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Installment 2 of "Creating a Sustainable Food Future"

REDUCING FOOD LOSS AND WASTE

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SUMMARY

The Food and Agriculture Organization of the United Nations (FAO) estimates that 32 percent of all food produced in the world was lost or wasted in 2009. This estimate is based on weight. When converted into calories, global food loss and waste amounts to approximately 24 percent of all food produced. Essentially, one out of every four food calories intended for people is not ultimately consumed by them.

Food loss and waste have many negative economic and environmental impacts. Economically, they represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses. Environmentally, food loss and waste inflict a host of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide.

"Food loss and waste" refers to the edible parts of plants and animals that are produced or harvested for human consumption but that are not ultimately consumed by people. In particular, "food loss" refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer. Food loss is the unintended result of an agricultural process or technical limitation in storage, infrastructure, packaging, or marketing. "Food waste" refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded—either before or after it spoils. Food waste is the result of negligence or a conscious decision to throw food away.

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Big inefficiencies suggest big savings opportunities. We estimate that if the current rate of food loss and waste were cut in half—from 24 percent to 12 percent—by the year 2050, the world would need about 1,314 trillion kilocalories (kcal) less food per year than it would in the business-as-usual global food requirements scenario described in "The Great Balancing Act," the first installment of this World Resources Report working paper series. That savings—1,314 trillion kcal—is roughly 22 percent of the 6,000 trillion kcal per year gap between food available today and that needed in 2050. Thus reducing food loss and waste could be one of the leading global strategies for achieving a sustainable food future.

Many approaches can be used to reduce food loss and waste. We profile a subset of approaches that experts suggest are particularly practical and cost-effective, that could be implemented relatively quickly, and that could achieve quick gains. These approaches include but are not limited to: facilitating food redistribution or donation, using evaporative coolers in places where refrigeration is unavailable, introducing hermetically sealed plastic storage bags for crops, using small metal silos, using plastic crates instead of bags for crops, changing food date labels to reduce consumer confusion about when food is unsafe, conducting consumer awareness campaigns about how to reduce household food waste, and reducing portion sizes at restaurants and cafeterias. This non-exhaustive list hints at the spectrum of approaches available across selected stages of the food value chain.

Each of these approaches—and others like them—can help reduce food loss and waste. To further galvanize commitment to reducing food loss and waste, several cross-cutting strategies are needed. These strategies will require action from multilateral and bilateral donors, intergovernmental agencies, national governments, and the private sector, among others. We recommend five strategies:

1. Develop a food loss and waste measurement protocol
2. Set food loss and waste reduction targets
3. Increase investment in reducing postharvest losses in developing countries
4. Create entities devoted to reducing food waste in developed countries
5. Accelerate and support collaborative initiatives to reduce food loss and waste

The world faced an analogous failure of efficiency in the 1970s with energy. In the face of record oil prices and growing demand, the world waged war on energy wastefulness and significantly improved its energy efficiency. Yet a "war on waste" has yet to be waged when it comes to food. With food prices recently hitting historic highs and global food demand continuing to rise, now is the time.

AT A LOSS

Approximately one out of every four calories grown to feed people is not ultimately consumed by humans.[1] Food is lost and wasted to a varying extent across the globe, across all stages of the food value chain, and across all types of food. As a result, overall global food availability is lower than it would be otherwise, negatively affecting food security[2] and requiring the planet's agriculture system to produce additional food to compensate for the food that is not ultimately consumed by people.

The potential benefits of reducing food loss and waste are large. As a strategy for closing the food gap between food available today and food needed in 2050 to adequately feed the planet's projected 9.3 billion people,[3] reducing food loss and waste satisfies each of the development and environmental criteria we introduced in the first installment of the *Creating a Sustainable Food Future* series (Table 1). While increasing food availability, reducing food loss and waste can alleviate poverty and provide gender benefits while reducing pressure on ecosystems, climate, and water. Reducing food loss and waste may be one of those rare multiple "win-win" strategies.

How can the world go about reducing food loss and waste on a large scale? This installment of the forthcoming World Resources Report *Creating a Sustainable Food Future* (Box 1) addresses that question. This working paper, which will feed into that report, begins by clarifying definitions of food loss and waste, then quantifies the scale of the problem and explores the impact addressing the problem could have on the food gap. The paper then focuses on practical solutions for reducing food loss and waste and presents case studies of successful initiatives. It concludes by offering recommendations for how to scale up reductions in food loss and waste.

Table 1 | **How "Reducing Food Loss and Waste" Performs Against the Sustainable Food Future Criteria**

● = positive ○ = neutral/it depends ⊗ = negative

CRITERIA	DEFINITION	PERFORMANCE	COMMENT
Poverty Alleviation	Reduces poverty and advances rural development, while still being cost effective	●	■ Reducing postharvest losses can increase the amount of food available to farmers for their own consumption or for sale to market ■ Reducing postharvest losses can reduce the likelihood that small-holders become net food buyers ■ Reducing losses in the value chain lowers expenditures of processors and retailers per unit of food grown or harvested ■ Reducing food waste can lower household expenditures per unit of food consumed ■ Reducing quality losses can better maintain nutritional value of food
Gender	Generates benefits for women	●	■ Reducing food losses increases the return on investment of time spent farming and could reduce the total time needed to work in fields ■ Reducing food waste could reduce total household expenditures on food, freeing up resources for health, education, and other household benefits
Eco-systems	Avoids agricultural expansion into remaining natural terrestrial ecosystems and relieves pressure on overstrained fisheries	●	■ Better utilizing food already grown reduces the need to convert more ecosystems into food production or to harvest more wild food (e.g., fish)
Climate	Helps reduce greenhouse gas emissions from agriculture to levels consistent with stabilizing the climate	●	■ Better utilizing food already grown reduces the need to convert more land, apply more fertilizers, raise more livestock, and use energy for producing, processing, transporting, and storing food ■ Diverting food loss and waste from landfills prevents methane emissions from rotting food
Water	Does not deplete or pollute aquifers or surface waters	●	■ Better utilizing food already grown reduces the need to withdraw more water from aquifers or add more agricultural chemicals that may pollute water bodies

Box 1 | **The World Resources Report**

The world's agricultural system faces a great balancing act among three needs. By mid-century, it needs to simultaneously close a gap of more than 60 percent between food available now and food required in 2050, help advance economic and social development, and reduce agriculture's impact on the environment.

This balancing act poses one of the paramount questions of the next 40 years: *How can the world adequately feed more than 9 billion people by 2050 in a manner that advances social and economic development while reducing pressure on ecosystems, climate, and water resources?* The forthcoming World Resources Report, *Creating a Sustainable Food Future*, seeks to answer this question by proposing a menu of solutions that can achieve the great balancing act. "Reducing Food Loss and Waste" profiles one of the solutions on this menu and is an installment in a series of working papers leading up to the World Resources Report.

Since the 1980s, the World Resources Report has provided decision-makers from government, business, and civil society with analyses and insights on major issues at the nexus of development and the environment. For more information about the World Resources Report and to access previous installments and editions, visit www.worldresourcesreport.org.

DEFINITIONS

In this working paper, "food loss and waste" refers to 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.

Although the terms loss and waste are used in conjunction throughout this working paper, they have distinct drivers and, as a result, distinct solutions. "Food loss" refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer.[4] Food loss typically occurs at the production, storage, processing and distribution stages of the food value chain, and is the unintended result of agricultural processes or technical limitations in storage, infrastructure, packaging, and/or marketing.

"Food waste" refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded—either before or after it spoils.[5] Food waste typically, but not exclusively, occurs at the retail and consumption stages in the food value chain and is the result of negligence or a conscious decision to throw food away.

Food loss and waste apply to food products in the value chain starting from the moment that:[6]

- Crops are ripe in the field, plantation, or orchard;
- Animals are on the farm—in the field, sty, pen, shed, or coop—ready for slaughter;[7]
- Milk has been drawn from the udder;
- Aquaculture fish are mature in the pond; and
- Wild fish have been caught in the net.

The value chain ends at the moment food products are consumed by people, discarded, or otherwise removed from the food chain intended for direct human consumption. Therefore, 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.[8]

Food loss and waste can occur at each stage of the food value chain (Table 2). Some examples of how they can occur at each stage are:

- During *production* or harvest in the form of grain left behind by poor harvesting equipment, discarded fish, and fruit not harvested or discarded because they fail to meet quality standards or are uneconomical to harvest.
- During *handling and storage* in the form of food degraded by pests, fungus, and disease.
- During *processing and packaging* in the form of spilled milk, damaged fish, and fruit unsuitable for processing. Processed foods may be lost or wasted because of poor order forecasting and inefficient factory processes.
- During *distribution and marketing* in the form of edible food discarded because it is non-compliant with aesthetic quality standards or is not sold before "best before" and "use-by" dates.
- During *consumption* in the form of food purchased by consumers, restaurants, and caterers but not eaten.[9]

In this working paper, food loss and waste do not include:

- By-products—such as bones, organs, skins, seeds, peels, hulls, and bran—that could be considered unavoidable food waste because in specific supply chains they are not intended for human consumption and are discarded or used in non-food products;
- Surplus food that is redirected to food banks and subsequently eaten by people;[10]
- Food grown intentionally for feed, seed, or industrial use; and
- Overconsumption beyond recommended caloric needs.

Table 2 | **Food Loss and Waste Along the Value Chain**

Production	Handling and Storage	Processing and Packaging	Distribution and Market	Consumption
DEFINITION				
During or immediately after harvesting on the farm	After produce leaves the farm for handling, storage, and transport	During industrial or domestic processing and/or packaging	During distribution to markets, including losses at wholesale and retail markets	Losses in the home or business of the consumer, including restaurants/caterers
INCLUDES				
Fruits bruised during picking or threshing	Edible food eaten by pests	Milk spilled during pasteurization and processing (e.g., cheese)	Edible produce sorted out due to quality	Edible products sorted out due to quality
Crops sorted out post-harvest for not meeting quality standards	Edible produce degraded by fungus or disease	Edible fruit or grains sorted out as not suitable for processing	Edible products expired before being purchased	Food purchased but not eaten
Crops left behind in fields due to poor mechanical harvesting or sharp drops in prices	Livestock death during transport to slaughter or not accepted for slaughter	Livestock trimming during slaughtering and industrial processing	Edible products spilled or damaged in market	Food cooked but not eaten
Fish discarded during fishing operations	Fish that are spilled or degraded after landing	Fish spilled or damaged during canning/smoking		

SCALE OF THE PROBLEM

The Food and Agriculture Organization of the United Nations (FAO) estimates that 32 percent of all food produced in the world was lost or wasted in 2009.[11] Although the waste estimates provided by the FAO have many uncertainties, they are the most comprehensive global numbers currently available (Box 2).

The FAO estimate is based on weight. When considering weight, a ton of grain is the same as a ton of fruit, which is the same as a ton of meat. However, food types vary widely in terms of their water and caloric content per kilogram. For instance, a kilogram of wheat flour on average contains 12 percent water and 3,643 kcal whereas a kilogram of apples on average contains 81 percent water and 1,704 kcal.[12] Consequently, measuring by weight does not consistently reflect the energy in food products that could have been consumed by people.

Using the FAO Food Balance Sheets,[13] we converted FAO's loss and waste estimates into calories. Measured this way, global food loss and waste equates to approximately 24 percent of all food produced—a lower but still substantial amount.[14] *Essentially, one out of every four food calories produced for humans is not being consumed.*

Box 2 | **Scope of the Data**

The FAO data on food loss and waste used in this working paper cover the following basic commodities and their derived products:

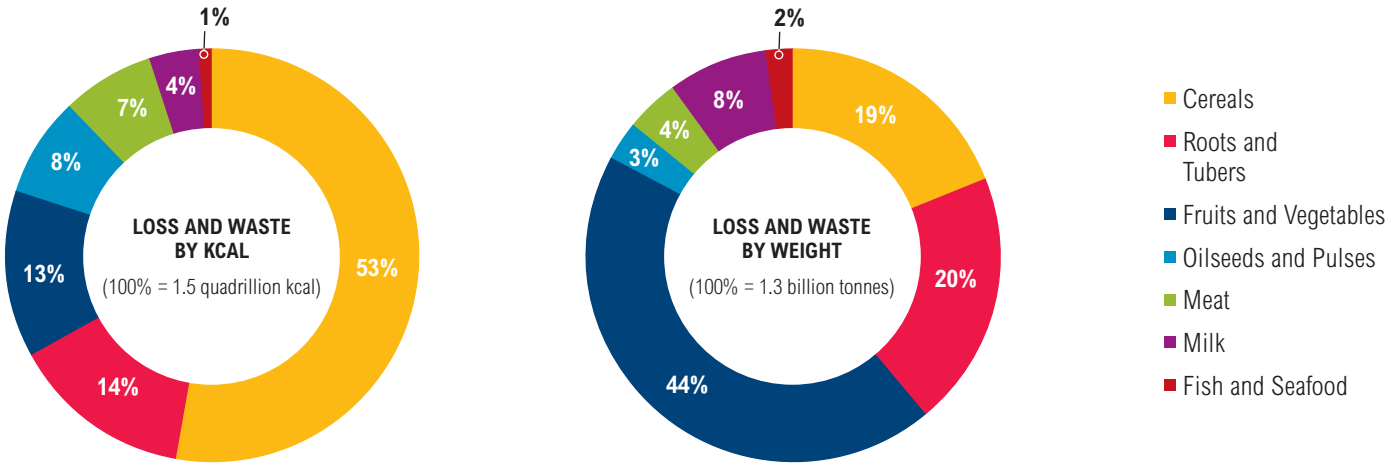
- Cereals
- Roots and tubers
- Fruits and vegetables
- Oilseeds, pulses and nuts
- Meat
- Fish and seafood
- Milk and eggs

Food products not included in this data are:

- Herbs, spices, and condiments
- Coffee, tea, cocoa
- Sugar, honey
- Alcoholic beverages
- Confectionary products

Source: FAO (2013).

