019)

APPENDIX B. LIST OF SOURCES IN FIGURE 1.11 (CONTINUED)

EXAMPLE	FOOD TYPE / GEOGRAPHY	SOURCE
C	All food categories / United States Data point represents total of household food waste, food service, and hospitality as a percentage of total food lost and wasted from primary production up to and including the household.	ReFED (2016)
D	All food categories / United Kingdom Data point represents total of household food waste, food service, and hospitality as a percentage of total food lost and wasted from the farm gate (not including primary production) up to and including the household.	WRAP (2017a)
E	All food categories / 28 EU countries Data point represents total of household food waste, food service, and hospitality as a percentage of total food lost and wasted from primary production up to and including the household.	Stenmarck et al. (2016)
F	21 food product groups / Norway Data point represents total of household food waste as a percentage of total food lost and wasted from primary production up to and including the household.	Stensgård and Hanssen (2016)

APPENDIX C. EXAMPLES OF INTERVENTIONS PER UNDERLYING DRIVER

CATEGORY	UNDERLYING DRIVER	DESCRIPTION
Technological	Poor infrastructure	Lack of or poor-quality infrastructure (public or private) along the food supply chain. Public infrastructure includes reliable power supplies, reliable communication, usable roads, and access to markets. Private infrastructure includes storage facilities, cold chains, processing facilities, and distribution- or market-related logistics (e.g., handling facilities).
	Inadequate equipment	Lack of or suboptimal equipment along the food supply chain. This includes equipment used during harvesting (e.g., combines), storage (e.g., bags), distribution (e.g., pallet jacks), merchandising (e.g., displays), and food preparation (e.g., stoves, refrigeration).
	Suboptimal packaging	Suboptimal pack sizes, and insufficient packaging to protect products after harvest from deterioration and damage.
Managerial	Inadequate food management practices, skills, and knowledge	Lack of or inadequate management practices or use of equipment due to a lack of knowledge, skills, or incentives. Among producers, this could include poor use of mechanical harvesters, improper use of fishing gear, and inadequate animal care practices. Among households this includes a lack of knowledge about planning and preparing meals, as well as how to assess product freshness and interpret date labels.
	Inflexible procurement requirements	Contractual practices (e.g., last-minute order changes, take-back clauses) or quality and cosmetic standards (e.g., undesired attributes) that result in food leaving the supply chain. While some procurement requirements may reduce the amount of unusable food that is sent further down the supply chain, other requirements may result in nutritious, edible food exiting the human food supply chain.

APPENDIX C. EXAMPLES OF INTERVENTIONS PER UNDERLYING DRIVER (CONTINUED)

