The Problem Domain

The Problem Overview

Food waste is one of the most pressing global challenges to date. The USDA claims 40% of the food produced in the United States is thrown away, 95% of which ends up in landfills. Such waste has consequences for producers and consumers alike. From the consumer side, wasted food means less food to sustain oneself or one's family. It is found that 1 in 8 Americans have difficulty acquiring healthy, sustainable food consistently, and food waste makes things harder. Producers like farmers and manufacturers also face an increase in demand due to having to replace what is lost due to waste. Our goal is to research, create, and design a digital solution to help lower the percentage of food wasted globally.

Existing Solutions

There are already a number of solutions designed to cut down on food waste, but most of them only focus on one part of the issue. Sales-to-purchase apps such as Too Good to Go connect consumers with restaurants and supermarkets offering leftover food at discounted prices. Similarly, platforms like MyFoody and Leloca allow people to purchase items close to expiration. While these tools help reduce waste at the business level, they do little to solve the everyday waste that occurs in households.

Other apps focus on leftovers and meal planning. Germany’s Beste Reste-App, for instance, suggests recipes based on ingredients you have in your pantry, while the website, Save the Food, generates meal plans and grocery lists based on the number of people you are feeding. Although these approaches can be effective, they rely heavily on users consistently logging their food, which acts as a major hurdle.

Food sharing is another strategy. For instance, Olio enables neighbors to exchange extra food, and the Food Loop App links grocery store inventory systems with customers so they can see discounts on items before they expire. These initiatives promote community involvement but their effectiveness depends on active participation, which can limit their success.

Traditional methods still exist as well, such as writing paper grocery lists, donating to food banks, or improving meal prep habits. While these approaches are simple and accessible, they lack the integration and automation that technology can offer. Ultimately, while these solutions address parts of the problem, none of them provide a blanket approach. What’s missing is a single system that enables people to plan, track, share, and learn in a way that is both user-friendly and sustainable.

Potential Stakeholders

Primary Stakeholders

This category of stakeholders includes individual consumers who generate household waste and seek affordable, healthy meal options. Our first target group is off-campus students who do not have a meal plan, and thus are responsible for purchasing and preparing their own food. It is found that over half of Gen Z students lack fundamental cooking skills and lack the knowledge to prepare food. Plus, the obligation of coursework often supersedes the need for proper food management. Families are probably the largest party involved when it comes to food waste. While most food waste comes from supermarkets unable to move their stock, we found that it occurs in families and households of all income levels, which play a role in or are impacted by food waste. Families whose parents are busy, working professionals, lack the time to prevent food spoilage and plan out meals. The average American household can dispose of up to 257 pounds of food annually. On the other end, we have low-income families who often struggle to find affordable, healthy meal options. Considering 1 in 8 Americans are “food insecure”, food waste only makes their problems worse. Our final group of primary stakeholders exists within the producer side of the market. These groups include: farmers, food banks and pantries, store managers, and grocery stores as a whole. As stated before, this group is the largest contributor of food waste. The agriculture industry often produces more stock than what is needed to feed the population to account for shifts in the market. Unfortunately, this practice also results in crops often being wasted. In reality, this practice is unwarranted as the global agricultural scene already produces enough food to feed the world 1.5 times. The manufacturing industry accounts for 15 percent of food loss, as goods that fail quality standards are discarded despite being still usable. Grocery stores and markets are also flawed in this way. Their customers tend to only accept the best produce, but food that stays on the shelf is discarded for not meeting standards.

Visual Accessibility Considerations: Users may have visual impairments that significantly impact food management tasks, Low visions or blindness makes reading expirations dates, identifying food items, and navigating mobile interfaces challenging. Color blindness affects the ability to distinguish between visual indicators(like red/green expiration alerts) age-related vision changes in older adults may require larger text and high contrast modes, adjustable text sizing, colorblind-friendly color schemes, and screen reader compatibility.

