ENDING RURAL HUNGER

Innovative Approaches to Food Loss and Waste Issues

FRONTIER ISSUES BRIEF

Lisa Kitinoja

2016

Submitted to the
Brookings Institution's
Ending Rural Hunger Project

Lisa Kitinoja is the founder and president of Postharvest Education Foundation

This paper reflects the views of the author(s) alone. It is provided as background research for the Ending Rural Hunger project, one of many inputs to the process.

Suggested Citation:
Kitinoja, Lisa. 2016. "Innovative Approaches to Food Loss and Waste Issues," Frontier Issues Brief submitted to the Brookings Institution's Ending Rural Hunger project. https://www.endingruralhunger.org/

Reducing global food loss and waste will require innovative approaches, technologies, and policies and will require raising awareness of the issues and of their broader effects on global hunger. Because these issues are diverse and highly context-specific, no single solution can resolve them. But if the recently agreed upon Sustainable Development Goal to end hunger is to be met, global food loss and waste—which has been documented to be very high[1]— must be addressed.

1. Defining food loss and waste

Postharvest food loss occurs within the farm-to-market period during harvesting, handling, storage, and distribution of food (see Table 1). These losses contribute to global hunger by decreasing both the supply of locally produced foods and purchasing power by reducing financial gains from crops. Food losses are mainly due to:

- Physical damage (through rough handling, unsuitable environmental conditions, or poor quality containers used for transport and storage)
- Poor temperature management after harvest
- Lack of access to facilities and equipment for proper cooling, food processing, or storage

Table 1. **Some common causes and sources of postharvest food losses**

Postharvest practices contributing to food losses	**Examples for various crops and food products**
Improper harvesting techniques	Knocking fruits from trees, dropping and throwing produce during harvest
Failure to use maturity indices at harvest	Harvesting overripe fruits or under-mature crops, harvesting grains whose moisture content is too high
Unsanitary conditions on the farm	Contamination of milk or dairy products during handling
Use of poor quality containers	Use of baskets, sacks, and bundles for fruits and vegetable crops
Rough handling	Bulk loads of bananas or mangoes, throwing or dropping fresh produce, walking upon or sitting on the load of foods during transport
Lack of curing	Root, tuber, and bulb crops placed into storage without being properly cured
Handling or storage at too high temperatures	Postharvest handling fish without cooling or use of ice, storage of fresh produce at ambient temperature
Delays during transport from farm to market	Loads of harvested foods waiting in the sun, traffic accidents, or vehicle breakdowns
Poor quality packaging that does not protect processed foods	Processed food products (dried or canned) deteriorate very quickly if exposed to air, light, heat, or insects

Source: HLPE 2014; Kitinoja 2013; Kitinoja & AlHassan 2012; Kader et al. 2012; Kitinoja et al. 2011; Gustavsson 2011.

Food waste occurs during distribution and consumption and is generated during the processing, handling, storage, sale, preparation, and serving of foods, according to the Food Waste Reduction Alliance. Some of the most common causes of food waste around the world include:

