

A Smart IoT-Driven Digital Platform for Sustainable Dry Fish Processing in Sri Lanka

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Project Proposal Report

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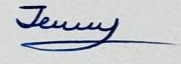
March 2026

DECLARATION

I declare that this is my own work, and this proposal does not knowingly incorporate any material previously submitted for a degree or diploma at any other university or higher education institution, nor does it contain any material that has been previously published or written by another person apart from where proper acknowledgment is given in the text.

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ABSTRACT

The dry fish processing industry plays an important role in Sri Lanka's coastal economy, providing income for many small-scale processors and contributing to the country's food supply. However, the traditional dry fish processing workflow relies heavily on manual practices and experience-based decision-making. During the fish cleaning stage, a considerable amount of fish waste, such as heads, bones, and internal organs, is generated. In most small and medium processing facilities, this waste is not properly recorded, predicted, or managed, which can lead to environmental pollution, inefficient resource utilization, and missed opportunities for waste reuse in industries such as fish meal production. Additionally, processors often estimate the required salt quantity based on experience rather than data, which can result in inconsistent product quality or increased risk of spoilage. Although existing research has explored IoT monitoring, spoilage detection, and quality grading in fish processing, limited attention has been given to predictive waste estimation and digital waste traceability within dry fish processing workflows. In particular, there is a lack of intelligent systems that can estimate cleaning waste in advance and support sustainable waste handling decisions. To address this gap, this research proposes an AI-based waste prediction and traceability component within a smart IoT-driven digital platform for sustainable dry fish processing. The proposed system uses machine learning models to estimate the expected waste amount based on batch attributes such as fish type and batch weight. The predicted waste information is used to notify third-party recycling or fish meal processing companies in advance, enabling better waste collection and reuse planning. Additionally, the system predicts appropriate salt quantities for each processing batch to support consistent product quality. The platform also maintains digital batch records to ensure transparency and traceability throughout the processing lifecycle. The expected outcomes include improved waste management, enhanced sustainability practices, reduced environmental impact, and more consistent dry fish product quality. The proposed solution also supports circular economy practices by connecting fish processors with waste reuse industries.

Keywords: Dry Fish Processing, Waste Prediction, Machine Learning, Sustainable Food Processing, Traceability System.

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LIST OF ABBREVIATIONS

Abbreviations	Description
SDG	Sustainable Development Goals
IOT	Internet of Things
MAE	Mean Absolute Error
RMSE	Root Mean Squared Error

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1. INTRODUCTION

1.1 Background and Context

The fisheries sector plays a significant role in Sri Lanka's economy and food security. Among the various fish preservation methods used in the country, dry fish processing is one of the most common traditional techniques for extending the shelf life of fish. Dry fish production supports the livelihoods of thousands of small-scale processors and traders in coastal regions such as Negombo, Chilaw, Mannar, and Jaffna. However, despite its importance, much of the dry fish processing industry still relies on manual and experience-based practices, with limited adoption of digital technologies or data-driven decision-making systems.

During the dry fish processing workflow, particularly during the fish cleaning stage, significant waste is generated. This waste includes fish heads, bones, scales, and internal organs. In many small and medium-scale processing sites, these waste materials are not properly measured, recorded, or managed. As a result, fish waste is often disposed of in open areas or directly into nearby water bodies, leading to environmental pollution, unpleasant odors, and public health concerns. At the same time, fish waste is a valuable resource that can be reused in industries such as fish meal production, fertilizer manufacturing, and animal feed production. The lack of proper waste prediction and management systems, therefore, results in both environmental damage and economic loss.

In addition to waste management challenges, processors typically estimate the amount of salt required for fish preservation based on personal experience rather than accurate data. Incorrect salt levels may lead to inconsistent product quality, reduced shelf life, or increased spoilage risks. Furthermore, most processing sites do not maintain proper digital records of processing batches, making it difficult to track production history, waste generation patterns, and processing conditions.

According to global food waste studies, approximately 30–35% of fish biomass can be processed waste, depending on the fish species and processing method. In developing countries, a large portion of this waste remains underutilized due to poor waste management practices. Improving the utilization of waste and sustainability in fish processing has therefore become an important goal in modern food production systems.

Several existing studies have explored technological solutions, including IoT-based monitoring systems, machine learning models for spoilage detection, and computer vision approaches for fish quality grading. However, most of these solutions focus on monitoring environmental conditions or detecting spoilage after it occurs. There is limited research focusing on predictive waste estimation and digital traceability of waste within dry fish processing operations.

To address these limitations, this research proposes the development of a smart digital component for sustainable waste tracking and prediction within a dry fish processing platform. The proposed system uses machine learning techniques to estimate the expected amount of fish cleaning waste based on batch attributes such as fish type and batch weight. The predicted waste information can then be used to notify third-party recycling or fish meal companies in advance, enabling better planning for waste collection and reuse. In addition, the system predicts the appropriate salt requirement for each processing batch and maintains a digital record of processing activities to improve traceability and sustainability.

