



Waste and see:

Taking a deeper look at the scale and impact of food waste in the United States

Final Project Report
InfoViz Spring 2023

Team members

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Links to visualization elements

- Final Website: <https://alzhxo.github.io/waste-and-see/>
Contains the following embedded charts:
 - Tableau chart 1:
<https://public.tableau.com/app/profile/alicia.zhao/viz/Top20FLWCountries/FLWCountryChart>
 - Tableau chart 2:
<https://public.tableau.com/app/profile/alicia.zhao/viz/FoodWastebySector-ReFEDData/FoodWastebySector>
 - Tableau chart 3:
<https://public.tableau.com/app/profile/alicia.zhao/viz/FoodWaste-ReFEDData/ResidentialFoodWasteCauses>
 - Tableau chart 4:
https://public.tableau.com/app/profile/alicia.zhao/viz/FoodStorage101dataforromsavethefood_org/FoodStorageDashboard
 - D3.js Observable Notebook:
<https://observablehq.com/d/14472a5a08975da3>
- Figma prototype: <https://tinyurl.com/msshffnp>

Project goals

Food waste is an ever-growing problem, and the United States is one of the largest producers of food waste in the world, both in absolute terms and per capita. According to the US Department of Agriculture, over one-third of the food produced in the United States is never eaten, wasting both the resources used to produce it and contributing to greenhouse gas emissions as food waste sits and decomposes in landfills. In fact, food waste is the single most common material landfilled and incinerated in the US.

While policy, legislation, and corporation-level changes are indeed major components in repairing the overall system, a key leverage point in fighting climate change starts at the consumer level as well. When scaled across the larger population and taken in aggregate, small changes in how consumers view and handle food waste can result in substantial gains toward reducing what goes to landfills.

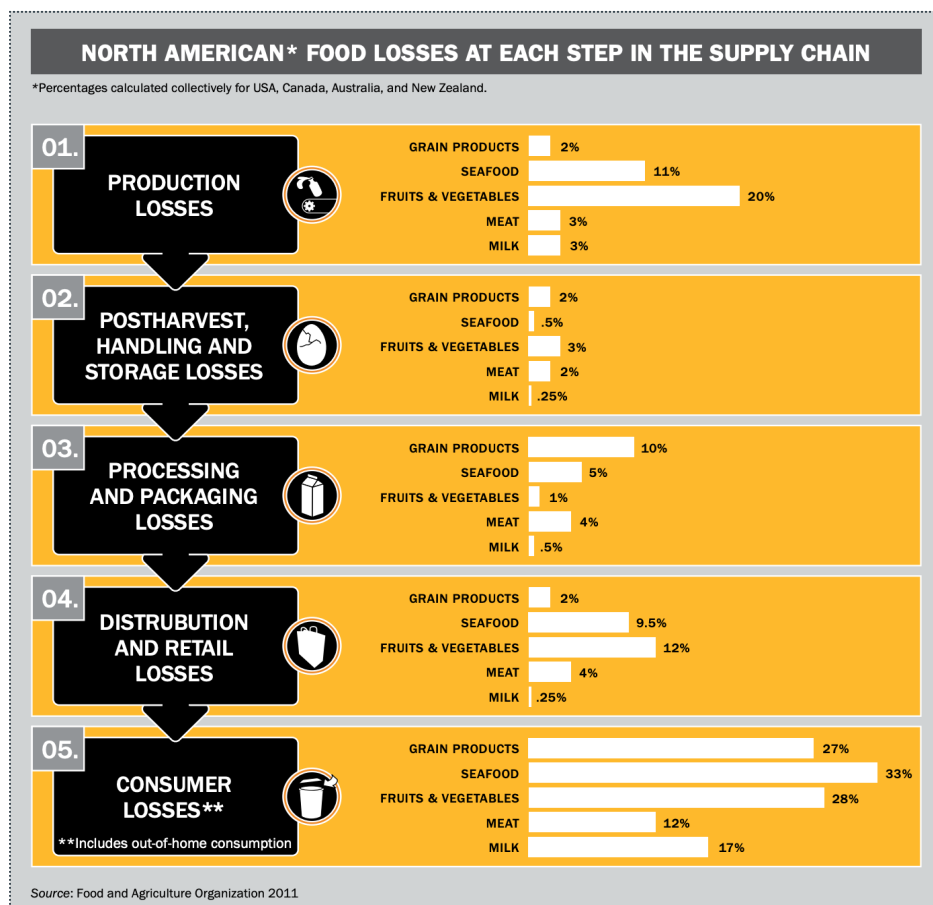
The main goal of this project was to create a visualization of food waste across the entire supply chain with a key emphasis on the consumer level. This integrates with our capstone project, an information platform where our target users (currently, college students) can obtain information about how to lead a more sustainable lifestyle and

visualize how personal choices scale up when each individual takes on the role of a 'sustainability steward'.

