ONLINE FOOD WASTE MANAGEMENT SYSTEM :CASE STUDY MBALE CITY

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APPROVAL

I hereby certify that this research, conducted by OKETCHO SOLOMON, is an original work that has been thoroughly developed and reviewed under my supervision. It is now ready for submission to the Department of Computing and Technology for further consideration and academic evaluation.

Signature: …… Date: …01/10/2024.....

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Chapter One

Introduction

Online food waste management system (Mbale city)

Chapter one of this project present the background information to the study highlighting the problem statement, objectives, scope and significance to the study

Background to the Study

Online Food waste management has become an increasingly critical issue worldwide. According to the Food and Agriculture Organization (FAO, 2011), approximately one-third of the food produced for human consumption is lost or wasted globally, amounting to about 1.3 billion tons per year. This waste occurs throughout the food supply chain, from initial agricultural production down to final household consumption. Effective food waste management is crucial not only for reducing environmental impacts, such as greenhouse gas emissions from landfills but also for addressing food insecurity and improving resource efficiency.

In recent years, various strategies have been implemented to mitigate food waste, including food donation programs, improved supply chain logistics, and consumer education campaigns. Technological advancements, such as smart packaging and waste-to-energy technologies, also offer promising solutions (Parfitt, Barthel, & Macnaughton, 2010). Despite these efforts, the problem persists, indicating a need for more integrated and innovative approaches to food waste management.

Problem Statement

Despite the significant efforts to address food waste, a substantial amount of food is still being wasted, contributing to environmental degradation and economic losses. The current food waste management systems are often fragmented and lack the necessary coordination across different stages of the food supply chain. There is a critical need to develop a more holistic and efficient food waste management system that can effectively reduce food waste and its associated impacts.

Main Objective

The main objective of this study is to develop a comprehensive online food waste management system that minimizes food waste throughout the supply chain and maximizes the recovery of resources.

Specific Objectives

To analyze the current state of food waste management practices across different stages of the food supply chain.

To identify key factors contributing to food waste in the supply chain.

To develop an integrated food waste management framework that incorporates technological, logistical, and policy solutions.

To evaluate the effectiveness of the proposed food waste management system through case studies and pilot programs.

To provide recommendations for policymakers, businesses, and consumers on reducing food waste.

Scope

This study will focus on food waste management practices in both developed and developing countries, considering various stages of the food supply chain, including production, processing, distribution, retail, and consumption. It will explore different strategies and technologies for reducing food waste and propose an integrated framework that can be adapted to different contexts. The study will also consider the social, economic, and environmental impacts of food waste and the potential benefits of improved food waste management.

Significance

Effective food waste management is essential for sustainable development, as it can help mitigate environmental impacts, improve food security, and enhance economic efficiency. By developing a comprehensive food waste management system, this study aims to provide practical solutions that can be implemented by various stakeholders, including policymakers, businesses, and consumers. The findings of this study will contribute to the broader discourse on sustainable food systems and support efforts to achieve the United Nations' Sustainable Development Goals, particularly Goal 12, which aims to ensure sustainable consumption and production patterns (United Nations, 2015).

Chapter Two

Literature Review

2.0 Introduction

Chapter One presented the background information to the study highlighting the objectives, scope and significance to the study. This chapter is about the literature review of food waste management system.It specifies what an online food waste management system is, what it needs and how it works for its enhancement.

2.1 Online Food waste management system.

According to the United Nations Food and Agriculture Organization (FAO), approximately one-third of allfood produced for human consumption is lost or wasted globally, amounting to about 1.3 billion tons per year (FAO, 2013). Food waste management is a critical issue that intersects environmental, economic, and social dimensions. The increasing generation of food waste presents significant challenges, including greenhouse gas emissions, loss of resources, and economic inefficiencies (FAO, 2013). This substantial level of waste necessitates effective management systems to mitigate its impacts.

Multiple strategies have been developed to manage food waste, each with its strengths and weaknesses. Composting, anaerobic digestion, incineration, landfilling, food redistribution, and conversion to animal feed are among the primary methods utilized. These systems vary in their technological requirements, environmental benefits, and implementation challenges. According to Bhattet al. (2020), composting is a sustainable method that transforms organic waste into valuable compost, enhancing soil fertility and reducing landfill use. Meanwhile, anaerobic digestion, as described by Yadvika et al. (2004), offers the dual benefits of waste reduction and renewable energy production.

2.2Types Food Waste Management Systems

2.1.1 Composting

According to Bhatt et al. (2020), composting is an effective method to manage food waste because itreduces landfill usage and produces valuable compost that can enhance soil health and agricultural productivity. Compositing is a biological process where organic waste decomposes into a nutrient- rich soil amendment. Composting

can be performed at various scales, from household to industrial levels (Kumar et al., 2020).

2.1.2 Anaerobic Digestion

Anaerobic digestion involves the breakdown of organic matter by microorganisms in the absence of oxygen, producing biogas and digestate. Incineration involves burning waste athigh temperatures to reduce its volume and mass, generating energy in the process. As described by Yadvika et al. (2004), this process not only helps in managing food waste but also generates renewable energy in the form of methane. The digestate can be used as a fertilizer, closing the loop of nutrient recycling (Lundie & Peters, 2005).

2.1.3 Incineration

According to Tsai and Kuo (2021), while incineration can effectively manage large quantitiesof food waste, it also poses challenges such as emissions control and ash disposal. However, modern technologies aim to mitigate these environmental impacts.

2.2.4. Landfilling

Landfilling is the most traditional method of waste disposal, where waste is buried in land. While it is simple and cost-effective, Sharma et al. (2019) highlight that landfilling food waste leads to significant methane emissions, a potent greenhouse gas. It also presents challenges interms of land use and potential groundwater contamination (Zaman, 2014).

2.2.5. Food Redistribution

According to Buzby and Hyman (2012), this method not only reduces food waste but also addresses food insecurity. Food redistribution involves redirecting surplus food from producers, retailers, or consumers to those in need. Effective redistribution requires robustlogistics and partnerships with food banks and charities.

2.2.6. Animal Feed

Converting food waste into animal feed is a sustainable practice that repurposes waste intovaluable resources. Myer et al. (1999) indicate that certain food wastes can be safely
Incorporated into animal diets, reducing the need for conventional feed. This practice isregulated to ensure the safety and nutritional adequacy of the feed.

2.3. Related Systems

2.3.1. Waste-to-Energy (WtE)

2.3.1. Waste-to-Energy is a system that converts non-recyclable waste materials into usable heat, electricity, or fuel through various processes, including combustion, gasification, and

anaerobic digestion. Companies like Covanta and Veolia use WtE technologies to reduce waste volumes and generate energy. Covanta operates numerous facilities across the United States, turning municipal solid waste into electricity, while Veolia manages WtE plants in Europe and Asia, focusing on sustainable waste management and energy recovery (Veolia, n.d.). As noted by Themelis and Kim (2002), these systems help reduce waste volume while generating electricity or heat, contributing to energy security and waste management.

2.3.1.1. How It Works: Waste-to-Energy systems convert waste into energy through combustion or anaerobic digestion. In combustion, waste is burned at high temperatures to generate steamthat drives turbines, producing electricity. In anaerobic digestion, organic waste is broken down by microorganisms in the absence of oxygen, producing biogas that can be used for energy (Themelis & Kim, 2002).

2.3.1.2. Modules:

- **Feedstock Preparation:** Waste is sorted and pre-processed to remove recyclables and non-combustible materials.
- **Combustion or Digestion:** Waste is burned in incinerators or digested anaerobically.
- **Energy Recovery:** Heat from combustion or biogas from digestion is captured and convertedinto electricity or heat.
- **Emission Control:** Systems to reduce pollutants such as particulate filters, scrubbers, andcatalytic converters.
- **Ash Handling:** Residual ash is collected and disposed of or reused.

2.3.1.3. Benefits/Strengths:

- Reduces waste volume significantly.
- Generates renewable energy, contributing to energy security.
- Can process mixed waste streams, making it versatile (Tsai & Kuo, 2021).

2.3.1.4. Weaknesses/Problems:

- High capital and operational costs.
- Potential emissions of pollutants, which require stringent controls.
- Requires a continuous waste input to be efficient (Tsai & Kuo, 2021).

Conclusion: Waste-to-Energy systems are a vital component of sustainable waste management, converting non-recyclable waste into usable energy, thus reducing landfill use and greenhouse gas emissions. Companies like Covanta and Veolia demonstrate the effectiveness of WtE in transforming waste into valuable energy resources. These systems not only address waste disposal issues but also contribute

to renewable energy generation, showcasing a pragmatic approach to managing waste sustainably (Veolia, n.d.).

2.3.2. Circular Economy

According to Ellen MacArthur Foundation (2013), integrating food waste management into a circular economy framework enhances resource efficiency and reduces environmental impacts by keeping materials in use for as long as possible. The circular economy model aims to eliminate waste through the continual use of resources. Companies such as Patagonia, IKEA, and Made of Air have implemented circular economy principles. Patagonia promotes recycling and reusing through its Worn Wear program, IKEA offers a take-back service for old furniture, and Made of Air produces carbon-negative materials from bio char for use in various industries. These initiatives help in minimizing environmental impact and promoting sustainable practices (World Economic Forum, 2023; ClimateSort, 2023).

2.3.2.1. How It Works: The circular economy focuses on designing products and systems thatmaximize the lifecycle of materials through reuse, repair, and recycling. Industries
Collaborate to use each other's by-products, minimizing waste and resource extraction. This approach shifts the economic model from a linear "take, make, dispose" to a circular systemwhere resources are kept in use for as long as possible (Ellen MacArthur Foundation, 2013).

2.3.2.2. Modules:

- **Design for Longevity:** Products are designed to last longer.
- **Reuse and Repair:** Systems to facilitate the reuse and repair of products.
- **Recycling:** Efficient recycling processes to recover materials.
- **Product-as-a-Service:** Shift from ownership to service-based models.
- **Industrial Symbiosis:** Exchange of materials and energy between industries.

2.3.2.3. Benefits/Strengths:

- Promotes sustainable consumption and resource efficiency.
- Reduces environmental footprint by keeping materials in use.
- Encourages innovation in product design and business models (Ellen MacArthur Foundation,2013).

2.3.2.4. Weaknesses/Problems:

- Requires systemic changes and cooperation across industries.
- Initial costs and investments can be high.
- Regulatory and market barriers can impede implementation (Ellen MacArthur Foundation,2013).

  Conclusion: The circular economy model fosters sustainability by keeping products and materials in use for as long as possible through reuse, repair, and recycling. Companies like Patagonia, IKEA, and Made of Air exemplify this approach by integrating recycled materials and promoting product longevity. The circular economy helps reduce waste, conserve natural resources, and decrease environmental impact, making it a critical strategy for sustainable development (World Economic Forum, 2023; ClimateSort, 2023).

2.3.3. Zero Waste Initiatives

According to Zaman (2011) discuss that these initiatives promote practices such as composting, recycling, and reducing food waste at the source, aligning with broader sustainability goals. Zero waste initiatives aim to reduce waste sent to landfills and incinerators by redesigning resource life cycles. Companies like Dell and Levi Strauss are leading examples. Dell has integrated a closed-loop recycled plastic supply chain and is committed to recycling e-waste, while Levi Strauss recycles old jeans into new products, significantly reducing textile waste. These initiatives help in conserving resources and reducing pollution (GreenBiz, 2023).

2.3.3.1. How It Works: Zero waste initiatives focus on reducing waste generation and maximizing diversion from landfills through recycling, composting, and encouraging sustainable practices. Policies, community engagement, and educational campaigns are key componentsto foster a culture of waste reduction and responsible consumption (Zaman & Lehmann, 2011).

2.3.3.2. Modules:

- **Source Reduction:** Minimizing waste generation at the source.
- **Recycling Programs:** Comprehensive recycling systems.
- **Composting:** Organic waste composting facilities.
- **Public Education:** Campaigns to promote waste reduction behaviors.
- **Policy and Regulation:** Laws and policies to support zero waste goals.

2.3.3.3. Benefits/Strengths:

- Significantly reduces landfill waste.
- Lowers greenhouse gas emissions.
- Promotes sustainable practices and community engagement (Zaman & Lehmann, 2011).

2.3.3.4. Weaknesses/Problems:

- Requires widespread behavioral change.
- Initial implementation can be challenging.
- Depends on robust infrastructure and regulatory support (Zaman & Lehmann, 2011).
  Conclusion: Zero waste initiatives aim to minimize waste by redesigning products and processes to eliminate waste generation. Companies like Dell and Levi Strauss lead by example, showing that it is possible to achieve significant waste reductions through recycling and resource recovery. These initiatives play a crucial role in shifting towards a more sustainable and resource-efficient economy, reducing the burden on landfills and lowering environmental pollution (GreenBiz, 2023).

2.3.4. Industrial Symbiosis

According to Chertow. (2000) explains that food waste can be used asa resource in other industrial processes, such as biogas production or composting, enhancing overall resource efficiency. Industrial symbiosis involves the collaboration between industries to use each other's by-products and waste materials. A notable example is the Kalundborg Symbiosis in Denmark, where companies in the region exchange waste materials and energy, benefiting from reduced costs and environmental impact. This model helps in achieving greater resource efficiency and reducing industrial waste (GreenBiz, 2023).

2.3.4.1. How It Works: Industrial symbiosis involves creating networks where companies shareresources like materials, energy, and water. By using each other's by-products, waste isminimized, and resource efficiency is maximized. This collaborative approach enhances sustainability and reduces operational costs (Chertow, 2000).

2.3.4.2. Modules:

- **Material Exchange:** Sharing of materials between companies.
- **Energy Exchange:** Sharing of energy resources and by-products.
- **Water Reuse:** Shared water management and reuse systems.
- **Logistics Optimization:** Coordinated logistics to reduce transportation impacts.
- **Information Sharing:** Platforms for sharing information and best practices.

2.3.4.3. Benefits/Strengths:

- Efficient use of resources.
- Can lead to innovation and new business opportunities.

- Reduces environmental impact of industrial activities (Chertow, 2000).

2.3.4.4. Weaknesses/Problems:

- Requires collaboration and trust between firms.
- Complex to coordinate and manage.
- Initial setup and integration can be challenging (Chertow, 2000).
  Conclusion: Industrial symbiosis promotes resource efficiency by facilitating the exchange of waste materials and by-products between industries. The Kalundborg Symbiosis in Denmark is a prime example, illustrating how industries can collaborate to achieve mutual benefits, such as cost savings and reduced environmental impact. This system underscores the importance of cooperative approaches in managing industrial waste and enhancing sustainability (GreenBiz, 2023).

2.3.5. Bio refinery

According to Cherubini (2010) points out, bio refineries offer a sustainable wayto manage food waste by converting it into valuable bio-based products, supporting the bio economy. Bio refineries convert biomass into energy and other valuable products, such as chemicals and materials. Companies like LanzaTech use bio refinery principles to convert waste carbon from industries into fuels and chemicals. LanzaTech's process captures waste gases and transforms them into valuable products, promoting a sustainable approach to waste management (GreenBiz, 2023).