The proposed solution contributes to the United Nations Sustainable Development Goals (SDGs), particularly SDG 12: Responsible Consumption and Production, by promoting sustainable resource utilization and reducing waste in the food processing industry. It also aligns with research clusters related to Artificial Intelligence, Sustainable Food Systems, and Smart IoT-enabled Food Processing Technologies, which aim to apply advanced technologies to improve efficiency, sustainability, and transparency in traditional industries.

Through the integration of machine learning-based prediction models and digital traceability mechanisms, this research aims to support more sustainable and data-driven dry fish processing practices in Sri Lanka.

1.2 Literature Review

Recent research has explored various technological solutions to improve fish processing, quality monitoring, and sustainability in seafood supply chains. Many studies have focused on applying Internet of Things (IoT), machine learning techniques, and digital monitoring systems to improve efficiency and reduce spoilage in fish processing environments. Several studies have investigated IoT-based monitoring systems for fish processing and preservation. These systems typically use sensors to monitor environmental parameters such as temperature and humidity during the drying process. Such systems help detect unsafe drying conditions and provide real-time monitoring capabilities. However, while these solutions improve environmental monitoring, they often focus primarily on drying conditions and spoilage detection, rather than addressing waste management during the cleaning stage.

Other research has explored digital traceability systems in seafood supply chains. These systems record the processing history of fish products, allowing better transparency and accountability throughout the production process. Traceability systems can track information such as fish origin, processing time, and quality inspection results. Although these systems improve transparency, most of them do not include mechanisms to track waste generation or predict waste quantities during fish processing. Machine learning techniques have also been applied in the fisheries sector to solve various problems such as fish freshness detection, spoilage prediction, and quality grading. Some studies use predictive models to analyze environmental data or image data to determine fish quality. While these approaches demonstrate the potential of artificial intelligence in seafood processing, they mainly focus on quality assessment and spoilage detection, rather than predicting waste generation or supporting sustainable waste management practices.

A few studies have examined sustainable waste utilization in fish processing industries. These studies highlight the importance of converting fish waste into valuable by-products such as fish meal, fertilizer, or animal feed. However, most of these approaches focus on waste reuse after waste is generated, rather than predicting waste quantities in advance to support better planning and logistics. In addition, existing technological solutions often require high-cost infrastructure or specialized equipment, which may not be suitable for small-scale processors in developing countries. Many coastal dry fish processing facilities operate with limited technological resources and therefore require low-cost, simple, and scalable digital solutions.

The comparison in Figure/Table (Technology Comparison Matrix) highlights that most existing studies address individual aspects such as IoT monitoring, traceability, or machine learning independently. However, none of the reviewed systems fully integrate waste tracking, predictive waste estimation, sustainable waste management, and low-cost deployment for small-scale processors within a single platform.

Therefore, there is a clear need for a comprehensive system that combines machine learning-based waste prediction, digital traceability, and sustainable waste management practices in dry fish processing. The proposed research aims to address this gap by developing a component within a smart digital platform that predicts fish-cleaning waste, recommends salt usage, and maintains digital records for sustainable dry-fish processing operations.

Technologies /Methods	Paper[1]	Paper[2]	Paper[3]	Paper[4]	Paper[5]	Proposed System
IoT-based monitoring	✓	✓	✗	✓	✓	✓
Digital traceability	✗	✓	✓	✗	✓	✓
Waste tracking in fish processing	✗	✗	✗	✗	✗	✓
Machine learning prediction	✓	✗	✓	✓	✗	✓
Sustainable waste management	✗	✗	✓	✗	✗	✓
Real-time data recording	✗	✓	✓	✗	✓	✓
Low-cost solution for small processors	✗	✗	✗	✗	✗	✓

Table 1.1 Comparison of the existing research methods and proposed methods

1.3 Research Gap

Although recent studies have introduced various technological solutions to improve fish processing and seafood quality monitoring, several important limitations remain regarding the sustainability of dry fish processing and waste management. Existing research has primarily focused on areas such as fish freshness detection, shelf-life prediction, IoT-based environmental monitoring, and computer vision-based quality grading. While these approaches improve product quality and monitor storage conditions, they do not sufficiently address waste generation and management during fish processing operations, particularly at the fish cleaning stage.

Most current studies focus on detecting spoilage after processing or during storage, rather than supporting proactive decision-making before or during the processing workflow. For example, machine learning models have been used to estimate fish shelf life and freshness levels, while smartphone-based sensing applications have been developed for spoilage detection. However, these systems are designed primarily for quality inspection, and they do not provide mechanisms to estimate the amount of processing waste generated from a batch of fish. As a result, processors still lack the ability to predict waste quantities in advance, which limits their capacity to plan sustainable waste-handling or coordinate waste-reuse activities.

Furthermore, existing traceability systems in the seafood industry primarily focus on supply chain transparency and product origin tracking rather than on internal processing-level traceability in small-scale fish processing environments. In many traditional dry fish processing sites, there is still no digital record of batch activities, waste generation, or processing parameters, making it difficult to analyze waste patterns or improve sustainability practices. Another limitation of existing approaches is that most proposed technological solutions are not designed for small-scale processors operating in low-resource coastal environments, which are common in developing countries such as Sri Lanka. Many systems require expensive infrastructure, complex sensors, or advanced equipment that may not be practical for adoption by small and medium dry fish processors.

