FARM FUSION

Capstone Project Report

END SEMESTER EVALUATION

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ABSTRACT

At the convergence of agriculture, technology, and ecommerce lies an innovative undertaking. Seamlessly blending machine learning, online commerce, and soil quality evaluation, this initiative reimagines farmer engagement. Through the amalgamation of image classification and predictive algorithms, the endeavor empowers farmers to make informed decisions about crop quality and diversity. Extending this empowerment to consumers, the ecommerce component facilitates convenient access to freshly harvested yields and vital agricultural resources. Furthermore, integrating sensor-based hardware for soil analysis enhances resource efficiency, bolstering both productivity and environmental responsibility. This project intricately recounts the journey of harmonizing traditional farming with state-of-the-art technology, highlighting the potential to revolutionize the trajectory of agriculture.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled *Farm Fusion* is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Anamika Sharma during 7th semester (2023).

Date: 19th December 2023

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Sno.	Abbreviation	Meaning
1.	CV	Computer Vision
2.	CNN	Convolutional Neural Networks
3.	NPK	Nitrogen-Phosphorus-Potassium
4.	MLP	Multilayer perceptron
5.	LR	Logistic Regression
6.	RF	Random Forest
7.	BN	Bayesian Network
8.	CBDA	Case-Based Distance Approach
9.	DCT	Discrete Cosine Transform
10.	SVM	Support Vector Machines
11.	AHP	Analytic Hierarchic Process
12.	DL	Deep Learning
13.	MERN	Mongo Express React Node

1. INTRODUCTION

1.1 Project Overview

The agriculture industry is rapidly modernizing with the help of technology, such as precision agriculture and smart irrigation systems, leading to increased yields and reduced waste. E-commerce and online marketplaces are enabling farmers to buy and sell farming products and produce, providing better market access and customer experiences. Machine learning is also being used to classify crops based on their appearance, helping farmers monitor crop growth and health more efficiently.

The project is driven by the desire to create a more efficient and transparent agricultural supply marketplace. So by the fusion of machine learning models and an ecommerce website along with hardware integration, we hope to eliminate the barriers that have historically prevented farmers from selling their crops directly to consumers.

The smart crop quality detection system uses image analysis to assess seed and soil parameters, aiding farmers in marketing their produce and enabling informed consumer choices. By combining crop quality measures with market price trends, fair prices for produce can be predicted, thus giving a transparent agricultural ecosystem. The e-commerce platform allows customers to browse and select products based on quality parameters, facilitating secure transactions. Our project aims to streamline the transition to online shopping with secure payment systems.

Our project integrates soil quality detection into e-commerce platforms for farmers using sensor-based hardware controlled by an Arduino chip. It aims to empower farmers with valuable soil health information and features a machine learning-based Crop and Fertilizer Recommendation System using algorithms like Decision Tree, Naive Bayes, and SVM. This integration enables informed crop selection, cultivation practices, and resource allocation, optimizing fertilizer and pesticide use. Soil quality detection provides insights into soil type, nutrient content, temperature, and moisture, reducing input costs and environmental impact. Nitrogen, Phosphorus, and potassium are vital nutrient components.

Our website allows busy farmers to focus on farming instead of market trips. It's designed for all farmers, even those not tech-savvy. Our goal is to make soil quality

tools easy to use, letting farmers upload samples, get recommendations, and buy fertilizers and pesticides online without tech hassle.

1.1.1 Technical Terminology

- Precision Agriculture: A farming method that uses GPS, satellites, and other technology to monitor and manage crop growth.
- Smart Irrigation Systems: Automated systems that use sensors to measure soil moisture and adjust watering accordingly.
- E-commerce: The buying and selling of goods and services online.
- Machine Learning: A subset of artificial intelligence that enables computers to learn from and make predictions or decisions based on data.
- Image Classification: The process of categorizing images into predefined classes based on their visual features.

1.1.2 Problem Statement

So after a considerable amount of research and discussion, our problem statement is:

"To develop a machine learning based ecommerce system for classifying crop quality and price prediction along with hardware based soil assessment system"

1.1.3 Goals

The goal of this project is to create a more efficient and transparent agricultural supply marketplace by integrating machine learning models and e-commerce websites with hardware for soil quality detection. This will enable farmers to better market their produce and consumers to make informed purchasing decisions, ultimately promoting a healthier, more transparent agricultural ecosystem.

1.1.4 Solution

Our project will have the following phases to solve the above said problem statement:

- We will gather plenty of information about soil health, crop quality and market trends and gather accurate and representative datasets.

- We will create powerful algorithms that can recommend crop and fertilizers based on soil condition parameters, assess crop quality from images through image processing.
- We will integrate all these features into a fully functional e-commerce website named Farm Fusion.
- Before launch, we will test the algorithms and platform to ensure accuracy, reliability, and a seamless user experience.

Our e-commerce platforms will become more than just transactional spaces, where nature meets innovation, where fields and screens collaborate, and where growth, sustainability, and convenience are there.

As we conclude this exciting project overview, we stand at the threshold of transforming agriculture through innovation. By integrating e-commerce platforms, soil quality detection, crop quality assessment for farmers and customers both, and ML-driven crop and fertilizer recommendations, we have embarked on a journey to revolutionize the agricultural industry.

1.2 Need Analysis

To bridge the gap between farmers and consumers, increase transparency and efficiency in the supply chain, and benefit the agriculture industry as a whole, we aim to provide a solution that is acceptable to all. We need such a platform because of the following reasons:

- The Farmers' Produce Trade and Commerce Act, of 2020 aimed to give farmers more options for marketplaces and give them more negotiating leverage, enabling them to sell products to anyone even without a license. This would enable them greater flexibility and freedom, but it concerned the farmers as they might get into a poor arrangement with a person causing them to sell harvest at a price less than the market price.
- Farmers would benefit as they can now get a wider market wherein they can sell their product across cities or even countries, thus reducing the need for a middlemen and increasing their profit. The farmers and the customers could have a direct communication which leads to better pricing.

- The industry's adoption of quality measuring tools has also encouraged an estimation based mindset. This, together with machine learning estimations, might make an ecommerce platform more effective than traditional selling techniques.
- Machine learning-based algorithms could increase crop productivity and quality, decrease waste, improve food safety, and help people make better decisions since they would enable farmers to monitor crop issues and receive better feedback.
- Crop quality detection enables customers to get a top-notch product and pay a better and fairer price for the product they are buying.
- Soil quality detection combined with recommendations on fertilizers and crops to be grown on a particular type of soil provides farmers with better decision-making, reduce resource wastage, better cultivation practices and increased productivity.
- Instead of wasting time going to physical market, farmers can buy fertilizers and sell the crops online and can now spend more time doing actual farm work.
- Furthermore, the web application could also offer real-time market data and trends, allowing farmers to make informed decisions regarding their crops and sales. This would enable them to adjust their production based on demand, thereby minimizing waste and maximizing profit.

1.3 Research Gaps

In the pursuit of creating an innovative agriculture-focused e-commerce platform empowered by machine learning, several research gaps have been identified that merit attention for future advancements. These gaps are highlighted based on an analysis of the project's objectives and existing accomplishments:

1. **Advanced Crop Quality Classification Algorithms:**
   While the project successfully employs machine learning algorithms for crop quality classification, there is potential to explore more advanced models than Convolutional Neural Networks (CNN). These models could further enhance accuracy by capturing intricate visual features of crops, potentially leading to more nuanced quality assessments.
2. **Enhanced Price Prediction Modeling:**
   Although the project has developed price prediction algorithms, incorporating time-series analysis and predictive modeling techniques like Long Short-Term Memory (LSTM) networks could yield more accurate and dynamic price forecasts. This

would enable the platform to provide insights into price trends over specific time periods.

3. **Multi-Crop Expansion and Optimization:**

   Currently focused on corn, the project can expand its reach by including a broader range of crops. This requires creating specialized models for each crop, accounting for their unique attributes. Additionally, devising strategies to efficiently handle multi-crop integration while maintaining high prediction accuracy presents an interesting research challenge.

4. **Incorporation of Satellite Imagery:**

   To augment crop quality assessments, integrating satellite imagery analysis can provide real-time insights into crop health, growth, and potential yield. This presents a promising avenue for enhancing the precision of quality predictions by considering external environmental factors.

5. **Personalized Fertilizer and Pesticide Recommendations:**

   While the project includes a fertilizer and pesticide recommender system, incorporating individualized data such as historical crop yield, past fertilizer usage, and soil health can create a more tailored recommendation system. This can be achieved through predictive modeling based on historical data.

6. **Integration of IoT and Sensor Data:**

   Expanding the hardware component to include more IoT devices and sensors can provide real-time data on various environmental parameters, including mineral and pest infestations. Developing algorithms to leverage this dynamic data for enhanced crop health assessments and prediction accuracy is a valuable research direction.

7. **User Behavior Analysis for Market Adaptation:**

   While the project enables farmers to connect directly with consumers, analyzing user behavior and preferences can provide insights into market trends. Exploring methods to capture and analyze user interactions can contribute to adapting the platform to changing consumer demands.

8. **Robustness and Security in Recommendations:**

   Ensuring the robustness and security of the recommendation system against malicious inputs or inaccurate data is crucial. Investigating techniques to enhance the system's resilience while maintaining its accuracy is a relevant research area.

9. **Localized Solutions for Regional Agriculture:**
   As agriculture practices vary globally, tailoring the platform's algorithms and recommendations to specific regional characteristics and constraints can enhance its applicability and impact.
10. **Long-Term Sustainability Monitoring:**
    Incorporating a monitoring mechanism that tracks the long-term sustainability of agricultural practices resulting from the platform's recommendations can contribute to assessing its ecological impact.

Addressing these research gaps has the potential to elevate the project's effectiveness, impact, and relevance in transforming the agriculture industry through technology-driven solutions.

1.4 Problem Definition and Scope

In our project focusing on e-commerce platforms with soil quality detection, crop quality detection, and crop and fertilizer recommendation systems in agriculture, we are addressing the challenge of bridging the gap between farmers and customers, enhancing agricultural productivity, and sustainability through technology. We aim to overcome the limitations that farmers face in understanding and improving soil health, ensuring crop quality and help customers get a fair pricing and better quality products.

The scope of our project is:

- **Soil Quality Detection:** We will develop a system that allows farmers to analyze the quality of their soil. This will involve assessing factors like nutrient levels, moisture and temperature. Farmers can submit soil samples, receive detailed reports, and gain insights into their soil's health.
- **Crop Quality Detection and Price prediction:** Our project will also incorporate the ability to assess the quality of crops and predict a fair price. Farmers and customers will be able to use the platform to evaluate the appearance, freshness, and overall quality of harvested produce, ensuring transparency and trust in the agricultural supply chain.
- **Recommendation System:** Machine learning algorithms will analyze the soil quality data. Using this information, the system will provide tailored recommendations for crop selection and fertilizers.

- **E-commerce Integration:** All these features will be seamlessly integrated into an ecommerce platform, wherein buying and selling of the products would take place.

1.5 Assumptions and Constraints

The assumptions for our project are:

- We expect farmers to actively engage with the website features. We expect them to use the recommendations for their farming practices.
- Customers will actively provide feedback so that other users can be guided by them while buying products.
- We assume that farmers and customers have access to the required technology, such as smartphones with internet connectivity and SIM to access the features.
- Continuous learning and feedback will lead to improved accuracy over time for both soil and crop quality detection, as well as for the recommendation systems.
- Our hardware equipment sensors are working in correct order.
- Farmer will upload clear sample images and accurate details about the crop and deliver the right product as it is that is shown in images.

The constraints for our project are:

- The crop recommendation system will not consider the parameters like weather conditions.
- The field must not have stagnant water for soil quality detection.
- The farmer has to calculate soil readings at different parts of the field.

1.6 Standards

The platform will be able to handle the increased user base of farmers and customers without compromising on performance.

- The datasets used will be accurate and up to date so that their predictions could be relied on.
- Ensuring data protection and confidentiality of customers and farmers data.
- Provide a way for farmers and customers to provide feedback on the accuracy and usefulness of the recommendations and predictions. This helps in continuous improvement.

- The platform will be straightforward to navigate and user friendly.
- Minimize disruptions and maximize availability of use.

1.7 Approved Objectives

The potential objectives behind the project are:

- To study the available techniques and approaches of machine learning in crop quality classification.
- To find a relevant dataset (images) for training the model.
- Elevate the e-commerce platform's value proposition by incorporating more innovations that cater to both farmers and customers.
- Promote sustainable farming practices by offering soil insights and ML-based recommendations for efficient resource usage.
- To develop an optimal technique for crop quality classification to ensure customers receiving high-quality produce and paying fairer prices.
- To develop a hardware based soil quality measurement device.

1.8 Methodology

The methodology would manifest the flow of the processes behind the work of the project.

Part-1

1. Initially the farmer will login into the portal and put up a soil inspection request with location and preferred time slot. The administrators upon receiving the request will respond to it in the form of acceptance or neglectance which will be shown to farmer on web page.
2. The hardware will measure the levels of nitrogen, phosphorus, potassium, moisture and temperature of soil with the help of Arduino Mega 2560 and sensors and average accuracy will be generated. This information will be received by farmer through SMS.
3. The farmer will again login into the portal and enter the soil quality details as measured. The ML based crop recommender will recommend the suitable crop. Then the farmer again enters the soil details with suggested crop.

4. ML models Decision tree, Naive Bayes, SVM, Logistic regression, RF and XGBoost work on the data and the result is predicted with the higher accuracy model.
5. The following stage is Deployment: The predictions generated in the previous steps are then deployed on the webpage to the farmer.

Part-2

1. Initially the farmer would login to the portal and create a selling inventory post. The process would include registering a crop with various meritorious features like seed size, shape, color, type, weight etc.
2. The next step would include capturing and uploading the seeds images (image acquisition). The images should be of high quality with proper resolution and lighting conditions.
3. This would be followed by pre-processing the images to enhance their quality and eliminate any noise present in them. This step includes operations like image filtering, edge detection, and image normalization.
4. Image Segmentation: The processed image is then segmented to identify the regions of interest. In this step, the regions of interest like the seed area are separated from the background.
5. Feature Extraction: The features of the segmented seed image are then extracted. Features can be described as the characteristics of an object that distinguish it from other objects. In seed quality detection, features like size, shape, color, and texture are extracted from the seed image.
6. Feature Selection: Once the features are extracted, the most relevant features are selected for classification. The selection of features depends on the type of classification algorithm used.
7. Classification: In this step, the selected features are fed into a classification algorithm to classify the seed as good or bad. Classification algorithms like Support Vector Machines, Decision Trees, Random Forest, and Neural Networks can be used for seed quality detection.
8. Quality Estimation: Once the seed is classified, the quality of the seed is estimated based on the classification result. If the seed is classified as good, it is considered of good quality, and if it is classified as bad, it is considered of poor quality.

9. Price Prediction: After the quality of the crop is predicted, it is fed into another predicting algorithm to generate a decent price for the crop – depending on the results generated in the previous step. The price generated is in accordance with the current market prices in the local markets.
10. Deployment: The prices generated in the previous steps are then deployed on the webpage for the item being sold and the entirety is closed.

Part –3

1. If the user is a Customer, he would go through the following path:
2. Select a product he desires on the basis of price, quality, and availability.
3. Adds them to Cart for making a purchase.
4. Makes a purchase and does the payment.

Dataset:

Datasets with the various crop features would be merged with the results from image processing to generate a final dataset for price prediction. The image classification algorithms would generate quality categories using one hot encoding. The final outputs of predicted prices would be based on this dataset using regression.

Pre-Processing:

This stage would enable to remove anomalies, outliers and noise from the dataset generated in the preceding stage. If the seller doesn't input the feature data at the time of registration, the prediction could generate poor results. Data smoothing techniques like Z-Score and Interquartile Ranges would be used to remove the anomalies.

Proposed Algorithms:

With the availability of datasets associated with crop diseases and quality categorization, the project would be using algorithms for quality classification using image processing algorithms like – Convolutional Neural Networks, Support Vector Machines, Random Forests and KNN, while the price prediction would be based on – Linear Regression, Decision Trees, Random Forest or Neural Networks; depending on the accuracy generated at the time of implementation.

The algorithms used for Crop and fertilizer prediction are Decision tree, Naive Bayes, SVM, Logistic regression, RF and XGBoost.

1.9 Project Outcomes and Deliverables

The project outcomes that we expect are:

1. **Market Outlet Diversification:** The e-commerce platform will stand out as an industry leader, the current farming supply market would be supplemented with an online market place that would have genuine crop prices as compared to local markets.
2. **Soil quality prediction:** Farmers will be equipped with a powerful tool to assess their soil's health which leads to enhanced agricultural productivity and reduced resource wastage through precision farming.
3. **Quality Prediction:** The crop qualities would be predicted using machine learning algorithms that can accurately define the standard of the crops.
4. **Price Prediction:** The price of the crop would be anticipated upon the quality of the crop predicted by the previous algorithms. The price prediction would also consider the local market prices to predict the new outcomes.
5. **Customer and Farmer Convenience:** Customer who cannot visit local market for purchase would now have a reliable market place to buy crops as well as farmers can save their time by buying fertilizers and pesticides online.

Deliverables:

- A hardware kit for soil quality prediction
- Crop quality and price prediction feature
- Crop and fertilizer recommendation system
- Integrated Ecommerce Platform

1.10 Novelty of work

The uniqueness and innovation of our project lie in the way we are revolutionizing how farming and online shopping intersect

- **Complete Farming Ecosystem:** Unlike traditional e-commerce platforms, our project offers a comprehensive ecosystem for farmers. It goes beyond just selling

products; it empowers farmers with tools to analyze their soil health, predict crop quality, and make data-driven decisions for better yields.

- **Predictive Price Insights:** Our project introduces a pioneering concept of using crop quality detection to predict prices. By combining data on crop quality with market trends, we empower farmers with insights into potential pricing, helping them plan and strategize effectively.
- **Advanced AI Recommendations:** Our ML-based recommendation systems are a game-changer. They deeply analyze individual soil conditions and historical data to provide personalized recommendations that maximize productivity and minimize waste.
- **User-Friendly Interface:** We ensure that the innovative technology is accessible to all. Our easy-to-use platform ensures that even farmers with limited technical knowledge can benefit from soil and crop quality analysis, making it inclusive and user-friendly.
- **Transparent Customer Experience:** For customers, our platform offers unprecedented transparency. They can make informed choices by accessing reliable information about the quality of the crops they're interested in purchasing.
- **Unique Market Position:** This project positions our e-commerce platform as a pioneer in bridging technology and agriculture. Its multifaceted approach addresses various aspects of farming, giving it a competitive edge and a unique market position.

2. REQUIREMENT ANALYSIS

2.1 Literature Survey

2.1.1 Theory Associated with Problem Area

The presented research papers revolve around the theme of integrating e-commerce and modern technology into the agricultural sector to address various challenges and enhance efficiency. These studies emphasize the potential benefits of leveraging advanced techniques, such as machine learning, computer vision, and wireless sensor networks, to transform agricultural practices. The overarching theory associated with this problem area asserts the following:

- Advancing Agriculture through Digital Transformation: Integrating e-commerce platforms, digital technologies, and data-driven approaches can significantly enhance various aspects of agriculture, from product sales and quality assessment to soil nutrient analysis and monitoring. This digital transformation streamlines processes, enhances decision-making, and increases transparency, ultimately contributing to sustainable agricultural practices and economic growth.
- Integration of Modern Technologies: The theory centers on the integration of modern technologies such as machine learning, computer vision, and wireless sensors. These tools enable accurate assessments of crop quality, soil nutrient levels, and moisture content, facilitating informed decision-making and optimized resource utilization in agriculture.
- Enhancing Quality Assurance and Transparency: A core aspect of the theory is ensuring product quality and authenticity through digital means. By leveraging technology, farmers and consumers can access detailed product information, fostering trust and confidence in the supply chain. This transparency extends to pricing, product details, and sourcing.
- Optimizing Agricultural Efficiency and Sustainability: The theory underscores how digital transformation enhances agricultural efficiency and sustainability through process optimization and data-driven insights. Addressing the challenge of inefficient and excessive fertilizer use is critical. Striking the right balance is imperative, as inadequate application limits yields, while excessive use harms the environment, soil health, and financial viability.

2.1.2 Existing System and Solution

1. **KisanMandi.com** is the First Free online Agri-Market where you can Buy or Sell or Advertise fruits & vegetables, Agri produces or any Agri machinery or Tools or Tractors, etc & it aims to fulfil the dream "Sabko Sahi Mol".
   KisanMandi Online Agri market Private Limited (KisanMandi.com) is a startup in India who started Free Agri Market Place in India and KisanMandi.com is providing assistance to farmers with the help of Gram Sahayaks from grading, packing, logistic support to sell their agriculture produce directly to end customers, and farmers will get the better price of agriculture produce as compared to the current APMC mandi price.
2. **Agrimp.com:** Agri Marketplace is a digital B2B market solution that brings together Farmers and Industrial Buyers. They drive agricultural transactions through our digital platform in combination with our service partnership network. Agri Marketplace accommodates online payments between buyer and seller, product quality check options, and end-to-end logistic services. Agri Marketplace does not buy or sell crops and is not a broker. Instead, they offer customers the ability to effortlessly market your crop via our platform.
3. **AgriBros:** AgriBros Market is a digital platform specialized in the promotion and marketing of agricultural products, connecting farms to markets and promoting local products internationally. Web, mobile and SMS platform (USSD) connecting local farmers and producers to potential buyers and end consumers on a digital market and allowing crowdfunding of projects in the agricultural and agri-food sector.
4. **AGRINEX** Soil Doctor Plus (HC 106 NPK pH) is an integrated kit to access primary nutrients (N-P-K) as well as pH levels of soil. Test your soil to determine the exact fertility status of N-P-K & pH to apply fertilizer/ nutrients in the crop effectively and economically. It is an available solutions for measuring soil parameters.

2.1.3 Research Finding for Existing Literature

A quality amount of research has been done in the Agro-Tech field. A few of the relevant works done by some people have been discussed below:

Chen et al. [1] presented their research on the rapid development of agricultural product sales via e-commerce in China in their paper. Their conclusion was that the evaluation of agricultural product suppliers or vendors has become crucial for customers. The paper proposed an evaluation model that uses a case-based distance approach to vendor evaluation by employing the ranking decision in MCDA. The proposed method utilizes the available prior evaluation information as a case set to produce a case-based distance method to handle a multiple-criteria ranking decision more efficiently and effectively. The model is flexible to construct and could simplify and improve the current model of vendor evaluation for agricultural products.

Huang et al. [2] described that E-commerce has experienced significant growth in almost all fields over the past two decades, driven by computer and internet technology. Ecommerce has significantly changed the rules of business, and numerous research institutions and enterprises have made it more intelligent and convenient. The authors propose a novel prototype of a next-generation e-commerce platform with an architecture framework and theoretical models. Each subject, including individuals, enterprises, and administrative departments, has a personalized portal to synchronize subject information, release supplies, satisfy demands, and make social contacts. Using the personalized portal, consumers and suppliers can complete intelligent matching transactions without intermediaries, instead of the traditional trading platform.

Patel et al. [3] have described that agriculture plays a crucial role in the development of a country's economy and provides numerous opportunities to innovate and apply innovations. However, trading in agriculture from farmers to consumers goes through a lengthy process where farmers negotiate the yield's price with a middleman. The middleman charges a set fee of brokerage on yield from farms based on quality, which consumes significant time and deteriorates quality, while the farmer gets no return on investment. To overcome these issues, an e-commerce solution can be found, which is transparent enough to ensure that the farmer gets a return on investment with profits and is used without a middleman (broker) to sell the yield. Currently, there is no proper solution that exists for transparent trading between farms and consumers. This paper highlights the importance of e-commerce in agriculture with minimal or no brokerage and emphasizes that it can also help farmers invest in ways that increase the yield.

In their paper, Ali et al. [4] concluded that seed purity is an important indicator of crop seed quality. Moreover, corn is a crucial crop in modern agriculture, accounting for over 40% of worldwide grain production. The objective of this study was to investigate the feasibility of a machine learning (ML) approach for classifying different types of corn seeds. The digital images (DI) of six corn varieties, namely Desi Makkai, Sygenta ST- 6142, Kashmiri Makkai, Pioneer P-1429, Neelam Makkai, and ICI 339, were captured using a digital camera in a natural environment without the need for a complicated laboratory system. The acquired DI dataset was converted into a hybrid feature dataset, which combined histogram, texture, and spectral features. For each corn seed image, a total of fifty-five hybrid features were acquired on every non-overlapping region of interest. Nine optimized features were obtained using the correlation-based feature selection technique with the Best First search algorithm. Random Forest (RF), BayesNet (BN), LogitBoost (LB), and Multilayer Perceptron (MLP) were used to build the classification models, employing optimized multi-features using a cross-validation approach.

