

Waste2Meal: A Literature Review of Food Waste Management, NGO-Based Food Donation and Intelligent Food Redistribution System

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Abstract

Food waste and food insecurity are closely connected problems, yet existing technological solutions often address only one part of the redistribution process. This literature review examines six studies covering digital food donation, NGO coordination, food-spoilage prediction, food-waste prediction, geographic redistribution, and AI-supported resource allocation. The reviewed systems range from lightweight web applications using Firebase to integrated platforms using machine learning, geospatial services, blockchain, recommender systems and online optimization. The comparison shows that digital donation platforms can improve visibility and coordination, while AI models can add prediction and prioritization capabilities. However, important limitations remain: some systems do not use quantitative datasets, some rely on small or simulated datasets, several prototypes have limited real-world validation, and AI-based systems introduce issues related to data availability, bias, privacy and deployment. The review identifies a research gap in combining donor-NGO matching, food safety or waste prediction, location-aware prioritization, real-time coordination and practical role-based workflows within one deployable system. These findings provide a foundation for designing an integrated food redistribution platform such as Waste2Meal.

Key Words: Food Waste Management, NGO Donation Systems, Food Redistribution, AI-Based Matching, Food-Rescue Optimization

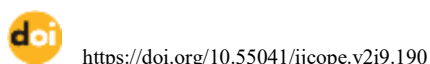
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1. INTRODUCTION

Food waste management is not only an environmental problem; it is also a coordination problem. Surplus edible food may exist at restaurants, events, households and other donor locations while nearby communities and NGOs require food. The reviewed literature indicates that traditional donation processes can depend on manual records, phone calls or social-media communication, which can delay collection and make donation information difficult to manage. Digital platforms attempt to reduce this friction by allowing donors to publish food details and enabling NGOs to discover,

claim and coordinate collections in a more structured manner. [1], [3], [4]

The six studies selected for this review represent different technical approaches. FoodConnect+ focuses on an expanded web platform with volunteers, rewards, chatbot assistance and food-spoilage prediction. AI-FEED explores a broader food-charity ecosystem involving donors, charities, clients and community leaders. Food-For-All concentrates on donation management, inventory-related needs, expiration tracking and user acceptance. A simpler Food Donation Web Application demonstrates real-time donor-NGO listing through HTML, CSS and Firebase. The

Random Forest Redistribution System connects waste prediction with geospatial donation workflows, while Shi et al. address the harder optimization problem of selecting volunteers for food-rescue operations under limited and changing data. [1]-[10]

Accordingly, this review compares the methods, data used, reported results and limitations of these studies and then derives a consolidated research gap relevant to integrated food redistribution systems.

2. LITERATURE REVIEW AND RESEARCH GAP

2.1 FoodConnect+: Donation, Volunteers and Food-Spoilage Prediction

Pol et al. present Food Connect+, an enhanced web-based framework intended to connect restaurants with NGOs and strengthen the logistics of surplus-food redistribution. The system adds a volunteer role, certificates and badges, event scheduling, chatbot support and a machine-learning food-spoilage module. The platform uses Flask, PostgreSQL, TensorFlow and related AI components. Its database stores user, donation, food information, spoilage prediction, event and reward data. [1]

For the AI component, the paper reports approximately 500 records covering food categories such as fruits, vegetables, bread, rice, salad and meat under different environmental conditions. Inputs include food type, preparation time, temperature, humidity and storage conditions. The reported model achieved 92.86% overall accuracy, with a macro/weighted F1-score of about 0.93. [1]

The study is important because it moves beyond a basic donation listing and introduces food-safety prediction and community participation. However, the reported dataset is relatively small for a broad food ecosystem, and the paper's strongest evidence concerns the spoilage-prediction module rather than large-scale end-to-end redistribution impact. Thus, the work demonstrates technical feasibility but leaves room for stronger real-world validation and more comprehensive matching between donors, NGOs and logistics. [1]

2.2 AI-FEED: Integrated Food-Charity Ecosystem

Sammer et al. introduce AI-FEED as a web-based platform designed around four stakeholder groups: food charities, donors, food-charity clients and community leaders. Its development began with stakeholder research and 20 initial interviews representing food charities of different sizes and urban, suburban and rural contexts. The findings were used to define and refine four modules through prototyping and iterative stakeholder feedback. [2]

The platform combines AI, blockchain, GIS, APIs and generative-AI techniques. Its community-planning component incorporates information such as socioeconomic indicators, health risks and transportation networks. Its recipe/content component uses retrieval-augmented generation and verified recipe sources, while user feedback can support iterative improvement. The platform also shares selected data across modules through standardized APIs, allowing donation and demand information to contribute to broader community-level planning. [2]

