

Smart-Cost : Smart Supply Chain Cost Analytics and Profit Prediction System for Micro-SMEs

**(Adaptive Thermal Receipt Restoration Pipeline:
Transformer-Based Document Understanding and
Diffusion Inpainting for Degraded Thermal Images)**

R26-IT-026

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

Micro and small-scale food businesses such as bakeries and local cafés commonly rely on physical purchase receipts to track ingredient costs and operational expenses. However, these receipts are typically printed on thermal paper, which deteriorates over time due to fading ink, wrinkles, folds, and poor lighting conditions during image capture. These issues significantly reduce the accuracy of traditional Optical Character Recognition (OCR) systems, making it difficult for small businesses to digitize receipt data and utilize digital tools for inventory and profit analysis.

Despite the availability of mobile document scanning applications, most existing systems are designed for clean office documents and do not effectively handle degraded thermal receipts used by micro-SMEs. Furthermore, current solutions rarely integrate receipt digitization with predictive financial analytics and inventory intelligence, which limits their usefulness for business decision-making.

To address this gap, this research proposes the development of a Predictive Profit and Inventory Management System for Micro-SMEs, which digitizes physical receipts, extracts ingredient purchase information, and integrates predictive analytics to support real-time business insights. The system introduces an adaptive image preprocessing pipeline designed specifically for degraded thermal receipts. The proposed method utilizes Perspective Transformation to correct geometric distortions, Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance faded text, Gaussian Adaptive Thresholding to improve text segmentation, and morphological image processing techniques to remove noise before OCR extraction.

The system is implemented using React Native for the mobile interface, OpenCV for computer vision processing, Python-based OCR engines such as Tesseract, and cloud-based APIs for backend integration. The expected outcome is a mobile solution capable of improving OCR accuracy and reducing Character Error Rate (CER) when processing degraded receipts.

The proposed system aims to support data-driven decision making for micro-SMEs, enabling better inventory tracking, improved cost visibility, and enhanced financial planning, while also offering strong commercial potential as an affordable digital management tool for small businesses.

Keywords: Computer Vision, OCR, Receipt Digitization, Inventory Management, Micro-SME Analytics.

ACKNOWLEDGEMENT

First and foremost, we would like to express our sincere gratitude to our research supervisor for the invaluable guidance, encouragement, and constructive feedback provided throughout the development of this research proposal. The supervisor's expertise, patience, and continuous support played a vital role in shaping the direction and quality of this research project.

We would also like to extend our appreciation to the faculty members of the Department of Information Technology/Computer Science for providing the necessary academic knowledge and technical foundation required to conduct this research.

Special thanks are extended to our project team members for their collaboration, dedication, and commitment in developing different components of the proposed system. The teamwork and shared effort among members significantly contributed to the successful planning and design of the project.

We would also like to acknowledge the contributions of the open-source research community and software developers whose tools, libraries, and research publications in fields such as computer vision, natural language processing, mobile application development, and predictive analytics have provided essential support for this work.

Finally, we would like to express our heartfelt gratitude to our families and friends for their continuous encouragement, understanding, and motivation throughout our academic journey.

Their support has been invaluable in completing this research proposal successfully.

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LIST OF ABBREVIATIONS

ARIMA	Auto Regressive Integrated Moving Average
API	Application Programming Interface
AI	Artificial Intelligence
ERP	Enterprise Resource Planning
MAPE	Mean Absolute Percentage Error
RMSE	Root Mean Square Error
SME	Small and Medium-Sized Enterprise
Micro-SME	Micro Small and Medium-Sized Enterprise
NLP	Natural Language Processing
OCR	Optical Character Recognition
WBS	Work Breakdown Structure
SDG	Sustainable Development Goals

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1. INTRODUCTION

1.1 Background and Context

Micro, small, and medium-sized enterprises (MSMEs) play a crucial role in economic development by generating employment, supporting local supply chains, and contributing significantly to national GDP. According to global economic reports, SMEs represent more than 90% of businesses worldwide and contribute over 50% of global employment. In developing economies such as Sri Lanka, small-scale food businesses including bakeries, cafés, and street food vendors form a major portion of the informal economy. Despite their economic importance, many micro-SMEs continue to rely on manual record-keeping practices for tracking purchases, inventory costs, and daily expenses.

One of the most common methods used by small food businesses to record ingredient purchases is through printed supplier receipts. These receipts are typically printed on thermal paper, which is highly susceptible to environmental damage such as fading ink, creasing, crumpling, and exposure to heat or sunlight. Over time, these receipts become difficult to read and are often lost or discarded, resulting in poor financial record management.

This problem affects several stakeholders including small business owners, shop managers, and accounting personnel, who require accurate cost information to calculate product pricing, manage inventory levels, and evaluate profit margins. Without reliable data, business owners may unknowingly sell products at reduced profit margins or experience financial losses due to fluctuating ingredient costs.

Studies on SME financial management indicate that over 60% of small businesses fail to maintain proper digital financial records, particularly in developing countries where access to advanced management systems is limited. Additionally, many existing digital inventory systems require manual data entry, which is time-consuming and prone to human error.

Existing receipt-scanning applications and OCR-based document digitization tools provide some level of automation, but they are primarily designed for clean office documents rather than degraded retail receipts. Thermal receipts captured using smartphone cameras often suffer from perspective distortion, shadows, low contrast, and faded text, leading to high recognition errors during OCR processing. As a result, existing systems fail to reliably extract structured information from real-world receipt images used by micro-SMEs.

To address these limitations, this research proposes the development of a Predictive Profit and Inventory Management System for Micro-SMEs, which integrates computer vision, mobile computing, natural language processing, and predictive analytics to transform physical purchase receipts into structured digital records and actionable financial insights.

The system begins with a mobile receipt capture interface built using React Native, enabling users to quickly scan receipts using a smartphone camera. A key innovation of this research is the Adaptive Pre-Processing Pipeline for Degraded Thermal Receipt Restoration, which utilizes computer vision techniques such as Perspective Transformation, Contrast Limited Adaptive Histogram Equalization (CLAHE), Gaussian Adaptive Thresholding, and morphological image processing operations to restore damaged receipt images before OCR

extraction. This preprocessing stage significantly improves the readability of faded text and reduces recognition errors.

After restoration, the extracted text is processed by additional system modules responsible for semantic inventory normalization, predictive ingredient price forecasting, and dynamic profit margin analysis, allowing businesses to monitor financial performance in real time.

This research aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 8: Decent Work and Economic Growth, by supporting digital transformation and operational efficiency for small businesses. It also contributes to SDG 9: Industry, Innovation, and Infrastructure, through the development of intelligent digital solutions that enhance business productivity.

From a research perspective, this project falls within the Artificial Intelligence and Data Science research cluster, combining technologies from computer vision, machine learning, natural language processing, and mobile application development to address real-world business challenges.

By enabling small food businesses to digitize purchase receipts and analyze financial data more effectively, the proposed system aims to support data-driven decision-making, improved inventory management, and sustainable business growth for micro-SMEs.