Secondary Stakeholders

This group includes food banks and charitable organizations that currently handle food redistribution who need an easy way to connect to the community. All members of this group act as an in-between party and often are tasked with connecting the producer and consumer groups identified as primary stakeholders. Considerations for these stakeholders include integrating technology connecting them to widely used platforms like facebook, instagram, and other social media to promote their charity. Environmental advocacy groups wouldn't necessarily have interaction with the app but would be invested in its success as it aids their goals.

Food delivery services are an intermediary between the producer and the consumer. Meal kits like Hello Fresh and Factor offer a solution to food waste. They take the guesswork out of meal prep and also provide exact quantities of food needed for certain meals, eliminating food scraps and leftovers in households altogether. Unfortunately, these services are unappealing to a lot of consumers who view them as too expensive and don't offer much in the way of experimentation(making custom recipes).

Safety inspectors and waste management are responsible for setting food safety standards and also managing the handling, storage, and disposal of food waste. While food safety inspectors play an important role in ensuring only healthy and safe food makes it to shelves, the standards they set also target perfectly edible food.

Municipal waste management comes into play towards the end of the food waste cycle. This party receives the waste produced by our primary groups and must determine what to do with it. A solid 60% of the waste received will end up in a landfill, but there are other avenues for food waste to take. Some management companies try to ensure that food waste can be used for positive outcomes. Roughly 3% of food waste goes towards feeding farm animals, and 5% of waste goes into composting, which is used to feed crops. Unfortunately, these numbers aren't terribly large, as this combined 8% is sourced from the few supermarkets that coordinate adequate food waste disposal. In the case of household-generated waste, it typically goes towards landfills, as most families lack the time or reason to ensure waste goes towards a positive destination.

Tertiary Stakeholders

The last group encompasses waste management companies, whose business models could be impacted by successful waste reduction, and technology platform providers who might integrate with or compete against such a solution. Educational institutions seeking to implement sustainability programs and researchers studying food systems also represent tertiary stakeholders. These groups do not have a direct hand in either creating or disposing of food waste, but rather attempt to promote healthy and sustainable waste management through activism.

Sustainability organizations such as ReFED and the EPA work with supply chains and governments to produce sustainable solutions for reducing food waste. They work on the sidelines of food production, gathering data regarding food production and consumption, while

also advising businesses on ways to reduce the waste they produce. Ultimately, their goal is to reduce the inadequate disposal of food waste, as they best understand the consequences of food waste.

Environmental advocates are organizations that, while not strongly tied to food waste, have something to gain from food waste reduction. They understand that food waste not only negatively impacts stores and consumers but also leaves a mark on the environment. The EPA recognizes that the second largest contributor to pollution is methane produced by rotting food in landfills, and that 6% of greenhouse gas emissions come from the food disposal process used by waste management.

Task Analysis

Environment

Depending on how the system is implemented, users will interact with the app in a variety of environments. In the home, individuals will use the system to plan meals, track inventory, and receive reminders about food that may spoil. For college students and young adults living independently, this environment often includes small kitchens, limited budgets, and a lack of cooking experience. Busy families face similar struggles, with time constraints often forcing them to rely on quick purchases instead of careful planning. In grocery stores, restaurants, and farmers markets, food producers and vendors may use the system to post surplus goods, discounted items, or community giveaways. Community spaces like food banks, pantries, or gardens provide another environment where the app could facilitate donations and exchanges. These different contexts show that food waste is not confined to one location, and the app must be flexible enough to adapt to household, retail, and community uses.

Tasks

Food waste reduction spans a wide set of tasks, many of which overlap between households, producers, and community organizations. While there are countless ways individuals and groups interact with food, several recurring categories emerge as the most common and impactful tasks for users. Listed are several categories of tasks and actions a user may want to take.

1. **Planning and Shopping**
   One of the first points where waste occurs is during food purchasing. Users must plan meals, make grocery lists, and decide how much food is realistic for their household. Without proper planning, people over purchase, give in to impulse buys, or forget what they already have at home. The app could address these tasks by generating shopping lists based on existing inventory, syncing with store or farmers market offerings, and suggesting meal prep strategies that align with budget and health goals.

