Assessment of Food Waste Reduction Strategies

FOR UNIVERSITY DINING LEADERSHIP

April 2022

This project was completed with the assistance of

SEAS SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY UNIVERSITY OF MICHIGAN

DINING

Thank you

We would like to extend our gratitude to the University of Michigan School for Environment and Sustainability (SEAS) and MDining team for sponsoring this project.

Although our team all come from different professional backgrounds, we share one common thread — our passion for creating a more sustainable, equitable, and just food system. This interest brought our team together in Fall 2020, and it has been a pleasure to work alongside one another, learn from each other, and build a report to support university sustainability initiatives for years to come. Navigating our graduate school journeys through the COVID-19 pandemic has been eye-opening in a variety of ways, including the impact on the food system. From the implications of supply chain issues on food waste to the coalition building spirit of universities across the country, we all have learned so much through this research and thank all who supported us over the past year.

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DINING

LAND ACKNOWLEDGMENT

We acknowledge and recognize that the land in this region of Michigan was originally called Michigami and belongs to Anishinaabek, the Three Fires People: the Odawa, Ojibwe, and Bodewadami as well as Meskwahkiasahina (Fox), Peoria and Wyandot.[1]

REPORT CITATION

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Design by Alicia Adams

A SPECIAL THANKS TO:

Andrew Hoffman (project advisor) is the Holcim (US) Professor of Sustainable Enterprise at the University of Michigan; a position that holds joint appointments in the Stephen M. Ross School of Business and the School for Environment and Sustainability. Andy is a leader in using organizational, network and strategic analyses to assess the implications of environmental issues for business, and has published 18 books and over 100 articles and book chapters on the topic.

Steven Mangan (Senior Director - MDining) joined MDining in 2014. His expertise comes from three decades in the food service industry—first as a chef and restauranteur, and later in leadership roles at three Big Ten colleges. His successes come through a philosophy of meeting customers' needs, working collaboratively with his team and creating a culture of innovation. Steve holds a B.S. in Psychology from Michigan State University and an A.O.S. in Culinary Arts from the Culinary Institute of America.

Keith Soster (Director of Student Engagement - MDining) is responsible for student and community connections both on and off campus, and serves as the sustainability lead for Student Life. In this capacity, he oversees programs in buildings accounting for nearly one-fifth of the square footage of the University of Michigan Ann Arbor campus. He has over 30 years in the hospitality industry and graduated from Bowling Green State University.

And thank you to all the experts who graciously offered their time during interviews, observations, and practitioner feedback.

Image Source: Michigan Dining

Our Team

CELIA BRAVARD
(she/her)

Celia Bravard is a dual MBA/MS candidate at the University of Michigan Erb Institute for Global Sustainable Enterprise, a partnership between the Ross School of Business and School for Environment and Sustainability (SEAS). She holds a B.S. in Food Science from Iowa State University. Prior to Michigan, Celia spent 5 years as a food scientist at Conagra Brands in Omaha, NE where she formulated innovative products, investigated functionality of plant-based ingredients, and collaborated with supply chain partners on raw material optimization. Through these experiences, she found her passion for combining science, business frameworks, and systems thinking to tackle the massive challenges facing today's food industry. From food waste and land use change to carbon accounting and regenerative agriculture practices, Celia is excited to dedicate the rest of her career to finding solutions at the intersection of food systems and sustainability. She is originally from a small town outside of Des Moines, IA and enjoys writing poetry, spending time with her family, and continuing to build her yoga practice.

COLTON BABLADELIS
(he/him)

Colton Babladelis is a dual MBA/MS candidate at the University of Michigan Erb Institute for Global Sustainable Enterprise, a partnership between the Ross School of Business and the School for Environment and Sustainability (SEAS). He holds B.A.s from the University of Michigan in Environmental Studies, Cultural Anthropology, Spanish Literature, and Modern Greek. Prior to joining the Erb Institute, Colton worked in program management at the Erb Institute, and later in supply chain management and environmental and social governance (ESG) reporting at Domino's Pizza. Colton has a deep interest in food systems, with a background in agricultural science and food system supply chain management. While at Domino's Pizza, he was able to implement material recycling and food waste reduction initiatives for supply chain operations, furthering his interest in large scale food waste solutions.

JANET GENSER
(she/her)

Janet Genser is a dual degree MBA/MS candidate at the University of Michigan Erb Institute for Global Sustainable Enterprise, a partnership between the Ross School of Business and the School for Environment and Sustainability (SEAS). She holds a BA in Comparative Studies in Race and Ethnicity from Stanford University in California. At Michigan, Janet co founded a new student-run climate tech VC fund focused on deep decarbonization in the food & ag, mobility, and circular economy sectors. Prior to Erb, she worked for a social impact-driven nonprofit finance firm where she focused on internal process operations and strategic initiatives. Janet is excited to leverage her skills and experience to accelerate sustainable solutions to the world's food system challenges. In her free time she enjoys anything active, outdoors, and having to do with food.

MARNEY COLEMAN
(she/her)

Marney Coleman is a dual MBA/MS candidate at the University of Michigan Erb Institute for Global Sustainable Enterprise, a partnership (or dual degree program) between the Ross School of Business and School for Environment and Sustainability (SEAS). Marney earned a BS in Environmental Studies and a BS in International Relations from American University in Washington, DC. Prior to joining the Erb Institute, Marney worked in the environmental education field, most recently working as Sustainability Coordinator at a progressive public school in Chicago aligning the school's curriculum, culture, and operations to its mission of sustainability. Within this context she worked on managing the school's food waste program and became passionate about reducing food waste and scalable solutions. She is passionate about developing a sustainable, equitable and more resilient food system and is excited to leverage the power of the private sector to scale sustainable solutions. In her free time she enjoys gardening, cooking, cycling, and yoga.

Image: Dan Gold on Unsplash

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Executive Summary

Food and agricultural wastes and losses have been identified as major contributors to greenhouse gas (GHG) emissions, natural resource consumption, and land use change.[2]

According to the UN Environment Report *Waste Not, Want Not* “food loss refers to food leakages at upstream stages of the food supply chain such as in food production and processing, while food waste refers to discarded food at the downstream stages of the supply chain — in distribution, retail, food service and households.”[3] Global food loss and waste have a carbon footprint of approximately 4.4 gigatons (Gt) of carbon dioxide equivalents (CO_2e) per year, meaning if food waste were a country, it would rank as the third top emitter after the United States and China.[4] While greenhouse gas (GHG) emissions occur across the food supply chain (and vary by commodity), the majority of GHGs are emitted in the production and growing phase.[5] Beyond emissions, the USDA Economic Research Service (USDA ERS) estimates food loss value exceeds $161 billion (2010 USD) annually and consumes over 21% of all freshwater use.[6, 7] The United States Environmental Protection Agency (EPA) estimates landfilled food is the second highest material (behind paper and paperboard) constituting ~22% of discarded municipal solid waste. Notably, landfills have been identified as the third largest source of human-related, potent methane emissions in the US.[8]

Of the 21 food waste reduction strategies (referred to as interventions going forward) analyzed across the back of house (BOH), front of house (FOH), and end of life (EOL) stages, smaller portions yielded the greatest benefit across food waste reduction, economic, and feasibility criteria followed closely by tray removal, smaller plate sizes, and FOH signage.

Food waste and loss occur across the value chain. In the US, the largest amount of food organics enter the waste stream directly from consumer homes (30M tons).[9] Consumer-facing businesses, including university dining foodservice operations,

Image Source: Michigan Dining

generate the second-largest amount of food waste (23M tons). Therefore, this sector has the incredible potential to influence broad, positive impact through systemic changes and application of targeted, strategic interventions.

Of particular note to this report, cross-institutional collaboration such as NACUFS (National Association of College and University Food Services)[10] and reporting frameworks such AASHE STARS (Association for the Advancement of Sustainability in Higher Education)[11] have catalyzed food waste awareness and reduction in the higher education space. Many institutions have already implemented strategies, created policies, and engaged students over the past decade. Knowing university dining programs have a critical role to play in the foodservice ecosystem based on their scale and ability to directly interact and educate their consumers (students), the objective of this report is to build upon existing literature and initiatives to assist institutions as they further refine their approach to implementing food waste reduction solutions.

This report outlines 21 food waste reduction strategies (called interventions in this report), selected from a robust literature review, ReFED Insights Engine, and expert and practitioner interviews. Each intervention was given a score of Favorable, Medium, or Unfavorable across these 7 attributes: economic, labor, political, environmental, food waste reduction, spatial, and time horizon.

Introduction

This project was sponsored by the University of Michigan School for Environment and Sustainability (SEAS) centered around food waste reduction in such dining centers.

The team's objective was to identify and analyze a variety of different food waste interventions and solutions across the value chain within the university context in back of house (BOH), front of house (FOH), and end of life (EOL). The interventions were assessed on 7 attributes with more than 15 supporting sub-attributes.

According to the UN Environment Report *Waste Not, Want Not* "food loss refers to food leakages at upstream stages of the food supply chain such as in food production and processing, while food waste refers to discarded food at the downstream stages of the supply chain — in distribution, retail, food service and households."[12]

Food and agricultural wastes are major contributors to greenhouse gas (GHG) emissions, water consumption and many other environmental and social impacts. Global food loss and waste equate to approximately 4.4 gigatons (Gt) of carbon dioxide equivalents (CO_2e) per year, meaning if food waste were a country, its carbon footprint would rank as the third top emitter after the United States and China.[13] While emissions occur across the food supply chain (and vary by commodity), the majority of greenhouse gases are emitted in the production phase (Figure 2).[14] The US Environmental Protection Agency (EPA) estimates landfilled food is the second highest material (behind paper and paperboard) constituting ~22% of discarded municipal solid waste.[15] Additionally, landfills have been identified as the third largest source of human-related, highly-potent methane emissions in the US.[16] Methane is considered a highly potent GHG due to its Global Warming Potential

THE FOOD RECOVERY HIERARCHY

The Food Recovery Hierarchy shows the preferred ordering of food loss and waste responses.

