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FOOD WASTE CRISIS IN THE UNITED STATES OF AMERICA: THE KNOWN, THE OVERLOOKED AND THE UNDISCLOSED

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ABSTRACT

With a loss of 1,250 calories per day per person or 140 kg/p/yr, the United States (U.S.) has a large problem with food waste. The later a product is wasted in the supply chain, the greater its environmental cost. Many food waste mitigation efforts focus on the retail and consumer stages, but there is also considerable food waste in the production phase, which includes growing, harvesting, transportation, storage and processing. The study is conducted in two steps: a bibliometric analysis of 218 articles on food waste in the U.S., followed by an investigation of options to meet food waste recovery targets. The study has identified three options to reduce food waste that are partially based on the bibliometric analysis. The options, Secondary Retail Food Stores, Enhanced Tax Credits, and a Task Force, were evaluated based on cost-effectiveness, diversion from landfills, and waste reduction using the Criteria Analysis Matrix method. The study found that establishing a multi-modal, multi-directional non-governmental Task Force to create awareness and spread knowledge among stakeholders, mainly consumers was the preferred policy alternative to tackle food waste issues in the U.S.

1. INTRODUCTION

Food waste is distinct from food loss. Food waste is food produced for human consumption that was not consumed. Food loss is the change in overall edible material originally intended for human consumption. Food waste occurs in the retail and consumer stages; however, food loss occurs in the agriculture, post-harvest, and processing stages (Thyberg & Tonjes, 2016). One estimate was the United States (U.S.) produced the fifth largest amount of household food waste at 19.3 million tonnes (MT), which was less than China (91.6 MT), India (68.8 MT), Nigeria (37.9 MT) and Indonesia (20.9 MT). The U.S. had an additional 80 kg/p/yr of retail and food service waste, which has been estimated to be 40% of all food waste worldwide (UNEP, 2021). That translates to a per capita estimate of U.S. household food waste of 140 kg/p/yr for all food waste, which is smaller than some other estimates of approximately 175 kg/p/yr by EPA (2020a) or 200 kg/p/yr by Natural Resources Defense Council (NRDC) (Gunders & Bloom, 2017). The total amount of food waste and food loss post-harvest, excluding food left in the fields, was estimated to be 60 MT in 2010 (Buzby et al., 2014), which translates to approximately 200 kg/p/yr out of a total food production of 200 MT or 625 kg/p/yr. This suggests that food loss in the U.S. is greater than 30% of all food production; NRDC sets the total overall at 40% of all food production (Gunders & Bloom, 2017). In a global context, food loss is thought to be substantially lower for developed nations like the U.S. (Thyberg & Tonjes, 2016; Gunders & Bloom, 2017). A UNEP report (2017) found that per capita household food waste was greatest for low-income countries. The report found that food harvesting, distribution, and preservation may not be as effective in developing countries as in developed nations. This occurs even if overall food availability is lower. Although food loss and waste are acute problems in the U.S., they are also a worldwide concern of similar or even greater scope.

Food loss and food waste have microeconomic and macroeconomic consequences. At the national scale, food loss impacts the economy because it reflects ineffective production and distribution processes. In contrast, at the individual scale, food waste has a direct effect on household expenses, both through buyer behavior and resource access. Food loss and food waste may account for 1% to 1.5% of the U.S. GDP or approximately $200 billion (Gunders & Bloom, 2017). There are many reasons for food waste, including spillage or breakage, destruction during transportation or handling of product, or waste produced in the distribution phase, and management of food in the retail sector, preparation and serving of food in restaurants and other service venues, and choices made by consumers as they prepare, serve, and manage the food they bought and

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brought home (Schultz, 2017). An especially troublesome source of food waste is that approximately 80% of U.S. citizens dispose of good and edible food products due to their misunderstanding of the "best used by," "sell by," or "use by" labels (EPA, 2020a). There are at least 50 alternate kinds of food date labeling approaches in the U. S. (Kavanaugh & Quinlan, 2020). Except for infant formula, no regulations require food dating (NYSDA&M, n.d.). Instead, a system of open and closed food dating is voluntarily adopted by manufacturers, distributors, and retailers. Essentially, open dating is used for stock rotation and consumer information; closed dating is used for batch identification, to support product recall, and other product management (Newsome et al., 2014). Labels on food items often confuse consumers as they try to avoid illness from consuming "spoiled" food. About 80% of Americans discard food items based on the labels, although about 40% to 50% report they understand the meaning of food labels (Kavanaugh & Quinlan, 2020). This reflects large quantities of food are being incorrectly discarded due to an inaccurate understanding of the label guidelines. Use by, best by, and sell by labels are quality guides; they are not determinants of food safety (Newsome et al., 2014). Hence, discarding food based on these labels disposes of perfectly edible food items.

There is a conundrum, "food insecurity," that affects one in seven American households (REFED, 2016). Food insecurity refers to a situation where households lack access to sufficient and nutritious food or reliable supplies of culturally appropriate food (Barrett, 2010), which underscores the seriousness of food loss rates of 30% or more in the U.S. For those households with food insecurity, food waste is an immediate and troublesome issue. However, given that food waste amounts to 1% to 1.5% of the U.S. GDP, it is a relatively trivial economic issue for most Americans as it only impacts a relatively small amount of the overall household budget. Food waste is thus overlooked as it does not impact most people's daily lives significantly. Therefore, there may be little impetus to reduce food waste or to change habits that lead to the generation of food waste (Gunders & Bloom, 2017).