2.3.5.1. How It Works: Bio refineries convert biomass, including food waste, into fuels, chemicals, and materials. Through processes such as fermentation and pyrolysis, biomass is broken down and transformed into high-value products, promoting a sustainable bio economy. Thisapproach maximizes the use of biomass and minimizes waste (Cherubini, 2010).

2.3.5.2. Modules:

- **Biomass Pretreatment:** Preparation and processing of biomass feed stocks.
- **Conversion Technologies:** Methods like fermentation, pyrolysis, and gasification to convertbiomass.
- **Product Separation:** Isolation and purification of bio-products.
- **Co-product Management:** Utilization of by-products for energy or other uses.
- **Integration with Existing Systems:** Connection with existing industrial processes andinfrastructure.

2.3.5.3. Benefits/Strengths:

- Converts waste into valuable products.

- Supports renewable energy and bio-based products.
- Reduces reliance on fossil fuels and enhances sustainability (Cherubini, 2010).

2.3.5.4. Weaknesses/Problems:

- High initial investment and technological complexity.
- Market and regulatory challenges.
- Requires a consistent and reliable feedstock supply (Cherubini, 2010).

Conclusion: Bio refineries offer a sustainable solution for converting biomass into energy, chemicals, and materials. Companies like LanzaTech highlight the potential of bio refineries to transform waste carbon into valuable products, contributing to a circular economy. By utilizing renewable resources and reducing reliance on fossil fuels, bio refineries support sustainable industrial practices and help mitigate climate change (GreenBiz, 2023).

2.3.6. Sustainable Agriculture

According to Lal. (2004) suggests that incorporating compost and dig estate from food waste into agricultural practices can improve soil health, reduce the need for chemical fertilizers, andenhance sustainability. Sustainable agriculture focuses on practices that maintain the health of the environment, economy, and society. Companies like IKEA are exploring regenerative agriculture to improve soil health and reduce carbon footprints. Sustainable agriculture practices include crop rotation, organic farming, and the use of renewable energy, which help in promoting long-term agricultural productivity and environmental health (Goodnet, 2023).

2.3.6.1. How It Works: Sustainable agriculture integrates various practices to maintain productivity while minimizing environmental impact. Techniques like composting, efficient water use, andintegrated pest management enhance the sustainability of farming systems.

2.3.6.2. Modules:

- **Soil Health Management:** Practices like crop rotation, cover cropping, and compost application.
- **Water Management:** Efficient irrigation and rainwater harvesting.
- **Integrated Pest Management:** Combining biological, cultural, and mechanical control methods.

- **Biodiversity Enhancement:** Promoting diverse cropping systems and agroforestry.
- **Nutrient Management:** Using organic fertilizers and optimizing nutrient cycles.

2.3.6.3. Benefits/Strengths:

- Enhances soil fertility and health.
- Reduces environmental impact and chemical input dependency.
- Improves water use efficiency and supports long-term productivity (Lal, 2004).

2.3.6.4. Weaknesses/Problems:

- Requires knowledge and expertise for implementation.
- Transition can be challenging for conventional farmers.
- Initial costs can be higher compared to traditional practices (Lal, 2004).
  Conclusion: Sustainable agriculture practices are essential for maintaining long-term agricultural productivity and environmental health. Companies like IKEA's exploration of regenerative agriculture practices demonstrate the benefits of improving soil health and reducing carbon footprints. Sustainable agriculture promotes biodiversity, conserves resources, and ensures food security, making it a cornerstone of environmental sustainability (Goodnet, 2023).

2.4. Comparison of related systems

2.4.1. Table 1: Comparisons for the Related Systems

System	Strengths	Weaknesses	Technology
Waste-to-Energy (WtE)	- High waste reduction efficiency - Generates continuous energy supply - Can process mixed waste streams	- High capital and operational costs - Potential emissions of pollutants - Requires continuous waste input for efficiency	- Incineration - Anaerobic digestion - Emission control systems - Energy recovery systems

Circular Economy	- Promotes sustainable consumption - Reduces environmental footprint - Encourages innovation in product design	- Requires systemic changes and cooperation - Initial costs and investments are high - Regulatory and market barriers can be significant	- Design for longevity - Reuse and repair systems - Efficient recycling processes - Product-as-a-service models
Zero Waste Initiatives	- Comprehensive approach to waste reduction - Engages community and businesses	- Requires widespread behavioral change - Initial implementation challenges	- Source reduction - Comprehensive recycling programs - Composting facilities - Public education campaigns

System	**Strengths**	**Weaknesses**	**Technology**
	- Substantial environmental benefits	- Depends on robust infrastructure and regulatory support	
Industrial Symbiosis	- Efficient use of resources - Innovation and new business opportunities - Reduces environmental impact of industries	- Requires collaboration and trust between firms - Complex coordination and management - Initial setup and integration challenges	- Material and energy exchange systems - Shared water management systems - Coordinated logistics - Information-sharing platforms
Bio refinery	- High potential for innovation - Diversifies energy and product base - Reduces greenhouse gas emissions	- High initial investment and technological complexity - Market and regulatory challenges - Requires consistent feedstock supply	- Biomass pretreatment - Conversion technologies (fermentation, pyrolysis, gasification) - Product separation and purification systems

Sustainable Agriculture	- Promotes resilience to climate change - Reduces dependency on chemical inputs - Supports ecological balance and biodiversity	- Requires knowledge and expertise - Transition challenges for conventional farmers - Higher initial costs	- Soil health management (crop rotation, cover cropping, composting) - Efficient water management (irrigation, rainwater harvesting) - Integrated pest management

2.3. Conclusion

This chapter mainly described the literature review of food waste management systems where Igathered information about other related systems, how they function and the enhancements needed in order to improve the current food waste management system.

Chapter Three

Research Methodology

Topic: online Food Waste Management System.

2.0 Introduction

The methodology focuses on the patterns of research, approaches to data collection, techniques for
Analysis and tools that were used for designing and implementation of the system. The Methodology was in line with the specific objectives of food waste management System.
3.1 System Study and Analysis In this project fact finding techniques were used in order to determine the system and user requirements
As well as system inputs and out puts. This greatly determined what the system was expected to do. They included:
3.2 Data collection techniques

3.2.1 **Surveys and Questionnaires**:

The researcher used these tools to gather quantitative data on food waste generation, management practices, and attitudes towards food waste. Surveys can target different stakeholders such as households, businesses, and institutions to obtain a broad understanding of food waste patterns and behaviors.

3.2.2 **In-depth Interviews**:

Qualitative data can be collected through structured or semi-structured interviews with key stakeholders, such as managers, chefs, kitchen staff, and food service workers. These interviews help explore in-depth perspectives on food procurement, inventory management, food service planning, and disposal practices. This method was used in a study focusing on food waste in the hotel industry, where interviews were conducted with staff to understand food service planning and procurement processes (Emerald Insight, 2020).

3.2.3 Direct **Waste Analysis**:

This is where by a researcher involves physically sorting and analyzing waste to determine the composition and amount of food waste. This method provides accurate data on what is being wasted and can identify specific waste streams that need attention. For example, research at Molson Coors classified different types of food waste and analyzed their management options (Waste and Biomass Valorization, 2020).

3.2.4 Food **Waste Audits**:

Regular audits was conducted to monitor food waste generation over time. This method helps in identifying trends, peak waste periods, and the effectiveness of waste reduction strategies.

3.2.4 Observation **and Recording**:

Then researcher used observational studies that provided insights into food handling and waste generation processes in real-time. This can be coupled with photographic evidence or video recordings to document waste generation and disposal practices.

3.2.5 **Content Analysis**:

The researcher Analyzed written or recorded communications, such as interviews or survey responses, to identify common themes and insights related to food waste management. This technique helps in understanding the underlying reasons behind food waste and potential areas for improvement (Emerald Insight, 2020).

3.2.6 **Life Cycle Assessment (LCA)**:

This method evaluates the environmental impacts of food waste from production to disposal. It helps in understanding the broader environmental implications of food waste and identifying sustainable waste management practices (Springer Link, 2019).

3.3 Data Analysis Methods

The researchers used data analysis application software which included

3.3.1 **Content Analysis**:

Used to interpret and identify themes within qualitative data, such as interview transcripts and survey responses. It helps uncover underlying perspectives and attitudes towards food waste management (Babbie, 2020; Bryman, 1992).

3.3.2 **Statistical Analysis**:

Applied to quantitative data from surveys and waste audits to identify trends, correlations, and significant factors contributing to food waste.

3.3.3 **Comparative Analysis**:

The researcher Compared data across different periods, locations, or stakeholder groups to identify patterns and differences in food waste generation and management.

3.3.4 **Life Cycle Assessment (LCA)**:

The researcher also carried analysis of environmental impacts associated with food waste, helping identify stages where waste reduction would be most beneficial (Guven et al., 2019)(Springer Link).

3.4 System Analysis

System analysis is the process of studying an existing system and its components to identify its functions, problems, and requirements. In the context of a food waste management system, system

analysis involves understanding the current waste generation, handling processes, and identifying areas for improvement. Here are the key steps:

Requirement Gathering:

- **Stakeholder Interviews**: Conduct interviews with stakeholders such as kitchen staff, managers, and waste disposal personnel to gather requirements and understand pain points.
- **Surveys and Questionnaires**: Use surveys to collect data on current food waste practices and challenges.
- **Observation**: Observe the food preparation and disposal processes to identify inefficiencies and areas where waste occurs.

Process Mapping:

- **Flowcharts and Diagrams**: Create flowcharts to map the current processes from food procurement to disposal. Identify points where waste is generated.
- **Data Collection**: Collect quantitative data on the amount and types of food waste generated at different stages of the process.

Gap Analysis:

- **Identify Inefficiencies**: Compare current practices with best practices in food waste management to identify gaps and inefficiencies.
- **Root Cause Analysis**: Use techniques like the 5 Whys or Fishbone Diagram to identify the root causes of food waste.

Feasibility Study:

- **Technical Feasibility**: Assess the technical requirements and feasibility of implementing new waste management solutions.
- **Economic Feasibility**: Evaluate the cost-benefit analysis of implementing the proposed solutions.
- **Operational Feasibility**: Determine the practicality of implementing new solutions within the existing operational framework.

3.4.2 System Design

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. For a food waste management system, system design involves creating a blueprint for implementing the identified solutions. Here are the key steps:

Conceptual Design:

- **Define Objectives**: Clearly define the objectives of the food waste management system based on the findings from the system analysis phase.
- **Develop Models**: Create conceptual models that represent the proposed system, including flowcharts, data flow diagrams (DFDs), and entity-relationship diagrams (ERDs).

Detailed Design:

- **Component Design**: Design the individual components of the system such as waste tracking, inventory management, and reporting modules.
- **Interface Design**: Design user interfaces for the system, ensuring they are user-friendly and intuitive.
- **Database Design**: Design the database schema to store data related to food waste, including tables, relationships, and constraints.

System Architecture:

- **Define Architecture**: Choose the appropriate system architecture (e.g., client-server, cloud-based) that supports the system's requirements and scalability needs.
- **Technology Stack**: Select the technology stack (e.g., programming languages, frameworks, databases) for developing the system.

Integration Design:

- **Integration Points**: Identify and design integration points with existing systems such as inventory management, point of sale (POS), and waste disposal services.
- **APIs and Middleware**: Design APIs and middleware for seamless data exchange between the food waste management system and other systems.

Security and Compliance:

- **Security Measures**: Design security measures to protect sensitive data, including user authentication, data encryption, and access controls.
- **Compliance**: Ensure the system design complies with relevant regulations and standards, such as food safety laws and data protection regulations.

Prototyping and Validation:

- **Build Prototypes**: Develop prototypes of critical components and interfaces to validate the design with stakeholders.
- **User Feedback**: Gather feedback from users on the prototypes and make necessary adjustments to the design.

3.5 System Implementation

System implementation is the process of deploying and integrating a new system within an organization. It involves multiple stages to ensure that the system meets user requirements and functions effectively within the organizational context. The key steps in system implementation

3.5.1 Implementation Tools

3.5.2 PHP (Hypertext Preprocessor)

PHP is a server-side scripting language widely used for web development. It is particularly useful for creating dynamic and interactive web applications.

- **Role in Food Waste Management**: PHP can be used to develop the backend of the food waste management system, handling server-side logic, processing user inputs, and interacting with the database.
- **Features**:
    - **Form Handling**: Collecting and processing data from web forms (e.g., waste logs, inventory updates).
    - **Session Management**: Managing user sessions to maintain state across pages (e.g., user authentication).
    - **Database Interaction**: Using PHP to connect to and manipulate the MySQL database, performing CRUD operations (Create, Read, Update, and Delete).

3.5.3 HTML (Hypertext Markup Language)

HTML is the standard markup language for creating web pages. It provides the structure for web content.

- **Role in Food Waste Management**: HTML is used to design the front-end interface of the food waste management system.
- **Features**:
    - **Form Elements**: Creating forms for data entry (e.g., logging food waste, registering new users).
    - **Content Structuring**: Structuring the layout of the web pages to display data and user inputs in a readable format.
    - **Hyperlinks and Multimedia**: Embedding links, images, and videos related to food waste management practices and tips.

3.5.4 XAMPP

XAMPP is a free and open-source cross-platform web server solution stack package developed by Apache Friends. It consists of Apache HTTP Server, Maria DB (or MySQL), and interpreters for scripts written in PHP and Perl.

- **Role in Food Waste Management**: XAMPP provides a local development environment to develop, test, and deploy the food waste management system.
- **Features**:
    - **Local Server Setup**: Allows developers to set up a local web server to test the application before deploying it to a live server.
    - **Database Management**: Comes with phpMyAdmin, a web-based interface to manage MySQL databases easily.
    - **Cross-Platform Support**: Can be installed on various operating systems, including Windows, macOS, and Linux.

3.5.5 MySQL

MySQL is an open-source relational database management system (RDBMS). It is widely used for storing and managing data.

- **Role in Food Waste Management**: MySQL is used to store all the data related to food waste, including user information, waste logs, inventory records, and more.
- **Features**:
    - **Data Storage**: Storing data in structured tables that can be efficiently queried.
    - **Data Relationships**: Establishing relationships between different tables to maintain data integrity and support complex queries.
    - **Scalability**: Handling large amounts of data efficiently, which is essential for extensive food waste management systems.

3.6 System Testing and Validation

3.6.1 System Testing

System testing is the process of verifying that the complete and integrated software product meets the specified requirements. For a food waste management system, this can include various testing phases:

Unit Testing: This involves testing individual components or modules of the system to ensure they work correctly in isolation.

Integration Testing: Here, the interaction between integrated modules is tested to identify any issues in the way different parts of the system work together.

3.6.2 Validation

Validation is the process of ensuring that the system meets the needs and requirements of the users and stakeholders. It often involves the following steps:

Requirement Validation: Ensuring all specified requirements are testable and have been met by

the system.

Performance Validation: Checking if the system performs well under expected load and stress conditions.

Compliance Validation: Ensuring that the system complies with relevant standards and regulations, such as food safety standards

3.6.3 Conclusion

In summary, this chapter described the methodologies that were used for the different patterns of Research, approaches to data collection, techniques for analysis and tools that were used for designing and implementation of the system.