Unlike the Random Forest and FoodConnect+ studies, AI-FEED is primarily a prototype and ecosystem-design study rather than a single benchmarked prediction experiment. Consequently, its contribution is strong at the system and stakeholder-integration level, but quantitative evidence of operational food-waste reduction is limited. The paper also explicitly discusses privacy, demographic bias, human oversight, data availability and the challenge of moving from prototypes to a sustainable operational entity. [2]

2.3 Food-For-All: Structured Donation Management

Jalaluddin and Mat Rejab propose Food-For-All to address practical problems in food donation management, including overstock, shortages, manual expiration tracking and paper-based donor records. The system provides a mobile-view interface for donors and a web interface for NGOs. It was developed using the Waterfall model, beginning with requirements gathering, followed by design, development and testing. Requirements were informed by examination of an existing NGO process and questionnaires for relevant NGO and donor participants. [3]

The system introduces several functions that are directly relevant to redistribution management: donors can see needed items, submit online donations, receive distribution updates, while the system monitors expiration dates and generates program reports. User acceptance testing involved 11 donor respondents and 3 admin respondents. Among donors, 100% reported being able to view donation programs, make donations and edit profile information without issues; satisfaction and interface ratings were also predominantly positive. For administrators, all respondents agreed that the system handled the modules effectively. [3]

The main limitations reported were mobile-view issues, absence of notifications and limited map-filtering capabilities. The authors therefore recommend notification functionality, volunteer

management, improved mobile support and a beneficiary module. Importantly, this study demonstrates that workflow organization and usability can be evaluated even without an advanced AI model, but it does not provide an AI-based matching mechanism for prioritizing the best donor-NGO pair. [3]

2.4 Food Donation Web Application Using HTML, CSS and Firebase

Adarsha A. M. and Gajanan M. Naik present a comparatively lightweight web application that connects food donors and nearby NGOs. The interface is implemented with HTML and CSS, while Firebase provides data storage, authentication and hosting. Donors enter details such as name, contact information, food type, quantity and pickup location. The records are stored in Firebase and displayed on an NGO dashboard, where NGOs can contact donors or arrange collection. [4]

The reported evaluation is mainly functional and usability-oriented. The authors state that the application was tested across platforms, was responsive and offered live visibility of donation information. The study does not report a machine-learning dataset or quantitative prediction benchmark. Its value lies in showing that a simple cloud-backed architecture can digitize the basic donor-to-NGO workflow. [4]

The paper identifies future improvements such as Firebase authentication refinement, Google Maps integration, messaging, a Flutter mobile version and possible integration with government or NGO initiatives. Therefore, the study establishes a useful baseline architecture, but its matching process remains largely manual and does not intelligently rank donations using urgency, distance, food safety or NGO demand. [4]

2.5 Food Waste Prediction using Random Forest and Redistribution System

Kumar et al. combine food-waste prediction with an operational redistribution workflow. Donor-side data include food type, quantity, estimated guests, event information, storage requirements, seasonality, preparation method, location and price. Numerical attributes are standardized and categorical information is encoded. The target waste quantity is estimated from post-event donor feedback and historical records; when historical data are unavailable, controlled simulation data are generated using domain-informed heuristics. [5]

The authors compare Linear Regression, Decision Tree, Gradient Boosting and Random Forest. Random Forest performs best in the reported

comparison, with MSE 7.371716 and R^2 0.928884, compared with R^2 values of 0.644036 for Linear Regression, 0.877049 for Decision Tree and 0.907665 for Gradient Boosting. The platform also provides NGO list and map views, distance-based filtering, donation claims, role-based access and automated notifications. [5]

A major strength is the direct connection between prediction and redistribution. Nevertheless, the paper itself indicates that part of the training data may be simulated and that the current storage approach is lightweight. Future work includes deep-learning models, a shared online database for large-city analysis and carbon-footprint computation. These points suggest that broader real-world datasets and richer sustainability metrics are still required. [5]

2.6 Bandit Data-Driven Optimization for Crowdsourcing Food Rescue Platforms

Shi, Wu, Ghani and Fang study food rescue from an optimization perspective. Instead of simply predicting which volunteer is likely to respond, the proposed PROOF framework combines offline predictive analytics with online bandit learning. The approach was motivated by four practical challenges: small datasets, historical data collected under default interventions, objectives that may be incompletely specified, and unexpected consequences of interventions. [6]