Food waste has several environmental impacts, such as excessive water and land use change from misapplied agricultural effort in food production, wasted energy in food processing and transportation, and greenhouse gas impacts and methane generation in landfills, among others (Gunders & Bloom, 2017). About 34% of human-related methane emissions in the world accrue from food waste (Buzby et al., 2014). These methane emissions have 21-34 times more impact on global warming than the equivalent amount of carbon dioxide on a 100-year time horizon (Chai et al., 2016). It is estimated that unconsumed food in the U.S. is derived from more than 50 million hectares of agricultural land (16% of U. S. agricultural land), utilizes 20 trillion liters of water, and nearly a billion kilograms of fertilizer, and results in 150 million MT CO_2eq. of greenhouse gas emissions (land emissions excluded) (Read et al., 2020). The ecological impact of food waste is especially concerning since the growth in population and changing consumption patterns are likely to increase over the coming years. This will substantially increase the food demand, further escalating the burden on food systems and the environment.

In 2015, the U.S. government announced plans to reduce food waste by 50% by the year 2030 from a 2010 baseline (EPA, 2021). However, according to all estimates (Gunders & Bloom, 2017; USDA, n.d.-a; EPA, 2020b), the amount of food waste in the U.S. keeps rising. There are, however, additional plans by the U.S. government to reduce food waste, such as social marketing toolkits and the Excessive Food Opportunity (EFO) map. Toolkits are designed to guide the government, non-governmental organizations, and society in minimizing food waste and facilitating composting efforts by providing them with targeted planning approaches to improve composting, minimize contamination, and roll out behavior change initiatives (EPA, 2024a). The EFO interactive map facilitates the nationwide diversion of surplus food from landfills by identifying surplus food generators, compost feedstocks, infrastructure gaps and landfill alternatives (EPA, 2024b).

This research was conducted through bibliometrics to determine recent academic trends in food waste research. These findings would then be applied to identify ways to reduce food waste in the U.S. and evaluate which options might be best to implement using the Criteria Analysis Matrix method. Establishing an organized approach to information dissemination across stakeholders best met the evaluation criteria of cost-effectiveness, overall food waste reduction, and food waste source reduction.

2. MATERIAL AND METHODS

This study was accomplished through two primary steps.

Step 1: A bibliometric analysis following Djeki et al. (2022) and Donthu et al. (2021) of the Web of Science database was conducted for food waste in the United States from 2005 to 2023. Analysis and generation maps were retrieved from VOS viewer software. VOS viewer was selected to create a broader and more graphic analysis of the results. Through the VOS viewer, it is possible to construct connections between the bibliometric results. The keywords search used were "Food waste" and "United States." The systematic review of the literature was carried out based on the following steps: criteria establishment for selecting the articles, defining keywords and examining strategies, refining articles and sorting possible exclusions, analyzing titles, keywords, and abstracts of the articles, tabulating and evaluating the data and finalizing the database. The term "United States" was used instead of "US" or "USA" to improve accuracy in the number of relevant studies for the bibliometric analysis. Publications were refined by limiting the articles to subject areas, namely, environmental science, social sciences, engineering, agricultural and biological sciences, energy, economics, business management, decision sciences, etc. The results were then advanced by applying filters to different criteria, such as "final" articles for the publication phase, "journal" and "review" for the source, and the articles' medium of language only in English. A set of 218 articles was generated after QA/QC processes.

Step 2: Key terms from the bibliometric study suggested areas of recent research interest in the food waste field. These helped determine three broad areas to address food waste: 1) direct management by the government of food waste; 2) private sector actions to improve food management by changing consumer behavior; and 3) indirect government activities to change industry and consumer behaviors. An exemplar was selected for each broad area to be evaluated. The evaluation criteria were chosen to be cost-effectiveness, food waste recovery, and source reduction. Data were collected, and a Criteria Analysis Matrix was used to evaluate the three policy options. A Criteria Analysis Matrix ranks policy options over different criteria on a scale of 1-5, with the criteria also being weighted from least to most important (in this case, from 1-3). This enables a quantitative assessment of disparate options.

2.1 Selection of policy alternatives

The bibliometric study suggested that besides the obvious terms of the United States and food waste, the more descriptive terms sustainable consumption, reduction, and management were important concepts in recent food waste research in the U.S. Sustainability implies a long-term horizon for actions and a focus on environmental consumption implied a focus on household food waste, as that is where food consumption predominantly occurs. Reduction implies that solutions other than alternative technologies for the management of food waste would be important so that overall food waste would be less rather than only seeking to reduce the environmental impact of management. Management implied identifying specific actors that were involved in food waste should be a goal. In the U.S., policies that impact the public are usually initiated by the government, even though there are always exceptions. We therefore thought that two of our three alternatives should be government-originating policies. For balance, we thought one initiative should originate from and affect the private sector. Labeling clearly was an element that affected household food waste, so that should be one target for our policies. Labeling would be a waste-reduction activity, as well. Food waste composting is a management technique that has been of growing interest over the past several decades, but it is a technological solution, not a reduction element, so it was of lesser priority. Activities that bridged public decisions with private actions also seemed to have a certain appeal.