Therefore, there is a clear research gap in developing an integrated, low-cost digital system that combines waste prediction, support for sustainable waste management, and batch traceability within dry fish processing workflows. Specifically, there is limited research on using machine learning to estimate quantities of fish cleaning waste based on batch attributes, such as fish type and batch weight. To address this gap, the proposed research introduces an AI-based waste prediction and traceability component within a smart IoT-driven digital platform for sustainable dry fish processing. The proposed system predicts fish cleaning waste before processing begins, enables better coordination with waste-recycling industries, such as fish meal production, and maintains digital batch records to support transparency and sustainability. By integrating predictive analytics with waste tracking and traceability, the proposed solution offers a novel, practical approach to improving sustainability in dry fish processing environments.

2. OBJECTIVE

2.1 Main Objective

To develop and evaluate an **AI-based waste prediction and digital traceability component** that estimates fish cleaning waste quantities and recommends appropriate salt levels using batch attributes such as fish type and batch weight, while maintaining digital waste records to support **sustainable waste management and efficient dry fish processing in Sri Lanka**.

2.2 Specific Objectives

1. To design a digital batch recording system that captures key processing information such as fish type, batch weight, cleaning waste amount, and disposal method to maintain traceability within dry fish processing workflows.
2. To develop a machine learning model that predicts the expected amount of fish cleaning waste using batch attributes such as fish type and initial fish weight.
3. To implement a waste notification mechanism that communicates predicted waste quantities to third-party recycling or fish meal processing companies in advance to support sustainable waste handling.
4. To design and implement a salt requirement prediction model that recommends the appropriate salt quantity for each batch based on fish type and cleaned fish weight.
5. To integrate the prediction models and traceability features into a digital platform that enables processors to monitor waste generation patterns and maintain digital records of processing activities.
6. To evaluate the accuracy and practical usefulness of the proposed system using performance metrics such as Mean Absolute Error (MAE) for prediction models and usability feedback from potential users.

3. METHODOLOGY

3.1 Research Approach

This research adopts a Design Science Research (DSR) approach, which focuses on designing and developing an innovative technological artifact to solve a real-world problem. In this study, the artifact is a digital platform component that predicts fish cleaning waste, recommends salt requirements, and maintains traceability records for dry fish processing batches.

The design science methodology involves several stages, including problem identification, artifact design, system development, and evaluation. First, the existing challenges in waste management and batch traceability within dry fish processing are analyzed. Based on these challenges, a digital solution is designed that integrates machine learning prediction models with a mobile-based data recording system. The system is then implemented and evaluated using real or simulated processing data to assess its effectiveness in supporting sustainable waste management and improving processing decisions.

This approach is appropriate for the study because the research aims to design, implement, and evaluate a practical system that can improve real-world dry fish processing operations.

3.2 Technical Methods and Algorithms

The proposed system consists of two main intelligent components: waste prediction and salt requirement prediction.

The waste prediction model estimates the expected amount of fish cleaning waste generated during processing. The model uses batch attributes such as fish type and initial fish weight as input variables. A supervised machine learning approach will be used to train the prediction model using historical batch data.

Similarly, a second machine learning model will be developed to estimate the required salt quantity for each processing batch based on factors such as fish type and cleaned fish weight. These models enable processors to make data-driven decisions before and during the processing workflow.

Standard machine learning techniques suitable for small datasets will be considered, such as Linear Regression, Random Forest Regression, or Gradient Boosting models. The data preprocessing stage will include data cleaning, feature encoding for categorical variables such as fish type, and normalization where necessary.

The trained models will generate predictions that are integrated into the digital platform and displayed to users through the mobile application.

3.3 Tools and Platforms

The system will be implemented using a combination of modern software development and machine learning tools.

Mobile Application (Frontend): Flutter

Flutter will be used to develop the mobile application interface. Flutter enables cross-platform development and allows the application to run on Android devices commonly used by small-scale processors. The mobile interface will allow users to input batch details, view predicted waste amounts, and access batch history records.

Backend Server: Node.js

Node.js will be used to develop the backend server that manages system logic, API services, and communication between the mobile application, database, and machine learning prediction module. Node.js provides efficient asynchronous processing and supports scalable web services.

Database: MongoDB

MongoDB will be used as the database system to store batch records, waste data, salt predictions, and traceability information. MongoDB is suitable because it supports flexible document-based data structures, which are useful for storing processing batch records with varying attributes.

Machine Learning Environment: Python

Machine learning models will be developed using Python with libraries such as **Pandas for data processing and Jupyter Notebook for experimentation and model training**. Python is widely used in machine learning research due to its extensive ecosystem of data science libraries.