CATEGORY	UNDERLYING DRIVER	EXAMPLES OF INTERVENTIONS (NOT EXHAUSTIVE)	MARKETS WHERE MOST SALIENT
Technological	Poor infrastructure	<ul style="list-style-type: none"> ■ Improve general infrastructure (e.g., roads, electricity access). ■ Improve (e.g., more energy-efficient, low-carbon) and expand cold chains. ■ Build processing facilities to convert unmarketable crops and by-products into value-added products (e.g., near-farm mobile processing units). ■ Use backhauling or other logistics solutions to enable the return of reusable storage containers, or rescue of surplus food for people in need. 	Low-income countries
	Inadequate equipment	<ul style="list-style-type: none"> ■ Improve availability of harvesting and handling equipment that reduces damage. ■ Improve access to storage equipment (e.g., through cost-sharing cooperatives), and ensure these are available to smallholders as well (e.g., crates that are suited for smaller volumes of product). ■ Invest in equipment (e.g., merchandising displays, kitchen products) that extend the quality and freshness of perishable foods. 	Low-income countries
	Suboptimal packaging	<ul style="list-style-type: none"> ■ Improve packaging design and materials to reduce risk of damage or spoilage, and to keep food fresher for longer while balancing other ecological considerations related to packaging. ■ Improve packaging to allow for incremental consumption (while the remainder stays secure from spoilage). ■ Provide consumers with smaller package options. ■ Allow consumers to customize portions through bulk bins, half orders, or optional refills. 	High-income countries
Managerial	Inadequate food management practices, skills, and knowledge	<ul style="list-style-type: none"> ■ Use proven models to encourage more sustained adoption of practices that reduce food loss during the production stage (e.g., harvesting and handling practices, protecting crops against pests and diseases to reduce losses during and after harvest). ■ Use fishing gear recommended for target species to reduce bycatch. ■ Standardize procedures for staff (e.g., develop a common inventory management process) and invest in ongoing training to reduce human errors that lead to loss and waste. ■ Reengineer production processes and product designs (e.g., to reduce waste during product line changeovers in processing facilities). ■ Improve practices through software and related ICT (e.g., to analyze waste and suggest reduction tactics, to track temperature and ensure freshness, to assess ripeness, to accelerate delivery of food to consumers, to rescue surplus food). ■ Standardize date labels (e.g., "use by," "best before," "sell by") and educate consumers about label definitions. ■ Educate consumers about meal planning, food storage, food handling, food preparation, and use of leftovers. 	Low- and high-income countries
	Inflexible procurement requirements	<ul style="list-style-type: none"> ■ Increase flexibility in contract terms to better manage variability in demand and supply. ■ Broaden cosmetic standards to encompass a wider array of physical attributes. ■ Build secondary markets for items that do not meet highest cosmetic standards and/or for alternative fish species. 	High-income countries with powerful retailers

APPENDIX C. EXAMPLES OF INTERVENTIONS PER UNDERLYING DRIVER (CONTINUED)

CATEGORY	UNDERLYING DRIVER	DESCRIPTION
Managerial	Poor supply-and-demand forecasting and planning	Poor forecasting and information flow between buyer and supplier. At the farm, this includes suboptimal crop scheduling and forecasting. In the middle of the supply chain, this includes suboptimal inventory management. At the consumption stage, this includes buying and preparing more food than will be consumed.
	Marketing strategies	Promotions, merchandising displays, or other marketing strategies that increase the likelihood of product damage, surplus, or overpurchasing by consumers.
Behavioral	Norms and attitudes	Norms and attitudes that influence food production and consumption behaviors and cause products to be removed from the food chain at any stage. These include what types of foods are considered appealing (e.g., whether certain parts of an animal are typically eaten), the preferred appearance of products (e.g., no blemishes), showing off “abundance” to indicate wealth or hospitality, attitudes about food generally (e.g., dislike of leftovers, desire for variety, preference for “fresh”), and social values that accept resource waste and its impacts.
	Lack of awareness	Lack of awareness that food loss and waste happens and has an impact, and how one contributes to the problem. Farmers, business managers, and consumers often do not think they lose or waste food, but measurement suggests otherwise. Lack of awareness also can include a limited understanding of how reducing food loss and waste can provide direct (personal or business) benefits (e.g., enhanced product freshness, reduced costs).
	Concerns about possible risks	Actual or perceived risks related to food safety (including food labeling), reputation, and liability. This includes concerns about safe food consumption, or fear about liability linked to food donation.

APPENDIX C. EXAMPLES OF INTERVENTIONS PER UNDERLYING DRIVER (CONTINUED)