Therefore, we sought policies in scientific, technical, and gray literature that might illustrate these goals. One common governmental action is to ban a deleterious activity. There have been nine state food waste disposal bans enacted since 2014 (Anglou et al., 2024); although some of the prohibitions require following a management hierarchy oriented towards food waste minimization, most of the food waste bans see composting and anaerobic digestion as the primary means of managing food waste. The only effective food waste ban has been in Massachusetts, which Anglou et al. (2024) attribute to enforcement actions and a widespread, large network of compost sites. Another common action is to create a tax incentive. There is an existing federal tax incentive for businesses that donate food. This was first passed in 2005 and was enhanced in 2015 (REFED, 2016). It allows businesses donating food to charities to deduct up to 15% of taxable income. The 2015 enhancements allowed businesses to claim more than the cost value of the food. REFED (2016) has proposed specific enhancements to the tax credit (technical tweaks to cover some unavoidable costs). Another expansion could be for states to create their own tax deductions or credits, as some states have done with clean energy projects (Milne, 2017). California, Colorado, Iowa, Maryland, Missouri, New York, and Pennsylvania offer tax credits for donated food; Arizona offers a tax deduction (National Gleaning Project, 2023). Ensuring that the federal tax credit covers all costs associated with food donation and supplementing the federal program with state credits and donations should make food donation more enticing for retail food stores and farms (NRDC, 2021). Donating food to charities (food banks and soup kitchens) would clearly be a step toward reducing food waste at the retail level.

Food waste management requires public engagement since the largest share of food is wasted by individuals in households (UNEP, 2017). Public education for waste management purposes has long been espoused as a necessary element of achieving better management; however, the past 20 years have mainly seen stagnant recycling rates (at below-optimal levels) in the U. S. despite ongoing education efforts (MacBride, 2012). Newer paradigms for engagement seem to be warranted. One is exemplified by the Center for Sustainable Materials Management, a State University of New York Environmental Science and Forestry (SUNY-ESF) research and outreach group with a focus on improving New York State recycling. It is largely funded by New York State (https://www.centerforsmm.org/). It has a somewhat traditional education element, with a website, outreach and education staffers, and a social media presence. However, it is not only looking to reach out to the general public but also to the governments in New York that plan and manage solid waste programs. It not only developed a GIS-based web portal where individuals can determine what recycling rules apply based on their phone's location but also has worked to harmonize those rules across the hundreds of New York jurisdictions that set recycling rules. It has developed a database of suppliers that can provide "green procurement" materials to local governments and supports seminars for purchasing officers to educate them on their legal and regulatory responsibilities under New York State law. It not only works to create videos supporting recycling programs but has also conducted a "needs assessment" in support of a potential Extended Producer Responsibility law for packaging for New York State. This organization, therefore, conducts work in multiple directions for multiple stakeholders in support of a unified overall goal. We are describing these kinds of organizations as "Task Forces," given their potential for acting in multiple directions in support of a single goal, and we think a similar organization at the federal level in support of reducing food waste could have great effectiveness. Communicating and clarifying information related to food waste data and food date labels such as "use-by," "sell-by," and "best-by" could really help decrease the levels of food

waste. It is important for consumers to know that "sell-by" and "best-by" dates are meant as indicators for retailers to help them know when their product will become sub-optimal, not inedible. Similarly, past "use-by" dates don't automatically make them suitable for the garbage. In addition, harmonizing the vocabulary and purpose of such labels by manufacturers and packagers could help ensure that the education program had a greater focus. This would be a campaign for behavior change through multiple channels to consumers and the business community, fostered by the government's regulatory power.

There have been a number of private sector initiatives that intend to reduce food waste. Food waste collection programs have been created to manage source-separated food wastes (mostly through associated compost sites). Many of these have been started in cities, as collection is easier to accomplish with greater population density (Krones, 2019). Some of them used alternative means of transportation, such as bicycle collection (Tsang, 2020). However, even in rural areas, certain compost entrepreneurs have pioneered food waste collection programs (Tonjes et al., 2024). This is a management-oriented program. Another initiative attempts to address food waste by reducing it at the retail level. Grocery stores have been established in Denmark and Britain that sell blemished, irregularly shaped, or otherwise slightly off-spec food (Overgaard, 2016; Gunders & Bloom, 2017). These kinds of stores could be encouraged in the U.S. The focus would be food items that are nearing their use by, best by, or sell-by dates alongside the produce, which is aesthetically subpar. Approximately 10% of food waste in the U.S. is generated at the retail level (UNEP, 2017), so the creation of small secondary stores could lead to significant food waste reduction (Overgaard, 2016). Governments could provide support to entrepreneurs with siting and permitting, even perhaps financial incentives, similar to other small business support mechanisms. The secondary stores would need to work together with nearby grocery outlets to collect food that is going to be removed from food racks and have to access farmer distribution networks to receive "ugly vegetables" and similar off-spec items. Minnesota has supported these kinds of efforts for direct shipments to food banks and soup kitchens from farmers; however, it is a relatively small program (120 farmers across the state have donated vegetables and fruit since 2015, and the state purchases milk for these programs at current retail levels, and in 2020 only 150,000 kg of protein were donated) (Second Harvest Heartland, n.d.). Other industrial reuse programs, where businesses could arrange to off-load unwanted or overstock supplies, faced some difficulties in manufacturing reuse, such as selling or donating unwanted materials, because these actions were associated with the perception that the donor was supporting potential rival companies. This was a significant headwind in industrial reuse opportunities in New York City in the 1990s (Hammer et al., 1997) and may be difficult to overcome in the retail food sphere, which usually has small profit margins and is often highly competitive.

The three policy options selected for evaluation were secondary stores, tax incentives, and Task Forces.

2.2 Selection of evaluation criteria

Three criteria were identified as suitable for evaluating the policy choices: cost-effectiveness, recovery, and source reduction.

Cost Effectiveness (Criteria weighting = 3): Cost-effectiveness will provide a demonstration of decision uncertainty linked with an intervention in this scenario policy alternative. The cost-effective assessment will present the possibility that the decision to implement an alternative is suitable. For example, will the policy alternative option save money, will it cost money, is there a determination of savings per unit of food waste repurposed, etc?

