Cleveland State University

March 1st, 2025

WASTEWISE

Maximizing Resources, Minimizing Waste

— Strategic Approaches to Mitigating U.S. Food Waste —

PROPOSAL

IST 621 Advanced System Analysis & Design

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1. Needs Assessment

1.1 Problem Statement

Food waste is a significant challenge in the United States, with 30-40% of the national food supply—equivalent to 60 million tons (120-133 billion pounds) annually—going to waste (*Food: Material-Specific Data | US EPA*, 2025). This results in economic losses ranging from $161 billion to $218 billion each year (*Food Waste FAQs*, 2025). Beyond financial impacts, food waste affects businesses, the environment, and social well-being, contributing to inefficiencies in distribution, supply chain logistics, and food security. Addressing this issue through data-driven strategies can enhance distribution efficiency, optimize food logistics, and reduce overall waste. This project proposes an AI-powered, real-time food waste prediction system that leverages blockchain technology to facilitate efficient food redistribution, minimize surplus waste, and improve transparency in the supply chain.

Impact on Organizations

- **Economic Costs:** Businesses suffer substantial losses due to unsold goods, inefficient supply chains, and disposal expenses, contributing to a global economic loss of approximately $2.6 trillion annually (*Addressing the Impacts of Food Loss and Waste - FP Analytics*, 2022).
- **Environmental Consequences:** Food waste contributes to 8-10% of global greenhouse gas emissions, exacerbating climate change through methane emissions from landfills and resource wastage (Goodwin, n.d.).
- **Social Implications:** Despite widespread food waste, millions experience food insecurity. In the U.S., 38% of all food remains unsold or uneaten, equating to 145 billion meals wasted each year (*Food Waste in America: How You Can Help Rescue Food | Feeding America*, n.d.).

Data Collection for Waste Management

To effectively reduce food waste, organizations must implement data-driven strategies to:

- **Quantify Waste:** Accurately measure discarded food volume, financial losses, and environmental impact.

- **Identify Inefficiencies:** Collect and analyze data from supply chain processes, storage conditions, and distribution networks.
- **Stakeholder Insights**: Gather feedback from producers, retailers, and consumers to understand behavioral and operational contributors to food waste.

1.2 Root Cause Analysis

1.2.1 Flowchart Diagram

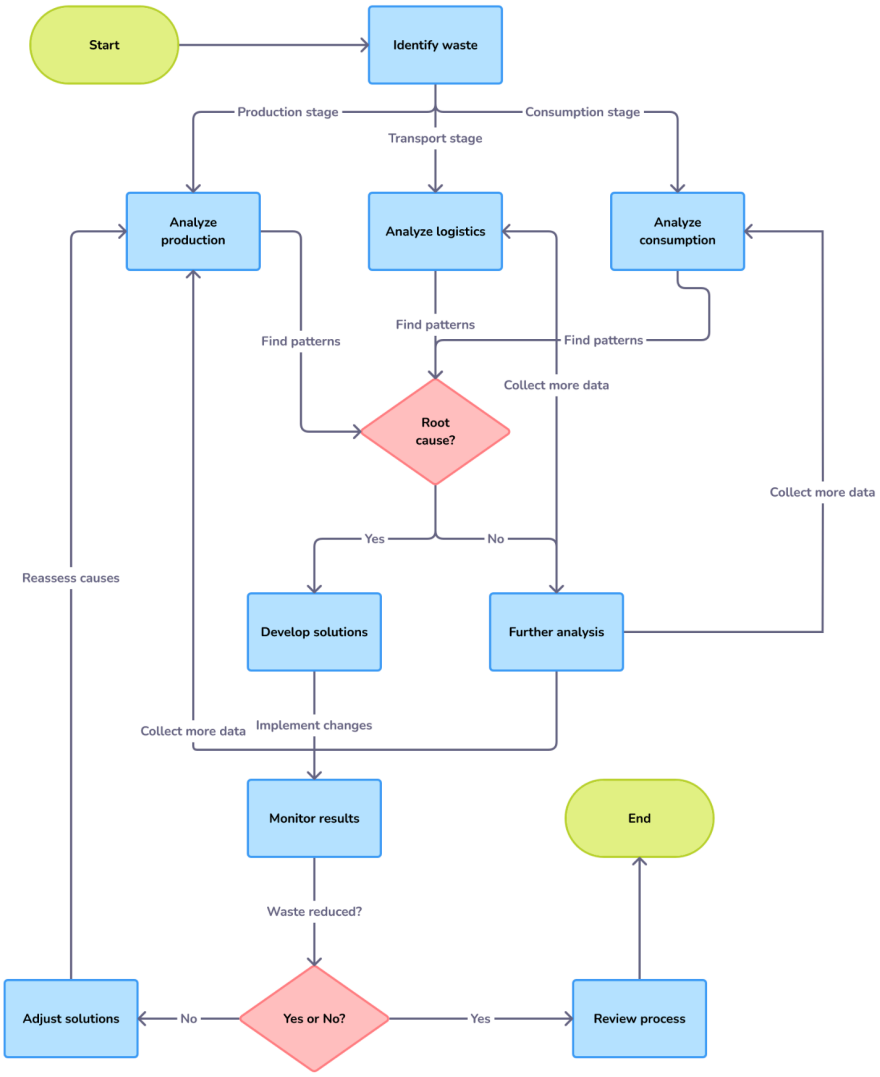
The WasteWise initiative employs a structured and iterative method to discovering, assessing, and reducing food waste using data-driven insights and AI-powered predictive analytics. The method starts with identifying important food waste sources, which can come from three major sections of the food supply chain: production, logistics, and consumption. Each of these categories is examined individually to identify inefficiencies and waste trends. (Figure 1)

- Analyze Production: This step looks at inefficiencies in food manufacturing, agricultural, and inventory management techniques that contribute to surplus production. Businesses frequently overproduce to fulfill unpredictable demand or to comply with strict supply agreements, resulting in extra food that may go unsold or spoil before consumption.
- Analyze Logistics: Transportation, storage, and distribution issues are evaluated to determine how inefficiencies in handling, spoiling in transit, and insufficient redistribution contribute to food waste. Perishable commodities are frequently abandoned due to ineffective cold-chain management, delays, or mismatched supply schedules that impede timely consumption.
- Analyze Consumption: This phase looks into consumer behavior, retail stocking techniques, and expiration date mismanagement that contribute to food waste. For example, supermarkets overstock shelves to keep them filled, resulting in unsold perishable goods. Restaurants and families both abandon food owing to portion mismanagement or a lack of understanding about food shelf life.