CATEGORY	UNDERLYING DRIVER	EXAMPLES OF INTERVENTIONS (NOT EXHAUSTIVE)	MARKETS WHERE MOST SALIENT
Managerial	Poor supply-and-demand forecasting and planning	<ul style="list-style-type: none"> ■ Improve communication and change incentives among business units to reduce decisions that inadvertently create waste; e.g., holding on to safety stock to ensure in-stock availability even though the majority of that stock may go to waste. ■ Introduce technologies and business-to-business partnerships to improve supply-demand forecasting and information flow among all actors in the supply chain. ■ Use software or other tools that help farmers better schedule planting and harvesting. 	Low- and high-income countries
	Marketing strategies	<ul style="list-style-type: none"> ■ Adjust pricing and promotion strategies (e.g., quantity discounts) to avoid lower prices leading to overpurchasing. ■ Adjust promotions to avoid excessive purchase of additional items (e.g., offer half off or mix-and-match rather than two-for-one deals). ■ Develop a clear promotion planning process to reduce the likelihood of waste (e.g., consider whether special packaging during a promotion will result in wasted food after the promotion ends). ■ Redesign in-store merchandising to achieve the desired appearance of abundance but with less damage and excess product (e.g., through smaller bins and bowls, or other props). 	High-income countries
Behavioral	Norms and attitudes	<ul style="list-style-type: none"> ■ Conduct consumer education campaigns about food loss and waste to shift social attitudes (e.g., to general public, to schools). ■ Encourage diners to take home leftovers in low-impact containers. ■ Implement techniques that reduce waste (e.g., trayless dining) in lunchrooms, cafeterias, and other foodservice settings. ■ Promote the value of food so that the cultural mindset is less likely to accept wasted food. 	High-income countries and urban centers
	Lack of awareness	<ul style="list-style-type: none"> ■ Conduct food loss and waste inventories (or “audits”) to identify the quantity and hotspots of food loss and waste, and communicate the results. ■ Engage employees and supply chain actors about food loss and waste (how much is it, why it matters, who is responsible, what they can do) and provide relevant tools to track and reduce it. 	Low- and high-income countries
	Concerns about possible risks	<ul style="list-style-type: none"> ■ Pass “Good Samaritan” laws that reduce or eliminate liability of those donating food, and raise awareness of such liability protection. ■ Improve consumer understanding of the meaning of date labels (and which are about food safety). ■ Improve consumer understanding of how to reduce risk of spoiled food (and how to accurately identify it). 	High-income countries and urban centers

APPENDIX C. EXAMPLES OF INTERVENTIONS PER UNDERLYING DRIVER (CONTINUED)

CATEGORY	UNDERLYING DRIVER	DESCRIPTION
Structural	Demographics	Household size, urbanization, and growth in the middle class (which is linked to higher disposable income) impact food production and consumption. This includes reduced availability of labor to harvest food in the production stage, which can increase food losses. The rise of the middle class can change how people acquire, eat, and manage food (e.g., portion sizes, shopping habits, preference for "fresh"), which can increase the likelihood of food waste.
	Climatic conditions	Weather (e.g., rain, snow, ice, wind, cold, heat) and impacts from a changing climate affect growing conditions, which can result in damage to crops or surplus product. These conditions also affect other factors such as the degree of damage by pests and diseases, and the ability to get a product to market (e.g., disruptions in transportation networks).
	Policies and regulations	Policies and regulations may be barriers, be poorly coordinated, or be absent, resulting in food leaving the food supply chain. Policy barriers may relate to food safety, food quality, labeling, packaging, trade and customs, tax incentives, agricultural extension services, and use of unsold food for animal feed or energy.
	Economics	Costs of avoiding or reducing food loss and waste are (or are perceived to be) high in comparison to the benefits that would be obtained. Growers, especially smallholders, may not invest in loss reduction practices or technologies due to poverty. Growers may harvest crops prematurely (increasing the risk of food losses) because they need cash or because market prices are currently high. Conversely growers may not harvest crops where the cost to do so exceeds the market price, and if alternative markets for second-grade products are not profitable. A food processor may accept food loss and waste as the "cost of doing business" or because disposal costs are low. In many countries, food comprises only a small share of household expenditures, lowering the cost of waste and the perceived value of conserving food.
	Access to financing	Inability to access sufficient financing (e.g., investment, loans, grants) to purchase, implement, or scale technologies, capacity-building programs, and/or enterprises that would reduce food loss and waste.