Chapter Four

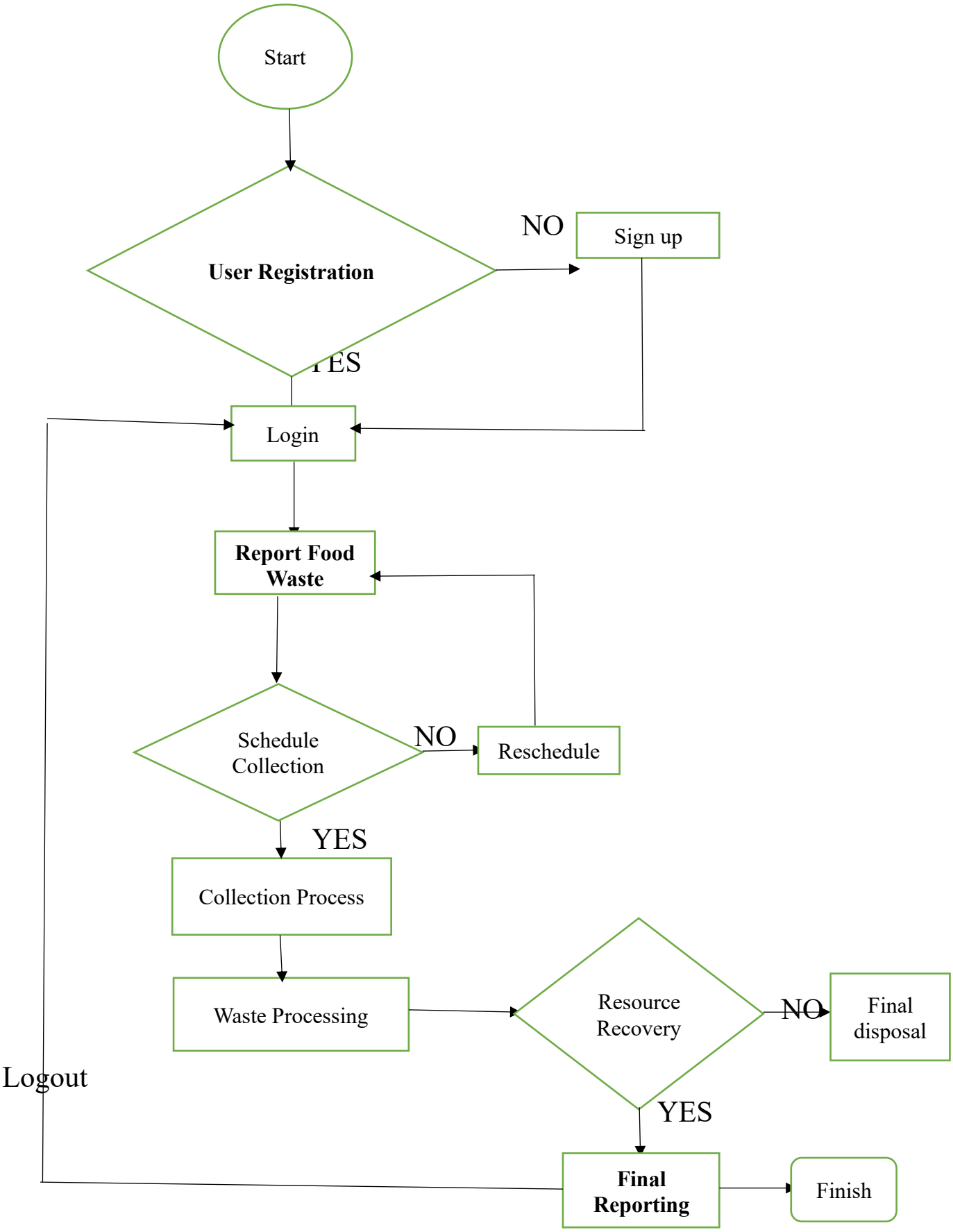
System Study, Analysis and Design

This chapter concerns the study of the existing system, analysis of the requirements for the system, process and data modeling.

4.1 The study of the Existing System

The study of existing food waste management systems often highlights the challenges and inefficiencies present in current practices. Traditional systems typically involve a mix of inadequate waste separation, limited recycling, and a heavy reliance on landfilling, which contributes to environmental degradation. These systems struggle to recover valuable nutrients from food waste, leading to significant resource loss and increased greenhouse gas emissions. Recent efforts aim to improve these systems by implementing more sustainable practices such as composting, anaerobic digestion, and better waste collection methods (FAOHome).

4.1.1 Workflow for the Food Waste Management System Processes


Start
User Registration
NO
Sign up
YES
Login
Report Food Waste
Schedule Collection
NO
Reschedule
YES
Collection Process
Waste Processing
Resource Recovery
NO
Final disposal
YES
Final Reporting
Finish
Logout

4.1.2 Strength of the existing System

Technology Integration: The current food waste management systems increasingly use technologies like AI, IoT, and specialized apps to reduce waste. For example, AI can predict food demand, minimizing overstocking, while apps like Copia and Flash food help redistribute surplus food to those in need, thereby reducing waste and contributing to social welfare (Light speed) (SC Publishing).

Environmental Impact Reduction: Some systems convert organic waste into compost or energy, significantly reducing the environmental impact of food waste. Companies like Maeko provide composters that transform food waste into usable compost, helping to divert waste from landfills(light speed).

Awareness and Education: Campaigns and educational programs targeting food waste reduction have been implemented to encourage sustainable behavior among consumers and businesses. These efforts have shown positive results in reducing plate waste and promoting more sustainable consumption practices (RSC Publishing).

4.1.3 Weakness of existing System

Inconsistent Consumer Behavior: Despite various awareness campaigns, consumer behavior remains a challenge. Many people still lack the knowledge and motivation to engage in sustainable practices, such as properly reading food labels or reducing portion sizes, leading to continued waste (RSC Publishing).

Limited Reach and Implementation: While technology and campaigns exist, their implementation is often limited by factors such as demographic reach, inconsistent standards (like food labeling), and the accessibility of these technologies to all sectors, including small businesses and households (RSC Publishing).

Dependence on Voluntary Participation: Many systems rely heavily on voluntary participation from businesses and consumers. This can lead to inconsistent results, as not all

stakeholders may be equally committed or able to contribute to waste reduction efforts (light speed).

4.2 Data analysis results

Data analysis results in the context of food waste management reveal several key insights that can help inform better decision-making and more effective strategies. According to recent reports, there has been significant progress in reducing food waste, particularly in sectors like hospitality and food services. For example, a 2023 report from the International Food Waste Coalition (IFWC) highlighted a 23% reduction in food waste at member sites since 2019, demonstrating the impact of consistent monitoring and reporting.

Furthermore, organizations like ReFED have developed advanced tools like the ReFED Insights Engine, which centralizes data from over 50 public and proprietary datasets. This platform offers a comprehensive analysis of food waste across the supply chain, providing stakeholders with cost-benefit analyses of potential solutions and measuring the social and economic impacts of food waste reduction efforts.

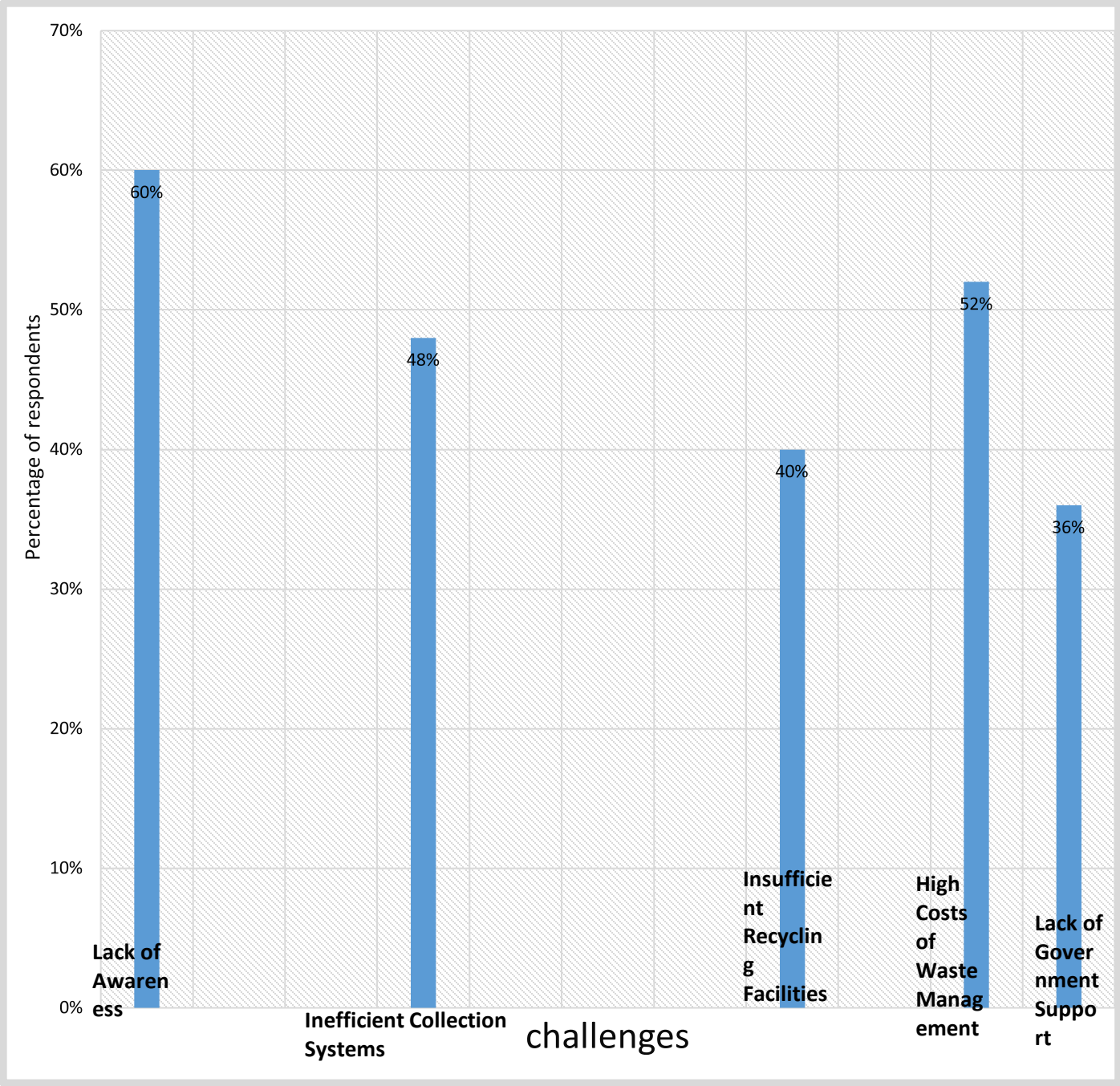
Overall, the data suggests that targeted interventions, supported by robust data analysis, can significantly reduce food waste and offer economic and environmental benefits. However, the challenge remains to expand these successful practices across more organizations and sectors to achieve broader impact (Food Waste Solutions) (International Food Waste Coalition).

4.2.1 The tabular representation of the challenges associated with the current food waste management system

Table 1: Challenges associated with the current system.

Challenges	Number of respondents	Percentage of respondents
Lack of Awareness	150	60%
Inefficient Collection Systems	120	48%
Insufficient Recycling Facilities	100	40%
High Costs of Waste Management	130	52%
Lack of Government Support	90	36%

4.2.2 The Graphical Representation of the Challenges faced by the current food Waste Management system.



4.2.1 User Requirements

User requirements for a food waste management system typically focus on ensuring that the system is user-friendly, efficient, and capable of handling the various aspects of food waste management. Key requirements include:

1. **User Interface and Experience (UI/UX):** The system should have an intuitive and easy-to-navigate interface that allows users to register, log in, donate food, and track their contributions effortlessly. The user experience should be smooth, with clear instructions and minimal steps to complete actions.
2. **Food Donation Process:** Users, such as restaurants or individuals, should be able to easily input the type and quantity of food they wish to donate. The system should match these donations with the nearest needy organizations or individuals.
3. **Real-Time Tracking:** Users and administrators should be able to track the status of food donations in real-time, from the point of donation to the final delivery. This includes knowing the location of the delivery personnel and the status of the donation.
4. **Secure Login and Data Protection:** The system should have secure login features to protect user data. This is particularly important for handling sensitive information such as contact details and donation records.
5. **Admin and Delivery Modules:** The system should include administrative tools for managing food donations, including tracking, matching, and distributing donations. A delivery module is essential for coordinating the pickup and delivery of food donations to ensure that they reach the intended recipients efficiently.
6. **Mobile Compatibility:** The system should be mobile-friendly, allowing users to access the platform from various devices, including smartphones and tablets, to facilitate on-the-go donations and tracking.
7. **Notification System:** The system should have a robust notification system that informs users of the status of their donations, reminders for upcoming donations, and updates on the food waste management process.

These requirements aim to create a system that not only reduces food waste but also ensures that surplus food is effectively distributed to those in need, ultimately contributing to both environmental sustainability and social welfare (MDPI) (GitHub).

4.2.2 Functional requirements

The functional requirements of a food waste management system focus on the essential operations that the system must perform to ensure efficient collection, distribution, and tracking of food waste. These requirements typically include:

1. **User Registration**: Restaurants, cafes, volunteers, and needy individuals must be able to register on the platform. This includes creating profiles with necessary details.
2. **Food Collection Requests**: Registered restaurants and cafes can place requests for the collection of leftover food, which are then managed by volunteer organizations.
3. **Task Assignment**: Volunteer organizations receive collection requests and assign them to their workers, who are responsible for picking up and delivering the food to designated locations.

4. **Tracking and Record-Keeping**: The system maintains records of food collection, distribution points, and the needy individuals receiving the food. It also tracks the status of food requests and deliveries.
5. **Admin Oversight**: Administrators have the ability to manage user accounts, monitor food distribution activities, and ensure that the system operates smoothly.

These functional requirements are critical to the success of a food waste management system, as they enable efficient coordination between food donors, volunteers, and recipients, ensuring that surplus food is properly utilized to help those in need (LovelyCoding.org) (Research Writing & Editing Services).

4.2.3 Non-functional requirements

Non-functional requirements (NFRs) for a food waste management system are crucial as they define the system's performance and quality attributes, ensuring that it meets the necessary standards. Here are some of the key NFRs for such a system:

1. **Scalability**: The system should be able to handle an increasing amount of food waste data and users as the number of participants in the food waste management process grows. For example, it should be scalable to support 10,000 concurrent users without degrading performance.
2. **Security**: Protecting sensitive data such as user information and waste management records is vital. The system must implement strong security measures to prevent unauthorized access and ensure data privacy.
3. **Performance**: The system should perform efficiently, with quick response times even under heavy loads. For example, operations such as logging data, retrieving records, and generating reports should be completed within a defined time limit, e.g., under 2 seconds.
4. **Reliability**: The system must be reliable, ensuring that it operates consistently and without failure. This includes high availability and robust error-handling mechanisms to minimize downtime.
5. **Usability**: The system should be user-friendly, with an intuitive interface that makes it easy for users to input data and retrieve information. This is particularly important as it will be used by various stakeholders, including waste management companies, donors, and beneficiaries.
6. **Compliance**: The system should comply with relevant environmental and data protection regulations, ensuring that all legal requirements are met.
7. **Maintenance**: The system should be easy to maintain and update. It should allow for regular updates and bug fixes without significant downtime or impact on its operation.