1.2 Literature Review

Recent research confirms that OCR performance is highly dependent on document image quality, especially when the input contains blur, uneven illumination, low contrast, folds, or geometric distortion. A 2023 survey on document image quality assessment emphasizes that image degradation directly affects downstream document analysis tasks such as segmentation, text recognition, and OCR reliability. Similarly, recent reviews on document binarization note that degraded documents remain challenging because background noise, faded text, and non-uniform lighting reduce the effectiveness of standard thresholding methods. These findings are highly relevant to thermal receipt digitization, since supplier receipts used by micro-SMEs are often physically damaged and captured under uncontrolled mobile conditions.

Several scholarly studies have therefore focused on preprocessing as a critical stage before OCR. Research on degraded document OCR shows that enhancement pipelines combining contrast improvement, adaptive thresholding, and noise removal can improve text visibility before recognition. Recent work such as *PreP-OCR* further demonstrates that restoration before OCR can improve extraction quality in degraded documents by treating image enhancement as a separate but essential stage in the recognition pipeline. Although much of this work is evaluated on historical or archival documents rather than receipts, the core insight remains important: OCR alone is not sufficient when the visual quality of the source document is poor.

A related line of research examines document geometry correction for mobile capture. Smartphone-scanned receipts frequently suffer from skew, perspective warping, and partial shadows caused by hand-held capture. Recent work on handheld document scanning shows that perspective correction and stabilization remain essential for converting casual mobile captures into OCR-ready document images. Other OCR-oriented studies also highlight de-

skewing and normalization as necessary preprocessing steps because geometric misalignment reduces line segmentation accuracy and consequently increases character recognition errors.

Receipt-specific research has also expanded in recent years. The CORU dataset was introduced in 2024 as a large multilingual receipt-understanding dataset containing over 20,000 annotated receipts, reflecting the growing importance of noisy real-world receipts as a research problem. In another 2024 study, researchers working on Thai receipt images proposed a deep learning and template-based method for extracting food and beverage items from receipts, showing that receipt processing is more complex than ordinary OCR because it must deal with irregular layouts, multilingual content, and variable item structures. A 2025 review of invoice and receipt OCR likewise reports that Tesseract remains widely used, but it also notes ongoing limitations in noisy financial documents and the increasing shift toward more advanced learning-based approaches.

Beyond academic studies, several commercial products and services already provide receipt scanning and expense capture. Expensify offers mobile receipt scanning using its SmartScan workflow, Dext provides AI-based receipt and invoice capture for small businesses, Zoho Expense supports automated receipt scanning and categorization, and Veryfi markets an OCR API that extracts structured receipt data and line items. These platforms demonstrate strong market demand for automated receipt digitization and show that receipt capture through mobile devices is commercially viable.

However, the literature and product landscape reveal several important limitations. First, many existing academic approaches focus either on general degraded documents or on post-OCR information extraction, rather than specifically addressing degraded thermal receipts captured in micro-SME operating environments. Second, commercial products are mainly optimized for expense management and bookkeeping, not for restoring crumpled, faded thermal-paper receipts prior to OCR in low-resource SME settings. Third, while some systems extract structured receipt data, they typically stop at digitization and do not integrate receipt capture with inventory costing, profit-margin recalculation, or predictive alerting for small food businesses.

Therefore, the reviewed literature supports the need for a specialized solution that combines mobile receipt capture, adaptive restoration of degraded thermal receipts, and OCR-ready preprocessing as the first stage of a larger predictive profit and inventory platform. In this project, the Member 1 contribution addresses that need by introducing a pipeline based on Perspective Transformation, CLAHE, Gaussian Adaptive Thresholding, and morphological operations to improve receipt readability before OCR. This creates a stronger foundation for the later modules responsible for semantic normalization, forecasting, and financial decision support.

1.3 Research Gap

Although significant research has been conducted in the areas of Optical Character Recognition (OCR), document image processing, and automated receipt analysis, several critical limitations remain when these technologies are applied to real-world scenarios faced by micro and small-scale businesses. The literature reviewed in the previous section indicates that most existing studies focus primarily on clean documents, historical archives, or structured invoice datasets, rather than highly degraded thermal receipts commonly used in small retail environments.

One major gap identified in existing research is the lack of specialized preprocessing techniques designed specifically for degraded thermal receipt images captured through mobile devices. Thermal receipts frequently suffer from multiple types of degradation including faded ink, crumpled paper, shadows caused by lighting conditions, and geometric distortions due to angled camera capture. Standard OCR systems such as Tesseract perform well on high-quality scanned documents but show significantly reduced accuracy when applied to low-contrast or distorted receipt images. Many existing approaches assume relatively clean input images and therefore fail to address the practical challenges encountered in real-world micro-SME environments.

Another limitation of current research is that many receipt-processing solutions focus mainly on post-OCR information extraction or template-based data parsing, rather than improving the visual quality of receipt images prior to OCR processing. Without proper image restoration, the OCR stage introduces high Character Error Rates (CER), which subsequently affects downstream processes such as inventory tracking and financial analysis.

Commercial receipt-scanning applications such as expense management platforms demonstrate the feasibility of automated receipt digitization; however, these systems are typically designed for corporate expense reporting rather than small-business operational analytics. Additionally, many commercial systems rely on cloud-based processing pipelines optimized for well-structured receipts and do not explicitly address the restoration of severely degraded thermal paper receipts.

Furthermore, most existing solutions treat receipt digitization as a standalone task and do not integrate it with predictive financial analysis, inventory normalization, or dynamic profit monitoring, which are essential capabilities for supporting decision-making in micro-SME environments.

To address these limitations, this research introduces an Adaptive Pre-Processing Pipeline for Degraded Thermal Receipt Restoration, which combines Perspective Transformation, Contrast Limited Adaptive Histogram Equalization (CLAHE), Gaussian Adaptive Thresholding, and morphological image processing techniques to improve image quality before OCR extraction. By specifically targeting the restoration of degraded thermal receipts captured through mobile devices, the proposed solution aims to significantly reduce OCR errors and provide a reliable data foundation for subsequent modules including inventory normalization, predictive price forecasting, and profit margin analysis.

Therefore, the novelty of this research lies in the integration of a mobile-based receipt capture system with an adaptive image restoration pipeline specifically designed for micro-

SME receipt conditions, enabling more accurate digitization of supplier receipts and supporting intelligent financial management for small food businesses.

2. OBJECTIVE

2.1 Main Objective

The main objective of this research is to design and develop a mobile-based adaptive receipt digitization system that restores degraded thermal receipt images using computer vision techniques in order to improve OCR extraction accuracy and reduce Character Error Rate (CER) for inventory data capture in micro-SME food businesses.

This objective will be achieved by implementing a computer vision preprocessing pipeline integrated within a React Native mobile application, capable of correcting perspective distortions, enhancing faded receipt text, and removing visual noise before OCR processing. The effectiveness of the proposed system will be evaluated by measuring improvements in OCR accuracy when processing degraded thermal receipts compared to standard OCR without preprocessing.

The system aims to provide micro and small-scale food businesses with an efficient and reliable method for converting physical supplier receipts into structured digital data, enabling better inventory tracking and supporting downstream modules for predictive analytics and profit monitoring.

2.2 Specific Objectives

To achieve the main objective of this research, the following specific objectives are defined. These objectives are measurable and aligned with the identified research problem and the technical components of the proposed system.