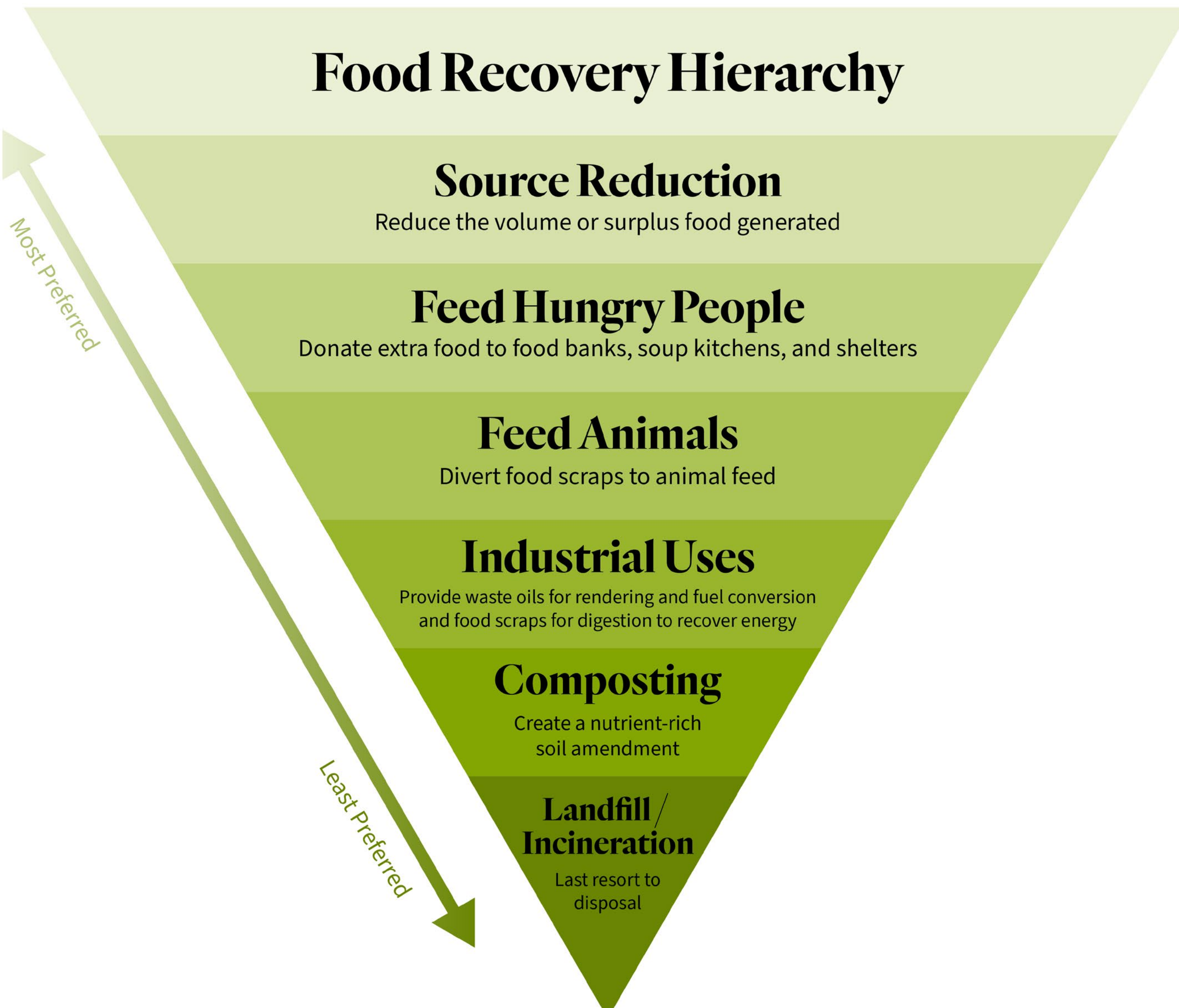
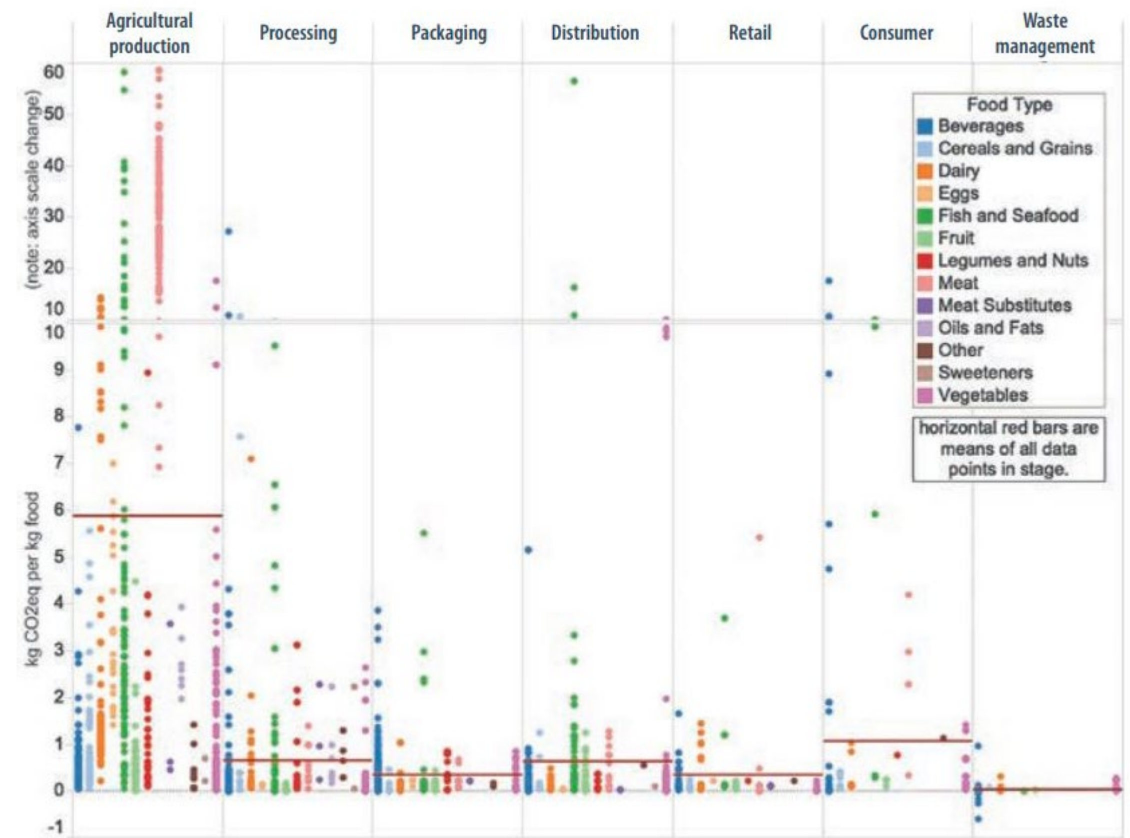


Figure 1: EPA Food Recovery Hierarchy
Source: Adapted from US EPA 2017[29]

Greenhouse gas emissions associated with the life cycle stages of a variety of foods



Note: The figure demonstrates that emissions predominantly occur in upstream (production) stages. Red horizontal lines are the mean value of all data in the life cycle stage. Many of the LCA studies included here do not consider the full cradle-to-grave life cycle; hence, the decreasing number of data points in successive life cycle stages.

Source: LCA literature review described in Heller *et al.* 2018.

Figure 2: Greenhouse gas emissions associated with the life cycle stages of a variety of foods

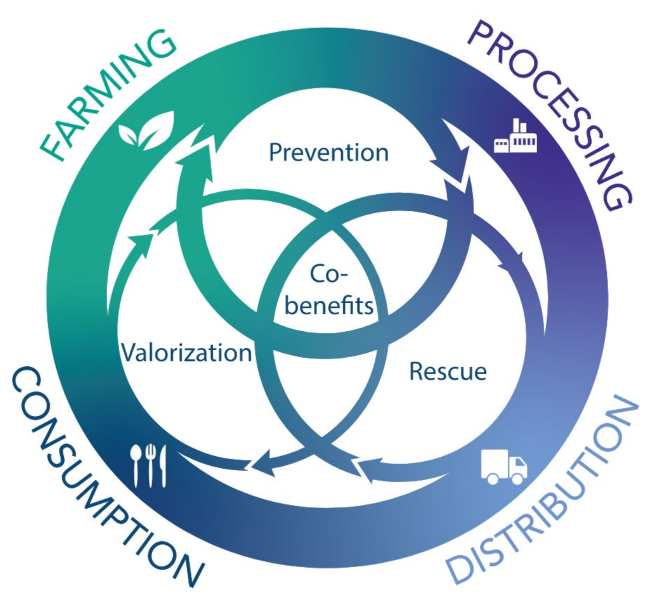
(GWP) of anywhere between 28-36x the potential of CO_2.[17, 18] Additionally, as stated in the 2018 Intergovernmental Panel on Climate Change (IPCC), to stay below the 1.5C threshold, global cumulative carbon must reach net-zero by 2050.[19] Considering the fact that food waste is responsible for ~7% of the total carbon budget, and global agriculture is responsible for ~26% of total GHG emissions,[20] the impetus and urgency for galvanizing transformational solutions in this space are high.

The impact of food loss and waste goes beyond the environment. From an economic perspective, the USDA Economic Research Service (USDA ERS) estimates food loss value exceeds $161 billion (2010 USD) annually.[21,22] According to ReFED — Rethink Food Waste through Economics and Data, the US-based nonprofit and leader whose mission is to 'end food loss and waste across the U.S. food system' — in 2019, the economic value of surplus food was $408 billion USD, with 70% ($285 billion) resulting from food waste.[23] Currently, 35% of the food grown is not sold or eaten, with 54 million tons sent straight to landfill, incinerated, or left in the field.[24] However, land and resources

Spotlight
on American University

In September, American University launched Multiscale RECIPES for Sustainable Food Systems with 14 other institutions and more than 40 researchers encompassing stakeholders across the value chain. This initiative will produce a public database accessible online that will outline gaps in food systems research. The topics will range from the environment, public health, economy, transportation, and others. This multidisciplinary, 5-year project is funded by a $15 million grant from the National Science Foundation.[30]

LEARN MORE!



Circular System: American University's "transformed food system inspired by circular economy solutions, in which materials and value are used, reused, and recovered, and waste is minimized." Source: American University.

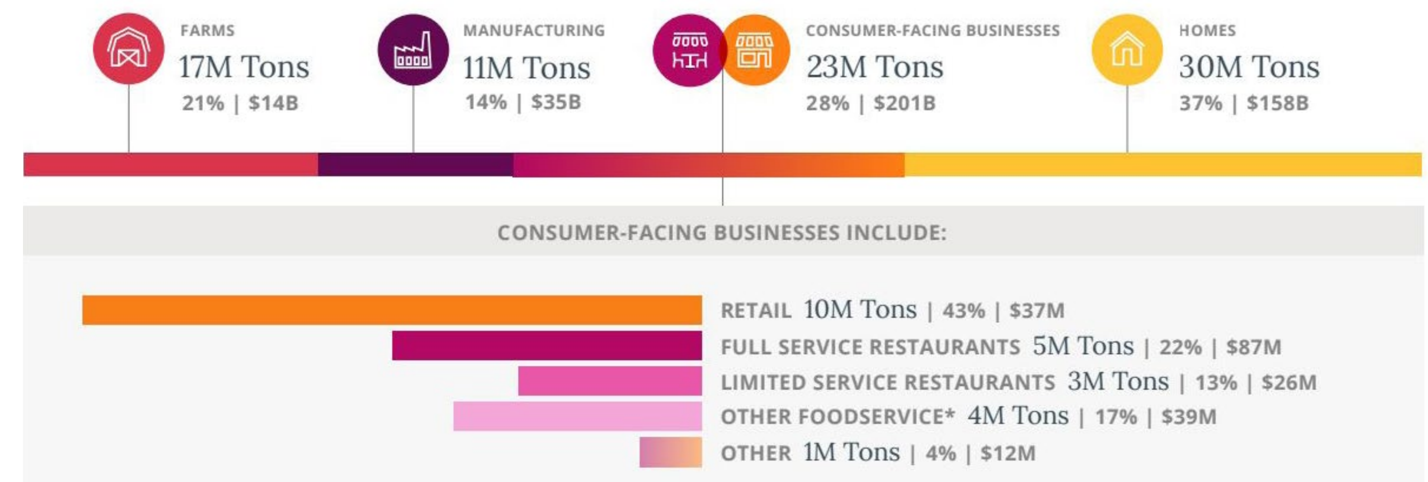
are still required to produce this food even though it does not make it to consumer's tables. The magnitude of food waste and loss is consequential when considering land use change, economic impacts, as well as social and justice implications. Food access, food deserts, food insecurity, and displacement due to agricultural expansion are all very real challenges faced by communities across the country, especially in historically marginalized areas.[25] The pandemic has only exacerbated the inequalities that were present long before March 2020.