These NFRs ensure that the food waste management system is robust, secure, and capable of supporting its users effectively as it scales (Visure Solutions) (Modern Requirements).

4.2.4 System requirement

The system requirement includes requirements that are needed to include certain functionality in the system. It involved describing the system and the properties in that system. They include the hardware and software requirements as follows;

4.2.4.1 Hardware Requirements

Table 2: Hardware requirements

Hardware component	**System requirement**	**Justification**
Server	High-performance server with multi-core processors (e.g., Intel Xeon or AMD EPYC) and 32 GB RAM	To handle multiple simultaneous connections, process data efficiently, and ensure system reliability.
Storage	1 TB SSD or more	To store a large amount of user data, transaction records, and food distribution details securely and efficiently.
Network Interface	Gigabit Ethernet or higher	Ensures fast and reliable data transfer between servers, clients, and other connected devices.
Backup Storage	External HDD or Cloud Backup with 2 TB capacity	To maintain data integrity and allow for recovery in case of system failure or data loss.
Firewall	Dedicated hardware firewall	To provide a robust security layer, protecting the system from unauthorized access and cyber threats.
Workstation	Standard desktop with 16 GB RAM, Intel Core i5 or higher	For system administrators to monitor, manage, and maintain the system efficiently.

Uninterruptible Power Supply (UPS)	1500 VA or higher	To protect against power interruptions, ensuring continuous system operation and preventing data loss.
Database Server	High-performance server with at least 64 GB RAM and multi-terabyte SSD storage	To manage large databases with fast query processing and high availability for critical system operations.
Router/Switch	Managed gigabit switch with VLAN support	To manage network traffic effectively, ensuring smooth communication between different components of the system.

4.2.4.2 Software Requirements

Table 3: Software requirements

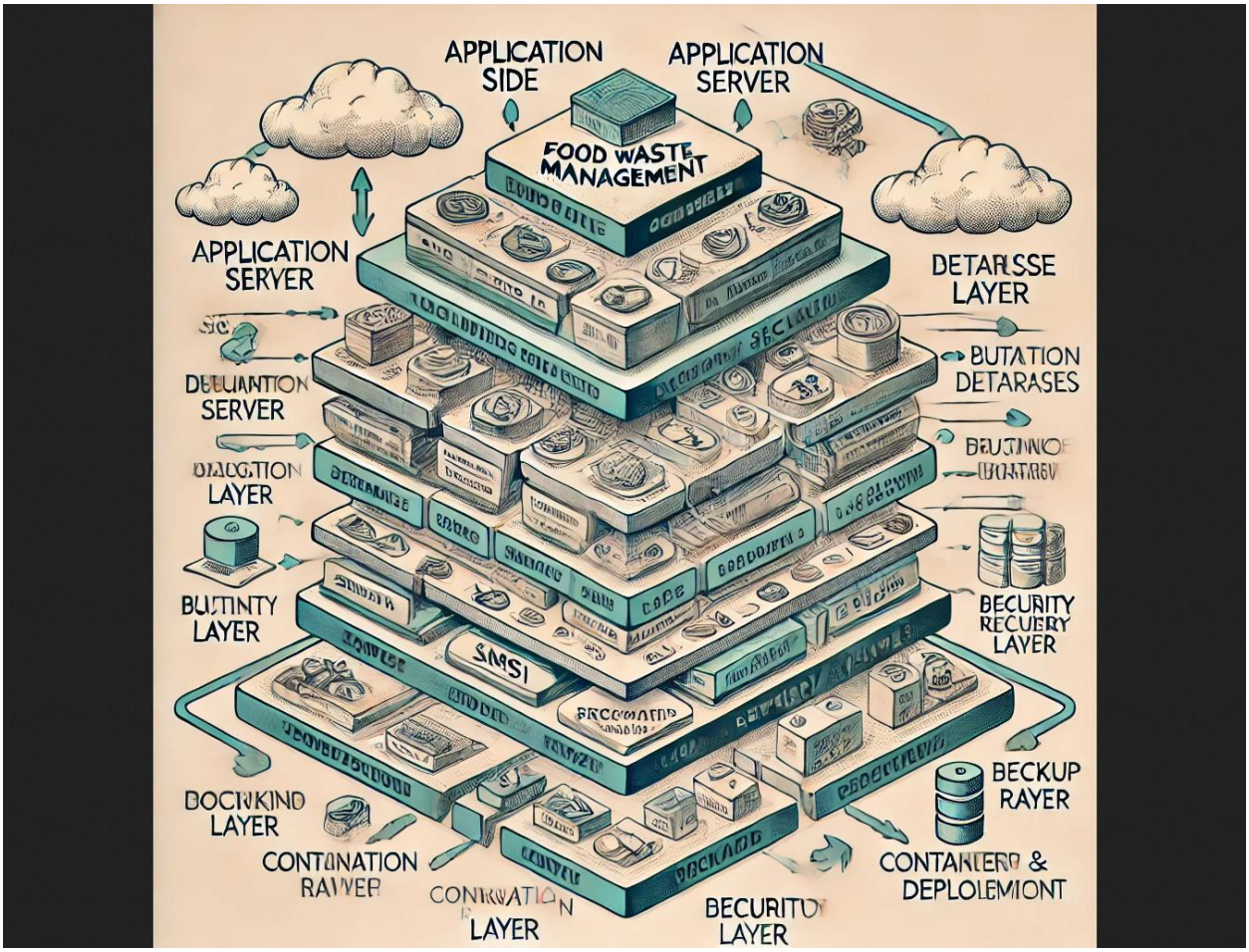
Software component	**System requirement**	**Justification**
Operating System	Linux (e.g., Ubuntu Server), Windows Server 2019	A stable and secure OS is essential for hosting the application and managing server operations.
Web Server	Apache HTTP Server or Nginx	To handle incoming HTTP requests and serve web pages to users efficiently.
Database Management System (DBMS)	MySQL, PostgreSQL	For storing, managing, and querying large datasets, such as user profiles and transaction records.

Programming Languages	PHP, Python, JavaScript	For developing the core application logic, backend services, and frontend interactions.
Frameworks	Laravel (PHP), Django (Python), or Express.js	To provide a structured and efficient environment for building and scaling the application.
Version Control System	Git, GitHub or GitLab	To manage code versions, track changes, and collaborate with other developers effectively.
Monitoring Tools	Nagios, Zabbix	
Security Software	SSL/TLS certificates, firewalls, and anti-virus software	To protect the system from cyber threats, secure data transmission, and ensure user privacy.
Development Environment	IDEs like Visual Studio Code, PyCharm, or PhpStorm	For providing a robust environment for developers to write, debug, and test code effectively.

4.3 System Design

In the system design phase, process modeling involved use of Data Flow Diagrams (DFD), and Data modeling involved use of Entity Relationship Diagrams (ERD).

4.3.1 Architectural Design for the System

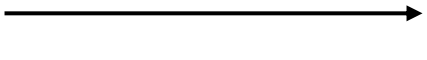


4.3.2 Process Modeling

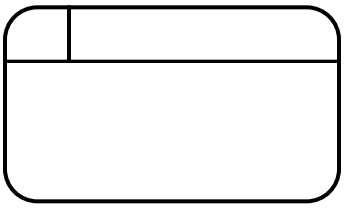
These show how information or data will be moving around the food Waste Management System from the entry to various repositories or data stores.

4.3.2.1 Key Symbols

Symbol	Name
	External entity
	Data store



Data flow



Process

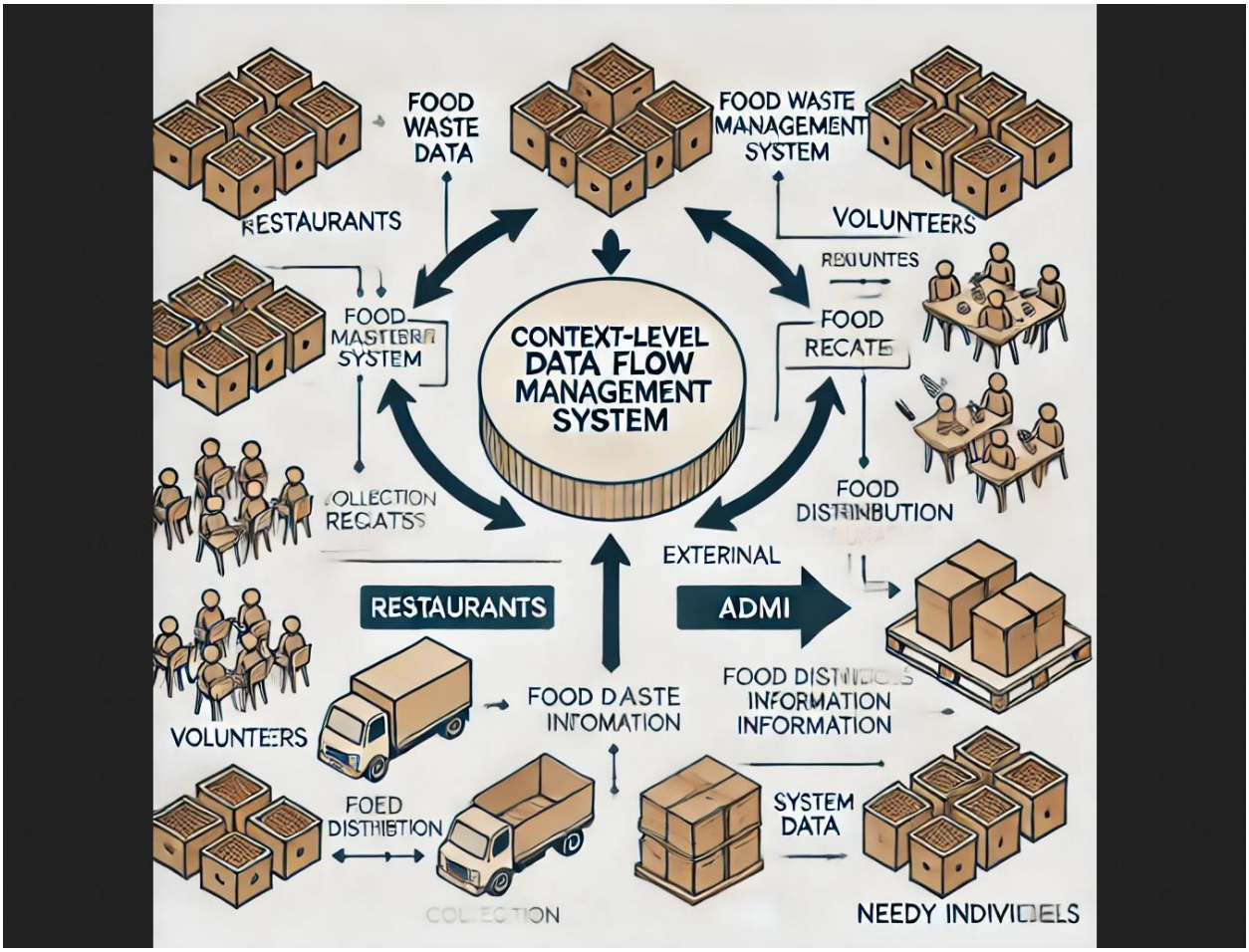
Description of the above key symbols;

i. An Entity is a real life object with an independent existence that interacts with the system.
ii. Data store shows where data is stored after being processed. This can be a database or a file.
iii. Data flow shows the movement of data within the system and also connects processes, data stores and external entities.
iv. A Process is a series of activities or actions to accomplish a desired task.

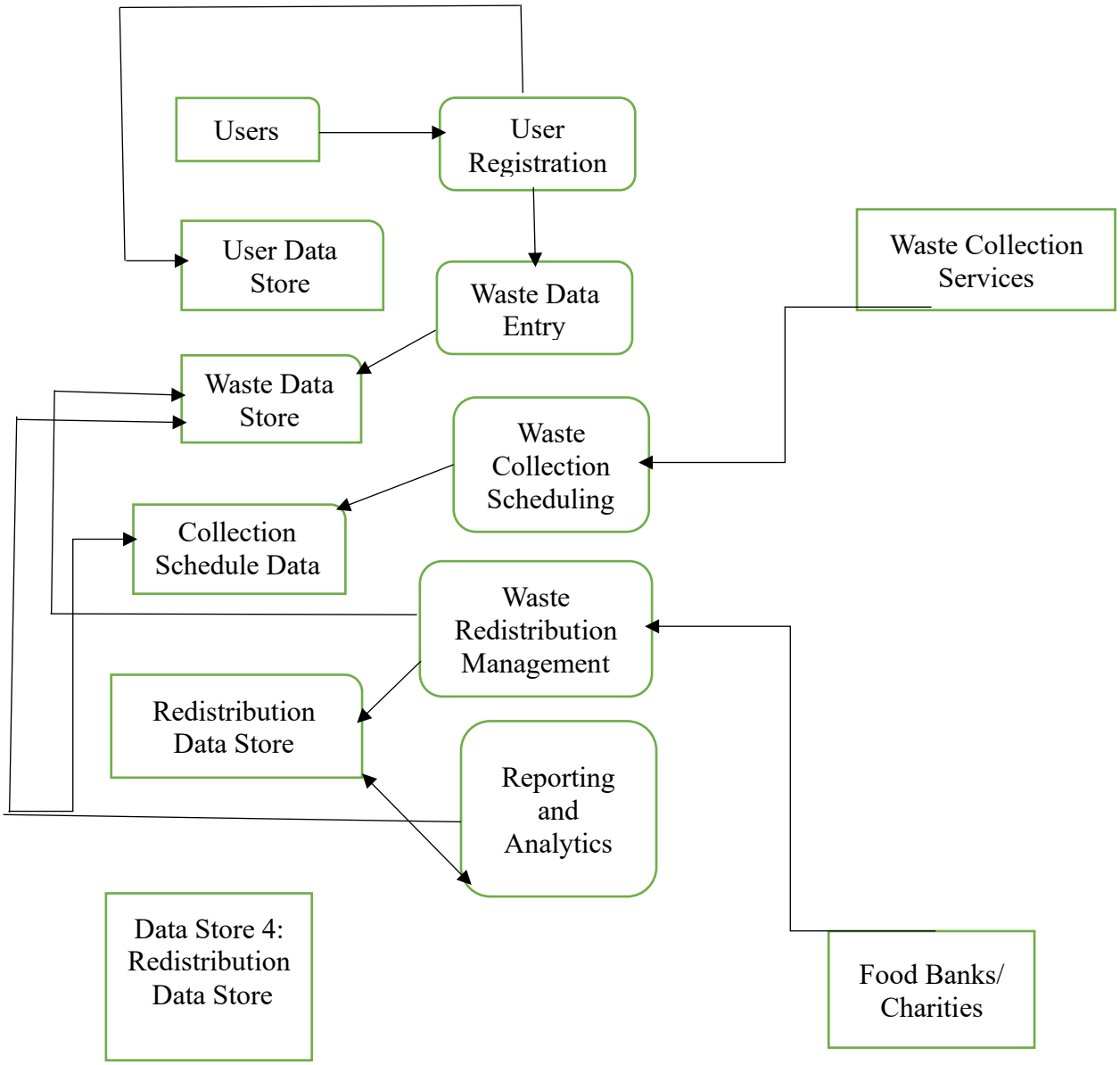
4.3.3 Data Flow Diagrams (DFD).