1. To design and develop a mobile-based receipt capture interface using React Native that allows micro-SME users to easily scan and upload supplier receipts using smartphone cameras.
2. To implement an adaptive computer vision preprocessing pipeline incorporating Perspective Transformation, Contrast Limited Adaptive Histogram Equalization (CLAHE), Gaussian Adaptive Thresholding, and morphological image processing techniques to enhance degraded thermal receipt images before OCR processing.
3. To improve OCR text extraction accuracy by reducing the Character Error Rate (CER) when processing faded or distorted thermal receipts compared to standard OCR processing without preprocessing.
4. To integrate the receipt image restoration module with the backend OCR engine and data processing pipeline, enabling automatic extraction of ingredient purchase information from supplier receipts.
5. To develop a mobile dashboard interface that visualizes extracted receipt data and system insights, allowing users to review scanned receipts, extracted inventory data, and financial indicators generated by the system.
6. To evaluate the effectiveness of the proposed preprocessing pipeline by testing it on a dataset of real-world thermal receipts collected from small food businesses and comparing OCR performance metrics before and after image restoration.

3. METHODOLOGY

This section describes the research methods, technical approaches, tools, and evaluation strategies used to develop the proposed Predictive Profit and Inventory Management System for Micro-SMEs. The methodology focuses particularly on the design and implementation of the mobile receipt capture interface and the adaptive image preprocessing pipeline for degraded thermal receipts.

3.1 Research Approach

This research adopts a Design Science Research (DSR) approach, which is widely used in information systems and computer science research to develop and evaluate innovative technological artifacts that solve real-world problems.

The Design Science methodology is appropriate for this project because the research aims to design and implement a functional system artifact, specifically a mobile-based receipt digitization module capable of restoring degraded thermal receipts and improving OCR extraction accuracy.

The research process follows several stages:

1. Problem Identification – Analyze the challenges faced by micro-SMEs when managing supplier receipts and tracking ingredient costs manually.
2. System Design – Design a mobile receipt capture interface and a computer vision preprocessing pipeline capable of improving the readability of degraded receipts.
3. Artifact Development – Implement the proposed solution using mobile development frameworks and computer vision algorithms.
4. Evaluation – Assess the effectiveness of the proposed preprocessing pipeline by comparing OCR performance metrics before and after image restoration.

Through this iterative design and evaluation process, the research aims to produce a technological artifact that improves receipt digitization reliability for small businesses.

3.2 Technical Methods and Algorithms

The proposed system introduces an Adaptive Image Pre-Processing Pipeline designed to enhance degraded thermal receipt images prior to OCR processing. The pipeline consists of multiple computer vision stages.

1. Image Acquisition

The receipt image is captured using a smartphone camera through the React Native mobile application interface. The captured image is transferred to the backend processing module.

2. Perspective Transformation

Receipt images captured by mobile devices often suffer from geometric distortions due to angled camera positioning. Perspective transformation is applied to correct these distortions and align the receipt image into a rectangular format suitable for further processing.

3. Contrast Enhancement using CLAHE

Thermal receipts frequently contain faded text due to heat-sensitive printing technology. To improve text visibility, the system applies Contrast Limited Adaptive Histogram Equalization (CLAHE) to enhance local contrast without amplifying noise excessively.

4. Adaptive Thresholding

Gaussian Adaptive Thresholding is used to convert the enhanced grayscale image into a binary image, separating text from background noise. This step improves OCR recognition by increasing character clarity.

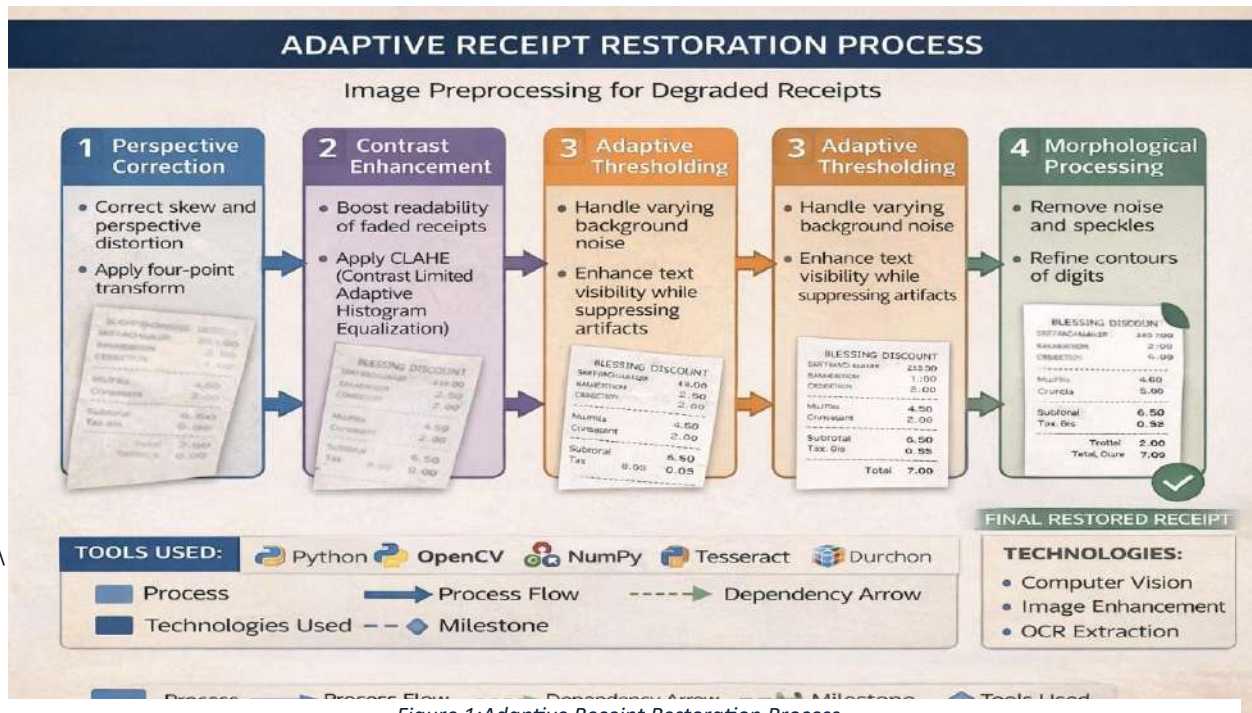
5. Morphological Image Processing

Morphological operations such as erosion and dilation are applied to remove small noise artifacts and strengthen the structure of textual characters.

6. OCR Text Extraction

After preprocessing, the cleaned image is passed to the Tesseract OCR engine, which extracts textual information from the receipt.

The extracted raw text is then forwarded to subsequent modules responsible for inventory normalization and financial analysis.



3.3 Tools and Platforms

The system utilizes several software tools and development platforms selected based on performance, flexibility, and compatibility with mobile systems. Visualization libraries such as Matplotlib and Seaborn will also be used to generate graphical representations of ingredient price trends and forecasting results, which can be integrated into the mobile system dashboard.