ReFED categorizes food waste reduction strategies into three areas: Prevention, Recovery, and Recycling, with estimated economic savings of $64 billion, $9 billion, and $1 billion respectively. Consumer-facing businesses have the potential to reduce losses due to food waste by nearly $200 billion. The financial business case is clear for all stakeholders across the value chain; however, this report focuses on the strategies (referred to as interventions going forward) for foodservice stakeholders, specifically university dining and institutional dining.

Over the past several years, ReFED has compiled information from public and private sources to create the Insights Engine and Solution Database platform. This publicly

Where does food waste occur?

Loss and waste occur at each stage of the supply chain, with the majority happening at consumer-facing businesses and in homes. Food waste is systemic in nature, and what happens at one stage is often influenced by something that happens at another stage, either upstream or downstream. Surplus food breaks out across the supply chain as follows:



** Other foodservice includes healthcare, assisted living, military, and other*

Figure 3: ReFED Where does food waste occur? A visual representation of food waste value chain in US tons[31]

available platform was developed leveraging established frameworks, such as the EPA Food Recovery Hierarchy[26] (Figure 1), as well as innovative systems-level approaches integrating supply chain solutions. The ReFED tools were a foundational aspect to our research into the food waste challenges, key players, and impacts in foodservice.

The *ReFED Roadmap to 2030* highlights where and how food waste occurs the value chain (Figure 3). In the US, the largest amount of food waste enters the waste stream directly from consumer homes (30M tons).[27,28] Consumer-facing businesses, including university dining operations, represent the second-largest source of food waste (23M tons) and have the potential to cultivate broad impact through scale, systemic changes through coalition building, and application of targeted, strategic interventions. A unified approach is more important snow than ever based on the immense disruptions to supply chains, impact on the labor force, and change in college learning modalities due to the COVID-19 pandemic.

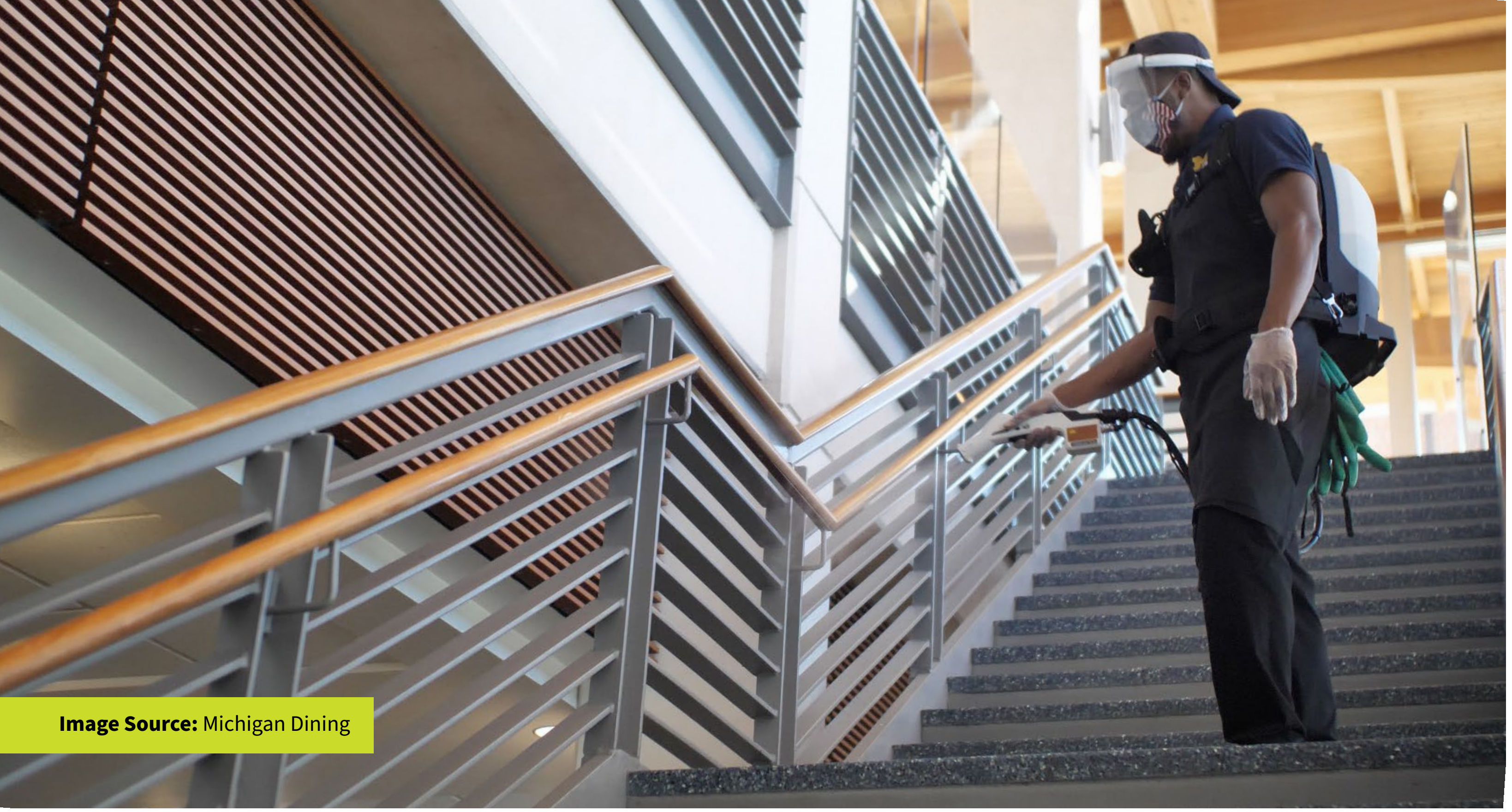
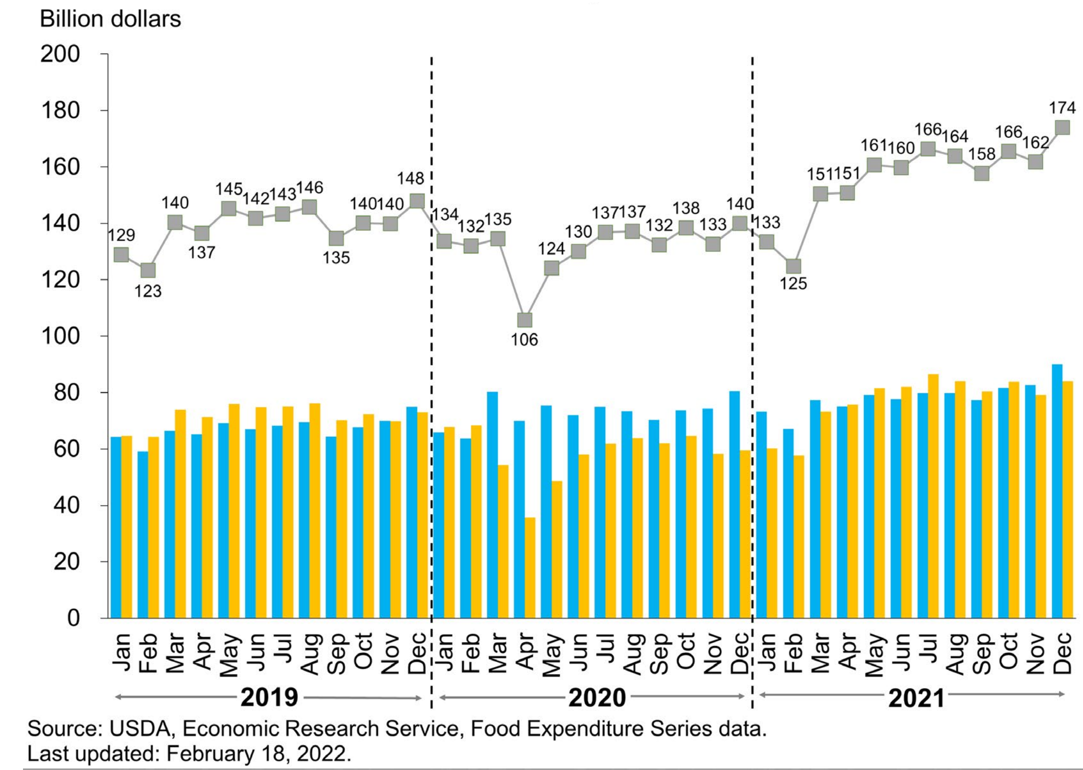


Image Source: Michigan Dining



Total food expenditures continued to rise through December 2021

Legend

- Food at home
- Food away from home
- Total food sales

Figure 4: USDA ERS Total Food Expenditures 2019 - 2021.[36]

COVID-19 Pandemic Impact on Food Waste and Operations

The COVID-19 pandemic impacted the food system in many ways.

Food service operations across the country transformed almost overnight. According to the USDA Economic Research Service (USDA ERS) Food Expenditure Series, the total dollar spent in food service locations (such as restaurants, schools, sports venues, and other food away from home occasions) “fell from $68 billion in February 2020 to $54 billion in March 2020 and $36 billion in April 2020” (Figure 4).[32]

In the university context, the pandemic pushed learning to online environments, and many students chose to return home or be closer to friends and family.[33] Average number of students visiting the dining halls decreased, as did the total number of meals served and total purchased goods. Higher levels of precaution during early stages of COVID-19 resulted in adjustments to dining operations that meant less food was able to be donated. Additionally, several changes in the dining halls were made due in part to labor shortages that resulted in a lack of sufficient workforce. There were not enough employees to conduct normal dish washing operations, and so a large amount of disposable, single-use plates, bowls, cups, and silverware was purchased for daily use. More pre-packaged, chopped produce or proteins were purchased, as there was not enough staff to process fresh items in the back of house. Institutional dining operations across the world had to adapt and offer to-go meals for students, reducing density of students in dining halls and providing access to food service for those that needed to quarantine or isolate.[34]

More broadly, supply chain shocks were felt almost immediately as processors scrambled to convert the foodservice pack size products into retail or consumer-sized products. Headlines in the New York Times read “*Dumped Milk, Smashed Eggs, Plowed Vegetables: Food Waste of the Pandemic: with restaurants, hotels and schools closed, many of the nation’s largest farms are destroying millions of pounds of fresh goods that they can no longer sell.*”[35] These challenges directly impacted dining procurement teams’ ability to obtain the necessary ingredients to continue serving students on campus. As we have seen, the supply chain disruptions seen in 2020 were only the beginning. The past two years have continued to highlight the need for a more agile system to handle food storage, processing, transport, food waste reduction, and management.

While the impact of the pandemic will reverberate for years to come, this moment in time represents an opportunity to reimagine and introduce a multi-criteria framework for how strategic food waste interventions can be deployed across the university dining ecosystem.