Figure 1 | **Share of Global Food Loss and Waste By Commodity, 2009**



Source: WRI analysis based on FAO. 2011. *Global food losses and food waste—extent, causes and prevention.* Rome: UN FAO.

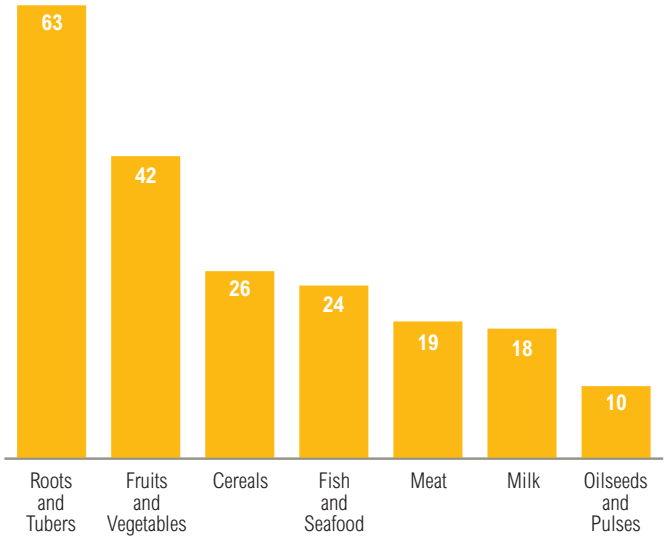
What is being lost and wasted?

Cereals comprise the largest share of global food loss and waste by caloric content—53 percent (Figure 1). Meat is a relatively small share—7 percent. However, not all loss and waste is created equal. The relatively large environmental impacts of meat in terms of greenhouse gas emissions, land use, and water consumption per calorie combined with the high economic costs of meat suggest that reducing meat loss and waste should receive at least as much attention as other commodities, despite comprising a smaller share of caloric losses.[15]

Whether one measures food loss and waste in terms of calories or weight highlights different food commodities. Whereas cereals comprise the most food loss and waste relative to other food commodities on a caloric basis, fruits and vegetables are the largest source of loss and waste on a weight basis (Figure 1). This variance primarily results from differences in water content; much of the lost and wasted weight in fruits and vegetables is water. Nonetheless, reducing the loss and waste of fruits and vegetables is clearly important since these foods provide people many essential vitamins and minerals such as vitamin A, vitamin C, and potassium needed for leading healthy lives.[16]

Figure 2 shows the percent of kcal lost or wasted for each food commodity. Roots and tubers experience the greatest amount of loss and waste—63 percent on a caloric basis.

Figure 2 | **Share of Commodity Lost or Wasted, 2009 (Percent of kcal)**



Note: Values displayed are of waste as a percent of food supply, defined here as the sum of the "Food" and "Processing" columns of the FAO Food Balance Sheet.

Source: WRI analysis based on FAO 2011.

Forty-two percent is the rate for fruits and vegetables, and about a quarter of cereals and seafood produced are lost or wasted.

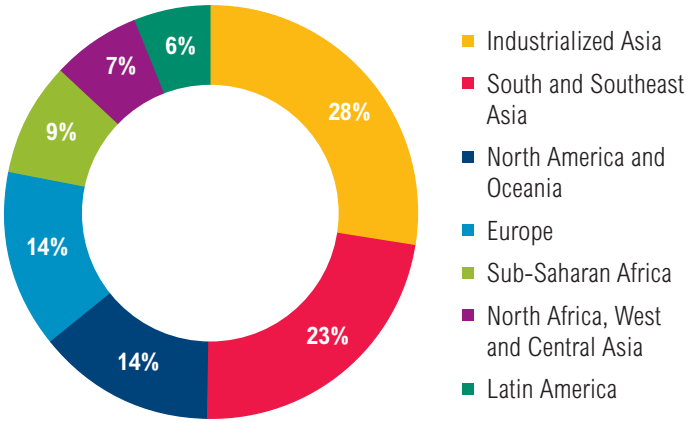
Where is food loss and waste occurring?

Any effort to reduce food loss and waste needs to start with a diagnosis of where it occurs. Analyzing the FAO data provides some insights.[17]

Regionally, about 56 percent of total food loss and waste occurs in the developed world—North America, Oceania, Europe, and the industrialized Asian nations of China, Japan, and South Korea—whereas the developing world accounts for 44 percent of the loss (Figure 3). On a per capita basis, however, North America and Oceania[18] stand out from other regions (Figure 4), with about 1,500 kcal per person per day lost or wasted from farm to fork.

In terms of stages of the food value chain, 24 percent of global food loss and waste occurs at production, another 24 percent during handling and storage, and 35 percent at consumption. These three stages taken together account for more than 80 percent of global food loss and waste.

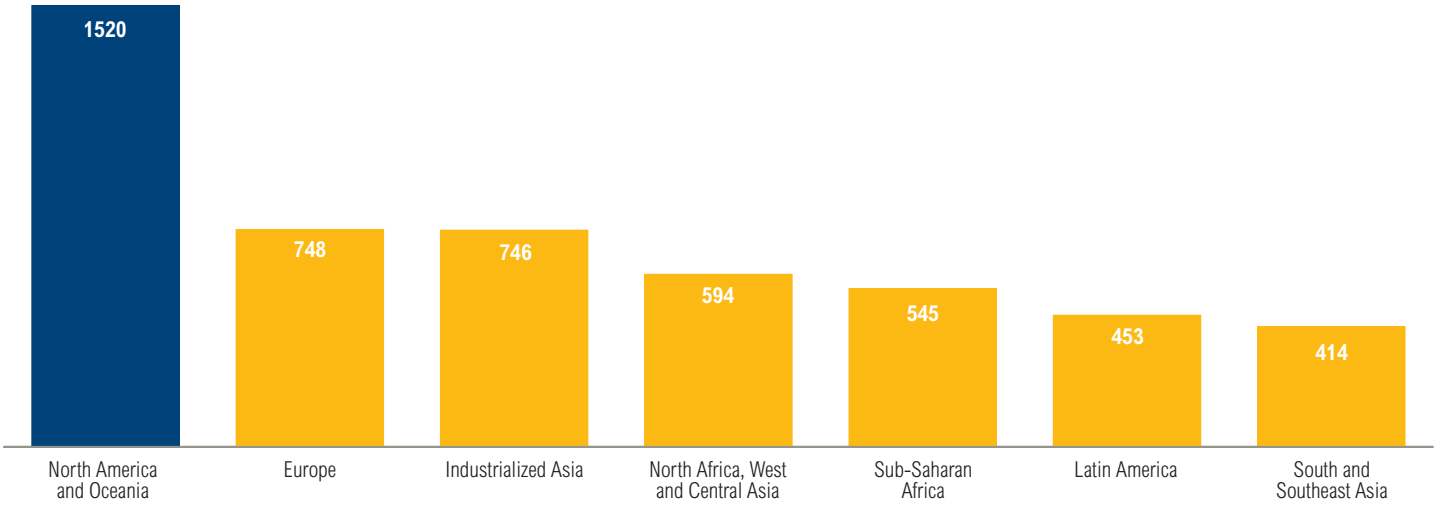
Figure 3 | **Share of Global Food Loss and Waste by Region, 2009 (100% = 1.5 quadrillion kcal)**



Note: Number may not sum to 100 due to rounding.

Source: WRI analysis based on FAO. 2011. *Global food losses and food waste—extent, causes and prevention.* Rome: UN FAO.

Figure 4 | **Food Lost or Wasted By Region, 2009 (Kcal/capita/day)**



Source: WRI analysis based on FAO. 2011. *Global food losses and food waste—extent, causes and prevention.* Rome: UN FAO.

The distribution of this food loss and waste varies significantly between developed and developing regions with developed countries seeing more at consumption and developing countries seeing more during production and handling and storage (Figure 5).

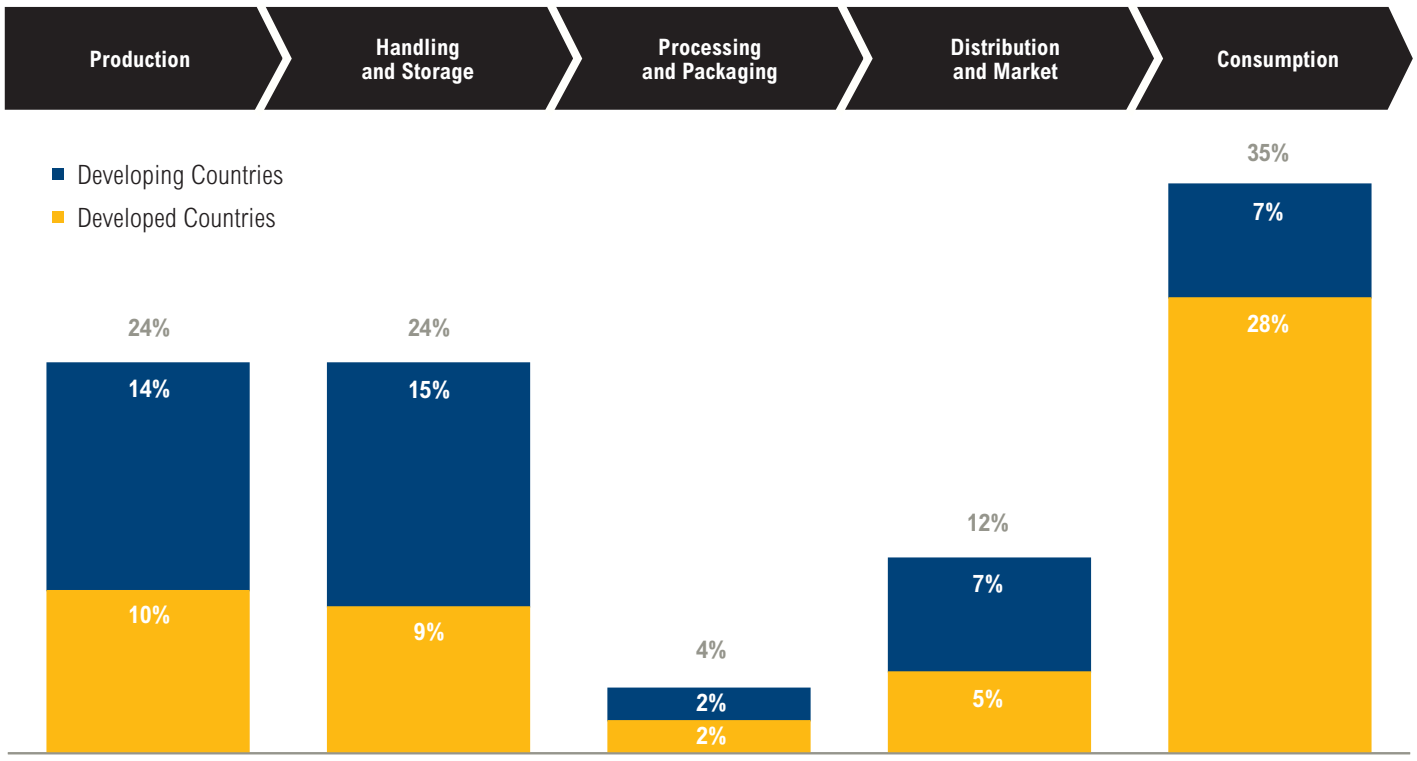
Figure 6 shows that more than half of the food loss and waste in North America, Oceania, and Europe occurs at the consumption stage. In contrast, the two stages closest to the farm—production and storage—account for two-thirds to three-quarters of food loss and waste, respectively, in South and Southeast Asia and in Sub-Saharan Africa. This distribution suggests that efforts to reduce food loss and waste should focus on stages "close to the farm" in most developing regions and focus on stages "close to the fork" in developed regions. However, it should be noted that almost all urban areas experience significant levels of food waste, regardless of whether they are located in developed or developing countries. These levels of waste may even be higher in cities located in developing countries, which lack the infrastructure to address this problem.[19]

The total share of food lost or wasted ranges from 15 percent to 25 percent across most regions (Figure 6). The one exception is North America and Oceania, where loss and waste is approximately 42 percent of all available food, suggesting the need for concentrated efforts to reduce the waste levels in those regions.