Sobhana et al. [5] presented their research in a paper which concluded that the quality of seeds is crucial for farmers to obtain a good yield. Typically, farmers purchase high-quality seeds from companies, but there is a risk that they might replace good quality seeds with damaged ones while collecting them manually. Therefore, it is necessary to predict the seed quality to prevent this problem. The aim of this study is to provide a solution that eliminates the need for manual seed quality checks in commercial farming. To detect pure and damaged seeds without human intervention, computer vision and deep learning techniques are used. The proposed model uses OpenCV to detect each seed grain in the seed lot and a convolutional neural network to predict the quality of the detected seed grain. The model's output is a prediction of the seed lot's purity percentage. This paper suggests a solution that reduces the amount of manual labour and time required to filter out damaged seeds, thus increasing the efficiency of the farming process.

M. Pyingkodi et al. [6] proposed that soil fertility is an important factor in determining soil quality as it reflects how well the soil can support plant growth in agriculture. Soil sensor and Arduino can be used to quickly determine the nutrient content of the soil. Nitrogen, phosphorus, and potassium are all considered as important nutrient source components. These components should be measured in order to determine how much

extra nutrient content should be added to the soil in order to increase the crop fertility. Soil fertility can be detected by using NPK sensors. Soil nutrient concentration data can help us to determine whether the soil used to support plant production is nutrition deficient or abundant. The nutrient content of the soil samples can be obtained in various ways by using sensing element or mass spectrogram. However, the spectral analysis method is inconvenient, where the records are only 60-70% accurate. By comparing the spectrum analysis method with classic wet chemistry methods, the accuracy of the products needs to be fully resolved due to a scarcity of data. Hence, to detect soil nitrogen, phosphorous, and potassium, a soil NPK sensor should be used. Its advantage over a standard detection approach is that it provides extremely fast measurements with accurate data. This paper analyses and compares different nutrient levels in soil by using kernel density estimation algorithm and machine learning.

R. Madhumathi et al. [7] stated that Agriculture plays a vital role in the economic development of our country. Crop yield primarily depends on soil fertility and moisture level. Fertilizers are normally recommended based on the nutrient present in the soil. To recommend a suitable fertilizer level, the soil nutrient analysis is essential which is done mostly using laboratory techniques. Manual methods of measuring soil nutrients are time consuming. Many farmers refrain to perform soil testing in the laboratory and grow the same crop in the land continuously, hence soil loses its fertility. A system has been proposed to adopt precision agriculture using Wireless Sensor Networks, which enables remote monitoring of soil fertility and other parameters namely soil moisture, pH and temperature. This data is transmitted to the cloud and the corresponding values are displayed on a mobile application.

Pedro et al. in the paper [8] stated that the race for automation has reached farms and agricultural fields. Many of these facilities use the Internet of Things technologies to automate processes and increase productivity. Besides, Machine Learning and Deep Learning allow performing continuous decision making based on data analysis. In this work, we fill a gap in the literature and present a novel architecture based on IoT and Machine Learning / Deep Learning technologies for the continuous assessment of agricultural crop quality.

S. No.	Roll Number	Name	Paper Title	Tools/ Technology etc.	Citation (reference)
1	102003627	Sarthak	Seed Quality Prediction using Computer Vision and Convolutional Neural Networks	Open CV , CNN.	M. Sobhana [5]
2			Soil NPK and Moisture analysis using Wireless Sensor Networks	Hardware Identified: NPK , Moisture Sensors	R. Madhumati [7]
3	102016021	Mohd Al. Sumaim	Machine learning approach for the classification of corn seed using hybrid features	Algorithms: MLP, LB, RF & BN	Ali [4]
4			Architecture of next-generation e-commerce platform	N/A (Theoretical)	Y. Huang [2]
5	102016032	Armandeep	A case-based distance approach to agricultural product's vendor evaluation in e-commerce	AHP , CBDA	Y. Chen [1]
6			An Approach Towards E-Commerce for Agriculture with Modern Technologies	N/A (Theoretical)	[3]
7	102003646	Vishvam	IoT based Soil Nutrients Analysis and Monitoring System for Smart Agriculture	Hardware Identified: Temperature Sensor, NPK sesnor	Patel [6]
8	102003663	Meghna	FARMIT: Continuous assessment of crop quality using machine learning and deep learning techniques for IoT-based smart farming	DCT , CNN, SVM , DL	Gomez [8]

Table 1 –Literature Survey Findings

2.1.4 Problems Identified

From the above research papers, we have observed that there is high demand of ecommerce in agricultural field but it comes with its own challenges. We will try to overcome those challenges observed in our project as follows:

1. Good Prediction Accuracy: We will make a user-friendly website with a detailed description of the agricultural products and ensure the products are of good quality and provide multiple images of the products.
2. Partnership with farmers: We will ensure a partnership with farmers to ensure a constant supply of agricultural products. This will help in maintaining the quality of the products and builds trust with customers.
3. Competitive pricing: We will offer competitive pricing to attract customers and stay ahead of the competition. It is also essential to maintain transparency in pricing.
4. Responsive Application: We will ensure that the website is mobile-friendly as a significant percentage of user's access websites through mobile devices.
5. Localization: Understanding the local market and provide relevant products to customers is also necessary. It also involves providing the products using local currencies.
6. Accurate Measurements: The sensor measurements must be accurate and thus useful.
7. Other Small Challenges:
    a. Handheld hardware capabilities.
    b. Sending the results via SMS for saving them so that they can be used for predictions later on.
    c. Getting a good value to farmers for their crops.
    d. Advertising our solution properly for better adaptation of it.

2.1.5 Survey of Tools and Technologies Used

Researchers in Agro-Tech are integrating a range of advanced technologies to bring transformative changes to agriculture:

- Machine Learning & IoT Integration: Researchers are applying machine learning algorithms and IoT technologies to tasks like classifying seeds, predicting crop

quality, and continuously monitoring crop health. These tools enable data-driven decisions and ongoing assessment.

- E-commerce Platforms & Transparency: Novel online platforms tailored for agriculture are connecting farmers and consumers directly. These platforms streamline transactions, eliminating intermediaries and fostering transparency in trade.
- Computer Vision and Sensor Automation: By using computer vision and sensor-based systems, researchers are automating seed quality checks and soil nutrient analysis. This enhances efficiency by automating quality assessments.
- Advanced Data Analysis & Informed Choices: Researchers are using sophisticated data analysis methods to consolidate information from diverse sources. This data-centric approach empowers decision-makers with comprehensive insights, enabling well-informed agricultural choices.
- Precision Agriculture: Wireless sensor networks and technologies offer real-time data on soil conditions, including moisture, pH, and temperature. This enables farmers to make timely decisions for optimal resource allocation.
- Efficiency & Transparency in E-commerce: E-commerce solutions are redefining traditional agricultural trading. By directly connecting farmers and consumers, these platforms reduce costs, increase returns for farmers, and create a transparent trading environment.
- Supporting Sustainable Farming Decisions: Researchers are developing decision support systems that analyze aggregated data, offering actionable insights for sustainable crop management. These systems provide recommendations for water usage and nutrient supplementation.
- Next-Gen E-commerce Solutions: Advancements in e-commerce extend beyond basic transactions, encompassing user-focused portals and innovative architectures. These platforms streamline trading processes and modernize agricultural trade.

2.2 Software Requirement Specification

2.2.1 Introduction

2.2.1.1 Purpose of this Document

The purpose of this SRS document is to provide a detailed overview of our software product, its parameters, and its goals. This document describes the project's target audience, user interface, hardware, and software requirements. It defines how our client, team, and audience see the product and its functionality. The document has been formatted in such a way that the deliverables are divided into smaller components thereby, describing the functions, goals and tasks that the system can perform.

2.2.1.2 Intended Audience and Reading Suggestions

Intended Audience:

- Researchers, academics, and scholars in agriculture, technology, and innovation.
- Agricultural professionals, farmers, agronomists, and consultants.
- Tech enthusiasts curious about modern agricultural practices.
- Entrepreneurs and start-ups interested in Agro-Tech ventures.
- Policy makers and government officials in agriculture.
- Students studying agriculture, technology, and related fields.

Reading Suggestions:

- "The Third Plate" by Dan Barber: Explores the future of food production and its technological aspects.
- "The Vertical Farm" by Dickson Despommier: Discusses vertical farming and urban food production with technology.
- "Artificial Intelligence in Agriculture" by Adam Price: Overviews AI's role in crop and livestock management.
- "Sustainable Agriculture Reviews" (Journal): Covers various topics in sustainable agriculture.
- "Journal of Agricultural Science and Technology" (Journal): Explores recent research in agriculture and technology.

2.2.1.3 Project Scope

This project aims to modernize agriculture by using technology to enhance market access for farmers through an e-commerce platform. It integrates machine learning and sensor-based hardware to provide farmers with insights into soil quality and crop recommendations, enabling informed decisions. The project's core goals are to increase transparency, improve crop quality assessment, and empower farmers for better productivity and sustainability.

The project will encompass the development of an integrated e-commerce platform called "Farm Fusion" that connects farmers and consumers. It involves the creation of a user-friendly website with functionalities for farmers to upload soil samples, receive crop and fertilizer recommendations based on soil quality, and purchase agricultural products online. Machine learning algorithms will be employed to analyse crop images for quality assessment. The project will also incorporate sensor-based hardware using NPK, temperature, and moisture sensors to evaluate soil health. The platform's scope includes accurate price prediction for crops by combining quality measures with market trends. Testing, refinement, and continuous improvement of algorithms and user interface are essential aspects of the project. The project's scope focuses on enhancing market access, transparency, and productivity within the agricultural ecosystem.

2.2.2 Overall Description

2.2.2.1 Product Perspective

The project introduces an innovative e-commerce platform that revolutionizes agriculture by seamlessly merging technology and farming. This platform empowers farmers to reach a broader market, leveraging machine learning for crop quality assessment and sensor-based hardware for soil health evaluation. The system ensures fair pricing, optimal resource use, and sustainable practices. Its user-friendly design caters to all farmers, fostering a transparent and efficient agricultural ecosystem. Through continuous enhancements, "Farm Fusion" transforms agriculture into a data-driven, accessible, and productive industry.

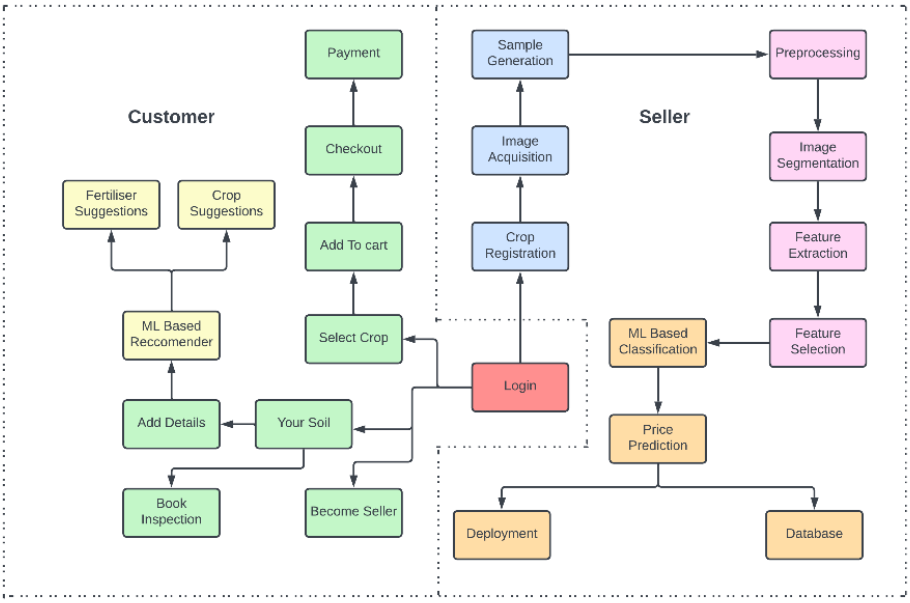


Figure 1 – Block Diagram

The block diagram portrays our web-based FarmFusion application, merging an e-commerce platform with predictive analytics. Customers input crop data, leading to quality and price predictions. The software operates across devices, with components like the web server, payment gateway, and machine learning enhancing the user experience

2.2.2.2 Product Features

Table 2 shows a template that is being used to describe functional requirements for three types of users: student, staff, student cum staff as one can easily deduce the functional requirements for other user types with this template.

Purpose	A description of the functional requirements and its reasons.
Inputs	What are the inputs; in what form will they arrive; from what sources can the inputs come; what are the legal domains of each input.
Processing	Describes the outcome rather than the implementation; includes any validity checks on the data, exact timing of operation (if needed).
Outputs	The form, shape, destination and volume of output; output timing; range of parameters in the output; unit of measure of the output;

Table 2: Template for describing functional requirements

1. Register

Purpose	To authenticate the users and register them with farm fusion.
Inputs	Users are required to register themselves by creating an account on the site giving their email and creating a password and providing other personal information.
Processing	A login info will be generated and an account will be created on the website and the credentials will be saved in the database.
Outputs	Along with the successful account creating , the user will be logged in with the newly registered credentials.

Table 3 – Feature: Register

2. Login

Purpose	The website will ask users to login before making a purchase and some other functions like adding something to a wishlist etc.
Inputs	User must enter his/her login credentials to authenticate himself/herself on the website.
Processing	The website will look up for the given credentials in the site's database and will find a match.
Outputs	User will be logged in in case of a successful authentication. In case of a unsuccessful login attempt , the user will be asked to enter credentials again.

Table 4 – Feature: Login

3. Edit cart

Purpose	A fully functional cart feature where users can modify the quantity of desired products.
Inputs	The customer will press the designated buttons like remove from cart or the quantity button to edit cart.
Processing	The website will accordingly increase or decrease the quantity of the products from the respective cart space.
Outputs	The cart is created with the desired quantity of each product which the customer wanted and now the customer can proceed making the purchase by selecting the proceed-to-checkout option.

Table 5 – Feature: Edit Cart

4. Add to cart

Purpose	A feature wherein users can add products that they want to purchase. The users can also select the desired quantity of the products.
Inputs	The customer will press the add to cart button on the desired product's page to add it into a virtual cart.
Processing	Website will create a virtual cart space and will add the selected products in it. The website will append new products if there are items already waiting in the cart.
Outputs	The cart is created and now the customer can edit the cart if he/she wants and the proceed making the purchase.

Table 6 – Feature: Add to Cart

5. Search

Purpose	A searching tool for customers to search for different crops.
Inputs	The user will enter the crop name or a part of the name in the search box given in the console.
Processing	The website will refine the products against the search query and will process the result that should be displayed.
Outputs	The website will display the searched products.

Table 7 – Feature: Search

6. Payment redirection

Purpose	A payment redirection when a customer wants to make payment for the product after selecting the payment mode.
Inputs	Customer proceeds to checkout after signing in and selecting the product.
Processing	Website redirects the payment info to selected mode using respective APIs in a safe environment.
Outputs	The payment can now be done safely and quickly.

Table 8 – Feature: Payment Redirection

7. Pending orders

Purpose	The farmers will be able to deal with their pending orders which they need to deliver to the respective customers.
Inputs	Farmers will go to their dashboard and confirm the customer's orders.
Processing	Website will add the order to confirmed list and process the information to be displayed.
Outputs	The customers will now be able to track their product until it is delivered.

Table 9 – Feature: Pending Orders

8. Register item

Purpose	This feature enables farmers to add new crops to the product catalogue.
Inputs	Farmers will go to add new crops and upload the details and sample image of the crop.
Processing	Website will save the details of the crop within the database and further processes the image and predicts the price of the crop.
Outputs	The crop gets added to the product catalogue with the predicted market price.

Table 10 – Feature: Register Item

9. Get crop suggestions

Purpose	This feature enables farmers to get crop suggestions that they should grow according to the quality of their soil.
Inputs	Farmers will go to their dashboard and add the soil quality index as accordingly measured.
Processing	Website will process the details provided by the farmer and produce suitable results.
Outputs	The website predicts the suitable crops as per soil conditions so that the farmer and produce and sell with maximum profit and minimum wastage.

Table 11 – Feature: Get Crop Suggestions

10. Buy fertilizers

Purpose	The farmers can buy better predicted fertilizers according to the soil quality provided.
Inputs	Farmers will go to their dashboard and add the soil quality parameters as accordingly measured.
Processing	Website will process the details provided by the farmer and produce suitable results..
Outputs	The website predicts the suitable fertilizers as per soil conditions and also provide the link to buy those from the website only.

Table 12 – Feature: Buy Fertilizers

11. Rate & Review

Purpose	To rate products and write reviews for them.
Inputs	Customer rates the product and writes review about it.
Processing	The website checks if the user is signed in or not and then it allows the user to write reviews about different products.
Outputs	The reviews and ratings are updated and are reflected on the respective product pages.

Table 13 – Feature: Rate & Review

12. Add to wishlist

Purpose	The customers can add the products to a wishlist to save them for later to decide upon whether to buy them or not.
Inputs	Customer opens the desired product page and click on add to wishlist button.
Processing	The website adds the information to the database.
Outputs	The customers now can see the selected product in the wishlist anytime.

Table 14 – Feature: Add to wishlist

13. Raise a complaint

Purpose	The feature provides the customers with the ability to raise an issue or complaint regarding the product or contact the seller.
Inputs	Customer opens the contact us/raise an issue button and sets up a message to send and fills in the required details.
Processing	The website generates a network contact with the required seller through e-mail.
Outputs	The desired message gets sent to the required seller.

Table 15 – Feature: Raise a complaint

14. Order status

Purpose	The feature provides the customers with the details of their placed orders. They can track it, cancel it, etc.
Inputs	Customer opens the My Order button and select the desired crop for which he wants to see the order status.
Processing	The website extracts the status, expected delivery date from the database
Outputs	The customer can now track his order and know the expected delivery date of his product and opt for cancellation also if he/she wants.

Table 16 – Feature: Order Status

15. Become a seller

Purpose	Authentication of sellers and registering them with farmfusion.
Inputs	sellers are required to register themselves by providing their personal details and verify the authority.
Processing	A request info will be generated by the website to become a seller to the admin and the corresponding verification will be done by the admin before giving the seller rights to the user.
Outputs	After successful authorization and verification, the farmer gets a seller id and seller facility and controls over the website

Table 17 – Feature: Become a seller

16. Seller Inventory

Purpose	A product catalogue that will be maintained by admin so that the product availability can be regularly updated.
Inputs	Admin can add / remove / edit the products that are to be listed on site.
Processing	The website processes the changes done by the admins and updates it into the database.
Outputs	The changes reflect and the catalogue on the website gets updated.

Table 18 – Feature: Seller Inventory

17. Request soil inspection

Purpose	The feature of soil quality testing is provided wherein our members will themselves visit the spot to measure the soil quality.
Inputs	Customers will click the get soil checked button and enters the location and preferred time slot.
Processing	The website process the details and make them available at the staff's page.
Outputs	According to the final time slot decided by the staff, the user gets notified with the details of location and time and soil quality is checked accordingly.

Table 19 – Feature: Request Soil Inspection

2.2.3 External Interface Requirements

2.2.3.1 User Interfaces

Two interfaces required. One for seller and one for customers. The two consoles will provide separate controls to the two different types of users as follows:

Customer controls-

- Browse available sellers and their products and services
- Place order for the available items (within delivery service hours)
- Add descriptive reviews for the products and store
- Access purchase history
- Maintain a shopping cart

Seller/admin controls-

- Maintain an inventory of the products and services offered by the store
- Accept or deny the order requests received
- Make changes in the price of their products and services
- Change the order delivery service hours

2.2.3.1 Hardware Requirements

Hardware required for soil nutrient measurement system:

- Arduino 2560
- NPK sensor
- RS485 Modbus Module
- SIM 800A
- OLED O.96" Display
- Soil Moisture Sensor
- DS18B20 Temperature Sensor
- LM2596 DC Buck
- Wires & Resistors
- PCBs

2.2.3.3 Software Interfaces

- The application requires the following software interfaces:
- Flask
- ML Models (Decision Tree, Naive Bayes Classifier, Random Forest, XGBoost)
- HTML
- CSS
- JAVASCRIPT
- MERN
- CNN
- PYTORCH

2.2.4 Other Non-functional Requirements

2.2.4.1 Performance Requirements

The system should be available 365/24/7 days and the performance should not be degraded with the increase in the number of users.

- **Consistent uptime**

  This system will be able to stay up and running at least 98% of the time. Any downtime would be due to maintenance or upgrades. This downtime also includes any potential failures/crashes.
- **Load and Concurrency**

  The system must be able to serve at least two thousand users concurrently without crashing.
- **Familiar Interface**

  The new system will have an interface that shares some of the feel of the general system so that users who are familiar with the other such ecommerce system will not have trouble adjusting to our new system.

2.2.4.2 Safety Requirements

The database may get crushed at any certain time due to virus or operating system failure. There for it is required to take the database backup so that the database is not lost. Proper UPS/ Inverter facility should be there in case of power supply failure

2.2.4.3 Security Requirements:

- The security of each user is provided with a login id and password.
- System will use secured database.
- Normal users can just read information but they cannot give reviews and change anything.
- System will have different types of users and every user has access/control constraints.

2.3 Cost Analysis

The following cost analysis outlines the financial considerations associated with the implementation of an innovative agriculture focused ecommerce platform powered by technology integration. This breakdown encompasses various hardware components and essentials required to establish a robust system that facilitates efficient communication, data collection, and user interaction.

1. **Arduino 2560 (Micro Controller):**

The Arduino 2560 serves as the project's central microcontroller for data processing between different hardware components. Its versatility and computational power are essential for managing sensor data and user interactions.

2. **NPK Sensor:**

The NPK sensor plays a pivotal role in assessing soil health by measuring nitrogen, phosphorus, and potassium levels. Its integration enables accurate recommendations for fertilizers, fostering optimal crop growth and resource utilization.

3. **RS485 Modbus Module:**

The RS485 Modbus module facilitates seamless communication between sensors and the microcontroller, enabling efficient data exchange and synchronization.

4. **SIM 800A (GSM Module):**

The SIM 800A GSM module enables the platform to send essential notifications and data updates to users' mobile devices. This module ensures realtime communication and user engagement.

5. **OLED 0.96" Display:**

The OLED display enhances user interaction by providing realtime insights and information. It acts as a visual interface, offering users an intuitive way to engage with the platform's features.

6. **Soil Moisture Sensor:**

The soil moisture sensor detects soil moisture levels, a critical factor in efficient irrigation management. Its integration aids in optimizing water usage and preventing overwatering.

7. DS18B20 Temperature Sensor:

The DS18B20 temperature sensor captures environmental temperature data, contributing to accurate crop growth assessments and enabling informed decision making.

8. LM2596 DC Buck:

The DC Buck converter regulates power supply, ensuring stable voltage levels for various hardware components. It enhances the longevity and reliability of the system.

9. Wires & Resistors:

Wires and resistors are essential for the proper connection and operation of hardware components. They facilitate smooth data transmission and electrical continuity.

10. PCBs (Printed Circuit Boards):

Printed Circuit Boards provide a structured layout for connecting various components effectively. They enhance the project's organization and stability.

11. Power Adaptor & Cables:

Power adaptors and cables ensure consistent power supply to the hardware components.

S. No.	Item	Price(INR)
1.	Arduino 2560	1800
2.	NPK sensor	7000
3.	RS485 Modbus Module	100
4.	SIM 800A	700
5.	OLED O.96" Display	250
6.	Soil Moisture Sensor	150
7.	DS18B20 Temperature Sensor	150
8.	LM2596 DC Buck	150
9.	Wires & Resistors	100
10.	PCBs	100
11.	Power Adaptor & Cables	300
	Total	**11300**

Table 20 – Hardware Costs

The cumulative cost covers the acquisition of all hardware components necessary for building the project tailored to the agriculture industry's unique needs.

2.4 Risk Analysis

As the project advances towards its goals of revolutionizing the agriculture industry through technology integration, it's essential to identify potential risks that could impact its successful execution. By recognizing these risks, the project team can proactively develop mitigation strategies and contingency plans to ensure smooth progress and minimize adverse outcomes.

1. Technical Challenges:

Risk: Hardware Integration Complexities

Mitigation: Engage experienced hardware engineers to handle the integration of NPK sensors, temperature and moisture sensors, Arduino micro-controller, SIM GSM module, and OLED. Extensive testing and prototyping can help identify and resolve compatibility issues early in the development phase.