It is one of the most important modeling tools used by system analysts. It is used to illustrate how data flows in a system. DFD's use a number of symbols to represent systems. There are four kinds of symbols. These are used to represent four kinds of system components. Processes, data stores, data flows and external entities

4.3.3.1 The Context Level DFD



4.3.3.2 The Level 1 DFD for the Online Financial Transfer


Users
User Registration
User Data Store
Waste Data Entry
Waste Collection Services
Waste Data Store
Waste Collection Scheduling
Collection Schedule Data
Waste Redistribution Management
Redistribution Data Store
Reporting and Analytics
Data Store 4: Redistribution Data Store
Food Banks/ Charities

Description for the level 1 DFD

In this subsection, there are tables describing all the design objects used in developing the system. They include Processes, Data flows, Data stores and the External entities.

Description for Processes

Table 4: Description of Processes

Process	Description
User Registration and Authentication	Handles the registration and login of users, including profile management and authentication.
Waste Data Entry	Allows users to input details about food waste they want to report, such as type, quantity, and condition.
Waste Collection Scheduling	Manages the scheduling of waste collection based on the data entered by users and the availability of waste collection services.
Waste Redistribution Management	Coordinates with food banks and charities to manage the redistribution of edible food waste.
Reporting and Analytics	Provides reporting and analytics on waste management activities, including user engagement and system performance.

Description of Data Stores

Table 5: Description for Data stores

Data store	Description
User Data Store	Stores user profiles and authentication information, including registration details and login credentials.
Waste Data Store	Contains records of food waste entered by users, including details like type, quantity, and condition.
Collection Schedule Data Store	Keeps track of schedules for waste collection,

	including timing and frequency of pickups.
Redistribution Data Store	Manages information related to the redistribution of edible food waste, including interaction details with food banks and charities.

Description for External Entities

Table 6: Description of External Entities

External Entity	Description
Users	Individuals who interact with the system to report food waste, manage their profiles, and request waste collection services.
Waste Collection Services	Organizations responsible for collecting and processing food waste from users as scheduled by the system.
Food Banks/Charities	Organizations that receive edible food waste for redistribution to those in need, interacting with the system for redistribution planning.

4.3.4 Identification of Entities and their Attributes

Table 7: Identification for Entities and their Attributes

Entity	**Description**	**Attributes**
User	Individuals who use the system to report food waste and manage their profiles.	- User ID - Name - Email Address - Password - Phone Number - Address - Registration Date

Waste Collection Service	Organizations responsible for collecting and processing food waste from users.	- Service ID - Organization Name - Contact Person - Contact Phone - Contact Email - Service Area
Food Bank/Charity	Organizations that receive edible food waste for redistribution.	- Organization ID - Name - Contact Person - Contact Phone - Contact Email - Address - Receiving Capacity

4.3.5 Modeling Relationships between Entities

Entities and Their Relationships

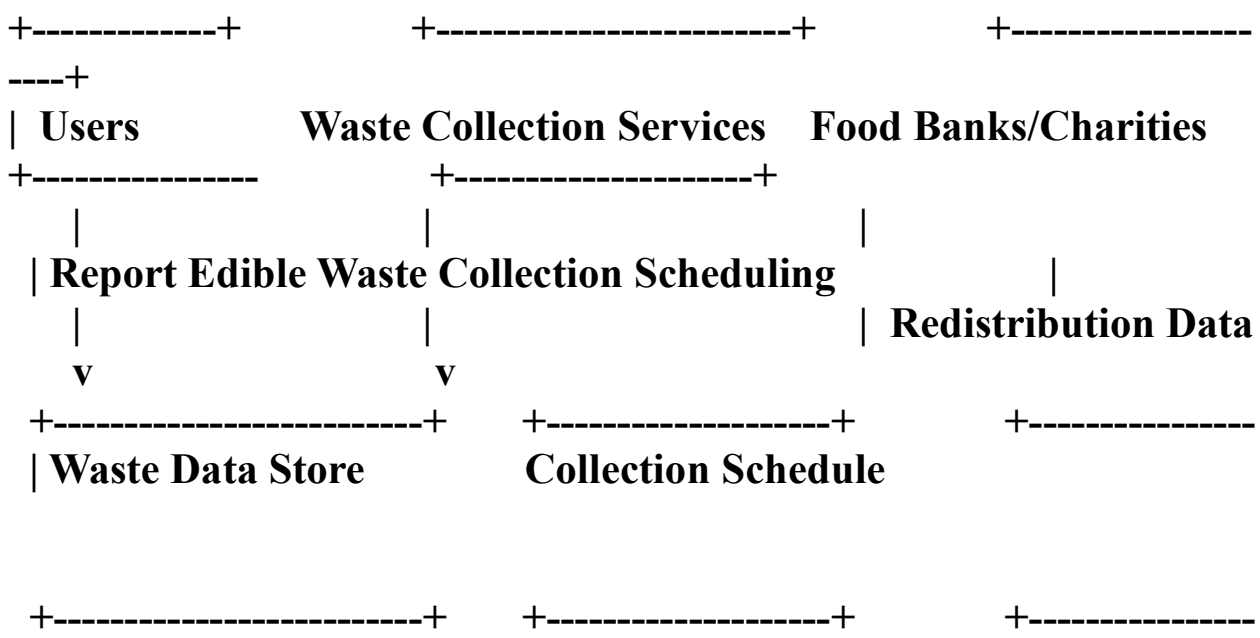
1. **Users** interact with **Waste Collection Services** and **Food Banks/Charities** through the system.
2. **Waste Collection Services** are responsible for picking up waste reported by **Users**.
3. **Food Banks/Charities** receive edible food waste reported by **Users** for redistribution.

Relationships:

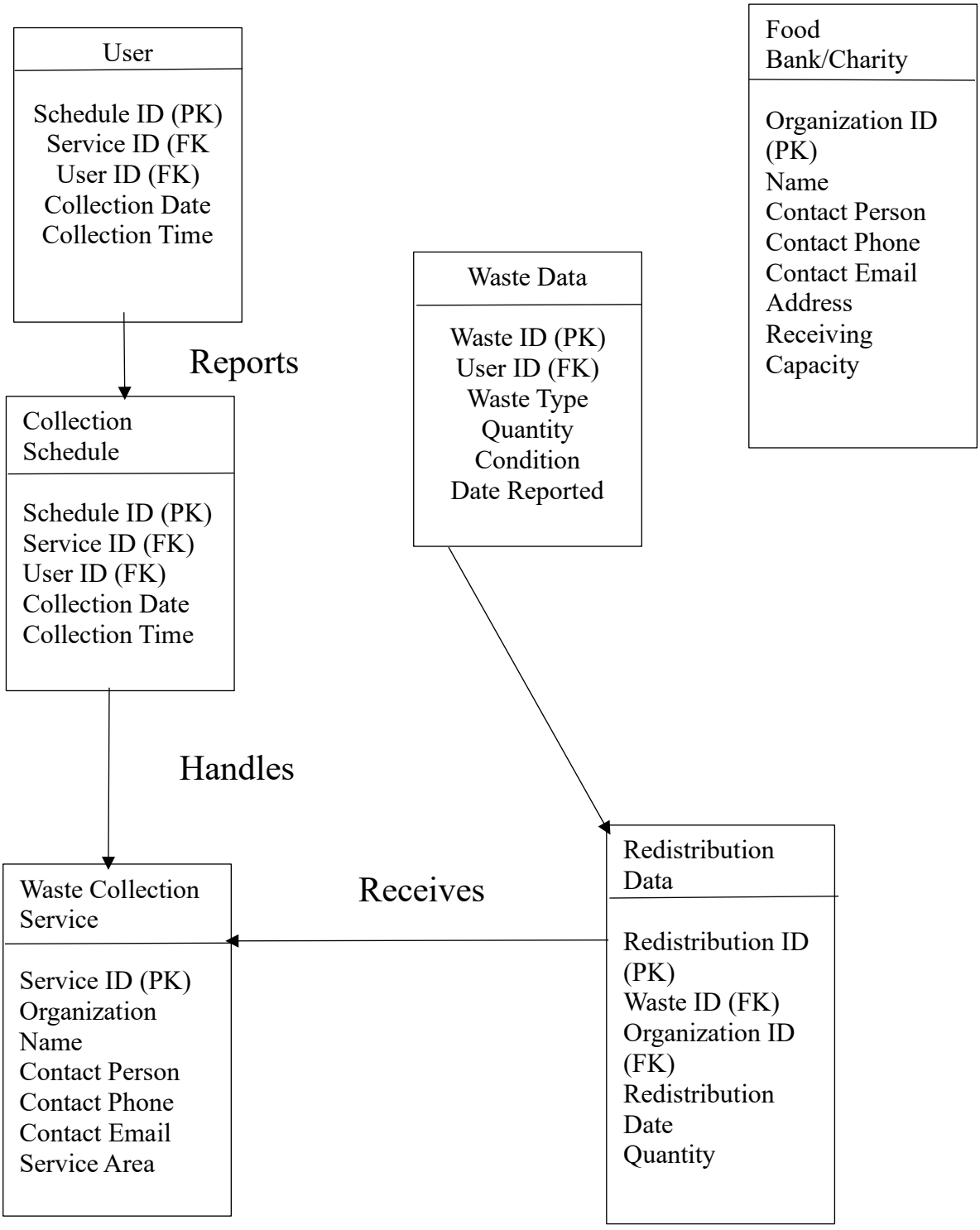
1. **Users** to **Waste Collection Services**:
    - **Relationship**: Request Collection
    - **Description**: Users request the collection of food waste, which is handled by waste collection services. The system schedules and coordinates these requests.
    - **Type**: One-to-Many (One user can request multiple collections, but each collection request is associated with one user).
2. **Users** to **Food Banks/Charities**:
    - **Relationship**: Report Edible Waste
    - **Description**: Users can report edible food waste that can be redistributed to food banks or charities. The system manages this data and communicates with the food banks or charities for redistribution.
    - **Type**: One-to-Many (One user can report waste to multiple food banks/charities, and each report is associated with one user).
3. **Waste Collection Services** to **Users**:

- **Relationship**: Collection Scheduling
- **Description**: Waste collection services interact with users to schedule and perform waste pickups based on the collection requests entered by users.
- **Type**: Many-to-One (Many collection services can serve many users, but each service operates in specific areas).

4. **Food Banks/Charities** to **Users**:
   - **Relationship**: Receive Donations
   - **Description**: Food banks and charities receive donations of edible food waste reported by users. They interact with the system to manage the redistribution process.
   - **Type**: Many-to-One (Many food banks/charities can receive donations from many users, but each donation is associated with one food bank or charity).



4.3.6 The Entity Relationship Diagram



4.3.7 Mapping of ERD to Relational Schema

4.3.7.1User Table

Field Name	Data Type	Constraint

UserID	INT	PRIMARY KEY, AUTO_INCREMENT
Name	VARCHAR(100)	NOT NULL
EmailAddress	VARCHAR(255)	UNIQUE, NOT NULL
Password	VARCHAR(255)	NOT NULL
PhoneNumber	VARCHAR(15)	NULL
Address	VARCHAR(255)	NULL
	DATE	NOT NULL

4.3.7.2 Waste Data

Field Name	Data Type	Constraint
waste_id	INT	
waste_type	VARCHAR(100)	
quantity	ECIMAL(10, 2)	
collection_date	DATE	
status	ENUM('Collected', 'Pending', 'Redistributed')	

4.3.7.3 Food Bank/Charity

Field Name	Data Type	Constraint
food_bank_id	INT	PRIMARY KEY, AUTO_INCREMENT
food_bank_name	VARCHAR(100)	NOT NULL
location	VARCHAR(255)	NOT NULL
contact_person	VARCHAR(100)	NOT NULL
contact_number	VARCHAR(15)	NOT NULL
email	VARCHAR(100)	NULL

4.3.7.5 Waste Collection Service

Field Name	Data Type	Constraint
service_id	INT	PRIMARY KEY, AUTO_INCREMENT
service_name	VARCHAR(100)	NOT NULL
service_area	VARCHAR(255)	NOT NULL
contact_number	VARCHAR(15)	NOT NULL

email	VARCHAR(100)	NULL

4.3.7.6 Redistribution Data

Field Name	Data Type	Constraint
redistribution_id	INT	PRIMARY KEY, AUTO_INCREMENT
waste_id	INT	FOREIGN KEY REFERENCES `waste_data(waste_id)`, NOT NULL
food_bank_id	INT	FOREIGN KEY REFERENCES `food_bank(food_bank_id)`, NOT NULL
quantity_redistributed	DECIMAL(10, 2)	NOT NULL
date_redistributed	DATE	NOT NULL
comments	TEXT	NULL

4.3.7.7**Collection Schedule**

Field Name	Data Type	Constraint
schedule_id		
service_id		
waste_id		
collection_date		
collection_time		
collection_status		

4.4 Conclusion

In summary, this chapter was mainly based on the study of the existing system, analysis of the requirements for the system, processes and data modeling.

Chapter Five

System Implementation, Testing and Validation

This section describes the implementation of the design models in of the system and also shows the different results generated by the system. Therefore screen shots of the system will be displayed to show how the system displays results given a command.

5.1 System Functions

An online food waste management system typically includes several key functions aimed at reducing food waste across various stages of the food supply chain.

1. **Donation Management**: This function enables businesses and individuals to donate surplus food to charities and food banks, thereby reducing waste.
2. **Inventory Management**: Helps track food inventory, predict demand, and optimize ordering processes to prevent over-purchasing.
3. **Waste Tracking and Analytics**: Monitors food waste levels, provides data-driven insights, and helps businesses adjust practices to minimize waste.
4. **Resource Optimization**: Integrates technologies like AI and cloud computing to align food supply with demand more efficiently.

These functions collectively support sustainable food management by leveraging technology to address the complex issue of food waste.

5.1.1 Functions provided to all users.

The functions provided to all users in an online food waste management system include:

1. **Registration and Login**: Users can create accounts, log in, and access personalized features.
2. **Food Donation**: Users can list and donate surplus food to organizations or individuals in need.
3. **Tracking Contributions**: Users can view and manage their past food donations.
4. **Access to Resources**: Users can access educational materials on reducing food waste and sustainable practices.
5. **Notification System**: Users receive alerts and updates regarding food donations, events, or community needs.

These features ensure that all users can actively participate in minimizing food waste.

5.1.2 Functions provided to the customers

For customers using an online food waste management system, the functions typically provided include:

1. **Browse Available Donations**: Customers can view a list of available food donations from various donors.
2. **Request Food Donations**: Customers can request or claim food donations that meet their needs.
3. **Track Orders**: Customers can monitor the status of their food requests or orders.
4. **Feedback and Ratings**: Customers can provide feedback on received donations, helping improve service quality.
5. **Receive Notifications**: Customers are notified of new food availability or relevant updates.

