ReNosh: AI-Driven Food Management for Waste Management and Sustainability

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Abstract—**ReNosh is a cross-platform mobile and web application developed using Flutter to address the growing issue of food waste in restaurants and food establishments. The system leverages AI-driven predictions and real-time data tracking to optimize food production, minimize surplus, and promote sustainable practices. By integrating Firebase for authentication and cloud storage, along with machine learning models such as XGBoost and external APIs like the Gemini API, the platform provides intelligent demand forecasting and actionable insights.**

The application enables users to monitor surplus food, donate excess meals, and visualize sustainability metrics such as food saved, meals donated, and waste reduction impact through interactive dashboards. Additionally, ReNosh supports offline functionality using local caching, ensuring uninterrupted access to essential features. The system is designed with scalability in mind, using modular architecture and cloud-based services. This solution aims to assist food businesses in reducing operational inefficiencies while contributing to environmental sustainability and social good.

Index Terms—**Food Waste Management, AI Predictions, Sustainability, Flutter, Firebase, Surplus Food, Smart Inventory, Gemini API**

I. INTRODUCTION

A. Overview

The rapid growth of the food service industry has brought with it a significant challenge: the efficient management of food resources and the reduction of food waste. Restaurants and food establishments frequently produce excess food due to inaccurate demand forecasting, dynamic customer preferences, and operational inefficiencies. This surplus often goes unutilized, leading to financial losses and contributing to serious environmental concerns such as increased carbon emissions and resource wastage.In recent years, there has been a growing emphasis on sustainability and responsible consumption. However, many establishments still rely on traditional inventory management practices that lack predictive capabilities and real-time monitoring. These systems are often reactive rather than proactive, making it difficult to prevent overproduction or effectively manage surplus food. Additionally, the absence of integrated platforms that combine forecasting, tracking, and sustainability analysis further limits the ability of businesses to make data-driven decisions. To address these challenges, ReNosh is proposed as a comprehensive, AI-driven solution designed to optimize food management processes. The application leverages advanced technologies such as machine learning-based prediction models, cloud computing, and real-time data analytics to provide accurate demand forecasts and actionable insights. By utilizing the XGBoost Model for predictive analysis and the Gemini API for intelligent recommendations, the system enables establishments to align production with expected demand and reduce unnecessary surplus. ReNosh also incorporates features for tracking and managing surplus food, allowing users to monitor excess items and take appropriate actions such as redistribution or donation. Furthermore, the platform provides interactive dashboards that visualize key sustainability metrics, including meals donated, food saved in kilograms, and overall waste reduction impact. These visual insights help organizations evaluate their performance and adopt more sustainable practices. .

B. Problem Statement

Food establishments often face difficulties in accurately predicting daily demand, leading to overproduction and significant amounts of food waste. The absence of intelligent forecasting tools and real-time monitoring systems makes it challenging to optimize inventory and reduce surplus. Additionally, existing solutions do not provide integrated features for surplus tracking, donation management, and sustainability analysis. This results in missed opportunities to redistribute excess food and reduce environmental impact. The lack of offline accessibility further limits usability in real-world scenarios where consistent internet connectivity may not be available. Therefore, there is a need for a scalable and intelligent system that can predict demand, manage surplus efficiently, and provide actionable insights to minimize food waste and improve sustainability outcomes.

C. Objectives

The primary objective of this project is to develop an intelligent and scalable system that helps food establishments reduce waste and optimize resource utilization through AI-driven insights. The specific objectives are as follows:

- To develop an AI-based demand prediction system that analyzes historical consumption patterns and external factors to accurately forecast daily food requirements.
- To design and implement a surplus food management module that enables establishments to systematically track, monitor, and manage excess food items .
- To ensure secure and efficient user authentication and data management through integration with Firebase Authentication and Firestore, allowing real-time data access and synchronization across multiple devices.
- To promote sustainable practices within the food industry by encouraging responsible production, efficient resource utilization, and the redistribution of surplus food to reduce environmental impact and support social welfare initiatives.
- To design a responsive, intuitive, and visually appealing user interface using Flutter, ensuring seamless user experience across both mobile and web platforms.
- To implement offline functionality using local caching techniques, enabling users to access previously stored data and continue essential operations even in the absence of a stable internet connection.