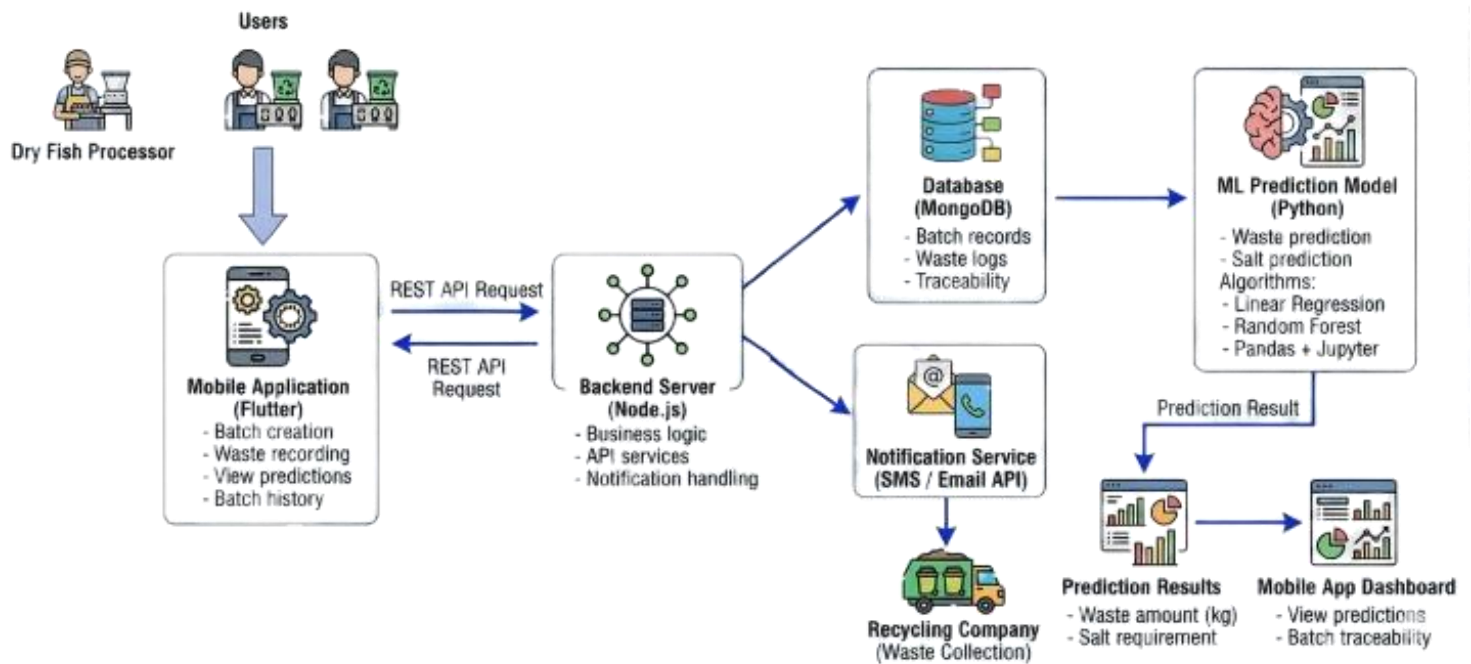


Figure 3.1: Overview of Working Memory Identification Diagram

3.4 Data Collection and Ethical Considerations

The dataset used for training the prediction models will consist of processing batch records that include attributes such as fish type, raw fish weight, waste amount generated during cleaning, cleaned fish weight, and salt quantity used. These records may be collected through field observations, interviews with processors, or simulated datasets based on typical processing ratios reported in literature.

To ensure ethical research practices, the study will avoid collecting any personally identifiable information (PII) related to individuals. Data collected from processing sites will only include operational processing parameters relevant to the research objectives. If industry stakeholders or processors participate in providing data or feedback, their consent will be obtained, and the collected data will be used strictly for academic research purposes.

3.5 Validation Strategy and Performance Metrics

The developed machine learning models will be evaluated using a training and testing dataset split, typically dividing the dataset into training and validation sets. Model performance will be assessed using standard regression evaluation metrics

For the waste prediction and salt prediction models, Mean Absolute Error (MAE) will be used as the primary performance metric to measure the difference between predicted values and actual values. A lower MAE indicates higher prediction accuracy.

In addition to quantitative evaluation, the practical usefulness of the system will be assessed through usability testing of the mobile application interface. Feedback from potential users or simulated processing scenarios will be used to evaluate whether the system improves decision-making in waste management and batch monitoring.

Through these validation methods, the research will demonstrate both the technical accuracy of the prediction models and the practical feasibility of the proposed digital solution for sustainable dry fish processing.