These features empower customers to access and utilize surplus food effectively.

5.1.4 Functions provided to the manager/administrator

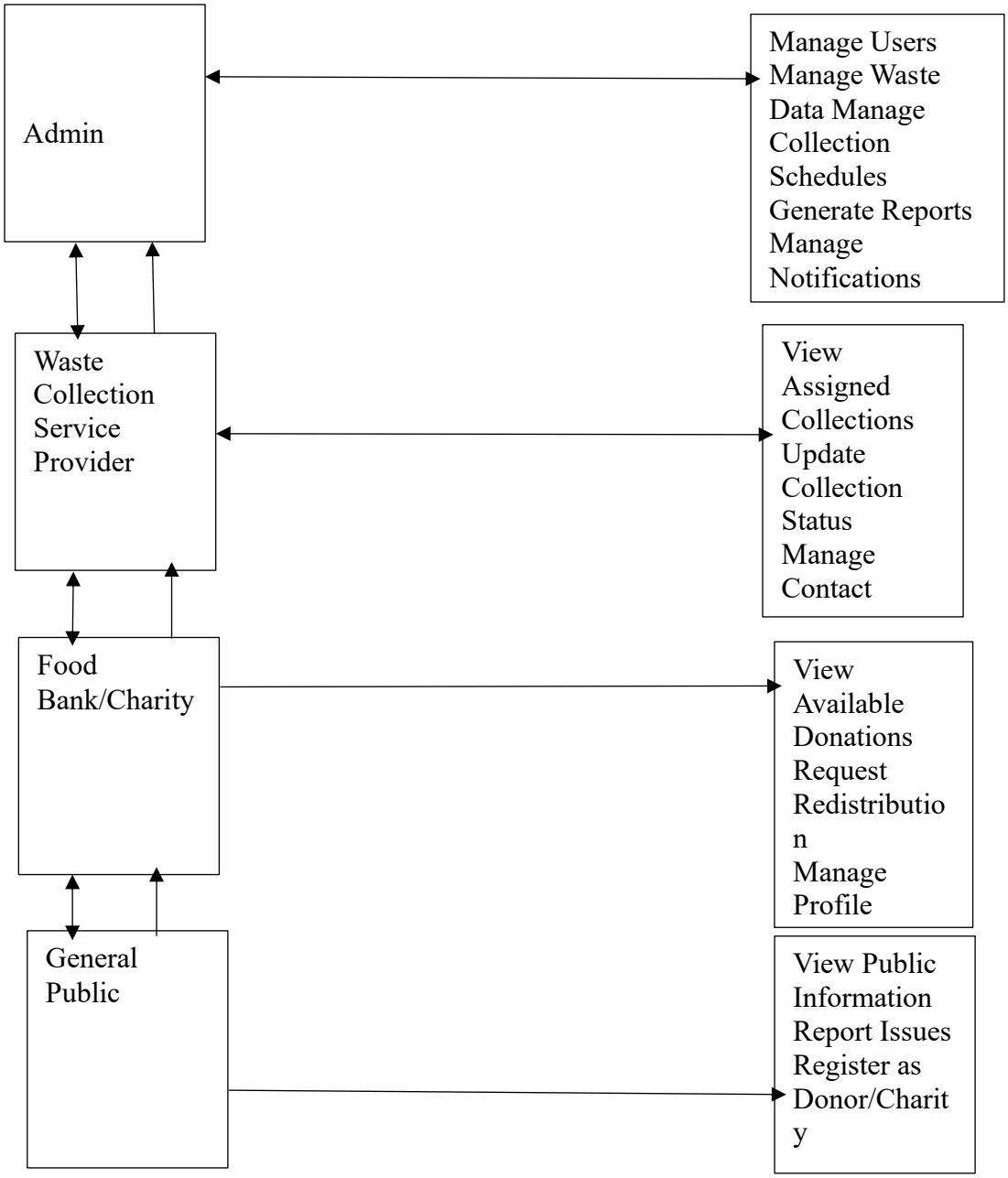
or managers or administrators in an online food waste management system, the functions provided typically include:

1. **User Management**: Admins can manage user accounts, including adding, removing, or editing user details.
2. **Review and Approve Donations**: Admins can review food donations before they are listed and approve or reject them based on quality or other criteria.
3. **Generate Reports**: Admins can generate reports on food waste statistics, donation trends, and system performance.
4. **System Configuration**: Admins can manage settings, configure notifications, and optimize system parameters.
5. **Monitor Activity**: Admins can track user activities, view logs, and ensure compliance with system policies.

These functions help managers oversee and maintain the effective operation of the food waste management system

5.2 System map

Figure 5.1: System Map showing functions provided by the system to each user


Admin
Manage Users
Manage Waste Data Manage Collection Schedules
Generate Reports
Manage Notifications
Waste Collection Service Provider
View Assigned Collections
Update Collection Status
Manage Contact
Food Bank/Charity
View Available Donations
Request Redistributio n
Manage Profile
General Public
View Public Information
Report Issues
Register as Donor/Charit y

5.3 Sample Screen-shots

5.3.1 System home page

The home page of an online food waste management system serves as the central hub for users to access information, navigate the system, and perform key actions. Administrator, login page for the administrator will be displayed as shown on the screenshot below.

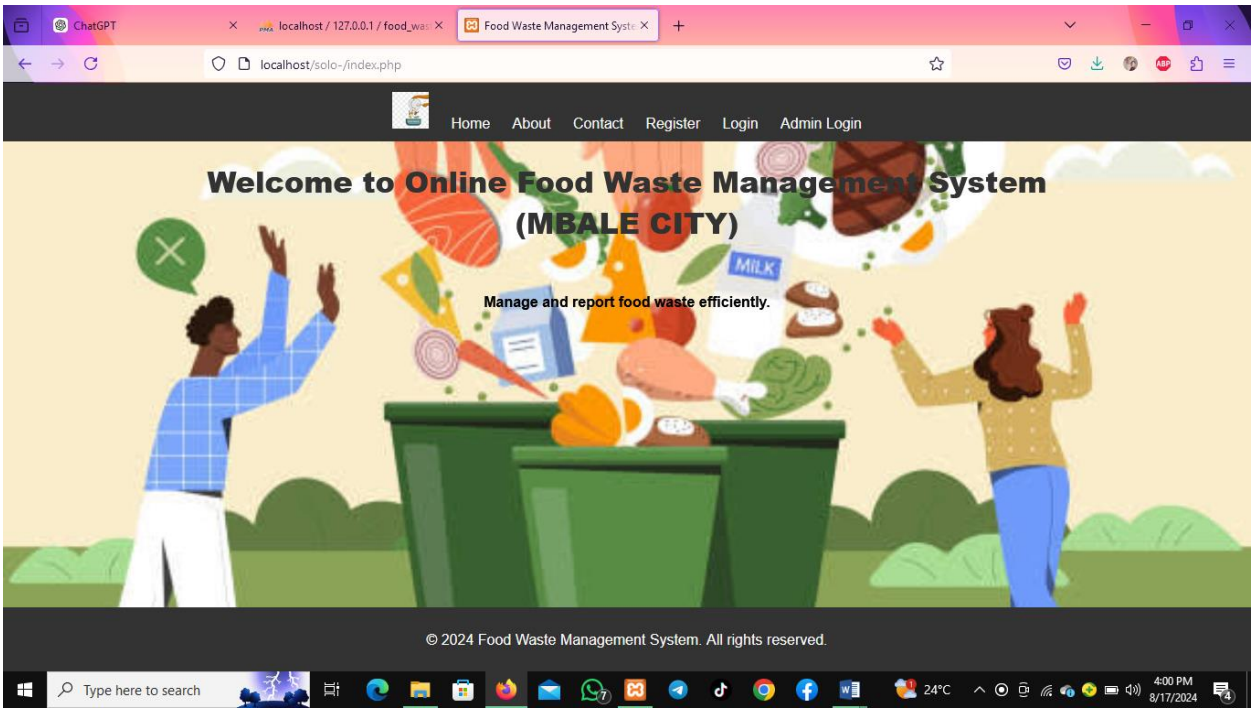


Figure 5. 1: System home page

5.3.2 Administrator's login page

Figure 5.3: Shows the administrator's login page where he or she selects the Admin option and fills in his or her password to login into the system. This gives an administrator access to view the following: manage wastes, manage donors, manage users, manage contact submissions and responses, manage collection services, and manage waste requests.

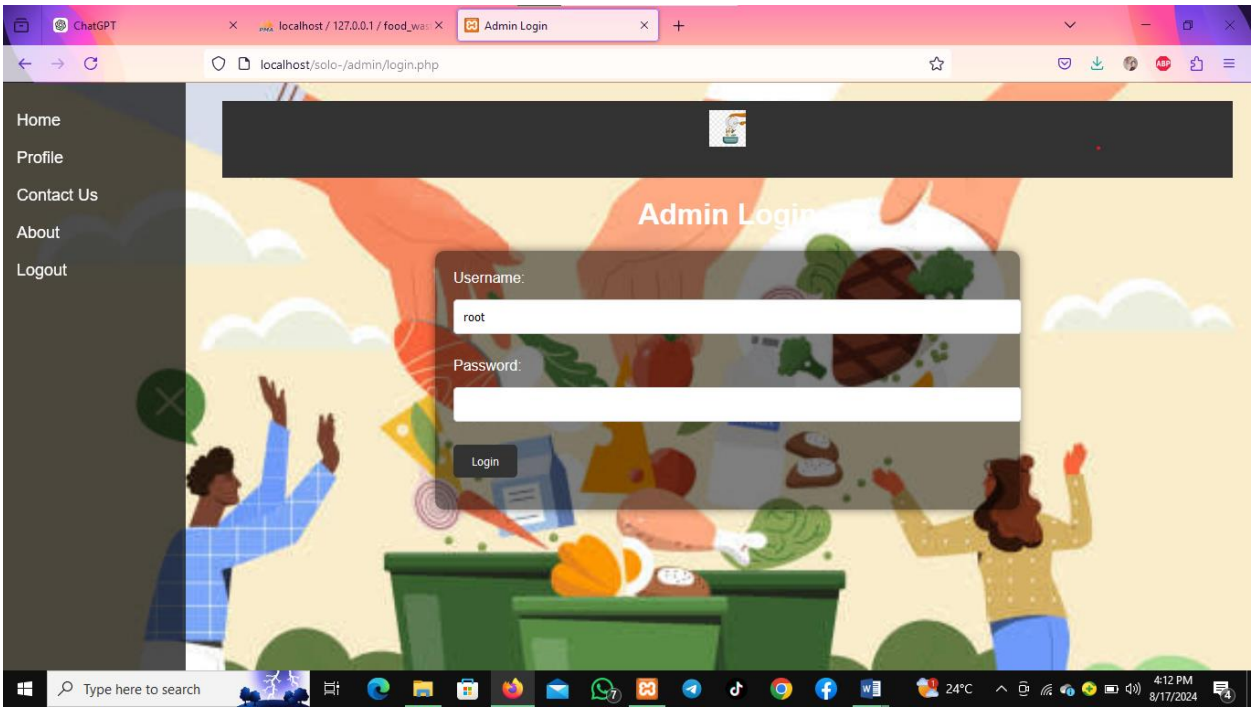


Figure 5. 2: Administrator login page

5.3.3 Administrative view page

Figure 5.4: Shows the administrator fully logged in where he can perform all duties assigned to him through navigating on the links shown on the screenshots in colors below. He can approve collection services update schedules, delete donors and do other activities **Figure 5.4:** Shows the administrator fully logged in where he can perform all duties assigned to him through navigating on the links shown on the screenshots in red color below. He can create accounts, set the passwords, view different account types, view transactions, manage transactions and verify and validate all transactions of the customers.

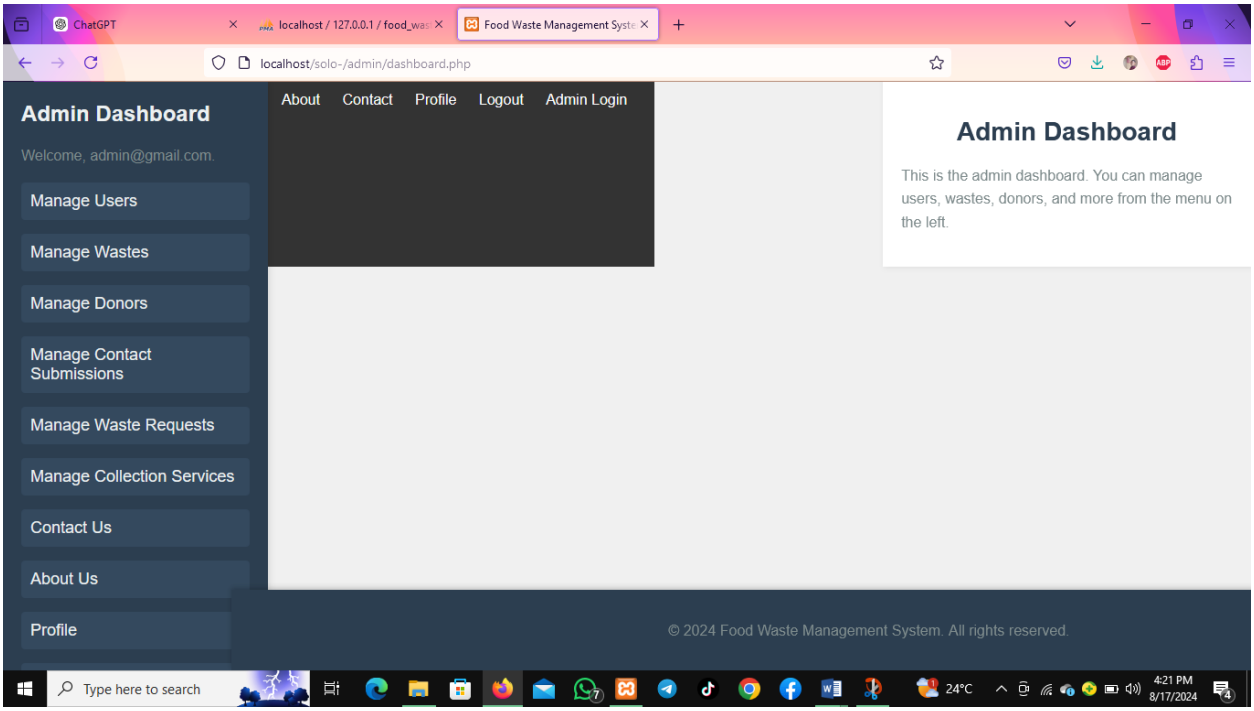
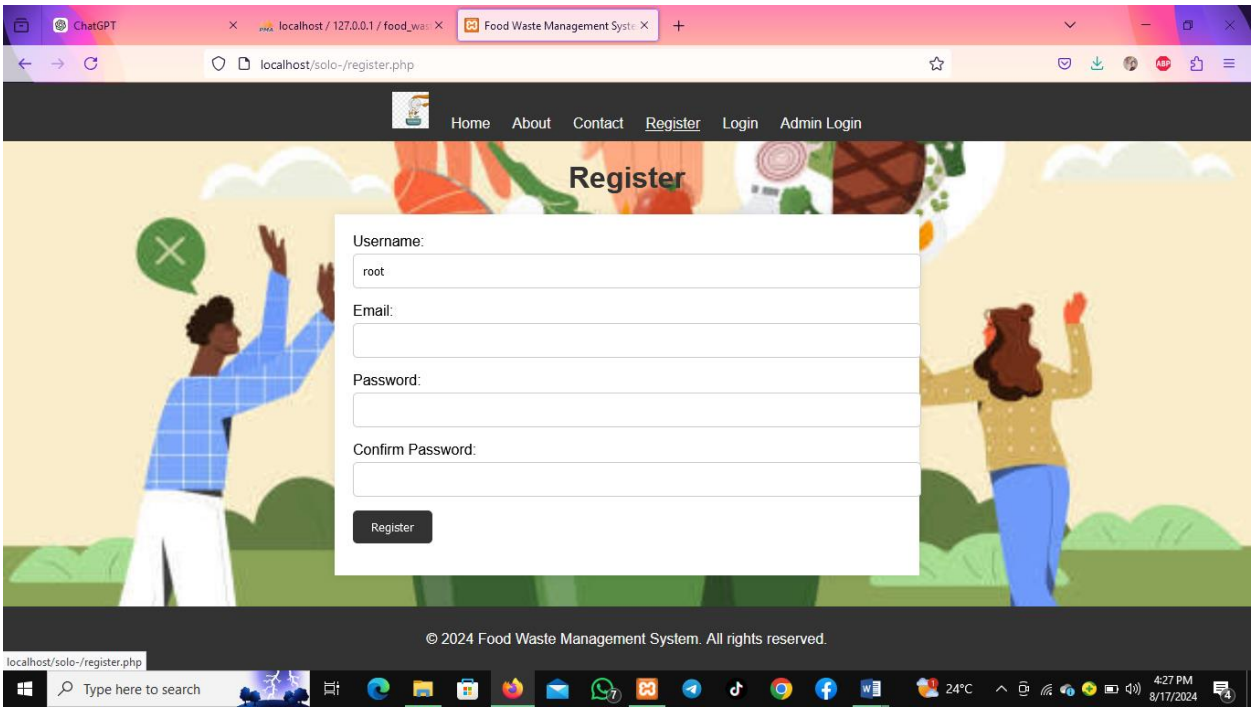