Related work

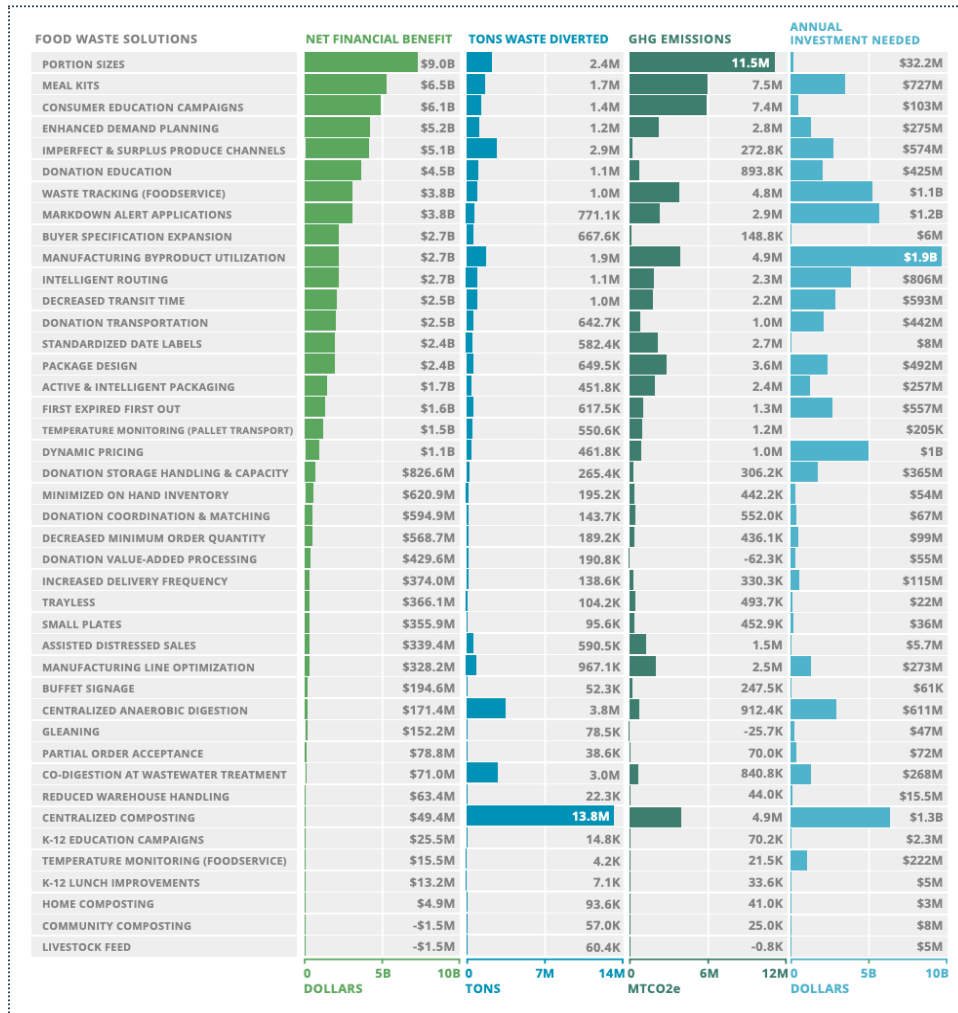
1 [Wasted: How America Is Losing Up to 40% of Its Food from Farm to Fork to Landfill](#)

This paper presents a comprehensive analysis of the extent and impact of food waste in the United States. Up to 40% of the food produced in the United States is never eaten, which translates to a staggering 63 million tons of wasted food annually. Food waste occurs at every stage of the food supply chain, from production and processing to retail and consumer levels. Food waste is not only a moral and ethical issue, but also a solvable problem that can help address issues of hunger, food insecurity, and sustainability. This paper relates to our work in that it provides recommendations to individuals and organizations to combat food waste.



2 Significant efforts are required to cut down food waste by 2030

the ReFED 2022 Annual Report provides a comprehensive and informative overview of the current state and future direction of food waste reduction efforts in the United States. It highlights both progress and challenges in this important area and offers actionable recommendations for stakeholders across sectors to help achieve a more sustainable and equitable food system.







3 Environmental impacts of food loss and waste (FLW)

Food waste is a significant contributor to greenhouse gas emissions, with an estimated 4.3% of total US greenhouse gas emissions attributable to food waste in 2018. Food waste also contributes to other environmental impacts, such as water and land use, energy consumption, and biodiversity loss. The report provides a comprehensive and

informative overview of the environmental impacts of food waste in the United States. It underscores the urgent need for action to reduce waste and promote a more sustainable and resilient food system and offers valuable insights and recommendations for stakeholders across sectors to help achieve this goal.

TABLE 4-7. ANNUAL METHANE AND NITROUS OXIDE EMISSIONS ASSOCIATED WITH U.S. FLW

Source Scope of FLW	GHG Emissions - CH ₄ and N ₂ O emissions			
	Total (million MTCO ₂ e)	Per Person (kg CO ₂ e)	Scope of GHG Emissions	Emission Factors
Hiç et al. (2016) 	43	124		U.S.
Estimated emissions using country-level data on agricultural emissions from FAOSTAT.				
Chen et al. (2020) 	52*	167		Intl
Determined emissions by matching recently available global average characterization factors per food group (i.e., cropland use [g CO ₂ e/g]) to product resolution.				

* = calculated value

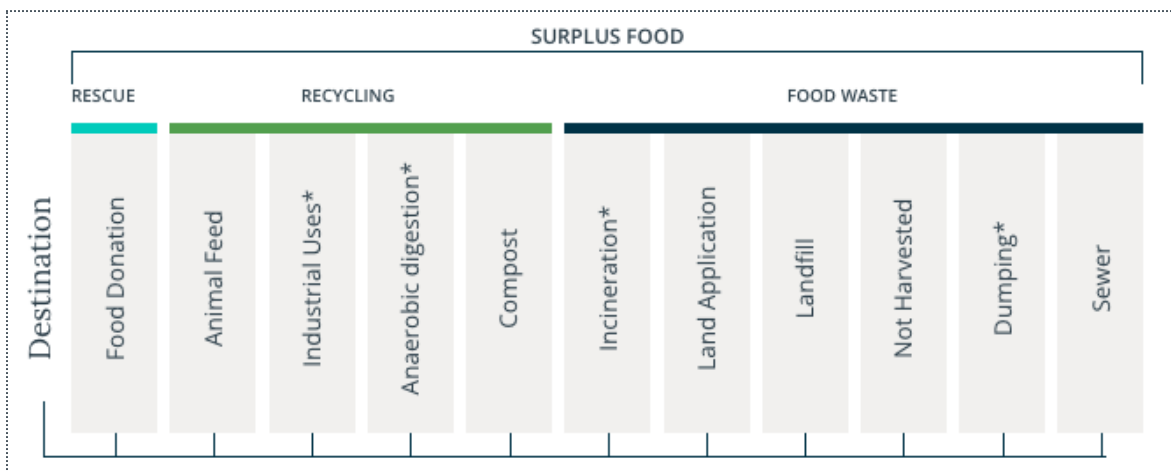
4 Greenhouse Gases (GHG) emissions are increasing at an alarming rate

Human-caused greenhouse gas (GHG) emissions drive climate change. About 60% of GHG emissions come from just 10 countries, while the 100 least-emitting countries contributed less than 3%. Agriculture and waste are significant sources of GHG emissions, contributing to about 20% of global emissions in 2019. Emissions from agriculture are highest in Asia and Latin America, while emissions from waste are highest in North America and Europe. There is significant potential for reducing emissions from both sectors through improved management practices, such as reducing food waste and improving manure management in agriculture, and increasing recycling and reducing landfill methane emissions in the waste sector.