Recovery (Criteria weighting = 1): The most significant direct impact of food waste on the environment is the generation of methane in landfills. Despite programs and policies to prevent emissions of landfill gas into the environment, a substantial portion of landfill-generated methane escapes into the atmosphere. Landfill-generated methane is estimated to be 22% of anthropogenic methane in the U.S. (Nesser et al., 2024). Food has long been identified as the material that generates more methane than any other MSW constituent (Wang et al., 1997). Since methane has a relatively short atmospheric lifespan (half-life estimates range from 10-14 years) (Chai et al. 2016), reducing methane emissions may result in significant reductions in greenhouse gas content over relatively short time frames (Bistline et al., 2022). Therefore, reducing food inputs to landfills (which we are characterizing as "recovery") has great potential to have a large environmental benefit from greenhouse gas mitigation.

Source Reduction (Criteria weighting = 2): It is a truism in solid waste management that reducing the amount of waste that needs management is the most effective means of managing waste. Materials that are not managed do not have direct costs, do not require infrastructure, require no decision-making burdens on consumers, etc. (Zhang et al., 2021). Policies that result in source reduction usually have ancillary benefits that are indirectly oriented toward other aspects of the economy and society. Food waste source reductions can include water conservation, reduced land use impacts, hunger reduction, economic diversification, and entrepreneurship (Thyberg & Tonjes, 2016).

3. RESULTS AND DISCUSSION

3.1 Step 1 Bibliometric Study

Food waste research is accelerating. The mean number of publications per year was 12, but over half (115) of the papers were published in the last four years (mean of 29 publications/yr), with 37 published in 2022 (Figure 1).

To create the co-occurrence map, words with a minimum of seven occurrences in the title and abstract were selected across the papers. The co-occurrence analysis revealed various prominent clusters. For example, the green cluster shows the research centered on "behavior" and "consumption," indicating a number of studies focusing on human behavior and consumption patterns with respect to food. The red cluster focused on "food waste," "management," and "greenhouse gas emissions." It provided research on the importance of managing food waste and

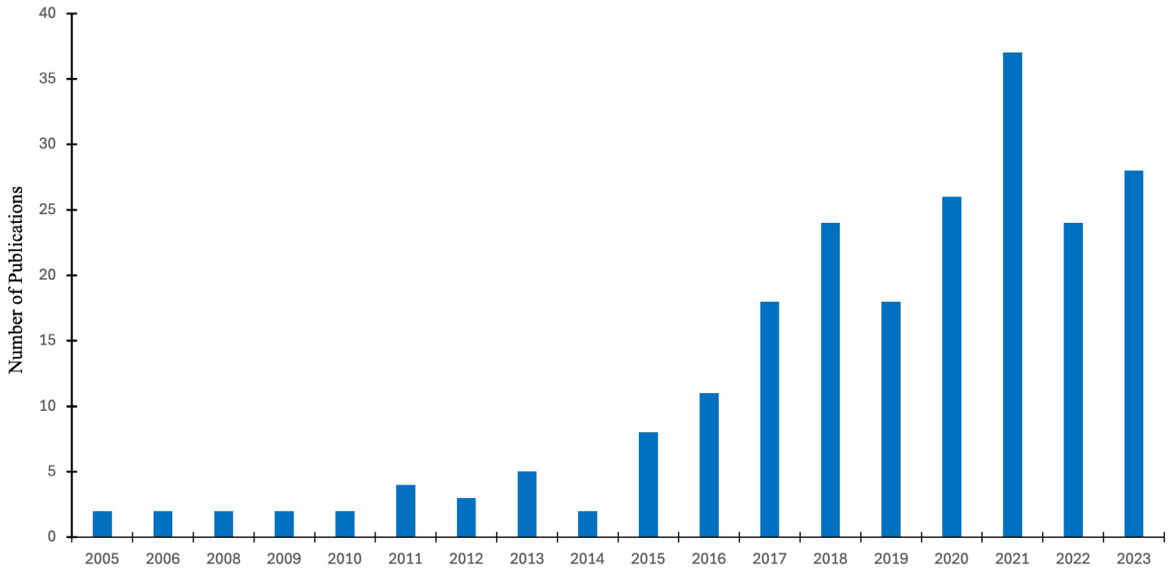

FIGURE 1: Publications per year (2005-2023).

understanding the different environmental impacts of food waste (Figure 2).

3.2 Analysis of Policy Alternatives

3.2.1 Creating Secondary Retail Food Stores

Some retail groceries donate edible food to charities for tax savings because of regulatory requirements or as an ethical choice (Lowrey et al., 2023). Donations can be difficult to manage, as there are transportation and other logistics issues and a loss of potential revenue (offset by tax savings). A model of diversion to alternative retail sales found that this had the potential for greater revenue for the seller, additional entrepreneurial opportunity for the purchasing operation, and perhaps greater diversion from disposal overall (Lee & Tongarlak, 2017). To enhance such operations with off-farm, off-spec fruits and vegetables, as is the model in Denmark and England, it was found that farmers would need expanded processing infrastructure and consistent pricing structures (Johnson et al., 2019). On-site processing of crops, including technical innovations such as dehydration or vacuum-sealing, could provide expanded use for off-spec crops (Birch et al., 2014). Secondary stores selling food items that might otherwise be disposed of might co-opt part of the "good food" perception associated with farmers' markets, where consumers will forgo a degree of convenience and pay more to be part of what is perceived as more sustainable, and healthier food chain that is more supportive of local agriculture