Table 1-Tools and Technologies Used in System Development

Tool / Platform	Purpose	Justification
React Native	Mobile application development	Enables cross-platform development for Android and iOS with a single codebase
OpenCV	Image processing and computer vision	Provides robust libraries for image enhancement and geometric correction
Python	Backend development	Widely used for computer vision and OCR integration
Tesseract OCR	Text extraction	Open-source OCR engine with strong performance on structured text
FastAPI	API communication	Enables efficient integration between mobile frontend and backend services
Firebase / Cloud Storage	Data storage	Provides scalable storage for receipt images and extracted data

3.4 Data Collection and Ethical Considerations

To evaluate the performance of the proposed receipt restoration pipeline, a dataset of thermal receipt images will be collected from small food businesses such as bakeries and cafés.

The dataset will include receipts with varying conditions, including:

- Faded ink
- Crumpled paper
- Shadow interference
- Perspective distortion
- Low lighting conditions

Approximately 50–100 receipt images will be collected for experimental evaluation.

Ethical considerations will be strictly followed during data collection:

- Business identities and sensitive financial details will be anonymized.
- Only non-confidential receipt information will be used for research purposes.
- Permission will be obtained from participating businesses before collecting receipt images.
- Collected data will be stored securely and used solely for academic research.

3.5 Validation Strategy and Performance Metrics

The effectiveness of the proposed preprocessing pipeline will be evaluated by comparing OCR performance **before and after image restoration**.

Several performance metrics will be used:

Table 2-Table X: OCR Performance Evaluation Metrics

Metric	Description
Character Error Rate (CER)	Measures the percentage of incorrectly recognized characters
Word Recognition Accuracy	Measures the accuracy of recognized words
OCR Confidence Score	Indicates reliability of extracted text
Processing Time	Measures computational efficiency of the preprocessing pipeline

Experimental testing will be conducted using the collected receipt dataset. The results will demonstrate whether the proposed adaptive preprocessing pipeline significantly improves OCR accuracy when processing degraded thermal receipts.

4. HIGH-LEVEL SYSTEM ARCHITECTURE

The proposed Predictive Profit and Inventory Management System for Micro-SMEs is designed as an integrated intelligent platform that converts physical supplier receipts into structured digital records and actionable financial insights. The system combines mobile computing, computer vision, OCR, natural language processing, predictive analytics, and financial rule-based decision support to help small food businesses manage inventory costs and monitor profit margins more effectively.

At a high level, the system consists of five major components:

1. Mobile Receipt Capture and Dashboard Interface
2. Image Restoration and OCR Processing Module
3. Semantic Inventory Normalization Engine
4. Price Forecasting and Predictive Analytics Module
5. Profit Margin Calculation and Alert Engine

Among these, the contribution of Member 1 focuses on the first two layers from the user-facing and image-processing perspective, specifically the React Native mobile application, receipt scanning workflow, dashboard visualization, and the adaptive pre-processing pipeline for degraded thermal receipt restoration.

4.1 System Overview

The proposed solution begins when a user captures a supplier receipt using the mobile application. Since many supplier receipts are printed on fragile thermal paper and may contain faded ink, folds, shadows, and perspective distortion, the captured image is first passed to a specialized computer vision preprocessing module. This module restores the image quality before OCR is performed.

Once the text is extracted, the raw output is forwarded to the semantic normalization module, which converts inconsistent receipt item descriptions into standardized ingredient names and quantities. After normalization, the cleaned data is used by the inventory and costing engine to update ingredient cost records. The predictive forecasting module then estimates future ingredient price movement using historical purchase data, and the financial engine recalculates current and projected profit margins. Finally, the mobile dashboard presents these insights to the business owner using clear visual indicators and health alerts.

This architecture supports an end-to-end workflow from receipt capture to predictive business decision support

4.2 System Component Diagram



Figure 3: Predictive Profit and Inventory Management System for Micro-SMEs

This component diagram shows that the system follows a modular layered architecture, where each stage performs a specific function and passes processed data to the next stage

4.3 Component Interactions

The individual contribution of Member 1 is the Mobile Receipt Capture and Computer Vision Restoration Component, which acts as the entry point to the entire system. This component includes both frontend and backend-facing image processing subfunctions.

Member 1 Component: Frontend UI and Receipt Restoration Module

This component contains the following sub-parts:

1. Mobile Receipt Capture Interface

This is the smartphone-based interface that allows users to:

- open the camera,
- capture a receipt image,
- preview the captured image,
- confirm or retake the image,
- submit the receipt for processing.

This interface must be simple and user-friendly because the target users are small business owners who may have limited technical experience.

2. Image Upload and Transfer Handler

Once the user confirms the captured image, the application sends the image securely to the backend processing service through an API. This stage ensures image compression, metadata handling, and transmission reliability.

3. Perspective Transformation Module

This module detects receipt boundaries and corrects camera-angle distortion so that the receipt appears flattened and aligned for OCR-ready processing.

4. Contrast Enhancement Module

This stage applies CLAHE to improve faded text visibility on thermal paper without excessively increasing noise.

5. Adaptive Thresholding Module

This module transforms the enhanced grayscale image into a cleaner binary representation, helping to separate textual characters from uneven background shading.

6. Morphological Processing Module

This stage removes background artifacts and strengthens text regions using dilation, erosion, and related operations.

7. OCR Extraction Integration

After preprocessing, the restored image is passed to the OCR engine for text extraction, and the output is returned for downstream processing.

8. Dashboard Visualization Interface

Once the full system processes the extracted data, the frontend displays:

- scanned receipt summaries,
- updated ingredient costs,
- current profit margins,
- alert status levels,
- projected financial trends.

This makes the Member 1 module both a data acquisition layer and a decision-visibility layer.

4.4 Data Flow Explanation

The system components interact in a sequential and coordinated manner.

First, the mobile application captures the receipt image and sends it to the image restoration module. The restoration module preprocesses the image and forwards the cleaned result to the OCR engine. The extracted raw text is then sent to the semantic normalization engine, which standardizes ingredient names and quantities.

Next, the normalized records are stored in the inventory database and passed to the costing and profit analysis engine, which updates the weighted average cost and recalculates profit margins based on the latest ingredient prices. Simultaneously, the forecasting engine uses historical cost trends to estimate future price increases and predicted margin degradation.

Finally, the results are returned to the mobile dashboard, where users can view alerts, trends, and updated cost insights in real time.

Thus, each component is interdependent, and the quality of downstream analysis depends heavily on the accuracy of the initial receipt capture and preprocessing stages.

4.5 Scalability and Security Considerations

The overall data flow of the proposed system can be summarized in the following sequence:

1. The user captures a physical receipt image using the React Native mobile app.
2. The receipt image is uploaded to the backend image-processing service.
3. The image restoration pipeline applies perspective correction, contrast enhancement, thresholding, and morphological cleaning.
4. The restored image is passed to the OCR engine for raw text extraction.
5. The extracted text is forwarded to the semantic normalization module.
6. Normalized ingredient and quantity data are stored in the system database.
7. The financial engine updates inventory costing using the new purchase values.
8. The forecasting module predicts future ingredient cost changes.
9. The profit engine recalculates real-time and projected profit margins.
10. The alert engine assigns Green, Yellow, or Red business health indicators.
11. The dashboard displays all outputs to the user.