What are the implications?

Food loss and waste have many negative economic and environmental impacts. Economically, they equate to a wasted investment that reduces the economic wellbeing of actors in the food value chain. For example, food waste at the consumption stage costs an average of US$1,600 per year for a family of four in the United States and £680 (about US$1,000) per year for the average household in the United Kingdom.[20] Annually, about US$32 billion worth of food is thrown away in China.[21] In Sub-Saharan Africa, where many farmers earn less than US$2 a day, postharvest losses have a value of up to US$4 billion per year.[22]

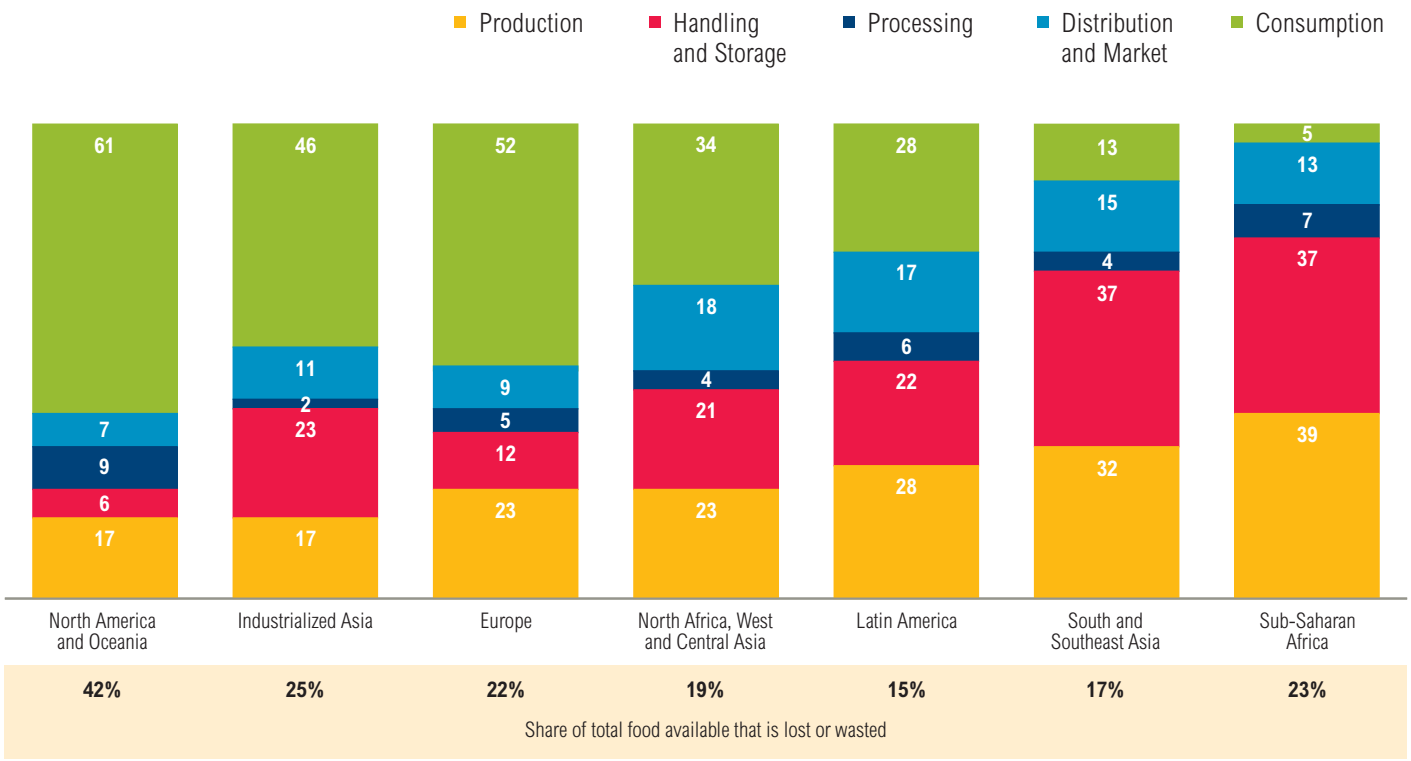
Figure 5 | **Share of Total Food Loss and Waste by Stage in the Value Chain, 2009 (100% = 1.5 quadrillion kcal)**



Note: Number may not sum to 100 due to rounding.

Source: WRI analysis based on FAO. 2011. *Global food losses and food waste—extent, causes and prevention.* Rome: UN FAO.

Figure 6 | **Food Lost or Wasted By Region and Stage in Value Chain, 2009 (Percent of kcal lost and wasted)**



Note: Number may not sum to 100 due to rounding.

Source: WRI analysis based on FAO. 2011. *Global food losses and food waste—extent, causes and prevention.* Rome: UN FAO.

Environmentally, food loss and waste represent unnecessary greenhouse gas emissions and wasted water and land.[23] Globally, the amount of food loss and waste in 2009 was responsible for roughly 3,300–5,600 million metric tons of greenhouse gas emissions (carbon dioxide equivalent), the upper end of which is almost equivalent to the amount of carbon dioxide emissions from energy consumption by the United States in 2011.[24] Food loss and waste are associated with approximately 173 billion cubic meters of water consumption per year, which represents 24 percent of all water used for agriculture.[25] The amount of cropland used to grow this lost and wasted food is 198 million hectares per year, an area about the size of Mexico.[26] And 28 million tons of fertilizer are used annually to grow this lost and wasted food.[27] Beyond these quantified impacts, natural landscapes and the ecosystem services they provide are also adversely affected by the resources that go into producing this lost and wasted food.

POTENTIAL BENEFITS OF REDUCING LOSS AND WASTE

Big inefficiencies suggest big savings opportunities. But how big is the potential? In 2012, the European Commission set a target of reducing by 50 percent the rate of food loss and waste in Europe by 2020.[28] If this target were extended globally to 2050, our analysis suggests that achieving it would reduce the need to produce 1,314 trillion kcal of food per year in 2050 relative to the business-as-usual scenario described in "The Great Balancing Act," the first installment of this World Resources Report working paper series.[29] In other words, cutting the global rate of food loss and waste from 24 percent of calories down to 12 percent would close roughly 22 percent of the 6,000 trillion kcal per year gap between food available today and that needed in 2050.[30] Thus our analysis suggests that reducing food loss and waste could be one of the leading global strategies or "menu items" for achieving a sustainable food future.

Table 3 | **Possible Approaches For Reducing Food Loss and Waste (Not Exhaustive)**

Production	Handling and Storage	Processing and Packaging	Distribution and Market	Consumption
Facilitate donation of unmarketable crops *p. 12–13*	**Improve access to low-cost handling and storage technologies (e.g., evaporative coolers, storage bags, metal silos, crates)** *p. 14–21*	Re-engineer manufacturing processes	**Facilitate increased donation of unsold goods** *p. 12–13*	**Facilitate increased donation of unsold goods from restaurants and caterers** *p. 12–13*
Improve availability of agricultural extension services	Improve ethylene and microbial management of food in storage	Improve supply chain management	**Change food date labeling practices** *p. 22–23*	**Conduct consumer education campaigns** *p. 24–25*
Improve market access	Introduce low-carbon refrigeration	Improve packaging to keep food fresher for longer	**Change in-store promotions** *p. 24–25*	**Reduce portion sizes** *p. 26–27*
Improve harvesting techniques	Improve infrastructure (e.g., roads)		Provide guidance on food storage and preparation to consumers Improve inventory systems	Ensure home economics taught in schools, colleges and communities

There is some precedent for progress. The Waste and Resource Action Programme (WRAP) in the United Kingdom achieved a 13 percent reduction in household food waste from 2007 to 2010. Manufacturers and retailers that signed up for Phase 2 of the Courtauld Commitment, a voluntary agreement convened by WRAP, reduced their food and drink waste by 8.8 percent between 2009 and 2011.[31] Pilot efforts in Benin, Cape Verde, India, and Rwanda have documented reductions of food loss by more than 60 percent during field trials of a variety of low-cost storage techniques and handling practices.[32]

However, meeting a global 50 percent reduction goal by 2050 is daunting. For example, even if approaches to reduce losses at the production and storage stages in developing countries prove successful, these gains might be offset by increases in food waste at the consumption end of the value chain as the global middle class grows. Likewise, changing consumer behavior anywhere is never easy. Nonetheless, the potential scale and multiple benefits of reducing food loss and waste make the effort worthwhile and desirable.

POSSIBLE APPROACHES

A wide range of approaches for reducing food loss and waste are in use (Table 3). We do not cover all of them, however, in this working paper. For instance, building roads and introducing electric-powered refrigeration in low-income countries would likely reduce food losses during the handling and storage phase by enabling fresh food to get to market more quickly and by preventing spoilage.[33] Instead, we profile a subset of approaches that literature reviews, expert interviews, and co-author insights suggest are particularly practical and cost-effective, could be implemented relatively quickly, and could achieve near-term gains once put into place. This non-exhaustive subset is meant to indicate a range of approaches available across selected stages of the food value chain. Some interventions, such as evaporative coolers for storage, directly affect food, whereas others, such as consumer education campaigns, indirectly affect food by influencing people's consumptive behavior.

We organize the approaches by stage in the value chain. Approaches listed under the production, the handling and storage, and the processing stages focus on reducing food loss, and those listed under the distribution and market and the consumption stages focus on reducing food waste. Some approaches, such as increasing food redistribution or donations, cut across multiple stages.

It is important to note that many technical solutions can be effective only when other parts of the food supply chain are effective. For example, improved on-farm storage will not ultimately lead to reductions in food loss if farmers have no access to a market where they can sell their harvest surplus. Retailers using poor forecasting techniques may place food orders and later cancel them, negating per unit efficiency gains made by food processors. Therefore, progress in reducing food loss and waste will require an integrated supply chain approach.[34]

Likewise, all actors in the food value chain need to be involved if food loss and waste rates are to be significantly curtailed. Farmers, agribusiness firms, and consumers all have a role to play. Targeting solutions toward women may be especially effective in many cases (Box 2).

Box 2 | The Role of Women in Reducing Food Loss and Waste

Women in both developing and developed countries have an important role to play in reducing food loss and waste, since women interact with food at each stage of the value chain from farm to fork. Close to the farm, women comprise 41 percent of the agricultural workforce worldwide and make up the majority of agricultural workers in South Asia and Sub-Saharan Africa.[a] Close to the fork, surveys in a wide range of countries show that women are responsible for 85-90 percent of the time spent on household food preparation.[b] Therefore, targeting women in food loss and food waste reduction campaigns could result in greater reductions than pursuing an unfocused campaign.

One such gender-targeted initiative in Tanzania focused on providing female farmers with greater access to markets and supplied participants with access to solar drying technology that allowed for surplus fruits—that might other be lost—to be dried and preserved.[c] Another campaign in Australia called "1 Million Women" encourages women to take action on a number of environmental issues, including reducing food waste. The campaign has hosted events with a celebrity chef to raise awareness of food waste, and its official website provides tips on how to reduce waste and recipes for how to efficiently use food.[d]

a. FAO (2007); World Bank, FAO and IFAD (2009)
b. World Food Programme (2013)
c. The Seed Initiative (2013) as cited in Think.Eat.Save (2013)
d. 1 Million Women (2012) as cited in Think.Eat.Save (2013)

Food redistribution

Food redistribution or donation programs are a method for reducing both food loss and waste. As used here, "food redistribution" means voluntarily giving away food that otherwise would be lost or wasted to recipients such as food banks, which then redistribute the food to those who need it. This strategy applies at the production stage with crops that otherwise would go unharvested, at the manufacturing stage with overproduced products, and at the distribution and market stage with food left unsold at stores and markets.