Each of those three areas then takes two different paths:

- Finding Patterns: If patterns in food waste buildup develop, they are investigated further to see if they hint at an underlying source of inefficiency.
- Collecting More Data: If clear patterns are not immediately apparent, extra data collecting and analysis are carried out to sharpen insights and enhance decision-making.

Figure 1 - Food Waste Flow Analysis



If a root cause is discovered, the process proceeds to develop specific solutions to address the problem. These solutions may include AI-driven demand forecasts, supply chain optimization, real-time tracking of food redistribution, or governmental interventions to improve food safety compliance. Once a solution is implemented, the system determines whether food waste has been successfully decreased. If the solution is successful, the process advances to the review step to assure long-term viability. However, if food waste persists, additional analysis is performed, necessitating changes to the solution or a thorough reconsideration of waste sources to improve methods.

1.2.2 Five Whys Analysis

The project utilizes the Five Why analysis to identify the underlying causes of food surplus within the U.S. supply chain, particularly among food suppliers, distributors, and food banks. By systematically examining the contributing factors, this analysis provides a structured understanding of inefficiencies that lead to food waste. Addressing these root causes through an AI-powered food waste prediction and redistribution system will enable a more sustainable and efficient approach to food management.

- **Excess food accumulation within the supply chain:** Why do businesses consistently overproduce and overstock perishable goods, leading to significant food surplus?

Inaccurate demand forecasting results in a big surplus of food, prompting food suppliers, retailers, and distributors to overproduce and overstock. Businesses typically purchase more perishable commodities than they require to maintain consistent inventory levels and avoid stockouts, resulting in excess food that goes unsold or underutilized. Grocery stores, for example, frequently buy too much fresh food to make their shelves appear full, but fluctuating client demand causes a significant fraction of perishable commodities to be sold before their shelf life expires.

- **Ineffective demand forecasting methodologies:** Why do traditional demand forecasting methods fail to accurately predict food demand, resulting in frequent supply-demand mismatches?

Traditional forecasting approaches, which rely mostly on historical sales data rather than real-time consumer behavior patterns, external market conditions, and environmental factors such as seasonality and climate variations, contribute significantly to the inability to effectively predict food demand. These antiquated approaches fail to account for dynamic market variations, resulting in frequent supply-demand mismatches. For

example, a restaurant chain may base ingredient procurement on historical sales data while failing to account for real-time factors such as seasonal dietary preferences or economic downturns that influence client purchase behavior. Misaligned demand predictions result in surplus inventory accumulation.

- **Limited redistribution mechanisms for surplus food:** Why do food suppliers, retailers, and distributors lack an efficient, decentralized system for redistributing surplus food before it becomes waste?

Despite the existence of food donation programs, many suppliers, merchants, and distributors lack a centralized, real-time tracking system for efficiently redistributing excess food. The absence of a digital network that seamlessly connects food donors and food banks impedes timely distribution, leading perishable food products to decay before being repurposed for consumption. For example, a large bakery that produces excess bread daily may be willing to contribute excess inventory. However, due to the difficult and time-consuming nature of food supply coordination, the bakery regularly discards extra rather than spreading it to people in need.

- **Regulatory complexity and liability concerns:** Why are food suppliers and retailers hesitant to participate in food donation programs despite existing legal protections?

Because of the legal ambiguities around food safety and responsibility, many food suppliers and merchants are hesitant to take part in surplus food donation schemes. Food donors are legally protected by laws like the Food Safety Modernization Act (FSMA), but many firms are either ignorant of these protections or believe that compliance requirements are too complicated. As a result, even when food is still fit to eat, excess food is thrown away rather than donated. For instance, despite current rules that protect donors when food is handled carefully, supermarket stores routinely throw away almost expired but still viable food products because of concerns about possible liability issues.

- **Lack of standardized regulatory compliance tracking:** Why is there no universally adopted system for tracking and managing food donations to ensure regulatory compliance?

Participation in donation programs is made more difficult by the sometimes uneven legislative framework controlling food donations between jurisdictions. Companies that are eager to give food often do not have the necessary infrastructure to track and record gifts in a way that guarantees adherence to food safety

laws. Food waste results from the inability of food suppliers to effectively manage excess donations due to the lack of a standardized, transparent tracking mechanism. A food manufacturing company, for example, might be prepared to give its excess packaged foods, but it might not have access to a blockchain-based monitoring system that would provide an auditable and unchangeable record of donation activities. Without this infrastructure, it is still difficult to report compliance, which makes companies throw out food rather than run the risk of breaking food safety regulations.

1.2.3 Causal Factors Identification of Food Waste:

Understanding causal factors across the food supply chain is critical for developing targeted interventions. Key contributors to food waste include:

- **Overproduction:** Agricultural practices focus on maximizing yields, often leading to excess supply that never reaches consumers due to market saturation or storage limitations.
- **Inadequate Storage & Handling:** Poor storage infrastructure, refrigeration failures, and improper handling accelerate spoilage, particularly for perishable goods.
- **Inefficient Supply Chain Management:** A mismatch between supply and demand results in food being transported to areas where it cannot be sold in time, leading to waste at distribution centers and retail locations.
- **Over-Purchasing by Consumers:** Marketing strategies, bulk discounts, and promotional offers encourage excessive purchases, causing household-level food waste.
- **Inaccurate Demand Forecasting:** Retailers and food service providers struggle with demand predictions, leading to overstocking, unsold inventory, or inadequate supply replenishment.
- **Cultural Attitudes & Awareness:** Consumer expectations, lack of awareness, and preference for aesthetically perfect produce result in significant food discards.