- Unrealistic quality standards

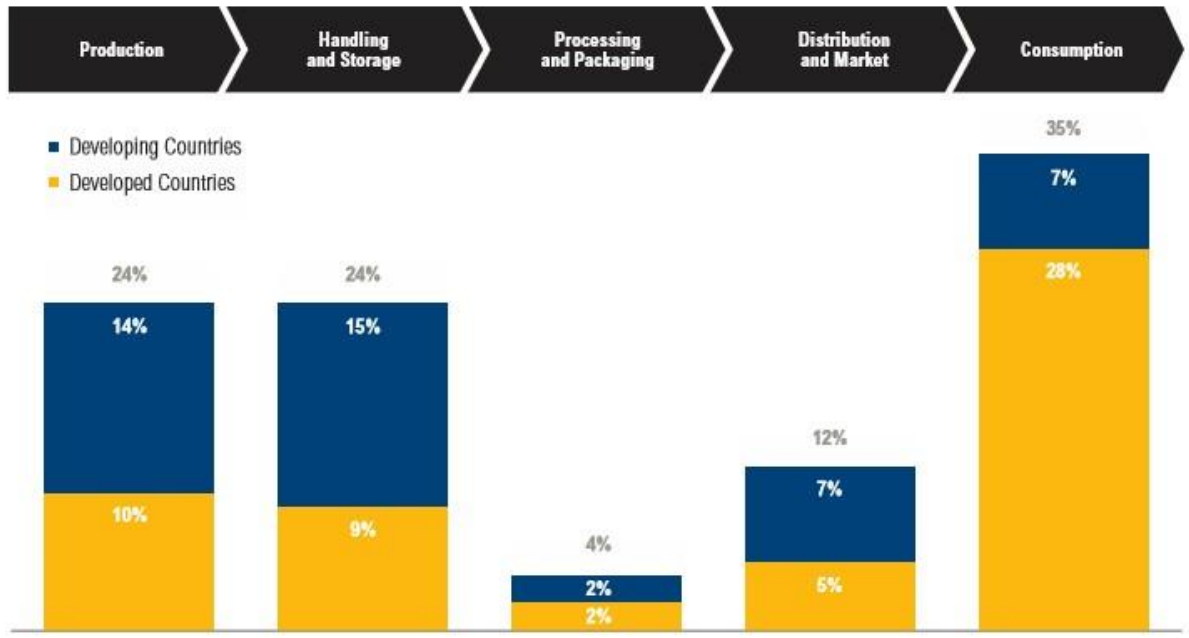
- Mismatch of food preparation volumes to immediate demand
- Lack of access to adequate cooling and cold storage
- Poor quality packaging
- Delays in marketing/consumption of perishables

2. Food loss and waste along the value chain

The characteristics of food loss and waste vary greatly by region, type of crop or food product, and income. In middle- and high-income countries, most of the waste occurs at the distribution and consumption stages, with one-third of foods being discarded in the home and by the food service industry (see Figure 1). In comparison, food loss in low-income countries is concentrated during production and postharvest. For example, in developing countries, when calculated by weight, 44 percent of fruits and vegetables, 20 percent of roots and tuber crops, and 19 percent of cereals, legumes, and pulses are lost before even reaching the consumption stage.

Food waste during distribution, marketing, and consumption is generally much lower in developing countries. However, as modern food retailing expands and consumer demand increases due to a growing middle class, the lack of reliable cold storage in retail markets and food service facilities, and limited home refrigeration will lead to new and increasing food waste.

Figure 1. **Food losses and waste (in % of total kCal) along the stages of the value chain**



Source: Lipinski et al. 2013; based on original data from the UN FAO and Gustavsson 2011.

3. Innovative approaches, technologies, and policies

Because the nature of the problems within food loss and waste are diverse and highly context-specific, solutions that are innovative, diverse, and cost-effective are needed. These solutions may come from a variety of fields, including food science, engineering, and packaging sciences, or they can be developed specifically for use in the postharvest sector. Wherever the solutions come from, those most likely to succeed will be those that are cost-effective for smallholders and small- to medium-scale enterprises. Solutions that are too complex to manage or too expensive to maintain will have limited impact, as exemplified by the numerous well-intentioned but unutilized modern packinghouses, food processing, storage, and marketing facilities in the developing world.

The majority of technologies and best practices for reducing food loss and waste throughout the value chain fall into three categories: packaging, cold chain management, and promotion of 100 percent utilization of food.

- **Packaging**: Improved packaging has the potential to "extend shelf life, monitor freshness, display information on quality, improve safety, and improve convenience."[2] These improvements will likely affect all areas of the value chain. For example, PICS bags,[3] which are triple-layer, hermetically sealed plastic bags, allow for pesticide-free home storage of grains and dry beans. By preventing moisture, air, and light from interfering with the grains and dry beans, PICS bags limit damage to the stored foods and kill insects from the low concentration of oxygen inside the bags. Another example is modified atmosphere packaging for fruits, which uses a protective gas instead of atmospheric air inside packaging to ensure that the product stays fresh for as long as possible. Recently, packaging has also started to include intelligent functions, such as sensing, detecting, recording, and tracing, which allow for monitoring and identifying potential issues.