II. RELATED WORKS

Gustavsson et al. [1] conducted a comprehensive study on global food waste and reported that nearly one-third of the food produced worldwide is lost or wasted. Their work highlights the environmental and economic consequences of food wastage and emphasizes the importance of efficient food management systems. However, the study does not propose a technological solution for real-time waste reduction in food establishments.

Choi et al. [2] explored the application of machine learning techniques for food demand forecasting in restaurants. Their model uses historical sales data to predict future demand, thereby reducing overproduction. Although the approach improves prediction accuracy, it lacks integration with surplus management and sustainability tracking features.

Mourad [3] analyzed food redistribution systems and their role in reducing surplus food waste. The study focuses on connecting food providers with charities and communities. While effective in redistribution, the system does not include real-time tracking or predictive analytics to prevent surplus generation at the source.

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Ricci et al. [5] studied recommender systems and their ability to provide personalized and data-driven suggestions. These systems have been successfully applied in various industries to improve decision-making. However, their application in integrated food waste management systems remains limited.

From the existing literature, it is evident that while individual solutions exist for demand prediction, food redistribution, and data management, there is a lack of a unified platform that combines these functionalities. The proposed ReNosh system aims to bridge this gap by integrating AI-based prediction, surplus food tracking, sustainability analytics, and cloud-based scalability into a single comprehensive solution.

III. MATERIALS AND METHODS

The proposed ReNosh system is developed using modern technologies to address the challenges of food waste management in food establishments. The application is built using Flutter, a cross-platform development framework that enables the creation of responsive and high-performance applications for both mobile and web platforms using a single codebase [6]. This ensures consistency in user experience and reduces development complexity.

Firebase is used as the backend infrastructure for the system. It provides secure user authentication and real-time cloud-based data storage through Firestore. Firebase Authentication ensures that only authorized users can access the system, while Firestore enables efficient storage, retrieval, and synchronization of data across devices. Cloud-based solutions such as Firebase are widely recognized for their scalability and reliability in modern applications [4].

The backend system handles data processing, storage, and communication between the frontend and machine learning components. It ensures efficient handling of user data, prediction results, and surplus tracking information within the application.

The system integrates machine learning models and external APIs to enhance its functionality. The XGBoost Model is used to perform AI-based demand prediction by analyzing historical food consumption data. This helps in forecasting daily food requirements and minimizing overproduction. In addition, the Gemini API is utilized to generate intelligent insights and recommendations based on user data and system trends, enabling better decision-making and operational efficiency [7]. The working methodology of the system begins with data collection from users, including daily food preparation and surplus records. This data is stored in the cloud database and processed using predictive algorithms to estimate future demand. Machine learning-based forecasting techniques have been shown to improve accuracy and reduce wastage in similar applications.