1.2.4 Root Causes of Food Waste:

Addressing food waste at its core requires identifying systemic root causes that drive inefficiencies across the supply chain.

- **Market Demand Misalignment:**

    - Agricultural overproduction occurs due to uncertain market conditions and contractual obligations.
    - According to the USDA, market fluctuations can cause up to 20% excess production, leading to surplus disposal.
- **Consumer Expectations & Buying Behavior:**
    - Consumers prefer visually appealing produce, causing large-scale rejection of imperfect fruits and vegetables.
    - The Food and Agriculture Organization (FAO) estimates that 30% of crops are discarded based solely on appearance.
- **Inefficiencies in Food Supply Chain Logistics:**
    - Poor transportation planning, warehouse storage, and inventory mismanagement contribute to 12% of all food waste (logistics and warehousing losses).
    - The lack of smart redistribution networks prevents excess food from reaching food banks and high-need areas efficiently.
- **Regulatory & Policy Barriers:**
    - Confusing expiration labels (sell-by, use-by, best-before dates) lead to premature disposal, accounting for 20% of consumer-level food waste.
    - Strict food safety policies and liability concerns discourage businesses from donating surplus food, even when it remains safe for consumption.

1.3 Change Strategy

1.3.1 Current State:

Food waste in the U.S. persists due to fragmented food redistribution networks, inadequate real-time tracking, inefficient supply chain logistics, and regulatory challenges. Many food suppliers lack predictive analytics to anticipate surplus food, leading to last-minute disposal instead of redistribution. Compliance with FSMA regulations remains complex, discouraging businesses from donating excess food due to liability concerns and tracking difficulties. Additionally, there is no centralized system to connect suppliers with food banks efficiently, causing valuable food to go to waste instead of reaching those in need.

1.3.2 Future State:

The WasteWise system will introduce an AI-powered food waste prediction platform that enables food suppliers, distributors, and food banks to proactively manage surplus food. By leveraging machine learning models and blockchain transparency, the system will:

- **Predict surplus food** and provide real-time insights for suppliers to take action before waste occurs.
- **Ensure regulatory compliance** by securely logging food transactions on the Ethereum blockchain, providing an immutable and auditable record.
- **Enhance food redistribution** by automating food donation matching between suppliers and food banks based on availability, demand, and proximity.
- **Reduce food waste at every stage** of the supply chain through data-driven decision-making, benefiting businesses economically and communities socially.

1.3.3 Change Strategy Selection:

To achieve the above objectives, the system will incorporate:

- Real-Time AI/ML Analytics: An AI-powered demand forecasting model will analyze historical trends, inventory levels, and real-time market conditions to predict surplus before it occurs.
- Blockchain-Based Transparency: Food suppliers and food banks will have access to an immutable blockchain ledger, ensuring secure, tamper-proof tracking of surplus food transactions to comply with FSMA and liability protections.
- Automated Food Redistribution Network: The system will match surplus food with the nearest food banks based on demand, urgency, and logistical feasibility, ensuring faster, more efficient donations.
- Smart Alerts & Compliance Tracking: Businesses will receive automated compliance notifications, donation reminders, and real-time updates on food expiration risks to encourage timely redistribution.

This integrated, technology-driven approach will enable predictive waste management, seamless regulatory compliance, and a streamlined donation network, positioning WasteWise as a transformative solution for food waste reduction in the U.S.

2. Stakeholder Identification

2.1 Stakeholder List:

- **Food suppliers and distributors:**

  Definition: Food suppliers and distributors are companies that source, store, and transport food to retailers, restaurants, and consumers. They play a key role in making sure food reaches the right places at the right time.

  Roles in the Project:

  - Share real-time data on surplus inventory, fluctuations in demand, and spoilage rates to enhance predictive accuracy.
  - Utilize AI-powered insights to optimize inventory management, preventing overstocking and unnecessary waste.
  - Collaborate with food banks and nonprofit organizations to streamline the donation process, ensuring surplus food is redistributed efficiently instead of being discarded.
  - Improve forecasting and supply chain coordination by integrating AI-driven analytics into their operations.

- **Regulatory agencies (FDA, USDA):**

  Definition: The FDA and USDA are government agencies responsible for establishing and enforcing food safety and waste management regulations. They ensure compliance with food handling, distribution, and donation standards.

  Roles in the Project:

  - Provide regulatory guidelines to ensure food safety during surplus redistribution, minimizing legal risks for suppliers and donors.
  - Support food waste reduction through policy advocacy, incentives, and regulatory frameworks that encourage responsible food donation.

- Work with stakeholders to simplify compliance with the FSMA and other relevant food safety laws.
- Facilitate partnerships between businesses and food donation programs by clarifying liability protections under legislation like the Bill Emerson Good Samaritan Food Donation Act.

- **Nonprofit organizations and food banks:**

  Definition: Nonprofit organizations and food banks collect and distribute extra food to people in need. They help reduce food waste by connecting suppliers with those who lack access to food.

  Roles in the Project:

  - Leverage AI-driven food waste prediction models to optimize collection schedules and distribution logistics.
  - Work closely with food suppliers and logistics teams to ensure that excess food reaches people in need before spoilage.
  - Provide feedback on the effectiveness of redistribution efforts, helping refine the AI model to improve efficiency over time.
  - Expand partnerships with suppliers and donors by demonstrating the effectiveness of data-driven redistribution strategies.

- **Logistics and transportation companies:**

  Definition: Logistics and transportation companies handle the movement of food from suppliers to stores, restaurants, and food banks. They ensure food is delivered on time and stays fresh during transport.

  Roles in the Project:

  - Utilize AI-generated insights to optimize delivery routes, reduce fuel consumption, and lower transportation costs.
  - Improve cold-chain logistics to ensure perishable food remains safe and usable during transit.
  - Facilitate real-time tracking of food shipments to enhance visibility and minimize delays in redistribution efforts.

- Collaborate with food banks to ensure efficient and timely pickup of surplus food for redistribution.