Methodology

The following seven attributes were identified as material to reducing food waste and were selected to provide a more holistic lens for evaluation of food waste reduction interventions. The research methods employed were extensive literature reviews, expert and practitioner interviews, publicly available statistics, government databases, and in-person observations of dining hall operations. These attributes, supported by sub-attributes, were the criteria used to evaluate each intervention and yield and overall feasibility matrix. (Figure 4) This matrix can be leveraged by university dining and procurement teams to inform decision making, rank priorities, and align on the best food waste reduction interventions to implement. The feasibility of each intervention should be considered in ranges and should be expected to be unique to each particular operational usage in each facility.

The following pages outline each attribute (with supporting sub-attributes) and are represented in the full matrix on the facing page (Figure 5).

The team would like to thank all involved in supporting this research.

ATTRIBUTE	SUB-ATTRIBUTE
ECONOMIC	ROI
	Cost per ton
	Upfront cost
	Cost savings per ton
	Total Economic
LABOR	Requires extra headcount
	Requires technical training
	Total Labor
POLITICAL	Alignment with management goals
	Change management required
	Multiple departments involved
	Total Political
GHG REDUCTION	GHG savings potential
	Total GHG
FOOD WASTE	Waste reduction potential
	Cleanliness of waste stream
	Total Food Waste
SPATIAL	Available space
	Modifications to building needed
	Total Spatial
TIME HORIZON	Need for immediate solution
	Long term viability
	Total Time Horizon

		IMPACT POTENTIAL						
	Initiative	Economic	Labor	Political	GHG Reduction	Food Waste	Spatial	Time Horizon
BACK OF HOUSE	Compost Bins in Prep Areas	Favorable	Favorable	Medium	Not applicable	Unfavorable	Favorable	Favorable
	Staff Training	Favorable	Medium	Favorable	Not applicable	Unfavorable	Favorable	Favorable
	Signage	Favorable	Favorable	Favorable	Not applicable	Unfavorable	Favorable	Favorable
	Internal Upcycling	Favorable	Unfavorable	Medium	Not applicable	Medium	Favorable	Medium
	Waste Tracking	Favorable	Unfavorable	Medium	Not applicable	Favorable	Medium	Favorable
FRONT OF HOUSE BEHAVIOR	Tray Removal	Medium	Favorable	Favorable	Not applicable	Medium	Favorable	Favorable
	Smaller Plates	Medium	Favorable	Favorable	Not applicable	Medium	Favorable	Favorable
	Unlimited Food Plan	Favorable	Favorable	Medium	Not applicable	Unfavorable	Favorable	Favorable
	To-Go Meals	Favorable	Favorable	Favorable	Not applicable	Unfavorable	Favorable	Favorable
	Customized Portions	Favorable	Medium	Favorable	Not applicable	Unfavorable	Favorable	Favorable
	Smaller Portions	Favorable	Favorable	Favorable	Not applicable	Favorable	Favorable	Favorable
	Taste and Try Stations	Favorable	Medium	Medium	Not applicable	Medium	Medium	Favorable
	Signage	Favorable	Favorable	Favorable	Not applicable	Medium	Favorable	Favorable
	Education Campaigns	Favorable	Medium	Medium	Not applicable	Unfavorable	Favorable	Favorable
	Reusable Plateware	Medium	Favorable	Favorable	Not applicable	Favorable	Favorable	Medium
END OF LIFE	Landfill	Medium	Favorable	Medium	Unfavorable	Unfavorable	Favorable	Medium
	Composting	Medium	Medium	Favorable	Favorable	Unfavorable	Favorable	Favorable
	Anaerobic Digestion	Medium	Unfavorable	Unfavorable	Favorable	Favorable	Unfavorable	Medium
	Upcycling	Unfavorable	Medium	Medium	Favorable	Favorable	Favorable	Medium
	Animal Feed	Favorable	Medium	Medium	Favorable	Favorable	Favorable	Medium
	Food Rescue (donations)	Favorable	Medium	Medium	Favorable	Favorable	Favorable	Favorable

Figure 5: Impact Potential Across Food Waste Interventions

LEGEND

Favorable Medium Unfavorable

This sub-attribute is not applicable to the intervention

ECONOMIC

The economic implications of different food waste reduction interventions were determined from literature, primarily ReFED's Insights Engine Solutions Database 2020 Methodology.[37] In some cases, amounts were calculated based on known average labor cost and estimated time spent performing the intervention, as in the case of Taste & Try Stations. Data were compiled from available literature for initial investment (upfront fixed costs), variable costs paid annually, and gross benefit (cost savings) per ton of food wasted. The financial benefit listed in the ReFED methodology for each intervention was assumed to be gross benefit, and as such, net benefit was calculated based on subtracting variable costs from gross benefit (each on a per ton basis). Payback period was the exclusive criteria of the ROI calculation, which divided upfront cost by net benefit. Despite best efforts, there were some interventions where no relevant literature was found and thus a "no data" value was assigned. As there are still financial implications for these interventions, estimates were made to assign ranges to upfront costs, variables costs, and benefits.

Gross benefit will vary for a particular institution and may be higher or lower than the national average based on state and local rates and policies. For example, tipping fees vary widely by state, ranging from $0.55/ton in Michigan to $122.63/ton in Massachusetts. Additionally, wholesale food prices vary dramatically depending on institution-specific contracts with vendors. Data quality for economic impact is generally low due to variability, so numbers were given on a per ton basis whenever possible to be more adaptable to each institution's situation. Institutions would need to multiply these numbers based on the estimated tonnage diverted for their facilities.

LABOR

The labor impacts on food waste reduction interventions were determined primarily through expert and practitioner interviews, publicly available labor statistics, observations of dining hall operations, and analysis of interventions as described in the literature review. Labor is especially important in the current market, as there is a widespread labor shortage driven by complex dynamics in the economy and supply chain due to the pandemic.[38, 39] Therefore, interventions that required either additional headcount to be added to staff in either permanent or student-temporary positions should be evaluated on the amount of additional headcount needed and the feasibility of being able to hire for those new positions. It was determined that interventions requiring advanced technical training must be considered, as this could require either additional technical specialists to be hired while taking available labor time from existing staff for training.

		ECONOMIC					LABOR		
	Intervention	ROI[1]	Cost per ton	Upfront cost	Cost Savings per ton	Total Economic	Requires Extra Headcount	Requires Technical Training	Total Labor
BACK OF HOUSE	BOH - Compost bins in prep areas**	✓	✓	✓	✓	✓	✓	✓	✓
	BOH - Staff training**	✓	O	✓	✓	✓	✓	✗	O
	BOH - Signage**	✓	O	✓	✓	✓	✓	✓	✓
	BOH - Internal upcycling**	✓	✓	✓	✓	✓	✗	✗	✗
	BOH - Waste tacking	✓	✗	✓	✓	✓	✗	✗	✗
FRONT OF HOUSE	FOH - Tray removal	O	✓	✓	✓	O	✓	✓	✓
	FOH - Smaller plates	O	✓	✓	✓	O	✓	✓	✓
	FOH - Unlimited food plan**	✓	✓	✓	✓	✓	O	✓	✓
	FOH - To go meals**	✓	O	O	✓	✓	O	✓	✓
	FOH - Customized portions**	✓	✓	✓	✓	✓	✗	O	O
	FOH - Smaller portions	O	✓	✓	✓	✓	✓	O	✓
	FOH - Taste and try stations	✓	O	✓	✓	✓	✗	O	O
	FOH - Signage	✓	O	✓	✓	✓	✓	✓	✓
	FOH - Education campaigns**	✓	✓	O	✓	✓	✗	✓	O
	FOH -Reusable plateware**	O	O	O	O	O	✓	O	✓
END OF LIFE	EOL - Landfill	✓	O	✓	✗	O	✓	✓	✓
	EOL - Composting	✗	O	✓	✓	O	O	O	O
	EOL - Anaerobic Digestion	✗	O	✓	✓	O	✗	✗	✗
	EOL - Upcycling**	✗	✗	✗	✗	✗	O	✗	O
	EOL - Animal Feed	✓	✓	✓	✗	✓	O	O	O
	EOL - Food Rescue *(donations)*	✓	✓	✓	✓	✓	✗	O	O

LEGEND

✓ Favorable O Medium ✗ Unfavorable

** These interventions used economic estimates based on expert and practitioner interviews and secondary research.

1 ROI: (payback period for fixed upfront costs); Cost per ton (variable); Upfront cost (fixed); Cost Savings per ton (net benefit)

POLITICAL

Universities are multi-layered and often siloed systems that require cross-departmental collaboration for many projects. Through expert and practitioner interviews, it was determined that intervention alignment with management goals of the impacted unit is a critical aspect. Further consideration should be given to the degree of cultural change needed and must be planned and enacted in the implementation of food waste reduction interventions. As many universities operate on decentralized systems, multi-unit buy-in is an important factor as well. While collaboration generally is encouraged, the more units that are involved in the intervention, the more buy-in that is needed to align goals and time that is needed to roll out the intervention.

ENVIRONMENTAL GREENHOUSE GAS (GHG) EMISSIONS

The food and agriculture space requires many resource-intensive inputs and results in a multitude of environmental impacts (water use, human health, primary energy consumption, greenhouse gas emissions, biodiversity loss, deforestation, etc). This section will focus on greenhouse gas (GHG) emissions since the impact of the food system on climate change is substantial and the timeline for decarbonization is narrowing.

For many foods, the majority of GHG emissions result from the growing, harvesting and production processes with variation between commodities and on-farm practices. End of life (EOL) emissions vary based on what solution is chosen (see end of life section for more details).[40] Some emit greenhouse gases while other disposal methods result in net negative emissions.[41]

Any meaningful reduction in GHG emissions from food waste reduction efforts in a university dining context would primarily be from the following:

1. **Diverting food waste from landfill disposal.** This can be done by converting the emissions-intensive waste strategy (landfill) to a less emissions-intensive strategy (e.g. composting, anaerobic digestion, etc.). See end of life section for additional detail.[42]

2. **Reducing the quantity of food purchased by procurement teams.** This volume reduction is based on the success of the food waste prevention and reduction interventions taken in back of house and front of house. Because the majority of emissions occur in the growing and harvesting phase, the feedback mechanism driven by decreased demand (at a large enough scale) would trigger the reduction in acres planted. This decrease in purchased volume would directly flow into a university's Scope 3 emissions calculation, resulting in a reduction of Scope 3 emissions. These assumptions are based on the purchased good Scope 3 category and upstream growing emissions reduction; however, it does not go as far as to calculate consequential life cycle assessment impacts (CLCA).