1.1 Assess current inventory 1.1.1 Check refrigerator contents 1.1.2 Review pantry items 1.1.3 Note expiration dates 1.2 Plan meals for upcoming period 1.2.1 Consider household size and preferences 1.2.2 Account for budget constraints 1.2.3 Factor in time availability for cooking 1.3 Generate shopping list 1.3.1 Compare planned meals with current inventory 1.3.2 Add missing ingredients 1.3.3 Verify quantities needed 1.4 Execute shopping trip 1.4.1 Navigate to store/market 1.4.2 Purchase items from list 1.4.3 Avoid impulse purchases

2. **Inventory and Consumption**
   Once food enters the home, tracking becomes the main task. Users monitor expiration dates, organize storage, and decide how to use ingredients before they spoil. In reality, this often fails, as food is pushed to the back of the fridge or pantries and forgotten. With features like barcode scanning, expiration reminders, and recipe suggestions based on what is about to expire, the app could make inventory management seamless. These tasks not only prevent food from being wasted but also encourage users to try new meals and adopt healthier eating habits. Visual accessibility considerations for inventory tasks include ensuring expiration date displays use hight contrast text and colorblind-safe (blue/yellow/ instead of red/green).

   2.1 Track food items 2.1.1 Log new purchases using barcode scanning 2.1.2 Input expiration dates 2.1.3 Organize by storage location (fridge, pantry, freezer) 2.2 Monitor food status 2.2.1 Receive notifications about approaching expiration dates 2.2.2 Assess food condition regularly 2.2.3 Prioritize items for immediate use 2.3 Consume food efficiently 2.3.1 Access recipe suggestions for expiring items 2.3.2 Prepare meals using available ingredients 2.3.3 Store leftovers properly Visual accessibility considerations: Ensure expiration date displays use high contrast text and colorblind-safe colors (blue/yellow instead of red/green).

3. **Sharing and community**
   Food waste can also be reduced by connecting households and organizations. Users may have surplus items they no longer need, which could be given to neighbors, community groups, or food banks. Sharing platforms like Olio have shown promise, but they often rely heavily on active user participation. By integrating sharing into the core of the system, the app could make donation or giveaway tasks easier. For example, when an item is flagged as close to expiration, the system could prompt users to post it to the community feed or suggest a local food bank drop off. In addition, community gardens and farmers markets could use the app to distribute extra produce or connect with volunteers.

   3.1 Identify surplus items 3.1.1 Recognize excess food quantities 3.1.2 Determine items approaching expiration 3.1.3 Assess personal consumption capacity 3.2 Post items for sharing 3.2.1 Create listing with item details 3.2.2 Upload photos if needed 3.2.3 Set pickup preferences 3.3 Coordinate exchange 3.3.1 Communicate with interested parties 3.3.2 Arrange pickup time and location 3.3.3 Complete transfer of items

4. **Education and Advocacy**
   Another important task is learning about food waste and building better habits. While most users understand waste is a problem, many lack knowledge about food storage, expiration labeling, or the environmental costs of throwing food away. The app could embed educational features that teach these skills, but in a way that feels interactive and rewarding rather than like a lecture. Gamification could be used here by allowing users to earn badges or rewards for completing challenges such as finishing leftovers, cooking from pantry staples, or reducing weekly waste. Over time, these tasks could shift attitudes about food, making sustainability feel both accessible and personal.

   4.1 Access learning materials 4.1.1 View storage tips and guidelines 4.1.2 Learn about food waste environmental impact 4.1.3 Discover new recipe techniques 4.2 Participate in challenges 4.2.1 Complete waste reduction goals 4.2.2 Earn badges for sustainable practices 4.2.3 Track progress over time 4.3 Share knowledge 4.3.1 Contribute tips to community 4.3.2 Rate and review educational content 4.3.3 Encourage others in sustainability efforts

5. **Distribution**
   On a broader scale, producers and retailers must complete distribution related tasks. Farmers, manufacturers, and grocery stores often have surplus food that they cannot sell through normal channels. Food banks and charities try to absorb some of this waste, but current redistribution systems are fragmented. The app could streamline this by creating a digital marketplace for surplus food, allowing producers to post excess inventory and connect directly with consumers or charitable organizations. By making distribution more transparent and efficient, the app would help keep large amounts of food out of landfills.