Figure 5. 3: Administrative view page

5.3.4 user's login page

Figure 5.5: users' login page where he or she selects the option as his or her username and fills in a password to login into the system where he or she can add wastes and donors.


ChatGPT
localhost / 127.0.0.1 / food_was
Food Waste Management Syste
localhost/solo-/register.php
Home
About
Contact
Register
Login
Admin Login
Register
Username:
root
Email:
Password:
Confirm Password:
Register
© 2024 Food Waste Management System. All rights reserved.
localhost/solo-/register.php
Type here to search
24°C
4:27 PM
8/17/2024

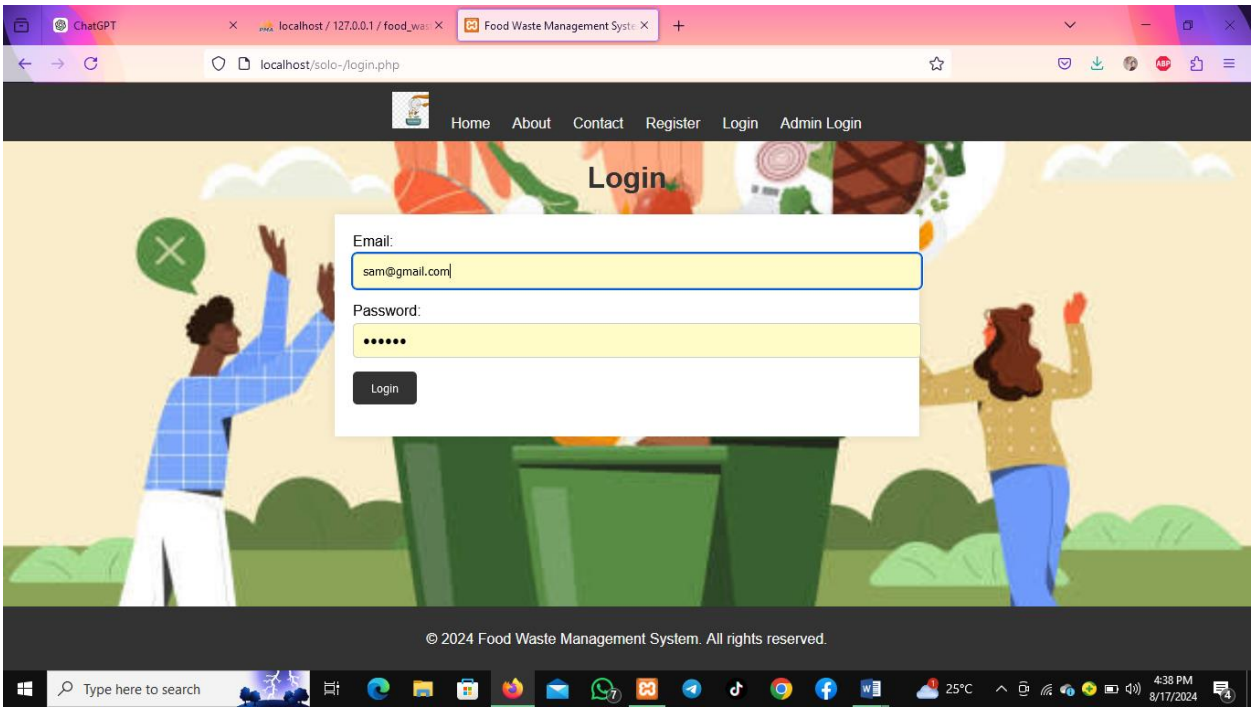


Figure 5. 4: User's login page

5.3.5 add waste page

Figure 5.6: this page allows the use to report the waste into the system including description, location and quantity.

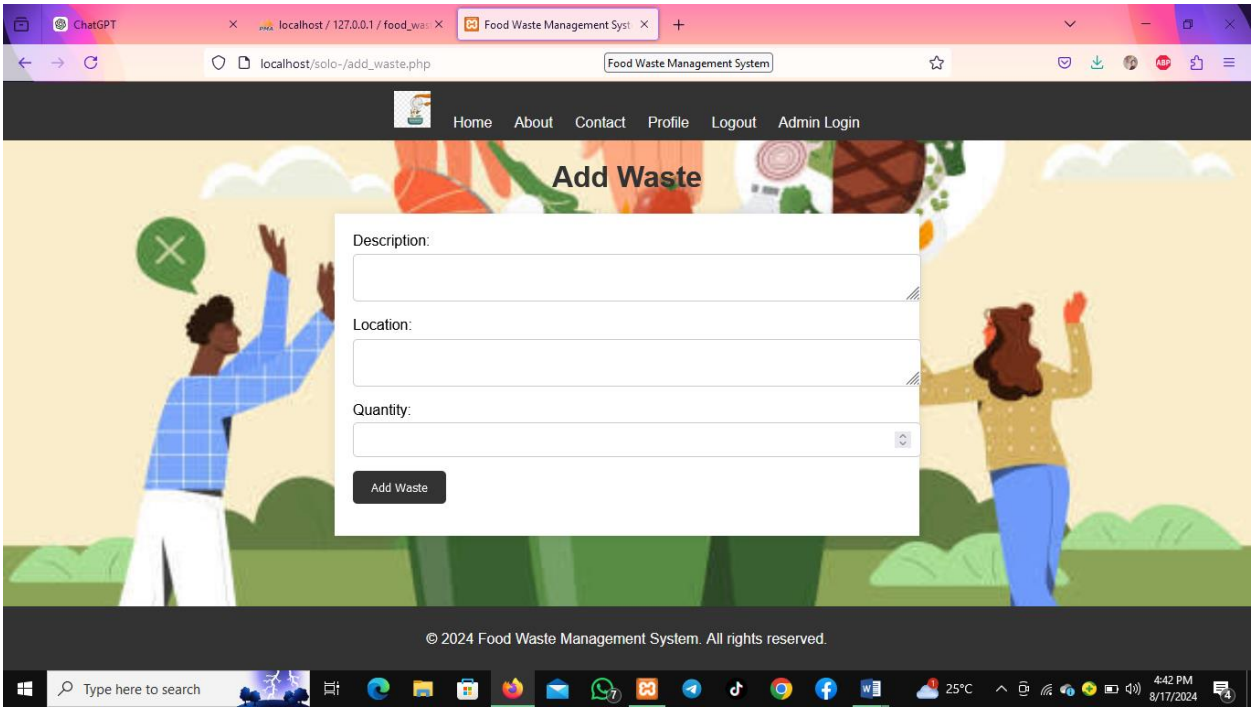


Figure 5. 5: add waste page.

5.3.7 Donor's page

Figure 5.8: Shows details of donors who donate access food waste to be reduced or to those in need.

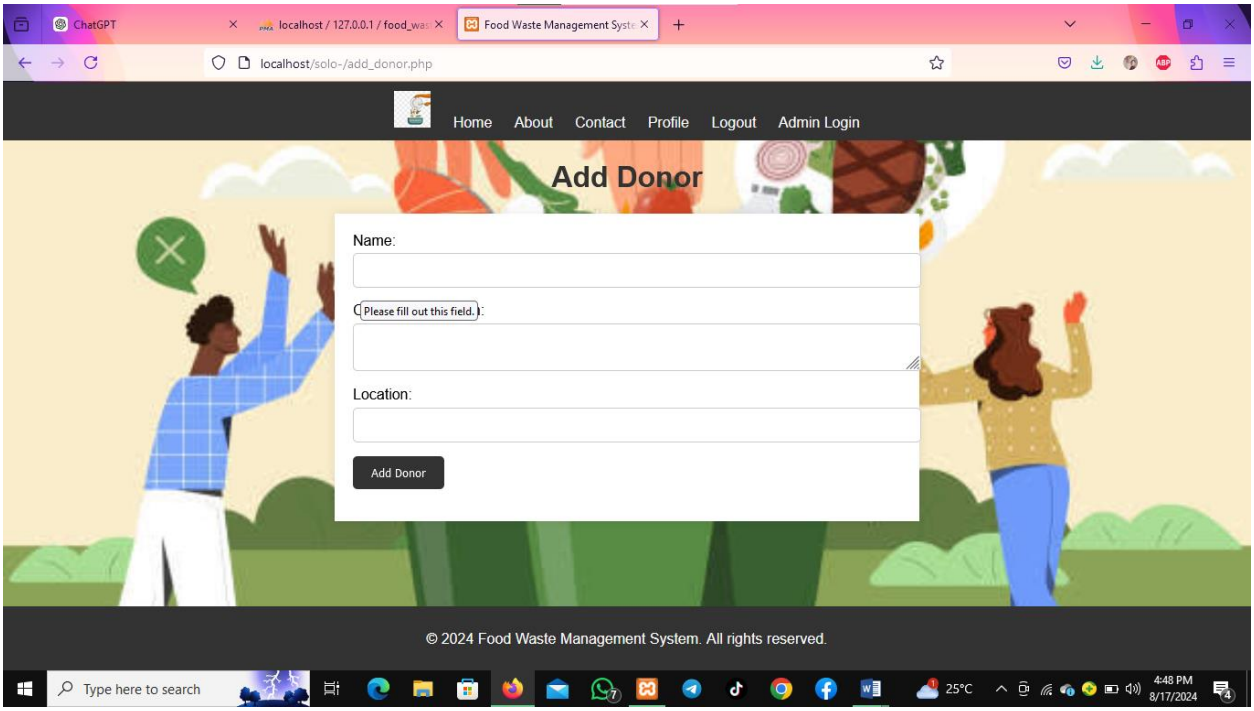


Figure 5. 6: Donors page

5.3.8 Request collection service page

Figure 5.9: Shows when the user requests for the collection of the wastes and needs an approval.

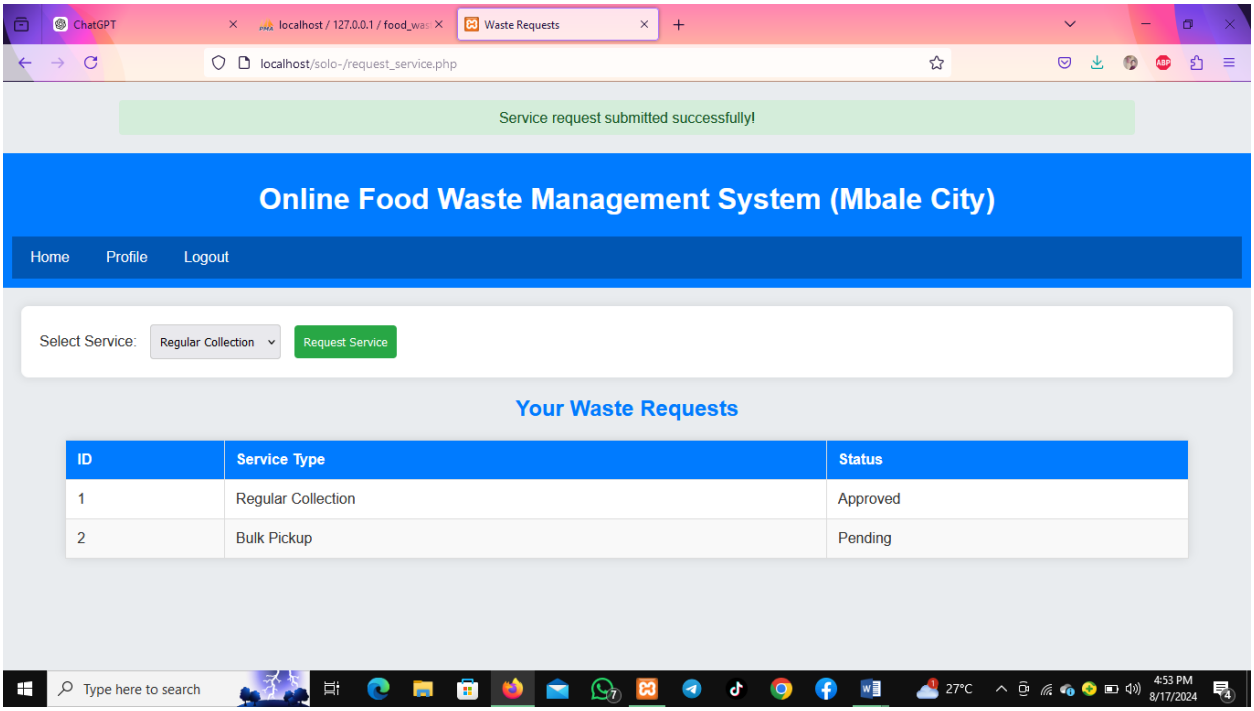


Figure 5. 7: user request collection service page

5.3.9 Logged in User's account

Figure 5.10: Shows a user logged into his account where he is able to view his account details, view waste reports made among others.