- **Developer team:**

  Definition: The developer team consists of AI engineers, data scientists, and software developers who will build the food waste prediction system. They will create a smart platform that helps track and predict food surplus.

  Roles in the Project:

  - Develop machine learning models capable of accurately forecasting food surplus and demand fluctuations.
  - Design an intuitive dashboard interface that enables stakeholders to track surplus food and optimize redistribution in real-time.
  - Integrate the system with supply chain tools, logistics software, and regulatory compliance databases.
  - Implement blockchain-based tracking to ensure transparency and accountability in food donations.
  - Continuously refine the AI model by incorporating real-time data, feedback, and external market conditions

2.2 Stakeholder Power-Interest Grid:

The Power-Interest Grid categorizes stakeholders based on their level of influence (power) over the project and their interest in its success. Below is how the stakeholders in the AI-powered food waste prediction system fit into this grid:

1. High Power – High Interest (Key Players)

- Food Suppliers and Distributors → They directly control food supply, distribution, and waste, making them essential for implementing AI-driven food management strategies.

- Regulatory Agencies (FDA, USDA) → These agencies set the rules for food safety and redistribution, influencing how the system must comply with legal standards.

2. High Power – Low Interest (Key Players)

- Logistics and Transportation Companies → They influence food distribution and waste reduction but may not actively engage unless efficiency improvements impact their operations positively.
- Developer Team → They have power over technical implementation but may not be directly invested in food waste reduction beyond building the system.

3. Low Power – High Interest (Keep Informed)

- Nonprofit Organizations and Food Banks → They are highly interested in the project's success as it helps them get food to people in need but have little power to enforce changes.

4. Low Power – Low Interest (Monitor)

- General Public & Consumers (not listed in the original stakeholders but indirectly affected) → While they may benefit from reduced food waste and better food access, they have limited influence on the project's execution.

Grid Representation:

Stakeholder	**Power**	**Interest**	**Category**
Food Suppliers & Distributors	High	High	Key Players
Regulatory Agencies (FDA, USDA)	High	High	Key Players
Logistics & Transportation Companies	High	Low	Key Players
Developer Team	High	Low	Key Players
Nonprofit Organizations & Food Banks	Low	High	Keep Informed
General Public & Consumers	Low	Low	Monitor

3. Requirements Elicitation

3.1 Interview Guides:

To gather essential requirements for the AI-powered food waste prediction system, structured and unstructured interviews will be conducted with key stakeholders. These interviews will help identify challenges, expectations, and potential improvements in food redistribution.

- **Structured interviews:** will be conducted with food suppliers, distributors, and regulatory bodies such as the FDA and USDA. These stakeholders play a crucial role in food distribution and compliance, making it important to collect precise and standardized information. The interviews will focus on understanding surplus food generation, current inventory management practices, regulatory constraints, and data availability. This structured approach ensures consistency in responses, making it easier to identify trends and key system requirements.
- **Unstructured interviews:** with nonprofit organizations and consumers will help identify food redistribution challenges such as logistical issues, donation barriers, and transportation inefficiencies. These open-ended discussions will provide insights into food accessibility, public awareness, and consumer trust in redistributed food. Understanding these real-world problems will ensure the AI-powered system effectively improves food redistribution and minimizes waste.

3.2 Document Analysis:

A thorough document analysis will be performed to create a strong AI-powered food waste prediction system that meets both regulatory and operational needs. This process will include analyzing legal norms, industry laws, and historical data to ensure compliance while improving forecast accuracy. This examination will include a review of FSMA regulations.FSMA is critical to food safety and waste management, and this assessment will assist in establishing compliance criteria for food handling, storage, transportation, and redistribution. When repurposing extra food, regulatory compliance is critical, especially for donation and redistribution operations. Furthermore, compliance with other legal frameworks, such as the Bill Emerson Good Samaritan Food Donation Act, will be assessed to provide liability protection for stakeholders engaging in food donation projects.

Aside from regulatory compliance, a complete historical data analysis will be conducted to discover patterns and major variables contributing to food waste. The AI model will be trained to detect inefficiencies and estimate surplus more precisely by using US government food waste statistics, supply chain reports, and market trends as inputs. This data-driven approach will enable the system to identify the best redistribution techniques, decreasing waste while increasing the effective use of surplus food. The WasteWise solution will help food producers, distributors, and organizations reduce food waste efficiently and legally by combining regulatory compliance reviews with AI-powered analytics. This dual strategy assures that the system not only maximizes redistribution efforts, but also complies with food safety regulations, industry best practices, and environmental objectives.

4. Possible Solutions

4.1 Potential Solutions:

To address the issue of food waste, several solutions have been considered, ranging from manual tracking to advanced AI-driven systems. Each solution has its strengths and limitations in terms of cost, efficiency, and effectiveness in optimizing food redistribution.

- **Manual Tracking System:** A low-cost method that records food surplus manually using spreadsheets or logs. However, it is inefficient, prone to errors, and lacks real-time tracking, making food waste reduction difficult.
- **Basic Data Collection Platform:** A digital system that improves tracking accuracy but lacks predictive capabilities. While it helps monitor food waste trends, it does not provide real-time insights or optimize food redistribution.
- **AI-Driven Predictive Analytics Platform (Proposed Solution):** An advanced system that uses AI to analyze waste patterns, predict surplus, and optimize food redistribution. It offers real-time monitoring, improves efficiency, and significantly reduces food waste.
- **Blockchain-Based Food Tracking System (Future Improvement):** A transparent and tamper-proof solution ensuring full traceability of food movement. While it enhances accountability, its high implementation costs and adoption challenges make it less feasible for immediate use.

4.2 Justification:

The AI-driven predictive analytics platform is the most effective solution as it aligns with FSMA regulations, ensuring compliance with food safety and waste management laws. By leveraging real-time monitoring and machine learning, it optimizes logistics and distribution, reducing inefficiencies in food supply chains. The system helps minimize food waste by accurately forecasting surplus food availability and directing it to where it is needed most. Additionally, it enhances social impact by streamlining food redistribution to nonprofits and food banks, ensuring surplus food reaches those in need before it spoils. This data-driven approach improves operational efficiency, reduces costs, and supports sustainable food management.