Why is there surplus food to redistribute?

There are a number of reasons edible grains, fruits, and vegetables never leave the field. Some food might go unharvested due to economic realities. If the price of a given crop is too low to even pay for the labor required to pick that crop and the transport costs associated with selling it, it may be economically rational for the farmer to let that food be lost. Crops also may not be harvested due to weather or pest damage, blemishes, or imperfections relating to shape, size, and color,[35] although these crops are often used for processed goods, given the wide range of markets available to most farmers.[36]

At the manufacturing stage, a food processor might produce a surplus amount of food when a product is generated to meet an order but then the order is subsequently reduced by the retailer that placed it. This food is then available to be redistributed to food banks.[37]

At the market stage, surplus food might be generated when a store purchases too much of a certain item that then approaches or goes past the "sell-by" or "display until" date printed by the manufacturer.[38] Food is generally still safe to eat after these dates, as it is only a measure of when a food item has passed its peak quality. But stores are unable to sell such items in most places due to local regulations and consumer concerns that the food has thus "expired."[39] In addition, fresh-cooked meals at food retail stores that are unsold at the end of a day typically are thrown away.[40]

What are the key obstacles?

The leading obstacles to food redistribution are related to transportation, legal, and economic factors. For instance, farmers and stores with surplus food might not be physically close enough to food banks or food rescue groups to economically deliver unused food. Prospective food donors can be concerned about legal repercussions should the food somehow be unsafe and the recipients of the food suffer health consequences.[41] Furthermore, if economic considerations make it prohibitive for a farmer to harvest and sell a type of food on the market, it seems unlikely that the same farmer will then incur the labor, logistical, and transportation costs to donate that food.

What could facilitate increased food redistribution?

The transportation obstacle for food redistribution can be difficult to address. Establishing additional food bank locations could lessen travel distances and make redistribution easier for many farmers and retailers. Likewise, an adequately-funded nonprofit organization could run scheduled retrieval services, driving to farms and retail stores, picking up donated goods, and delivering to food banks.

To address the legal obstacle, governments can pass "Good Samaritan" laws which limit the liability of donors in case redistributed food unexpectedly turns out to be somehow harmful to the consumer. These laws generally do not protect against gross negligence or intentional misconduct, but instead assure food donors that they will not be penalized for redistributions made in good faith.[42] In addition to granting legal protection to donors, these laws may also be seen as a symbolic endorsement of food redistribution efforts, bringing attention to redistribution to those who might not have considered it in the past.[43]

One such example of this type of law is the Bill Emerson Good Samaritan Act in the United States, enacted in 1996. This law protects food donors from civil and criminal liability if the product they redistributed in good faith to a charitable organization later causes harm to the needy recipient. It also standardizes donor liability exposure – donors no longer have to accommodate 50 different liability laws in 50 different states.[44]

To help address the economic obstacles, governments can introduce tax incentives for food donations. In the United States, California, Arizona, Oregon, and Colorado each have passed state laws providing tax credits for food redistribution to state food banks, but there is currently no federal tax incentive for food donation.[45]

Case Study: SecondBite[46]

In Australia, the nonprofit organization SecondBite facilitates food donation by linking farmers and retailers with community groups and food banks. SecondBite effectively functions as a broker, first collecting food from donors and then distributing it among community groups that are already aware of where hunger and malnutrition are most prevalent. In this way, SecondBite draws upon existing knowledge and expertise of other organizations to further its mission. SecondBite also works with state governments in Australia to introduce Good Samaritan Acts to promote food donation. In 2012, SecondBite rescued and redirected 3,000 metric tons of fresh food that otherwise would have been lost or wasted.

Evaporative coolers

Evaporative coolers extend the shelf life of food and avoid spoilage by keeping food at lower-than-room temperatures without having to use electricity. This low-cost, low-energy technique provides an opportunity to store perishable foods longer in areas that lack electricity infrastructure or that have low-income farmers.

How does evaporative cooling work?

When air passes over a wet surface, water from the surface evaporates into the air. As the water evaporates, it withdraws heat from the surface, creating a cooling effect upon that surface.[47] Evaporative coolers harness this effect in a number of different ways, but the general design of each is similar. One vessel, holding the food being stored, is placed inside another vessel filled with water. As the water evaporates, the inner vessel stays cool. Water is then refilled as needed.[48]

What are some example applications?

One of the simplest evaporative coolers is the "zeer," invented by Nigerian teacher Mohammed Bah Abba in 1995.[49] The zeer follows the standard evaporative cooling process, except that the outside vessel is filled with wet sand instead of water, which yields an added insulating effect for the internal vessel. The sand is generally re-wet twice a day. The zeer itself costs less than US$2 to produce, can hold up to 12 kg, and can be reused for several years before becoming saturated with salts and needing replacement.[50] The zeer dramatically extends the shelf life of the items kept in it. For example, tomatoes and guavas, which might normally expire within two days without any storage, last up to 20 days in a zeer.[51]

A somewhat more complex evaporative cooler is the "zero energy cool chamber." The zero energy cool chamber (ZECC) consists of two brick walls, one nested inside of the other, with the cavity between the two filled with wet sand. The external wall is submerged in water before construction in order to soak the bricks and then is removed for construction. The chamber has a cover constructed out of bamboo and an awning to avoid direct sunlight or rain.[52] The outer wall and the sand inside are re-wet twice daily while the chamber is in use.[53] The total cost of construction is about US$74, and the finished chamber can hold 100 kg. Like the zeer, the ZECC can be reused for many years.

Studies in India found that a ZECC was up to 11°C cooler than the outside air temperature in the hottest months of the year.[54] The chamber significantly increases shelf life and reduces weight loss for fruits and vegetables stored within it (Table 4). Thus far, ZECCs seem to be most common in India, and are now being actively promoted in Tanzania by the World Vegetable Center (AVRDC).[55]

What are the benefits?

Evaporative cooling is a relatively low-cost method of preserving fruits, vegetables, roots, and tubers, especially in regions where electric refrigeration is either prohibitively expensive or unavailable due to lack of a reliable electricity supply.[56] Almost all of the costs associated with evaporative cooling are up-front, which provides certainty around the expenses associated with using these coolers. Furthermore, the materials necessary to construct evaporative coolers tend to be locally available and relatively simple to acquire.[57]

What are some limitations?

Limitations to evaporative coolers center on storage capacity, ambient humidity levels, and water availability. For instance, evaporative coolers tend to have relatively low storage capacity, limiting their use to households and small farms. Evaporative cooling as a principle does not work in areas with high levels of humidity, since the air is already saturated with moisture and thus not much evaporation will occur.[58] In addition, evaporative coolers may also not be feasible in locations with limited access to water, although the water used does not need to be potable as long as food stored in the coolers is protected from contamination.

What can promote the use of evaporative coolers?

Since evaporative coolers are constructed from locally-available materials and do not require an extensive amount of training to properly use, the primary challenges for the spread of evaporative coolers are the need for greater awareness about evaporative coolers and education on how to use them. Extension agencies could play a role in spreading awareness of evaporative cooling via farmer engagement. Agencies could also create demonstration sites showing how to construct a ZECC, as is being done during 2012–13 in Tanzania by the University of California-Davis, the World Food Logistics Organization (WFLO), and AVRDC.[59] These sites could then reach a large number of people at the same time and could train farmers and households on how to spread the word to others—a "train the trainers" type of approach.[60] In addition, public service announcements from extension agencies and development organizations in the form of radio stories, newspaper articles, and mobile texts could reach farmers to spread information about evaporative cooling.

Case study: Evaporative coolers in India[61]

In the mid-1990s, the extension organization Krishi Vagyan Kendra (KVK) began to investigate a common problem for farmers in dryland villages in India. Farmers were taking their crops to market far more often than they would prefer because otherwise the crops would spoil. Taking the crops to market every other day was strenuous and time-consuming, but lacking adequate storage, the farmers had no choice.

Table 4 | **Increases in Shelf Life Via Zero Energy Cool Chamber**

CROP	SHELF LIFE (IN DAYS)		ADDED SHELF LIFE (PERCENT)
	ROOM TEMPERATURE	ZERO ENERGY COOL CHAMBER	
Banana	14	20	**43%**
Carrot	5	12	**140%**
Cauliflower	7	12	**71%**
Guava	10	15	**50%**
Lime	11	25	**127%**
Mango	6	9	**50%**
Mint	1	3	**200%**
Peas	5	10	**100%**
Potato	46	97	**111%**

Source: Adapted from Roy. n.d. "On-farm storage technology can save energy and raise farm income." Presentation.

The KVK determined that ZECCs would be a useful solution for farmers facing this problem. With funds provided by the National Horticulture Board of India, the KVK constructed 200 ZECCs in 10 villages and conducted 40 training programs on their construction and use during the period of 1997 through 2000. The KVK estimates that 1,200 farmers were reached as a result of this project, and found that additional farmers outside the program area were requesting the installation of the chambers in their own villages.

Plastic storage bags

Damage from pests is a major source of food loss during the handling and storage phase of the supply chain. Take cowpeas for instance. The crop is important for many smallholder farmers due to the cowpeas' ability to adapt to dry, hot conditions.[62] The crop is especially important in West and Central Africa, regions that account for approximately 69 percent of the world's total production of cowpeas by volume.[63] However, damage to cowpeas from insects can result in lower prices for farmers and even in outright loss of the crop.[64] Researchers at Purdue University in the United States have worked to reduce this damage by developing a simple reusable plastic storage bag, the "Purdue Improved Cowpea Storage" (PICS) bag.

How does PICS work?

PICS uses three bags nested within each other, with the innermost bag holding the crop being stored. After filling, each bag is tied tightly so as to form an airtight seal. Once the bag is tied, any pests remaining in the bag have a finite amount of oxygen to draw upon. As oxygen is depleted, the insects stop feeding on the cowpeas and become inactive, eventually drying out entirely and dying.[65] PICS bags allow the crop to remain in storage for many months without degradation in quality due to pests. The bags may also be useful for other crops, such as maize,[66] although use to date has primarily focused on cowpeas.

What are the barriers to uptake?

A number of barriers to widespread use of PICS bags exist. Limited availability of PICS bags is the main constraint in many countries, due to an insufficiently dense network of agricultural input retailers in many countries.[67] For example, the average distance to a PICS retailer is nearly 13 kilometers in some parts of Niger.[68]

Low levels of awareness about PICS bags can also be a constraint. In a survey of Nigerian villages that were not part of any PICS pilot project, only about half of survey respondents had heard of the PICS bags, suggesting that word-of-mouth is not sufficient to spread awareness of a new technology.[69] Up-front purchasing costs may also deter some farmers, although relatively few farmers cite this as the main barrier to adoption.[70] High import tariffs on raw materials for manufacturing the bags add to the cost, as do high transportation costs for vendors who sell the bags.

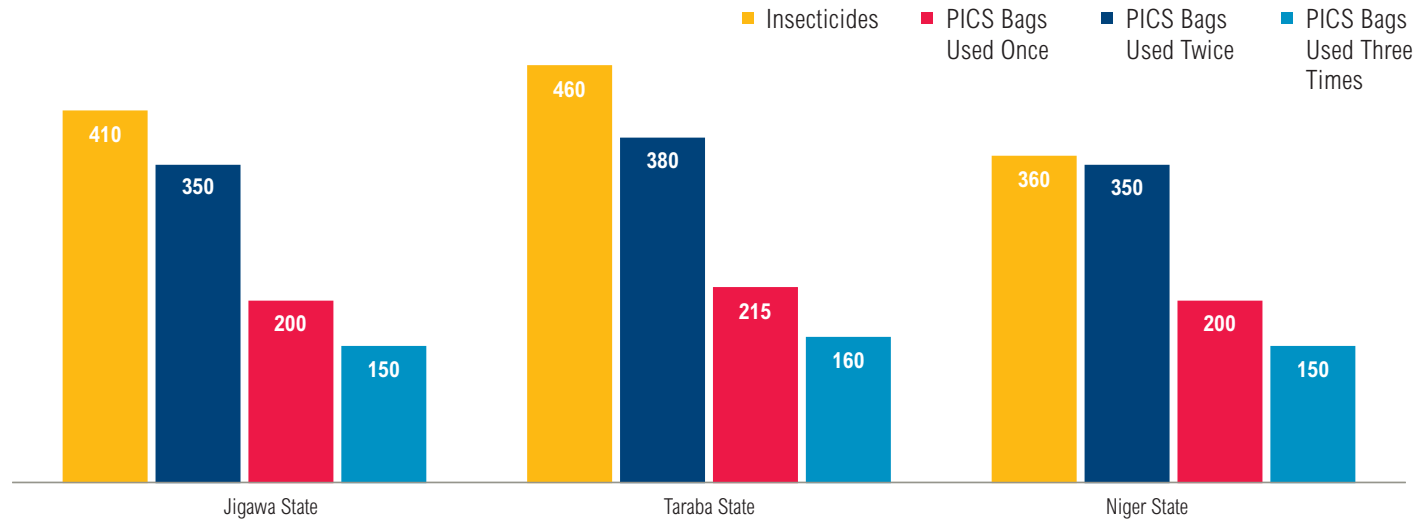
The prevalence of other methods of storage may also adversely affect the spread of PICS bags. Many farmers use pesticides to kill insects in stored crops and are skeptical of non-pesticide technology, despite the often higher costs of using pesticides.[71]

How can PICS be scaled up?