APPENDIX C. EXAMPLES OF INTERVENTIONS PER UNDERLYING DRIVER (CONTINUED)

CATEGORY	UNDERLYING DRIVER	EXAMPLES OF INTERVENTIONS (NOT EXHAUSTIVE)	MARKETS WHERE MOST SALIENT
Structural	Demographics	<ul style="list-style-type: none"> ■ Use policy and economic levers to reduce labor shortages (e.g., in farming, among truck drivers). ■ Support population in gaining relevant skills that avoid food waste (e.g., incorporate in education curriculum lessons in food preparation and planning). ■ Make packaging adjustments for smaller households. 	Low- and high-income countries
	Climatic conditions	<ul style="list-style-type: none"> ■ Use ICT to gather better data on weather (e.g., to inform planting and harvesting, to predict consumer demand). ■ Use storage containers that protect against variations in temperature and precipitation. ■ Expand cold storage systems during wholesale and logistics to protect products vulnerable to heat damage. 	Low- and high-income countries
	Policies and regulations	<ul style="list-style-type: none"> ■ Embed into agricultural extension services (and in farmer subsidy programs) food loss reduction awareness, technical assistance, and financial aid. ■ Introduce tax incentives for donating unsold but still safe food to food rescue organizations. ■ Pass laws that increase the cost of discarding food. ■ Amend laws to allow unsold food to be used in animal feed. ■ Adjust procedures at “ports of entry” to reduce wait times and risk of spoilage. ■ Adopt policies that encourage improved trade linkages (e.g., organized group membership for smaller producers, improved availability of, and access to, markets). ■ Develop policies that help small businesses improve their operations (e.g., by incentivizing and providing support for food handling practices that reduce contamination). 	Low- and high-income countries
	Economics	<ul style="list-style-type: none"> ■ Conduct benefit-cost analyses of food loss and waste reduction programs to discern the financial return on investment (relevant for farmers, companies, government agencies, households). ■ Launch communications campaign about the financial returns of food loss and waste reduction efforts. ■ Together with the community and relevant actors in the supply chain, create or expand financially viable markets (e.g., secondary surplus markets, donation, value-added processing) for products that would otherwise be lost or wasted. 	Low- and high-income countries
	Access to financing	<ul style="list-style-type: none"> ■ Create funds (and associated project preparation facilities) dedicated to reducing food loss and waste. ■ Introduce financial product lines in commercial and development banks focused on food loss and waste reduction technologies and programs. ■ Introduce “pay-as-you-go” programs to make technologies marketed to large-scale commercial operations affordable for smallholder operations (e.g., for solar-powered refrigeration units). 	Low-income countries

Sources: WRI analysis based on Canali et al. (2014); CEC (2017, 2018, 2019); Clowes et al. (2018a, 2018b, 2019); Food Loss and Waste Protocol (2016); Global Knowledge Initiative (2017); Gooch et al. (2019); Gunders and Bloom (2017); Hegnholt et al. (2018); HLPE (2014); ReFED (2016); and WWF-US (2018).