4. HIGH-LEVEL SYSTEM ARCHITECTURE

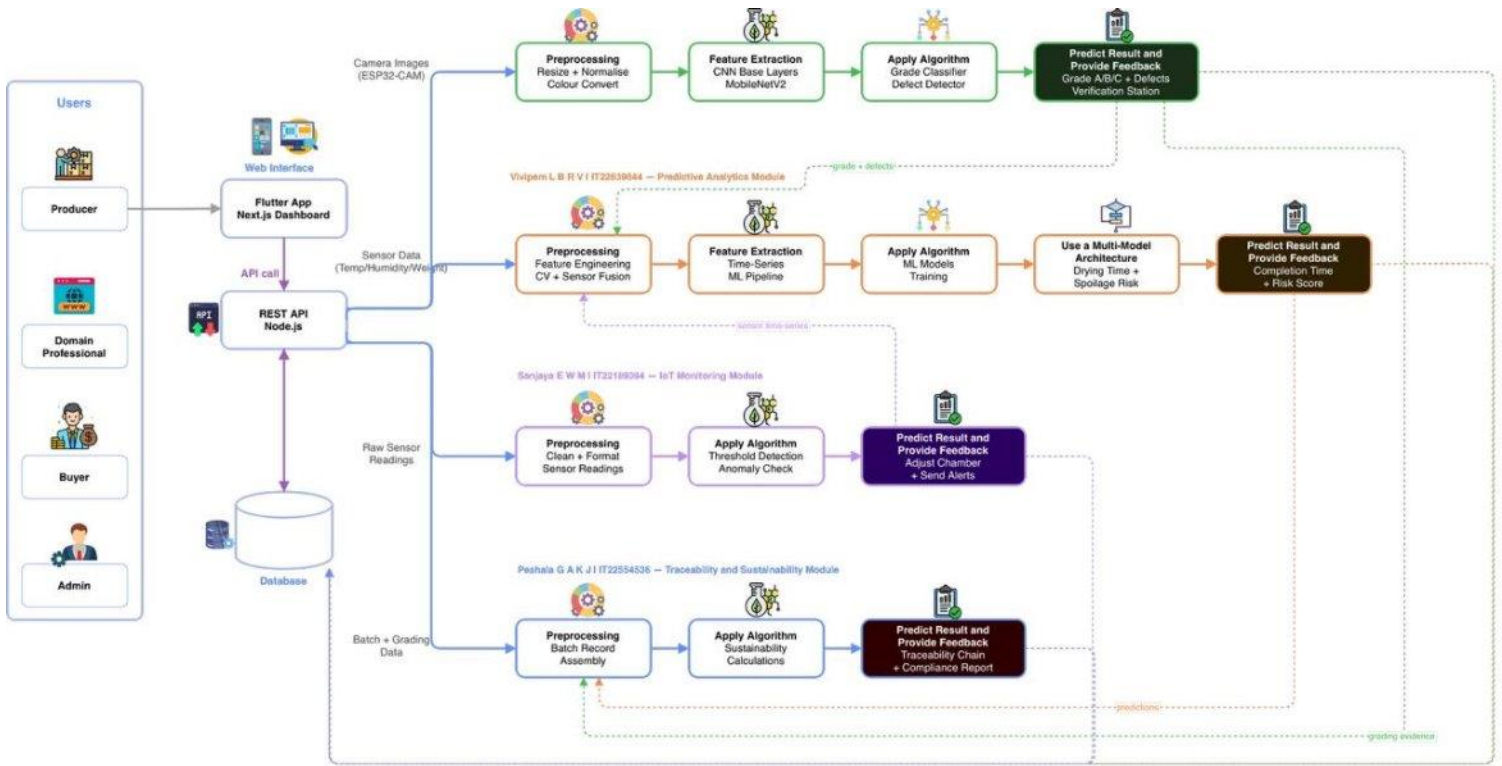


Figure 4.1 System Architecture

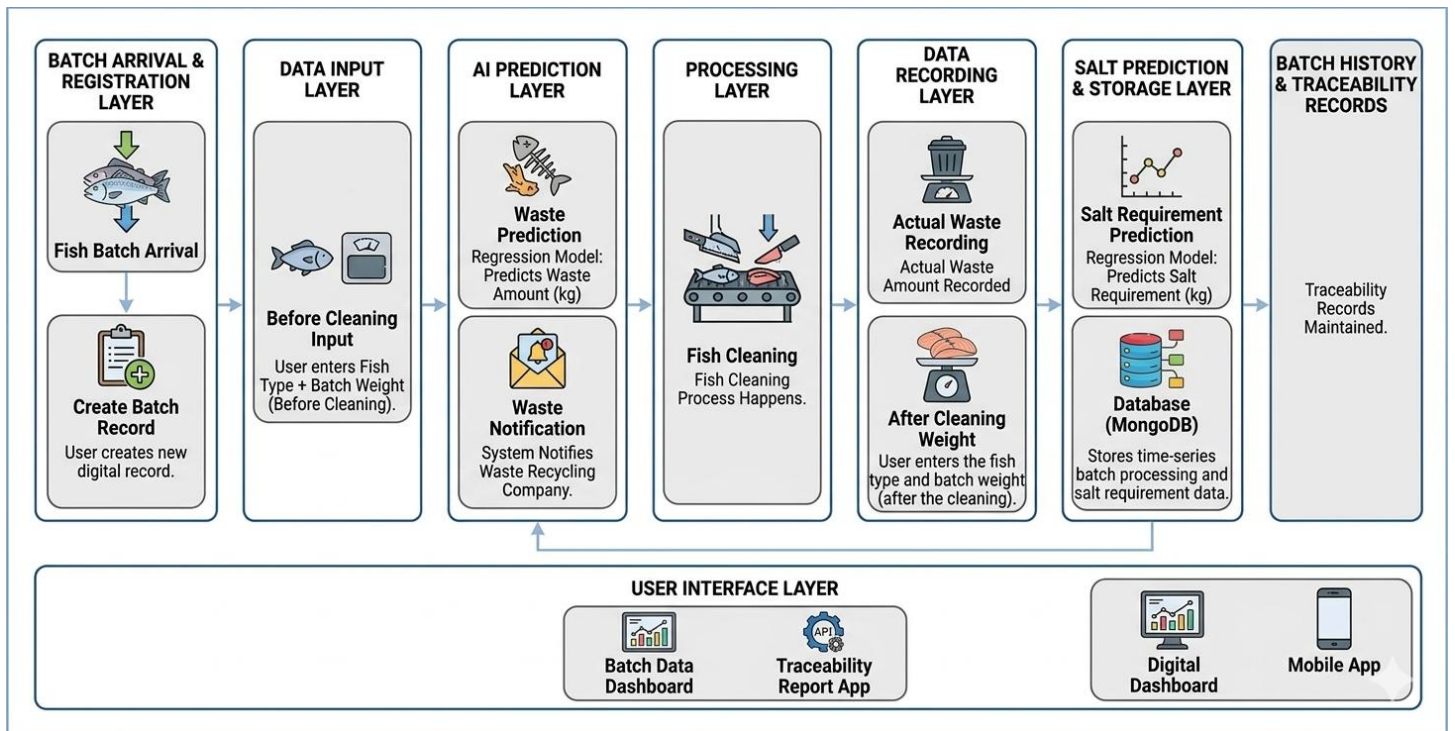


Figure 4.2 Individual System Diagram

5. USER REQUIREMENTS

5.1 Stakeholder Identification

The proposed system involves several stakeholders who interact with or benefit from the digital platform for sustainable dry fish processing.

1. Dry Fish Processors

These are the primary users of the system. They use the mobile application to record batch details, view predicted waste quantities, receive salt recommendations, and maintain digital records of processing activities.

2. Waste Recycling / Fish Meal Processing Companies

These third-party stakeholders receive notifications about predicted waste quantities. This allows them to plan waste collection and reuse activities such as fish meal production or fertilizer manufacturing.

3. System Administrators

Administrators manage the system, monitor platform usage, maintain the database, and ensure that the system operates correctly.

4. Researchers / Industry Analysts

Researchers or industry analysts may use aggregated system data to analyze waste generation patterns and sustainability practices within dry fish processing operations.

5.2 Functional Requirement

The system must provide the following functional capabilities:

- **FR1. User Registration and Login**

The system shall allow processors and administrators to securely register and log in to the mobile application.

- **FR2. Batch Creation and Recording**

The system shall allow users to create a new processing batch by entering information such as fish type, batch weight, and processing date.

- **FR3. Waste Prediction**

The system shall generate a prediction of the expected fish cleaning waste quantity based on batch attributes such as fish type and initial fish weight.

- **FR4. Salt Requirement Prediction**

The system shall recommend the appropriate salt quantity for each processing batch using a machine learning prediction model.

- **FR5. Waste Event Recording**

The system shall allow users to record the actual waste generated during the cleaning process and specify the disposal method used.

- **FR6. Waste Notification System**

The system shall send notifications to third-party recycling or fish meal companies regarding predicted waste quantities for upcoming batches.

- **FR7. Batch Traceability Records**