Extension services have an important role to play in spreading awareness of new technologies such as PICS bags and educating farmers on how to use them. Extension services can answer questions, assuage concerns, and provide training by hosting demonstrations and holding events where PICS bags are filled with cowpeas, stored for months, and then reopened to show the lasting freshness of the stored cowpeas.

Donor agencies and governments can increase the availability of PICS bags and similar technologies through interventions such as pilot programs that purchase large volumes of the bags and distribute them to villages, thereby priming demand for the bags. In addition, governments could reduce tariffs on the raw materials—primarily plastics—used to make the bags so that they can be made in-country at lower cost, which in turn can make the bags more affordable to farmers.

Figure 7 | **Per-Use Cost Comparisons of Insecticides and PICS Bags in Nigeria Naira (local currency)**



Source: Grace, J., U. Ugbe, and A. Sanni. 2012. "Innovations in the Cowpea Sector of Northern Nigeria: Research Into Use Nigeria." Presentation.

PICS bags are an example of a simple technology that is easy to use. Similar approaches for other crops may be attractive options for tackling storage-related losses.

Case study: PICS in Nigeria

A study led by Research Into Use (RIU) in Nigeria in 2009 distributed PICS bags to approximately 600,000 farmers in an effort to introduce a commercially viable, non-toxic method of storing cowpeas.[72] Before distributing any bags, RIU conducted a survey to assess awareness levels among farmers in the study areas. They found that only about half of surveyed farmers were even aware of improved storage techniques, such as PICS bags, while only about 25 percent were making use of improved storage techniques.[73] Many farmers were skeptical of the viability of the PICS bags, despite PICS bags being cheaper than pesticides per use (Figure 7). One farmer who volunteered to store some of her cowpeas in a PICS bag was told by her neighbors that she would have to feed her crop to the chickens due to how infested it would be after a six-month storage period.

However, after the bags were distributed, farmers who used the PICS bags saw an increase in cowpea-related income of 48 percent on average, and cowpeas that had been stored in bags generally fetched a price 5 to 10 percent higher than cowpeas stored using other methods.[74] The bags have proven popular enough that Lela Agro, the manufacturer of PICS bags in Nigeria, produced half a million PICS bags in 2012.[75]

Small metal silos

Small metal silos, which are intended for use by one farmer or by one household and generally hold between 250–1000 kg of crops, can be an effective strategy for reducing food loss at the storage stage, especially for cereals and pulses. Insufficient storage is a major source of food loss for farmers, especially in developing countries, where storage structures often do not keep harvested crops in hermetic—or airtight—conditions. Failure to have airtight storage structures allows moisture and pests to enter containers, potentially causing mold, toxins, or pests to contaminate the crop.[76]

How does lack of airtight storage affect farmers?

When farmers do not possess adequate storage capabilities, they may have to resort to selling off their entire crop immediately after harvest, which can mean at low prices since the supply of a crop relative to demand is more likely to be high just after harvest.[77] As a result, farmers are not able to retain surplus crop for sale later, when the value of the crop might rise as it becomes less available. Insufficient storage also has consequences for food security, since farm families may need to purchase a larger share of their food when self-storage options are limited.[78] A farmer's harvest is also sometimes used as collateral to access credit, so a lack of stored harvest can curtail access to loans.[79]

What are the advantages of silos?

Metal silos can be extremely effective in reducing food loss. One study in Kenya compared metal silos to the use of a basic polypropylene bag for six months. The study found that while the polypropylene bag with no added pesticide experienced crop losses of 24 percent, a metal silo with no added pesticide experienced crop losses of just 1.4 percent.[80]

The hermetic nature of metal silos makes them well-suited to long-term storage. Once grain is properly dried and sealed into a silo, it can safely be stored for up to three years, and the structures themselves can last up to fifteen years.[81]

Metal silos are relatively easy to construct and require minimal materials. In an ongoing project in 16 developing countries[82] to bring such silos to farmers, FAO has been enlisting local tinsmiths who already possess the necessary knowledge and tools to construct the silos.[83] These tinsmiths gain an income from such production; one estimate is that the production of metal silos alone brings individual tinsmiths an extra US$470 annually.[84]

What are the disadvantages?

A disadvantage of metal silos is their up-front costs of production. Costs vary a great deal between countries, but among those with FAO-sponsored projects, a metal silo with a 500 kg storage capacity costs anywhere between US$30–97.[85]

However, in a survey of Bolivian farmers, more than half described the cost of these silos as "cheap" or "normal."[86] Other studies find that the net economic benefits are high. The Kenyan study found that the economic benefits of using a silo were three times greater than that of using a polypropylene bag, even with up-front costs taken into account.[87]

How can silo use be scaled up?

FAO has had success in promoting the use of metal silos. 45,000 of them have been built in 16 countries since 1997, allowing for a total storage of approximately 38,000 metric tons of grain.[88] Insights from the FAO program suggest several strategies for scaling up use of small metal storage silos, including:

- International governments, foundations, and/or national governments can provide seed money or low-interest loans for the purchase of small metal silos.
- Agricultural extension agencies and international agricultural development organizations can raise awareness of metal silos, their benefits, and how to construct them.
- "Train the trainers" programs can be a cost-effective and rapid means of raising awareness and disseminating technical know-how. For example, the FAO approach has been to train a group of people in the production and maintenance of metal storage silos, and then have these trainers go out and train additional individuals on their own.

Case study: Metal silos in Afghanistan and Kenya[89]

In 2009 in Afghanistan, an FAO project funded largely by the German government provided metal silos to 18,000 households. These silos were produced by local tinsmiths, who were trained in proper production methods. Almost immediately, recipients of the silos began reporting higher net incomes due to increased market sales and lower food losses, which fell from 15–20 percent to 1–2 percent per year. Perhaps the most telling sign of success was that local tinsmiths were subsequently hired by local non-participating farmers to build an additional 4,500 silos after they saw the success of their neighbors.

In 2012 in Kenya, FAO worked with a number of Kenyan non-governmental organizations to promote metal silo technology within the country. Funding from the governments of Sweden and Spain sponsored the training of 16 metal artisans in eastern Kenya in how to produce the silos, and about 300 metal silos have been distributed to farmer groups. FAO has also been promoting the use of the silos through extension services and farmer groups and facilitating access to credit through community banks so that farmers without savings can purchase the silos.

Plastic crates

Using plastic crates instead of other forms of containerization has demonstrated significant reductions in food losses during handling and storage, particularly among fruits, vegetables, and other forms of fresh produce. In developing countries, 19 percent of fruit and vegetable loss occurs in the handling and storage stage of the food value chain.[90] Minimizing losses at this stage is especially important in reducing overall loss and waste, as external and internal damage and blemishes during this stage can lead to high rates of deterioration later in the value chain.[91]

What are the problems with typical handling and storage containers?

Many common storage containers used to transport fruits and vegetables can lead to losses in quality, such as bruising, or even outright food loss due to being crushed or smashed during transport. Sacks and bags, commonly used transportation containers in many developing countries, provide little protection against quality losses from compression, puncture, and impact.[92] Bamboo baskets offer a higher defense against these sorts of injuries because they are semi-rigid, but their rough interior surfaces can still damage produce. Avoiding such damage requires that an additional lining be inserted to protect the produce from basket interiors, which adds material cost and an extra step to the labor involved in the handling process.[93] Bamboo baskets are also often not reusable or only last a few uses, which entails that baskets be remade or new ones purchased on a regular basis.

What are the benefits of plastic crates?

Plastic crates avoid many of the pitfalls of these other container types. Plastic crates are reusable for long periods of time; many last for about five years.[94] Despite having higher upfront costs relative to baskets and sacks, plastic crates can have significantly lower average cost per use over the long term. For example, one study found that plastic crates have a lower cost per use and lower cost per kilogram for tomatoes relative to bamboo baskets and wooden crates in the Philippines (Table 5). Likewise, the study found that plastic crates increase the value of a kilogram of fruits and vegetables by up to 40 pesos—16 percent of the total market price—when compared to using bamboo baskets for handling and storage.[95] These savings arise primarily from the low cost per kg of handling and storage enabled by reusable crates.

Plastic crates ease the manual labor associated with handling and storage due to their manageable size and built-in handles. Plastic crates can also greatly reduce food loss. A crate's rigidity leads to less damage from impact during transport, since the crate limits the amount of collision between the goods, and the smoothness of the material precludes the need for linings to reduce friction.[96] One pilot program in Sri Lanka found that plastic crates reduced vegetable losses by weight from 30 percent down to 5 percent and fruit losses from 30 percent down to 6 percent when compared to prior methods of handling.[97]

What are the drawbacks?

There are some drawbacks, however, to the use of plastic crates. Like all reusable storage technologies, plastic crates can carry and spread crop-eating insects or illness-causing microorganisms when improperly cleaned between uses.[98]

Farmers may also have difficulty obtaining crates. In one study of Nigerian farmers, 78 percent of farmers felt that plastic crates would be preferable to palm baskets and sacks. Yet every single person surveyed reported that plastic crates were unavailable and felt that they were too expensive.[99] The survey also found that a local plastic crate factory required an up-front purchase of US$40,000 worth of crates and a three-month waiting period before any crates would arrive. These cost and timing parameters had triggered the farmer concerns.

How can plastic crate use be scaled up?

Several actions could accelerate scale up of plastic crate use. For instance, crate manufacturers, extension agencies, and/or development organizations could reduce the risk of spreading pests and microorganisms by training farmers how to properly clean plastic crates between uses.

The same actors could run public education campaigns to raise awareness of the benefits—economic and food quality—of crates. For instance, The Postharvest Education Foundation provides a free cost-benefit calculator spreadsheet for determining whether plastic crates will be cost-effective for any given user, based upon local costs and the market value of the crop.[100]

The interrelated problems of cost and availability could be addressed through additional interventions. For instance, national governments could reduce tariffs on imported plastics or plastic raw materials, making it less expensive to produce the crates domestically and reduce purchase prices for farmers. Likewise, governments, foundations, and/or development agencies could subsidize the purchase of crates for farmers for a few years until production volume and awareness scale up.

Case study: Plastic crates for tomatoes in Afghanistan[101]

In Karokh, Afghanistan, tomato growers were experiencing tomato losses of up to 50 percent due to rough shipping and handling while transporting their crop to the nearest market in the city of Herat. As a result, these farmers had a difficult time selling their damaged products at the market and often had to accept whatever price was offered, since transporting leftovers back to Karokh would just result in even greater losses.

To assist farmers in reducing their losses, the development organization CNFA, in partnership with Catholic Relief Services, awarded a US$60,000 grant to Karokh's farmers in August 2005. This award matched a US$60,000 contribution from the farmers themselves and allowed the farmers' collective to purchase 1,500 plastic crates and an overnight storage space in Herat for surplus goods.

The farmers saw immediate benefits from this purchase. The plastic crates reduced transportation spoilage from 50 percent down to 5 percent, and the incomes of farmers and their families in Karokh increased by a total of US$75,000 compared to the prior year, recouping more than their own US$60,000 investment. Buyers also were willing to pay up to 33 percent more for Karokh tomatoes compared to the market price of tomatoes from other villages due to the increased quality and reliability that came with the introduction of the crates and the storage space.