2. Data Security and Privacy:

Risk: Unauthorized Data Access

Mitigation: Implement robust data encryption and access controls to safeguard user data. Comply with data protection regulations, and conduct regular security audits to identify vulnerabilities.

3. Sensor Reliability:

Risk: Sensor Malfunction

Mitigation: Conduct thorough testing of sensors to ensure accuracy and reliability. Implement redundancy mechanisms, where possible, to ensure that sensor failures do not compromise critical data collection.

4. User Adoption and Usability:

Risk: User Resistance to Technology

Mitigation: Prioritize user-centered design and conduct usability testing to ensure that the platform is intuitive and user-friendly. Provide training and support resources to help users effectively utilize the technology.

5. Communication and Network Issues:

Risk: GSM Module Communication Failures

Mitigation: Evaluate network coverage and potential signal disruptions. Implement mechanisms to resend messages in case of communication failures, and provide alternative communication channels if needed.

6. System Scalability:

Risk: Inadequate System Scalability

Mitigation: Design the system with scalability in mind, considering increased user adoption and data volume. Implement cloud-based solutions and efficient database management to handle increased load.

7. Regulatory Compliance:

Risk: Non-Compliance with Regulations

Mitigation: Stay updated with relevant regulations for hardware components, data handling, and communication. Work with legal advisors to ensure the project aligns with regional and industry-specific requirements.

8. Hardware Maintenance:

Risk: Component Failure Over Time

Mitigation: Design the hardware with easily replaceable components. Provide users with guidelines for regular maintenance and troubleshooting, as well as avenues for technical support.

9. Cost Overruns:

Risk: Budget Exceeds Projection

Mitigation: Thoroughly estimate costs during project planning. Regularly monitor expenditures and adjust the budget as needed. Consider alternative sourcing options for cost-effective components.

3. METHODOLOGY ADOPTED

3.1 Investigation Techniques:

1. **Requirement Elicitation and Analysis:**
    - Interviews were conducted with farmers, consumers, traders, and agricultural experts in India.
    - Small-scale farmers face difficulty reaching local markets due to transportation constraints.
    - Consumers prefer purchasing crops directly from farmers.
    - Workshops highlighted the need for a platform connecting farmers and consumers.
    - Surveys revealed that farmers seek better market access, and consumers prioritize quality and transparency.
2. **Market Research and Feasibility Analysis:**
    - Extensive research conducted on India's agriculture sector.
    - Agriculture contributes to a significant portion of the country's GDP and workforce.
    - E-commerce adoption has grown, with an increase in online grocery sales.
    - Machine learning integration supported by the use of AI in crop monitoring and precision agriculture.
3. **Risk Analysis and Mitigation:**
    - Historical data analysis revealed pricing exploitation by middlemen and concerns about data privacy.
    - Risk mitigation strategies include transparent pricing models and robust data encryption protocols.
4. **Domain Modeling and System Design:**
    - UML diagrams created to illustrate the flow of crops from farmer to consumer.
    - Data models capture key parameters related to crop quality, soil conditions, and climate data.
5. **Technology Selection:**
    - Machine learning algorithms such as Convolutional Neural Networks (CNN) identified for image classification.

- E-commerce platforms like Magento and WooCommerce evaluated for scalability and suitability for the Indian market.

6. **Data Collection and Analysis:**
   - Dataset of crop images from various regions of India compiled.
   - Data analysis revealed factors influencing crop quality, such as soil pH, rainfall, and temperature.
7. **User Experience and Interface Design:**
   - User persona analysis showed limited digital literacy among farmers, emphasizing the need for a user-friendly interface.
   - Wireframes and mockups of the platform designed with step-by-step guides and intuitive navigation.
8. **Testing and Quality Assurance:**
   - Test scenarios designed to assess the accuracy of quality predictions, with evaluation of test images.
   - Integration tests conducted to verify the connection between the e-commerce platform and machine learning modules.
9. **Regulatory and Legal Compliance:**
   - Examination of the Farmers' Produce Trade and Commerce Act, 2020 highlighted the importance of transparent pricing and fair trade practices.
   - Collaboration with legal experts to create comprehensive terms of use and privacy policies.
10. **Training and Support:**
    - Training modules designed for farmers with varying levels of digital literacy.
    - User guides and tutorials tailored to address common challenges faced by Indian farmers.
11. **Continuous Feedback and Iteration:**
    - Feedback loops established with farmers and consumers during development.
    - Plans for iterative releases to incorporate user feedback and enhancements.

3.2 Proposed Solution:

The proposed solution aims to address the challenges faced by Indian farmers, consumers, and traders in the agriculture industry. Leveraging the power of machine learning, e commerce, and agricultural expertise, this platform seeks to revolutionize the supply chain, bridge the gap between farmers and consumers, and ensure fair and efficient trade practices. By providing a seamless and transparent ecosystem, the platform will empower farmers, promote quality assurance, and enhance the overall agricultural market experience.

Platform Features and Functionalities:

1. **Smart Crop Quality Detection System:**
    - Utilizes machine learning algorithms for image classification.
    - Analyzes key crop parameters such as seed size, shape, weight, color, soil conditions, and climate.
    - Provides comprehensive quality analysis for each crop to help farmers market their produce effectively.
2. **Ecommerce Product Catalogue:**
    - Features a user friendly interface for farmers to list their crops.
    - Allows consumers to browse a wide range of crops based on preferred quality parameters.
    - Provides real time pricing information and market trends to help farmers set competitive prices.
3. **Verified Seller and Buyer Profiles:**
    - Ensures transparency by verifying the authenticity of seller and buyer profiles.
    - Builds trust between farmers and consumers, mitigating concerns about product quality and authenticity.
4. **Real time Pricing and Payment:**
    - Provides up to date pricing information based on crop quality and market trends.
    - Enables secure and seamless payment transactions, ensuring timely payments to farmers.
5. **Quality Checks and Certifications:**
    - Implements quality assurance mechanisms to validate crop quality claims.

- Offers certifications for crops meeting specific quality standards, further enhancing consumer trust.

6. **User Support and Resources:**
    - Offers training modules and user guides for farmers, traders, and consumers to navigate the platform.
    - Provides resources to help users understand regulatory changes, agricultural best practices, and pricing strategies.
7. **Market Data and Trends:**
    - Offers real time market data and trends, enabling farmers to make informed decisions about crop production and sales.
    - Minimizes waste and maximizes profit by allowing farmers to adjust production based on demand.
8. **Soil Testing Equipment Integration:**
    - Provides an integrated module for soil testing equipment, enabling farmers to determine soil nutrient content.
    - Recommends appropriate fertilizers and treatments for optimal crop growth based on machine learning insights.

Advantages of the Proposed Solution:

1. **Direct Farmer Consumer Interaction:**
    - Empowers farmers to directly connect with consumers, eliminating the need for intermediaries.
    - Reduces the risk of unfair pricing and exploitation by middlemen.
2. **Quality Assurance and Transparency:**
    - Ensures transparency by providing comprehensive quality analysis of crops.
    - Enhances consumer trust by offering verified profiles and certifications.
3. **Efficient Market Access:**
    - Provides small scale farmers with a global customer base, overcoming transportation constraints.
    - Enables farmers to sell their produce at competitive prices, improving profitability.
4. **Data Driven Decision Making:**
    - Equips farmers with real time market data and trends to make informed decisions.

- Minimizes wastage and maximizes profit by aligning production with consumer demand.

3.3 Work Breakdown Structure:

The following is the Work Breakdown Structure of our project:

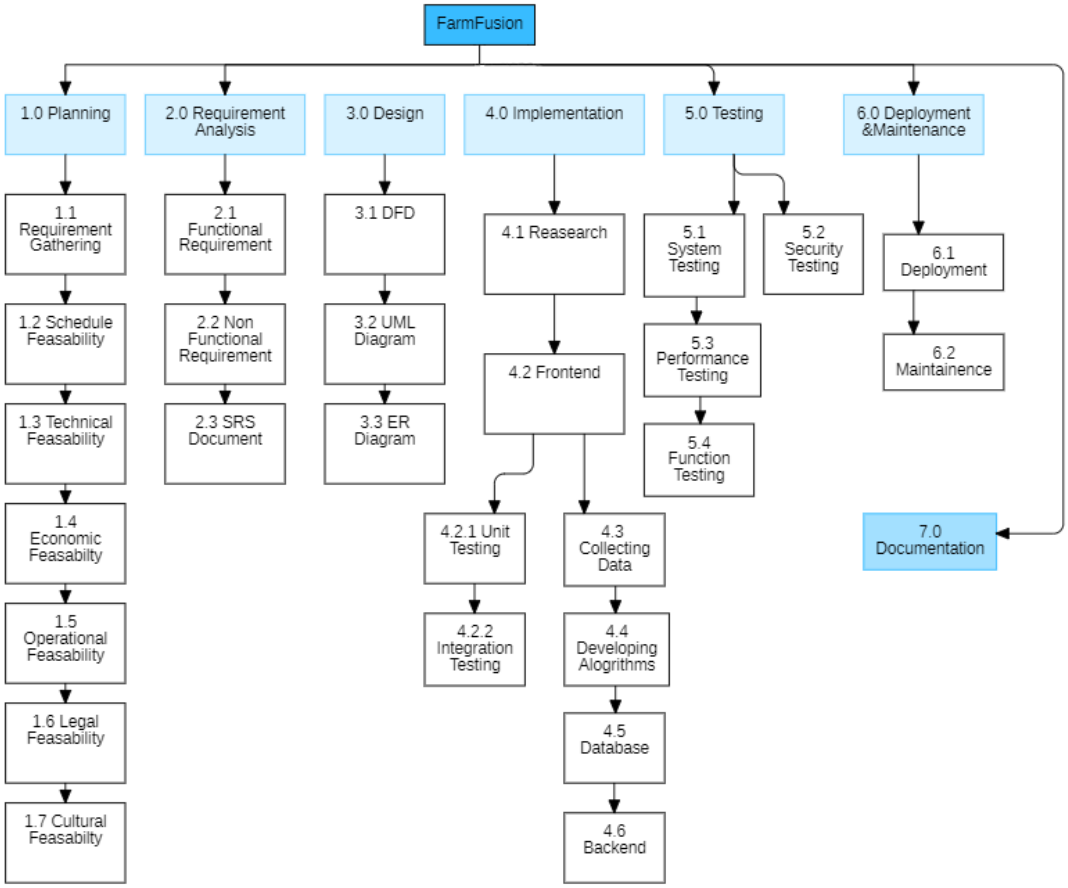


Figure 2 – Work Breakdown Structure

3.4 Tools and Technologies:

1. **Programming Languages:**
   - Python: For developing machine learning algorithms and backend logic.
   - JavaScript: For frontend development and interactive user interfaces.
   - HTML and CSS: For structuring web pages and styling the user interface.
2. **Web Development Frameworks:**
   - Django or Flask (Python): For building the backend application and handling data processing.
   - React or Angular (JavaScript): For creating dynamic and responsive user interfaces.

3. **Machine Learning Libraries:**
    - TensorFlow or PyTorch: For developing and training machine learning models for crop quality prediction and image classification.
4. **Database Management:**
    - PostgreSQL or MySQL: For storing user profiles, crop data, transaction records, and other relevant information.
5. **Version Control:**
    - Git and GitHub/GitLab: For collaborative development and version control of the project codebase.
6. **Data Visualization:**
    - Matplotlib or Seaborn (Python): For creating visualizations and graphs to display market trends and crop quality insights.
7. **Web Hosting and Deployment:**
    - Heroku, AWS, or DigitalOcean: For hosting the web application and deploying the backend and frontend components.
8. **Security and Encryption:**
    - SSL certificates: To ensure secure communication between users and the platform.
    - OAuth or JWT: For user authentication and authorization.
9. **Design Tools:**
    - Design and modelling tools like Star UML, Project Libre, Figma and Canava be used for creating optimized designs.
10. **Development Environment:**
    - VS Code, Jupyter NB, PyCharm, Google Collab, SQL, Browser, Atom etc.

4. DESIGN SPECIFICATIONS

4.1 System Architecture

4.1.1 MVC Architecture

Our project employs the following MVC architecture, dividing functionality into Model (XGBoost-based predictions), View (Python web app for visualization), and Controller (orchestrating data flow). This structure enhances modularity, enabling efficient data processing, visualization, and user interaction within the FarmFusion system.

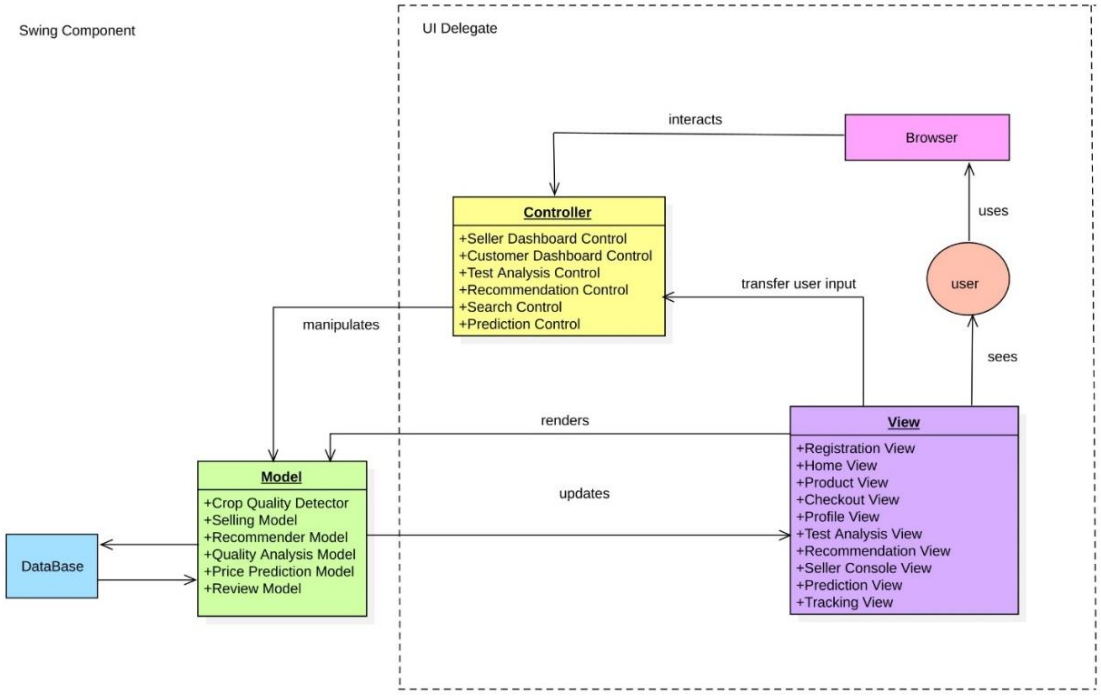


Figure 3 - MVC Architecture

4.1.2 Data Flow Diagrams:

DFD Level 0 (Context Level)

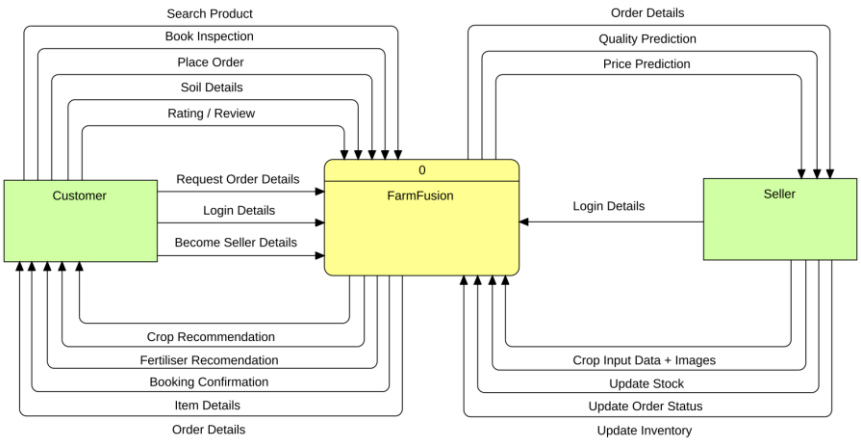


Figure – 4 Level 0 DFD

It shows that the "FarmFusion" process connects "Customer" and "Seller".

DFD Level 1

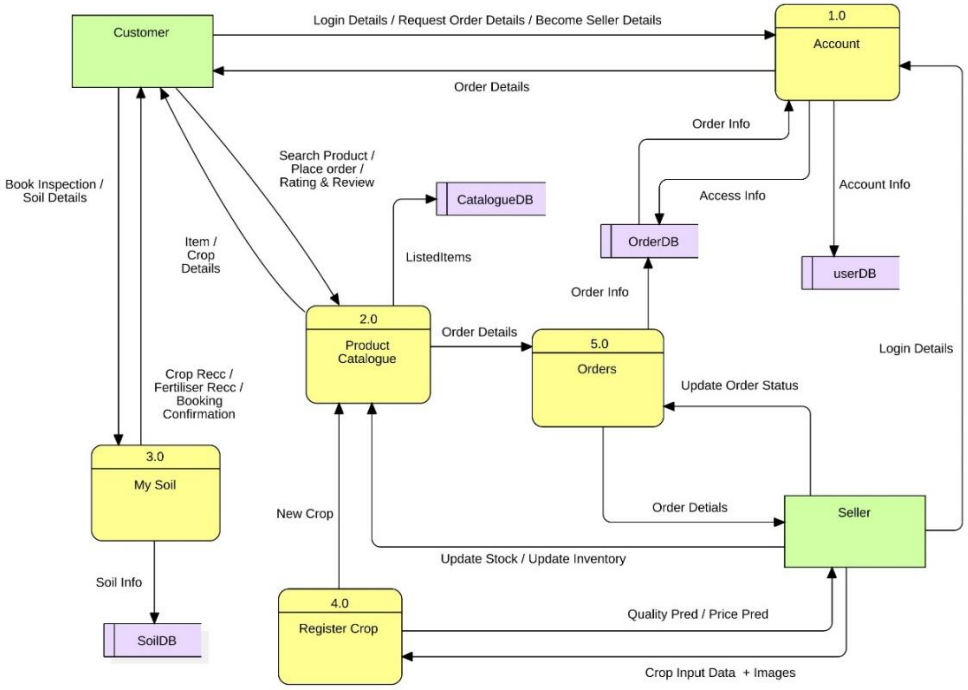


Figure 5 - Level 1 DFD

Core processes detailed - "Account Management," "Product Catalogue," "My Soil," "Crop Registration," "Order Processing." Roles and data flows clarified.

DFD Level 2:

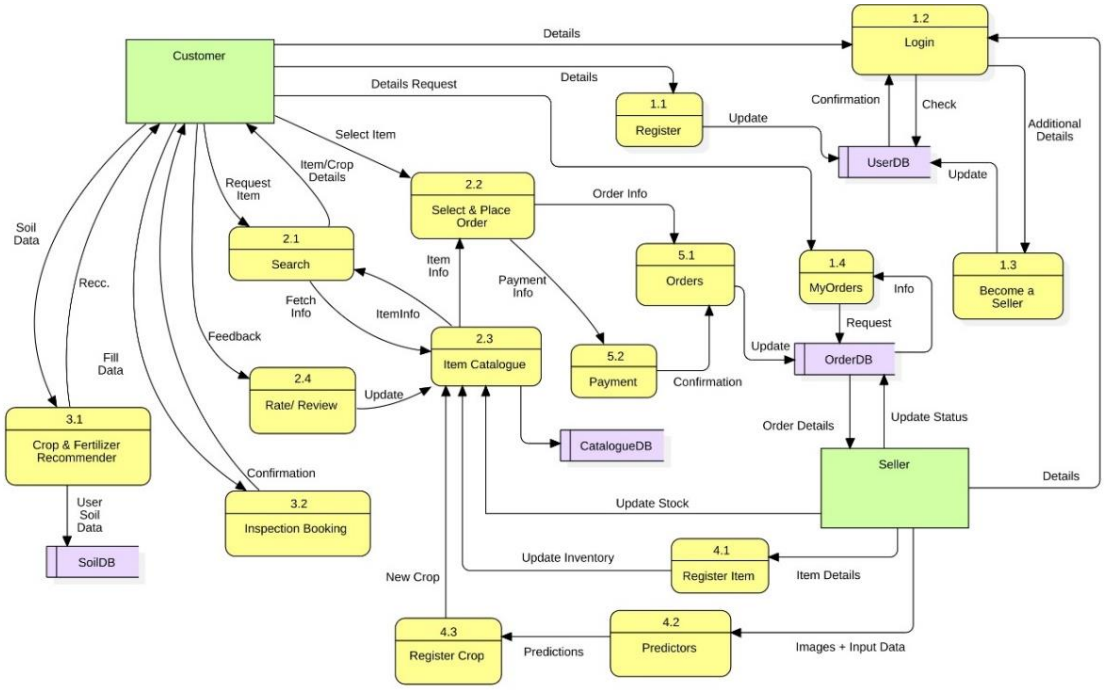
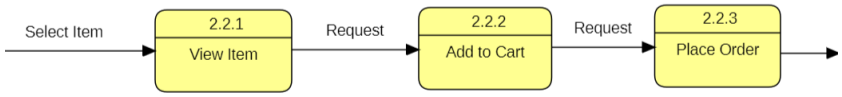


Figure 6 - Level 2 DFD

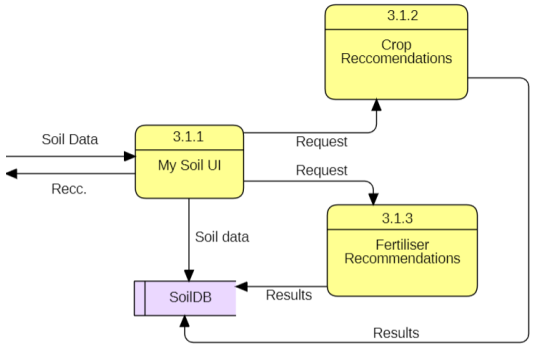
Sub-processes within key functions revealed - account actions, product interactions, soil processes, crop registration, order processes.

DFD Level 3:

Process 2.2 :



Process 3.1 :



Process 4.2 :

Figure 7 - Level 3 DFD

It delves deeper into sub-processes - "Select & Place Order," "Crop & Fertilizer Recommender," "Predictors."

4.1.3 ER Diagram

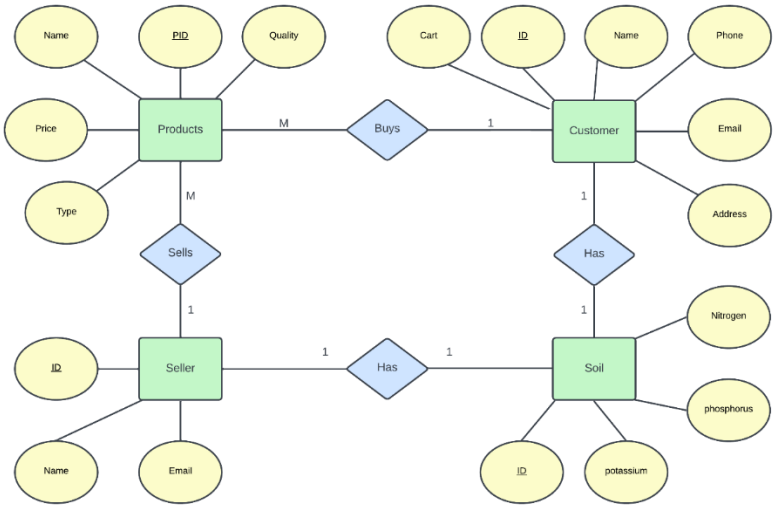


Figure 8- ER Diagram

The ER diagram visualizes the relationships and attributes of system entities: "Products," "Customer," "Seller," and "Soil."