The system shall maintain a digital history of each processing batch including batch details, predictions, waste amounts, and processing outcomes.

- **FR8. Dashboard for Monitoring**

The system shall provide a dashboard where users can view batch information, predicted waste values, salt recommendations, and historical records.

5.3 Non-Functional Requirements

The system must also satisfy several quality and performance requirements to ensure reliable operation.

Security

The system shall implement secure authentication mechanisms to ensure that only authorized users can access system features and data.

Performance

The system shall provide prediction results and dashboard updates within a reasonable response time to support real-time decision-making during processing operations.

Usability

The mobile application shall provide a simple and user-friendly interface that can be easily used by processors with minimal technical knowledge.

Scalability

The system shall be capable of supporting multiple users and processing batches without performance degradation.

Reliability

The system shall ensure reliable storage and retrieval of batch data using the database to prevent data loss.

Data Integrity

The system shall validate user inputs and maintain accurate records of batch data and prediction results.

Compatibility

The mobile application shall be compatible with common Android devices used by small-scale processors.

6. COMMERCIALIZATION PLAN

6.1 Target Market and Customer Persona

The primary target market for the proposed system consists of small and medium-scale dry fish processors operating in coastal regions of Sri Lanka, including areas such as Negombo, Chilaw, Mannar, and Jaffna. These processors typically rely on traditional methods and manual decision-making for fish processing, waste management, and batch monitoring. The main customer persona can be described as a small-scale dry fish processor or processing facility operator who manages daily fish batches and requires a simple digital tool to improve operational efficiency and reduce waste. These users generally possess basic smartphone usage skills but may not have access to advanced technological systems. Secondary stakeholders include fish waste recycling companies and fish meal producers, who can benefit from advanced waste predictions that allow them to plan waste collection and resource reuse activities more efficiently.