   5.1 Post surplus inventory 5.1.1 Assess excess stock quantities 5.1.2 Create marketplace listing 5.1.3 Set pricing or donation terms 5.2 Manage distribution logistics 5.2.1 Coordinate with buyers/recipients 5.2.2 Arrange pickup or delivery 5.2.3 Process payments if applicable 5.3 Track impact 5.3.1 Monitor food waste reduction 5.3.2 Measure community engagement 5.3.3 Adjust distribution strategies

Specific Example Solution

A practical example of how these tasks could come together would be the app's integration with a local farmers market. Vendors could post daily surplus produce, which students and families nearby could claim through the app either at reduced prices or for free. At the same time, the app could notify users that certain items in their home are expiring and suggest recipes combining those ingredients with the available market produce. If a user had too much food to handle, they could offer it on the app's sharing feature, allowing neighbors or local food banks to pick it up. This specific use case demonstrates how planning, inventory, sharing, education, and distribution all operate within one connected system.

Data Analysis

Walkthrough of an existing system:

One existing system that attempts to address food waste is **Too Good To Go**. When a user opens the app, they are immediately shown nearby restaurants, bakeries, and grocery stores offering surplus food at discounted prices. The user selects a location, views a “surprise bag” of items available, and makes the purchase through the app. After payment, the system generates a digital receipt and a pickup time window. At the designated time, the user arrives at the store to collect their order.

This walkthrough reveals both strengths and limitations. Too Good To Go successfully connects consumers with businesses that would otherwise discard food, offering a cost-saving incentive for users while reducing commercial waste. However, the app does not address household-level waste, which accounts for a large portion of discarded food. It also requires users to travel to participating stores, which can be a barrier to consistent adoption.

Scholarly Research:

Scholarly work highlights the urgency of addressing food waste and the effectiveness of digital interventions. The UN Food and Agriculture Organisation (FAO) (2011) estimates that 1.3 billion tonnes of food are wasted globally each year, amounting to one-third of all food produced for human consumption. Collins (2022) discusses how gamification in sustainability-focused applications can increase user engagement and long-term adherence, an approach relevant to household food waste solutions.

Yu et al. (2023) conducted a comprehensive study on the FoodWise system, which combined data visualization dashboards with gamification elements to reduce food waste on university campuses. Their two-week deployment at Hong Kong University of Science and Technology engaged over 200 participants and resulted in over 800 logged food-saving actions. The research demonstrated that combining awareness-raising through data visualization with behavioral incentives through gamification can effectively promote sustainable food consumption behaviors in institutional settings.

A study by Sijtsema et al. (2020) in the *Journal of Cleaner Production* found that consumers are more willing to change behaviors when digital tools provide both convenience and motivation. Additionally, research by Hebrok and Boks (2017) highlights that a lack of knowledge about storage and meal planning is one of the key drivers of household food waste. Collectively, these studies suggest that integrating **education, behavioral nudges, and user-friendly interfaces** into digital systems can enhance their impact.

1. Household Food Waste:

        - The average American household discards 257 pounds of food annually, suggesting that there is significant room for improvement through better planning, tracking, and consumption practices.
          Common causes include over-purchasing, lack of meal planning, and improper storage of perishable items.
        - 78% of respondents say reducing the amount of food they throw away would be good
        - https://www.nrdc.org/bio/andrea-collins/additional-research-household-food-waste
- 120 billion pounds of food waste in the states
    - https://www.rts.com/resources/guides/food-waste-america/

- Associated with food waste, packaging and non-consumable material used along the food chain add pressure on the environment and represent a burden for consumers and producers.