- **Cold chain management:** Through new technology and better refrigeration practices, improvement in cold chain management is a cost-effective solution for actors at all levels. Cold chain management technologies range from high-tech to basic, such as the use of a zero energy cool chamber on the farm or at home for temporary storage of perishable foods, a CoolBot™-equipped cold room for food storage in a restaurant or retail shop, or simply the use of ice in retail displays. At the household level, even learning how to best use a home refrigerator can greatly reduce food waste and safety problems.[4]

- **100 percent utilization:** In the 1980s, Dr. S. K. Roy began promoting 100 percent utilization of perishable foods produced in India. He developed many systems for using the portions of plants that were typically discarded, including using the leaf trimmings of cauliflower to make high-quality green vegetable powder, bottling a whole tomato concentrate, and drying overripe mangoes to make nutritious and low-cost fruit powders and confectionary products. Postharvest training teams based at Amity University in Uttar Pradesh are disseminating these food processing practices in many rural communities in India.[5] In addition, identifying secondary, non-food uses for foods that

are discarded throughout production, such as using it for biogas production, animal feed or composting, will further improve utilization.

Many new technologies and approaches are in research and development or startup phases. If these are successfully commercialized, they can be expected to significantly contribute to reducing food loss and waste in the coming years. For example:

- **Ozone systems:** Ozone can reduce decay incidence and the rate of ripening in fruits and kills all known human and food pathogens. The U.S. Food and Drug Administration and U.S. Department of Agriculture have approved the use of ozone for sanitizing wash water and surfaces of produce and containers.[6]

- **Technology to reduce postharvest losses:** The University of Guelph in Canada has invented a patented technology using a safe, plant-derived chemical compound (hexanal) that reduces postharvest losses. Separately, researchers in Israel announced at the AgriTech 2015 Conference on Global Food Losses and Waste that they are commercializing an edible coating that can reduce food losses at ambient temperature and protect fresh produce from water loss and decay for up to one month.[7] Tamil Nadu Agricultural University in India has also developed a nano-film to extend the shelf life of fruits and vegetables, and the Industrial Technology Institute in Sri Lanka has a bio-wax formulation that helps to reduce postharvest damage.[8]

- **High relative humidity storage:** High relative humidity (RH%) storage reduces the rate of water loss and delays deterioration due to wilting and shriveling, which is common in tropical crops when stored near ambient temperature. The Wakati is a low-cost, solar-powered, fresh produce storage system that uses RH% plus ozone to sanitize the air inside the storage chamber.[9] It was recently invented in Belgium by Arne Pauwels, and hundreds of storage chamber components are being 3D printed onsite in several developing countries.[10]

- **Better Refrigeration:** An Evaptainer is a "refrigerated" container that uses six liters of water to stay cold for up to 12 hours. The heat is drawn out of the unit's interior onto highly conducive aluminum plates, which are connected to a special fabric. The fabric is kept wet, and the heat moves out of the containers and dissipates naturally through evaporative cooling.[11] Another innovation, by the Dearman Engine Company in the United Kingdom, uses liquid, air-powered cryogenic piston engines to generate power and cooling for refrigerated transport. These cryogenic engines are supported by either solar, wind, or liquefied natural gas waste and will operate on a portable, refillable "tank of cold" as a zero emissions energy source.[12]

Other approaches to reduce food loss and waste include the promotion of value chain development, through activities such as:

- Micro-credit programs have been promoted in many countries, offering those in self-help groups, farmers associations, or marketing cooperatives a way to access cash to make investments in agriculture and postharvest improvements.

- Market access has been a focus of several large international development projects funded by the Bill and Melinda Gates Foundation.

- Community Supported Agriculture and urban delivery vans are approaches to marketing that bring fresh foods closer to buyers in urban communities.[13]

Additional examples of innovative technologies are listed in Table 1 of the Annex.