This data flow ensures that each receipt captured by the user contributes directly to updated business intelligence.

5. USER REQUIREMENTS

The user requirements define the needs and expectations of the stakeholders who will interact with the proposed Predictive Profit and Inventory Management System for Micro-SMEs. These requirements guide the design and implementation of the system to ensure that it effectively supports small food business owners in managing receipts, inventory costs, and profit insights.

5.1 Stakeholder Identification

Several stakeholders are involved in the usage and development of the proposed system. Each stakeholder interacts with the system in different ways depending on their role and responsibilities.

Table 3-Stakeholder Identification and System Roles

Stakeholder	Role	System Interaction
Micro-SME Business Owners (Bakeries, Cafés)	Primary users of the system	Capture receipts, monitor inventory costs, view profit margin alerts
Shop Managers	Operational monitoring	Track ingredient purchases and review financial performance
Suppliers	Indirect stakeholders	Provide purchase receipts used for digitization
System Administrators	Technical management	Manage system configuration, user access, and database maintenance
Developers / Researchers	System development and improvement	Maintain system functionality and evaluate system performance

The primary users of the system are small food business owners, who require a simple and efficient way to digitize receipts and monitor business profitability.

5.2 Functional Requirements

Functional requirements describe the specific functions and operations that the system must perform.

FR1: The system shall allow users to capture supplier receipts using the mobile device camera.

FR2: The system shall provide a scan preview screen where users can review captured receipt images before submitting them for processing.

FR3: The system shall automatically preprocess captured receipt images using computer vision techniques to improve text visibility.

FR4: The system shall extract textual data from receipt images using an OCR engine.

FR5: The system shall convert extracted receipt text into structured inventory records through the semantic normalization module.

FR6: The system shall store receipt images, extracted data, and processed inventory records in the cloud database.

FR7: The system shall update ingredient cost information and calculate the Weighted Average Cost (AVCO) after each receipt is processed.

FR8: The system shall calculate real-time product profit margins based on ingredient costs and recipe data.

FR9: The system shall display financial insights, including profit margins and cost trends, through a mobile dashboard interface.

FR10: The system shall generate alert notifications when profit margins fall below predefined thresholds.

FR11: The system shall allow users to review historical receipt records and financial data through the mobile application.

5.3 Non-Functional Requirements

Non-functional requirements define the quality attributes of the system, including performance, usability, security, and reliability.

Security Requirements

- The system shall ensure secure communication between the mobile application and backend services using encrypted HTTPS connections.
- User authentication mechanisms shall be implemented to restrict unauthorized system access.
- Sensitive business data such as financial records and receipts shall be securely stored in cloud databases.

Performance Requirements

- The receipt preprocessing and OCR extraction process should complete within a reasonable processing time (e.g., within a few seconds per receipt).
- The system should support simultaneous receipt processing requests from multiple users without significant performance degradation.

Usability Requirements

- The mobile interface should be simple and intuitive to ensure usability for non-technical business owners.
- The receipt scanning process should require minimal steps to complete.

Reliability Requirements

- The system should maintain consistent performance even when processing degraded receipt images.
- The system should ensure accurate OCR extraction to support reliable downstream analytics.

Scalability Requirements

- The system architecture should support expansion to handle larger datasets and multiple business users in the future.
- Cloud infrastructure should allow scaling of storage and processing resources as the number of receipts increases.

6. COMMERCIALIZATION PLAN

The commercialization plan outlines how the proposed Predictive Profit and Inventory Management System for Micro-SMEs can be transformed from a research prototype into a practical commercial product. The system aims to provide small food businesses with an affordable digital solution for receipt digitization, inventory tracking, and predictive financial insights.

6.1 Target Market and Customer Persona

The primary target market for the proposed forecasting system includes micro and small-scale enterprises that depend heavily on raw material procurement, particularly businesses operating in the food production and retail sectors. And examples of potential target users include:



Figure 4: Target Customer Personas for Micro-SME Food Businesses

6.2 Value Proposition

The value proposition of the proposed system lies in its ability to transform simple receipt images into actionable business intelligence for small businesses.

The system provides the following key benefits:

- Automated receipt digitization using mobile scanning and OCR
- Accurate inventory cost tracking through receipt-based data extraction
- Predictive insights into future ingredient price trends
- Real-time profit margin monitoring
- Automated financial alerts when margins decline

Unlike traditional bookkeeping tools, the proposed solution integrates computer vision, artificial intelligence, and predictive analytics to support data-driven decision-making for small businesses.

6.3 Revenue Model

The proposed system will follow a **Software-as-a-Service (SaaS) subscription model**, which allows small businesses to access the platform through a monthly or yearly subscription.

Possible revenue streams include:

- **Basic Subscription Plan** – Receipt scanning and basic inventory tracking
- **Standard Plan** – Includes predictive analytics and profit margin monitoring
- **Premium Plan** – Advanced forecasting, financial reports, and supplier insights

Additional revenue opportunities may include:

- Cloud storage upgrades
- Business analytics reports
- Integration with point-of-sale (POS) systems

This model allows businesses to adopt the system at a low initial cost while providing sustainable revenue for the platform.

6.4 Cost Estimation

The estimated costs for developing and maintaining the system include the following components:

Table 4-Estimated Cost Categories for System Development

Cost Category	Description
Software Development	Mobile app development, backend development, and system integration
Cloud Infrastructure	Storage of receipt images, database hosting, and API services
OCR and AI Processing	Computational resources required for image processing and analytics
Maintenance and Updates	Continuous system improvements and technical support
Marketing and Deployment	Promoting the platform to small business users

Using open-source technologies such as **React Native, Python, OpenCV, and Tesseract OCR** helps reduce development costs while maintaining high system functionality.

6.5 Pricing Strategy

The pricing strategy focuses on making the platform affordable for micro-SMEs, which often operate with limited budgets.

A possible pricing structure could be:

Table 5-Proposed Subscription Pricing Plans

Plan	Monthly Price	Features
Free Trial	Free	Limited receipt scanning and dashboard preview
Basic Plan	Low-cost subscription	Receipt digitization and inventory tracking
Standard Plan	Moderate subscription	Includes predictive cost analysis and alerts
Premium Plan	Higher subscription	Full analytics, forecasting, and financial reports

Offering a free trial period will encourage small businesses to experience the benefits of the system before committing to a subscription.

6.6 Competitive Advantage

The proposed system offers several competitive advantages compared to existing receipt scanning and expense management solutions.

Key advantages include:

- Specialized for micro food businesses rather than general expense tracking
- Adaptive image restoration pipeline for degraded thermal receipts
- Integration of receipt digitization with predictive financial analytics
- Automated profit margin monitoring and alert system
- Mobile-first design optimized for small business owners

While many existing applications focus only on receipt scanning, this system provides end-to-end business intelligence from receipt capture to financial forecasting.

6.7 Intellectual Property Considerations

The intellectual property (IP) associated with this research primarily involves the software architecture, algorithms, and system design developed as part of the project.

Possible IP protection strategies include:

- **Copyright protection** for the developed software code and mobile application interface
- **Algorithmic design documentation** for the adaptive receipt preprocessing pipeline
- **Trademark registration** for the system name and brand identity if commercialized

If the system demonstrates significant innovation, future work may explore patent protection for the image restoration workflow or predictive profit monitoring mechanism.