4.2 Structure Diagrams

4.2.1 Class Diagram

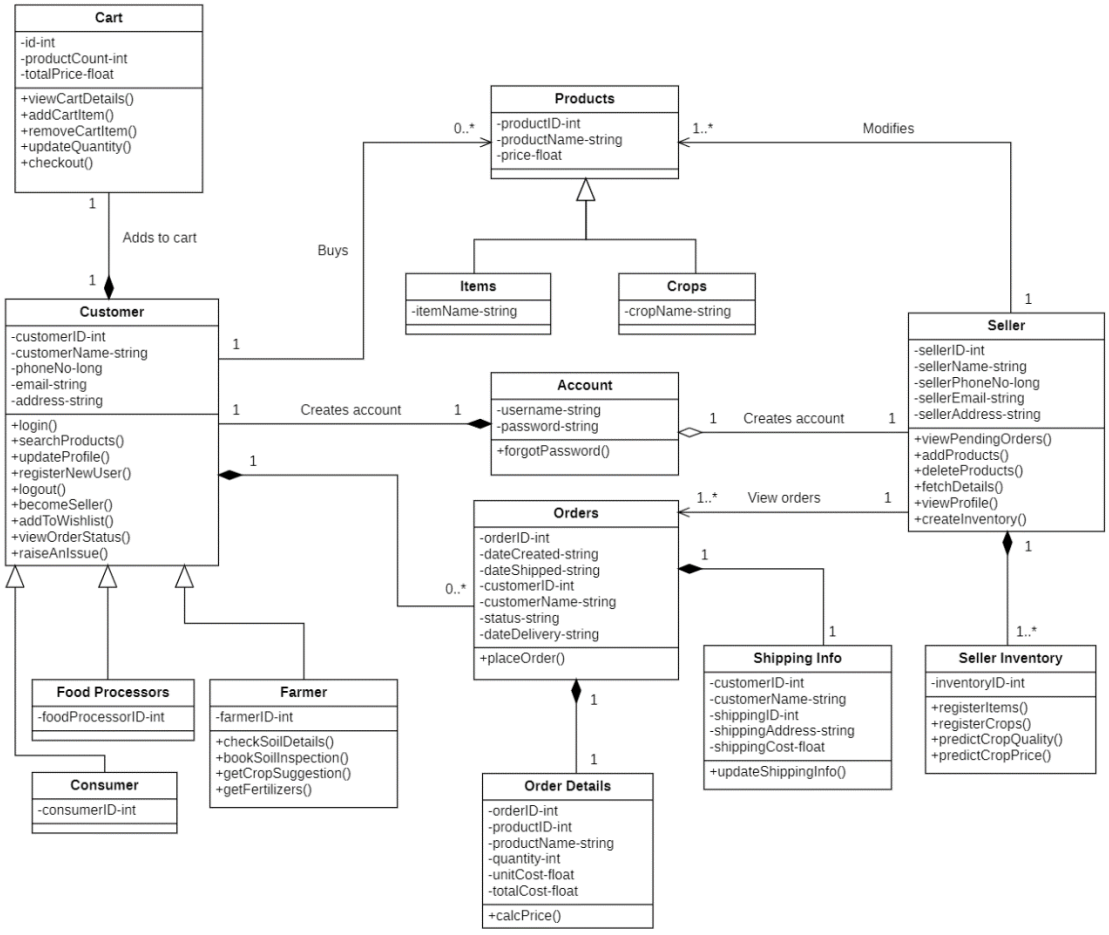


Figure 9 - Class Diagram

The above class diagram represents the following information:

- Customer hierarchy houses "Consumer," "Food Processors," "Farmer." Composition ties "Customer" with "Account" and "Cart."
- "Products" hierarchy branches to "Items" and "Crops," showcasing shared attributes. Associations link "Customer" and "Products."
- Composition link between "Order" and "Customer," illustrating the order's reliance on customer details. "Seller" aggregates "Account," associates with "Products" and "Orders."
- One-to-many composition link connects "Seller" and "Seller Inventory," capturing multiple inventory lists.

4.2.2 Object Diagram

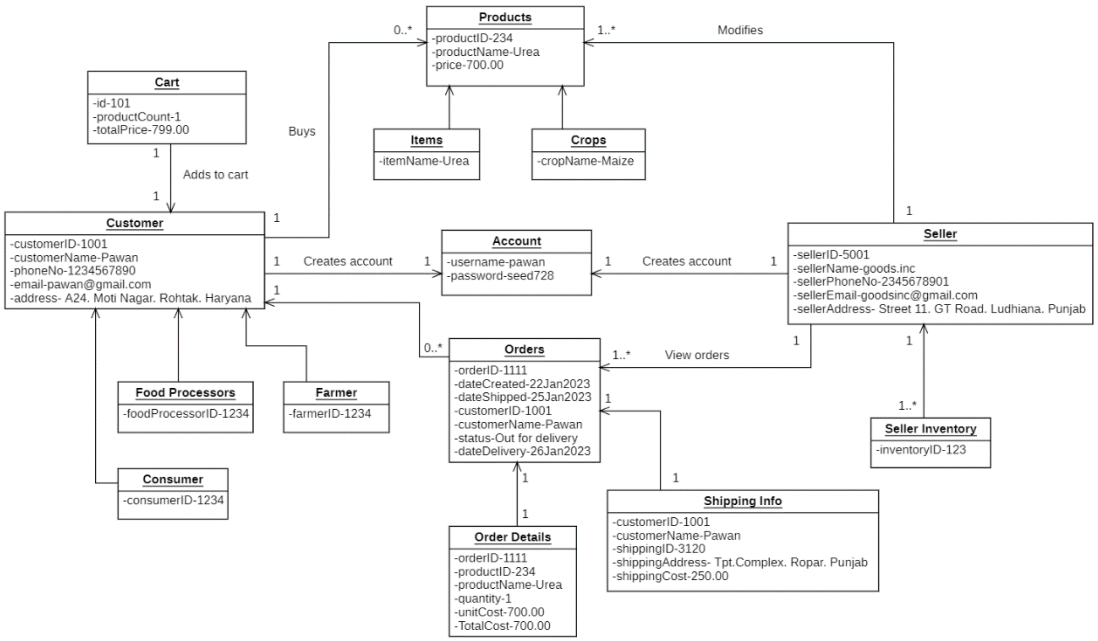


Figure 10 - Object Diagram

The object diagram instantiates classes and provides a visual of instances and their interactions.

4.2.3 Component Diagram

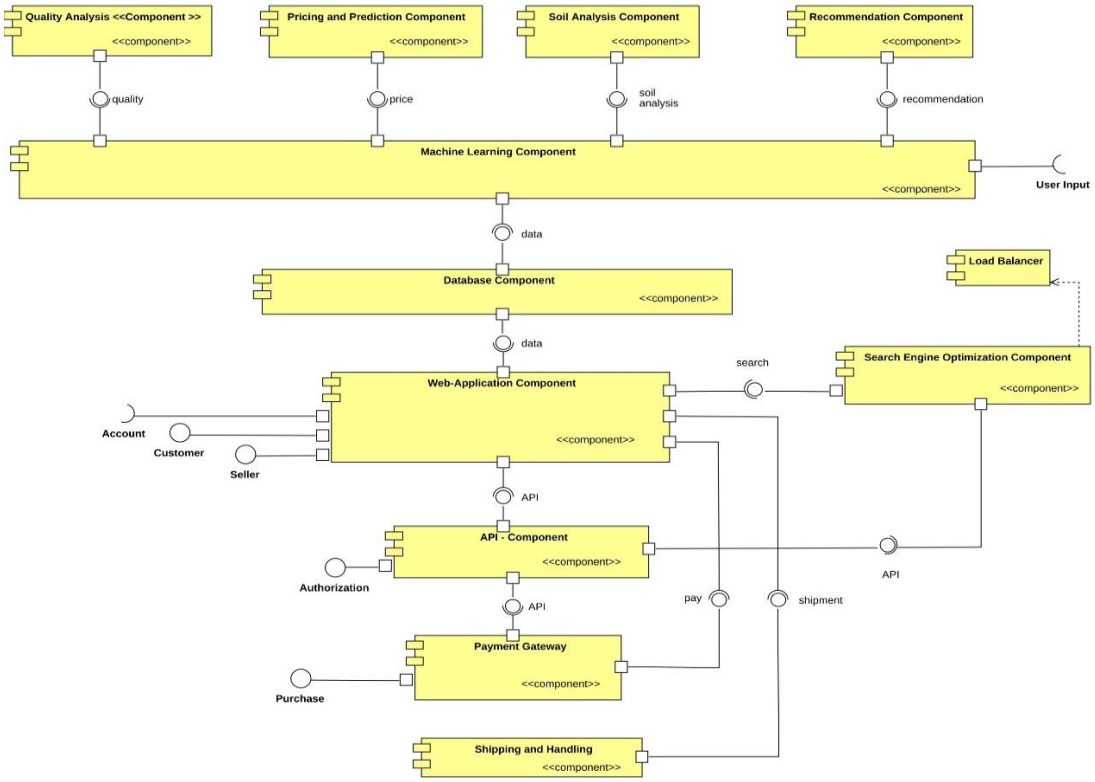


Figure 11 - Component Diagram

The Above picture represents the following:

- "Web-Application" interacts with "API," "Payment Gateway,"via "Load Balancer."
- "Machine Learning" comprises "Quality Analysis," "Pricing and Prediction," "Soil Analysis," "Recommendation."

4.2.4 Deployment Diagram:

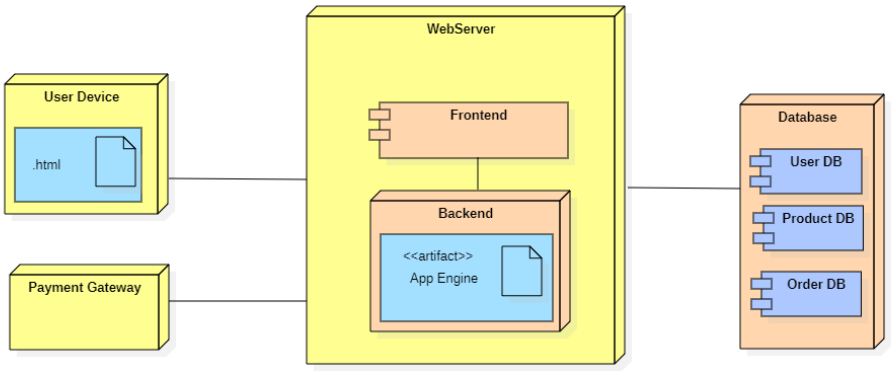


Figure 12 - Deployment Diagram

- "User Device" connects to "Web Server." "Web Server" links to "Payment Gateway," "Database."
- "Database" houses various databases. "User Device" has an ".html" artifact.

4.3 Behavioral Diagrams

4.3.1 Use Case Diagram

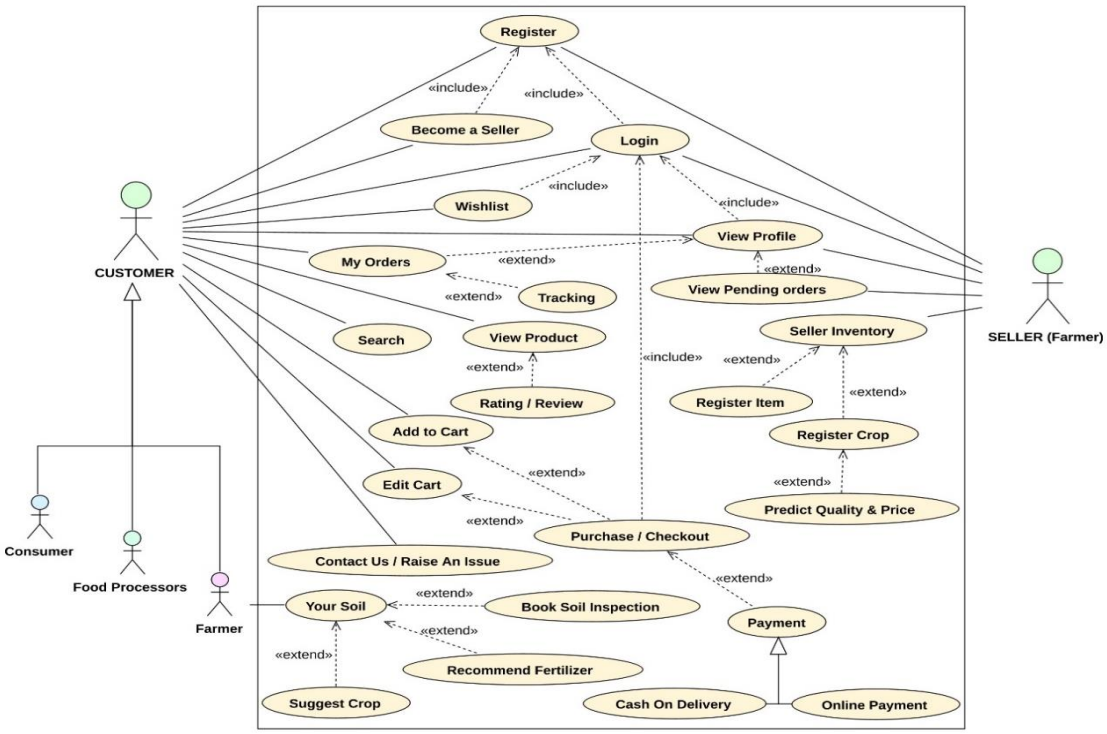


Figure 13 - Use Case Diagram

The use case diagram captures the system's essence: customers, consumers, food processors, and farmers, input soil data, seek predictions, and receive crop and fertilizer recommendations. Sellers register crops, manage inventory, and handle orders.

4.3.2 Swimlane Diagram

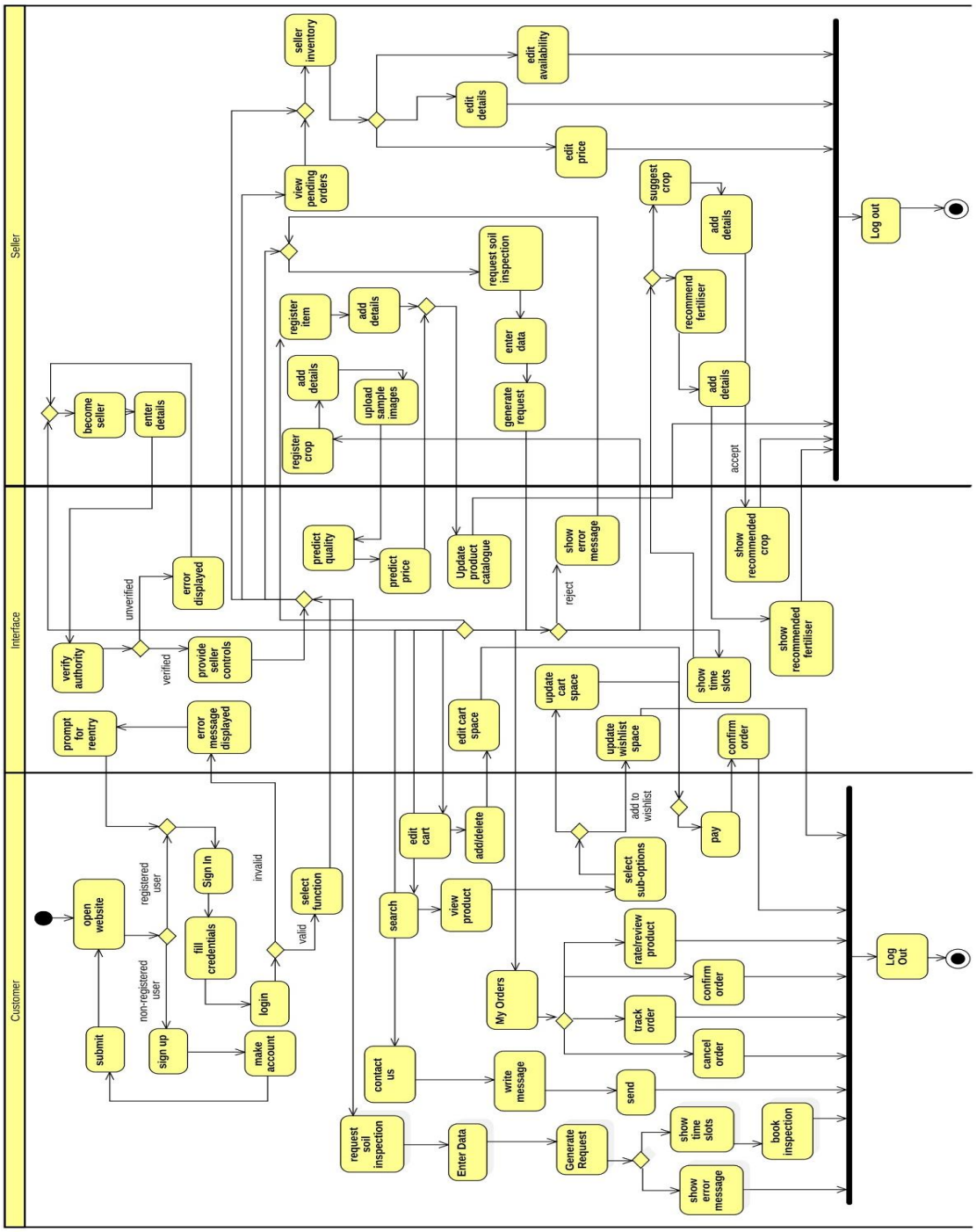
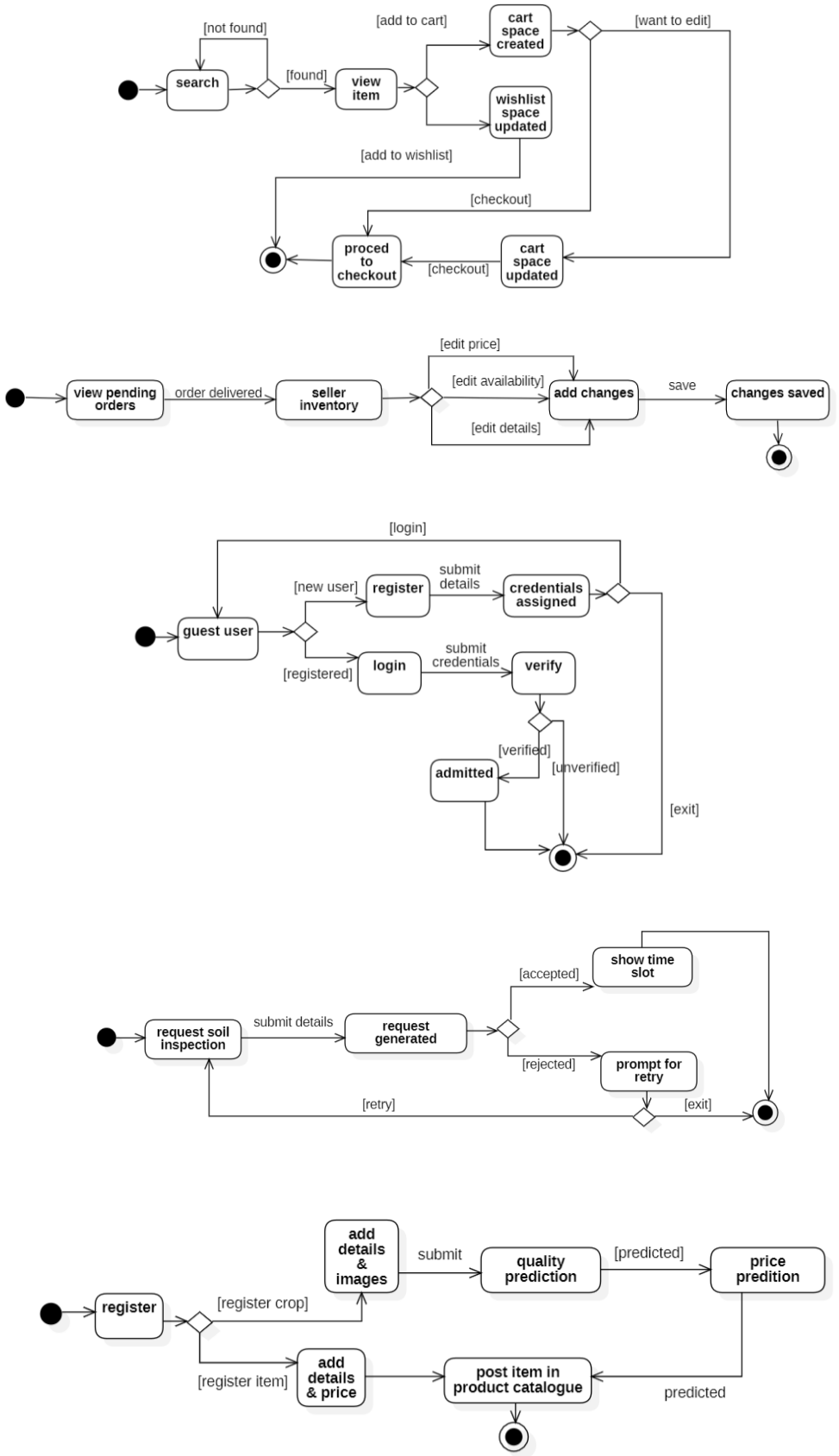


Figure – 14 Swimlane Diagram

The diagram illustrates actions of "Customer," "Interface," "Seller." User journey, process variations depicted. The lanes provide clarity on each actor's responsibilities and sub-processes.

4.3.3 State Chart Diagrams

The following are the various state chart diagrams of the proposed software.



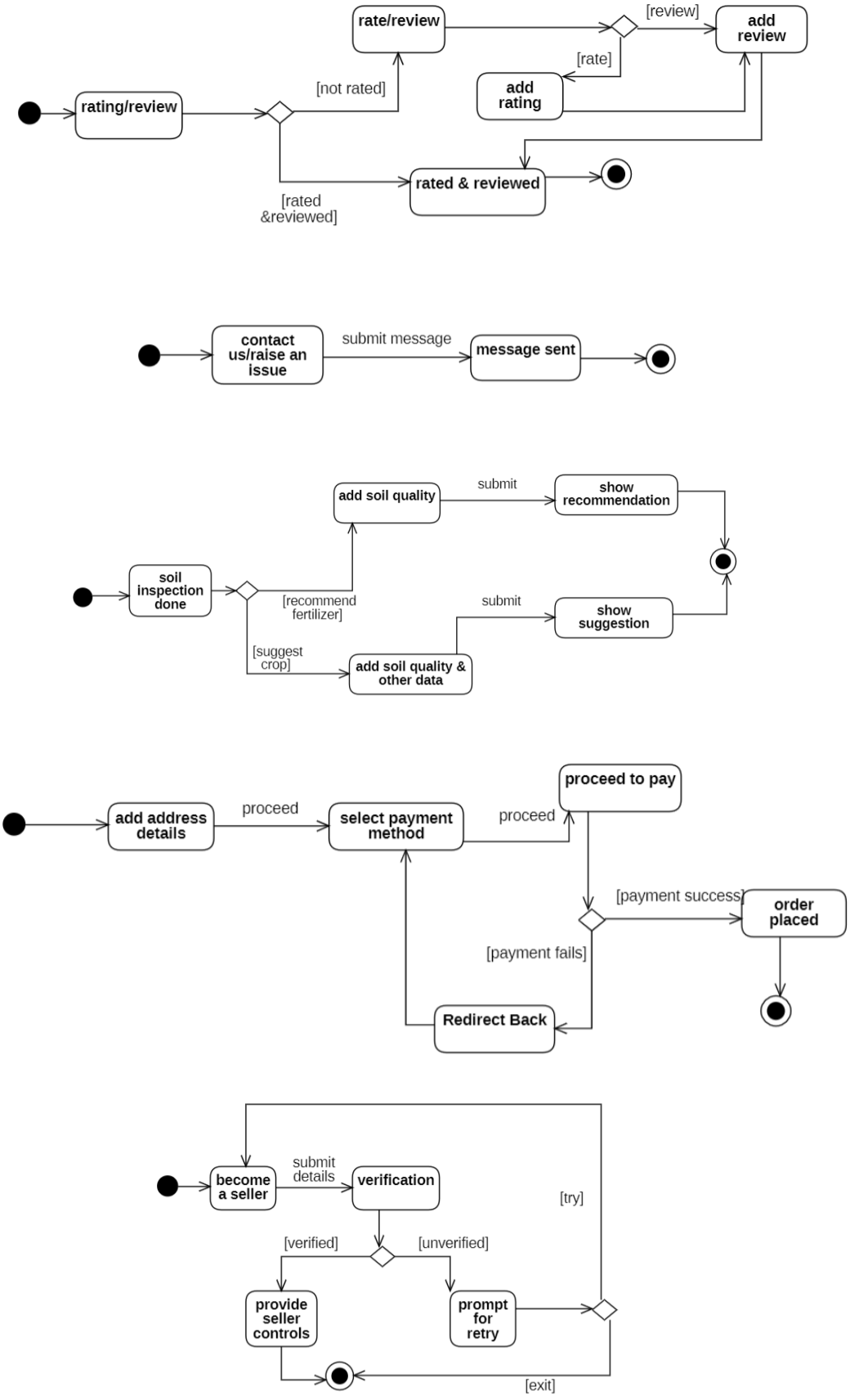


Figure 15 – State Chart Diagrams

4.3.4 Sequence Diagrams

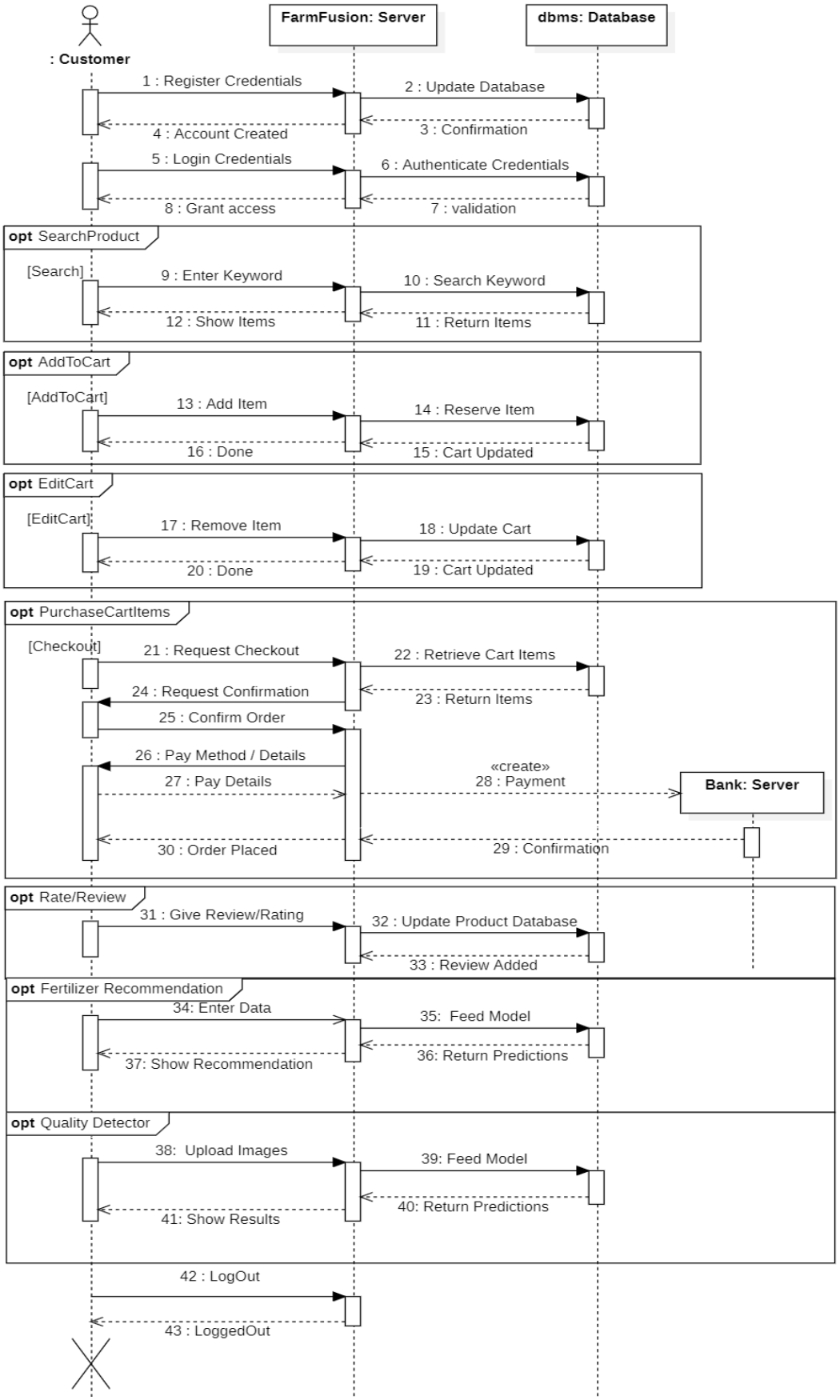


Figure 16 – Sequence Diagram (Customer)