Table 5 | **Costs of Packaging Tomatoes in the Philippines**

	BAMBOO BASKET	WOODEN CRATE	PLASTIC CRATE
Acquisition cost (Pesos/unit)	15	12	450
Useful life	Once	Once	5 years or 300 uses
Average cost per use (Pesos)	15	12	1.5
Number of containers per truck	96	117	117
Capacity per container (kg)	33	30	30
Volume per truck (kg)	3,186	3,510	3,510
Transport cost per container (Pesos)	3,000	3,000	3,000
Transport cost (Pesos/kg)	0.95	0.85	0.85
Packaging cost (Pesos/kg)	0.45	0.43	0.05
Packaging labor cost (Pesos/kg)	0.5	0.5	0.5
Handling labor cost (Pesos/kg)	0.6	0.6	0.6
Care and maintenance of packaging materials (Pesos/piece)	0	0	2.5
Maintenance cost (Pesos/kg)	0	0	0.1
Total cost (Pesos/kg)	2.5	2.38	2.1

Assumptions: Transport facility: Elf truck; route: Pangasinan to Manila; size of plastic crates: 50 cm x 30 cm x 30 cm; 3 layers, 39 crates per layer; wooden box approximately the same size as plastic crates; utilization: 60 days per year.

Source: Rapusas, R.S. and R.S. Rolle. 2009. "Management of reusable plastic crates in fresh produce supply chains: a technical guide." Food and Agriculture Organization of the United Nations. RAP Publication 2009/08.

Food date labeling

Dates provided on the packaging of food and drinks, such as "use-by,""sell-by," and "best before," are intended to provide consumers with information regarding the freshness and safety of foods. However, these seemingly simple dates can actually confuse consumers about how long it is safe for them to store food and when they should dispose of uneaten items. One study, for instance, found that a fifth of food thrown away by households in the United Kingdom is thrown away due to food being perceived as "out of date" due to labeling, when in fact some of the food was still suitable for human consumption.[102] This suggests that while some of this waste may be legitimate due to food safety concerns, there may be room to reduce unnecessary household food waste by clarifying the meaning of these dates and changing the way in which they are used, displayed, and interpreted by consumers.

What is the problem?

Part of the confusion surrounding product dating is that there are a number of different terms that might appear on packages. For example, in the United States, three commonly seen terms are "sell-by," "best if used by," and "use-by" (Table 6), none of which are required by the federal government.[103] These dates all refer to food quality or the flavor of the food instead of food safety, a measure of whether or not the food could potentially cause illness when eaten. However, consumers often view all of these dates as being a measure of food safety.[104] So while food that has passed its "sell-by" date might be less desirable than newly-purchased food, it is often still entirely safe to eat. This misperception may lead consumers to throw away edible food they believe is no longer safe to eat.

What can be done?

Governments could reduce food date confusion by implementing policies or providing guidance regarding what dates manufacturers and retailers should print on their packaging. For example, in 2011, the United Kingdom revised its guidance on date labels, suggesting that retailers should remove "sell-by" dates, use only "best before" dates to communicate food quality, and display "use by" dates only for matters of food safety.[105] This guidance, if followed uniformly by manufacturers and retailers, would minimize the amount of information consumers have to absorb and interpret and would remove guesswork from determining what a date on a package means.

Manufacturers and retailers can change what types of dates appear on a package to provide additional clarity to consumers. Furthermore, manufacturers of food products could move to a "closed date" system, which would replace a "sell-by" date with a code that can be scanned or read by the manufacturer and retailer, but not by the consumer.[106] This would prevent consumers from misinterpreting a date on a package and throwing the item away prematurely. Since there would be no date to misinterpret, consumers would instead rely on their own assessment of the food. This approach could be applied to non-perishable foods, but would be problematic for perishable foods, such as meat, if consumers end up eating spoiled food due to confusion around its freshness.

Who needs to act?

Manufacturers and retailers can reduce confusion around date labeling and the waste that results from it by removing unnecessary or confusing dates from packages and by changing how dates are displayed. Some dates important only to the manufacturer and retailer could be hidden, while dates relevant to consumers could be renamed for greater clarity. Any of these actions would likely require a small shift in packaging manufacturing processes, since packages would need to be only slightly redesigned.

Retailers can reduce date-related food waste by implementing consumer education efforts. For example, retailers can post in-store displays, provide leaflets and online guidance, or print messages on grocery bags that define the various food date labels and explain the differences between them.

Table 6 | **Definitions of Food Product dates**

TYPE OF DATE	DEFINITION
Sell-by or Display until	Tells the store how long to display the product.
Best-if-used-by or Best before	Recommends the date by when to consume the product in order to experience peak flavor and quality. It does not pertain to the safety of the product.
Use-by	The last date recommended for the use of the product from a food safety perspective.

Source: USDA. 2011. "Food Product Dating." Fact Sheet. Washington, DC: USDA; and UK Food Standards Agency. 2012. "Food Law Code of Practice (England)." London: UK Food Standards Agency.

Governments have a role, too. For instance, they could enact clear, consistent policies or guidelines on what dates appear on packages, and subsequently provide consumers with the information needed to understand these dates. Public service announcements would be helpful in spreading the word around these policies. Simplifying the categories of dates that appear on packages, as the UK government did, would provide consumers with clear information on just when a food item is actually no longer safe to eat.

Case study: Delivering "best-in-class" date coding

Tesco is one of the world's largest retailers, serving 50 million customers around the world and sourcing food from thousands of suppliers across more than 70 countries. The company has a stated ambition to lead in reducing food waste globally by working with its producers and suppliers, and helping its customers to reduce food waste.

In the United Kingdom, households throw away an estimated 7.2 million metric tons of food every year; of this around 2.9 million metric tons is wasted before ever being cooked or served.[107] According to the UK's Waste Resource Action Programme (WRAP), confusion around on-pack date labels and storage guidance is a major contributing factor. In 2013, Tesco carried out its most extensive research to date on food waste which supported these findings.

As a result, Tesco undertook a review of how date coding and storage information are applied to packaging, revealing inconsistency in its approach. Food packaging has a number of combinations of "best before" and "display until" dates, which advise store staff and customers on quality, and "use by" dates which relate to food safety. WRAP guidance states that customers prefer single date codes and that "best before" is best understood and acted on. "Use by" should only be used where there is a food safety issue.

Tesco has piloted the use of a single date code on meat, fruit, and vegetables in UK stores. On meat, a single "use by" date was tested. On fruit and vegetables, Tesco piloted "best before" on its packs, with "use by" only being implemented when necessary on prepared foods. Encouragingly, not only have these changes been well received by Tesco customers, dropping "display until" on these items has not created problems in stores–in fact pilot stores have actually seen reductions in food waste for items with a single date code. As a result, Tesco has rolled out the single code to pre-packed meat sold in more than 3,000 stores in the United Kingdom. The simplified date coding system for fruit and vegetable packs will be rolled out by the end of 2013.

To ensure it is applied consistently and can be extended to other food categories, Tesco is developing guidance, training, and auditing for its own staff and suppliers. Tesco is now looking to find ways to integrate the new date system into customer communications on storage advice and recipes.

Consumer awareness campaigns

Consumer attitudes and behavior play a large role in determining the amount of food that is wasted in households. Although changing the way people consume and throw out food can be difficult, communication campaigns can help influence consumer behavior at the household level.

What is the problem?

Waste of edible food at the household level occurs for a number of reasons. For example, food leftover on one's plate gets thrown into the garbage. And even if leftovers are saved for later, they may be eventually thrown out.[108] Confusion over the correct way to interpret date labels such as "sell-by," "display until" and "use-by" causes some consumers to throw out food that is actually still safe and nutritious.[109] Interestingly, some consumers do not realize the amount of waste that is actually occurring in their homes; in one survey conducted in the United Kingdom in 2006, 90 percent of consumers stated that they thought they wasted very little or no food at all.

How can consumer behavior be changed?

The grocery retailer can play an important role in reducing food waste at the consumption stage because of the retailer's direct interaction with food consumers. Pioneering retailers have implemented a number of approaches designed to tackle food waste. For example, the Co-operative Group, which has more than 2,800 grocery stores all across the United Kingdom, has begun printing tips for improving food storage and lengthening shelf-life for fruits and vegetables directly onto the plastic produce bags in which customers place their purchases. This change is an effort to overcome consumer misconceptions or ignorance about best storage practices and to assist customers in increasing the shelf-life of their purchases.[110] The Co-operative Group has also shifted away from "Buy-One-Get-One-Free" promotions for perishable goods, using price reduction promotions on such goods instead.[111]

Sainsbury's and Morrison's, the third- and fourth-largest grocery retailers in the United Kingdom, respectively, each have created waste reduction campaigns. These campaigns highlight the issue of food waste for consumers who might otherwise be uninformed while also providing them with tips for reducing waste. They reach customers through in-store displays, pamphlets, and websites that contain recipes, storage tips, and information on freshness and shelf lives of food products.[112]

Consumer education campaigns outside of the retail environment can also be effective in reducing household food waste. One example is the "Love Food Hate Waste" campaign, started by the UK Waste and Resources Action Program (WRAP). The campaign works with food manufacturers and retailers on customer-focused in-store waste reduction initiatives as well as with local authorities, community groups, and other businesses to reduce food waste. For instance, more than 300 local authorities in England run localized "Love Food Hate Waste" initiatives to encourage and assist residents in reducing waste. Activities run by these initiatives include hosting interactive events—such as cooking demonstrations and recipe-sharing gatherings—that help reduce waste stemming from the need to improve home economics skills and unused leftovers. These initiatives also prepare leaflets and newspaper advertisements that provide information about how to reduce food waste.[113]

How can these initiatives be scaled up?

Although signs of progress are emerging on how to reduce food waste at the consumption stage, they are still relatively nascent and concentrated in a limited number of countries. Scaling up will require more, and more rapid, replication by companies and countries. For instance, more food retail companies will need to replicate the initiatives of retailers such as the Co-op and Sainsbury's.

Case study: Worcestershire County Council[114]

In 2011, the Worcestershire County Council in England undertook a three-month campaign to reduce food waste in a small geographic area containing roughly 9,000 households in Worcester City. The council formed partnerships with more than 70 local businesses, community organizations, and schools, many of which posted displays that held commodity-specific leaflets describing how to reduce food waste for meat, fish, bread, fruits, and vegetables. The University of Worcester also hosted two free three-week cooking classes, which focused on teaching simple, healthy meals and effective reuse of leftovers.

The council sampled the amount of food wasted in households in the area before and after the campaign. The study found that at the campaign's conclusion, household food waste had declined by 14.7 percent after just three months. The campaign later won the 2011 award for "Best Waste Minimisation or Prevention Project" from the UK Local Authority Recycling Advisory Committee.

Reduced portion sizes

For restaurants and other food service providers, food portion sizes can dictate the amount of food waste that occurs within the four walls of their business, since larger portions increase the likelihood that a consumer will not consume all of the food purchased.[115] Reducing portion sizes for consumers in both direct and indirect ways can both decrease food waste and save money for food providers.

What is the problem?

Experience in the United States highlights the problem. Food portion sizes in U.S. restaurants have mostly been increasing since the 1970s (Table 7).[116] Restaurants use larger portion sizes as selling points to suggest to consumers that they are receiving a bargain for the food they purchase.[117] However, this trend toward larger sizes causes more food waste when customers are unable to finish a meal, and also contributes to obesity and overconsumption of food. On average, American diners do not finish 17 percent of the food they buy at restaurants and leave 55 percent of these leftovers behind.[118] In other words, about 9 percent of food purchased at the restaurant is disposed of at the restaurant.

What can be done?

One straightforward approach for reducing this food waste would be for à la carte restaurants to reduce the portion sizes for many of the items they offer. But this might lead customers to feel like they are receiving less value for their money if applied uniformly across an entire menu.[119] One way around this would be for the restaurant to offer smaller portion sizes at a lower price while still offering larger portion sizes at a higher price. This approach would allow customers with smaller appetites to order a smaller meal and presumably leave less of it behind, while also lowering preparation costs for the restaurant.[120] This approach would be a relatively small adjustment for the many restaurants that already offer children's menus with smaller portion sizes. To further hone the approach, a restaurant could examine how much and what types of food tends to be left on customers' plates and make modifications accordingly to both save money and reduce food waste.[121]

In a buffet or cafeteria-style food service environment, however, the customer generally determines the portion size of food purchased. Food service operators nonetheless have options for reducing waste. One approach is to post informational signs reminding customers to take only as much food for which they have the appetite.[122] Another approach is to not offer cafeteria-style trays; customers rather carry the food they purchase on plates. This approach prevents "hoarding" behavior. One study of dining halls in 25 American universities found that going trayless reduced food waste by 25–30 percent.[123] A third approach is to remove "all-you-can-eat" options from buffets and replace them with "pay-by-weight" systems in which the weight of the plate of food determines the cost of the meal. This approach might reduce food waste by giving the customer a clear economic incentive not to take more food than necessary. This could also save the retailer money, as less food would need to be prepared.