Proper intellectual property management ensures that the research output can be commercially deployed while protecting the creators' rights

7. BUDGET AND JUSTIFICATION

The development of the proposed Predictive Profit and Inventory Management System for Micro-SMEs requires several resources, including hardware devices, software tools, cloud infrastructure, and development effort. This section outlines the estimated costs required for the implementation and evaluation of the system during the research project.

The budget focuses on essential resources needed to support mobile application development, computer vision processing, cloud storage, and system deployment.

7.1 Hardware Costs

Table 6-Hardware Requirements and Cost Estimation

Item	Quantity	Estimated Cost (USD)	Purpose
Smartphone (Android test device)	1	LKR 50,000	Testing receipt capture and mobile application functionality
Laptop / Development Computer	1	LKR 180,000	Software development, model implementation, and system testing
External Storage Device	1	LKR 15,000	Backup of receipt image datasets and experimental results
Internet Router / Connectivity	1	LKR 10,000	Cloud access and API communication testing

Total Hardware Cost: LKR 255,000

Justification

Hardware resources are required to support software development, mobile testing, and data processing activities. The smartphone device is essential for testing the receipt scanning functionality, while the laptop provides the computational environment required to implement computer vision algorithms and backend services.

7.2 Software Licenses

Table 7-Software Tools and License Types Used for System Development

Software Tool	License Type	Estimated Cost
React Native Development Tools	Open Source	LKR 0
Python Programming Environment	Open Source	LKR 0
OpenCV Computer Vision Library	Open Source	LKR 0
Tesseract OCR Engine	Open Source	LKR 0
Development IDE (VS Code / PyCharm Community)	Free Version	LKR 0

Total Software Cost: LKR 0

Justification

The project intentionally utilizes open-source technologies to minimize development costs while maintaining high performance and flexibility. Tools such as React Native, Python, OpenCV, and Tesseract OCR are widely used in academic research and industrial applications, making them suitable for developing the proposed system without requiring expensive commercial licenses.

7.3 Cloud Services

Table 8-Estimated Cloud Service Costs for System Deployment

Cloud Service	Estimated Monthly Cost	Duration	Total Cost
Cloud Storage (Firebase / AWS S3)	\$10	12 months	LKR 50,000
Backend Hosting (API server)	\$15	12 months	LKR 30,000
Database Hosting	\$10	12 months	LKR 30,000
API and Data Processing Services	\$10	12 months	LKR 30,000

Total Cloud Cost: LKR 140,000

Justification

Cloud infrastructure is required to store receipt images, process OCR requests, and maintain system databases. Cloud services enable secure data storage, system scalability, and remote access, which are essential for testing real-world system deployment scenarios.

7.4 Human Effort Cost

Although this project is conducted as an academic research project, the estimated human effort cost can be calculated to reflect the development effort required.

Table 9-Estimated Human Effort Cost Distribution Among Project Members

Role	Estimated Hours	Hourly Rate (Estimated)	Total Cost
Frontend & Computer Vision Developer (Member 1)	200 hours	LKR 3,000	LKR 600,000
NLP & Data Processing Developer (Member 2)	180 hours	LKR 3,000	LKR 500,000
Predictive Analytics Developer (Member 3)	180 hours	LKR 3,000	LKR 500,000
Backend & Financial Logic Developer (Member 4)	200 hours	LKR 3,000	LKR 600,000

Total Human Effort Cost: LKR 2,222,000

Justification

Human effort represents the time invested by the development team in designing, implementing, and testing the system components. These activities include software development, algorithm implementation, dataset preparation, system integration, and experimental evaluation.

Although this cost is theoretical for the academic project, it reflects the real-world development value of the system if implemented commercially.

Total Estimated Project Budget

Table 10- Summary of Total Estimated Project Budget

Category	Estimated Cost
Hardware	LKR 255,000
Software	LKR 0
Cloud Services	LKR 140,000
Human Effort	LKR 2,222,000

Total Cost: LKR 2,595,000

8. WORK BREAKDOWN STRUCTURE (WBS)

The Work Breakdown Structure (WBS) defines the major tasks required to design, develop, and evaluate the **Predictive Profit and Inventory Management System for Micro-SMEs**. The tasks are distributed among the four team members based on their specialized research components. The WBS ensures balanced workload distribution and aligns the development activities with the project timeline.

Member 1 – Frontend UI & Computer Vision (Receipt Restoration Module)

Table 11-Work Breakdown Structure for Member 1 – Frontend and Computer Vision Module

Task ID	Task Description	Tools / Technology	Duration
M1-T1	Research on receipt image processing techniques	Research papers, literature review	2 Weeks
M1-T2	Design mobile UI wireframes for receipt capture and dashboard	Figma / Canva	2 Weeks
M1-T3	Develop React Native mobile interface	React Native, JavaScript	4 Weeks
M1-T4	Implement receipt image capture and preview screen	React Native Camera API	2 Weeks
M1-T5	Implement perspective correction algorithm	Python, OpenCV	2 Weeks
M1-T6	Apply CLAHE contrast enhancement	OpenCV	2 Weeks
M1-T7	Implement adaptive thresholding and morphological processing	OpenCV	2 Weeks
M1-T8	Integrate OCR extraction module	Tesseract OCR	2 Weeks
M1-T9	Develop dashboard visualization interface	React Native Charts / UI Libraries	3 Weeks
M1-T10	Testing and optimization of image restoration pipeline	Python, OpenCV	2 Weeks

Member 2 – NLP Engineer (Semantic Inventory Normalization)

Table 12-Work Breakdown Structure for Member 2 – Semantic Inventory Normalization Module

Task ID	Task Description	Tools / Technology	Duration
M2-T1	Literature review on semantic normalization techniques	Research papers	2 Weeks
M2-T2	Dataset preparation for ingredient names and variations	Python, Pandas	2 Weeks
M2-T3	Implement fuzzy string matching for ingredient detection	Python, FuzzyWuzzy / RapidFuzz	3 Weeks
M2-T4	Develop Named Entity Recognition (NER) model	SpaCy / NLP libraries	3 Weeks
M2-T5	Implement measurement unit normalization	Python	2 Weeks
M2-T6	Ingredient mapping and database structure	PostgreSQL / Firebase	2 Weeks
M2-T7	Integration with OCR output pipeline	API integration	2 Weeks
M2-T8	Testing and evaluation of normalization accuracy	Python evaluation scripts	2 Weeks

Member 3 – Predictive AI / Data Science (Price Forecasting)

Table 13-Work Breakdown Structure for Member 3 – Predictive Analytics and Forecasting Module

Task ID	Task Description	Tools / Technology	Duration
M3-T1	Research on time-series forecasting models	Research papers	2 Weeks
M3-T2	Dataset collection for ingredient price history	Python, Web data sources	2 Weeks
M3-T3	Data preprocessing and cleaning	Pandas, NumPy	2 Weeks
M3-T4	Implementation of ARIMA forecasting model	Python, Statsmodels	3 Weeks
M3-T5	Implementation of Prophet forecasting model	Python, Prophet library	3 Weeks
M3-T6	Model evaluation and comparison	Scikit-learn metrics	2 Weeks
M3-T7	API development for forecast output	FastAPI	2 Weeks