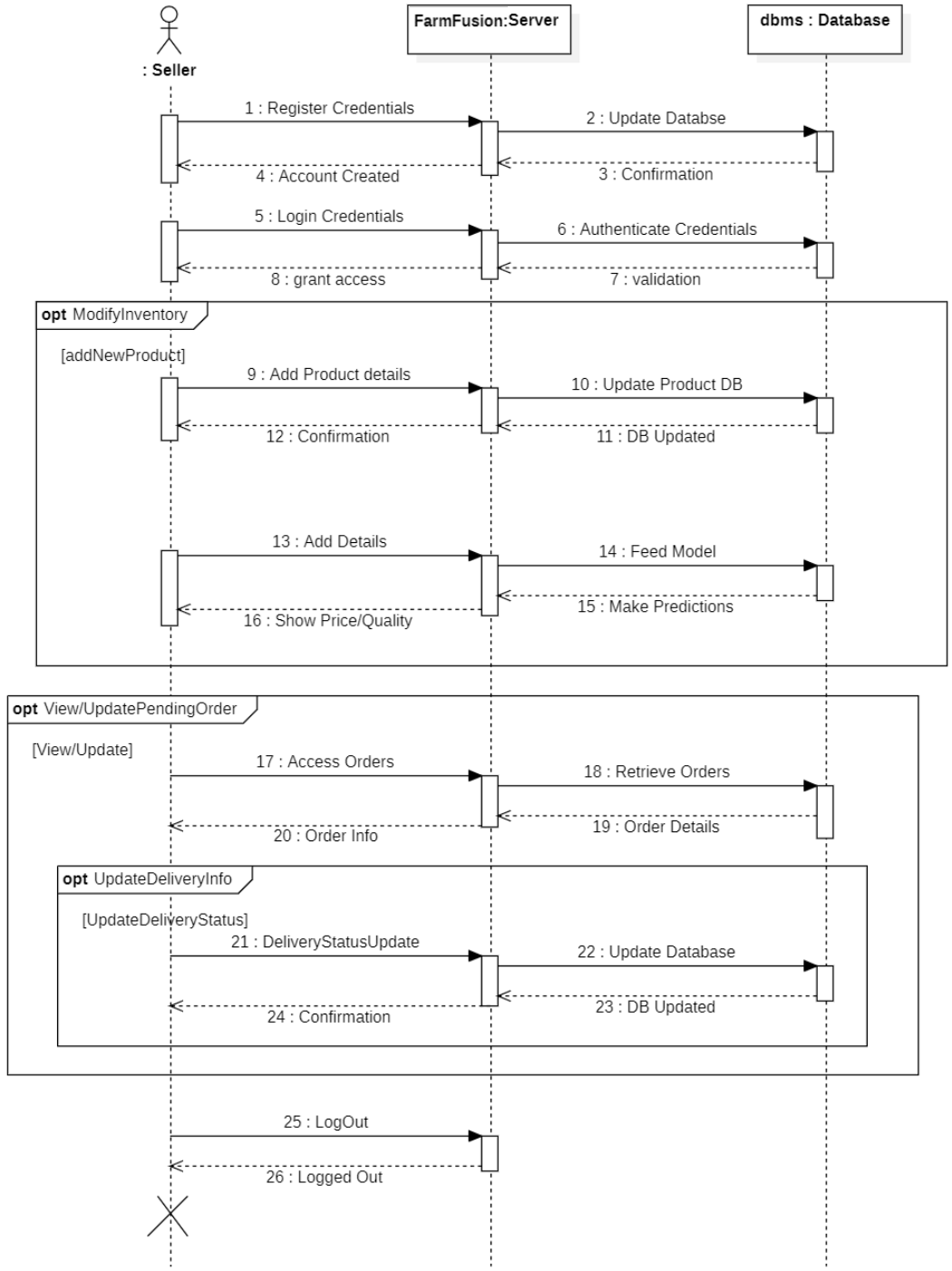


Figure 17 – Sequence Diagram (Seller)

The sequence diagram represents the dynamic interactions within FarmFusion. From customers searching products and placing orders to sellers managing inventory and crop predictions, this diagram illustrates the precise sequence of events, ensuring efficient communication and streamlined user experiences. The second diagram represents the actions of sellers. Both the diagrams tell the complete sequence of the project.

4.3.5 Collaboration Diagram

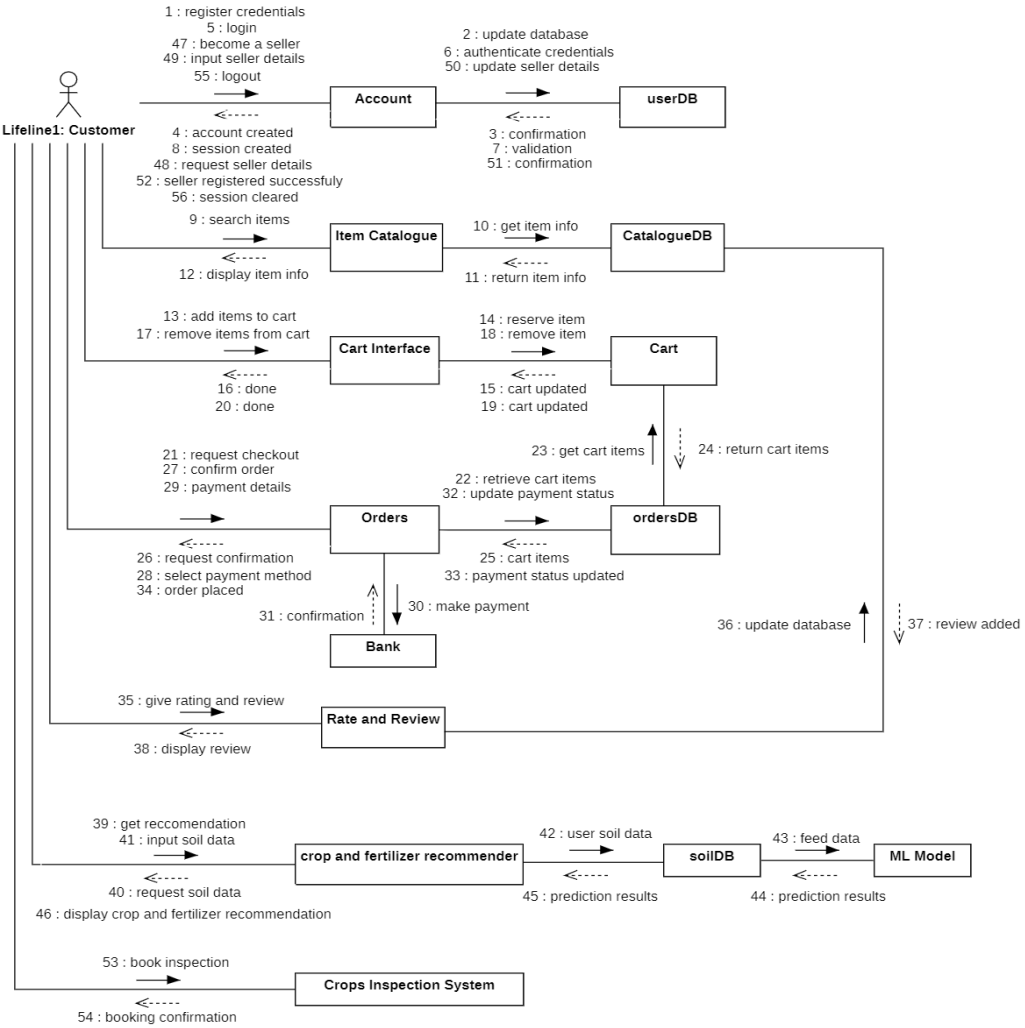


Figure 18 - Collaboration Diagram (Customer)

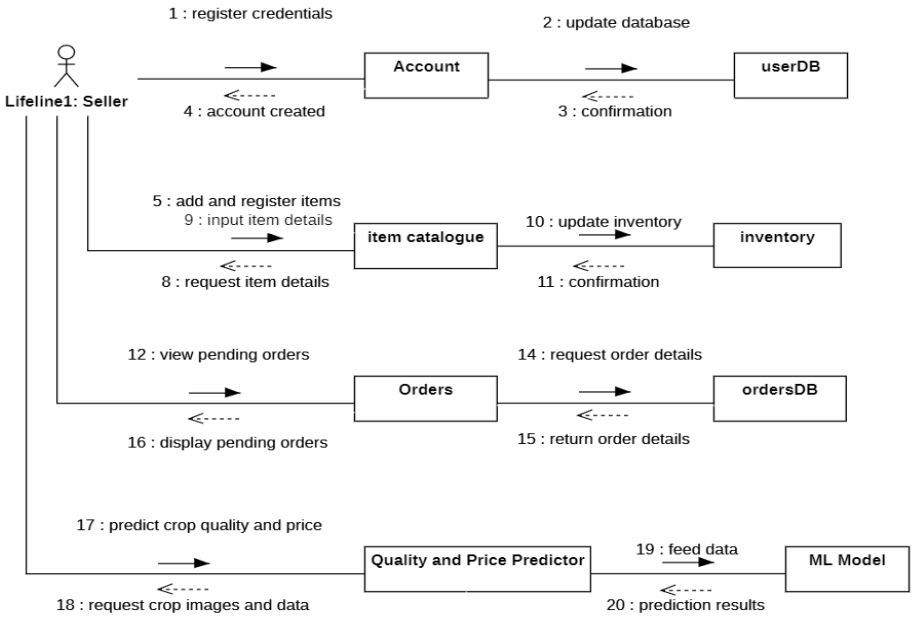


Figure 19 - Collaboration Diagram (Customer)

4.4 Use Case Templates

1. Use Case Title:	Register
2. Abbreviated Title:	Register
3. Use Case ID:	1
4. Actors:	Customer
5. Description: New users can register themselves as customers using the Register feature by providing valid login credentials and more personal information and other required details.	
5.1. Pre Conditions: 1. Customer ID should be unique.	
5.2. Task Sequence: 1. Click on Sign Up/Register button 2. Fill out all the columns with relevant info. 3. Click on Submit button.	
5.3. Post Conditions: 1. Customer can now login into his/her account with the registered email.	
6. Modification History: Date: 5-May-2023	
7. Author: Sarthak	

1. Use Case Title:	Login
2. Abbreviated Title:	Login
3. Use Case ID:	2
4. Actors:	Customer
5. Description: Customers who have already registered can login into their accounts and place orders or maintain carts.	
5.1. Pre Conditions: 1. Customer should have a registered account.	
5.2. Task Sequence: 1. Go to the login page. 2. Enter your credentials. 3. Click on login button.	
5.3. Post Conditions: 1. Customer will be logged into their account if credentials are valid. 2. Error message will be displayed if customer has entered wrong credentials.	
6. Modification History: Date: 5-May-2023	
7. Author: Sarthak	

1. Use Case Title:	View Profile
2. Abbreviated Title:	View Profile
3. Use Case ID:	3
4. Actors:	Customer
5. Description: View Profile feature allows the customer to view their personal details, past orders, payment Info , etc.	
5.1. Pre Conditions: 1. Customer must be logged in to his/her account.	
5.2. Task Sequence: 1. Login into your account. 2. Click on View Profile button.	
5.3. Post Conditions: 1. Customer profile page will be displayed.	
6. Modification History: Date: 5-May-2023	
7. Author: Sarthak	

1. Use Case Title:	Search
2. Abbreviated Title:	Search
3. Use Case ID:	4
4. Actors:	Customer
5. Description: With this search facility, customer can specify any search criteria to apply to products and find the products he/she needs.	
5.1. Pre Conditions: 1. Customers must have access to the site.	
5.2. Task Sequence: 1. Search Bar will be shown on the screen. 2. Type the name or part of the category of the product you want to search for. 3. Click on the search button and you will get desired results.	
5.3. Post Conditions: 1. Customers can view desired results. 2. Customers can go for another search.	
6. Modification History: Date: 5-May-2023	
7. Author: Sarthak	

1. Use Case Title:	Edit Cart
2. Abbreviated Title:	Edit Cart
3. Use Case ID:	5
4. Actors:	Customer
5. Description: Edit Cart can allow the customer to modify the quantity of items in the cart or to remove the items from the cart.	
5.1. Pre Conditions: 1. Customers must be logged in.	
5.2. Task Sequence: 1. Click on the cart button to land on the edit cart page. 2. Customers can then use the designated buttons like remove from cart, or the quantity button to edit craft	
5.3. Post Conditions: 1. Customers can purchase the items in the cart. 2. Customers can continue shopping for more items.	
6. Modification History: Date: 5-May-2023	
7. Author: Sarthak	

1. Use Case Title:	Add to cart
2. Abbreviated Title:	Add to cart
3. Use Case ID:	6
4. Actors:	Customer
5. Description: When a customer finds the product they want, they can add the product to the shopping cart. The system stores and tracks the information about products.	
5.1. Pre Conditions: 1. Customer should be registered and logged in.	
5.2. Task Sequence: 1. Customer enter the product to be searched. 2. The system searches the product in the database. 3. If customer find their product they can add it to cart	
5.3. Post Conditions: 1. Customer can now proceed to payment. 2. Customer can also remove the product from cart	
6. Modification History: Date: 5-May-2023	
7. Author: Vishvam	

1. Use Case Title:	Pay
2. Abbreviated Title:	Pay
3. Use Case ID:	7
4. Actors:	Customer
5. Description: Using this facility customer can move to checkout and can proceed to payment by selecting one of the payment options.	
5.1. Pre Conditions: Customer should be logged in and have product in cart for payment.	
5.2. Task Sequence: 1. Customer have to select a payment option. 2. Now they have to verify their details. 3. Confirm their payment.	
5.3. Post Conditions: 1. If payment was successful then inform the seller. 2.If payment was not successful, inform customer about it and ask them for payment.	
6. Modification History: Date: 5-May-2023	
7. Author: Vishvam	

1. Use Case Title:	Purchase Items
2. Abbreviated Title:	Purchase Items
3. Use Case ID:	8
4. Actors:	Customer
5. Description: This facility gives customers the facility of selecting a product and adding them to cart and confirming the order and moving towards payment.	
5.1. Pre Conditions: Customers should be logged in so that they can add to cart the desired product or can pay for it.	
5.2. Task Sequence: 1. Customer have to search for their product 2. If they can see the desired product then they have to add the product in cart or can pay	
5.3. Post Conditions: 1. Customer are allowed to add products to the cart. 2.They can proceed to payment after adding it to the cart.	
6. Modification History: Date: 5-May-2023	
7. Author: Vishvam	

1. Use Case Title:	View pending orders
2. Abbreviated Title:	View pending orders
3. Use Case ID:	9
4. Actors:	Seller
5. Description: This facility provides sellers with the feature of viewing their pending orders that need to be delivered to the respective customers	
5.1. Pre Conditions: 1. Seller must be logged in to their dashboard.	
5.2. Task Sequence: 1. Seller will go to their dashboard. 2. Then they can see their orders which are pending.	
5.3. Post Conditions: 1. After seeing their pending order if any they have to see their inventory and update it accordingly.	
6. Modification History: Date: 5-May-2023	
7. Author: Vishvam	

1. Use Case Title:	Register Item (fertilizer)
2. Abbreviated Title:	Register Item
3. Use Case ID:	10
4. Actors:	Seller
5. Description: This facility provides sellers with the feature of adding new item to the product catalogue.	
5.1. Pre Conditions: 1. Seller must be logged in to their dashboard.	
5.2. Task Sequence: 1. Seller will go to their dashboard. 2. Click on Add New Item. 3. Add Item details and price. 4. Post the item.	
5.3. Post Conditions: 1. The Item Gets listed in the website's product catalogue.	
6. Modification History: Date: 5-May-2023	
7. Author: Vishvam	

1. Use Case Title:	Register Crop
2. Abbreviated Title:	Register Crop
3. Use Case ID:	11
4. Actors:	Seller
5. Description: This facility provides sellers with the feature of adding new crops to the product catalogue.	
5.1. Pre Conditions: 1. Seller must be logged in to their dashboard.	
5.2. Task Sequence: 1. Seller will go to their dashboard. 2. Click on Add New Crop. 3. Add the details of the crop. 4. Upload Sample Images for predictions.	
5.3. Post Conditions: 1. The Crop gets registered for further predictions.	
6. Modification History: Date: 5-May-2023	
7. Author: Al Sumaim	

1. Use Case Title:	Predict and Post Crop
2. Abbreviated Title:	Predict and Post Crop
3. Use Case ID:	12
4. Actors:	Seller
5. Description: This facility provides sellers with the feature of publishing new crops after Quality & Price Prediction.	
5.1. Pre Conditions: 1. Seller must have uploaded the required data inputs for the predictions.	
5.2. Task Sequence: 1. Seller can see the Quality Prediction calculated by the website after uploading the images. 2. Seller can use the price prediction feature and decide to keep a price within a designated range. 3. Finally the Seller can publish the crop.	
5.3. Post Conditions: 1. The Crop Gets listed in the website's product catalogue.	
6. Modification History: Date: 5-May-2023	
7. Author: Al Sumaim	

1. Use Case Title:	Suggest Crop
2. Abbreviated Title:	Suggest Crop
3. Use Case ID:	13
4. Actors:	Any User (farmers)
5. Description: This facility provides users (farmers) with the feature for getting the suggestions of suitable crops that they can grow.	
5.1. Pre Conditions: 1. User must be logged in to their dashboard. 2. User has measured the soil quality and uploaded the results in the Add Soil Quality stage.	
5.2. Task Sequence: 1. User will add the specific details of the soil. 2. Users will click on Get Crop Suggestion.	
5.3. Post Conditions: 1. The user moves to the next page and gets crops recommended to him/her.	
6. Modification History: Date: 5-May-2023	
7. Author: Al Sumaim	

1. Use Case Title:	Recommend Fertilizer
2. Abbreviated Title:	Recommend Fertilizer
3. Use Case ID:	14
4. Actors:	Any User (farmers)
5. Description: This facility provides users (farmers) with the feature with which they can get fertilizer suggestions that they can use for improving their soil quality parameters and also the link to buy the fertilizer from the website itself.	
5.1. Pre Conditions: 1. User must be logged in to their dashboard. 2. User has measured the soil quality and uploaded the results in the Add Soil Quality stage.	
5.2. Task Sequence: 1. User will add the specific details of the soil. 2. Users will click on Get Fertilizer Suggestion.	
5.3. Post Conditions: 1. The user moves to the next page and gets fertilizers recommended to him/her.	
6. Modification History: Date: 5-May-2023	
7. Author: Al Sumaim	

1. Use Case Title:	Seller Inventory
2. Abbreviated Title:	Seller Inventory
3. Use Case ID:	15
4. Actors:	Seller
5. Description: This facility provides sellers with the feature of editing their items in the product catalogue.	
5.1. Pre Conditions: 1. Seller must be logged in to their dashboard. 2. Seller must have his products registered in the product catalogue.	
5.2. Task Sequence: 1. Seller will go to their dashboard. 2. Click on My Products. 3. Edit Item details, price and availability. 4. Save the changes	
5.3. Post Conditions: 1. The Item info gets updated on the website.	
6. Modification History: Date: 5-May-2023	
7. Author: Al Sumaim	

1. Use Case Title:	Order Status/Edit Order
2. Abbreviated Title:	Order Status/Edit Order
3. Use Case ID:	16
4. Actors:	Seller / Customer
5. Description: This facility provides the users with the feature of checking the details of all the orders placed. In the case of seller , the seller can see the info of pending orders , while the customer can see the same along with features like cancel order , Track Order , Return , Rate / Review , Download Invoice.	
5.1. Pre Conditions: 1. Seller/Customer must be logged in to their dashboard. 2. The User must have pending orders whose detail that they wish to acquire.	
5.2. Task Sequence: 1. User will go to their dashboard. 2. Click on My Orders. 3. See The details and perform some given actions / or go back.	
5.3. Post Conditions: 1. The user comes out of My Orders page to the home screen on the website.	
6. Modification History: Date: 5-May-2023	
7. Author: Meghna	

1. Use Case Title:	Tracking
2. Abbreviated Title:	Tracking
3. Use Case ID:	17
4. Actors:	Any User
5. Description: This facility provides users with the feature of tracking the package that is ordered .	
5.1. Pre Conditions: 1. User must be logged in to their dashboard. 2. User must have placed an order.	
5.2. Task Sequence: 1. User will go to their dashboard. 2. Click on My Orders 3. Select the order which you want the track. 4. Click on Track Package. 5. See the details and Go Back.	
5.3. Post Conditions: 1. The user goes back to my orders page.	
6. Modification History: Date: 5-May-2023.	
7. Author: Meghna	

1. Use Case Title:	Contact Us / Raise An Issue
2. Abbreviated Title:	Contact Us / Raise An Issue
3. Use Case ID:	18
4. Actors:	Customer
5. Description: This facility provides customers with the feature of raising an issue and contacting the seller by filling the required details.	
5.1. Pre Conditions: 1. Customer must be logged in to their dashboard.	
5.2. Task Sequence: 1. Customer will go to their dashboard. 2. Click on Raise a Complaint. 3. Fill up the required details. 4. Click o Send to send the message as an email.	
5.3. Post Conditions: 1. The user's message will be sent to the seller.	
6. Modification History: Date: 5-May-2023	
7. Author: Meghna	

1. Use Case Title:	Request Soil Inspection
2. Abbreviated Title:	Request Soil Inspection
3. Use Case ID:	19
4. Actors:	Any User

5. Description:
This facility provides the users with the feature of soil quality testing appointment where our members would visit the spot for testing.