		POLITICAL				GHG EMISSIONS	
	Intervention	Alignment with Mgmt. Goals	Change Mgmt. Required	Multiple Depts. Involved	Total Political	GHG Savings Potential	Total GHG
BACK OF HOUSE	BOH - Compost Bins in Prep Areas	Medium	Favorable	Medium	Medium		
	BOH - Staff (chef & student) Training	Favorable	Medium	Favorable	Favorable		
	BOH - Signage	Medium	Favorable	Favorable	Favorable		
	BOH - Internal Upcycling	Medium	Unfavorable	Favorable	Medium		
	BOH - Waste Tracking	Medium	Unfavorable	Favorable	Medium		
FRONT OF HOUSE	FOH - Tray Removal	Favorable	Favorable	Favorable	Favorable		
	FOH - Smaller Plates	Favorable	Favorable	Favorable	Favorable		
	FOH - Unlimited Food Plan	Favorable	Medium	Medium	Medium		
	FOH - To Go Meals	Medium	Favorable	Favorable	Favorable		
	FOH - Customized Portions	Medium	Favorable	Favorable	Favorable		
	FOH - Smaller Portions	Medium	Favorable	Favorable	Favorable		
	FOH - Taste and Try Stations	Medium	Medium	Favorable	Medium		
	FOH - Signage	Medium	Favorable	Favorable	Favorable		
	FOH - Education Campaigns	Favorable	Medium	Medium	Medium		
	FOH -Reusable Plateware	Medium	Favorable	Favorable	Favorable		
END OF LIFE	EOL - Landfill	Medium	Favorable	Medium	Medium	Unfavorable	Unfavorable
	EOL - Composting	Favorable	Favorable	Medium	Favorable	Favorable	Favorable
	EOL - Anaerobic Digestion	Medium	Unfavorable	Unfavorable	Unfavorable	Medium	Favorable
	EOL - Upcycling	Medium	Unfavorable	Medium	Medium	Medium	Favorable
	EOL - Animal Feed	Medium	Medium	Unfavorable	Medium	Medium	Favorable
	EOL - Food Rescue *(donations)*	Medium	Medium	Medium	Medium	Medium	Favorable

LEGEND

✓ Favorable ○ Medium ✗ Unfavorable ▭ This sub-attribute is not applicable to the intervention

FOOD WASTE REDUCTION

An extensive literature review was conducted to determine average values of food waste reduction for each intervention (presented in percentages of possible food waste reduction). Literature was vetted for relevance, veracity, and when possible multiple sources were utilized to align upon a reduction metric. Despite best efforts, there were some reduction interventions where no relevant literature was found and thus a "no data" value was assigned in the criteria table (see Description of Criteria and Ranges Table on pages 27-29). Additionally, upon review of literature surrounding nudging implementation and choice architecture in food waste, many types of nudges were grouped into study design, for example signage, smaller plates, portion size, etc. Therefore, the "nudging" intervention has been broken out into specific interventions in our summary table.

SPATIAL

As noted during both expert and practitioner interviews and operational observations, space constraints can present a severe limitation to any changes needed for food waste reduction interventions in both back of house (BOH) and front of house (FOH) of university dining halls. Many BOH areas of dining halls are operating at nearly full capacity at all times, from meal preparation to full service. The amount of space required for the intervention, as related to the amount of space available, must be considered when evaluating interventions to select for implementation. In addition to space availability, the need for modifications to the existing building must be considered, as significant renovations that require construction would be disruptive to operations and ultimately difficult to implement while dining halls are in use during the academic year.

		FOOD WASTE			SPATIAL		
	Intervention	Waste Reduction Potential[1]	Cleanliness of Waste Stream	Total Food Waste	Available Space	Modifications to Building Needed	Total Spatial
BACK OF HOUSE	BOH - Compost Bins in Prep Areas	—	—	✗	✓	✓	✓
BACK OF HOUSE	BOH - Staff Training	✗	—	✗	✓	✓	✓
BACK OF HOUSE	BOH - Signage	—	—	✗	✓	○	✓
BACK OF HOUSE	BOH - Internal Upcycling	○	—	○	○	✓	✓
BACK OF HOUSE	BOH - Waste Tracking	✓	—	✓	○	○	○
FRONT OF HOUSE	FOH - Tray Removal	○	—	○	✓	✓	✓
FRONT OF HOUSE	FOH - Smaller Plates	○	—	○	✓	✓	✓
FRONT OF HOUSE	FOH - Unlimited Food Plan	—	—	✗	✓	✓	✓
FRONT OF HOUSE	FOH - To Go Meals	—	—	✗	○	✓	✓
FRONT OF HOUSE	FOH - Customized Portions	—	—	✗	✓	✓	✓
FRONT OF HOUSE	FOH - Smaller Portions	✓	—	✓	✓	✓	✓
FRONT OF HOUSE	FOH - Taste and Try Stations	○	—	○	○	○	○
FRONT OF HOUSE	FOH - Signage	○	—	○	✓	○	✓
FRONT OF HOUSE	FOH - Education Campaigns	✗	—	✗	✓	✓	✓
FRONT OF HOUSE	FOH -Reusable Plateware	✓	—	✓	✓	✓	✓
END OF LIFE	EOL - Landfill	—	✗	✗	✓	✓	✓
END OF LIFE	EOL - Composting	—	✗	✗	✓	✓	✓
END OF LIFE	EOL - Anaerobic Digestion	—	✓	✓	✗	✗	✗
END OF LIFE	EOL - Upcycling	—	✓	✓	○	✓	✓
END OF LIFE	EOL - Animal Feed	—	✓	✓	✓	✓	✓
END OF LIFE	EOL - Food Rescue *(donations)*	—	✓	✓	○	✓	✓

LEGEND

- ✓ Favorable
- ○ Medium
- ✗ Unfavorable
- — This sub-attribute is not applicable to the intervention

1 Waste Reduction Potential is represented as percent of purchase volume.

	Intervention	TIME HORIZON: Need for Immediate Solution	TIME HORIZON: Long-term Viability	TIME HORIZON: Total Time Horizon
BACK OF HOUSE	BOH - Compost Bins in Prep Areas	✓	✓	✓
	BOH - Staff Training	○	✓	✓
	BOH - Signage	✓	○	✓
	BOH - Internal Upcycling	○	○	○
	BOH - Waste Tracking	○	✓	✓
FRONT OF HOUSE	FOH - Tray Removal	✓	✓	✓
	FOH - Smaller Plates	✓	✓	✓
	FOH - Unlimited Food Plan	✓	✓	✓
	FOH - To Go Meals	✓	✓	✓
	FOH - Customized Portions	✓	✓	✓
	FOH - Smaller Portions	✓	✓	✓
	FOH - Taste and Try Stations	✓	✓	✓
	FOH - Signage	✓	○	✓
	FOH - Education Campaigns	○	✓	✓
	FOH -Reusable Plateware	✓	✗	○
END OF LIFE	EOL - Landfill	✓	✗	○
	EOL - Composting	✓	✓	✓
	EOL - Anaerobic Digestion	✗	○	○
	EOL - Upcycling	○	○	○
	EOL - Animal Feed	○	○	○
	EOL - Food Rescue *(donations)*	✓	○	○

LEGEND

✓ Favorable ○ Medium ✗ Unfavorable

This sub-attribute is not applicable to the intervention

TIME HORIZON

Successful food waste reduction interventions must be measurable and time bound. The ability of the intervention to provide a solution to an immediate problem should be considered, as well as the long-term viability and sustainability (continuation) of the intervention. Based on climate science, the effects of climate change will be increasingly felt in the coming years, and there is a strong need for implementation of interventions that can be put in place in a relatively short time frame, while also maintaining a high degree of long term viability and continuity. Any university goals (such as Net Zero,[43] waste reduction, or other sustainability metrics)[44, 45] as well as future renovation or infrastructure construction plans should be integrated in the decision process when prioritizing intervention implementation speed.

Image Source: Michigan Dining

Description of Analysis Criteria

The previously described attributes and supporting sub-attributes of the feasibility matrix were selected based on expert and practitioner interviews, operational observations, and meta-analyses of available data from the literature review. The team then established ranges to classify “Unfavorable,” “Medium,” and “Favorable” for each of the sub-attributes. The sub-attribute ranges were then used to rank interventions in Back of House, Front of House, and End of Life. This matrix is designed to be an informative snapshot of the relative ranking of interventions as defined by this analysis. Users may need to adjust ranges for their particular context as needed.

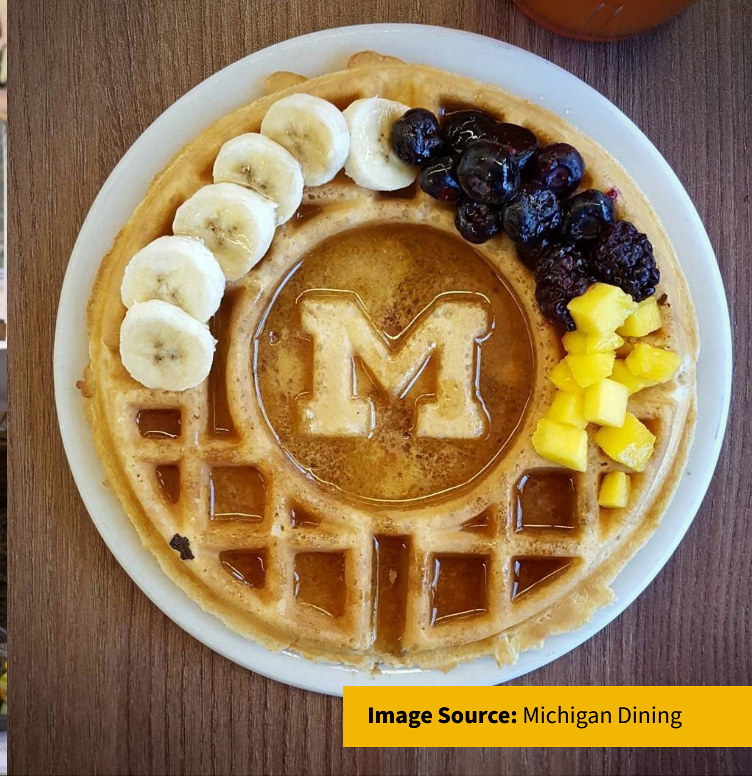


Image Source: Michigan Dining

DESCRIPTION OF CRITERIA AND RANGES

ECONOMIC - FINANCIAL		
SUB-ATTRIBUTE	**DESCRIPTION**	**RANGE**
ROI (payback period for fixed upfront costs)	Consideration and estimation of recouping the intervention’s cost of implementation and on what time scale it will pay for itself.	Based on literature review and data from ReFED Insight Engine and Methodology. **UNFAVORABLE** = 5+ years **MEDIUM** = 1 - 4 years **FAVORABLE** = < 1 year
Cost per ton (variable)	These are the variable costs associated with the interventions. The core question is: does the cost of the intervention have per ton operating costs to consider, and if so, do those fit into budgetary constraints?	Based on literature review and data from ReFED Insight Engine and Methodology. **UNFAVORABLE** = > $500 per ton **MEDIUM** = $1 - $500 per ton **FAVORABLE** = No annual cost
Upfront cost (fixed)	This is a one time investment (CAPEX) and is highly dependent upon the availability of budgetary discretion at the time of intervention implementation.	Based on literature review and data from ReFED Insight Engine and Methodology. **UNFAVORABLE** = > $10,000 **MEDIUM** = $5,001 - $10,000 **FAVORABLE** = $0 - $5,000
Cost savings per ton (net benefit)	The cost savings (net benefit) is calculated by subtracting variable costs from gross benefit per ton. The core question answered is: to what degree (if any) will the intervention provide cost savings?	Based on literature review and data from ReFED Insight Engine and Methodology. **UNFAVORABLE** = No cost savings **FAVORABLE** = Positive cost savings