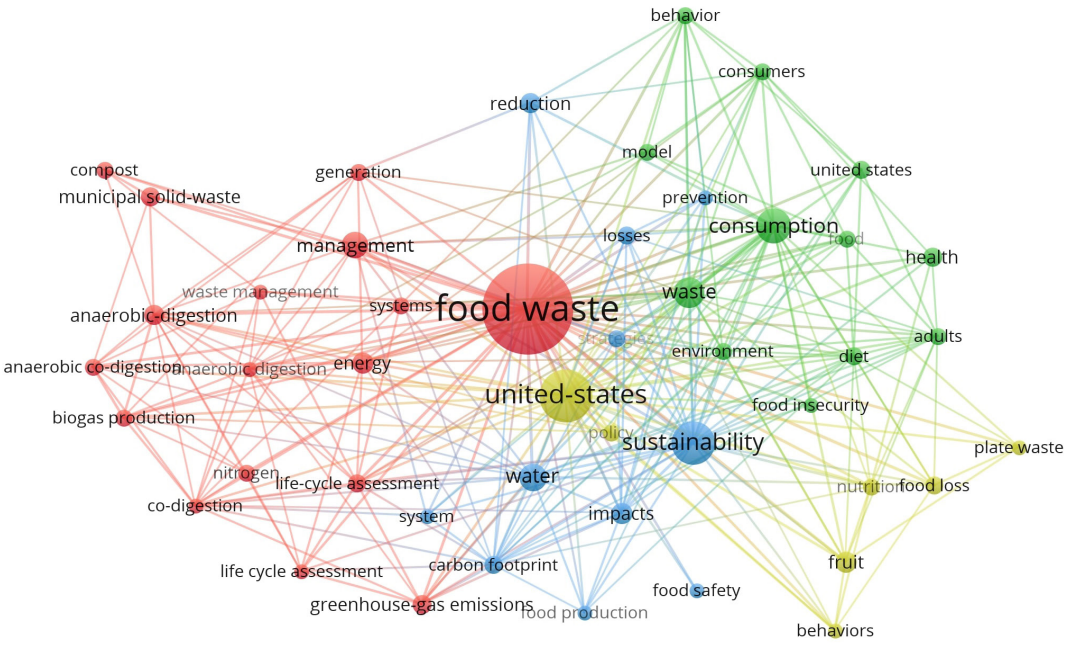

FIGURE 2: Keywords co-occurrence map.

(Connell et al., 2008). Danish (Overgaard, 2016) and English (Gunders & Bloom, 2017) versions of these stores have proven successful, but they have not yet been able to gain a U.S. foothold. This implies some form of government subsidy or other support may be required to begin this initiative in the U. S. In addition, off-spec food will need to overcome the primary consumer selection mechanisms of visual assessment, which means impressions of damaged or irregular food often equate to unhealthy food (Bolos et al., 2019).

- Cost-Effectiveness (Score = 2): Establishing a distribution network from farmers to stores separate from the established network for preferred food quality may have a substantial cost. Diversion of overstock and past-due date materials in established retail stores from disposal pathways is a complication that will probably have some additional costs; transporting food from retailers to these secondary stores will entail certain expenses. Analogies to other materials reuse opportunities imply that the logistics of organized diversion and potential "polishing" of these items to make them re-salable are not trivial (Gelbman & Hammerl, 2015).
- Recovery (Score = 4): The intention of this program is to divert materials from disposal, thereby meeting the goals of "recovery." Recovery may be enhanced at retail stores in establishing this program as once unsuitable materials are being diverted towards other-than-disposal (to the secondary stores), other options can also be considered, such as diversion of edible food to food banks and soup kitchens as well as to the secondary stores, and diversion from landfilling (or waste-to-energy incineration) to composting or anaerobic digestion. Creating a pathway for food losses to secondary stores from farms should actually increase landfilling to some extent; no process is waste-free, so processing and transporting food from farms to secondary stores and losses at the secondary stores should lead to some landfilling of food. This will increase landfilling as food losses on farms in the U.S. are rarely, if ever, landfilled. In addition, if the perception that off-spec food is unhealthy is not substantially changed, then the diversion of these food items into retail outlets may not result in substantial reductions in food waste; rather, since off-spec food on farms is rarely landfilled (Beausang et al., 2017) but retail food wastage is, it may lead to increases in landfilled food waste.
- Source Reduction (Score = 4): Food loss and waste reductions can be brought about in a meaningful manner by creating these secondary markets for excess food (Evans & Nagele, 2017). Preventing farm food loss conserves more resources than retail food waste diversion, probably even so compared to food donations or food waste composting. This alternative is most efficient in terms of source reduction. Again, however, the perception that off-spec food is unhealthy will need to be changed to result in substantial reductions.

3.2.2 Improving Tax Incentives

Tax code changes are common means in the U.S. to change behavior. These tax code changes can be focused on individuals or organizations. Here, there are no easy means to incentivize consumer choices; rather, tax changes are aimed at making farmers and other areas of the food industry change how they behave (NRDC, 2021). Expanding the somewhat limited scope of U.S. tax incentives to include all food diversion expenses is perceived as having benefits (Gunders & Bloom, 2017; NRDC, 2021). NRDC, in particular, believes that state tax incentives can be more effective because of better outreach efforts and the potential to target specific local industries in ways that broader approaches cannot (NRDC, 2021). State tax incentives seem most likely to be effective and result in savings for farms, whereas local extensions are often very effective at spreading information regarding many aspects of farm business practices (Wang, 2014); it seems less relevant for larger grocery chains that are already likely to use professional, comprehensive accounting and tax advisement services.