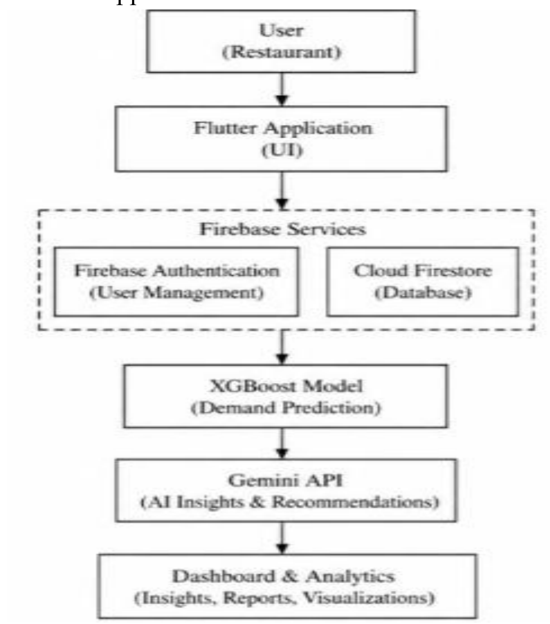

Figure 1: Block Diagram

The system also includes a surplus management mechanism that allows users to monitor and manage excess food. By analyzing surplus patterns, the system helps identify inefficiencies in production and suggests corrective actions. Furthermore, data visualization techniques are used to present sustainability metrics such as food saved, meals donated, and waste reduction. These visual insights assist users in understanding their impact and making informed decisions.

IV. ALGORITHM OF PROPOSED METHODOLOGY

1. Step 1: Start the system and initialize the application.
2. Step 2: Authenticate the user using Firebase Authentication.

   If the user is not authenticated, redirect to the login page.
3. Step 3: Collect user-specific data such as historical food preparation records and surplus data from the database.
4. Step 4: Store and retrieve data using Firebase Firestore for real-time synchronization [4].

5. Step 5: Send the collected data to the XGBoost Model for processing and demand prediction.
6. Step 6: Apply machine learning-based prediction algorithms to forecast daily food demand based on historical trends [2].
7. Step 7: Display predicted demand results on the dashboard for user reference.
8. Step 8: Monitor and record surplus food generated during operations.
9. Step 9: Update surplus data in the database and allow users to manage or donate surplus food items.
10. Step 10: Send relevant data to the Gemini API to generate AI-based insights and recommendations for optimization [7].
11. Step 11: Visualize sustainability metrics such as food saved, meals donated, and waste reduction using interactive charts.
12. Step 12: Store essential data locally using caching mechanisms (SharedPreferences) to support offline functionality.
13. Step 13: If the system is offline, retrieve cached data; otherwise, sync with the cloud database when connectivity is restored.
14. Step 14: Continuously update predictions and insights based on new data inputs.
15. Step 15: Stop the system

V IMPLEMENTATION

A. Overview

The ReNosh system is implemented as a cross-platform application using Flutter, enabling seamless deployment on both mobile and web platforms through a single codebase [6]. This approach ensures consistency in user interface design and performance while reducing development complexity. The application is designed with a modern and responsive UI to enhance user experience.

The backend is developed using Firebase services, including Firebase Authentication for secure login and user management, and Cloud Firestore for real-time data storage and synchronization across devices [4]. This cloud-based infrastructure ensures scalability, reliability, and efficient data handling. The system integrates external APIs to provide intelligent functionality. The XGBoost Model is used for AI-based demand prediction by analyzing historical food consumption data, helping establishments reduce overproduction. Additionally, the Gemini API generates actionable insights and recommendations to support better decision-making and operational efficiency [7]. The application includes core modules such as dashboard, demand prediction, surplus management, and sustainability tracking. These modules work