5 Food waste is a major contributor to carbon emissions and the United States is a leading contributor

The carbon emissions resulting from food waste in the U.S. is around 3 times greater than the entire U.S. aviation industry (passenger, commercial, and military). In 2019, of the 80.6 million tons of food surplus the U.S. produced, 54.2 million tons went to waste. Food waste is defined as the following end destinations of surplus food:



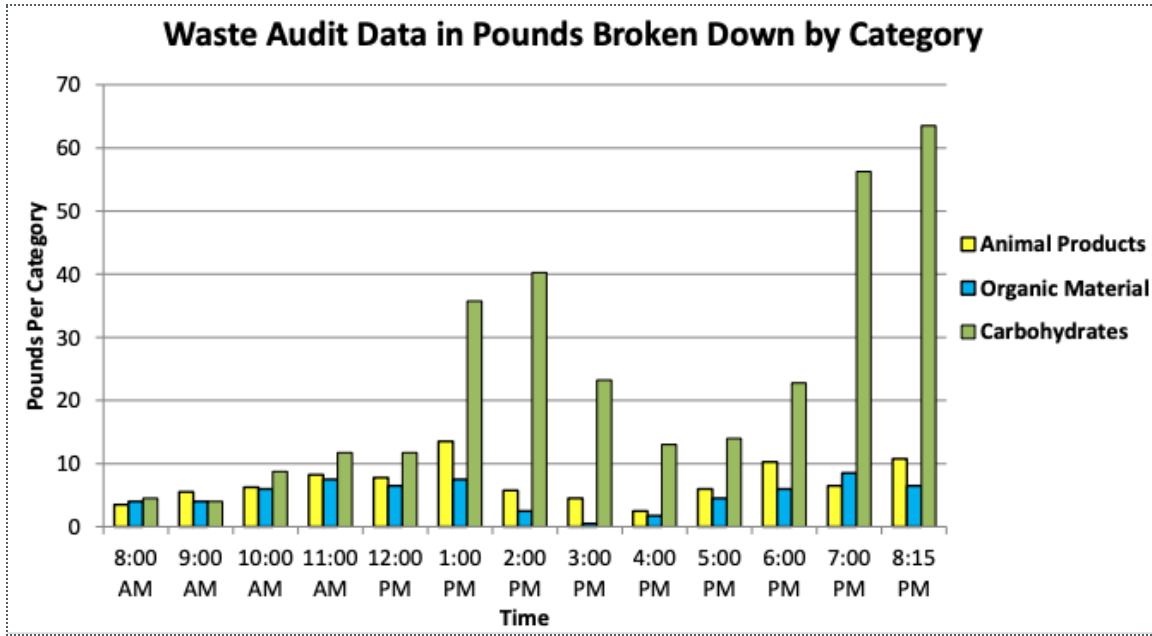
6 Food waste in colleges and universities is still quite an untouched topic in terms of research

In the United States, nearly 40% of food is wasted every year. Recycling Works of Massachusetts estimates that residential students waste 142 pounds of food per year and non-residential students waste 38 pounds of food per year, although it is unclear how accurate this data is or what the source is. There is not much solid data on how much food is wasted and in what ways on campuses (outside of trayless dining which has been well-researched). More importantly, the fiscal impact of food waste on college campuses has not been widely researched. MCURC's Senior University Administrators Committee, in combination with the MCURC Research Working Group, is uniquely poised to collect this data and fill in the lack of knowledge on this subject. This will lead to the prioritization of actionable outcomes that will reduce waste while saving money.

	Average Measurement		Material
Meals Served	0.35	lbs/meal	Food Waste
Students¹ [Residential]	141.75	lbs/student/year	Food Waste
Students² [Non-Residential]	37.8	lbs/student/year	Food Waste

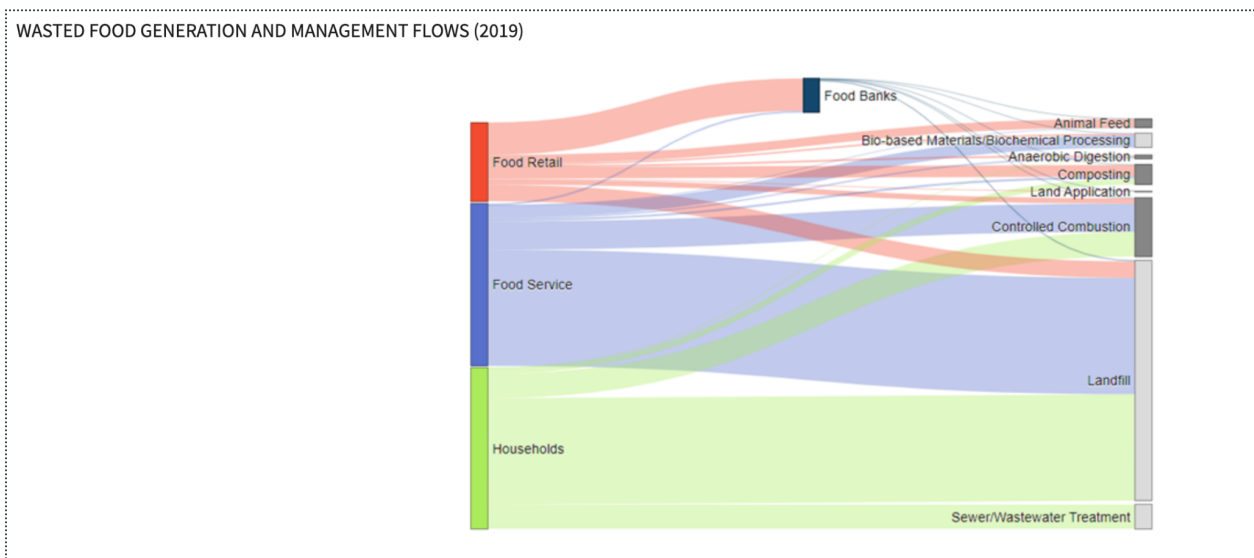
7 Anaerobic digestion could be a potential solution to diverting food waste from landfills

The study is based on a waste audit done by and at Western Michigan University. The study explores and suggests that anaerobic digestion has significant potential to address food waste and promote sustainability in the food service industry. However, it requires careful planning and investment to overcome barriers to implementation and realize its benefits.