DESCRIPTION OF CRITERIA AND RANGES

LABOR

SUB-ATTRIBUTE	DESCRIPTION	RANGE
Requires Extra Headcount	Staffing and labor shortages are a major consideration for operations. Does the intervention require hiring extra headcount?	Based on expert and practitioner interviews of the biggest challenges facing universities post-pandemic, labor is at the top. **UNFAVORABLE** = Requires 2 additional full time employees AND 5-15 more student employees **MEDIUM** = Requires only 1-10 additional student employees **FAVORABLE** = No additional labor needed
Requires Technical Training	Will the intervention require specialized, technical training, and if so does this training need to be regularly conducted for new team members?	Based on expert and practitioner interviews twice per year is standard (once per semester) **UNFAVORABLE** = Requires training at least four times per year **MEDIUM** = Requires training 2x per year (per semester) **FAVORABLE** = Requires annual training

POLITICAL

SUB-ATTRIBUTE	DESCRIPTION	RANGE
Alignment with Management Goals	Does the implementation of the intervention align with upper management goals for food waste reduction and dining hall operations? Or broader campus goals for waste, greenhouse gas, water, etc.?	Based on management performance goals, both short term and long term. **UNFAVORABLE** = 0 Goals in Alignment **MEDIUM** = 1 - 3 Goals in Alignment **FAVORABLE** = > 3 Goals in Alignment
Change Management Required	Does the intervention require cultural or operational changes in the system that would require change management plans?	Based on expert and practitioner interviews of the biggest challenges facing universities post-pandemic. **UNFAVORABLE** = High degree of project and change management needed **MEDIUM** = Some degree of project and change management needed **FAVORABLE** = No change management needed (passive implementation)
Multiple Departments/ Unit Involved	University functions are often highly decentralized. Does the intervention require cross-unit collaboration and buy in to implement?	Based on expert and practitioner interviews of the biggest challenges facing universities post-pandemic. **UNFAVORABLE** = High degree of multi-department buy-in required **MEDIUM** = Minimal degree of multi-department buy-in required **FAVORABLE** = No degree of multi-department buy-in required

GREENHOUSE GAS EMISSIONS

SUB-ATTRIBUTE	DESCRIPTION	RANGE
CO_2e impact	Greenhouse gas (GHG) emissions are expressed in carbon dioxide equivalents (CO_2e) and are calculated following accepted GHG accounting principles.	Values from ReFED Insight Engine Methodology were leveraged to indicate net benefit or emissions released for each of the technologies. [46] **UNFAVORABLE** = Intervention generates and results in release of emissions **MEDIUM** = Net benefit of emissions with a mean of less than 0.2 metric tons CO_2e per ton of food waste and/or large standard deviation. **FAVORABLE** = Net benefit of emissions with a mean of 0.2 metric tons CO_2e per ton of food waste and low standard deviation.

DESCRIPTION OF CRITERIA AND RANGES

FOOD WASTE

SUB-ATTRIBUTE	DESCRIPTION	RANGE
Waste Reduction Potential	Consider the volume of waste (poundage or tonnage) that can be reduced from each of the interventions.	Based on robust literature review and expert and practitioner interviews, ranges for food waste % reduction are below. **UNFAVORABLE** = < 16% **MEDIUM** = 17-30% **FAVORABLE** = > 30%
Cleanliness of Waste Stream	Consider the composition of the waste stream and the ability to separate materials and divert the waste from the landfill.	Based on technology constraints and basic waste management principles, the cleaner the waste stream the higher the value. **UNFAVORABLE**= Highly mixed (not separated) food waste **MEDIUM** = Somewhat mixed, but able to be easily separated **FAVORABLE** = "Pure," single stream

SPATIAL

SUB-ATTRIBUTE	DESCRIPTION	RANGE
Available Space	Many solutions require physical changes or installations of new technology or machinery. Space constraints can be an immediate limiting factor to installation of interventions (for example: on-site anaerobic digestion or adding compost bins to prep areas).	Based on expert and practitioner interviews of the biggest challenges facing universities post-pandemic. **UNFAVORABLE** = Requires a large amount of space (250+ sq. ft.) **MEDIUM** = Requires some space (50 - 250 sq. ft.) **FAVORABLE** = Little to no space requirement (0 - 49 sq. ft.)
Modifications to Building Needed	Interventions requiring renovations due to new machinery being installed or physical layout changes to promote behavioral changes should be considered (for example: gray water recirculation or compost pulper).	Based on expert and practitioner interviews of the biggest challenges facing universities post-pandemic. **UNFAVORABLE** = Significant building renovations and/or modifications needed. **MEDIUM** = Minor modifications needed (e.g. shelving installation). **FAVORABLE** = No modifications needed.

TIME HORIZON

SUB-ATTRIBUTE	DESCRIPTION	RANGE
Need for Immediate Solution	Consider the intervention's relevance to treat an acute and immediate problem vs. a longer term or undefined problem.	Based on climate science, in the next 8 years, significant reductions are necessary to avoid the most damaging outcomes. **UNFAVORABLE** = > 5 years for implementation **MEDIUM** = 1 - 5 years for implementation **FAVORABLE** = < 1 year for implementation
Long Term Viability	The ability to keep the intervention in place for an extended period without increasing work; does the intervention continue to improve food waste or does the effect plateau?	Based on climate science, in the next 8 years, significant reductions are necessary to avoid the most damaging outcomes. **UNFAVORABLE** = Solution only viable for a brief period (band-aid) **MEDIUM** = Solution is better than current state; however, it is not optimal as a long-term approach. **FAVORABLE** = Long term viable change for operations (systems change).

Image Source: Michigan Dining

Interventions

This section explores the 21 interventions across the locations within the scope of this project. Back of House (BOH), Front of House (FOH) and End of Life (EOL) were chosen because these are the stages in which institutional dining teams have the most direct influence on food flows and disposal methods.

Many solutions are available in the food waste space; therefore, a variety of criteria were used to refine and identify the most relevant and impactful interventions to include in the analysis. Robust review of current literature and recommended interventions from ReFED's Insights Engine guided many of the interventions listed in the following sections. Other interventions were aligned upon after expert and practitioner interviews at the University of Michigan and other institutions. All interventions directly interact with BOH, FOH, or EOL activities and are relevant to the university dining stakeholders.

In each section, the chosen interventions were analyzed based on their economic, labor, environmental, political, environmental, food waste reduction, spatial, and implementation time horizon impacts. In the following pages, the interventions are defined and summarized, along with supporting data. Some interventions were favorable across many impact attributes and some were a mix of all three rankings (Favorable, Medium, and Unfavorable). While universities vary in their priorities, the resulting matrix of these attributes and interventions will allow leadership teams additional flexibility to customize their action plan to effectively meet the current and future needs of their students, staff, and university communities (see Figure 5: Feasibility Matrix on page 17).

The term 'intervention' was chosen intentionally by our team. It symbolizes action toward solutions and offers a tangible next step. Some of the interventions aim to preempt food waste from occurring; whereas other interventions alter the disposition of the food waste (edible or inedible).

Back of House

The team defined back of house (BOH) as the stages of the process before food reaches the patron (student). This encompasses the point in which the dining staff receives food into their storage areas, all related storage, preparation, cooking, and any pre-portioning and/or packaging that occurs prior to being served. This includes:

Compost Bins in Prep Areas - Availability of compost bins for disposal of food waste from meal preparation areas.

Staff Training - Specific training sessions for both permanent and temporary employees on methods to reduce food waste.

Signage - Use of visual signs placed strategically near all points in which food waste can be generated. Signs should be updated at regular intervals.

Internal Upcycling - Ability to use food ingredients to make other meals or additional ingredients for consumption rather than disposal. Chefs are able to leverage their creativity to upcycle these ingredients. For example: using vegetable scraps to make a stock for soup.

Waste Tracking - Use of weighing and/or advanced scanning technology solutions to monitor type and quantity of organic waste being produced.

BACK OF HOUSE INTERVENTIONS

INTERVENTION	% FOOD WASTE REDUCTION	FINANCIAL CONSIDERATIONS	OTHER CONSIDERATIONS
Compost Bins in Prep Areas	*No data*	**Costs:** Purchasing bins and training or retraining staff to change kitchen flow **Benefits:** Tipping fee and wholesale food cost savings	Education for BOH staff is critical for success. Additionally, if the institution has multiple waste haulers, communication and labeling of waste toters is important.
Staff Training	✗ 7%[47]	**Costs:** Extra labor hours may be needed for training and supervision of new protocols	Costs for this intervention can vary widely depending on staff turnover, onboarding processes, and employee information retention.
Signage	*No data*	**Costs:** Sign design and printing **Benefits:** Tipping fee and wholesale food cost savings	Efficacy will likely be higher when paired with staff training. Consider adding to onboarding processes for new hires. Language considerations can also be important for success.
Internal Upcycling	○ 21.5%[48]	**Costs:** Staff retraining **Benefits:** Tipping fee and wholesale food cost savings	Some level of chef/dining unit autonomy is required for this intervention to be successful.
Waste Tracking	✓ 35.6%[49]	**Costs:** Hardware and software rental/license fees and coaching and reporting fees **Benefits:** Tip fee and wholesale food cost savings	Ensuring that waste tracking results are utilized in menu planning and procurement decisions is key to waste reduction.

LEGEND ✓ Favorable ○ Medium ✗ Unfavorable

INTERVENTION SPOTLIGHT

Internal Upcycling at Drexel University

Drexel University is leading the way incorporating upcycling into culinary education. Jonathan Deutsch is the founder and director of the Food Lab, which is housed within the College of Nursing and Health Professions. The goal of this Lab is to promote "sustainability, health and food access through the design of new food products and innovative culinary methods." He goes on to say, "the No. 1 way to reduce food waste is source reduction and full product utilization..." and that "upcycling can lead to culinary heights, he argues, by opening the door to unusual flavor combinations and experimentation. Watermelon toast, anyone?"[50]

LEARN MORE!

Photo: Jeff Fusco via Drexel University.

Image Source: Michigan Dining

Front of House

The team defined front of house (FOH) as the stage in which food is served to the patron (student). Front of house operations and staff interface with the consumer directly and typically encompass the area in which the consumer receives and eats the food as well as the disposal of waste and return of plates and utensils.

The most popular and effective intervention in FOH is going trayless. In 2013, more than 75% of universities (in the Sustainable Endowments Institute tracking program) were trayless, up from only 42% in 2009.[51] This trend toward trayless is widely implemented and is one of the best ways to reduce food waste (and save costs) in the university dining context. Since the 2008 study was published by Aramark, the provider implements trayless along with other food waste initiatives at most of their university client sites.[52]

Tray Removal - Removing trays from cafeteria or buffet style dining services to limit the number of plates a patron can carry during one pass through the unit.

Small Plates - Serving food on physically smaller plates, nudging patrons to self-serve smaller portion sizes.

Unlimited Food Plan - In a university setting, moving from meal plans that provide a finite number of meals to a plan that provides students with an unlimited number of meals over the same time frame.

To-Go Meals - Meals that are pre-portioned and pre-packaged for patrons to pick up and eat in a location outside of the dining unit.

Customized Portions - Patrons can request customized amounts of specific food items.