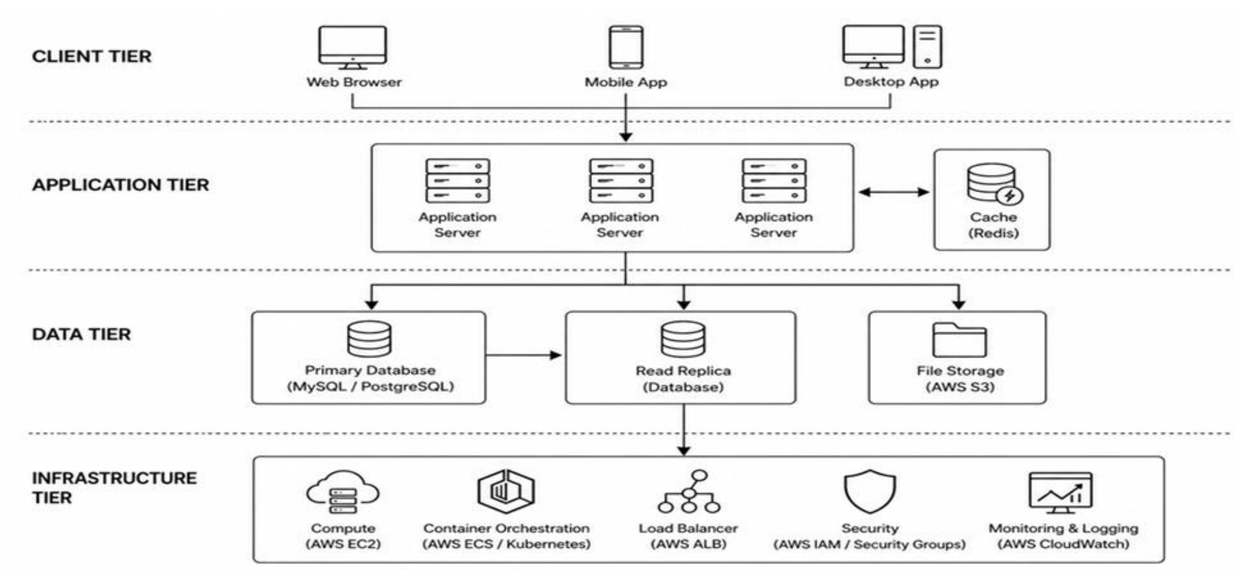

Figure 2: Architectural Diagram

together to provide real-time monitoring of food usage, surplus tracking, and visualization of key metrics like food saved and meals donated. The system also supports offline functionality through local caching, ensuring continuous access to essential data even without internet connectivity.

Overall, the implementation combines frontend design, cloud integration, and AI-driven services into a unified system for efficient food waste management and sustainability tracking.

B. System Architecture

C. Test Cases

- Valid admin login credentials – Correct username and password allows successful login into the system.
- Invalid admin login credentials – Incorrect username or password displays an error message, ensuring proper login validation.
- Data retrieval from database – User dashboard fetches and displays real-time data from Firestore database [4].
- Demand prediction functionality – Historical food data is processed to generate daily predictions using the XGBoost Model [2].
- Surplus food entry – Adding surplus food details updates and stores the data correctly in the system.
- AI insights generation – System generates recommendations based on user data using Gemini API [7].
- Sustainability metrics display – Charts correctly visualize food saved, meals donated, and waste reduction.
- Offline mode functionality – Cached data is displayed when there is no internet connection.
- Data synchronization – Local data is synchronized with the cloud database once internet connectivity is restored [4].
- Navigation between modules – Smooth and error-free transition between different screens of the application.

VI. RESULTS

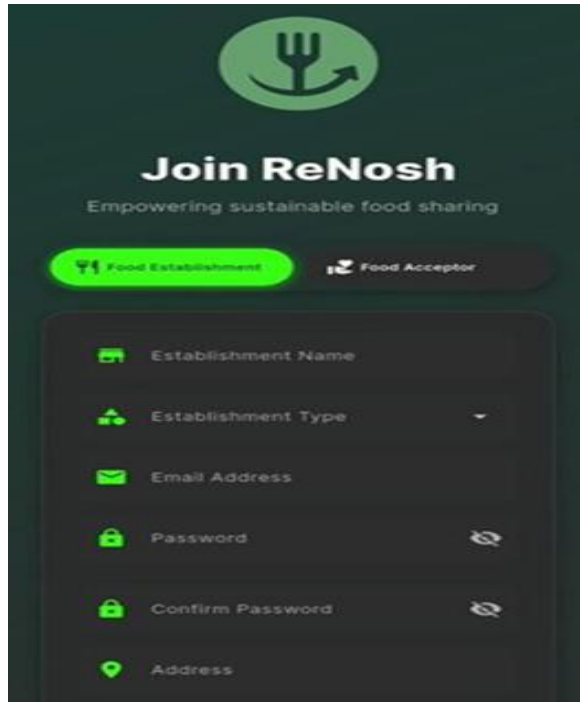

Figure 3: Login Page User authentication interface for secure login using Firebase Authentication [4]