Case study: Trayless cafeterias[124]

Cafeterias at American universities often offer "all you can eat" programs for students and staff, in which customers can take as much food as they like, and as much as they can fit on a tray, for a set cost. In 2007, officials at Grand Valley State University (GVSU), located in the state of Michigan, decided to experiment with a "trayless cafeteria." By eliminating trays, GVSU officials hoped to reduce the amount of food waste at its cafeterias, as well as reduce energy and water use associated with washing trays. Under this system, students could return to the cafeteria to take more food as desired, but were limited on each trip to the amount of food they could carry on a plate in their hands.

GVSU piloted the program in the spring of 2007, testing it for just a week to gauge reactions. During the pilot period, dining hall officials gained the support of administrators and the student body government by providing information on the resource and economic savings from eliminating trays. After a successful pilot, GVSU permanently adopted the trayless system in the fall of 2007. The university found that after going trayless, the university was throwing away almost 13 metric tons of food less than in previous years—about 25 kg per person annually—and was conserving 117,000 liters of water per year. The system was also economically beneficial, saving the university about US$79,000 per year compared to a system using trays.

Table 7 | **Trends in Portion Size of Various Food Types in U.S. Restaurants (Kcal Per Portion)**

TYPE OF FOOD	1977-1978	1994-1996	% CHANGE
Cheeseburgers	381	485	**+27%**
Desserts	259	306	**+18%**
French fries	168	222	**+32%**
Fruit drinks	133	201	**+51%**
Hamburgers	362	362	**0%**
Mexican food	396	495	**+25%**
Pizza	628	516	**-18%**
Salty snacks	113	178	**+57%**
Soft drinks	125	155	**+24%**

Source: Nielsen, S.J. and B. Popkin. 2003. "Patterns and Trends in Food Portion Sizes, 1977-1998." *Journal of the American Medical Association*: 289 (4): 450-453.

RECOMMENDATIONS

Each of these approaches—and others like them—can contribute to reducing food loss and waste, and efforts are underway to implement them. But what cross-cutting strategies could accelerate adoption of these and related approaches and, more generally, ramp up focused attention on reducing food loss and waste? We offer five recommendations.

Recommendation 1. Develop a food loss and waste measurement protocol

What gets measured gets managed. The current high rate of food loss and waste, therefore, makes some sense since frequently collected, systematically measured data on food loss and waste have been sparse.[125] If one does not know how much or where food loss and waste is occurring, how can one be expected to do something about it? Experts interviewed for this working paper agreed that across the food value chain, better measurement and monitoring of food loss and waste is needed.

FAO's "Global Food Losses and Food Waste—Extent, Causes, and Prevention" (2011), the first systematic effort to quantify food loss and waste at a global and regional level, was an important step in addressing this challenge. A next step would be to develop a standardized method or "protocol" for countries and companies in the food value chain to use to consistently and periodically measure and monitor food loss and waste in their boundaries and/or supply chains. Such a protocol would become the "generally accepted accounting principles" for food loss and waste.

Precedents for establishing global standardized measurement approaches exist in other sustainable development contexts. For example, more than 15 years ago, companies did not have a standard, consistent, mutually agreed upon method for measuring and monitoring their greenhouse gas emissions. There was a risk that a plethora of approaches would emerge, creating confusion among and non-comparability between companies. To address this gap, WRI and the World Business Council for Sustainable Development developed the "Greenhouse Gas Protocol," which has since become the standard for companies and other entities to measure greenhouse gas emissions from their own operations, their purchased electricity, and their supply chains.[126]

A "food loss and waste protocol" would provide guidance and requirements on what should be measured, how to measure it, what unit(s) of measurement to use, what data sources and quantification methods are appropriate, how to ensure comparability among users and over time, and how to report results, among other features. By conducting periodic food- loss and waste audits conforming to the protocol, countries and companies could quantify how much and where food loss and waste are occurring within their spheres of influence. Armed with this information, countries and companies would be better able to identify where opportunities for food loss and waste reduction exist, who needs to be engaged to achieve those reductions, what strategies may be appropriate, what targets to set, and how much progress is being made over time.

The protocol should be globally applicable to enable consistency, comparability, and transparency across users. It should cover both food loss and waste, and be relevant for both countries and private-sector entities. To maximize buy in and technical input, it should be developed through a process involving government, inter-governmental, private sector, and research institution stakeholders. Furthermore, it should recognize and be amenable to the different initial conditions of data availability between countries and food supply chains, yet encourage continuous improvement to more accurate and more frequent data collection and use.

Movement in the direction of standardized measurement is underway. FAO is in the process of developing a standard method to assess and monitor food losses at the national level, with a focus on developing countries.[127] The European Union is developing a method for assessing and monitoring food waste.[128] WRAP, in conjunction with UNEP and FAO, has developed methods for measuring food waste within corporate supply chains.[129] Several European countries such as Denmark, Sweden, and Norway are exploring establishing food loss and waste reduction targets and metrics.[130] We recommend bringing these and related efforts together in collaboration with other stakeholders to establish a food loss and waste measurement protocol that will be robust, globally relevant, and universally adopted by countries and companies.

Recommendation 2. Set food loss and waste reduction targets

Setting quantifiable, time-bound targets could raise awareness, stimulate focused attention, and mobilize resources toward reducing food loss and waste. Targets could be adopted across a range of geographic scales and types of entities. Four in particular come to mind:

- **GLOBAL TARGET.** The period of performance for the Millennium Development Goals comes to a close in 2015. The international community has already started dialogues on the possible nature and content of the post-2015 development agenda. The issue of food security is on that agenda. We recommend including a food loss and waste reduction target that contributes to a post-2015 goal on food and nutritional security. The target could be "By 2030, reduce the rate of postharvest food loss and waste by 50 percent." The target's associated indicator would be the share of food produced or harvested that is lost or wasted between the farm and the fork, and its metric would be percent of food loss and waste. This target would imply that the rate of food loss and waste in 2030 declines from its current level of about 24 percent to 12 percent (on a caloric basis) or from around 32 percent to 16 percent (on a weight basis). Furthermore, such a target would satisfy core principles of the post-2015 development agenda of poverty alleviation, human well-being, sustainability, and inclusiveness—involving all countries and involving all actors.[131]
- **NATIONAL TARGETS.** If a global target is established, national targets could then be set that support the global one while accounting for different country starting points and contexts. In the meantime, countries or regional government bodies could establish their own food loss and waste reduction targets. For instance, in 2012 the European Union established a target of reducing food loss and waste within its borders by 50 percent by the year 2020.[132]
- **SUB-NATIONAL TARGETS.** Similar targets could be set at the sub-national level, which includes provinces and cities. For instance, in 2013 New York City announced a Food Waste Challenge in which more than 100 participating restaurants agreed to reduce food waste by 50 percent by 2030.[133] Hong Kong has a target of reducing food waste by 10 percent between 2013 and 2016.[134]
- **CORPORATE TARGETS.** Companies, too, could set food loss and waste targets for their own operations or, particularly for those in the food business, for their food supply chains. For instance, Arla Foods, Europe's second largest dairy company, set a target in 2011 to reduce food loss and waste by 50 percent for the company and its supply chain by 2020 compared to 2010 levels.[135] Another example is the Courtauld Commitment, a voluntary agreement arranged by WRAP with more than 40 signatories including companies such as Nestlé, Tesco, Sainsbury's, and Unilever. Signatories agreed to do their part in reducing household food waste by 5 percent and supply chain waste by 3 percent between 2013 and 2015.[136] Sectors for which such targets may be most relevant include food distribution, processing, and retail.

Periodic measurement of food loss and waste, conforming to a food loss and waste protocol (recommendation 1), would facilitate setting baselines and tracking progress toward such targets over time.

Recommendation 3. Increase investment in reducing postharvest losses in developing countries

Approximately a fifth to a third of all food loss and waste in developing regions occurs at the handling and storage stage (Figure 6)—commonly called postharvest losses. However, various experts estimate that worldwide only 5 percent of agricultural research investment focuses on postharvest issues while 95 percent of funds focus on increasing crop production.[137] Yet as the World Bank, FAO, and others have shown, investment in reducing postharvest losses can be as cost-effective as other agricultural investments and can yield good returns, especially when food commodity prices rise.[138] In general, postharvest loss and waste reduction science is less expensive than production research, in which multiple studies must be conducted over years or seasons.

Doubling the share of investment in addressing postharvest losses from 5 percent to 10 percent would be a significant improvement and a step toward increasing adoption rates of technologies and approaches to reduce postharvest losses. National governments, multilateral development banks, bilateral development agencies, philanthropic

foundations, and international organizations dedicated to food security all have a role to play in increasing this investment. Food loss prevention training and education programs are ready to be implemented in many places around the world. In many cases, insufficient funds have prevented agricultural extension agents from implementing such programs.

Postharvest loss interventions should be appropriate to the socioeconomic, business, and political context of a country.[139] Strategies for considering these contexts suggested by Kitinoja et al. (2011) include:

- Integrating postharvest loss science and education into the general agricultural curricula and government extension services;
- Establishing "Postharvest Training and Services Centers" to test reduction innovations under local conditions, identify the most promising and cost-effective techniques and practices, provide demonstrations of innovations determined to be technically and financially feasible, and provide hands-on training and capacity building to farmers; and
- Establishing country-level Postharvest Working Groups that connect researchers, extension agents, farmers, and other food value chain actors concerned about reducing postharvest losses. Such groups could facilitate information exchange, training, shared learning, and national and regional collaboration on postharvest loss reduction.[140]

Recommendation 4. Create entities devoted to reducing food waste in developed countries

In North America and Europe, more than 60 percent of food loss and waste occurs during the market and consumption stages—in supermarkets, food and drink retailers, households, restaurants, and caterers (Figure 6). An emerging success story in reducing food waste in these stages of the value chain is WRAP's work in the United Kingdom. Established as a not-for-profit company in 2000, WRAP's vision is a world without waste, where resources are used sustainably. It works in partnership to help businesses, individuals, and communities improve resource efficiency.

WRAP has constructively worked with, and on behalf of, governments and engaged food and drink retailers as well as manufacturers and trade bodies to establish voluntary food waste reduction targets, design waste reduction techniques, help the sector make changes to processes, products and packaging to prevent waste, and raise consumer awareness.[141] WRAP has implemented several of the approaches profiled earlier in this working paper, including revising food date labels and designing consumer engagement campaigns.

WRAP has a proven track record so far. By 2010, annual household food waste in the United Kingdom decreased by more than 1.1 million tonnes compared to 2007—a 13 percent reduction over just a three year period.[142] Plus, every British pound spent by WRAP has prevented more than 100 British pounds worth of food from being wasted.[143] Such quantifiable progress can motivate further progress and help ensure long-term support for the organization and its mission.

Establishing and supporting entities like WRAP in other countries—starting with those where food waste instead of loss is the major issue—could help catalyze concentrated reduction efforts. Because the players in the food value chain and the drivers of food waste are often context-specific, an organization operating at a national level is quite appropriate. Such entities could be financed via private philanthropy, a fee-for-service model, or some combination. WRAP uses a unique funding model in which each of the four governments of the United Kingdom—England, Scotland, Wales, and Northern Ireland—provide funding for its operating costs in order to deliver waste policy goals. Yet the organization operates independently of the government, more like a non-governmental organization which can provide credible, independent evidence and technical expertise to focus action where it is needed, and act as a broker for delivering government policy and enabling competitive businesses come together to work to a common goal.[144]

Recommendation 5. Accelerate and support collaborative initiatives to reduce food loss and waste

Reducing food loss and waste requires action by a wide range of actors—households, companies, farmers, policymakers, and more. It also requires changes in technology, practices, behavior, and policy. These factors suggest that no single individual or group can sufficiently tackle this problem alone; collaboration is needed.

Collaborative initiatives can provide a number of benefits. They can help to build capacity within the entities that need to take on-the-ground action to reduce food loss and waste. They can facilitate sharing and transferring of best practices and common pitfalls. They can motivate and inspire action among their members. And they provide a venue for joint problem solving that cannot be done by a single entity.

Many actors need to be involved. Companies can take steps to reduce food loss and waste within their own operations and their supply chains, particularly those in the food sector. They can finance solutions and also engage consumers in reducing waste, while also improving their own profit margin by reducing waste within their own operations. Governments can finance efforts to reduce food loss and waste, raise awareness of the issue, and set reduction targets. Civil society, researchers, and intergovernmental organizations can identify and share best practices, provide technical assistance, and convene stakeholders.

Quite a few collaborative initiatives already tackle the challenge of food loss and waste (Table 8). They vary in terms of strategy pursued, partners involved, and geography covered. But the scope of the challenge and scale of the opportunity are so big that there is a need to increase investment in these and similar collaborative efforts. This investment is a role for governments, private foundations, multilateral institutions, and bilateral development agencies.

