Food Waste: Recent Findings and Implications for Policy

Jeta Rudi Polloshka

California Polytechnic State University - San Luis Obispo

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- Bellemare, Marc F., Metin Çakır, Hikaru Hanawa Peterson, Lindsey K. Novak, and Jeta Rudi. 2017. "On the Measurement of Food Waste". *American Journal of Agricultural Economics*, 99 (5), 1148-1158.

Motivation

- Food waste is one of the defining policy issues of our time, and discussion about it is often emotionally-charged
- Literature on food waste is limited, with few studies and some policy documents and advocacy group reports exploring the issue and providing estimates
- Ours is a conceptual study seeking to contribute to the literature on food waste, with a focus on the definition of food waste and its implications

Background

- Current literature on food waste uses definitions of food waste that vary substantially, resulting in huge differences in estimates, ranging from 35 mil. tons (EPA, 2016) to 103 mil. tons (FAO, 2011)
- The focus of our study is to:
  1. Provide a definition of food waste that focuses on food actually wasted, rather than food that is removed from the supply chain
  2. Provide a systematic way to think about the cost of food waste, considering the stage at which the waste occurs
  3. Document points in the life cycle of food items at which policy makers can intervene

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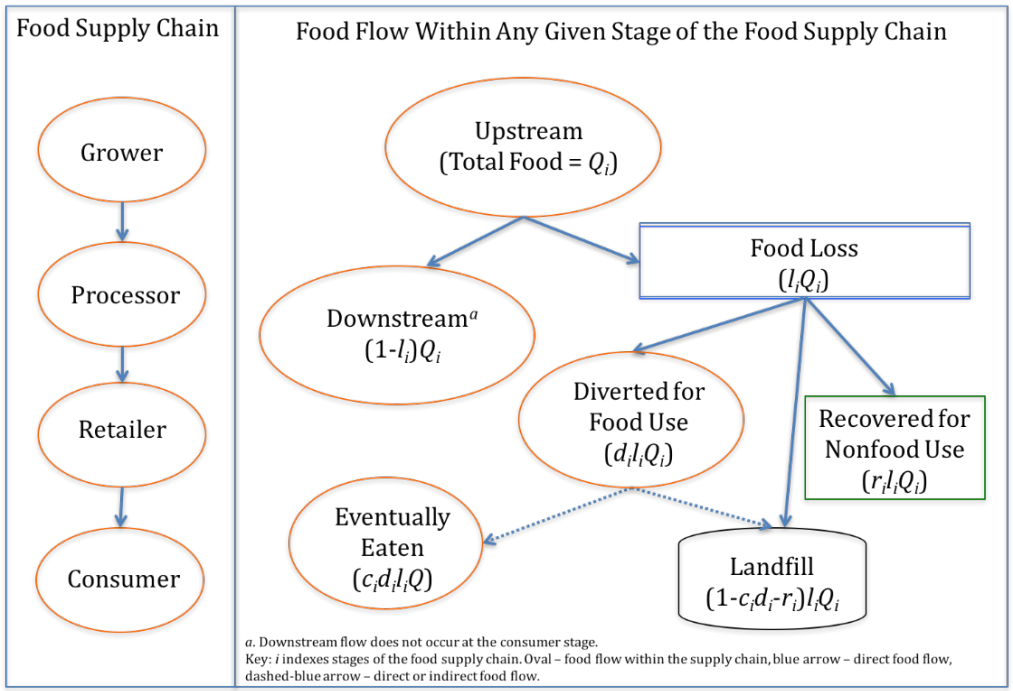
Life Cycle of a Typical Food Item



Food Waste Definitions

- We consider food waste definitions from FAO, USDA ERS, EU FUSIONS, and US EPA
- Definitions of FAO, ERS, and FUSIONS include the sum of "landfill" and "recovered for non-food use". EPA's definition includes "landfill" only from the household and retail stages
- FAO and ERS definitions only apply to edible and safe and nutritious food, whereas the definitions of FUSIONS and EPA apply to both edible and inedible parts of food
- ERS and EPA definitions exclude the food not harvested at farm level ▸ FAO ▸ ERS ▸ FUSIONS ▸ EPA

Food Waste Definitions

- Our definition of food waste:

Definition

Let $\bar{y}$ denote the quantity of food produced. Let $k \in \{1, ..., N\}$ denote the N potential productive uses for food. For each productive use, a certain amount of food $y_k < \bar{y}$ is employed. Food waste is any quantity $w > 0$ such that $w = \bar{y} - \sum_{k=1}^{N} y_k$.