Taste and Try Stations - Specified stations in the dining unit where patrons can try a small portion of a food before taking a full serving.

Signage - Verbal and visual signs around the dining unit informing patrons of the impacts of food waste, and directives on how to dispose of food waste.

Education Campaigns - Interactive engagements with dining patrons to further understand the impacts of food waste. This could include waste audits, waste tracking, and other campaigns.

Reusable Plateware - Providing reusable plateware for mealtimes across units, which reduces food waste in lieu of single use plateware.

Smaller portions - This will vary based on institution but entails an intervention in which portion sizes are reduced. For some institutions this will occur in Back of House where staff pre-portion food items into smaller sized portions for patrons to take on the line. In other institutions, this will occur in Front of House by adjusting scoop size.

INTERVENTION SPOTLIGHT

Customized Portions

at Stanford

Stanford is leading the way on customized portions, just-in-time preparation, and allowing students to taste and try before they commit. They are testing the hypothesis that "waste is caused by uncertainty" with the Tasting Table. Students are able to try a sample of the new food item in this format. Check out their "Food Waste Prevention Playbook" for more!

LEARN MORE!

Photo: Stanford University

FRONT OF HOUSE INTERVENTIONS

INTERVENTION	% FOOD WASTE REDUCTION POTENTIAL (RANGE)	FINANCIAL CONSIDERATIONS	OTHER CONSIDERATIONS
Tray Removal	○ **18.6% - 27.5%[53,54]**	**Costs:** Retrofitting tray return systems, if applicable **Benefits:** Tip fee and wholesale food cost savings	Some student education may be required to inform behavioral changes associated with trayless dining.
Small Plates	○ **4% - 30%[55,56,57]**	**Costs:** Replacement of plateware **Benefits:** Tip fee and wholesale food cost savings	New platewares may be different from what staff and employees are used to. It is critical to confirm the dishwashing equipment can handle the new plate size and employees can appropriately work with any changes to plates.
Unlimited Food Plan	*No data*	**Costs:** Unknown **Benefits:** Reduced labor hours; students overeat less at mealtimes, reducing waste and resulting in tip fee and wholesale food cost savings	Depending on the institution, larger conversations around student fees for Room & Board will likely factor into whether this is a feasible intervention.
To-Go Meals	*No data*	**Costs:** Purchase of to go containers, either disposable or reusable; if reusable, need for collection system and washing **Benefits:** Students may take food to go at mealtimes without need to hoard food at previous mealtimes; tip fee and wholesale food cost savings	Adding or bolstering to-go meals may be a large operational change for staff, and can be a cultural shift for students to eat outside of the dining hall. Consider broader cultural and behavioral changes this could incur.
Customized Portions	*No data*	**Costs:** Labor hours for manning food stations **Benefits:** Tip fee and wholesale food cost savings	At peak hours in a dining unit, this intervention has the potential to result in long queues.
Taste and Try Stations	○ **20%[58,59]**	**Costs:** Labor hours for set up, replenishment, and clean up of stations **Benefits:** Tip fee and wholesale food cost savings	This intervention requires additional staff and a dedicated space to run the station; diner flow could be interrupted if long queues form.
Signage	○ **3.9% - 20.5%[60,61,62]**	**Costs:** Sign design and printing **Benefits:** Tip fee and wholesale food cost savings	Some institutions' dining units may have limited wall or buffet space for signage. Additionally, dining units may experience 'information overload' with signage informing diners of menus, plate return, etc.
Education Campaigns	✗ **15%[63]**	**Costs:** Labor hours for campaign design and execution; any necessary materials **Benefits:** Tip fee and wholesale food cost savings	The wide variety of educational campaigns could present a challenge for marketing teams to frame up a cohesive message across the growing methods of communication.
Reusable Plateware	✓ **33%[64]**	**Costs:** Purchase of reusable plateware or disposable dishware **Benefits:** Tip fee and wholesale food cost savings	This intervention requires an industrial dishwasher on site and adequate labor supply to be successful.
Smaller Portions	✓ **35.6%[65,66]**	**Costs:** Staff retraining; purchase of smaller plateware or new menus, if applicable **Benefits:** Tip fee and wholesale food cost savings	This intervention impacts the staff and the student diners from a structural and behavioral point of view. Different serving utensils may be needed to portion out a smaller ounce weight of meat. Students may need to adjust to the culture of taking several smaller plates (like tapas) rather than one larger portion.

LEGEND

✓ Favorable ○ Medium ✗ Unfavorable

End of Life

Unfortunately, there will always be unrecoverable food — either from a prevention, reduction, or rescued perspective. Therefore, the analysis of end of life technology and solutions is critical to establishing a well-rounded food waste strategy for dining institutions. This section analyzes existing solutions in municipal waste management and also explores emerging solutions (see End of Life Interventions on the facing page).

Landfill is by far the least attractive option from a climate perspective and is the highest emissions release for any disposal strategy at 0.2-0.46 metric tons CO_2e emitted per ton of food waste.[67] However, tipping fees and convenience make this option highly competitive for large institutions. Some regions in the country only have landfill as the available organic waste disposal option and alternatives are not established or available. Even though recycling is growing in the non-organic space, the amount of composting has remained relatively flat since 2005 (Figure 6).[68]

Composting is generally known and used across states in the US. From home units to large industrial processors, this disposal method relies on the proper environment to avoid the anaerobic process, which produces methane. Composting is the food waste intervention most highly recommended based on the estimated -0.20 (+/-0.4) metric tons of CO_2e net benefit per ton of food waste.[69] If institutions are interested in reducing their carbon footprint and increasing landfill diversion quantities in the short term, setting up relationships with local, credible composting facilities is the best next step.

Anaerobic digestion is best implemented on a large scale; for example on dairy farms to manage manure.[70, 71] The challenge for universities and anaerobic digestion processing is the intermittent supply (when students go home in the summer) and the varying composition with lack of infrastructure to separate waste streams. Additionally, for full realization of the potential benefits, local restaurants, food establishments, and private companies must partner together and optimize organics hauling logistics. On a per ton of food waste basis, it is estimated that the impact is a net benefit, yielding -0.1 to -0.25 metric tons of CO_2e/ton of food waste.[72]

Diverting food waste to animal feed is a complex, logistics intensive solution. The regulatory landscape is one of the strongest drivers, yet policy and regulations are not consistent across the country. "Some states ban food donation for animal feed. Other states regulate what can be donated (often no meat or dairy). For example, businesses cannot donate coffee grounds and foods high in salt as they can harm animals."[73] Although previous literature and the EPA outline the positive environmental and socio-economic impacts of diverting food waste to animal feed, 33 states ban the use of food waste in animal (swine) feed.[74, 75] Logistically, diverting food waste from landfill to animal feed involves many moving pieces. From farmer partnerships to collection of waste in the dining centers, engagement is critical across the supply chain. While there have been several success stories, the logistics, the previously mentioned bans, storage, and transportation present challenges for advancement of this disposal strategy.

Manufacturing byproduct utilization (upcycling) is not as economically viable as the other solutions today. The two main barriers are infrastructure and technology. The infrastructure of separating wastes at the site of generation and logistics of moving waste to further processing plants are not well established. The current incentives for food waste generators, procurement teams, and processors are not built to support the advancement of upcycling. Secondly, from a technology perspective, using food waste as feedstock for even higher-value products (e.g., polylactic acid (PLA) used in plastics) is currently not economically viable due to new technology inefficiency and incoming feedstock heterogeneity;

END OF LIFE INTERVENTIONS

INTERVENTION	GREENHOUSE GAS IMPACT* (range metric tons CO_2e per ton of food waste)	FINANCIAL CONSIDERATIONS	OTHER CONSIDERATIONS
Food Rescue (donation)	Medium **-0.5 to -3.8** *Note this range indicates the emissions impact is widely variable based on location, partner, logistics, and type of food.	**Costs:** Labor hours for executing donations, including packaging and transportation, if applicable **Benefits:** Tip fee and wholesale food cost savings	Identification and maintenance of long-term partners required. For institutions with multiple dining units and multiple loading docks, logistic challenges are present, but not insurmountable.
Composting	Favorable **-0.16 to -0.24**	**Costs:** Labor hours, maintenance, and operating costs if applicable **Benefits:** Tip fee and wholesale food cost savings	Ensuring an uncontaminated food waste stream is crucial; for institutions that have multiple waste streams in their units, education campaigns and signage will likely need to be implemented in tandem.
Anaerobic Digestion	Medium **-0.1 to -0.25**	**Costs:** Operating and collection **Benefits:** Tip fee and wholesale food cost savings	For on-site anaerobic digestion, space and permitting are significant challenges. For off-site anaerobic digestion, consolidation of hauling and logistics of waste management arrivals vs. incoming ingredient arrivals may be challenging due to limited dock space.
Animal Feed	Medium **-0.08 to -0.23**	**Costs:** Collection and transportation plus labor hours **Benefits:** Tip fee and wholesale food cost savings	Proximity to farmers or processing companies that can handle food waste for animal feed could be a limiting factor. Local laws may have guidelines around food waste as animal feed that must be considered.
Upcycling	*Existing data not sufficient for recommended estimation*	**Costs:** Labor for packaging and transportation **Benefits:** Tip fee and wholesale food cost savings	The infrastructure for upcycling at scale is not yet in place. It may be challenging for universities to find a partner willing to take waste that varies based on time of year and composition.
Landfill	Unfavorable **0.20 to 0.46**	**Costs:** Tip fee - varies state to state **Benefits:** Landfill tipping fees vary across the country, presenting a potentially less costly disposal method	Landfill infrastructure is well established and is often the default option. Therefore, changing waste disposal methods may present a challenge for contracts and alternate services required.

*Negative emissions indicate the net benefit of this disposal method is advantageous from a greenhouse gas perspective. Positive emissions indicate CO2e are released as a result of this disposal method. All values were derived from ReFED Insights Engine Solutions Database: 2020 Methodology. Appendix A.

LEGEND ✓ Favorable ○ Medium ✗ Unfavorable however, these were identified as "hot spots" for future research.[76]

Food Rescue (donation) - According to the EPA Food Recovery Hierarchy (Figure 1), "feed hungry people" is the ideal end of life method for foods. However, while keeping food in the human value chain is of highest priority, some food is not or no longer is safe to donate. About 4.2% of all food donations end up in landfill because of these issues (food safety, handling, storage, or other logistics). Chefs and employees must package, label, and store the donations until items are picked up by the food donation partner.

Composting - Industrial composting controls the environment and balance as organic matter breaks down and maintains the proper aerobic environments. The end result of this process is nutrient-rich, decomposed matter. This matter (high in nitrogen, phosphorus, and potassium) can then be applied back onto the land aiding in water retention and overall soil health.[77]

Anaerobic Digestion - Anaerobic digestion is the breakdown of organic wastes via microbes without the presence of oxygen. From large dairy farms processing animal manure on site to more centralized food waste processing, the resulting outputs are biogas (which can be used for fuel) and digestate (which can be further processed into a nutrient-dense soil amendment). This process is conducted in a reactor (this will vary in shape and size based on incoming material) and requires onsite and offsite infrastructure.[78] Anaerobic digestion is ideally suited for a steady, homogeneous inflow of organic matter (i.e. on a dairy farm and receives cow manure).