5.1. Pre Conditions:
1. User must be logged in.

5.2. Task Sequence:
1. User will go to their dashboard.
2. Click on Get Soil Checked Button.
3. Enter details about the location and preferred time slot.
4. Request for the Soil Inspection.

5.3. Post Conditions:
1. The testing team would visit the location for examination

6. Modification History: Date: 5-May-2023

7. Author: Meghna

1. Use Case Title:	Become a seller
2. Abbreviated Title:	Become a seller
3. Use Case ID:	20
4. Actors:	Customer

5. Description:
This facility provides user with the feature of becoming a seller on the website.

5.1. Pre Conditions:
1. User must be logged in.

5.2. Task Sequence:
1. User will go to their dashboard.
2. Click on Become a seller tab
3. Enter details and verify the authority
4. Requests for becoming a seller

5.3. Post Conditions:
1. The user would be provided with the seller facility and controls.

6. Modification History: Date: 5-May-2023

7. Author: Armandeep

1. Use Case Title:	Wishlist
2. Abbreviated Title:	Wishlist
3. Use Case ID:	21
4. Actors:	Customer
5. Description: This facility provides customer to add products to a personalized wishlist to save for later.	
5.1. Pre Conditions: 1. Customer must be logged in.	
5.2. Task Sequence: 1. User will go dashboard 2. View a product. 3. Add the product to wishlist.	
5.3. Post Conditions: 1. The selected item would be added to wishlist.	
6. Modification History: Date: 5-May-2023	
7. Author: Armandeep	

1. Use Case Title:	Rate/Review
2. Abbreviated Title:	Rate/Review
3. Use Case ID:	22
4. Actors:	Customer
5. Description: This feature provides user the ability to rate and review any product they have purchased.	
5.1. Pre Conditions: 1. Customer must be logged in. 2. Customer must have purchased the item.	
5.2. Task Sequence: 1. User will go to their dashboard. 2. View the purchased product. 3. Rate the product. 4. Review the product.	
5.3. Post Conditions: 1. The selected item would be rated/reviewed.	
6. Modification History: Date: 5-May-2023	
7. Author: Armandeep	

1. Use Case Title:	View Product
2. Abbreviated Title:	View Product
3. Use Case ID:	23
4. Actors:	Customer
5. Description: This facility provides customer the ability to view and navigate through product catalogue.	
5.1. Pre Conditions: 1. Customer must be logged in.	
5.2. Task Sequence: 1. User will go to their dashboard. 2. Navigate through a category. 3. View the product.	
5.3. Post Conditions: 1. The selected item's page would be loaded.	
6. Modification History: Date: 5-May-2023	
7. Author: Armandeep	

Table 21 to 44 – Use Case Templates

5. IMPLEMENTATION & EXPERIMENTAL RESULTS

5.1 Experimental Setup

The experimental setup for the project is divided into four components which include Soil Quality measuring hardware, Web Application Frontend and Backed along with the integration of all these into one single unit. This section provides a detailed description of the key elements involved in the successful execution of the project.

5.1.1 Soil Quality Measuring Hardware

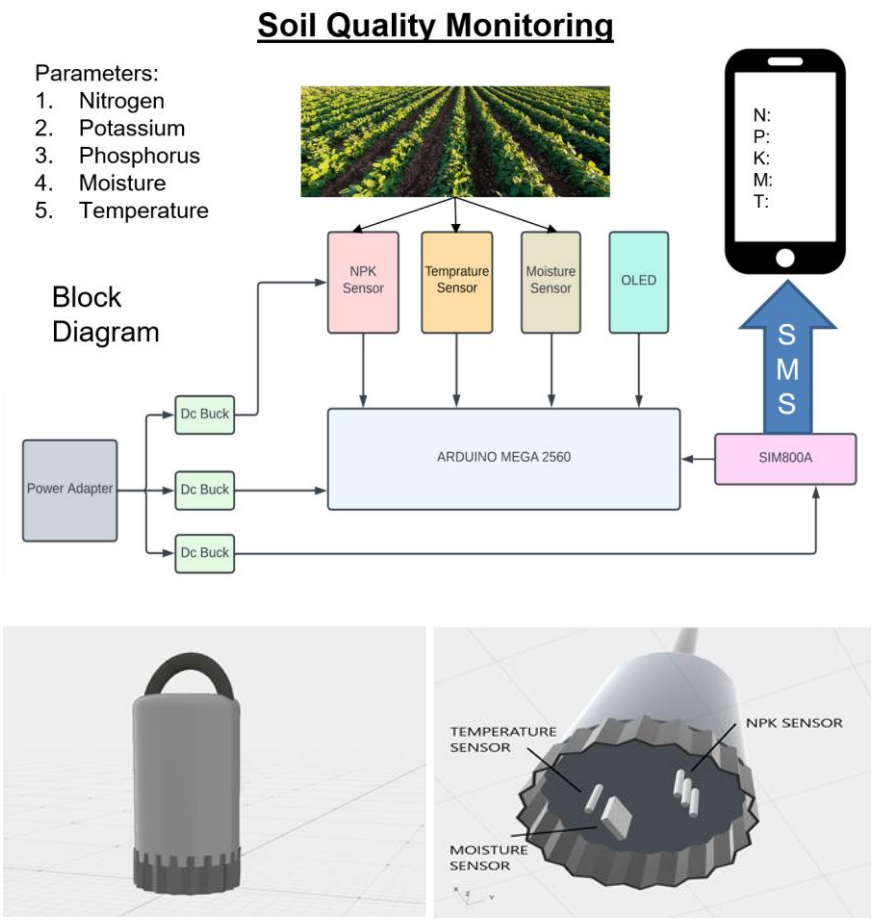


Figure - 20 Hardware kit for soil nutrients

The hardware kit is used for measure the quality parameters of the soil. The brain of the working model is the Arduino 2560. This has been used along with the sim module and oled display sensor. The kit measures the parameters using the NPK sensor, Temperature sensor and Moisture sensor. The DC Bucks are used for voltage regulation. The hardware kit is enclosure in a PVC pipe and is designed to be used as a

handheld kind of device that the user can use easily for measuring the values. These parameters will then be used for predictions on our web application.

5.1.2 Web Application Frontend

The frontend of the application is made up of React and Bootstrap. The app provides a user interface that gives us access to the features implemented in the application. The users can make use of the desired functionalities like Crop Quality and Price Prediction, Crop Recommendation and fertilizer recommendation along with an integrated ecommerce feature set. Here is a basic overview of the feature flow of the frontend.

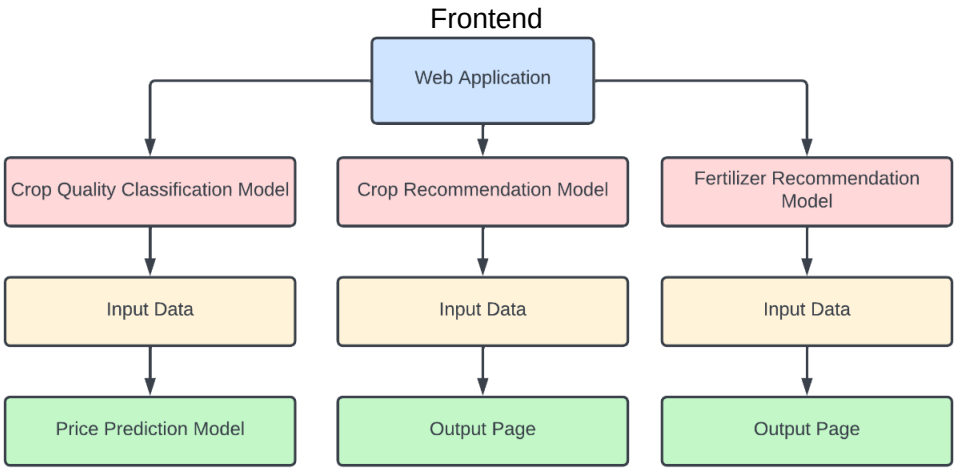


Figure – 21 Frontend of the Application

5.1.3 Web Application Backend

The backend of the application is made up of NodeJs, ExpressJs and Flask. Along with the these, the trained machine learning models for the prediction and recommendation features are made with models like Random Forest, Resnets, VGG16 and neural networks. The app is also integrated with a payment gateway api (stripe) for making purchases. The database is a NoQSL database that uses MongoDB. The app users can use all the functionalities seamlessly.

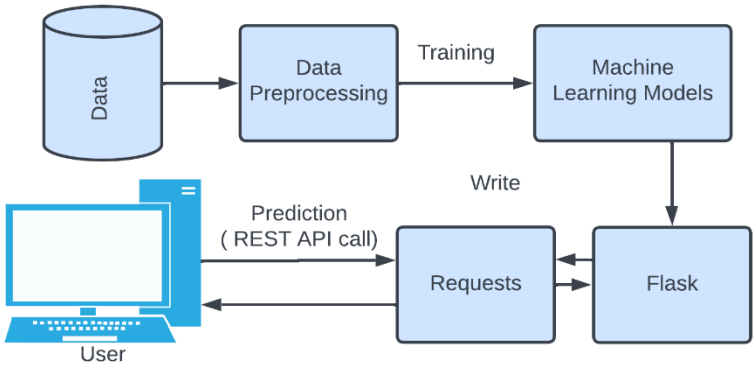


Figure – 22 – Backend of the Application

5.1.4 Integration

The frontend and backend are integrated with the help of Nodejs and flask for the machine learning models. The application needs a server for running it for testing in the further phases of experimentation.

5.2 Experimental Analysis

5.2.1 Data

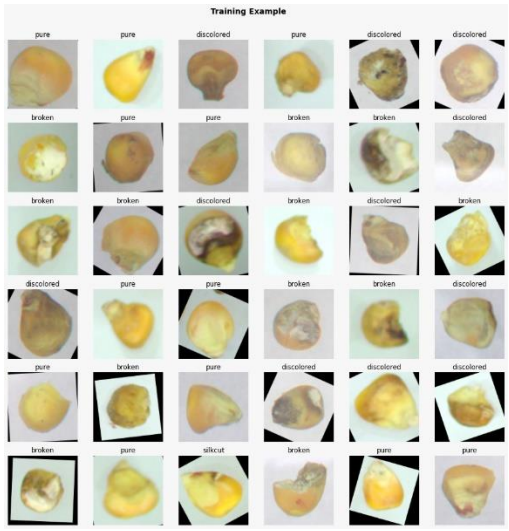


Figure 23 - Dataset Samples

For this project, we have used 4 different ML models, so we have four datasets with us.

1. Corn seed dataset. (Source- Mr. Sandeep Nagar – IIIT Hyderabad)
    - Contains 14,322 images in train set.

- Contains 3,474 images in test set.
- 4 different Classes- Pure , Broken, Discolored, Silkcut

2. Cost Price Dataset. (Source- Data Scraping)
    - Contains 20,000 data entries.
    - Contains 10 Parameters which are month, state, soil type, weather, irrigation, fertilizer usage, pesticide usage, quality and price.
3. Crop Suggestion Dataset. (Source- Kaggle)
    - Contains 2,200 Data entries.
    - Contains 7 Parameters which are Nitrogen, Potassium, Phosphorus, Temperature, Humidity and crop.
4. Fertilizer Recommendation Dataset (Source- Data Scraping)
    - Contains 1200 data entries.
    - Parameters include Crop, Nitrogen, Potassium and Phosphorus.

5.2.2 Performance Parameters

The project's success is evaluated based on several key performance parameters, with a primary focus on user satisfaction. The critical performance parameters include:

- **Errors in Readings:** Errors in reading of a hardware measurement kit can arise from various sources, including instrumental, environmental, and human factors. There must be proper readings being taken into consideration as it can affect our results in the predictions.
- **Model Accuracy:** The ML models need to be accurate for useful predictions.
- **Authentication & Security:** The application must do a proper authentication for login and keep the database safe from intrusion and errors.
- **Robustness:** The overall project must be robust when used for long time.
- **Response Time or Latency:** Response time or latency is a critical performance parameter for any website. It measures the time taken for a web server to respond to a request from a user's browser. A fast response time is essential for providing a seamless user experience, as it directly impacts user satisfaction and engagement.
- **Ease of Use:** A website that is easy to use allows visitors to navigate, find information, and complete tasks with minimal effort and confusion. Factors contributing to site ease of use include clear and logical navigation, intuitive layout

and design, concise and informative content, and responsive and accessible features.

These performance parameters collectively contribute to the overall user satisfaction, which is the ultimate benchmark for the success of this project. Regular monitoring and analysis of these parameters ensure that the system consistently meets or exceeds user expectations.

5.3 Working of the Project

5.3.1 Procedural Workflow

1. Customer Side: The Customer / User can use the application after he/she logins into the application after creating an account. Then he is offered features of the ecommerce website and also features of YOUR SOIL which include Crop Recommendation and Fertilizer Recommendation. The user is free to use these features and also buy the products listed on the website. Along with this, the user also has the option to become a seller to increase his use cases of the application. Once he becomes a seller, he gets logged out. After his account is upgraded to a seller, the user gets features like to add products and crops into the catalogue.

2. Seller Side: The seller side application consists of some additional features that the users get. Once they are logged in as a seller they get features like add a product and add a crop. Through the add a crop feature, the seller can do crop quality prediction which classifies the crop into its type.

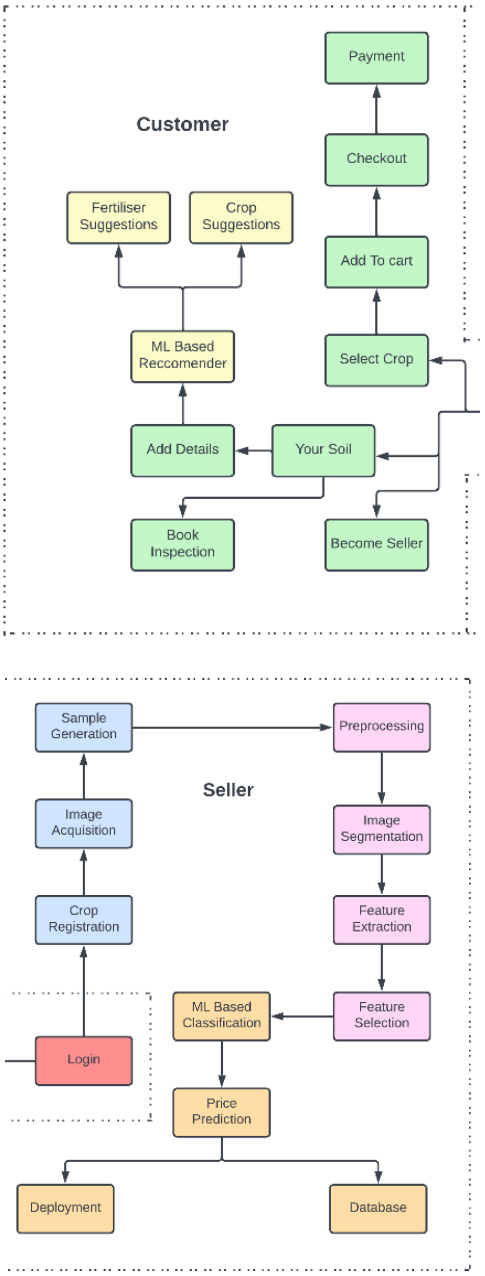


Figure - 24, 25 Two Sides

5.3.2 Algorithmic Approaches used

1. Crop Quality Model: The quality prediction of the crop is done from the input image by the seller. The seller inputs the image and gets a quality classification back. The algorithm running behind this uses a VGG16 as a base model plus some more layers added on top of it.

```
# Create a test generator that generates batches of images from the testing
data
test_generator = test_datagen.flow_from_directory(
    test_dir,
    target_size=(150, 150),
    batch_size=32,
    class_mode='categorical')

base_model = tf.keras.applications.VGG16(weights='imagenet',
include_top=False, input_shape=(150, 150, 3))

model = tf.keras.models.Sequential([
    base_model,
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(512, activation='relu'),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(4, activation='softmax')
])

model.compile(loss='categorical_crossentropy',
              optimizer=tf.keras.optimizers.Adam(learning_rate=1e-4),
              metrics=['accuracy'])
```

2. Crop Recommendation Model: The crop recommendation was trained on various different models like Decision Tree, Gaussian Naïve Bayes, Support Vector Machine, Logistic Regression, Random Forest and XGBoost. Out of these the Random Forest Model with estimators = 20 and random state = 0 was found to be predicting more accurately.

```
from sklearn.ensemble import RandomForestClassifier
RF = RandomForestClassifier(n_estimators=20, random_state=0)
RF.fit(Xtrain,Ytrain)
predicted_values = RF.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
```

3. Crop Price Prediction Model: The crop price prediction model was trained on the Random Forest Regressor Model with estimators = 100 and random state = 0. It was found to be predicting very accurately.

```
# Initialize the Random Forest Regressor model
model = RandomForestRegressor(n_estimators=100, random_state=42)
# Train the model
model.fit(X_train, y_train)
```

```
# Make predictions on the testing set
y_pred = model.predict(X_test)
# Evaluate the model
mse = mean_squared_error(y_test, y_pred)
```

4. Fertilizer Prediction Model: The fertilizer prediction model uses logistic regression and tries to achieve a N:P:K = 4:2:1. Accordingly it suggests the fertilizers on the basis of values inputted into it. The model predicts a correction ratio which is mapped to a intent that is returned to the user. The intent includes the suggestions for improving soil quality.

5. Arduino Code for hardware part:

```
#include <SoftwareSerial.h>
#include <Wire.h>
#include <OneWire.h>
#include <DallasTemperature.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
const int sensor_pin =
A1;                                                          // MOIS
#define ONE_WIRE_BUS 14   // Data wire is plugged into digital pin 14
#define SCREEN_WIDTH 128      // OLED display width
#define SCREEN_HEIGHT 64      // OLED display height
#define OLED_RESET -1         // Reset pin #
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire,
OLED_RESET);
#define RE 8  // RE set the RS485 module
#define DE 7  //RS485  DE =7
HardwareSerial& simSerial = Serial1;  // Hardware Serial for SIM800A module
SoftwareSerial mod(12, 13);          // Software Serial for NPK senso
// Modbus RTU requests for reading NPK values
const byte nitro[] = {0x01, 0x03, 0x00, 0x1e, 0x00, 0x01, 0xe4,
0x0c};                    // NPK
const byte phos[] = {0x01, 0x03, 0x00, 0x1f, 0x00, 0x01, 0xb5,
0xcc};                    // NPK
const byte pota[] = {0x01, 0x03, 0x00, 0x20, 0x00, 0x01, 0x85,
0xc0};                    // NPK
OneWire oneWire(ONE_WIRE_BUS);      // Setup a oneWire instance
DallasTemperature sensors(&oneWire);// Pass oneWire reference
int counter = 0;
int countDown = 5;
void setup() {
  Serial.begin(9600);    // Serial communication for debugging
  // Code for SIM800A module
  simSerial.begin(9600); // Initialize SIM800A module
  delay(6000);           // Wait for module to stabilize
  simSerial.println("AT"); // Handshake with the module
  delay(1000);
  simSerial.println("AT+CMGF=1"); // Set SMS mode to text
  delay(1000);
  // Code for NPK sensor
  mod.begin(9600);      // Initialize NPK
sensor                                          //NPK
  pinMode(RE, OUTPUT);
```

```
  pinMode(DE, OUTPUT);
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);  // Initialize OLED
  delay(500);
  display.clearDisplay();
  display.setCursor(25, 15);
  display.setTextSize(1);
  display.setTextColor(WHITE);
  display.println("  TIET");
  display.setCursor(25, 35);
  display.setTextSize(1);
  display.print("Initializing...");
  display.display();
  delay(2000);
  sensors.begin();      // Initialize DallasTemperature library
  delay(500);
}
void loop() {
  if(counter==10)counter=6;
  byte val1 = nitrogen();
  delay(250);
  byte val2 = phosphorous();
  delay(250);
  byte val3 = potassium();
  delay(250);
  // Print values to the serial monitor
  Serial.print("Nitrogen: ");
  Serial.print(val1);
  Serial.println(" mg/kg");
  Serial.print("Phosphorous: ");
  Serial.print(val2);
  Serial.println(" mg/kg");
  Serial.print("Potassium: ");
  Serial.print(val3);
  Serial.println(" mg/kg");
  // Read moisture sensor and print
  float
moisture_percentage;
        //MOIS start
  int sensor_analog;
  sensor_analog = analogRead(sensor_pin);
  moisture_percentage = (100 - ((sensor_analog / 1023.00) * 100));
  Serial.print("Moisture Percentage: ");
  Serial.print(moisture_percentage);
  Serial.println("%");
        //MOIS end
  // Read temperature sensor and print
  sensors.requestTemperatures();//Send the command to get
temperatures
  float temperature = sensors.getTempCByIndex(0);
  Serial.print("Temperature: ");
  Serial.print(temperature);
  Serial.println("C");
  // TEMP end
  delay(1000);
  // Send SMS after 5 readings
  if (counter == 5) {
    sendSMS(val1, val2, val3, moisture_percentage, temperature);
  }
  if(counter>=5)
```

```
  {
    // counter = 0;
    // Display values on OLED
    display.clearDisplay();display.setTextSize(1);display.setCursor(0, 5);
    display.print("N: ");display.print(val1);display.print(" mg/kg");
    display.setCursor(0, 15);display.print("P: ");display.print(val2);
    display.print(" mg/kg");display.setCursor(0, 25);display.print("K: ");
    display.print(val3);display.print(" mg/kg");display.setCursor(0, 35);
    display.print("Moisture: ");display.print(moisture_percentage);
    display.print("%");display.setCursor(0, 45);
    display.print("Temperature: ");display.print(temperature);
    display.print("C");display.display();delay(3000);
    // countDown=5;
  }
  if(countDown>0){`
  display.clearDisplay();display.setTextSize(1);display.setCursor(0, 5);
  display.print("calculating in ");display.setTextSize(2);
  display.print(countDown);display.display();
  delay(2000);
  }
  countDown--;
  counter++;
}
byte nitrogen() {
  digitalWrite(DE, HIGH);
  digitalWrite(RE, HIGH);
  delay(10);
  if (mod.write(nitro, sizeof(nitro)) == 8) {
    digitalWrite(DE, LOW);digitalWrite(RE, LOW);
    byte values[7];
    for (byte i = 0; i < 7; i++) {
      values[i] = mod.read();
      Serial.print(values[i], HEX);
    }
    Serial.println();
    return values[4];
  }
  return 0;
}
byte phosphorous() {
  digitalWrite(DE, HIGH);
  digitalWrite(RE, HIGH);
  delay(10);
  if (mod.write(phos, sizeof(phos)) == 8) {
    digitalWrite(DE, LOW);
    digitalWrite(RE, LOW);
    byte values[7];
    for (byte i = 0; i < 7; i++) {
      values[i] = mod.read();
      Serial.print(values[i], HEX);
    }
    Serial.println();
    return values[4];
  }
  return 0;
}
byte potassium() {
  digitalWrite(DE, HIGH);
  digitalWrite(RE, HIGH);
```

```
  delay(10);
  if (mod.write(pota, sizeof(pota)) == 8) {
    digitalWrite(DE, LOW);
    digitalWrite(RE, LOW);
    byte values[7];
    for (byte i = 0; i < 7; i++) {
      values[i] = mod.read();
      Serial.print(values[i], HEX);
    }
    Serial.println();
    return values[4];
  }
  return 0;
}
void sendSMS(byte val1, byte val2, byte val3, float moisture, float
temperature) {
  simSerial.println("AT+CMGS=\"+91XXXXXXXXXX\"");  // Replace ZZ with the
country code and xxxxxxxxxx with the phone number
  delay(1000);
  simSerial.print("N: ");simSerial.println(val1);simSerial.print("P: ");
  simSerial.println(val2);simSerial.print("K: ");simSerial.println(val3);
  simSerial.print("Moisture: ");simSerial.print(moisture);
  simSerial.println("%");simSerial.print("Temperature: ");
  simSerial.print(temperature);simSerial.println("C");
  simSerial.write(26);  // Send Ctrl+Z to indicate the end of the message
  delay(1000);
}
```

6. Web Application: The whole application is made by using MERN stack and FLASK. The whole code exceeds 4000LOC so cannot be included in the documented format. The FLASK App has 4 main routes for the ML models. The web app is built using 8 controllers for 8 routes that are implemented in the application. The routes are as follows:

1. Api
2. Auth
3. Cart
4. Checkout
5. contactForm
6. order
7. product
8. user

Additionally, there are total 12 different pages in the application included in the frontend app.