Figure 4: Food Tracking Interface for monitoring and managing food and surplus data in real time

The ReNosh system successfully demonstrated accurate demand prediction using the XGBoost model, enabling better planning and reduction of food waste. The application effectively tracked surplus food and provided real-time insights through interactive dashboards. Sustainability metrics such as food saved and meals donated were clearly visualized, helping users monitor their impact. The system showed reliable performance, efficient data handling, and usability in real-time scenarios.

VII. EXISTING APPROACHES

Existing approaches to food waste management in restaurants primarily rely on traditional inventory management systems that focus on stock monitoring and manual record-keeping. These systems help track available resources but lack predictive capabilities, making them ineffective in handling dynamic demand variations and preventing overproduction.

Several studies have explored the use of machine learning techniques for demand forecasting. These approaches utilize historical sales data to predict future consumption patterns, improving planning and reducing excess production [2]. However, most of these systems operate as standalone solutions and do not integrate surplus management or sustainability tracking features.

Food redistribution platforms have also been developed to address surplus food by connecting restaurants with charities and communities. While these systems help in reducing food waste through donation, they do not provide mechanisms to prevent surplus generation at the source and often lack real-time tracking capabilities [3].

Cloud-based systems have improved data accessibility and scalability by enabling real-time updates and multi-user access [4]. However, many existing solutions depend heavily on continuous internet connectivity and do not support offline functionality, limiting their usability in practical scenarios.

Overall, current approaches address specific aspects of food waste management but fail to provide a comprehensive solution that integrates prediction, surplus tracking, and sustainability analysis within a single platform.

Table 1: Existing Approaches

Application	Description	Drawback
Too Good To Go	Surplus food resale platform	No AI-based demand prediction
OLIO	Food sharing application	No real-time tracking
Karma	Connects users to surplus food	Limited analytics
Spoiler Alert	Food waste redistribution system	No prediction features
Winnow	Tracks food waste using AI	High cost, limited accessibility

VIII. CONCLUSION AND FUTURE SCOPE

The ReNosh system presents an efficient and scalable solution to the growing problem of food waste in food establishments. By integrating AI-based demand prediction, the system enables restaurants to forecast daily food requirements more accurately, thereby reducing overproduction and minimizing unnecessary waste [2]. This predictive capability plays a crucial role in improving operational planning and resource utilization.

The system also incorporates surplus food tracking, allowing establishments to monitor excess food in real time and take appropriate actions such as redistribution or donation. In addition, the use of cloud-based technologies such as Firebase ensures secure data management, real-time synchronization, and scalability, making the system reliable for practical deployment in diverse environments [4].

Another key contribution of the system is the use of AI-driven insights, which provide actionable recommendations based on historical data and usage patterns. These insights assist users in making informed decisions to optimize food production and reduce inefficiencies [7]. Furthermore, the inclusion of sustainability metrics, such as food saved and meals donated, enables establishments to measure their environmental impact and adopt more responsible practices.

The system also addresses practical challenges by supporting offline functionality through local data caching. This ensures uninterrupted access to essential features even in scenarios with limited internet connectivity, enhancing the overall usability and reliability of the application.

In future, the system can be further enhanced by integrating more advanced machine learning models to improve the accuracy and adaptability of demand predictions. Additionally, the application can be expanded to support multi-branch operations, allowing large food chains to manage data across multiple locations. Integration with external food donation networks and NGOs can further improve surplus redistribution and increase social impact.

Further improvements may include advanced data analytics, real-time alerts, and personalized recommendations to enhance user experience and decision-making capabilities.

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