For the food-rescue experiment, the framework considers 100 volunteers and selects at most 10 volunteers to receive notifications for each rescue. The system uses a content-based recommender to estimate the likelihood of a volunteer claiming a rescue, while the optimization layer chooses the intervention. The authors evaluate the method both on simulated data and on real-world food-rescue data. In the real-world experiment, an initial dataset of 300 rescues was followed by 50 time steps, and PROOF outperformed the vanilla OFU baseline by roughly 15%. [6]

This work exposes a limitation that is easy to miss in conventional ML-based donation systems: prediction accuracy alone does not guarantee that an intervention will improve the overall operation. Small or biased historical datasets can limit deployment, and an intervention can change future observations. The study therefore contributes an important lesson for food redistribution platforms: matching should be treated as a sequential decision problem when actions influence future data and operational outcomes. [6]

Table 1: Comparative Summary of the Reviewed Studies

Study	Primary focus	Method / technology	Dataset / evidence	Main reported result	Key limitation
[1] FoodConnect+	Donation + NGO + volunteer coordination; food spoilage	Web platform; Flask/PostgreSQL; ML spoilage prediction; chatbot; rewards	About 500 food/environment records	92.86% spoilage-classification accuracy; macro/weighted F1 $\approx$ 0.93	Small dataset; limited evidence of large-scale end-to-end impact
[2] AI-FEED	Food-charity ecosystem and community planning	Stakeholder interviews; prototyping; AI; blockchain; GIS; APIs; RAG	20 initial stakeholder interviews plus platform/community data sources	Integrated multi-stakeholder prototype with cross-module data sharing	Prototype stage; quantitative operational impact still limited; privacy/bias/deployment issues
[3] Food-For-All	Donation management and NGO operations	Waterfall SDLC; web/mobile-view system; expiration tracking; reporting	Questionnaires and UAT; 11 donor and 3 admin respondents	Predominantly positive usability and module-handling feedback	No notifications; limited map filtering; mobile-view issues; no intelligent matching
[4] Food Donation Web App	Basic donor-NGO digital connection	HTML/CSS + Firebase real-time database and dashboard	Functional demonstration; no ML benchmark dataset reported	Real-time visibility, responsive interface and simpler coordination	Manual selection/coordination; no AI, advanced matching or safety prediction
[5] Random Forest Redistribution	Waste prediction + location-aware redistribution	Preprocessing + RF regression + geolocation + role-based dashboards + notifications	Historical/post-event data plus controlled simulated data	RF: MSE 7.371716; R^2 0.928884; integrated donation workflow	Need for larger real-world datasets; future migration to shared database/deep learning
[6] Shi et al.	Volunteer recommendation and sequential optimization	PROOF: predict-then-optimize + online bandit learning	Simulations; real-world rescue data with 300 initial rescues + 50 steps	PROOF $\approx$ 15% better than vanilla OFU in reported real-world experiment	Small-data and intervention-distribution challenges; more complex deployment problem

3. COMPARATIVE ANALYSIS

Overall comparison: the literature progresses from basic digitization [4] to structured donation management [3], integrated stakeholder platforms [2], AI-based spoilage prediction [1], combined waste prediction and geographic redistribution [5], and sequential optimization for rescue operations [6]. No single reviewed study fully combines all of these capabilities with strong, large-scale real-world validation. This is the central synthesis of the reviewed literature. The comparative summary of all six studies is presented in Table 1.

Problem Identification

Food wastage is not only an environmental concern but also a coordination problem in the redistribution of surplus edible food. Existing studies show that considerable amounts of surplus food can be redirected toward people and communities in need, but the process of connecting food donors with suitable NGOs, volunteers, and beneficiaries is often affected by limitations in coordination, information sharing, location matching, and timely communication [1], [2].

The reviewed studies identify several important problems. First, food donors and NGOs may not have an efficient common platform for sharing information about available surplus food and current requirements [1], [3]. Second, manual processes for recording

donations, monitoring food availability, and coordinating collection can increase delays and administrative effort [3]. Third, the absence of effective location-based matching can make it difficult to identify suitable NGOs or volunteers for timely food collection and redistribution [4], [5]. Fourth, food availability and spoilage are time-sensitive, creating a need for systems that can support prediction and timely decision-making [1], [5].

Research on food rescue platforms also indicates that selecting appropriate interventions and coordinating volunteers can become difficult when available historical data is limited or when conditions change over time [6]. AI-FEED further highlights the need for an integrated ecosystem in which different stakeholders can share information and use intelligent technologies to improve food-charity operations [2].

Based on these observations, the major problem identified is the lack of an integrated, efficient, and intelligent mechanism for connecting food donors with appropriate NGOs and coordinating surplus-food redistribution in a timely manner. This problem motivates the development of Waste2Meal, which aims to provide a technology-based platform for donor-NGO coordination, suitable food donation matching, location-aware redistribution, and improved communication among stakeholders.