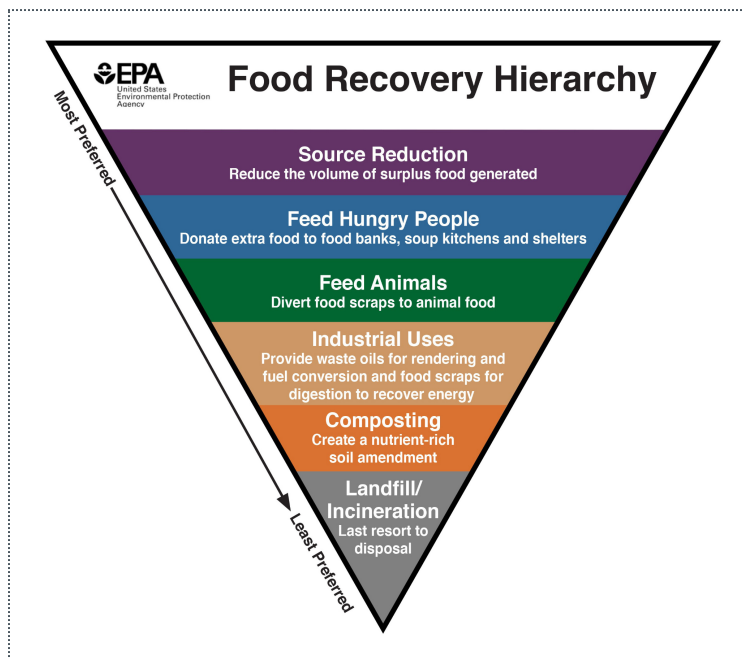
8 [Food waste generation and management flows](#)

EPA estimates that in 2019, 66 million tons of wasted food was generated in the food retail, food service, and residential sectors, and most of this waste (about 60%) was sent to landfills. An additional 40 million tons of wasted food was generated in the food and beverage manufacturing and processing sectors. The biggest portion of this (42.6%) was managed by anaerobic digestion.



9 Food waste hierarchy is a helpful framework for reducing food waste

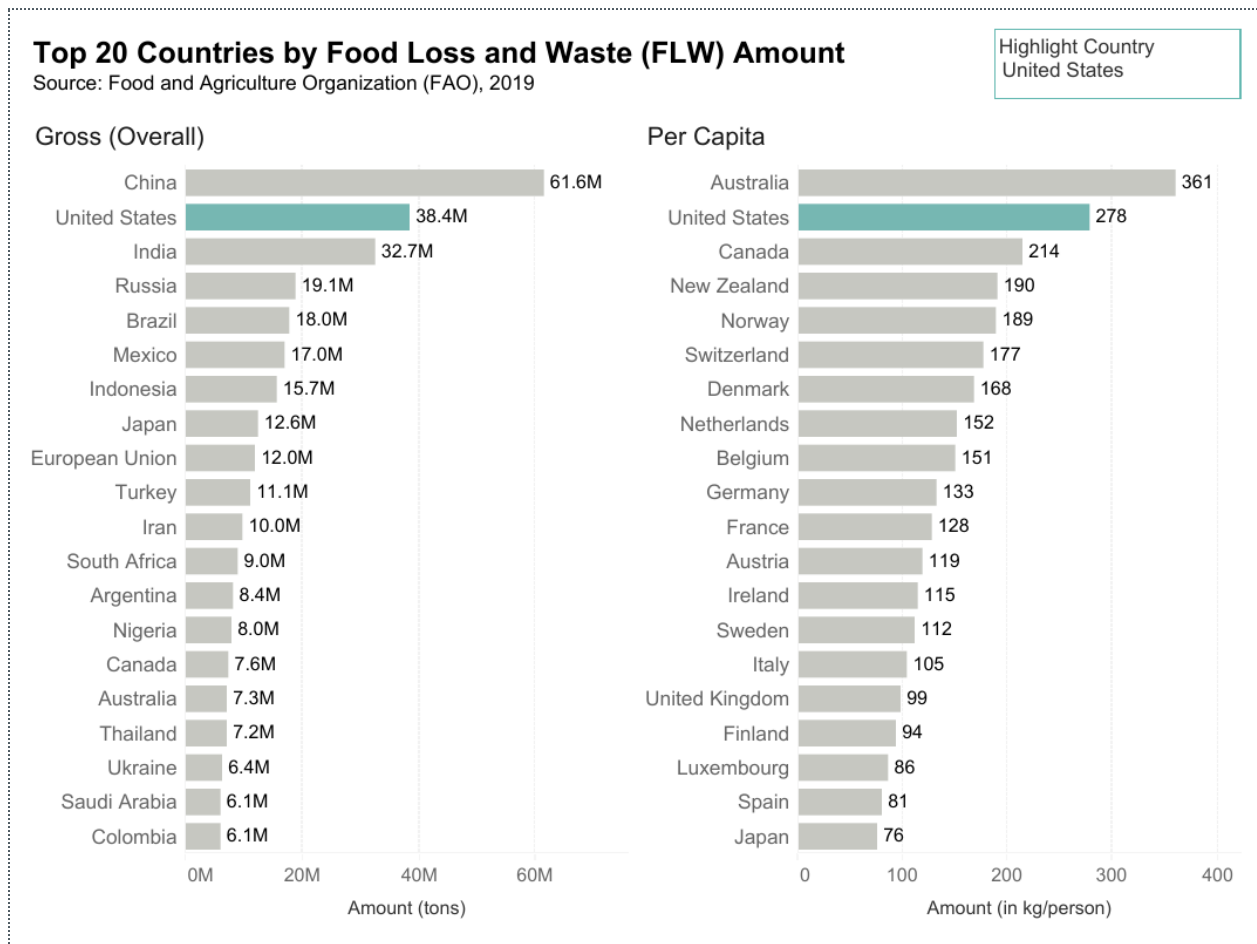
The Food Recovery Hierarchy prioritizes actions organizations can take to prevent and divert wasted food. Each tier of the Food Recovery Hierarchy focuses on different management strategies for your wasted food. The top levels of the hierarchy are the best ways to prevent and divert wasted food because they create the most benefits for the environment, society, and the economy.