ENDNOTES

1. The modeling was led by WRI and the French Agricultural Research Centre for International Development (CIRAD), and supported by the World Bank, UNEP, the UN Development Programme, and the French National Institute for Agronomic Research (INRA).
2. The modeling for Figures 1.1 and 1.2 was conducted out to 2050 in order to give an indication of the relative scale of impact of a wide variety of strategies on ability to achieve a sustainable food future (reducing food loss and waste being one of the strategies). Elsewhere, this report discusses reducing food loss and waste by 50 percent by 2030 in order to meet the target set by the Sustainable Development Goals.
3. This definition is in line with the recommendations of the FLW Standard. Counting losses from the point of harvest/slaughter is also used by other researchers. The database APHLIS also includes losses that occur during harvesting.
4. Understanding the amount sent to every destination is valuable for decision-making purposes, but when aiming for the common 50 percent reduction target suggested by Sustainable Development Goal 12.3 (see Chapter 2), excluding “animal feed” and “biobased materials” is practical and consistent with the recommendations of Champions 12.3. See Champions 12.3 (2017).
5. The FAO report did not separate data between North America and Oceania.
6. Figure 1.9 is based on authors’ calculations based on data from FAO (2011) and the FLW Value Calculator. FAO (2011) gives data on food loss and waste in metric tons distributed across seven near-continental geographies, five stages of the food supply chain, and seven food categories. Our “hotspot” analysis for tons disaggregates the data into all possible combinations of those three dimensions. Our analysis for calories converts the tonnage data into calories using FAO Food Balance Sheet conversion factors (e.g., x calories per ton of cereal). Our analysis for greenhouse gas emissions converts the tonnage data into tons of carbon dioxide equivalent (CO₂e) using conversion factors in the FLW Value Calculator (2018) (e.g., x tons of CO₂e per ton of meat). These conversion factors may underestimate the emissions arising from land-use change (thus meat emissions may be even higher than in the FLW Calculator). For each of these three dimensions (i.e., tonnage, calories, greenhouse gas emissions), our threshold for including it as a “hotspot” was >50,000 tons (at one stage of the supply chain or two adjacent stages), >50 billion calories (at one stage of the supply chain or two adjacent stages), and >30,000 tons of CO₂e.
7. See Chapter 2.
8. Tonnage could be a proxy for loss of micronutrients due to the quantitative loss of fruits and vegetables (for instance). It would not be a proxy for qualitative losses that can lead to losses in micronutrients.
9. Our analysis does not address whether or not too many calories of certain food categories are currently being grown relative to nutrition criteria. For that, see the EAT-Lancet Commission Report (Willett et al. 2019). Rather, we focus on loss and waste of food that is actually produced.
10. Although qualitative loss and waste is important, we focus here on quantitative loss and waste since that was the focus of FAO (2011). The purpose of this section is to assess whether or not FAO (2011) data are broadly correct.
11. Studies consulted are listed in Appendix B.
12. For example, the new estimates will only cover food lost from the farm gate up to, but not including, the retail level—as opposed to covering the whole supply chain as the FAO (2011) estimates did. The new estimates will exclude food intended for human consumption going to animal feed and bio-based materials, whereas the FAO (2011) estimates included food going to both of these destinations.
13. Many models that project future environmental impacts of the global food system, including the recent World Resources Report (Searchinger et al. 2018) and the EAT-Lancet Commission (Willett et al. 2019), project outward to 2050. They do not project outward to 2030, the year that the SDGs are due. Although these models provide an indication of the positive benefits of halving food loss and waste by 2050, global ambitions should aim to halve food loss and waste by 2030 if the world is to meet the SDG target for food loss and waste.
14. See “List of Countries by Greenhouse Gas Emissions,” https://en.wikipedia.org/wiki/List_of_countries_by_greenhouse_gas_emissions, based on data compiled by WRI.
15. See “List of Countries and Dependencies by Area,” https://en.wikipedia.org/wiki/List_of_countries_and_dependencies_by_area, based on data from the UN Statistics Division.
16. A global figure that shows the net cost of food loss and waste (i.e., the gross cost minus the cost of reducing food loss and waste) could not be found. The figure of US\$940 billion is therefore a gross cost. Figures for the net benefits of reducing food loss and waste are available for a number of companies, outlined in Box 2.1.