2. Global Food Waste Patterns:

- The FAO estimates that 1.3 billion tonnes of food are wasted annually worldwide, roughly one-third of all food produced for human consumption.

- This level of waste has severe environmental impacts, including methane emissions from landfills, excessive resource usage (water, energy, labor), and economic loss for both producers and consumers

3. Consumer Behavior & Food Waste Mitigation:

- Research shows that interventions such as gamification, recipe suggestions, and food sharing can positively influence consumer behavior toward reducing waste. For instance, apps like the “Beste Reste-App” encourage the use of leftovers, while Olio connects neighbors to share surplus food.

- Survey data suggests that people respond well to interactive, technology-driven solutions that are easy to use and integrate into daily routines.
- How do people respond to food waste mitigation?
    - https://dl.acm.org/doi/10.1145/3588001.3609364
    - Gamification example^^

The data indicates that household food waste is a key area for intervention, particularly among populations like students and busy families who may lack cooking skills or planning time.

Digital tools should focus on planning, tracking, and sharing, combining awareness, engagement, and convenience to reduce waste effectively.

Incorporating gamification, notifications, and easy-to-use interfaces can improve user adherence and foster sustainable habits.

The analysis of household, national, and global data demonstrates that food waste is a widespread and multifaceted problem. There is a clear opportunity for digital solutions that target consumer behavior, improve inventory management, and promote sharing and reuse of surplus food.

Functionality:

The proposed system will provide the following core functions to support users:

1. **Automated Food Tracking:** Track groceries and expiration dates to reduce spoilage.

2. **Recipe Suggestions:** Generate personalized recipes using items the user already has, help with meal planning and prepping food.

3. **Food Sharing Feature:** Enable users to share surplus items with neighbors or community members. Farmers markets and grocery stores can distribute/sell produce to users.

4. **Reminders & Tips:** Provide notifications about food nearing expiration and best practices for storage.

5. **Gamification & Rewards:** Encourage consistent use by rewarding users for reducing waste (e.g., badges, progress tracking).

6. **Accessibility Features**: High contrast visual modes for users with visual impairments, colorblind-friendly color schemes avoiding problematic red/green combinations, adjustable text size options, and simple toggle controls for customization.

Criteria for Success:

1. **Design Validation**
    a. The prototype successfully addresses at least 3 of the 5 task categories as listed under task analysis. The remaining 2 categories show clear design consideration or are excluded based on justified scope limitations.
2. **User Experience**

    a. At least 8 out of 10 users can navigate the core system without assistance and a minimal introduction
    b. Users rate the overall system and functionality 3.5 or higher on a 5 point scale
3. **Problem-Solution Alignment**
    a. Design decisions can be traced back to specific stakeholder needs identified in the analysis
    b. The user interface accounts for environmental constraints identified (small kitchens, time limitations, and budget constraints)
4. **Educational Impact**
    a. Users demonstrate improved knowledge about food storage and waste reduction practices after interacting with the system for 2 weeks
    b. At least 60% of users report feeling more confident about food storage and meal planning

Synthesis:

Survey data indicates that 78% of respondents believe reducing food waste would be beneficial, yet households continue to discard an average of 257 pounds of food per year. Global estimates from the FAO show that one-third of all food produced is wasted, while U.S. statistics highlight 120 billion pounds wasted annually. These findings underscore the widespread scale of the problem.

Existing systems, such as Too Good To Go, demonstrate that digital platforms can reduce waste at the business level, but household waste remains inadequately addressed. Scholarly research shows that interventions combining education, gamification, and convenience are most effective in changing consumer behavior. Stakeholder analysis further supports this direction: students, busy families, and low-income households require solutions that minimize manual effort and maximize usability.

By integrating food tracking, recipe suggestions, and sharing features into one platform, the proposed system responds to both user needs and research insights. It merges consumer motivation (desire to save money and waste less) with practical support (automated reminders, storage tips) and social features (sharing within the community). This synthesis of data, stakeholder needs, and academic research justifies the development of a comprehensive, household-focused solution to food waste.