5. System Value Analysis

5.1. Expected Costs & Benefits:

5.1.1 One-Time Costs:

Category	Description	Cost
System Development	AI model training and testing	$25,000
	Backend and frontend development	$20,000
	Database and API integrations	$10,000
Infrastructure & Deployment	Cloud storage and computing resources	$7,500
	Security and compliance setup (FSMA regulations)	$5,000
	Data acquisition and preprocessing	$5,000
Training & Implementation:	User training for food suppliers and food banks:	$2,500

	Initial onboarding and setup support	$5,000
Estimated One-Time Cost Total		$80,000

5.1.2 Recurring Costs:

Category	Description	Cost (Monthly)	Cost (Yearly)
Operational Maintenance	Server and cloud storage costs	$2,500	$30,000
	AI model retraining and updates	$1,500	$18,000
	Software updates, bug fixes, and security patches	$1,250	$15,000
Support & Customer Service	Technical support and stakeholder onboarding	$2,000	$24,000
	Compliance monitoring and reporting	$1,000	$12,000
Estimated One-Time Cost Total		$8,250	$99,000

5.1.3 Benefits:

- **Operational Efficiency:**
    - Improved food distribution by predicting surplus in real-time
    - Reduction in overstocking and expiration-related waste

- **Regulatory Compliance:**
    - Automated compliance tracking for FSMA requirements
    - Real-time reporting for regulatory agencies
- **Social & Environmental Impact:**
    - Increased food donations to food banks and nonprofit organizations
    - Reduction of greenhouse gas emissions from food waste decomposition
- **Economic Impact:**
    - Cost savings for food suppliers and retailers by reducing disposal expenses
    - Potential revenue from carbon credits due to lower food waste generation

5.2 Main Features:

- **AI/ML-Based Predictive Analytics:** Identifies patterns in food waste trends and predicts surplus generation.
- **Real-Time Data Tracking:** Monitors food stock levels and expiration timelines.
- **Automated Alerts for Redistribution:** Notifies food banks and suppliers when a surplus is detected.
- **Compliance Monitoring for FSMA Regulations:** Ensures food safety and adherence to waste disposal policies.
- **Integration with Food Banks & Donation Platforms:** Seamlessly connects excess food supply with demand through a digital platform.

6. Agile Project Planning

6.1 Sprint Requirements:

Each sprint will last two weeks, with incremental development and testing. Below is a breakdown of sprint activities:

Sprint #	Focus Area	Key Tasks
1	Research & Planning, Stakeholder Identification	Conduct market and regulatory research, define project scope, create a stakeholder list, and set up development

		tools.
2	Requirements Gathering, System Architecture	Conduct interviews, analyze documentation, draft system requirements, and develop use case diagrams.
3	Initial Wireframes, Blockchain Database Setup	Design UI/UX wireframes, set up Ethereum-based database schema, integrated smart contracts and outlined API structure using Node.js and Web3.js.
4	AI Model Development & Testing	Collect and preprocess food waste data, train AI model, and test prediction accuracy.
5	Backend API Development	Develop RESTful API endpoints, integrate AI predictions into the backend, retrieve blockchain-stored data using Node.js and Web3.js, and implement authentication and security measures.
6	Frontend Dashboard Implementation	Build supplier and food bank dashboards, integrate real-time data tracking, and refine UI/UX design.
7	System Integration & Optimization	Connect the front end with the backend, optimize API performance, and conduct load testing.
8	Final Testing & Deployment	Conduct unit and integration testing, deploy the system, gather user feedback, and finalize documentation.

6.2 User Stories:

The user stories highlight the core functionalities required for key stakeholders to ensure an efficient and transparent food waste management system. Food suppliers need real-time blockchain-powered alerts to track surplus food and facilitate instant redistribution, minimizing waste and maximizing inventory efficiency. Food banks depend on real-time tracking integrated with Ethereum-based storage, ensuring secure and verifiable data on surplus availability and expiration timelines, allowing them to prioritize collection efficiently. Regulatory bodies require automated FSMA compliance reports enhanced with blockchain transparency, providing tamper-proof analytics to detect inefficiencies and enforce food safety regulations effectively. By addressing these critical needs, the system enhances food redistribution accuracy, regulatory compliance, and long-term sustainability in food waste management.

User Type	Story

Food Supplier	As a supplier, I want to receive automated alerts when a food surplus is detected so that I can take immediate action to reduce waste and optimize inventory.
	As a supplier, I want to securely log surplus food details on the blockchain so that I can maintain transparency and compliance.
	As a supplier, I want to track food donation requests in real time so that I can efficiently distribute surplus food to food banks.
Food Bank	As a food bank manager, I want to view available surplus food in real-time with detailed expiration data so that I can prioritize collection and distribution effectively.
	As a food bank manager, I want to verify the authenticity of surplus food records on the blockchain so that I can ensure food safety compliance.
	As a food bank manager, I want to request food donations from suppliers through an automated system so that I can efficiently plan resource allocation.
Regulator	As a regulatory, I need automated compliance reports with data analytics to ensure adherence to FSMA regulations and identify potential violations in food waste handling.
	As a regulatory, I want to access an immutable record of food waste transactions stored on the blockchain so that I can conduct audits with transparency.
	As a regulatory body, I want to receive real-time notifications of potential food safety violations so that I can take immediate action and enforce regulations.