Visualization descriptions

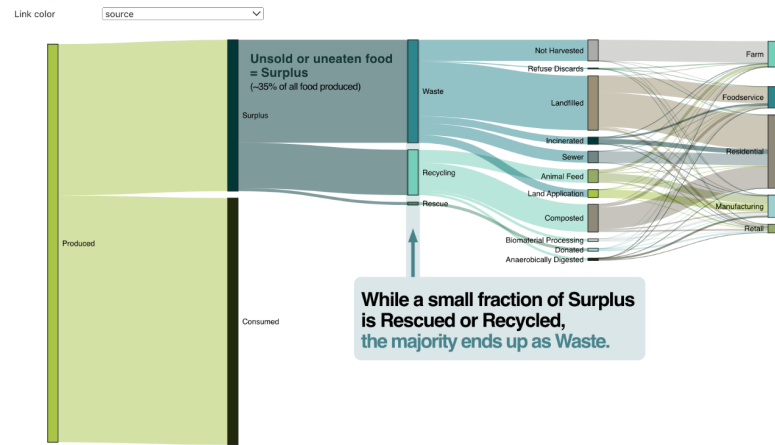
Section 1 - Food waste landscape in the United States

This section mainly comprises visualizations that lay the landscape and context of the problem of food waste in the United States. This section has charts comparing US food waste to other countries globally and a deeper look at food flows and waste data within the United States. This section also draws upon comparisons to social issues such as food insecurity in America to further contextualize why food waste is an issue the viewer should care about.



In the United States, 35% of all food produced for human consumption goes unsold or uneaten - this amount is called surplus.

The chart below tracks the flow of food surplus to its final destination, as well as which sectors were responsible.



Above: interactive Sankey chart created in d3 to allow the user to hover and explore the millions of tons of food waste that flow from production to surplus to waste.

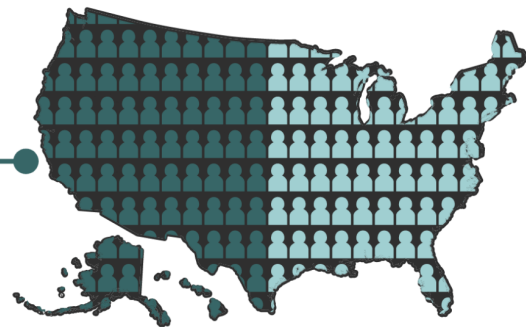
In 2021, of the 91 million tons of food surplus the U.S. produced,

62 million tons went to waste.

This uneaten food contains enough calories to feed more than 150 million people each year, or

almost half of the U.S. population.

It also amounts to almost **90 billion meals'** worth of food annually.



Population of U.S.: ~331 million (U.S. Census, 2020)
 Icon: ≈ 2M people

This is happening in the same country where it's estimated that more than **1 in 6 people face food insecurity.**



Above: various visualizations using ISOTYPES to illustrate the scale of food waste and compare it to the scale of food insecurity in America.

Section 2 - Economic impact of food waste

“Food waste isn’t just a social issue.” We used iconography to contextualize the massive economic scale of food waste by comparing its US dollar amount value to the national public education yearly expenditure.

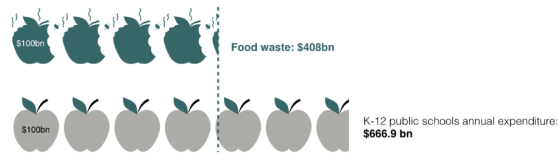
Food waste isn't just a social issue.

Economically, the amount of wasted food per year is valued at

\$408 billion

or approximately 2% of the United States' GDP.

For comparison's sake, that dollar amount is equivalent to 60% of all K-12 public education spending in the U.S.



Furthermore, NRDC research shows that the average American family of four spends **\$1,500 on uneaten food per year**.

That's more than enough to pay for an entire month's worth of groceries for that same family of four.

Section 3 - Environmental impact of food waste

Adapting an emissions flow chart from ReFED.org by vertically flipping the paths of the flows and changing the color palette to be more harmonious with our other visualizations, we used this chart to add context for why the emissions of food waste is more than just the end state of rotting food - it also encapsulates the emissions from all parts of the process that went into producing the food that went uneaten.

Screenshot below:

Food waste is wreaking havoc on our environment too.

When food is discarded, **all inputs used (such as land, energy, and water)** in producing, processing, transporting, preparing, and storing the discarded food **are also wasted**.

The greenhouse gas (GHG) emissions from each step of the supply chain add up quickly.

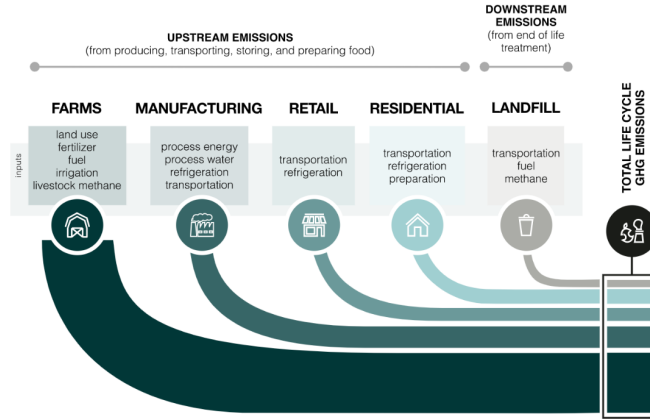


Image adapted from: <https://refed.org/food-waste/climate-and-resources/>

We then drove home the true environmental impact of food waste by using interactive “flip cards” to make the user first guess, then reveal, the equivalent amounts of land, carbon emissions, and water that is wasted when all food loss and waste is summed up. These amounts were represented with ISOTYPES and iconography.