17. Between 2012 and 2015 efforts did not result in further reductions (either in absolute metric tons or on a per-person basis), suggesting that the proverbial “low-hanging fruit” reductions were already realized or that some other factor was at play, making further reductions difficult (WRAP 2018c). Despite this leveling off, figures on UK food waste, restated in 2018, showed that the United Kingdom saw a reduction in avoidable household food waste of 23 percent, and a reduction in total avoidable post-farm gate food waste of 19 percent (measured in kilograms per person) between 2007 and 2015 (WRAP 2018c).
18. This city example is the only one the authors could find to date that has enough data to calculate benefit-cost ratios.
19. This synthesis drew heavily on the organization of causes used in HLPE (2014), which identified three different “levels of causes” (micro, meso, and macro). “Micro level” refers to the causes of food loss and waste at each particular stage of the food supply chain where loss and waste results from actions or nonactions of individual actors at a stage, in response (or not) to external factors (e.g., rough, careless handling; poor management of temperature conditions; inadequate facilities; poor planning; excess portions). “Meso level” causes include secondary causes or structural causes of food loss and waste (e.g., lack of private and public infrastructure, confusion around food date labeling). “Macro level” causes account for how food losses and waste can be explained by more systemic issues (e.g., policies, laws, and regulations). These overlap with the drivers in Figure 3.1 that are “structural.”
20. WRI analysis based on Canali et al. (2014); CEC (2017, 2018, 2019); Clowes et al. (2018a, 2018b, 2019); Food Loss and Waste Protocol (2016); Global Knowledge Initiative (2017); Gooch et al. (2019); Gunders and Bloom (2017); Hegnholt et al. (2018); HLPE (2014); ReFED (2016); and WWF-US (2018).
21. For suggestions on how to define one’s scope to align with SDG 12.3, see Champions 12.3 (2017).
22. This experience was shared by leaders of initiatives such as the Courtauld Commitment and some private sector programs.
23. This percentage is based on author calculations of what percentage of global food sales all CGF companies make up of an estimate of total global food sales at the retail/consumer level. A market research firm provided the estimate for global food sales, and the CGF provided the estimate of CGF member food sales, which were verified via corporate annual reports.
24. As of February 2019, the companies that do publicly report their food loss and waste inventories are Aeon, A. Gomez Ltd., Allied Bakeries, AMT Fruit Ltd., Aramark, Arla, Avara, Bakkavor Group, Branston, Campbell Soup Company, Cranswick, Danone, DPS, Espersen, Froneri, General Mills, Glinwell, Greencore, Greenyard Frozen, G’s Fresh, Hilton Foods, Icelandic Seachill, IKEA, Kellogg Company, Kepak Meat Division, Kerry Food, Kroger, Lidl, Morrison’s, Moy Park, Muller Milk & Ingredients, Nestlé, Noble, Ocado, Oruna, Premier Foods, Richard Hochfield Ltd., Royal Ahold Delhaize, Sainsbury’s, Samworth Brothers Ltd., Tesco, 2SFG, Unilever, and Walmart (in Canada, Japan, United Kingdom, United States) (Lipinski et al. 2016; Lipinski et al. 2017; Flanagan et al. 2018).
25. The FLW Standard was developed by the Food Loss and Waste Protocol, a multistakeholder effort convened by WRI and involving the CGF, FAO’s Save Food Initiative, the EU FUSIONS initiative, UNEP, the World Business Council for Sustainable Development (WBCSD), and WRAP.
26. Prepared by WRAP and WRI, with financial support from the Walmart Foundation and WRAP; www.thefoodwasteatlas.org.
27. Prepared by the WBCSD with technical input from Quantis and WRI; www.flwprotocol.org/why-measure/food-loss-and-waste-value-calculator/.
28. In 2019, Argentina, through the country’s National Plan for the Reduction of Food Losses and Waste, brought in new legislation that protects businesses from the risk of prosecution when redistributing unsold food, providing they comply with existing food safety laws (Michail 2019). In 2017, Ghana passed the National Food Donor’s Encouragement Bill, which creates a legal framework for food donation, establishes compliance and liability standards, and encourages donation through tax deductions. In 2016, Italy passed legislation making food donations easier, including provisions that businesses will not face sanctions for giving away food past its sell-by date and that businesses will pay less waste tax the more they give away (Zero Waste Europe 2016). Denmark has taken a number of legislative measures to decrease food waste, including changing taxation and rules to facilitate donations by food retailers of nonanimal food to charities (Lipinski et al. 2017).
29. In 2018 the Czech Republic amended its Food Act to require all supermarkets over 400 square meters in size to donate unsold but still consumable food to charities (Prague.tv 2017). In 2016, France adopted legislation that requires French supermarkets to donate unsold yet still safe and wholesome food to charities (Durandsmet 2018).
30. One study found that confusion around date labels was responsible for around 20 percent of household food waste (WRAP 2011).
31. For these online hubs, see FAO (n.d.); ReFED (2018); REFRESH Community of Experts (2019); and Reducing Food Waste (2018).
32. Food service providers prepare food at industrial scale for corporate offices, government operations, universities and

schools, prisons, and other large-scale canteens.