6.3 Sprint Backlogs & Breakdown:

Sprint #	Task	Detailed Task	Priority
1	Project Initialization	Conduct market and regulatory research	High
		Identify key stakeholders	High
		Define project scope	High

		Set up tools	Medium
	Stakeholder Identification	Research & gather stakeholder information	High
		Develop a stakeholder power-interest grid	High
		Document stakeholders and their needs	Medium
2	Requirements Gathering	Define Objectives	High
		Document functional and non-functional requirements.	High
		Validate and prioritize requirements	Medium
	System Architecture Design	Develop initial system architecture	Medium
		Develop a blockchain data structure	High
		Design compliance-tracking framework	Low
3	UI/UX Wireframing	Define user personas	Medium
		Design low-fidelity wireframes for supplier and food bank dashboards.	Medium

		Design high-fidelity wireframes	Low
	Private Blockchain Database Setup	Develop Ethereum-based blockchain schema	High
		Implement a basic smart contract structure	Medium
		Implement security measures	High
4	AI Model Data Collection	Collect and clean historical food waste data from various sources.	High
		Label data and set storage management	Medium
	AI Model Training & Evaluation	Split data and train AI model for food waste prediction	High
		Validate and test model accuracy	High
		Refine algorithms, iterate model, and retrain	Low
5	Backend API Development	Develop RESTful API endpoints for data storage and retrieval	High
		Implement CRUD Operations	Medium
		Deploy and test API	Medium

	Blockchain Integration	Set e-wallet for blockchain connection	Medium
		Retrieve and store food waste transactions on the blockchain using Web3.js	High
	Authentication & Security	Implement authentication and role-based access control for suppliers, food banks, and regulators.	High
		Implement secure password policies	Medium
6	Frontend Dashboard Development	Implement data integration & test functionality	Medium
		Implement UI components for supplier dashboard with real-time tracking.	Medium
	Real-Time Data Visualization	Fetch & integrate data with visualizations	Medium
		Integrate charts and reports for surplus food tracking and history.	Low
7	Full System Integration	Set up middleware	High
		Connect frontend with backend APIs, blockchain, and AI model.	High
	Performance Optimization	Optimize database queries, API response times	High

		Optimize blockchain transaction efficiency.	Medium
	Load & Security Testing	Develop test cases	Medium
		Conduct stress tests on system performance and security audits.	High
8	Final Testing & Deployment	Conduct full system testing, including unit, integration, and user acceptance tests	High
		Deploy and monitor the system	High
	Documentations	Prepare final project documentation	High
		Gather user feedback	Medium
	Closing Project	Obtain final approvals	High
		Project review and lesson learned	Medium
		Close project	Medium

6.4 System Requirements:

Functional Requirements

- The system shall allow food suppliers to log surplus food data and track inventory in real time.
- The system shall generate automated alerts for food banks when surplus food is available.

- The system shall utilize AI to predict food waste based on historical data trends.
- The system shall store all transactions securely on the Ethereum blockchain.
- The system shall enable regulatory bodies to generate compliance reports.
- The system shall provide an intuitive dashboard for suppliers and food banks to visualize surplus food data.
- The system shall support food donation requests and automated matching between suppliers and food banks.
- The system shall integrate with external food tracking and logistics APIs for real-time updates.
- The system shall include role-based access control to manage permissions for different users.
- The system shall allow suppliers and food banks to provide feedback on transactions for performance evaluation.

Non-Functional Requirements

- The system shall support at least 10,000 concurrent users without performance degradation.
- Data processing shall be completed within 2 seconds of request submission.
- The system shall ensure data security through encryption (AES-256) and blockchain immutability.
- The platform shall maintain an uptime of at least 99.5% to ensure service availability.
- The system shall be accessible via web and mobile interfaces, supporting multiple screen resolutions.
- The system shall comply with FSMA regulations and industry-standard food safety guidelines.
- The blockchain ledger shall be immutable to ensure transparency and prevent data tampering.
- The system shall log all transactions for auditing purposes with an exportable reporting feature.
- The system shall allow for modular expansion to accommodate additional functionalities in the future.
- The UI/UX design shall prioritize ease of use with a low learning curve for new users.

7. Prototype

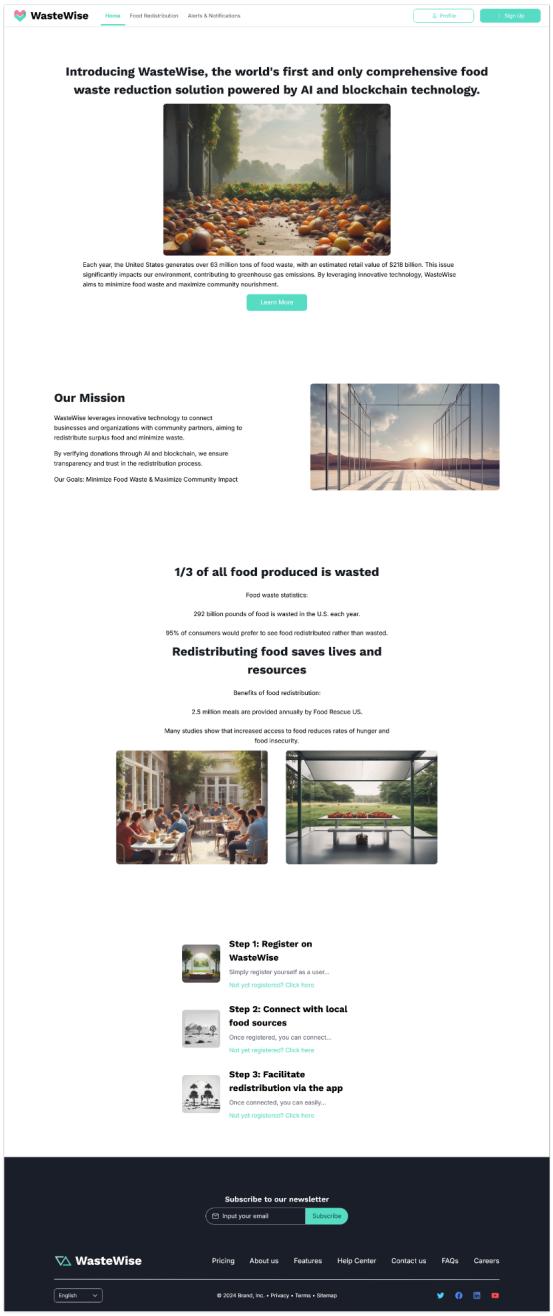
Our WasteWise project prototype will demonstrate the core functionalities of the blockchain-powered AI system designed to predict and prevent food waste through optimized redistribution. It integrates the Ethereum blockchain for secure data storage and AI models for food waste prediction, ensuring transparency

and efficiency in the supply chain. The prototype will consist of five key pages, each designed to showcase essential features:

1. **Landing Page – Introduction & Awareness**
    - Project Overview – Brief description of WasteWise and its purpose.
    - Mission Statement – The vision for reducing food waste through AI and blockchain.
    - Food Waste Statistics – Key facts and numbers on food waste in the U.S.
    - Redistribution Plan – Explanation of how surplus food will be reallocated.
    - Connection Step – How users (suppliers, food banks) can get involved.
2. **Signup Page – *User Registration***
    - Simple registration form with fields for:
        - Name
        - Email Address
        - Password
    - Secure authentication to protect user data.
3. **Home Page – Real-Time Insights & User Dashboard**
    - Real-Time Food Waste Prediction – AI-driven insights on expected surplus.
    - Profile Statistics – User-specific data on contributions and interactions.
    - Category-Based Analytics – Charts showing waste trends by food type.
4. **Food Redistribution Page – Matching Surplus with Needs**
    - Available Food Supply Listings – Displaying food items ready for redistribution.
    - Local Food Bank Connections – Real-time linkage between suppliers and recipients.
    - Food Flow Mapping Chart – Visualization of where food is moving in the network.
5. **Alerts & Notification Page – *Smart Notifications & Customization***
    - Custom Notification Settings – Choose email or SMS alerts.
    - Upcoming Available Food Alerts – Notifications for surplus food near expiration.
    - Tips & Efficient Redistribution Updates – Best practices for minimizing waste.

This prototype will provide a functional preview of how WasteWise will facilitate food redistribution, ensuring efficiency, compliance, and accessibility for all stakeholders.

Landing Page



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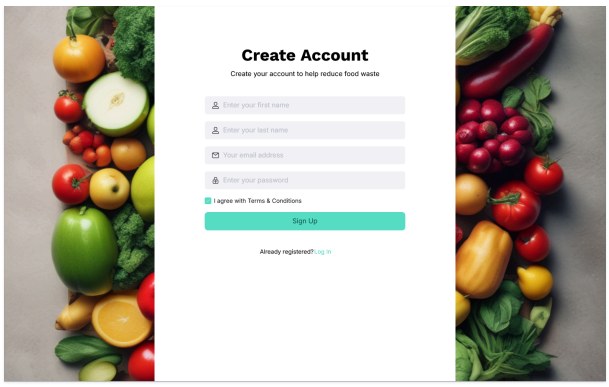
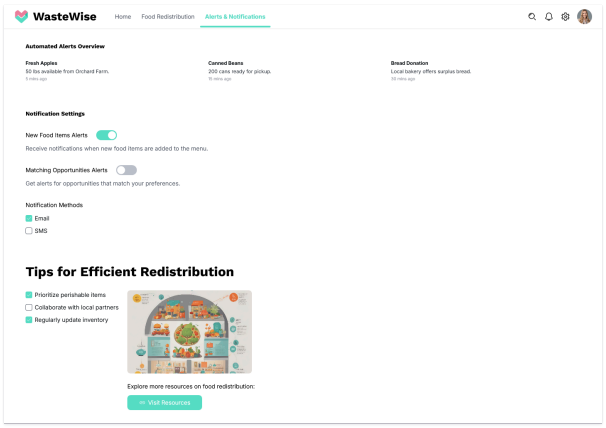
Sign Up Page



Made with Visily

Alerts & Notification Page



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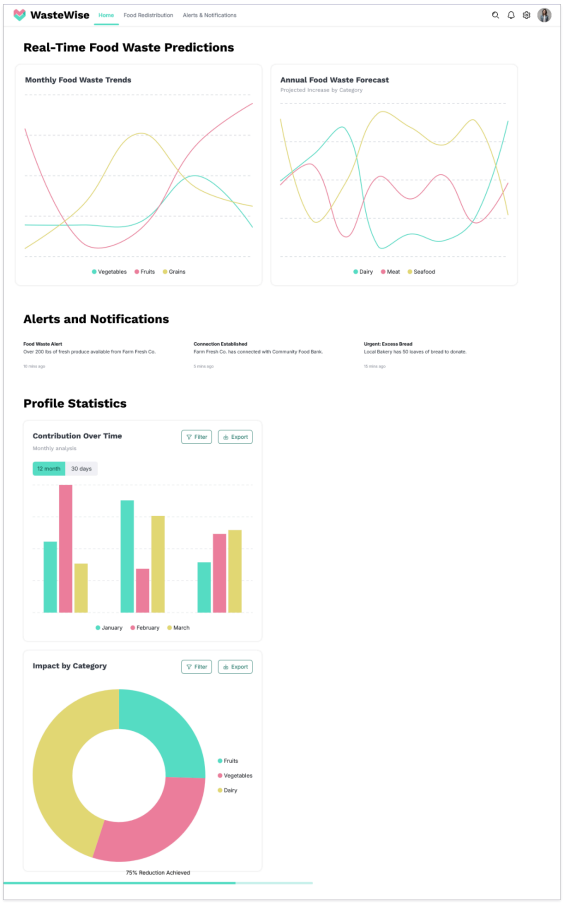
Home Page