Every year, U.S. Food Loss and Waste (FLW) uses up the equivalent of:

___ acres of land
click to reveal

___ metric tons of CO₂ equivalent (MTCO₂e)
greenhouse gas emissions
click to reveal

___ gallons of blue water
click to reveal

The image shows three light blue flip cards. The first card has a map of the United States icon. The second card has a factory icon. The third card has a water drop icon.

Screenshot above: Viewer is first presented with cards that conceal the values and is prompted to click on them sequentially to view the true amounts of resources wasted.

Every year, U.S. Food Loss and Waste (FLW) uses up the equivalent of:

140 million acres (560,000 km²) of agricultural land – an area the size of California and New York combined;



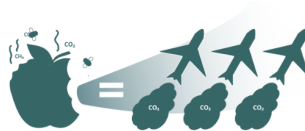
170 million MTCO₂e GHG emissions, equal to the annual CO₂ emissions of 42 coal-fired power plants;



5.9 trillion gallons (22 trillion L) of blue water, equal to the annual water use of 50 million American homes.



All in all, the greenhouse gas emissions resulting from food waste in the U.S. is around **3 times greater than the entire U.S. aviation industry** – passenger, commercial, and military.



This estimate doesn't even include the significant **methane emissions** from food waste rotting in landfills.

- Methane is more than **25 times as potent** as carbon dioxide at trapping heat in the atmosphere.

Screenshot above: the content that is revealed once the user clicks on all of the cards.

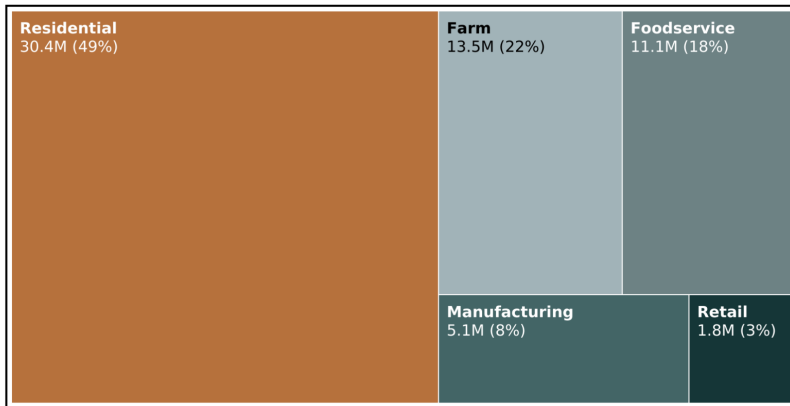
Section 4 - Do consumers really waste that much food?

A common misconception we wanted to debunk was that consumers on the residential level play only a minor part in the larger picture of food waste, or that it's really the restaurants and grocery stores that waste the majority of food in America. To debunk this misconception, we used a combination of treemaps and area charts to show that the residential sector, AKA we consumers, are actually the single largest sector contributing to food waste.

Screenshot of these charts below:

Food waste generated by sector (in tons), 2021

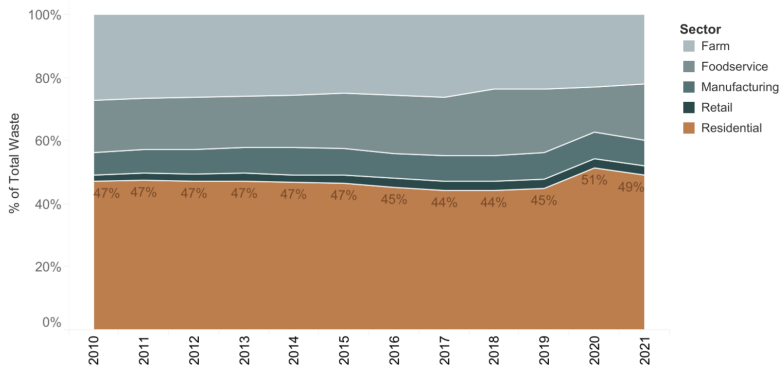
Select Year
2021



Total: 61.9M

This has held true, year after year.

% Food waste generated by sector (in tons), 2010-2021

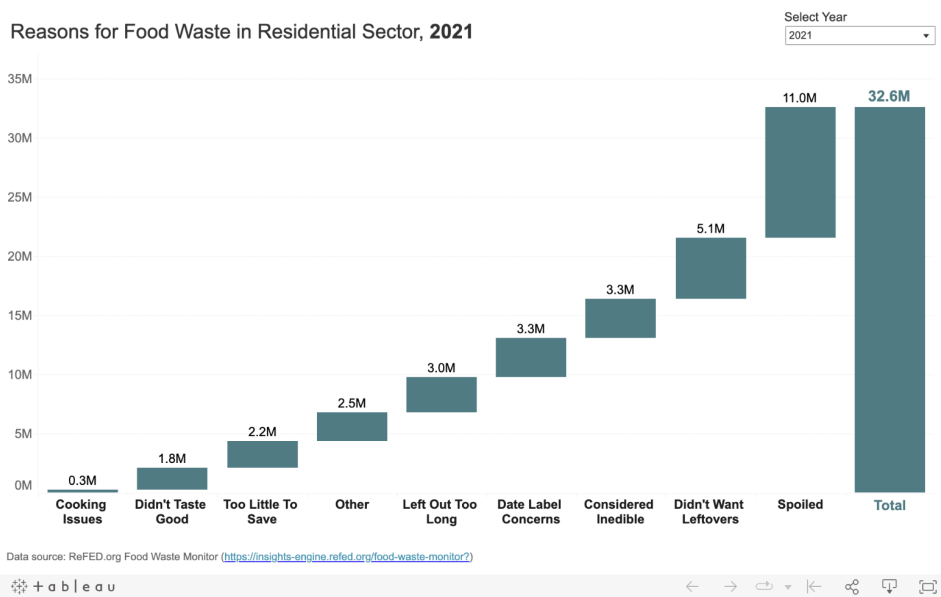


Data source: ReFED.org Food Waste Monitor (<https://insights-engine.refed.org/food-waste-monitor/>)

Screenshot below: a waterfall chart that breaks down the reasons that food was wasted in the Residential sector. The chart, built in Tableau, is interactive and allows the user to view any single year in the dataset, and view each waste reason individually, to see if any of the reasons sound familiar to them.