5.3.3 Project Deployment

The application to be deployed professionally needs dockerization and Microservices architecture that will use the two services. One is the Flask ML service and the other one is the NodeJS Website server. So considering all the requirements, AWS LAMBDA service is required for deployment. Considering the deployment cost of dockerizing and using AWS Lambda on the cloud, the deployment can be done if funded.

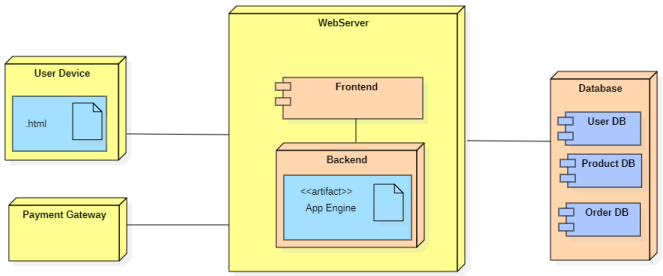
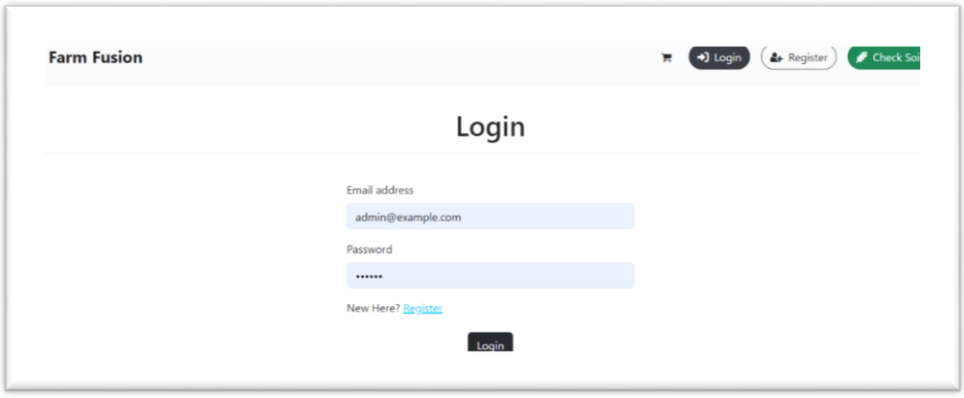


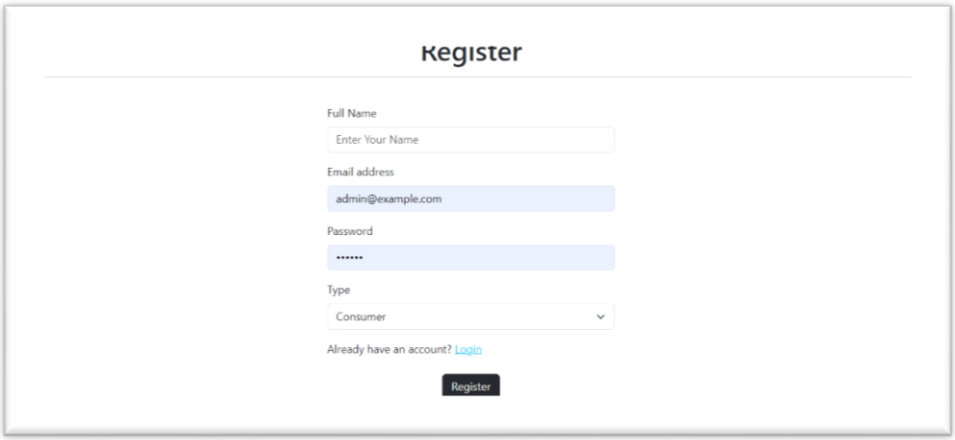
Figure 26 – Deployment Diagram

5.3.4 System Screenshots

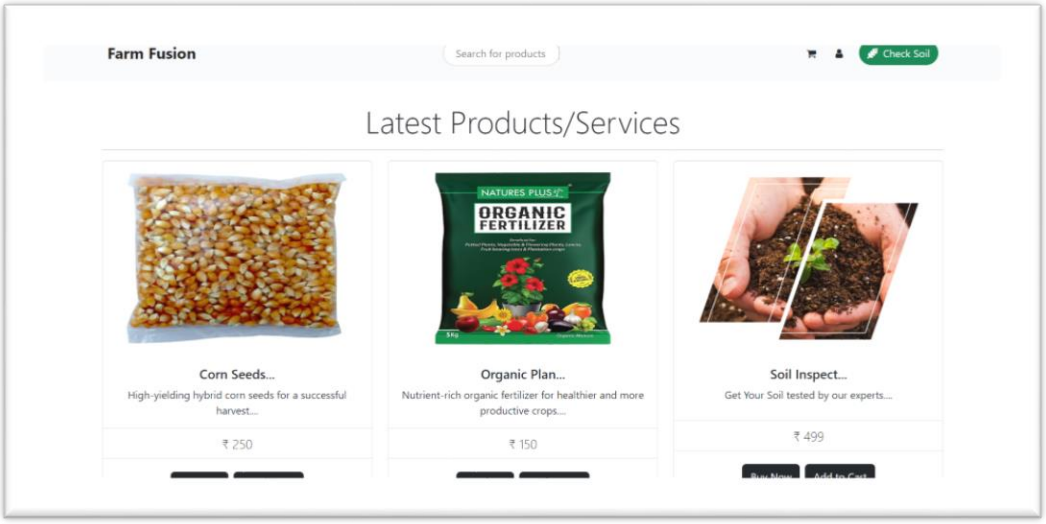
1. Login Page



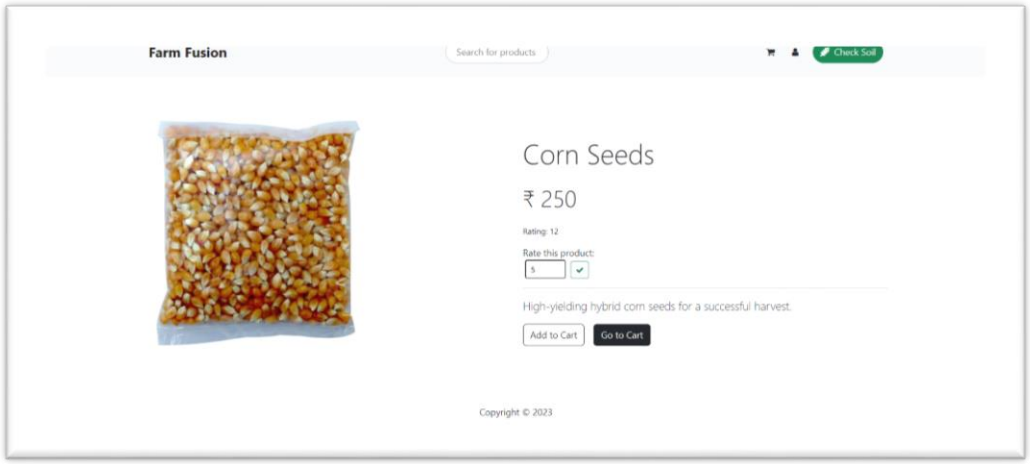
2. Register New User



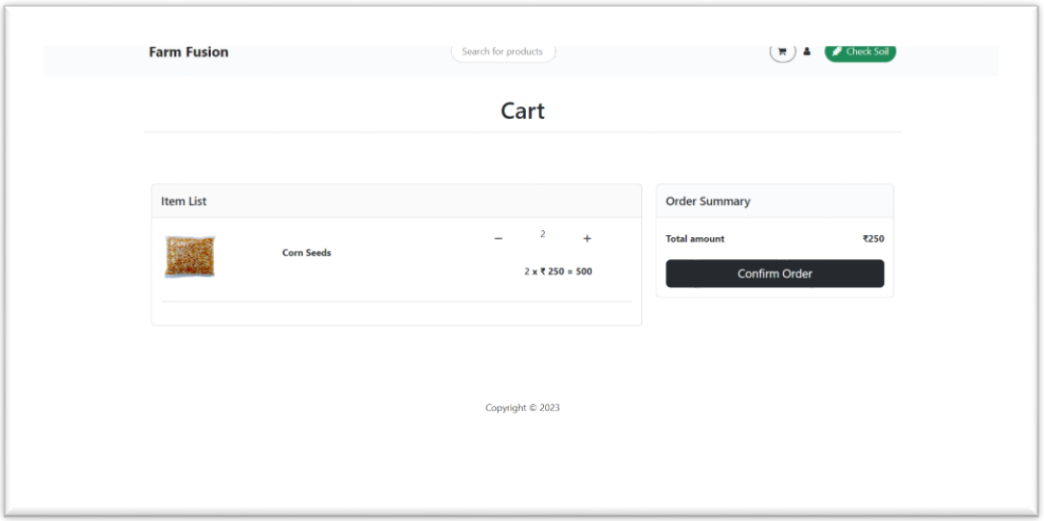
3. Product Catalogue



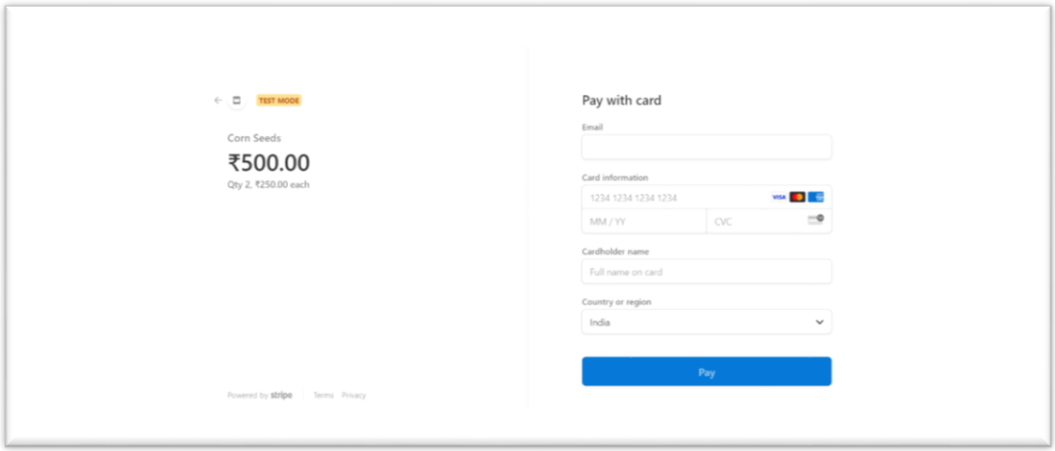
4. Product Page



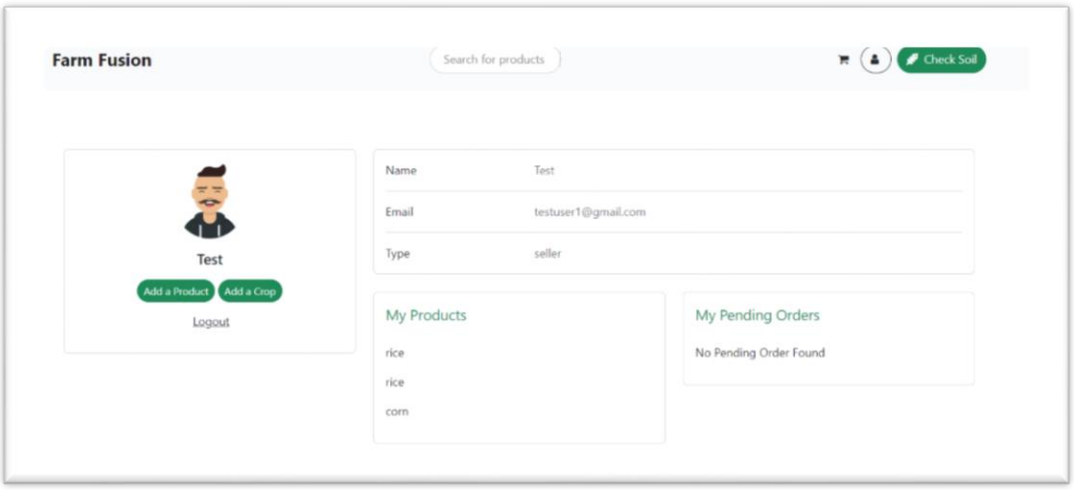
5. Cart



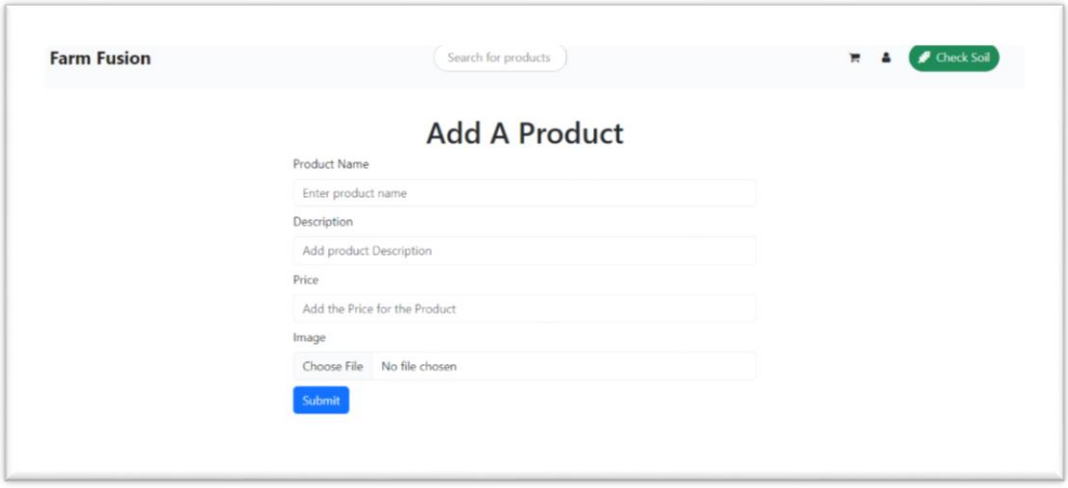
6. Checkout (Stripe Payment API Gateway)



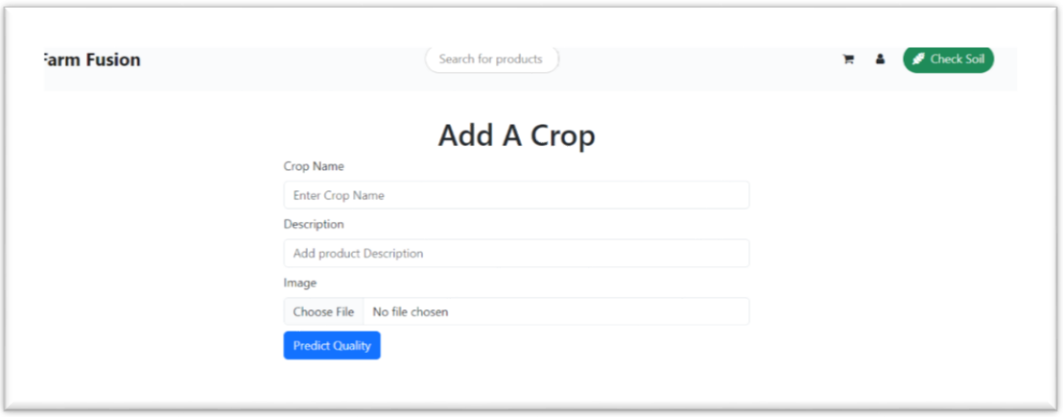
7. Profile Page



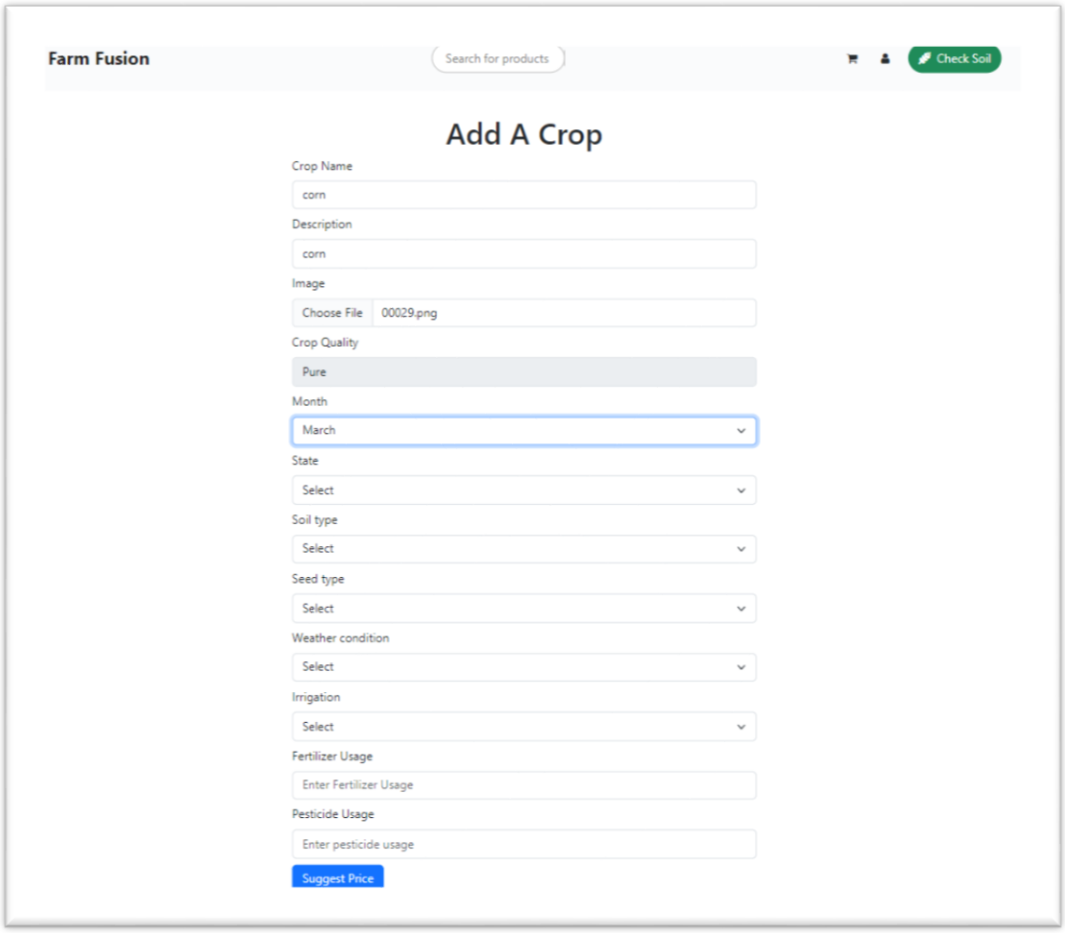
8. Add a Product



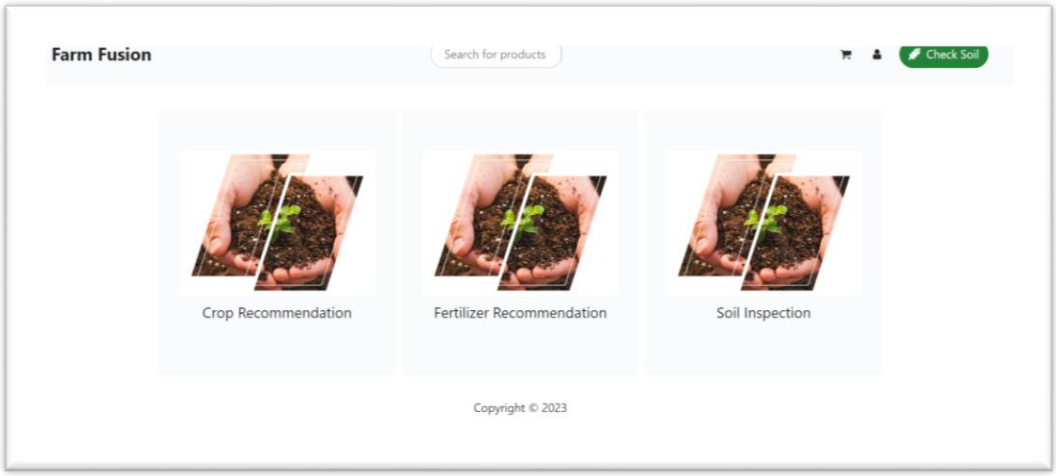
9. Add a Crop



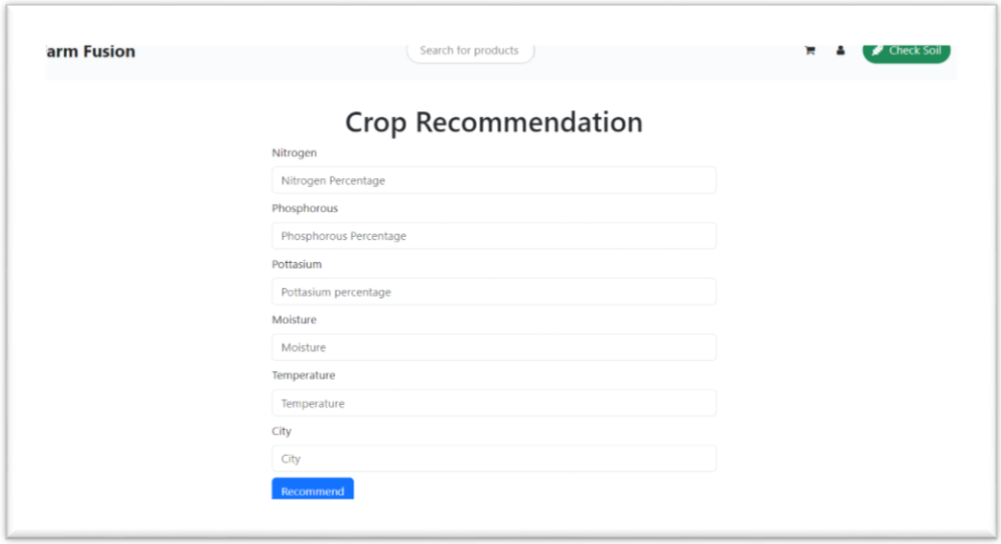
10. Add a crop (includes quality and price prediction)



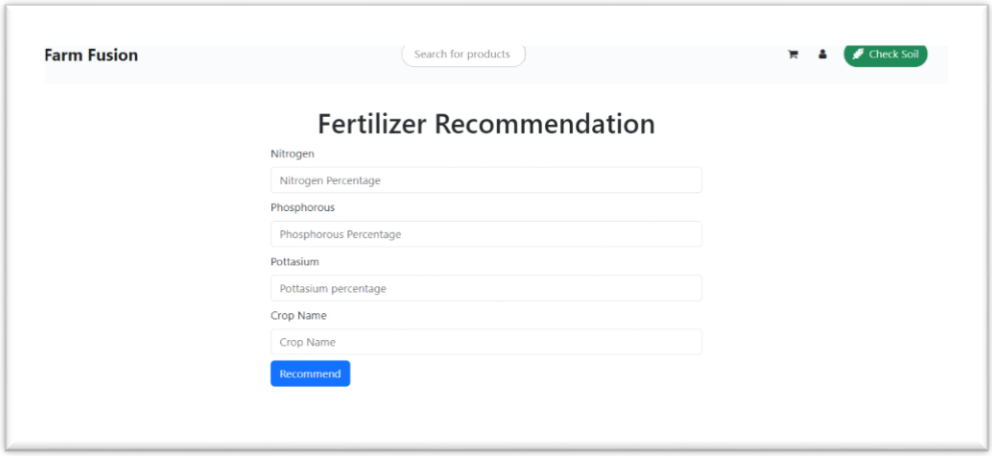
11. Your Soil Page



12. Crop Recommendation



13. Fertilizer Recommendation



5.4 Testing Process

5.4.1 Test Plan

The testing process is all about making sure that the web application, machine learning models, and hardware kit meet the standards we set and do what we want them to do. We have divided the testing process into stages to make sure we develop everything efficiently.

1. Hardware component Testing: All the sensors are test tested individually before combining them into the main hardware kit. This phase includes verifying the sensor measurements on extreme values. Like for Temperature sensor, testing in cold surrounding and also testing under heated surrounding to measure the extreme values.

2. Machine Learning Test Sets: The datasets for respective models are to be divided into training and testing datasets so that the prediction accuracy can be measured. Further improvement on models can be done only after seeing the results on test datasets.