6.2 Value Proposition

The proposed system offers several key benefits to processors and related stakeholders. First, it provides AI-based predictions of fish cleaning waste, enabling processors to estimate waste quantities before processing begins. This allows better planning for waste handling and reuse. Second, the system recommends appropriate salt quantities for each processing batch, helping maintain consistent product quality and reducing spoilage risks caused by incorrect salt levels. Third, the platform introduces digital traceability for dry fish processing batches, allowing processors to record batch details, monitor waste generation patterns, and maintain historical processing data. Overall, the system delivers a low-cost, easy-to-use digital platform that improves sustainability, reduces environmental impact, and enhances operational efficiency in traditional dry fish processing environments.

6.3 Revenue Model

The proposed platform can adopt a Software-as-a-Service (SaaS) model, where processors subscribe to the platform to access its features. The mobile application and prediction services would be hosted on a cloud-based infrastructure, allowing users to access the system through their smartphones. Revenue can be generated through monthly or annual subscription plans for processors who wish to use the platform to manage their processing operations and waste tracking. Additional revenue opportunities may arise from data analytics services, where aggregated processing data can be used to provide industry insights or sustainability reports for stakeholders and regulatory authorities.

6.4 Cost Estimation

The major costs associated with developing and deploying the system include software development costs, cloud hosting infrastructure, database storage, and maintenance. Initial development costs mainly involve building the mobile application using Flutter, implementing backend services with Node.js, developing machine learning models in Python, and setting up the MongoDB database. Operational costs may include cloud server hosting, database storage, system maintenance, and periodic model updates. Since the system is primarily software-based, the overall operational cost can remain relatively low compared to hardware-based solutions.

6.5 Pricing Strategy

A tiered subscription pricing strategy can be adopted to make the system affordable for small-scale processors while still generating sustainable revenue.

For example:

Basic Plan – Access to batch recording and waste tracking features.

Standard Plan – Includes waste prediction and salt recommendation features.

Premium Plan – Includes full analytics, traceability reports, and notification systems for recycling partners.

This tiered approach allows processors to choose services based on their needs and financial capability.

6.6 Competitive Advantage

The proposed system provides several advantages compared to existing solutions. Most existing research and commercial systems focus primarily on fish freshness monitoring, drying equipment, or supply chain traceability. In contrast, the proposed platform specifically addresses waste prediction and sustainability within the fish processing workflow. Another advantage is that the system is designed to be low-cost and accessible for small-scale processors, which are the most common stakeholders in Sri Lanka's dry fish industry. The integration of AI-based waste prediction, salt recommendation, and digital batch traceability within a single platform provides a unique solution that is not commonly available in existing systems.

6.7 Intellectual Property Considerations

The proposed system may generate intellectual property related to the machine learning models, system architecture, and integrated digital platform for sustainable dry fish processing. These innovations may potentially be protected through software copyrights or patents, depending on the novelty of the implemented algorithms and system design. In addition, the collected datasets related to waste prediction and processing patterns may become valuable research assets that can support future research and development activities. Proper data governance policies must be implemented to ensure that collected data is used ethically and securely.

7. BUDGET AND JUSTIFICATION

Description	Total Amount	Justification
Digital weighing scale for measuring fish waste	Rs10,000	Needed to measure waste quantities during processing accurately
Cloud storage or hosting services	Rs 7,000	Required to store batch data and run the digital platform
Internet access for cloud connectivity and system updates	Rs3,000	Needed for data synchronization and system operation
Notification Service (SMS/Email API)	Rs5,000	Required to send automated notifications to third-party waste processing companies about predicted waste quantities
Total Budget	Rs25,000	

Table 7.1 Estimated budget table.