What are the reasons that consumers throw out food?

Take a look for yourself, and see if any of these reasons sound familiar to you:



Section 5 - What can we do as consumers to reduce food waste?

With all the above information and obtained knowledge about food waste, we wanted to provide consumers with actionable information as a way forward.

Screenshot below: We used animation to expand and collapse cards that contain information about some of the most commonly used date labels used in food packaging. We wanted to provide the consumers with clear and concise information about what these dates mean and how they can use that to prevent food waste.

Commonly used date labeling phrases that can mislead

Click on a card to learn more.

▼ BEST IF USED BY:
"Best if Used By/Before"

- Indicates when a product will be of best flavor or quality
- Not a safety date** or purchase date

▼ SELL BY:
"Sell By"

- Tells the store how long to display the product for sale for inventory management
- Not a safety date**

▼ USE BY:
"Use By"

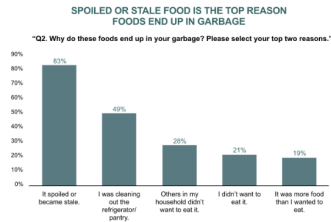
- The last date **recommended** for the product's use while at peak quality
- Not a safety date** except for when used on infant formula

▼ FREEZE BY:
"Freeze By"

- Indicates when a product should be frozen to maintain peak quality
- Not a safety date** or purchase date

Screenshot below: Bar charts with key information about top reasons why consumers throw out food and types of food wasted. As part of these charts, we also linked them externally to useful resources like savethefood.com.

3) Learn recipes that can use up foods "past their prime".

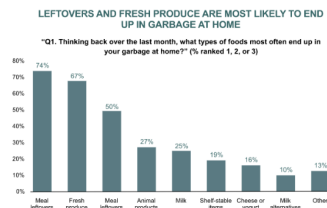


In a 2019 survey conducted by the International Food Information Council (IFIC) Foundation:

- 83% of consumers reported throwing out food because it spoiled or became stale, and
- 49% reported it was because they were cleaning out their fridge or pantry.

Before you throw those foods out, consider giving them a second life in delicious [recipes](#) such as soups, stews, and baked goods.

4) "Meal Prep" to reduce the chance of leftovers.



The same IFIC survey revealed that **leftovers and fresh produce were in the top 3 types of foods** thrown out at home.

Preparing your meals in advance can reduce the chance of ending up with leftovers that go in the garbage.

For some helpful meal prep guides, check out this [page](#) created by the NRDC.

Screenshot below: As a consumer and citizen, it's important to know the policies on food and food supply chains. We used a hex-map to highlight the inconsistent state regulations around food labeling. The US map was color-coded to denote the strictness levels of policy and the tooltips on hover provide detailed information about policies in each state.

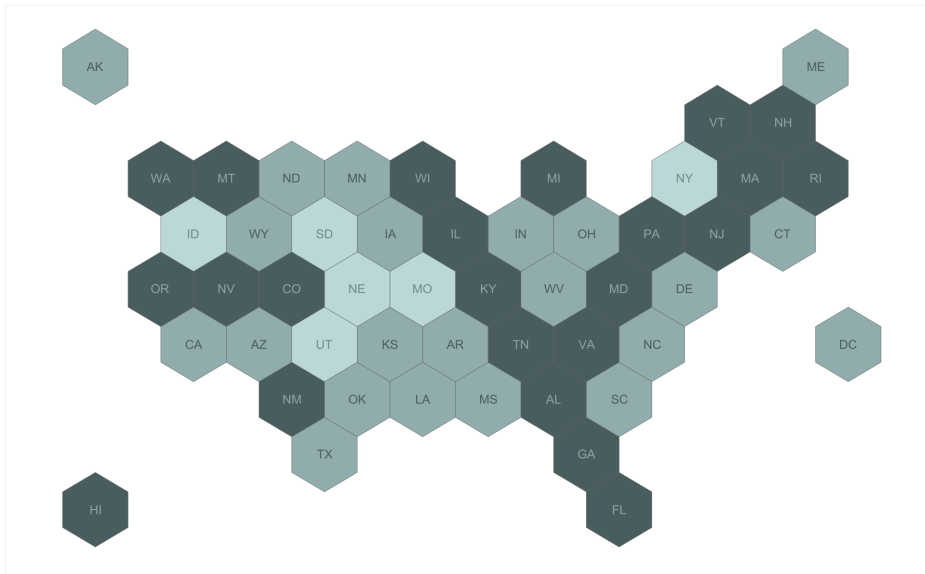
Food Date Labeling Policy Scores by State

According to ReFED.org, inconsistent state regulations around date labeling lead to 20% of U.S. consumer food waste. ReFED writes: "The extreme variations demonstrate how our current system creates confusion for consumers while not necessarily improving food safety, ultimately resulting in significant waste of wholesome food." **Negative policies** often prevent the sale of food beyond the labeled date, even when they are still safe to consume.

Explore for yourself these variations in state-level policies with the map below.

Policy Score
 No Policy
 Moderate Policy
 Negative Policy

Highlight State
 No items highlighted



Food Date Labeling Policy Scores by State

According to ReFED.org, inconsistent state regulations around date labeling lead to 20% of U.S. consumer food waste. ReFED writes: "The extreme variations demonstrate how our current system creates confusion for consumers while not necessarily improving food safety, ultimately resulting in significant waste of wholesome food." **Negative policies** often prevent the sale of food beyond the labeled date, even when they are still safe to consume.

Explore for yourself these variations in state-level policies with the map below.

Policy Score
No Policy
Moderate Policy
Negative Policy

Highlight State

Highlight State



Above: example of information that is provided in the tooltip when the user hovers on a state.

Data used

- Food Loss and Waste Database by Food and Agriculture Organization of the United Nations - <https://www.fao.org/platform-food-loss-waste/flw-data/en/>

The Food Loss and Waste database is the largest online collection of data on both food loss and food waste and causes reported in scientific journals, academic publications, grey literature, and countries among others.