Table 8 | **Some Leading Food Loss and Waste Reduction Initiatives**

INITIATIVE OR ORGANIZATION	GEOGRAPHY	DESCRIPTION
SAVE FOOD	Global	SAVE FOOD, a global initiative on food loss and waste reduction, is led by FAO and Messe Düsseldorf, a leading trade fair organizer. Since 2011, it has worked with donors, development agencies, financial institutions and the private sector (particularly the food packaging industry) to develop and implement a program to reduce food loss and waste. The program rests on four pillars: 1) awareness raising; 2) collaboration with like-minded initiatives; 3) policy, strategy, and program development; and 4) support to food supply chain actors and organizations involved in food loss and waste reduction. For more information, visit http://www.save-food.org and http://www.fao.org/save-food.
Think.Eat.Save campaign	Global	Think.Eat.Save is a campaign of the SAVE FOOD initiative led by UNEP, FAO, and Messe Düsseldorf. The campaign seeks to galvanize widespread global, regional, and national actions to reduce food waste, and specifically targets food wasted by consumers, retailers, and the hospitality industry. The Think.Eat.Save website is a portal showcasing inspiring ideas and solutions, and a one-stop shop for news and resources on reducing food waste. For more information, visit http://www.thinkeatsave.org.
Global FoodBanking Network	Global	The Global FoodBanking Network (GFN) is a global nonprofit organization committed to creating, supplying, and strengthening food banks and food bank networks throughout the world outside the United States. GFN supports food banks and national food bank networks in more than 25 countries that are home to more than one-third of the world's undernourished people. Food banks acquire donated food, much of which would otherwise be wasted, and make it available to those in need through a network of community agencies that provide food to the hungry. For more information, visit http://www.foodbanking.org.
OECD Food Chain Analysis Network	Global	The OECD Food Chain Analysis Network provides a broad platform for dialogue building on analytical work and policy experiences on emerging issues of relevance to the food chain. It consists of government officials, international organizations, industry stakeholders, consumers, academic experts, and non-governmental organizations. The Network's 4th annual meeting (June 2013) will be dedicated to the issue of reducing food waste along the supply chain. The meeting will help improve data and policy information on food waste, allow exchange of analysis and best practices, and identify appropriate policy and industry responses to food waste. For more information, visit http://www.oecd.org/site/agrfcn.
FUSIONS	Regional	FUSIONS (Food Use for Social Innovation by Optimising Waste Prevention Strategies) aims to reduce food waste in Europe. It is a four-year project running from 2012 to 2016, funded by the European Commission. FUSIONS has 21 project partners from 13 countries, including universities, research institutes, consumer organizations, and businesses. FUSIONS aims to support the European Commission target of a 50 percent reduction in food waste and the Roadmap toward a Resource Efficient Europe. For more information, visit http://www.eu-fusions.org.

INITIATIVE OR ORGANIZATION	GEOGRAPHY	DESCRIPTION
Programs in Africa, Asia and the Middle East	Regional	FAO and the EU have a number of regional programs aimed at reducing food loss and waste. For example, FAO collaborated with the African Development Bank (AfDB) from 2009 to 2011 to analyze the AfDB's agricultural portfolio and identify opportunities to introduce postharvest loss reduction activities in ongoing and planned projects (FAO (2012b)). The European Commission financed the African Postharvest Losses Information System (APHLIS), which estimates post-harvest losses for the cereal crops of Sub-Saharan Africa at the country and province level. Estimates of postharvest losses are important data for policy makers and agricultural development practitioners (http://www.aphlis.net).
WRAP UK	National	Established as a not-for-profit company in 2000, WRAP is backed by United Kingdom government funding from Defra (Department for the Environment, Food and Rural Affairs), the Scottish Government, the Welsh Government, and the Northern Ireland Executive. WRAP UK helps people recycle more and waste less, both at home and at work, which are practices that offer economic as well as environmental benefits. For more information, visit http://www.wrap.org.uk.

A note on waste at the consumption stage

Although the solutions and recommendations contained in this working paper can help reduce food loss and waste, waste at the consumption stage of the value chain remains a significant challenge. For example, in North America and Oceania, 61 percent of loss or waste occurs at the consumption stage and in Europe it is about 52 percent. The experience of WRAP in the UK has shown that household food waste can indeed be reduced, but the scale of consumption waste suggests that there may be larger systemic issues that would need to be addressed to truly achieve large reductions in food waste at the consumption stage in these regions.

The way that loss and waste occur in developing countries in the future also matters a great deal. South and Southeast Asia, for example, will need to avoid growing into the food waste patterns of North America if the 50 percent global reduction target we propose in this working paper is to be achieved.

Going forward, improved strategies for tackling consumption waste will need to be a priority for research and innovation for the global community dedicated to reducing food loss and waste.

A CALL TO ACTION

An amazing 24 percent of all food calories grown today are lost or wasted between the farm and the fork. This fact is ultimately a failure of economic and natural resource efficiency. The world faced an analogous failure of efficiency in the 1970s with energy. In the face of record oil prices and growing demand, the world essentially declared war on energy wastefulness and significantly improved its energy efficiency.[145] Yet a "war on waste" has yet to be waged when it comes to food. Given that food prices recently hit historic highs and global food demand continues to rise, now is the time.

ENDNOTES

1. Searchinger et al. (2013). Calories are just one unit of measurement of food.We recognize that in many populations malnutrition is due not to insufficient calories but to insufficient protein and micronutrients.
2. Along with access, utilization, and stability, food availability is one of the dimensions of food and nutritional security; Gross (2000).
3. UNPD (2012).
4. FAO (2013).
5. FAO (2013).
6. FAO (2013).
7. This means that taking the animals to the abattoir is a postharvest activity, and slaughtering is a form of processing.
8. FAO (2013).
9. FAO (2011), Gunders (2012), Kummu et al. (2012).
10. Surplus food that is thrown away is considered waste. But if that surplus food is donated or redistributed to people via food banks or other means, the food has then avoided becoming waste. This is why food redistribution is considered a solution to food waste.
11. FAO (2011).
12. Gebhardt and Thomas (2002).
13. The FAO Food Balance Sheets convert metric tons into calories per type of food.
14. This 24 percent figure comes from our own analysis. Kummu et al. (2012) separately found loss and waste on a caloric basis to equal 24 percent of all food produced.
15. Rejinders and Soret (2003), Searchinger et al. (2013).
16. Gebhardt and Thomas (2002).
17. Unless otherwise noted, figures and data in the rest of this section come from WRI analysis based on FAO (2011).
18. In FAO (2011), Oceania includes Australia and New Zealand.The FAO data combines North America and Oceania together.One cannot split the data apart.
19. Personal correspondence with James Lomax (Agri-food Programme Officer, UNEP), May 28, 2013.
20. WRAP (n.d.).
21. WRAP (2011a); Zhou (2013).
22. World Bank, Natural Resources Institute, and FAO (2011).
23. The numbers in this paragraph do not reflect fish or seafood waste.
24. CGIAR (n.d.); EIA (2012).
25. Kummu et al. (2012).
26. Kummu et al. (2012).
27. Kummu et al. (2012).
28. European Parliament (2012).
29. In our business-as-usual scenario described in Searchinger et al. (2013), global daily kcal availability of food for direct human consumption in 2050 is 30.3 trillion kcal.The rate of global food loss and waste in 2009 was 24 percent. Cutting this in half is 12 percent.The 12 percentage points of avoided food loss and waste translate into 3.636 trillion kcal (0.12 x 30.3 trillion kcal) per day or 1,314 trillion kcal per year.The food gap described in Searchinger et al. (2013) was approximately 6,000 trillion kcal per year by 2050.1,314/6,000 is 22 percent.
30. Searchinger et al. (2013)
31. WRAP (2011); WRAP (2012).
32. Kitinoja (2010).
33. However, the environmental and economic implications of these solutions can vary greatly based on where the roads are built and the type of fuel used to generate the electricity.
34. Personal communication. Robert van Otterdijk (Team Leader, Save Food, FAO). May 17, 2013.
35. Gunders (2012).
36. Personal correspondence with Estelle Herszenhorn (Programme Area Manager, WRAP), April 9, 2013.
37. Personal correspondence with Mark Barthel (Special Adviser and Head of Design, WRAP) and Estelle Herszenhorn (Programme Area Manager, WRAP), May 20, 2013.
38. Gunders (2012).
39. USDA (2011).
40. Stuart (2009).
41. Gunders (2012).
42. Morenoff (2002).
43. Morenoff (2002).
44. Bill Emerson Good Samaritan Food Donation Act of 1996.
45. Gunders (2012).
46. Adapted from www.secondbite.com.
47. Practical Action (2003).
48. Practical Action (2003).
49. Elkheir (2004).
50. Elkheir (2004).
51. Elkheir (2004).
52. Roy (n.d).
53. Roy (n.d).
54. Roy (n.d).
55. Roy (n.d).
56. Practical Action (2010).
57. Roy (n.d.)
58. Practical Action (2003).
59. Nenguwo (2013).
60. Kitinoja et al. (2011).
61. This case study is drawn from KVK (n.d.)
62. Singh et al. (2003).
63. Langyintuo et al. (2003).
64. Langyintuo et al. (2003).
65. Baributsa et al. (2012).
66. Hell et al. (2010).
67. Coulibaly et al. (2012).
68. Moussa et al. (2012).
69. Moussa et al. (2012).
70. Moussa et al. (2012).

71. Moussa et al. (2012).
72. Hirvonen (2011).
73. Grace et al. (2012).
74. Grace et al. (2012).
75. Coulibaly et al (2012).
76. Meija-Lorio and Nije. (2012).
77. Kimenju et al. (2009).
78. Tefera et al. (2010).
79. Semple et al. (1992), as cited in Tefera et al. (2010).
80. Kimenju and De Groote (2010).
81. Haraman (2010); FAO (2008).
82. These countries are: Afghanistan, Bolivia, Burkina Faso, Cambodia, Chad, Ecuador, Guinea, Iraq, Madagascar, Mali, Malawi, Mozambique, Namibia, Panama, Senegal, and Timor-Leste.
83. Haraman (2010).
84. Tefera et al. (2010).
85. FAO (2008).
86. FAO (2008).
87. Kimenju and De Groote (2010).
88. FAO (2008).
89. These cases are adapted from FAO (2009) and FAO (2012a).
90. WRI analysis based on FAO (2011).
91. Adegbola et al (2011).
92. Rapusas and Rolle (2009).
93. Rapusas and Rolle (2009).
94. Rapusas and Rolle (2009).
95. Rapusas and Rolle (2009).
96. Rapusas and Rolle (2009).
97. Fernando (2006).
98. Rapusas and Rolle (2009).
99. Adegbola et al (2011).
100. Kitinoja (2013).
101. Adapted from (CFNA 2006).
102. WRAP (2011b).
103. USDA (2011). The only product that is required in the United States to have a "use-by" date is infant formula. More than 20 states have laws regarding food date labeling, but these laws vary greatly.
104. USDA (2011); Gunders (2012).
105. Gunders (2012).
106. USDA (2011).
107. WRAP (2011a).
108. Dye (2013).
109. Gunders (2012).
110. Ferguson (2009).
111. Ferguson (2009).
112. See the website for Sainsbury's "Love Your Leftovers" campaign here: http://www.j-sainsbury.co.uk/responsibility/case-studies/2009/love-your-leftovers-campaign/ and the website for Morrison's "Great Taste Less Waste" campaign here: http://www.morrisons.co.uk/food-and-drink/GreatTasteLessWaste/.
113. WRAP (2013).
114. This case is adapted from WRAP (2011e).
115. US EPA (2013).
116. Nielsen and Popkin (2003).
117. Young and Nestle (2002).
118. Bloom (2011) as cited in Gunders (2012).
119. Young and Nestle (2002).
120. Gunders (2012).
121. US EPA (2013).
122. US EPA (2013).
123. Aramark (2008).
124. This case is adapted from Aramark (2008).
125. For example, when the International Centre of Insect Physiology and Ecology and the International Development Research Centre reviewed the literature on postharvest losses in Africa, they identified massive gaps in the data on the type and magnitude of losses, potential interventions, costs and benefits (ICIPE and IDRC (2012)).
126. Developed by WRI and the World Business Council for Sustainable Development, the Greenhouse Gas Protocol is the globally accepted standard for companies and other entities to measure their greenhouse gas emissions.It defines what emissions are to be measured and how to do it.For more information, visit www.ghgprotocol.org.
127. Personal communication. Robert van Otterdijk (Team Leader, Save Food, FAO), April 2, 2013
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