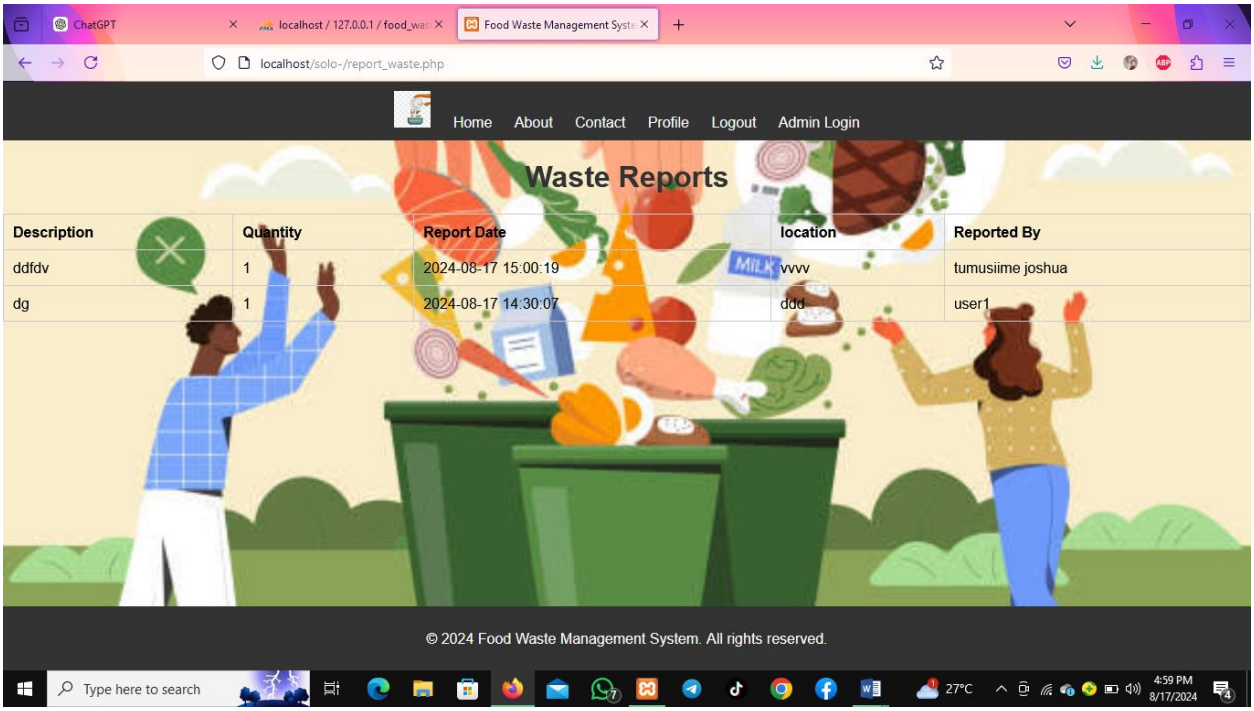


Figure 5. 8: Logged in user account.

5.4 System Testing and Validation Results

I carried out system testing with an aim of finding out errors that were in the system. I also performed system Validation to ensure that the system conformed to the then defined user needs and requirements. We presented the system to some of the users so as to get feedback about the system performance in relation to their requirements.

5.4.1 System Testing Results

The Online Food waste Management System was presented to users with the intent of finding errors and observing if it behaved as expected. The faults were corrected and the process was repeated until the system was proven to be working according to users' specification and performance requirements.

I also tested the system to see whether it was capturing valid data, this was done by putting wrong data and then the system responded by alert messages displaying the type of error. Testing and validation was done successfully.

5.4.2 Validation Results

The Online Food waste Management System was presented to different users so as to get feedback about the system performance as to whether the system met their needs or user requirements for which it was designed for. The process involved checking input and output data of the system to ensure that they are complete and accurate especially in the area of database to check whether the system conformed to the standards of similar systems under defined operating conditions. Further tests on validation were carried out on the system to verify that it met the specified user requirements.

The users were satisfied with the system and concluded that the system was simple to use allowing them to navigate through the system with ease. The system was fast in responding to the different requests and that it satisfied the intended user needs or requirements. A questionnaire was also designed to capture their responses and thoughts (see Appendix III page 47).

Table 8: System Validation.

Feature	Number of users out of 5	Percentage of users
Login Functionality	4	80%
Dashboard Navigation	5	100%
Data Entry	3	60%
Report Generation	4	80%
Notification System	5	100%
Profile Management	4	80%
Payment Processing	3	60%

5.5 Conclusion

In summary, this chapter described the system functions provided to all users like customers, employees, managers or administrators and the various screen shots used in the system. Testing and validation were performed where the system was checked to see if it had any errors and whether it met the specified user requirement respectively to which the results were gathered.

Chapter Six

Summary, Recommendations and Conclusion

6.1 Summary

All the stated objectives of the online food watse management system have been successfully achieved. The system has been designed to automate the online food waste management system that is be used. The customer is able to report waste, add donors. A user can change the account details and get new password and user name only is he/she has already been assigned an account into the system.

For security reasons, each user the user is required to register into the system before accessing it.

6.2 Recommendations

There is need for more research in this field so that the weaknesses of the system can be addressed as new food waste management system keep rising every day and have their own ways of carrying out their business operations.

Similar systems should be developed for the other food waste management system in the Uganda which are still lacking physical systems such as an online system for food waste management.

6.3 Future work

The system should be extended to;

i. Give customers a chance to interact using inbuilt forum so that customers can always discuss situations at hand.
ii. Report food wastes
iii. Review waste collection services.

6.4 Conclusions

The Online Food waste Management System objectives were achieved. The major strength of this system is the ability to carry out proper online food waste reporting and receiving donations of access food wastes. The user can interact with the system through reporting excess food wastes.

Appendix I: Interview Schedule Sample Questions for Online Food Waste Management System

Introduction:

Thank the interviewee for their time and explain the purpose of the interview. Mention that the focus is on understanding current practices, challenges, and potential improvements in food waste management.

General Questions:

1. **Can you briefly describe your role in the organization?**
    - *Objective*: Understand the interviewee's responsibilities and how they relate to food waste management.
2. **What are the main sources of food waste in your operations?**
    - *Objective*: Identify where food waste is most likely to occur.
3. **How do you currently track and manage food waste?**
    - *Objective*: Explore existing methods and tools for monitoring food waste.

Specific Questions on Food Waste Management:

4. **What strategies have you implemented to reduce food waste?**
    - *Objective*: Assess the effectiveness of current waste reduction practices.
5. **How do you decide what food is discarded or repurposed?**
    - *Objective*: Understand the criteria used in decision-making regarding food waste.
6. **Are there any partnerships or collaborations with external organizations to manage food waste?**
    - *Objective*: Explore external support systems and their effectiveness.
7. **What challenges do you face in implementing food waste management practices?**
    - *Objective*: Identify obstacles that hinder effective waste management.
8. **Have you adopted any technology or software to assist with food waste management? If so, how effective has it been?**
    - *Objective*: Gauge the impact of technology on improving food waste management.

Questions on Impact and Outcomes:

9. **What metrics or KPIs do you use to measure the success of your food waste management initiatives?**
    - *Objective*: Understand how success is measured and tracked.
10. **Can you share any notable outcomes or successes achieved through your food waste management efforts?**
    - *Objective*: Highlight successful practices and their impact.
11. **How do you educate or train staff about food waste reduction?**
    - *Objective*: Learn about internal education and training programs related to waste reduction.

Future Directions:

12. **What improvements would you like to see in your current food waste management system?**
    - *Objective*: Identify areas for potential enhancement.
13. **Are there any new trends or technologies in food waste management that you are considering?**
    - *Objective*: Explore future plans and interests in adopting new solutions.
14. **How do you think food waste management in your industry will evolve in the next 5-10 years?**
    - *Objective*: Gather insights into expected industry trends.
15. **Is there anything else you would like to add about your experience with food waste management?**

Section A: Demographics

1. **What is your age?**

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55 and above

2. **What is your gender?**
   - Male
   - Female
   - Prefer not to say
3. **What is your highest level of education?**
   - High School
   - Diploma
   - Bachelor's Degree
   - Master's Degree
   - Doctorate
   - Other (Please specify): _____
4. **What is your occupation?**
   - Student
   - Employed (Full-time)
   - Employed (Part-time)
   - Self-employed
   - Unemployed
   - Retired
   - Other (Please specify): _____

Section B: Awareness and Practices

5. **How aware are you of the issue of food waste?**
   - Very aware
   - Somewhat aware
   - Neutral
   - Somewhat unaware
   - Very unaware
6. **How often do you encounter food waste in your household or workplace?**
   - Daily
   - Several times a week
   - Weekly
   - Monthly
   - Rarely
7. **What methods do you use to manage food waste?** *(Check all that apply)*
   - Composting
   - Recycling
   - Donating to food banks
   - Repurposing leftovers
   - Other (Please specify): _____

- None

8. **How effective do you believe your current food waste management practices are?**
   - Very effective
   - Effective
   - Neutral
   - Ineffective
   - Very ineffective

Section C: Attitudes and Perceptions

9. **To what extent do you agree with the following statement: "Reducing food waste is important for environmental sustainability."**
   - Strongly agree
   - Agree
   - Neutral
   - Disagree
   - Strongly disagree
10. **Which factors do you believe contribute most to food waste?** *(Check all that apply)*
   - Over-purchasing
   - Poor meal planning
   - Expiry dates
   - Leftovers
   - Lack of storage space
   - Other (Please specify): _____
11. **What barriers prevent you from reducing food waste?** *(Check all that apply)*
   - Lack of time
   - Lack of knowledge
   - Inconvenience
   - Financial constraints
   - Other (Please specify): _____
12. **How willing are you to adopt new practices or technologies to reduce food waste?**
   - Very willing
   - Willing
   - Neutral
   - Unwilling
   - Very unwilling

Section D: Technology and Solutions

13. **Are you familiar with any food waste management apps or technologies?**
   - Yes
   - No
14. **If yes, which apps or technologies have you used?** *(Please specify)*
   - _____
15. **How effective do you find these technologies in reducing food waste?**
   - Very effective

- Effective
- Neutral
- Ineffective
- Very ineffective

16. **What features would you like to see in a food waste management system?** *(Check all that apply)*
    - Real-time tracking of food purchases
    - Expiry date reminders
    - Recipe suggestions based on available ingredients
    - Food donation options
    - Collaboration with local food banks
    - Other (Please specify): _____

Section E: Feedback and Suggestions

17. **What do you think can be done to improve online food waste management in your community?**
    - _____
18. **Would you participate in community initiatives aimed at reducing food waste?**
    - Yes
    - No
    - Maybe
19. **Do you have any additional comments or suggestions regarding food waste management?**

Section A: User Experience

1. **How easy is it to navigate the online food waste management system?**
    - Very easy
    - Easy
    - Neutral
    - Difficult
    - Very difficult
2. **How would you rate the user interface of the system?**
    - Excellent
    - Good
    - Fair
    - Poor
    - Very poor
3. **Were you able to accomplish your tasks efficiently using the system?**
    - Always
    - Most of the time
    - Sometimes
    - Rarely
    - Never
4. **What features did you find most useful in the system?** *(Check all that apply)*
    - Waste tracking
    - Collection scheduling
    - Reporting and analytics
    - Notifications and reminders
    - Integration with external services
    - Other (Please specify): _____
5. **How satisfied are you with the overall performance of the system?**
    - Very satisfied
    - Satisfied
    - Neutral
    - Dissatisfied
    - Very dissatisfied

Section B: Functionality and Reliability

6. **Did you encounter any technical issues while using the system?**
    - Yes
    - No
7. **If yes, please describe the issues encountered.**
    - _____
8. **How reliable is the system in terms of uptime and availability?**
    - Very reliable
    - Reliable
    - Neutral

Appendix III: The System Validation Questionnaire

-
-
-
- Unreliable
- Very unreliable

9. **How quickly does the system respond to your inputs?**
    - Very quickly
    - Quickly
    - Neutral
    - Slowly
    - Very slowly
10. **Are there any features that you believe are missing from the system?**
    - Yes (Please specify): _____
    - No

Section C: Effectiveness

11. **To what extent has the system helped you reduce food waste?**
    - Significantly
    - Moderately
    - Slightly
    - Not at all
12. **How useful are the reports generated by the system for monitoring waste?**
    - Very useful
    - Useful
    - Neutral
    - Not very useful
    - Not useful at all
13. **How effective is the system's notification and reminder feature in helping you manage food waste?**
    - Very effective
    - Effective
    - Neutral
    - Ineffective
    - Very ineffective
14. **Has the system helped you save money by reducing food waste?**
    - Yes
    - No
    - Not sure

Section D: Feedback and Suggestions

15. **What improvements would you like to see in future versions of the system?**

- ---

16. **How likely are you to recommend this system to others?**
    - Very likely
    - Likely
    - Neutral
    - Unlikely
    - Very unlikely
17. **Do you have any additional comments or suggestions?**

Appendix IV: Pseudo code

Pseudo code for Withdrawal Transaction

```
// User Registration

Function RegisterUser(userDetails):

    Validate userDetails

    If userDetails are valid:

        Save userDetails to database

        Send confirmation email

    Else:

        Return error message


// User Login

Function LoginUser(username, password):

    Retrieve user from database using username

    If user exists and password matches:
```

```
        Start user session
        Redirect to user dashboard
    Else:
        Return error message

// Admin Adds Collection Schedule
Function AddCollectionSchedule(scheduleDetails):
    Validate scheduleDetails
    If scheduleDetails are valid:
        Save scheduleDetails to database
        Notify users about the new schedule
    Else:
        Return error message

// User Views Collection Schedule
Function ViewCollectionSchedule(userID):
    Retrieve collection schedules from database
    Display schedules to user
// User Requests Waste Collection
Function RequestWasteCollection(userID, wasteDetails):
    Validate wasteDetails
    If wasteDetails are valid:
```

```
        Save request to database
        Notify admin about the request
    Else:
        Return error message


// Admin Approves/Rejects Waste Collection Request
Function ReviewWasteCollectionRequest(requestID, action):
    Retrieve request from database using requestID
    If action is 'Approve':
        Update request status to approved
        Notify user about approval
    Else If action is 'Reject':
        Update request status to rejected
        Notify user about rejection
    Else:
        Return error message
// Store Collection Schedule Data
Function StoreCollectionScheduleData(scheduleData):
    Validate scheduleData
    If scheduleData is valid:
        Save scheduleData to database
    Else:
        Return error message
```

```
// Retrieve Collection Schedule Data
Function RetrieveCollectionScheduleData(scheduleID):
    Retrieve schedule data from database using scheduleID
    Return schedule data
// Generate Waste Collection Report
Function GenerateWasteReport(startDate, endDate):
    Retrieve waste collection data from database within date range
    Generate report
    Return report

// View Waste Collection Analytics
Function ViewWasteAnalytics():
    Retrieve analytics data from database
    Display analytics dashboard
// Send Notification to User
Function SendNotification(userID, message):
    Retrieve user contact details from database
    Send message to user via preferred method (email, SMS, etc.)
// User Logout
Function LogoutUser(userID):
    End user session
    Redirect to login pages
```

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These references should provide a strong foundation for understanding the various dimensions of online food waste management systems.