- Cost-effectiveness (Score = 3): Tax incentives, such as tax credits provided to food rescuers, are often cost-effective as any monetary amount given through such schemes will directly motivate farms, organizations, and businesses to donate food if enough of the costs are covered. Therefore, if tax credits are provided, the expenditures will go exclusively towards their envisioned purpose, i.e., reducing food waste and feeding the needy people. Whenever a business or farm does not donate surplus food, it does not receive any tax benefits. Additionally, by encouraging the donation of healthy food, low-profit margin businesses, like farms, would be supported with these tax incentives by allowing them to recover the cost invested in producing food they could not sell. The issue is whether sufficient credits are available and easily accessible to create the incentive to spend pre-tax money.
- Recovery (Score = 4): The intention of making food donations more affordable for food sources is to divert materials from disposal, thereby meeting the goal of "recovery." The target materials and sources for food loss and waste reduction here are the same as those for the secondary stores, so the impact should be similar if they are equally successful.
- Source Reduction (Score = 4): The source reduction impact of tax incentives will be of the same scope as the secondary store impact.

3.2.3 Task Force

Wastage of food is, to a large extent, a consequence of consumer consumption and buying behaviors. Often, supermarkets tend to order an excessive stock of food items that are more than what is required in order to fulfill the overconsumption needs of the consumer. This puts a heavy strain on the agricultural sector (REFED, 2016). There's an imminent need to relieve this strain, and the same could be achieved through stakeholder collaboration and campaigns. It is imperative to highlight the environmental and social damage caused by overconsumption while promoting wise purchasing habits.

Recent studies have shown that consumers in the

U.S. consider themselves to be well-informed about food waste; however, many do not correctly apply sell-by-use-by-best-by advisories (Bolos et al., 2019). In addition, there are approximately 50 iterations of these kinds of labels, meaning manufacturers and retailers do not have a coherent process for providing good food consumption information (Kavanaugh & Quinlan, 2020). This describes a multi-sector, multi-directional information and guidance opportunity, which would be suitable for a non-governmental organization, has bonafides due to academic or think tank relations and is agile and aggressive in offering work products across many domains. We have described such an organization as a Task Force. To close the gap between information and implementable knowledge, the proposed working group will incorporate educational policies via tailored campaigns, useful resources and public engagement. Some of the ongoing initiatives are updating information on safe storage and developing a "FoodKeeper" App (provides users with information on proper storage, product dating, etc) (USDA, n.d.-b)

Such an organization could conduct work with a relatively small staff on the order of 20 or so and a relatively modest outreach budget focused on social media channels with polished products but no general mass media presence. The group should also have a two-sided, aggressive outreach program: to key regulators such as the U.S. Department of Agriculture and the Federal Trade Commission, plus states with existing food waste support programs, such as those with tax incentives, along with Texas and Florida, as the largest states without existing food waste reduction policies in place. It should have outreach to major food manufacturers and distributors through participation in industry groups and meetings and targeted individual information efforts. An example of this would be the Center for Sustainable Materials Management at SUNY ESF; another could be the Recycling Partnership (https://recyclingpartnership.org/), which has a much larger scope of work and is a much larger organization than envisioned here. Establishing a consistent messaging approach would increase the effectiveness of the labels, educate consumers, and create pathways for "nudges" to improve the use of these tools (Bolos et al., 2019; Thaler & Sunstein, 2008).

- Cost-effectiveness (Score = 5): Amongst the three policy alternatives, setting up a task force and nudging consumers is clearly the least expensive option. It has no direct impact on food waste, however, and will require social change to be effective.
- Recovery (Score = 3): When the consumers are educated about date labels of products and how sell-by, use-by, and best-by dates are indicative of food quality and not its safety, there should be reduced need for stores to aggressively clear shelves of such items. This would minimize the landfilling of food waste.
- Source Reduction (Score = 3): Better understanding of food labels should decrease the overall amount of food waste, similar to the anticipated decrease in landfilled food waste.

3.3 Criteria Analysis Matrix

Food waste remains a significant cause of concern in the United States. The government must adopt advanced policies to reduce the amount of food waste generated in the country and reach its reduction goal. Table 1 presents the analysis of the three selected policy alternatives by applying a Criteria Alternatives Matrix. As depicted in the CAM table, the policy alternative for the Task Force has the highest total score, and so it is the most favorable option of these three for addressing the food waste issue in the U.S.

4. CONCLUSIONS

Consistent with the increase in U.S. food waste, there has been a growth in the number of publications on food waste in recent years. This paper investigated the options to reduce food waste in the United States. Important themes for this research have been sustainability, reduction, manage consumption. Using these key terms as guides, three policy options across the realms of government action, public-private cooperation, and private initiatives were evaluated using the criteria of cost-effectiveness, recovery (as measured by decreases in landfilling of food waste), and source reduction. The first policy alternative is to create Secondary Stores for food that customarily ends up in waste owing to cosmetic concerns or compliance with date labels. In the criteria analysis matrix, creating the Secondary Store scored "4" in terms of both Recovery and Source Reduction. Its Cost-effectiveness was less (scoring a 2). Expanding the scope of federal tax credits and creating similar kinds of state programs was seen as creating similar recovery and source reduction impacts to the Secondary Store policy. It was evaluated as being more cost-effective than the Secondary Stores. Establishing a nimble, multi-target organization (a Task Force) to work with consumers and industry to harmonize the use of date labels for food and to educate consumers on their meaning

TABLE 1: Criteria analysis matrix of policy alternatives.