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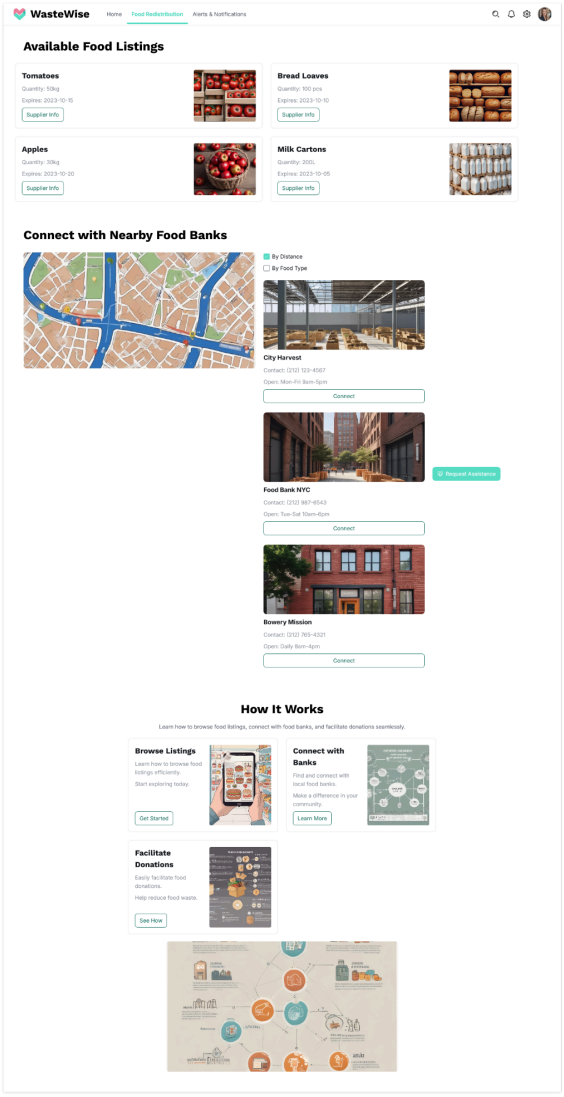
Food Redistribution Page



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8. Prioritized Backlog

The WasteWise project's prioritized backlog has been thoroughly developed to ensure optimal resource allocation and simplified execution. Even though the priority was previously outlined based on general

categories, this part delves deeper by categorizing tasks into two key factors: complexity and project value. This approach allows for a more granular and strategic prioritization, ensuring that tasks with both high complexity and high value—such as defining the project scope, developing the Ethereum-based blockchain schema, and integrating blockchain transactions with the backend API—are tackled first. These fundamental pieces establish the foundations for important system components such as an AI model for predicting food waste and backend API development.

After the high-complexity activities are completed, the focus will turn to medium-complexity, high-value projects such as frontend dashboard development with real-time tracking for suppliers and food banks. This phase will also incorporate data visualization and blockchain integration for transaction storage, both of which are critical to the system's functionality and usability. Smart contract implementation and establishing secure password regulations are medium-complexity tasks that must be completed and will be prioritized.

Simultaneously, less complex activities with considerable value will be addressed, such as documenting final project details, refining algorithms for AI training, and analyzing the project to ensure complete learning and closure. Finally, low-complexity and low-value tasks, such as tool setup or final approvals, will be deferred until the conclusion of the project's life cycle. This organized prioritization guarantees that the project moves forward quickly, with important system components completed and integrated before moving on to secondary activities.

High Complexity & High Project Value	Medium/Low Complexity & High Project Value
Project Initialization: ● Define project scope ● Identify key stakeholders **Stakeholder Identification:** ● Research & gather stakeholder information ● Develop a stakeholder power-interest grid **Requirements Gathering:** ● Define Objectives ● Document functional and non-functional requirements **System Architecture Design:** ● Develop a blockchain data structure **Private Blockchain Database Setup:**	**Stakeholder Identification:** ● Document stakeholders and their needs **UI/UX Wireframing:** ● Define user personas ● Design low-fidelity wireframes for supplier and food bank dashboards ● Design high-fidelity wireframes **Private Blockchain Database Setup:** ● Implement a basic smart contract structure **AI Model Training & Evaluation:** ● Refine algorithms, iterate model, and retrain **Frontend Dashboard Development:** ● Implement UI components for supplier

• Develop Ethereum-based blockchain schema • Implement security measures **AI Model Data Collection:** • Collect and clean historical food waste data from various sources **AI Model Training & Evaluation:** • Split data and train AI model for food waste prediction • Validate and test model accuracy **Backend API Development:** • Develop RESTful API endpoints for data storage and retrieval **Blockchain Integration:** • Retrieve and store food waste transactions on the blockchain using Web3.js **Authentication & Security:** • Implement authentication and role-based access control for suppliers, food banks, and regulators **Full System Integration:** • Set up middleware • Connect frontend with backend APIs, blockchain, and AI model **Performance Optimization:** • Optimize database queries, API response times • Optimize blockchain transaction efficiency **Load & Security Testing:** • Conduct stress tests on system performance and security audits **Final Testing & Deployment:** • Conduct full system testing, including unit, integration, and user acceptance tests • Deploy and monitor the system	dashboard with real-time tracking **Real-Time Data Visualization:** • Fetch & integrate data with visualizations • Integrate charts and reports for surplus food tracking and history **Authentication & Security:** • Implement secure password policies **Blockchain Integration:** • Set e-wallet for blockchain connection **Backend API Development:** • Implement CRUD Operations • Deploy and test API **Performance Optimization:** • Optimize blockchain transaction efficiency **Documentation:** • Prepare final project documentation **Closing Project:** • Project review and lesson learned • Close project
High Complexity & Low Project Value	Medium Complexity & Low Project Value
System Architecture Design: • Design compliance-tracking framework **Load & Security Testing:** • Develop test cases	**Project Initialization:** • Set up tools **Requirements Gathering:** • Validate and prioritize requirements **Closing Project:** • Gather user feedback

	• Obtain final approvals

9. References

Addressing the impacts of food loss and waste - FP Analytics. (2022, December 6). https://fpanalytics.foreignpolicy.com/2022/12/06/addressing-the-impacts-of-food-loss-and-waste/

Food: Material-Specific Data | US EPA. (2025, February 13). US EPA. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/food-material-specific-data

Food Waste FAQs. (2025, February 27). Home. https://www.usda.gov/about-food/food-safety/food-loss-and-waste/food-waste-faqs

Food Waste in America: How You Can Help Rescue Food | Feeding America. (n.d.). Feeding America. https://www.feedingamerica.org/our-work/reduce-food-waste

Goodwin, L. (n.d.). *The global benefits of reducing food loss and waste, and how to do it*. World Resources Institute. https://www.wri.org/insights/reducing-food-loss-and-food-waste