4. Outreach, education, and skill building

Prior to introducing innovations, simply building awareness of the immense volume of food waste and its associated problems is an important first step for addressing food loss and waste in many countries. One such campaign is Feeding the 5000, which launched in London in 2009 and partners with local farmers, nongovernmental organizations, and governments to reclaim wasted foods and host public events where people are provided with a free meal from food that would have been wasted. Another organization is the German-based Food Sharing, which coordinates 7,000 people to conduct food pickups at 1,000 businesses across Germany. Other initiatives around the globe have included:

- SAVE FOOD, a global online community and partnership launched by the Food and Agriculture Organization of the United Nations
- Slow Food and Belgian Federation of Food Banks in Brussels (launched in January 2014)
- EndFoodWaste.org in Oakland (launched in October 2014)
- "Just Eat It", a documentary film produced in Vancouver (launched in May 2015)

Another approach to reducing food loss and waste is through education and skill-building initiatives. One of the best and most effective tools for encouraging smallholder farmers to reduce food waste is to teach them how to determine the costs and benefits of potentially useful postharvest innovations. Further, sharing with farmers what postharvest technology is available and is cost-effective allows them to better assess their individual situation and move beyond believing that postharvest losses are out of their control.

Numerous platforms and tools exist to assist smallholder farmers with postharvest cost-benefit analysis. The ADM Institute for the Prevention of Postharvest Losses at the University of Illinois (ADMI) offers an investment tool for decisionmaking for staple food producers and handlers.[14] Postharvest extension learning platforms are also being developed by the Sasakawa Africa Association for its postharvest and food processing projects in Ethiopia, Mali, Nigeria, and Uganda.[15]

Capacity building in the field of postharvest technology is also underway through a variety of models. For instance, AVRDC's Postharvest Training and Services Center in Tanzania houses demonstrations on postharvest best practices and provides training for local women's groups and horticultural farmers' cooperatives. Trainees learn about improved handling, processing, and storage in terms of protecting nutritional value, adding market value, and extending shelf life.[16]

In addition, there is growing research on the topic of food loss and waste and the effectiveness of outreach and trainings. Recent evaluations by the World Food Logistics Organization have documented how small farmers and village-scale food processors in Tanzania and six other countries in sub-Saharan Africa use cost-benefit information to make decisions on their postharvest investments. The June 2014 Rockefeller Foundation report "Reducing Food Waste and Spoilage: Assessing resources needed and available to reduce postharvest food loss in Africa" includes case studies on a model postharvest training and services center, PICS bags, plastic crates, and 22 additional postharvest innovations.[17]

5. Synthesis and top near-term action priorities

Reducing food loss and waste is an important part of ending hunger. The earth cannot sustain the current practice of producing nearly twice as much food each year as necessary for consumption, then throwing half of it away. Whenever food is wasted, so are the land, seeds, agricultural inputs, water, energy, and labor resources that went into producing it.

Ending hunger requires more than increasing production and total food supply. It will require the improvement of local food systems, a full understanding of the local conditions and factors affecting the value chains for foods, and more attention to the barriers limiting investment in improved postharvest handling practices, technologies, and policy. Although many postharvest innovations have been identified and are being promoted across the globe, more local capacity building, research support, and knowledge dissemination are needed to reduce food losses and end hunger.

Annex

Table 1. Examples of Progressive/Successful Initiatives		
Name	**Description**	**URL**
Market Infrastructure, Value Addition and Rural Finance (MIVARF) project	In Tanzania, the MIVARF project has been underway for four years. Funded by the African Development Bank and International Fund for Agricultural Development, the project is providing extension education for local clientele, infrastructure (roads, markets) and matching grants for financing local value addition industries in food processing, storage and/or marketing.	Link
French law banning supermarket food waste	In France, it is now illegal for supermarkets to discard goods that are still edible. A law enacted in May 2015 requires companies to donate unsold food to a food bank or use any wasted foods to make compost.	
Ugly fruit initiatives	Supermarkets in Canada, France, and the UK are selling "ugly fruits and vegetables" using clever marketing advertisements, songs, posters, and videos. Several new companies are redefining beauty in produce, for example, with home deliveries of what they call cosmetically challenged produce in the East Bay area of Oakland, CA (http://www.imperfectproduce.com/). Others are reclaiming lost foods; Revive Foods, for example, makes jams using only recovered foods (http://www.revivefoods.co).	
Promising innovations		
Hungry Harvest	Launched in 2014 by three graduates of the University of Maryland, College Park, Hungry Harvest buys surplus produce at a discounted rate from local farmers and food distributors, then delivers it by the bagful to clients. For every bag of food a customer buys, Hungry Harvest donates another to a local shelter or food bank. Hungry Harvest was born out its founders' interest in addressing two conflicting food problems: millions of families struggle to put food on the table and pay their bills, while at the same time, farms and food suppliers routinely discard safe and edible food because it does not meet certain size or appearance specifications.	Link