Food Waste Numerical Example

- Consider a numerical example to highlight the importance in the differences between the definitions of food waste
- For simplicity, assume that:
  1. $Q_g = 100$
  2. Loss parameters $\ell_g = \ell_p = \ell_r = \ell_c = 0.2$

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  3. Lost food diverted for food use $d_g = d_p = d_r = d_c = 0.25$
  4. The proportion of diverted food that is eventually eaten $c_g = c_p = c_r = c_c = 0.1$
  5. Proportion of food loss that is recovered for nonfood use $r_g = r_p = r_r = r_c = 0.25$

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  5. Proportion of food loss that is recovered for nonfood use $r_g = r_p = r_r = r_c = 0.25$
  6. All food is 120% of all edible food production (FUSIONS and EPA definitions distinguish between edible and inedible foods)

Food Waste Numerical Example

Table: A comparison of quantity and cost estimates of food waste across definitions

	Quantity Estimate	Cost Estimate	Cost Estimate Using Our Cost Proposal
Our Estimate	42.8	27.6	—
EPA	20.0	—	17.8
FAO	57.6	39.6	37.1
ERS	57.6	57.6	37.1
FUSIONS	69.1	47.8	44.6

Note: $Q_g = 100$, $\ell_g = \ell_p = \ell_r = \ell_c = 0.2$, $d_g = d_p = d_r = d_c = 0.25$, $c_g = c_p = c_r = c_c = 0.1$, $r_g = r_p = r_r = r_c = 0.25$, food stuff as a proportion of edible food=1.2

Costs: $p_g = 0.4$, $p_p = 0.6$, $p_r = 0.8$, $p_c = 1$, markup at each stage of the supply chain=10%

Importance of Food Waste Definition

- This exercise shows our estimate for quantity of food waste is smaller than the quantities estimated by FAO, ERS, and FUSIONS definitions, and higher than EPA's
- Our proposed framework is useful, even if there are disagreements in terms of the definition provided
- In addition to measuring the quantity of food waste, there are problems with estimating the cost of food waste in the extant approaches, which largely rely on transaction prices of food

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Policy Implications

- It is problematic to suggest that total quantity of food stuff, Q_i, should decrease as this would increase food prices and worsen food insecurity
- All other parameters, d_i, r_i, and ℓ_i, are all actionable at every stage of the supply chain
- Policies should be context-specific, for example in developing countries most of the waste occurs at production, processing, and distribution stages; in developed countries most of the waste occurs at the consumer stage

Policy Implications

- Policy priorities are defined by the estimated cost of the waste generated at each stage, hence reductions in food waste downstream versus upstream should be considered
- Policy interventions are inter-dependent, hence requiring cooperation and coordination for all stakeholders to avoid resource misallocation
- Previous definitions consider whether food is edible. In addition to the ambiguity of what is edible, this ignores that all parts of food (including stalks, leaves, bones) should be considered as costs of input used to produce the food stuff, and hence should be included in estimates of food waste

Discussion & Conclusions

- Our study is a conceptual study addressing the measurement of food waste, both in terms of quantity as well as cost
- Finding current definitions of food waste lacking in some way, we propose a definition of food waste that accounts for: (1) Food loss and food diversion; and (2) Cost at the stage of waste
- Using a numerical example, we show that most current definitions overstate the quantity as well as the cost of food waste
- Our framework identifies the various points along the food supply chain where policy-makers can intervene in an effort to reduce food waste

- Appendix

Background

- Current estimates of the food waste in the US range from 35 mil. tons (U.S. EPA 2016) to 103 mil. tons (FAO 2011)
- Studies and reports focus on:
  1. The technology of repurposing wasted foods (Cuellar and Webber 2010)
  2. Understanding consumer awareness, attitudes and behavior related to food waste (Neff et al. 2015, Qi and Roe 2016, Wilson et al. 2017)
  3. Offering policy suggestions on how to reduce food waste (Rockefeller Foundation ReFED 2016)

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Definitions of Food Waste

- FAO definition (FAO 2016)

Definition

Food loss is defined as "the decrease in quantity or quality of food." Food waste is part of food loss and refers to discarding or alternative (nonfood) use of food that is safe and nutritious for human consumption along the entire food supply chain, from primary production to end household consumer level.