		Criteria			Total
		Cost-effectiveness	Recovery	Source Reduction	
(Weights)		3	1	2	
Alternatives	Creation of secondary stores	2 (2 x 3 = 6)	4 (4 x 1= 4)	4 (4 x 2 = 8)	6 + 4 + 8 = 18
	Increased Tax Incentives	3 (3 x 3 = 9)	4 (4 x 1 = 4)	4 (3 x 4 = 8)	9 + 4 + 8 = 21
	Task Force	5 (5 x 3 = 15)	3 (3 x 1 = 4)	3 (3 x 2 = 6)	15 + 4 + 6 = 25

was identified as the preferred option. The government has already run various campaigns in some states to spread awareness regarding food waste. However, the government can enhance the process by providing information on in-store display screens or conducting contests to engage more customers and educate them. When the consumers are educated about the date labels of products and how "sell-by" or "use-by" dates are just suggestions made by the manufacturer for a product's freshness and do not relate to consumer safety, the state could prevent wholesome foods from reaching landfills. Therefore, in terms of recovery and source reduction, it was found to be the most efficient option compared to other alternatives.

4.1 Study Limitations and Future Directions

Step 1 of this study was conducted on the Web of Science (WoS) database by making use of specific keywords to arrive at a holistic analysis. Since WoS Directory was the only platform referred to, other publications platforms comprising scientific documents, such as Scopus, were not part of the current study. The key terms of research that were used to perform the survey were "Food Waste" and "United States," because of which other publications of value may have been overlooked and were not included in the study.

Step 2 could have been enhanced by a more formal evaluation process, using expert opinion elicitation such as a Delphi technique. A wider range of alternatives could have been considered.

In the future, researchers can advance this work by studying other policy alternatives for reducing food waste in the United States. They might explore the effectiveness of policies such as required food waste reporting in companies or programs related to composting, which promotes the diversion of food from landfill sites. A comparative study could be carried out to examine the effectiveness of these options in other nations, offering insights into versatile models for reducing food waste in various regions. Furthermore, future studies could also assess technological innovations, such as smart packaging or food waste tracking systems, and their possible influence on reducing food waste across the distribution chain.

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REFERENCES

Anglou, F. Z., Sanders, R. E., & Stamatopoulos, I. (2024). Of the first five U.S. states with food waste bans, Massachusetts alone has reduced landfill waste. Science, 385, 1236-1240.

Barrett, C. B. (2010). Measuring food insecurity. Science, 327, 825-828.

Beausang, C., Hall, C., & Toma, L. (2017). Food waste and loss in primary production: Qualitative insights from horticulture. Resources, Conservation and Recycling, 126, 177-185.

Birch, C. J., Bonney, L., & Murray, S. (2014). Exciting future for graduates in the food industry – From agroecosystem to food health. Chronica Horticulturae, 54(1), 7-11.

Bistline, J., Abhyankar, N., Blanford, G., Clarke, L., Fakhry, R., McJeon, H., Reilly, J., Roney, C., Wilson, T., Yuan, M., & Zhao, A. (2022). Actions for reducing U.S. emissions at least 50% by 2030. Science, 376, 922-924.

Bolos, L. A., Lagerkvist, C. J., & Nayga, R. M. (2019). Consumer choice and food waste: Can nudging help? Choices, 34(1), 1–7. https://www.jstor.org/stable/26758662

Buzby, J., Wells, H., & Hyman, J. (2014). The estimated amount, value, and calories of post-harvest food losses at the retail and consumer levels in the United States. Economic Information Bulletin No. (EIB-121), 39 pp.

Chai, X., Tonjes, D. J., & Mahajan, D. (2016). Methane emissions as energy reservoir: Context, scope, causes, and mitigation strategies. Progress in Energy and Combustion Science, 56, 33-70.

Connell, D. J., Smithers, J., & Joseph, A. (2008). Farmers markets and the "good food" value chain: A preliminary study. Local Environment, 13(3), 169-185.

Djeki, E., Dégila, J., Bondiombouy, C., & Alhassan, M. H. (2022). E-learning bibliometric analysis from 2015 to 2020. Journal of Computers in Education, 9(4), 727–754. https://doi.org/10.1007/s40692-021-00218-4

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

EPA (United States Environmental Protection Agency). (2020a). Waste Food Methodology Scoping Memo.

EPA (United States Environmental Protection Agency). (2020b). Advancing Sustainable Materials Management: 2018 Tables and Figures. U.S. Environmental Protection Agency. 80 pp.

EPA (United States Environmental Protection Agency). (2021). United States 2030 food loss and waste reduction goal. https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal

EPA (United States Environmental Protection Agency). (2024a). Preventing wasted food in your community: A social marketing toolkit. Retrieved from https://www.epa.gov/sustainable-management-food/forms/preventing-wasted-food-your-community- social-marketing-toolkit

EPA (United States Environmental Protection Agency). (2024b). Excess food opportunities map. Retrieved from https://www.epa.gov/sustainable-management-food/excess-food-opportunities-map

Evans, A. I., & Nagele, R. M. (2017). A lot to digest: Advancing food waste policy in the United States. Natural Resources Journal, 58, 177–214.

Gelbman, U., & Hammerl, B. (2015). Integrative reuse systems as innovative business models for devising sustainable product-service systems. Journal of Cleaner Production, 97, 50-60.

Gunders, D., & Bloom, J. (2017). Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. Natural Resources Defense Council. https://www.nrdc.org/sites/default/files/wasted-2017-report.pdf (Retrieved October 2, 2021).

Hammer, S., Hess, E., and Okun, J. (1997) Waste Prevention Technical Assistance Toolkit. Manual prepared for the Waste Prevention Technical Assistance workshop series, NYC Partnership for Waste Prevention/NYC Department of Sanitation, Long Island City, NY. September 30-October 1. Paged in sections.