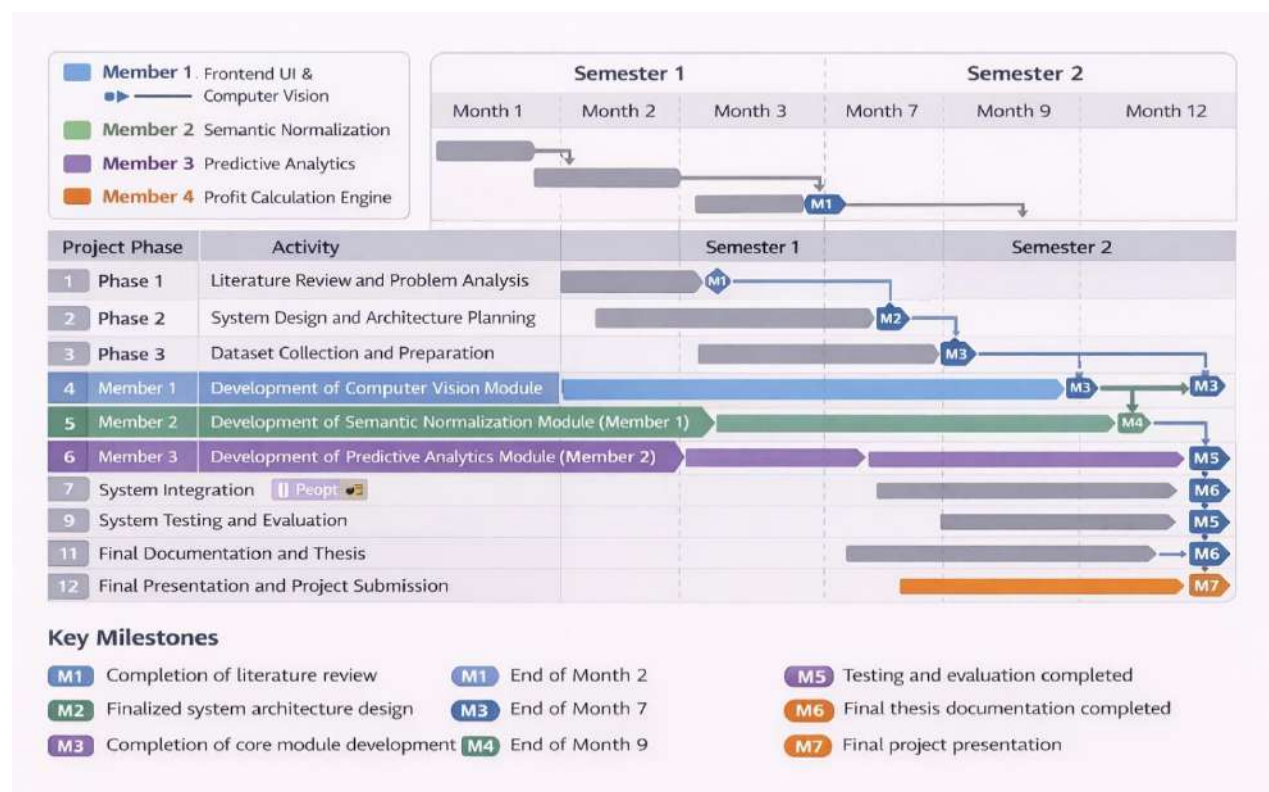
Task ID	Task Description	Tools / Technology	Duration
M3-T8	Integration with profit calculation module	REST API	2 Weeks

Member 4 – Backend & Financial Logic (Profit Engine)

Table 14-Work Breakdown Structure for Member 4 – Backend and Financial Calculation Module

Task ID	Task Description	Tools / Technology	Duration
M4-T1	Research on inventory costing algorithms	Research papers	2 Weeks
M4-T2	Design database schema for inventory records	PostgreSQL / Firebase	2 Weeks
M4-T3	Implement Weighted Average Cost (AVCO) algorithm	Python	3 Weeks
M4-T4	Develop recipe cost calculation module	Python	2 Weeks
M4-T5	Implement profit margin calculation system	Python	2 Weeks
M4-T6	Develop alert threshold logic (Green/Yellow/Red)	Python	2 Weeks
M4-T7	Backend API development for financial data	FastAPI	2 Weeks
M4-T8	Integration with forecasting outputs	API integration	2 Weeks
M4-T9	System testing and financial validation	Python testing tools	2 Weeks

9. GANTT CHART



10. REFERENCES LIST

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11. APPENDICES

The appendices provide supplementary materials that support the research proposal and offer additional details regarding data collection, system design, and implementation planning for the Predictive Profit and Inventory Management System for Micro-SMEs. provide additional context for the proposed research methodology and demonstrate how the forecasting module can be implemented and evaluated in real-world micro-SME environments.

11.1 Survey Instruments

To understand the challenges faced by micro food businesses in managing receipts and inventory costs, a preliminary survey will be conducted among bakery owners and small food business operators.

Sample Survey Questions

1. Do you currently store supplier receipts for ingredient purchases?
2. How do you track ingredient costs in your business?
3. How often do you experience difficulty locating old purchase receipts?
4. Do you currently use any digital tools for inventory or financial tracking?
5. How frequently do ingredient prices change for your business?
6. Would a mobile system that scans receipts and tracks profit margins be useful for your business?
7. What are the biggest challenges you face when managing financial records?

The survey responses will help validate the real-world problem statement and guide system design decisions.