Animal Feed - This intervention is generally defined as the diversion of food waste from institutional locations (that has been properly handled and stored) is sent to farms to be used as supplemental animal feed.[79] Farmers from a local radius or further distance are interested in the high nutritional composition of food waste for their animals. The range in GHG reduction signals variation in the logistics to transport.

Upcycling - Also called industrial symbiosis, upcycling is taking a food product destined for landfill and diverting it to be manufactured into a higher-value product. Nutrient rich food waste can be converted into other editable products or inedible, such as fiber extraction for packaging material.[80]

Recently, the UPCycled Food Association developed a standard "outlin[ing] three distinct designations: (1) Certified Upcycled Ingredient(s) (UI), (2) Product Containing Upcycled Ingredient(s) (PUI), and (3) Less Than PUI(s)." The current draft definition is "upcycled foods use ingredients that otherwise would not have gone to human consumption, are procured and produced using verifiable supply chains, and have a positive impact on the environment… Each adds additional value to food manufacturing by diverting food loss and waste to a higher value end destination, subsequently mitigating the total weight of food waste produced and encouraging more responsible production."[81]

Landfill - According to the EPA, "Modern landfills are well-engineered and managed facilities for the disposal of solid waste. Landfills are located, designed, operated and monitored to ensure compliance with federal regulations."[82] Landfills are sited in certain areas and there are regulations around where landfills can and cannot be placed. Additionally, landfills can be designated for certain waste streams, municipal, industries, biohazard, etc.

MUNICIPAL SOLID WASTE MANAGEMENT: 1960 - 2018

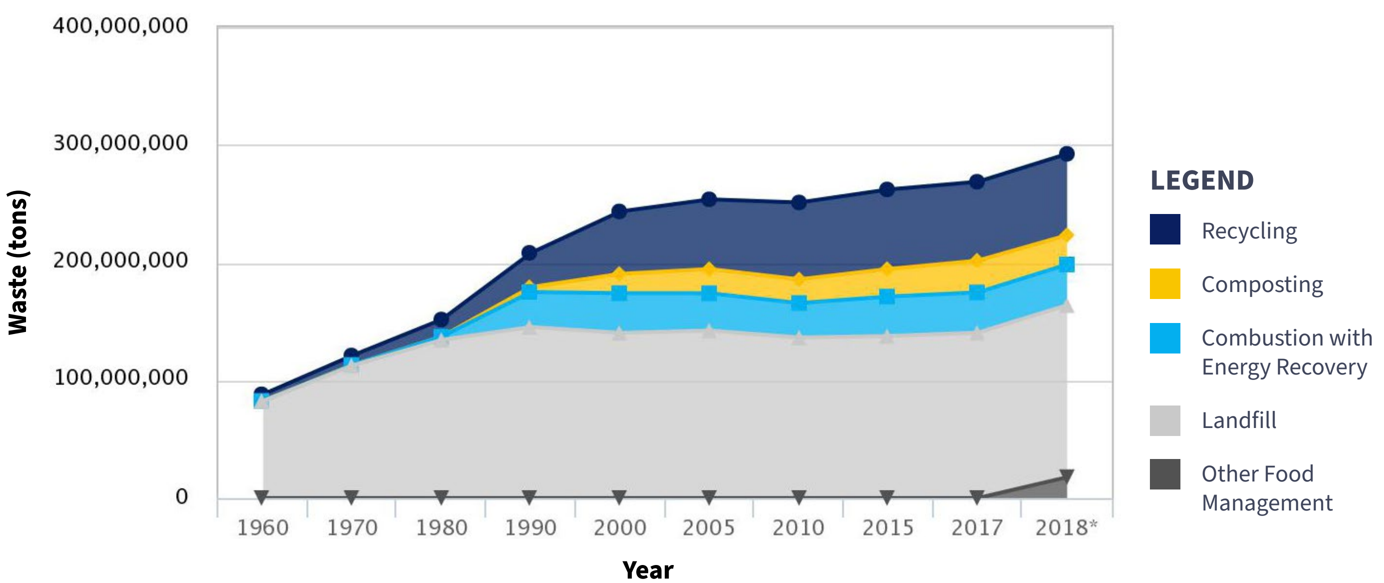


Figure 6: Municipal Solid Waste Management from 1960-2018. Source: EPA.

INTERVENTION SPOTLIGHT

Landfill Diversion

at the University of Michigan

MDining is dedicated to landfill diversion efforts including composting and food donations. MDining's composting program includes collection of 100% of the non-edible organics waste generated in the dining halls. The food waste is converted into nutrient dense compost at the Ann Arbor Compost Center operated by WeCare Organics. Any remaining edible food is donated through MDining's strong partnership with local food donation networks. MDining collaborates with the student-run Food Recovery Network (FRN) and Food Gatherers. To date, these efforts have resulted in donations of over 35,000 pounds of food donated to support the Washtenaw County community.[83]

LEARN MORE!

Image: Michigan Dining

Image Source: Michigan Dining

Conclusion

Food waste is a growing and complex challenge facing universities today. With many universities setting climate or waste reduction targets and students voicing increasing interest in sustainable actions, the need for actionable solutions is clear.

A variety of interventions exist across the food value chain — from prevention, reduction, and diversion. Prioritization of interventions has previously been based on a few attributes and this report outlines 7 attributes with more than 15 supporting sub-attributes through which to analyze.

Within the university dining center and institutional dining context, 21 interventions were identified and analyzed based on their economic, labor, environmental, and feasibility impacts. "Favorable," "Medium," and "Unfavorable" rankings were assigned based on available literature, expert and practitioner interviews, existing financial tools, and climate science. Many solutions have a mix of Favorable and Unfavorable designations, therefore universities and stakeholders must align on the importance of the attributes to their institution. Once priorities are determined, the matrix can be leveraged to select the interventions and execution strategies appropriate for them.

Moving forward, universities and institutions have a variety of interventions available across the sections of the value chain they control. This report and dynamic tradeoff representation will guide leadership, procurement, and sustainability teams to not only design actionable immediate next steps, but also adjust as priorities change. Individual actions by universities, along with coalition building across universities, have the potential to meaningfully advance the environmental, social, and economic benefits by implementing sustainable practices in their day-to-day operations. Twenty-three million tons of food waste from foodservice operations is not a small amount; however, with existing bodies of literature and now this report complete with the matrix and workbook, university leaders are well-equipped to take action today.

Continue to Workbook on next page

Workbook

PUTTING INSIGHTS INTO ACTION

The next two pages contain space for your institution's leadership and dining team to build out near- and long-term actions. An important first step is to articulate what areas are of highest importance for your institution today and where your strategy will take you in the future. Refining the focus will allow you to better leverage the insights in this report. Each institution is at a different stage in the food waste reduction journey. This workbook is designed for each team to create a customized, realistic roadmap to tackle the food waste challenges at their institution.

Following the guidance outlined in the workbook will equip your team to determine what are the best food waste reduction interventions to implement in the next 1-3 and 5-10 years. If your institution or dining team have specific sustainability goals, please reference them when doing this exercise. Many of these interventions have dual benefits across a variety of sustainability metrics measured at the university level. If your institution has upcoming renovations planned or a budget to dedicate for sustainability initiatives, you could include these estimates in the intervention selection process and overall strategy.

IMPACT POTENTIAL
(totals of the sub-attributes)

	Initiative	Economic	Labor	Political	GHG Reduction	Food Waste	Spatial	Time Horizon
BACK OF HOUSE	Compost Bins in Prep Areas	Favorable	Favorable	Medium		Unfavorable	Favorable	Favorable
	Staff Training	Favorable	Medium	Favorable		Unfavorable	Favorable	Favorable
	Signage	Favorable	Favorable	Favorable		Unfavorable	Favorable	Favorable
	Internal Upcycling	Favorable	Unfavorable	Medium		Medium	Favorable	Medium
	Waste Tracking	Favorable	Unfavorable	Medium		Favorable	Medium	Favorable
FRONT OF HOUSE BEHAVIOR	Tray Removal	Medium	Favorable	Favorable		Medium	Favorable	Favorable
	Smaller Plates	Medium	Favorable	Favorable		Medium	Favorable	Favorable
	Unlimited Food Plan	Favorable	Favorable	Medium		Unfavorable	Favorable	Favorable
	To-Go Meals	Favorable	Favorable	Favorable		Unfavorable	Favorable	Favorable
	Customized Portions	Favorable	Medium	Favorable		Unfavorable	Favorable	Favorable
	Smaller Portions	Favorable	Favorable	Favorable		Favorable	Favorable	Favorable
	Taste and Try Stations	Favorable	Medium	Medium		Medium	Medium	Favorable
	Signage	Favorable	Favorable	Favorable		Medium	Favorable	Favorable
	Education Campaigns	Favorable	Medium	Medium		Unfavorable	Favorable	Favorable
	Reusable Plateware	Medium	Favorable	Favorable		Favorable	Favorable	Medium
END OF LIFE	Landfill	Medium	Favorable	Medium	Unfavorable	Unfavorable	Favorable	Medium
	Composting	Medium	Medium	Favorable	Favorable	Unfavorable	Favorable	Favorable
	Anaerobic Digestion	Medium	Unfavorable	Unfavorable	Favorable	Favorable	Unfavorable	Medium
	Upcycling	Unfavorable	Medium	Medium	Favorable	Favorable	Favorable	Medium
	Animal Feed	Favorable	Medium	Medium	Favorable	Favorable	Favorable	Medium
	Food Rescue (donations)	Favorable	Medium	Medium	Favorable	Favorable	Favorable	Favorable

Figure 7: Impact Potential Across Food Waste Interventions

LEGEND

Favorable — Medium — Unfavorable

This sub-attribute is not applicable to the intervention

Workbook continues on next page

GETTING STARTED

If your institution has sustainability goals, please reference them when doing this exercise.

NEAR TERM GOALS

STEP 1

Check all that are of highest importance to your dining institution for the next 1-3 years.

- ☐ Economic
- ☐ Labor
- ☐ Political
- ☐ GHG Emissions
- ☐ Food Waste
- ☐ Spatial
- ☐ Time Horizon

STEP 2

Of the impact potential area(s) that is (are) most important, write down all "Favorable" interventions (those with green dots) in Figure 7 on page 45.

STEP 3

Of the interventions listed in the box above (in Step 2), choose one for which to write a SMART Goal (Specific, Measurable, Achievable, Relevant, and Time-bound).

For example: "By 2025, we will divert 100% of our dining center organics/food waste to compost."

LONG-TERM GOALS

STEP 1

Check all that are of highest importance to your dining institution for the next 5-10 years.

- ☐ Economic
- ☐ Labor
- ☐ Political
- ☐ GHG Emissions
- ☐ Food Waste
- ☐ Spatial
- ☐ Time Horizon

STEP 2

Of the impact potential area(s) that is (are) most important, write down all "Favorable" interventions (those with green dots) in Figure 7 on page 45.

STEP 3

Of the interventions listed in the box above (in Step 2), choose one for which to write a SMART Goal (Specific, Measurable, Achievable, Relevant, and Time-bound).

For example: "By 2027, we will implement waste monitoring technology in all back of house operations." or "By 2030, we will assess feasibility for on-site, modular anaerobic digestion and pilot with the local community."

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