Improved containers	Modern containers include reusable plastic crates, upgraded containers (smaller in size and sturdier than cloth or woven plastic sacks, bundles, and baskets), biodegradable packages, food safety protocols, on-farm storage structures and home-scale storage containers.	Link
Purdue Improved Crop Storage (PICS) bags	PICS are triple-layer, hermetically sealed plastic bags in 20 kg and 100 kg capacities for long-term storage of cowpeas, dried beans, and maize. They were developed by Purdue University for use in Africa.	Link
For grain storage	For stored grains, low-cost gadgets have been developed for insect control by Dr. Sarma Mohan of Tamil Nadu Agricultural University in India.[18]	Link
For horticultural crops	Combining heat with other treatments such as ethylene-action inhibitors, edible coatings, biological control agents, controlled atmospheres and/or appropriate packaging is under investigation. Combinations of treatments that could reduce decay, chilling injury, and softening while avoiding heat damage should be further investigated.[19]	
Low-cost refrigeration systems	CoolBot™ modules can convert a typical window-style air-conditioning unit (with a minimum temperature setting of 15°C) to a small-scale refrigeration system that can achieve a temperature as low as 2°C.	Link
	A portable version of this technology has been developed by postharvest specialists at the University of North Carolina, using an enclosed cargo trailer and the CoolBot™. The Pack N'Cool unit can be constructed locally using new or used materials and is used for transporting fresh produce or chilled food products from the farm or packinghouse to market.	Link
Mobile technology		
More specifically, mobile technology presents promising new solutions. In a recent article, *Fortune* magazine argued that mobile apps are perfect for making timely connections and facilitating donations."[20] Here are just a few of the many new apps that can be used by individuals as well as restaurants, farms, grocers, and truckers to deal with food waste and quickly get foods that are in danger of being wasted directly to those in need.		
• Gojee app	Both show young people how to cook and eat food made with the ingredients they can find in their refrigerator,[21] in order to help people to avoid food waste and use the foods they may already have on hand.	Link
• Handpick app		Link
• Waste No Food		Link

• Food Cowboy		Link
• AmpleHarvest.org		Link
• PareUp in NYC		Link
Multi-stakeholder partnerships		
In the United States, Congress has been called upon by the Chicago Council on Global Affairs to double investments in agricultural and food research over the next 10 years to help meet the many challenges that have been identified in building a sustainable global food system. In May 2015 the council recommended taking the following actions: • Forge a new science of agriculture to increase productivity sustainably, nutritiously, and economically. Production must be increased while using fewer resources, improving nutrition, and providing solid incomes to food producers. • Build research capacity. Support for university and research institutions in developing countries is critical to innovations that work in the local context. • Bolster research on climate change. Research must focus on building resilience and addressing threats to the food system by climate change. • Expand nutrition-sensitive agricultural research. Nutrition should be a key priority of research to combat chronic malnutrition. • Reduce food waste. Innovations for reducing food waste are vital to help offset the production needed to meet increased demand.		Link
Most recently, policy development and advocacy on food loss issues were included in the 2015 "Roadmap to end global hunger" drafted by 13 international aid organizations. The policy brief includes recommendations on how coordinated efforts led by U.S. government agencies can reduce global poverty and hunger through effective policies and international programs.		Link
Expo Milano 2015 (May 1-Oct. 31, 2015)		Link
UN Environment Programme, Food and Agriculture Organization of the United Nations, and Messe Düsseldorf's Think.Eat.Save		Link
European Union consortium "FUSIONS"		Link
Global FoodBanking Network® (GFN)		Link
Alliance Against Hunger and Malnutrition (AAHM)		Link
National initiatives in Brazil, Canada, Denmark, France, the Netherlands, Portugal, South Africa, Sweden, Thailand, United Kingdom, United States		
Thai SAVE FOOD Campaign launched on May 25, 2015		Link

End Notes

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