11.2 System Diagrams

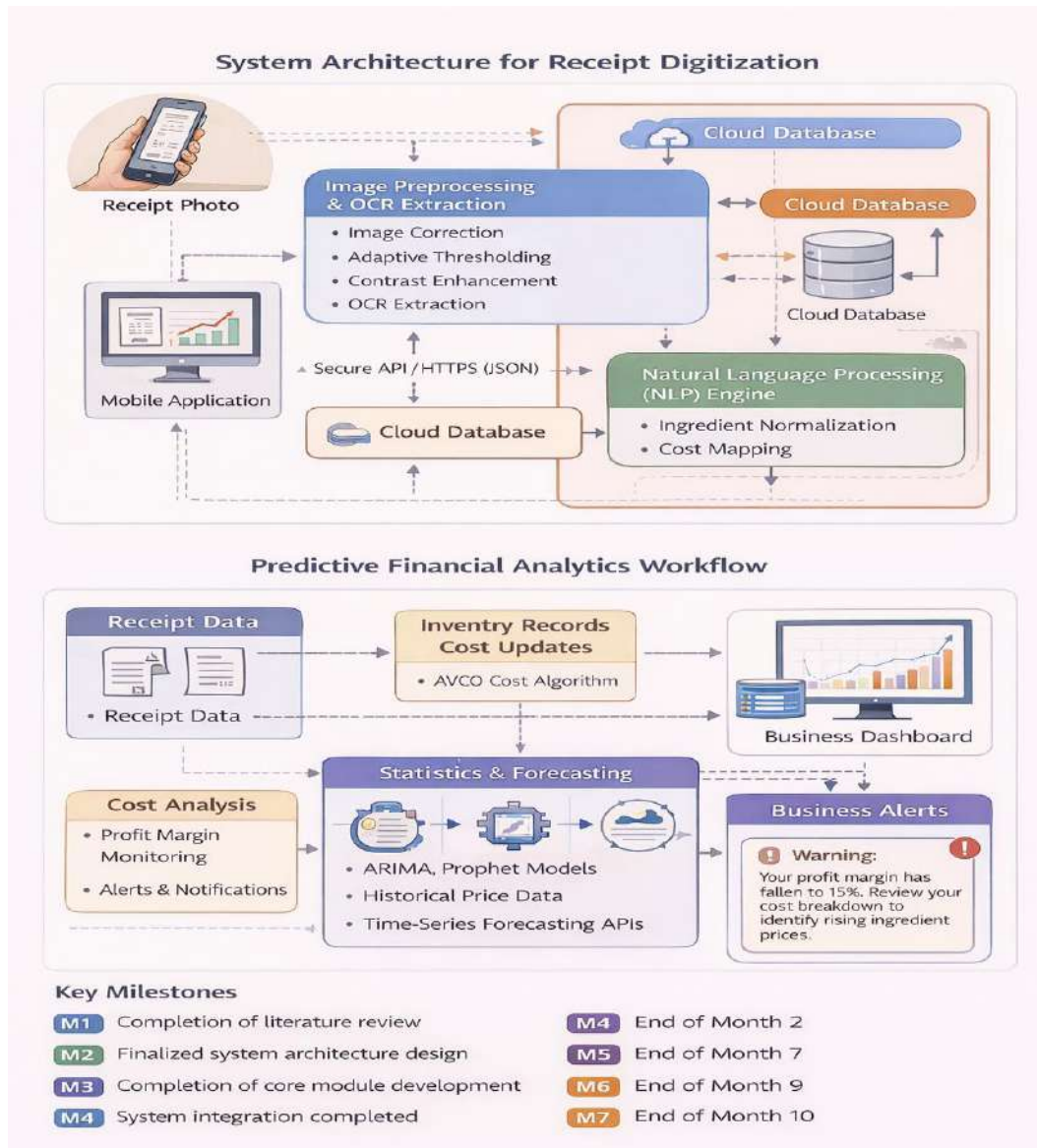


Figure 6: System Architecture and Predictive Financial Analytics Workflow

11.3 UI Mockups

The following user interface mockups illustrate the expected design of the mobile application.

1. Receipt Capture Screen

Allows the user to capture receipt images using the smartphone camera.

2. Scan Preview Screen

Displays the captured receipt image and allows users to confirm or retake the scan.

3. Dashboard Interface

Shows important business insights including:

- Updated ingredient costs
- Profit margin percentage
- Predictive price trend graphs
- Green / Yellow / Red business health alerts

4. Receipt History Screen

Allows users to view previously scanned receipts and extracted data.

11.4 Risk Analysis

Potential risks that may affect the project development are identified along with mitigation strategies.

Table 15-Risk Analysis and Mitigation Strategies

Risk	Description	Mitigation Strategy
Poor OCR accuracy	Degraded receipts may reduce text recognition accuracy	Implement advanced image preprocessing techniques
Insufficient dataset	Limited receipt samples for testing	Collect additional receipts from local businesses
Integration challenges	Difficulty integrating multiple system modules	Use standardized APIs and modular architecture
Performance limitations	Image processing may require high computational resources	Optimize preprocessing algorithms
User adoption barriers	Small business owners may hesitate to adopt new technology	Design a simple and intuitive mobile interface

11.5 Ethical Clearance Documents



RESEARCH ETHICS REVIEW FORM

All student submitting research projects for approval must fill out and submit this form to the appropriate administrator, depending on institution of the project.

SECTION I

1. Project/Research Type
 a) ☐ Lab ☐ Clinic ☐ Interview/Field

2. Project/Research Details
 Name: Age:
 Research Title: Number: Year: Title:

3. Student Adults (If the project is a group project, insert the details of group leader first)

Student ID	Name	Email	Phone
1	Student Name	Student Email	Student Phone
2	Student Name	Student Email	Student Phone
3	Student Name	Student Email	Student Phone
4	Student Name	Student Email	Student Phone

4. Research Details

Supervisor:	Dr. Elizabeth A. Anderson
Co-supervisor:	Dr. Robert Anderson
Research Supervisor:	Dr. Robert Anderson

SECTION II: DATA COLLECTION AND STORAGE

Read the following table before answering the questions.

Researcher	Description	Data Collection Methods
Primary Data	Primary data collection involves data that is collected directly from the source.	Surveys, Interviews, Focus Groups, etc.
Secondary Data	Secondary data collection involves data that is collected from a source other than the source of the data.	Archives, Existing Data, etc.

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[illegible]

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9. **DATA COLLECTION:** Explain the procedures you will be following to ensure privacy or participants or organizations during data collection, data analysis and publishing of results.

☐ I declare that data collection, participants will be given an informed consent to ensure procedures.

☐ I declare that participants will be informed that participants who have given consent through a validated form.

☐ I declare that participants' data will not be collected.

☐ I declare that data is present in the dataset. It will be either assigned to public.

Additional measures:

The research will properly collect, store, manage and analyze sensitive personal information, which do not contain personal information. If any business related information appears on research, such as shop names or addresses, it will be removed or anonymized during processing. All collected data will be used only for academic research purposes.

10. **DATA USABILITY:** If you are collecting information voluntarily people, in what form will the data be stored?

☐ Anonymously identifiable ☐ No identifiers ☒ Non-identifiable

11. **DATA STORAGE:** Where will data be stored and what measures will be taken to ensure security of data?

☐ Paper-based data stored in locked filing cabinet within JCU.

☐ Data stored in hard-drive and computers will be protected by password and encryption.

☐ Data will be encrypted and will not be in the cloud.

☐ After the completion of the project, all data will be permanently deleted from all storage devices. Only a single copy will be securely stored within a repository for the institution.

Additional measures:

All research data including sensitive research, personal financial history and security, must be properly stored, collected, analyzed and stored securely. Research data will be stored only in the research team members and supervisors. The dataset will be destroyed without delay by securely deleting computer.

12. **How would you rate the overall risk associated with the research?** (There might any occur when the collected data is exposed to unauthorized parties, etc.)

☐ High risk ☒ Low risk ☐ Negligible risk

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10. Declaration of the participants

I/we certify that the following form shows our decision and agreement to the conditions of approval specified by the panel. Furthermore, I/we will inform the End-User(s) of the Project and ensure that we will inform them of the specified details.

Student ID	Name	Signature
12345678	John Doe	
87654321	Jane Smith	
98765432	Michael Johnson	
10987654	Sarah Lee	

11. Approvals and Requirements

Supervisor Recommendation (please select one option)	☐ Ethics committee Approved NOT Required ☐ Ethics committee Approved Required	
	If approval required, clearly specify the reasons: 	
Supervisor Name	Supervisor Signature	Date

**** Please note that if the supervisor has recommended that ethics committee approval is required, please email the Ethics Review Panel of the NCTDRC and submit it to the Faculty Ethics Review committee.**

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