- ReFED Insights Engine Food Waste Monitor - <https://insights-engine.refed.org/food-waste-monitor>

A centralized repository of information built with data from more than 50 public and proprietary datasets and providing granular estimates of how much food goes uneaten in the U.S., why it's happening, and where it goes.

- Natural Resources Defense Council (NRDC) Save the food website - <https://savethefood.com/storage>

Resources to save food loss and waste for consumers. We used the 'storage' section of the website to build a dashboard for best food storage practices.

Tools

Here's a summary of the combination of tools we used for various purposes throughout the project.

- Tableau: We used Tableau for Students Desktop version 2022.4.0 to build a few visualizations and hosted them on the Tableau Public server.
- Observable: We created a few visualizations with d3.js on Observable Plot and hosted them on Observable.
- Figma: Used to create prototypes for usability testing
- Miro: Used for brainstorming and ideation
- Github pages: Our final website is hosted on Github pages.
- Google Workspace Suite: We used a few tools (Google Docs, Sheets, etc.) from the Google Workspace Suite extensively for writing reports, gathering reference sources, research ops, usability testing scripts and ops, etc.
- Zoom: We used Zoom to conduct usability testing sessions and record participant feedback.
- Slack: Used for asynchronous team communication.

Results and usability tests

We conducted three qualitative usability study sessions with participants on Zoom. Participants were asked to interact with a high-fidelity prototype of our final project website and share their screens. We aimed to test the usability of the whole website - visualizations, text, and overall design. Specifically, we were interested in understanding:

- User experience
- Usability of visualizations
- User understanding and assimilation of information pertaining to food waste reduction

Usability studies report: [☰ Final Project: Usability Study Report - Food waste reduction](#)

Usability script and notes: [☰ Usability Study Script & Notes - Food Waste Reduction](#)

Below are the results of the usability studies and some feedback we received from our prospective users:

Findings/learnings

- Interactive charts worked better than non-interactive ones (like infographics)
- Users would like the following displayed upfront in visualizations:
 - Data source
 - Technical details like units
- Use cases for using proportions (%) and absolute values
- Interactions and usability varies for type of charts –
 - Users more familiar with charts like bar charts vs. a Sankey diagram
 - More help sought for complex charts like Sankey diagram
- Familiarity with the tool (eg., Tableau) also matters a lot since they need to know how to reset filters and such
- Text and visualization interplay: we understood the role (positive and negative) text plays – in some areas it was helpful, in some areas it caused more confusion

Potential changes identified based on learnings

- Complex charts: extra help with complex charts like Sankey diagram by refining chart further to remove confusing elements (sector) and improving help text
- Chart Tools: quick tooltips for how to interact with Tableau (eg., reset filters)

- Text + Visualization: use text to strengthen visualization by choosing the right font type, size, placement, etc.
- Critical information: display critical information like data source, units in charts, etc. upfront
- Visually distinguish between
 - Interactive charts and infographics
 - Clickable and non-clickable parts in charts
- Redundant information: Check for redundant information

Selected quotes from users & coded sentiments

Result	Sentiment
“This bar chart is so easy to understand and interpret” (P3)	Positive
“I don’t want to be biased, but I think for non technical people, this chart is too complicated.” (P3)	Negative
“Far-right side is chaotic, I don’t understand what is going on” (P1)	Negative
“I don’t like chemistry. It seems like I am looking at the periodic table.” (P3)	Negative
“This [visual] took some time to understand, but once you get it, it’s powerful.” (P2)	Positive
“The planes emitting CO2 stand out. It is clear that I am getting aggregate of CO2 emissions from the aviation industry”	Positive
“I like the bold font and placement. Draws your eyes to it” (P1)	Positive
“This is cool, this makes sense to me. It makes me feel less scared to use food that’s gone past its use by date!” (P2)	Positive
“Love the font similar to the ones on packaging!”	Positive
“I could not get that I could hover over individual food items to get more information” (P3)	Negative
“I loved the Tableau chart about food pantry” would love to have a version of it on my mobile or on my fridge”	Positive
“I expected to be able to filter by clicking on these bars too.” (P2)	Neutral
“I didn’t expect the ‘As a voter’ section to be here, but I’m glad it is. It’s another way to think about [combating food waste].”	Positive
“I don’t really find this section useful and it’s redundant. “Section is about recipes, but it’s just a word in this section” (P1)	Negative

Appendix

Team contributions

Task	Name & Proportion of work		
	Alicia	Haritha	Adeel
Research	34%	33%	33%
Storyboarding	75%	10%	15%
EDA	40%	30%	30%
Figma prototype	98%	1%	1%
Visualizations & dashboards	98%	1%	1%
Website implementation	90%	0%	10%
Usability testing script	10%	90%	0%
Usability recruiting	66%	0%	33%
Usability testing	1%	66%	33%
Usability report	20%	75%	5%
Final report	5%	95%	0%

Links to data repository and code

- Host URL: <https://alzhxo.github.io/waste-and-see/>
- Code Repository: <https://github.com/alzhxo/waste-and-see>
- Food waste datasets (Google Drive folder):
<https://drive.google.com/drive/folders/1rSreuw-KLrfN6o2-h03t9c5hdE3oHv5Z?usp=sharing>

Thumbnail for website



[\(link to download the image file\)](#)

References

- "A Survey of Consumer Behaviors and Perceptions of Food Waste | IFIC FOUNDATION SEPTEMBER 2019" - foodinsight.org
 - "Food: Material-Specific Data | US EPA" - epa.gov
 - "Food Recovery Hierarchy | US EPA" - epa.gov
 - "Food Waste in America | Feeding America" - feedingmaerica.org
 - "From Farm to Kitchen: The Environmental Impacts of U.S. Food Waste" - epa.gov
 - "Historical GHG Emissions | Global Historical Emissions" - climatewatchdata.org
 - "ReFED | Food Waste Solutions - Reduce Food Waste, Food Recycling & Recovery" - refed.org
 - "Save The Food" - savethefood.com
 - "Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill" - NRDC.org
-