33. Meaning waste that ends up in a landfill, is incinerated without any energy recovery, or is discharged into wastewater.
34. In late 2019, FAO will be publishing updated global and regional estimates of food loss. However, these numbers will not be directly comparable to the 2011 estimates for several reasons. Among them is that the scope is different. For example, the new estimates will only cover food lost from the farm gate up to, but not including, the retail level—as opposed to covering the whole supply chain, as the FAO (2011) estimates did. The new estimates will exclude food intended for human consumption going to animal feed and bio-based materials, whereas the FAO (2011) estimates included food going to both of these destinations.
35. This observation is illustrated by Figure 1.8. The total share of food produced that is lost or wasted is roughly the same per region, hovering between 31 and 36 percent (except for South and Southeast Asia). Yet the share of food loss and waste occurring at the consumption stage is much higher in high-income regions than in low-income ones.

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ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of governments, businesses, and communities combine to eliminate poverty and sustain the natural environment for all people.

ABOUT THE PARTNERS

Consortium for Innovation in Postharvest Loss and Food Waste Reduction

Established in 2019, the Consortium for Innovation in Postharvest Loss and Food Waste Reduction brings together experts and thought leaders to advance a common research agenda for gaining efficiencies within the global food system. The Consortium represents expertise, knowledge, and innovation in postharvest loss and food waste reduction from institutions in the Americas, Europe, Middle East, and Africa, and across the public, private, and nonprofit sectors.

The Ed Snider Center, University of Maryland

Housed at University of Maryland's Robert H. Smith School of Business, the Ed Snider Center promotes free enterprise and markets by researching what makes individuals, organizations, and markets flourish; educating thought leaders and influencers; and partnering with executives to apply the center's research to real world challenges. Find out more at <https://www.rhsmith.umd.edu/centers-excellence/snider-center-enterprise-markets/about-us>.

Iowa State University

Iowa State University is a public, land-grant university, known worldwide for excellence in science and technology, discovery, and innovation, and a student-centered culture. Iowa State's research community aims to help solve society's greatest challenges and improve lives by integrating the research mission with the education and outreach missions of the university. Iowa State University leads the newly established Consortium for Innovation in Postharvest Loss and Food Waste Reduction.

The Natural Resources Defense Council

The Natural Resources Defense Council is an international nonprofit environmental organization with more than 2.4 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City; Washington, DC; Los Angeles; San Francisco; Chicago; Bozeman, Montana; and Beijing. Visit us at nrdc.org.

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The Rockefeller Foundation's mission—unchanged since 1913—is to promote the well-being of humanity throughout the world. Today the foundation advances new frontiers of science, data, policy, and innovation to solve global challenges related to health, food, power, and economic mobility. The Rockefeller Foundation seeks to inspire and foster large-scale human impact that promotes the well-being of humanity by identifying and accelerating breakthrough solutions, ideas, and conversations.

United Nations Environment Programme

Established in 1972, UNEP is the voice for the environment within the United Nations system. It acts as a catalyst, advocate, educator, and facilitator to promote the wise use and sustainable development of the global environment. Visit UNEP online at <http://www.unenvironment.org>.

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The mission of Wageningen University & Research is "to explore the potential of nature to improve the quality of life." Over 6,500 employees and 12,000 students from more than a hundred countries work everywhere around the world in the domain of healthy food and living environment. The strength of Wageningen University & Research lies in its ability to join the forces of specialized research institutes and the university.

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WRAP

WRAP's vision is a world in which resources are used sustainably. Our mission is to accelerate the move to a sustainable resource-efficient economy through reinventing how we design, produce, and sell products; rethinking how we use and consume products; and redefining what is possible through reuse and recycling. Find out more at www.wrap.org.uk.

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