4. RESEARCH GAP

- **Fragmented functionality:** Several systems solve donation listing, management, prediction or optimization separately. A unified workflow from surplus identification to donor-NGO matching and collection remains insufficiently developed. [1]-[10]
- **Limited intelligent matching:** Basic platforms allow NGOs to see donations, but they do not consistently rank donor-NGO pairs using multiple factors such as distance, quantity, urgency, expiry/safety and NGO requirements. [3], [4]
- **Data limitations:** AI studies use relatively small datasets, simulated data, prototype data or domain-specific records. The literature therefore highlights a need for larger, diverse and continuously updated operational datasets. [1], [5], [6], [9]
- **Weak end-to-end evaluation:** Some studies report model metrics, while others report usability or prototype outcomes. Few establish a common evaluation framework connecting prediction quality with actual redistribution efficiency, response time or reduction in food loss. [1]-[10]
- **Real-time and sequential decision-making:** Shi et al. show that an intervention can change future observations, meaning that static prediction may be insufficient for dynamic food-rescue environments. [6]
- **Safety, privacy and fairness:** Food safety prediction and community-level AI introduce risks around incorrect

predictions, privacy, demographic bias and the need for human oversight. [1], [2]

Based on these findings, a clear research opportunity is an integrated platform that supports donors and NGOs through real-time digital coordination, location-aware matching, food-status or waste prediction, role-based access, notifications and measurable workflow outcomes. Such a platform should also be designed to collect high-quality operational data so that future AI models can be improved using real interactions rather than relying mainly on simulated or small datasets.

5. Methodology of the Present Literature Review

This literature review uses a comparative qualitative synthesis of the six uploaded research papers. Each paper was examined for five common dimensions: 1) problem addressed and system objective, 2) methodology and technologies, 3) dataset or evidence base, 4) reported results, and 5) limitations and future directions. The studies were then grouped conceptually into digital donation systems, integrated

food-charity platforms, AI-based food-quality or waste prediction, geographic redistribution, and optimization-based food rescue. [1]-[10]

The review deliberately distinguishes between quantitative evidence and prototype/functional evidence. For example, FoodConnect+ and the Random Forest study provide numerical model results, Food-For-All provides user-acceptance measurements, while AI-FEED and the simpler web application primarily provide prototype, architecture and functional evidence. This distinction prevents direct comparison of metrics that measure different outcomes.

6. FUTURE SCOPE

- Develop larger, continuously updated datasets containing donor, NGO, food type, quantity, expiry/safety status, location, pickup time and successful/failed collection outcomes.
- Develop multi-factor AI matching that jointly considers distance, urgency, food quantity, NGO demand, expected pickup time and food safety.
- Move from static prediction toward adaptive or sequential matching so that system actions and feedback can improve future recommendations, following the lesson from PROOF. [6]
- Integrate real-time maps, notifications and route-aware pickup planning to reduce response time and spoilage risk. [3]-[5]
- Evaluate systems using common operational metrics such as successful-match rate, average response time, collection completion rate, food saved, spoilage avoided and user satisfaction.
- Use explainable AI and human approval for safety-critical recommendations, while protecting user privacy and monitoring potential bias. [2]
- Scale from lightweight prototypes to shared online databases and larger geographic deployments; the Random Forest study specifically identifies shared databases and deeper models as future directions. [5]
- Add sustainability indicators such as avoided food waste and carbon-footprint estimation to measure environmental as well as social impact. [5]

7. CONCLUSION

The reviewed literature demonstrates a clear transition from simple digital donation portals toward intelligent and integrated food-rescue systems. Food Donation Web Application establishes the basic donor-to-NGO digital workflow, while Food-For-All strengthens donation management and monitoring. FoodConnect+ adds volunteers, rewards, chatbot

support and spoilage prediction. AI-FEED broadens the problem into a multi-stakeholder food-charity ecosystem using AI, blockchain, GIS and shared data. The Random Forest Redistribution System directly links food-waste prediction with location-aware donation workflows, and Shi et al. demonstrate how sequential optimization can improve volunteer-selection decisions when real-world data are limited and interventions influence future observations. [1]-[10]

Despite this progress, the literature remains fragmented. The major research gap is the lack of a single, practical and empirically evaluated platform that combines intelligent food-waste or food-status prediction, multi-factor donor-NGO matching, location-aware prioritization, real-time communication, secure role-based workflows and continuous learning from operational feedback. Addressing this gap can make food redistribution more timely, measurable and scalable, while also providing a stronger data foundation for future AI research.

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