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Definitions of Food Waste

- ERS definition (Buzby et al. 2011)

Definition

Food loss represents the amount of food postharvest, that is available for human consumption but is not consumed for any reason. It includes cooking loss and natural shrinkage (for example, moisture loss); loss from mould, pests, or inadequate climate control; and food waste.
Food waste is a component of food loss and occurs when an edible item goes unconsumed, as in food discarded by retailers due to color or appearance, and plate waste by consumers.

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Definitions of Food Waste

- FUSIONS definition (FUSIONS 2016)

Definition

Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composed [sic], crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)

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Definitions of Food Waste

- EPA definition (EPA 2016)

Definition

The amount of food going to landfills from residences, commercial establishments (e.g., grocery stores and restaurants), institutional sources (e.g., school cafeterias), and industrial sources (e.g., factory lunchrooms). Pre-consumer food generated during the manufacturing and packaging of food products is not included in EPA's food waste estimates.

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Cost of Food Waste Overestimated

1. All current estimates value food waste at the transaction price of food $\mathcal{P}_i$, which is equal to the average cost of food (or price of food waste), p_i, and per unit markup that the seller may charge, μ_i. For example, for retailers $\mathcal{P}_r = p_r + \mu_r$, overestimating the cost of food waste by μ_r at this stage.

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2. Some of the estimates of the cost of food waste value all food waste, regardless of where it occurred in the supply chain, simply at the retail transaction price $\mathcal{P}_r$ (e.g., the ERS estimate of the cost of food waste). This leads to severely overstating the value of upstream food waste, because $\mathcal{P}_r w_g > p_g w_g$ and $\mathcal{P}_r w_p > p_p w_p$.

Cost of Food Waste Overestimated

- Formally, the total value of food waste is overestimated because extant estimates $\tilde{V}_j$, $j = 1, 2$, compute it such that:

$$\tilde{V}_1 = \mathcal{P}_g w_g + \mathcal{P}_p w_p + \mathcal{P}_r (w_r + w_c), \tag{1}$$

- or

$$\tilde{V}_2 = \mathcal{P}_r (w_g + w_p + w_r + w_h), \tag{2}$$

- when in fact the true value of food waste $\hat{V}$ is such that

$$\hat{V} = p_g w_g + p_p w_p + p_r w_r + p_c w_c, \tag{3}$$

- Hence $\hat{V} < \tilde{V}_1 < \tilde{V}_2$.

Cost of Food Waste

- These are only the equivalent of accounting costs of food waste, excluding the social and environmental costs, i.e. the economic costs
- Shortcomings of $\hat{V}$ (as well as $\tilde{V}_1$ and $\tilde{V}_2$) include: (1) not accounting for social and environmental costs of food waste; (2) the opportunity cost of using landfill space devoted to food waste; (3) the cost of transportation to landfill, etc.

Food Waste Numerical Example

- Consider the previous numerical example, and further assume:
  1. The average costs of production at the grower, processor, retailer and consumer levels are $p_g = 0.4$, $p_p = 0.6$, $p_r = 0.8$, and $p_c = 1$, respectively
  2. These costs are applied to all food lost at their corresponding stage that eventually ends up in landfill
  3. Where applicable, assume that sellers charge a markup value of 10% of the costs

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Policy Implications

- Our framework shows that policy intervention should consider both the loss rate as well as the rate of diversion
- Consider the quantity of food waste w_i, where $i \in \{g, p, r, c\}$ is such that

$$w_i = (1 - d_i - r_i)\ell_i Q_i + (1 - c_i)d_i\ell_i Q_i, \tag{4}$$

$$w_i = (1 - c_i d_i - r_i)\ell_i Q_i, \tag{5}$$

- The total quantity $\mathcal{W}$ of food waste is such that

$$\mathcal{W} = \sum_{i \in \{g,p,r,c\}} w_i \tag{6}$$

Policy Implications

- Previous equations show that the total quantity of food waste is decreasing in:
  1. the proportion of food diverted d_i
  2. the proportion of food recovered r_i
  3. the proportion of diverted food that is eventually consumed c_i at every stage
- And it is increasing in:
  1. proportion of food lost ℓ_i
  2. the quantity of food Q_i at each stage