8. WORK BREAKDOWN STRUCTURE (WBS)

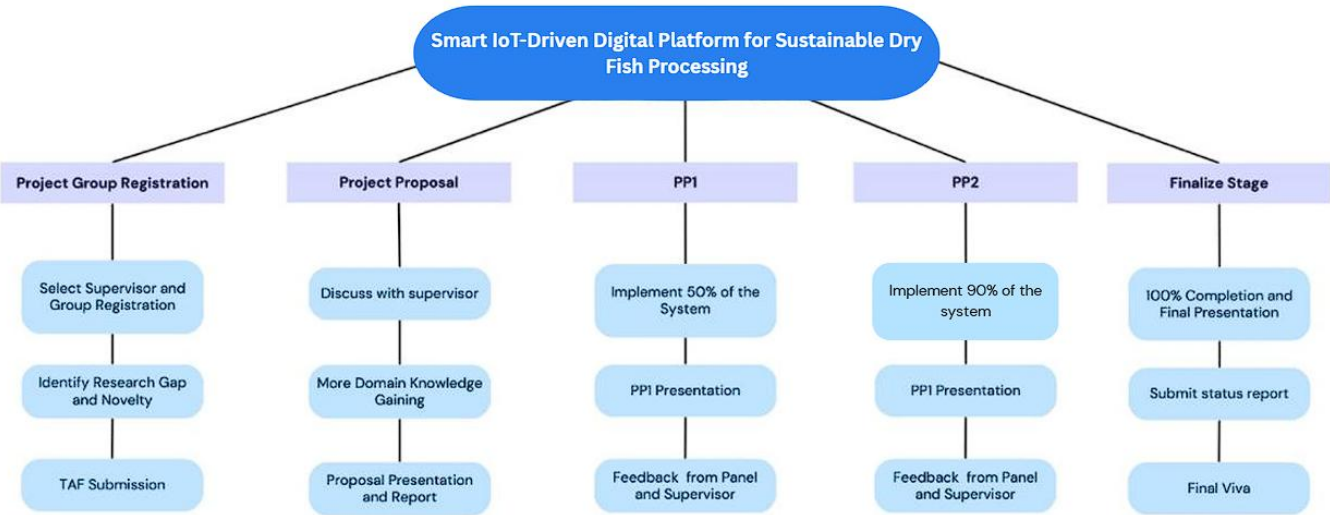


Figure 8.1 Work Breakdown Structure

9. GANTT CHART

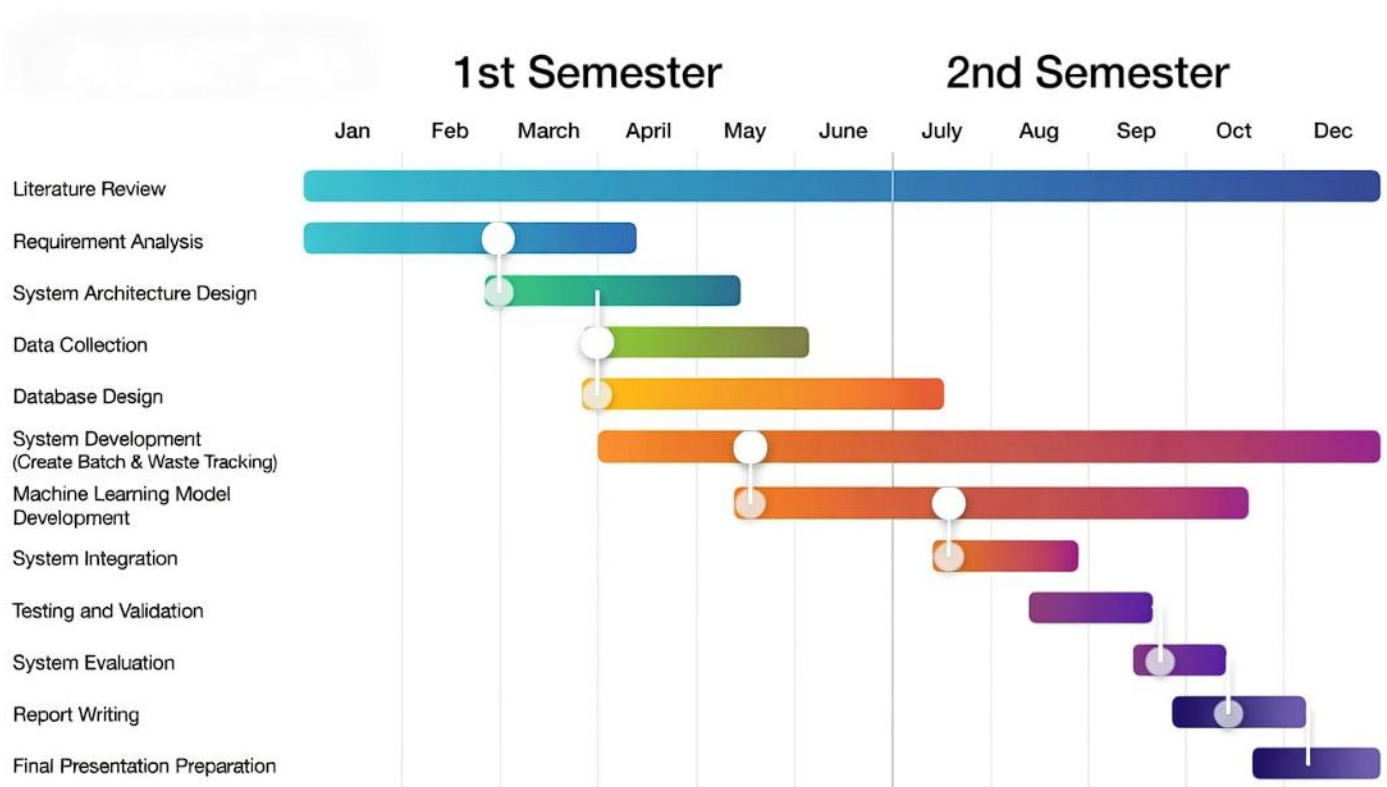


Figure 9.1 Gantt Chart

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11.APPENDICES



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