Johnson, L. K., Bloom, J. D., Dunning, R. D., Gunter, C. C., Boyette, M. D., & Creamer, N. D. (2019). Farmer harvest decisions and vegetable loss in primary production. Agricultural Systems, 176, 102672 (11 pp).

Kavanaugh, M., & Quinlan, J. J. (2020). Consumer knowledge and behaviors regarding food date labels and food waste. Food Control, 115, 107285 (5 pp).

Krones, J. S. (2019). The emergence of a food-waste-based commodity frontier in the United States. Capitalism Nature Socialism, 31(4), 91-105.
Lee, D., & Tongarlak, M. H. (2017). Converting retail food waste into by-product. European Journal of Operational Research, 257(3), 944-956.
Lowrey, J. D., Richards, T. J., & Hamilton, S. F. (2023). Food donations, retail operations, and retail pricing. Manufacturing & Service Operations Management, 25(2), 792-810.
MacBride, S. (2021). Recycling reconsidered: The present failure and future promise of environmental action in the United States. MIT Press.
Milne, J. (2017). Energy tax incentives in the United States: A comparative perspective on state aid. European State Law Quarterly, 16(1), 34-45.
NRDC (National Resources Defense Council). (2021). Great Lakes Food Waste Policy Gap Analysis and Inventory (R-21-07-E). National Resources Defense Council, New York, NY. 63 pp.
NYSDA&M (New York State Department of Agriculture and Markets). (n.d.). Food product dating. Agriculture and Markets. https://agriculture.ny.gov/food-product-dating
National Gleaning Project. (2023). Tax incentives and food donation for gleaning organizations. Association of Gleaning Organizations. 11 pp.
Nesser, H., Jacob, D. J., Maasakkers, J. D., Lorente, A., Chen, Z., Lu, X., Qu, Z., Sulprizo, M. P., Winter, M., Ma, S., Bloom, A. A., Worden, J. R., Stavins, R. N., & Randles, C. A. (2024). High-resolution U.S. methane emissions inferred from an inversion of 2019 TROPOMI satellite data: Contributions from individual states, urban areas, and landfills. Atmospheric Chemistry and Physics, 24(8), 5069-5091.
Newsome, R., Balestrini, C. G., Baum, M. D., Corby, J., Fisher, W., Goodburn, K., Labuza, T. P., Prince, C., Thesmar, H. S., & Yiannis, F. (2014). Applications and perceptions of date labeling of food. Comprehensive Reviews in Food Science and Food Safety, 13, 745-769.
Overgaard, S. (2016). Denmark's new grocer is selling expired food, and it's a hit. NPR. https://www.npr.org/sections/thesalt/2016/02/29/468301837/denmarksnewgrocerissellingexpiredfoodanditsahit (Retrieved November 2, 2021).
REFED (Rethink Food Waste Through Economics and Data). (2016). A roadmap to reduce U. S. food waste by 20 percent. https://www.refed.com/downloads/ReFED_Report_2016.pdf
Read, Q. D., Brown, S., Cuéllar, A. D., Finn, S. M., Gephart, J. A., Marston, L. T., Meyer, E., Weitz, K. A., & Muth, M. K. (2020). Assessing the environmental impacts of halving food loss and waste along the food supply chain. Science of the Total Environment, 712, 136255. https://doi.org/10.1016/j.scitotenv.2019.136255
Schultz, J. (2017). Fighting food waste. National Conference of State Legislatures. https://www.ncsl.org/research/agriculture-and-rural-development/fighting-food-waste.aspx (Retrieved October 3, 2021).
Second Harvest Heartland. (n.d.). Fighting hunger in Minnesota: Expanding farm to food shelf. https://www.house.mn.gov/comm/docs/7zBo_vEzMk_36v6woEoang.pdf
Thaler, R. H., & Sunstein, C. R. (2008). Nudge: Improving decisions about health, wealth, and happiness. Yale University Press.
Thyberg, K. L., & Tonjes, D. J. (2016). Drivers of food waste and their implications for sustainable policy development. Resources, Conservation and Recycling, 106, 110-123.
Tonjes, D. J., Manzur, S., Wang, Y., Firmansyah, F., Thyberg, K., & Hewitt, E. (2024). Chautauqua County MSW and Recyclables Waste Characterization Report September 2023. Waste Data and Analysis Center, Stony Brook University, Stony Brook, NY.
Tsang, C. R. L. (2020). Bike-powered food scraps collection: Mapping community composting green spaces (Master's thesis, California State Polytechnic University, Pomona).
UNEP (United Nations Environment Programme). (2021). Food Waste Index Report. https://www.unep.org/resources/report/unep-food-waste-index-report-2021
USDA (United States Department of Agriculture). (n.d.-a). Food loss and waste. U.S Department of Agriculture. https://www.usda.gov/foodlossandwaste
USDA (United States Department of Agriculture). (n.d.-b). Food waste activities. Retrieved from https://www.usda.gov/about-food/food-safety/food-loss-and-waste/food-waste-activities
Wang, S. L. (2014). Cooperative extension system: Trends and economic impacts on U.S agriculture. Choices, 29(1), 1-8.
Wang, Y-S., Odle, W. S. III, Eleazar, W. E., & Barlaz, M. A. (1997). Methane potential of food waste and anaerobic toxicity of leachate produced during food waste decomposition. Waste Management & Research, 15(2), 149-167.
Zhang, J., Qin, Q., Li, G., & Tseng, C.-H. (2021). Sustainable municipal waste management strategies through life-cycle assessment method: A review. Journal of Environmental Management, 287, 112238.