3. Integration Testing: Combining the components and testing them altogether as a single unit is required for the combined testing of the hardware kit. This involves verifying the readings and their consistency over the same sample as well.

4. Website's Testing: This includes a series of various tests as a application requires many tests like Unit testing, Integration Testing, Regression Testing, Security and Stress Testing etc.

5.4.2 Features to be Tested

1. **Ecommerce Features:** The website's ecommerce features like catalogue, cart, payment gateway, user management and product management etc. need to be tested thoroughly each one by one after their implementation.
2. **ML Models:** All the ML models need to be tested and their flask api routes must be thoroughly tested for their functionality and handling the model's output results on the web page. Backend part of ML model needs to have proper handling mechanism for any wrong input that the users may enter.
3. **Hardware Features:** The SMS system and the oled display must be robust. There must be proper check on that.

4. **User Interfaces:** All the frontend UI/UX interfaces must be thoroughly checked for errors and misplacement/ alignment issues. Moreover, the responsiveness of the site needs to be ensured on different devices while building the application and testing it.

5.4.3 Test Strategy

Analytical Strategy: This involves testing based on the risks and requirements. We set up tests by looking at what could go wrong or what needs to be done. Then we organize the results for further study and use.

Model-based Strategy: This strategy creates models based on expected situations, taking into account inputs, outputs, processes, and potential behaviors. It's very helpful for testing the parts of the system that are based on Arduino technology.

5.4.4 Test Techniques:

Unit Testing: This involves closely examining individual parts to make sure they work correctly, including hardware pieces, machine learning algorithms, and dashboard functions.

Integration Testing: This focuses on finding problems that arise when different parts work together, both within each application and when the solar panel system, machine learning model, and dashboard interact.

Regression Testing: This method checks to ensure that new changes haven't caused previously working features to stop working. It's like making sure that fixing one thing didn't break something else.

Security Testing: This type of testing looks for vulnerabilities in the system that could be exploited by unauthorized users.

Stress Testing: This involves pushing the system to its limits to see how it performs under extreme conditions.

Performance Testing: This involves combination of speed and accuracy and robustness of the application over various aspects.

5.4.5 Test Cases

Ecommerce Features:

S.No.	Description	Steps	Expected Outcome	Verdict
1.	Catalogue Features	Navigating through the products and clicking on the Buy Now or Add to Cart button. Also using the Search functionality by typing a product name.	Proper Product page must open on clicking Buy Now. The Product must be added to cart when add to Cart is pressed. Searching the Products fetches the desired results.	Pass
2.	Cart Features	Clicking on Add to Cart on product page. Clicking the remove button in the cart view area. Modifying the quantity of products in cart. Clicking on Proceed to Check out	Product gets added into the cart. Product gets removed from user's cart according to the input. Quantity gets modified accordingly. Proceed to Payment Gateway	Pass
3.	Payment Gateway	After the user clicks on checkout, the user is directed to make a purchase via the payment gateway api.	After the details are entered and pay button is clicked, the order gets placed and the user can view it in his profile.	Pass
4.	User Management	The user registers himself.	The account is created for the user.	Pass

		The user Logins into the application. The user clicks on become a seller.	Once logged in, the site redirects to the catalog. The site changes the account form customer to seller and logs out the user.	
5.	Product Management	The sellers add products and crops after checking the quality prediction. The users can add rating to a product	The site fixes the quality prediction done on the basis of image uploaded by the seller. The rating gets updated in the database	Pass

Table 45 – Ecommerce Testing

ML Models:

S.No.	Description	Steps	Expected Outcome	Verdict
1.	Prediction Accuracy	Predict the readings on input of test data	Accurate prediction comes.	Pass
2.	Real-time Adaptability	Introduce real-time changes in conditions	ML Models adjusts predictions in real-time	Pass

Hardware Features

S.No.	Description	Steps	Expected Outcome	Verdict
1.	SMS and Display	Insert SIM into the slot. Powering on the Display.	Sim Makes a connection to GPRS. The display lights up and starts displaying the values.	Pass

2.	In field Testing of Hardware	Connect all sensors and test readings.	Sensors work together and give accurate readings.	Pass

Table 46 – Hardware Testing

User Interfaces:

S.No.	Description	Steps	Expected Outcome	Verdict
1.	Real-time Data Display	Observe data on the interfaces like catalog, cart etc.	Real-time updates displayed.	Pass
2.	User Interaction	Interact with dashboard features	Responsive and intuitive	Pass

Table 47 – User Interfaces Testing

5.4.6 Test Results

All the planned tests have been passed, confirming that the ecommerce system, machine learning models, and hardware components work as intended, are accurate, and can be relied upon.

5.5 Result and Discussion

Model Accuracies:

1. Crop Quality Classification: 90.82% on Test Set (Validation Set)

```
loss: 0.3084 - accuracy: 0.8815 - val_loss: 0.3143 - val_accuracy: 0.8944

loss: 0.3043 - accuracy: 0.8859 - val_loss: 0.2890 - val_accuracy: 0.9082
```

Figure 27- Model 1 Accuracy

2. Crop Recommendation: 99% on Test Set using Random Forest

```
SVM --> 0.9795454545454545
Logistic Regression --> 0.9522727272727273
RF --> 0.990909090909091
```

Figure 28- Model 2 Accuracy

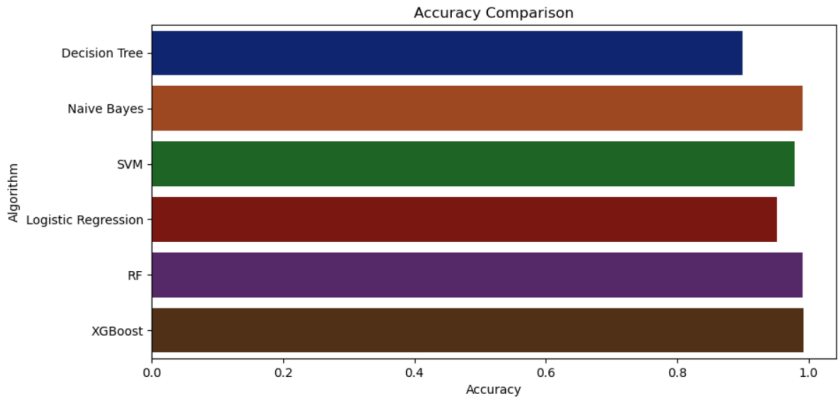


Figure 29- Model 2 Accuracy

3. Crop Price Prediction: 99% accuracy on Test Set using Naïve Bayes

```
Decision Tree --> 0.9
Naive Bayes --> 0.990909090909091
```

Figure 30- Model 3 Accuracy

4. Fertilizer Prediction: 88% accuracy on test set

```
336ms/step - loss: 0.3084 - accuracy: 0.8815
```

Figure 31- Model 4 Accuracy

- Our Project's Crop Quality Classification Model achieved more accuracy than the Sobhana et. al [5] CNN model that had an accuracy of 85% versus our 90% accuracy.

Hardware Testing: (*Readings are Calculated / Expected.)

Soil Type	Nitrogen (mm/kg)	Phosphorus (mm/kg)	Potassium (mm/kg)	Temperature (C)	Moisture (%)	Avg. Acc-uracy
Sandy	14/16	4/5	6/8	23.44	13.14%	84.1%
Silt	12/15	6/8	4/6	23.94	72.43%	68.2%
Clay	13/16	4/6	5/8	23.10	59.73%	76.4%
Loamy	18/24	5/8	8/9	23.21	24.12%	78.6%

Table 48 – Hardware Testing results

- Hardware is found to be 80% accurate according to the testing done.
- The Project demonstrates the use of multiple technologies for making a single platform to support farmers. All the web application features were tested successfully.

5.6 Inferences Drawn

The testing phase went through thorough validation of the e-commerce features, ML models, hardware components, and user interfaces. Unit testing ensured the correct operation of individual parts, while integration testing focused on interactions between different system components. Regression testing verified the stability of previously functioning features after new changes. Additionally, performance testing assessed the application's speed, accuracy, and robustness across various aspects. Overall, the testing phase provided valuable insights into the functionality, reliability, security, and performance of the system, ensuring its readiness for deployment.

5.7 Validation of Objectives

Upon successful completion of the stated objectives and tests, the following inferences can be drawn:

1. **Machine Learning Techniques**: The project involved a proper study of ML techniques and approaches for different classification and predictions, leading to an optimal techniques and models.
2. **Relevant Dataset Acquisition**: Relevant datasets and potentially comprising images were successfully obtained and utilized for training the models.
3. **Value Proposition Enhancement for E-commerce Platform**: The incorporation of innovative solutions, such as crop quality classification and soil insights, has increased the e-commerce platform's value proposition, by solving the needs of both farmers and customers and enhancing the overall user experience.
4. **Hardware-Based Soil Quality Measurement Device**: The successful making of a hardware-based soil quality measurement kit provides farmers with a practical tool for assessing soil quality parameters and making informed decisions from them.

Overall there is successful completion of the all the objectives proposed.

6. CONCLUSIONS & FUTURE SCOPE

6.1 Work Accomplished and Conclusion

1. E-Commerce website development:

The project started with the development of a comprehensive e-commerce website that acts as the focal point for communication between farmers and consumers. Through this platform, farmers may directly market their goods to consumers, who can then browse and buy agricultural items depending on their tastes and quality standards. To offer a consistent user experience, the website effortlessly incorporates a number of components, such as crop quality analysis, price projection, and fertilizer advice.

2. Machine Learning Algorithms:

To enable accurate crop quality classification and price prediction, the project successfully developed and implemented machine learning algorithms. These algorithms analyze various parameters to determine the quality of crops. Additionally, a sophisticated price prediction algorithm was developed, leveraging historical data from the compiled dataset of Indian Subcontinent. These algorithms were seamlessly integrated into the website's interface, allowing farmers and consumers to make informed decisions.

3. Soil Quality Measurement kit:

A significant aspect of the project involved designing and creating hardware components for soil quality measurement. This included the implementation of an NPK soil tester module, which allows farmers to determine essential mineral content in the soil, such as nitrogen, phosphorus, and potassium. The integration of this hardware component into the website's ecosystem enables farmers to gather vital information about their soil's health, aiding in informed decision-making for crop cultivation along with automatic messaging feature.

4. Fertilizer and Pesticide Recommender System:

Recognizing the importance of efficient fertilizer and pesticide usage, the project developed a sophisticated recommender system. This system employs machine learning algorithms to analyze soil quality data and recommend appropriate fertilizers and pesticides. The integration of this system into the website's architecture empowers farmers with personalized insights, ensuring optimal crop growth and minimizing waste.

5. **Datasets Compilation:**

The project meticulously collected and curated datasets essential for the successful implementation of machine learning algorithms. These datasets include the corn image dataset, which is pivotal for training the crop quality classification model, the price predictor dataset, aiding accurate price forecasting, and the fertilizer recommender dataset, crucial for enhancing crop cultivation practices.

6. **Documentation:**

A comprehensive documentation package was compiled to encapsulate the project's journey, methodologies, and outcomes. This documentation provides insights into the design, development, and integration processes, offering a valuable resource for future reference and potential scaling of the project.

Conclusions

In an era marked by rapid technological advancement and shifting paradigms, the project's journey to create a transformative e-commerce ecosystem for the agriculture industry stands as a testament to innovation, synergy, and the potential to reshape traditional practices. The endeavor set out to address key challenges faced by farmers, consumers, and stakeholders alike, with a holistic approach that encompasses machine learning, hardware integration, and user-centric design.

Through the creation of an intuitive e-commerce website, the project successfully provides a platform for farmers to directly connect with consumers. This fundamental shift empowers farmers by eliminating intermediaries, allowing them to present their products with transparency, and reach a global audience. Moreover, the integration of machine learning algorithms for crop quality classification and price prediction equips both sellers and buyers with accurate information, fostering informed decision-making and equitable transactions.

The addition of hardware components for soil quality measurement and the development of a fertilizer and pesticide recommender system underscore the project's commitment to addressing practical concerns faced by farmers. By facilitating soil health assessment and offering tailored recommendations, the project extends its impact beyond transactions to cultivating more sustainable and productive farming practices.

The compilation of datasets and meticulous documentation ensures the continuity of the project's achievements. These resources lay the foundation for future enhancements, iterations, and scaling efforts. As the agricultural sector continues to evolve, the project's holistic approach and synergy between technology and domain knowledge position it favorably to adapt to changing needs and demands.

The project's significance is not confined to its technical accomplishments but extends to its potential to catalyze broader societal change. By addressing concerns such as fair pricing, quality assurance, and knowledge dissemination, the project contributes to transforming the agriculture industry into a more transparent, efficient, and inclusive ecosystem. The ability to navigate uncertainties, such as the recent shifts in regulatory landscapes, attests to the project's resilience and relevance in dynamic contexts.

Looking ahead, the project's vision aligns with the trajectory of technological progress and the imperative to balance innovation with social impact.

6.2 Environmental, Social, and Economic Benefits:

The extensive web project designed to improve the agriculture industry offers a wide range of advantages in the areas of the environment, society, and the economy. Modernizing farming processes through the integration of technology, machine intelligence, and e-commerce also solves significant societal and economic issues.

1. **Environmental Benefits**

- **Reduced Waste:** Resource consumption is maximized by incorporating machine learning algorithms for crop quality classification and fertilizer advice. With less usage of pesticides and fertilizers, this precision-driven method lessens soil erosion and environmental contamination.
- **Sustainable Farming:** The initiative promotes sustainable farming methods by offering real-time soil quality evaluation and customized recommendations. As a result, the ecological impact is reduced, water use is decreased, and soil health is improved.
- **Minimized Food Waste:** Accurate price prediction and demand analysis empower farmers to align their production with consumer needs. This minimizes food waste caused by overproduction, contributing to a more sustainable food supply chain.

2. **Social Benefits:**

- **Empowered Farmers:** The e-commerce platform directly connects farmers with consumers, eliminating middlemen and enhancing their bargaining power. This empowerment ensures fair pricing, enabling farmers to earn a just income and improving their socio-economic status.
- **Transparency and Trust:** The platform's transparency in quality analysis, price prediction, and recommendation systems builds trust between farmers and consumers. This direct connection fosters better understanding and appreciation of each other's roles.
- **Access to Global Markets:** Particularly beneficial for small-scale farmers, the platform's global reach allows them to access a wider market beyond their local constraints. This exposure increases their customer base and potential revenue streams.

3. **Economic Benefits:**

- **Elimination of Middlemen:** By connecting farmers directly with consumers, the project eliminates intermediaries and their associated commissions. This results in increased profit margins for farmers and reduced costs for consumers.
- **Fair Pricing:** Accurate price prediction and real-time market data ensure fair pricing for both farmers and consumers. This balance boosts consumer trust and encourages consistent participation.
- **Improved Market Access:** The project's integration of machine learning and e-commerce provides farmers, regardless of scale, access to a global market. This expanded market reach enhances market competitiveness and economic resilience.

4. **Holistic Impact:**

The project's convergence of technological innovation with the agricultural sector generates a positive ripple effect across environmental, social, and economic aspects. It not only streamlines agricultural operations but also fosters inclusivity, sustainability, and equitable prosperity.

By mitigating environmental degradation, empowering farmers, and enhancing economic viability, the project exemplifies the potential of technology to drive meaningful change. As the project continues to evolve, its holistic impact can serve as a model for similar endeavors seeking to harmonize progress with societal well-being.

6.3 Reflections

The Farm Fusion project has been an innovative, cooperative, and exploratory experience. When one considers the advancements achieved and the difficulties faced, a number of important conclusions arise:

- Collaborating with one another has expanded our comprehension and facilitated a comprehensive strategy for tackling agricultural obstacles.
- It has been vital to stay up to date with technological developments, as doing so has expanded our comprehension of how technology might revolutionize conventional industries.
- Getting farmers, some of whom are not very tech-savvy, to use the site has proven to be a significant difficulty. When we consider this, we see how crucial it is to provide user-friendly interfaces and make investments in support and education networks.
- Reflecting on user feedback and iterative testing, we understand the importance of continuous improvement. Our future endeavors will be directed by this philosophy, guaranteeing that the platform adapts to the ever-changing demands of its users.

6.4 Future Work Plan

The project's current accomplishments provide a strong foundation, but there is ample opportunity to expand and refine its impact on the agriculture industry. The following future work plan outlines key directions for enhancing the project's effectiveness and extending its benefits across environmental, social, and economic domains.

1. **Algorithm Refinement and Diversification:**

- Enhance existing machine learning algorithms for crop quality classification and price prediction by incorporating more sophisticated models and leveraging additional parameters.
- Expand the algorithmic capabilities to cover a broader range of crops, ensuring that the platform caters to diverse agricultural needs.

2. **Real Time Data Integration:**

Implement real time market data integration into the platform to provide up to the minute pricing information and trends. This empowers farmers to make informed decisions aligned with market dynamics.

3. **User Centric Enhancements:**

- Gather feedback from farmers, consumers, and stakeholders to refine the user interface and experience of the ecommerce platform.
- Incorporate user suggestions to enhance usability, accessibility, and overall satisfaction.

4. **Sustainability Integration:**

Collaborate with environmental experts to incorporate advanced sustainability metrics into the crop quality analysis. This enables farmers and consumers to make environmentally conscious choices.

5. **Expanded Soil Health Analysis:**

- Further develop the soil quality measurement hardware to include additional parameters beyond NPK levels, such as pH, organic matter, and micronutrient content.
- Incorporate sensor technology for real time soil health monitoring and provide actionable insights for soil improvement.

6. **Collaboration with Certification Bodies:**

Collaborate with agricultural certification bodies to integrate quality certifications directly into the platform. This boosts consumer confidence and establishes the platform as a trustworthy source of information.

7. **Educational Resources:**

Develop a comprehensive educational portal within the platform, offering resources and guidance on sustainable farming practices, soil health improvement, and optimal fertilizer usage.

8. **Partnerships with Agricultural Institutions:**

Collaborate with agricultural research institutions to access the latest advancements in crop analysis, disease detection, and pest control. Integrate these findings into the platform to benefit farmers.

9. **Scaling and Global Reach:**

Explore opportunities to scale the platform's impact by expanding to different geographical regions, addressing region specific challenges, and tailoring solutions to local agricultural practices.

10. Regulatory Compliance and Support:

Keep the platform aligned with evolving agricultural regulations, and provide farmers and traders with resources to navigate regulatory changes effectively.

11. Continuous Documentation and Outreach:

Maintain and update the project documentation to reflect new developments and enhancements.

By pursuing these avenues, the project can continue to drive positive change in the agriculture industry, harnessing technology to foster sustainability, empower farmers, and promote economic growth. The future work plan is rooted in the project's core objectives and acknowledges the dynamic nature of the agricultural sector, ensuring its relevance and impact in the years to come.

7. PROJECT METRICS

7.1 Challenges Faced

1. **Hardware Accuracy and Reliability:** Ensuring the precise measurement of soil parameters using the NPK sensor, temperature sensor, moisture sensor, and Arduino Mega 2560 poses a challenge. Addressing potential inaccuracies in hardware readings is crucial for reliable soil quality assessments.
2. **User Adoption and Tech Literacy:** Farmers, particularly those with limited tech literacy, may face challenges in using the online platform for soil inspection requests and interacting with machine learning recommendations. Developing a user-friendly interface and providing adequate support and training becomes essential.
3. **Data Quality and Anomalies:** The quality of recommendations and predictions heavily relies on the accuracy and completeness of the input data. Challenges may arise in handling anomalies, outliers, and ensuring that farmers provide sufficient and accurate information during the registration process.
4. **Image Quality for Crop Assessment:** Obtaining high-quality images for seed quality detection is critical. Challenges may include variations in lighting conditions, resolution issues, and ensuring that farmers adhere to guidelines for capturing and uploading images.
5. **Algorithm Selection and Tuning:** Choosing the most suitable machine learning algorithms for both soil and crop quality prediction, and fine-tuning them for optimal performance can be challenging. The project must navigate the complexity of selecting algorithms that balance accuracy and efficiency.
6. **Market Price Variability:** Predicting fair prices for crops based on market trends introduces challenges due to the inherent variability in agricultural markets. The project must address fluctuations in prices and provide accurate predictions to benefit both farmers and consumers.

Addressing these challenges requires a combination of technological innovation, user education, and continuous monitoring and improvement throughout the project life cycle.

7.2 Relevant Subjects

These relevant subjects collectively contribute to the multidisciplinary nature of the project, emphasizing the need for a well-rounded team with diverse expertise to successfully address the challenges and goals outlined in the project overview.

- Software Engineering
- Machine Learning
- Engineering Design Project –II
- UI/UX
- Data Science Fundamentals
- Deep Learning

7.3 Interdisciplinary Knowledge Sharing

1. **Agricultural Science to Computer Science:** By exchanging knowledge on crop features, soil health, and farming techniques, agricultural scientists may help computer scientists create precise prediction models that are suited to specific agricultural requirements.
2. **Computer Science to Agricultural Science:** Computer scientists may help agricultural professionals comprehend and use cutting edge technology by providing them with explanations of machine learning algorithms, data pretreatment techniques, and image processing methods.
3. **Hardware Engineering to Agriculture and Computer Science:** To design dependable sensor systems and effectively integrate them into the agricultural process, hardware engineers must collaborate with specialists in computer science and agriculture.
4. **Data Science to Agronomy:** By working together, data scientists and agronomists can better grasp the importance of different data characteristics pertaining to crop and soil quality, and they may refine prediction models to better fit agricultural objectives and practices.
5. **Market Economics to Computer Science and Agriculture**: Economists and technology specialists working together can yield insightful information about pricing and market patterns, which can help design algorithms that forecast fair prices for agricultural goods.

Multidisciplinary knowledge exchange promotes a comprehensive strategy and enriches the project with a range of viewpoints and specialties. In order to meet the challenges of modernizing agriculture through novel technology and practices, collaboration is crucial.

7.4 Peer Assessment Matrix:

		Evaluation of				
		Sarthak	Sumaim	Vishvam	Armandeep	Meghna
Evaluation By	Sarthak	5	5	5	5	4
	Sumaim	5	5	5	4	5
	Vishvam	5	5	5	5	4
	Armandeep	5	5	4	5	5
	Meghna	5	5	5	4	5

Table 49 – Peer Assessment Matrix

7.5 Role Playing and Work Schedule

Sarthak	Lead Developer in H/W & S/W development and Documentation
Al Sumaim	Machine Learning, Web Development, Documentation
Vishvam	Hardware Development, Documentation
Armandeep	Data Analysis, Data Gathering
Meghna	UI/UX, Literature Survey

Table 50 – Role Playing

Gantt Chart of Work Flow:

		Name	Duration	Start	Finish
1		**FarmFusion**	**129 days?**	**2/1/23 8:00 AM**	**7/31/23 5:00 PM**
2		**Planning**	**6 days?**	**2/1/23 8:00 AM**	**2/8/23 5:00 PM**
3		Requirement Gathering	1 day?	2/1/23 8:00 AM	2/1/23 5:00 PM
4		Schedule Feasibility	1 day?	2/2/23 8:00 AM	2/2/23 5:00 PM
5		Techinical Feasibility	1 day?	2/3/23 8:00 AM	2/3/23 5:00 PM
6		Economic Feasibility	1 day?	2/4/23 8:00 AM	2/6/23 5:00 PM
7		Operatonal Feasibility	1 day?	2/6/23 8:00 AM	2/6/23 5:00 PM
8		Legal Feasibility	1 day?	2/7/23 8:00 AM	2/7/23 5:00 PM
9		Cultural Feasibility	1 day?	2/8/23 8:00 AM	2/8/23 5:00 PM
10		**Requirement Analysis**	**12 days?**	**2/9/23 8:00 AM**	**2/24/23 5:00 PM**
11		Functional Requirements	4 days?	2/9/23 8:00 AM	2/14/23 5:00 PM
12		Non-Functional Requirements	3 days?	2/15/23 8:00 AM	2/17/23 5:00 PM
13		SRS Document	5 days?	2/20/23 8:00 AM	2/24/23 5:00 PM
14		**Design**	**15 days?**	**2/27/23 8:00 AM**	**3/17/23 5:00 PM**
15		DFD	3 days?	2/27/23 8:00 AM	3/1/23 5:00 PM
16		UML Diagrams	6 days?	3/4/23 8:00 AM	3/13/23 5:00 PM
17		ER Diagrams	4 days?	3/14/23 8:00 AM	3/17/23 5:00 PM
18		**Implementation**	**64 days?**	**3/20/23 8:00 AM**	**6/15/23 5:00 PM**
19		Research	10 days?	3/20/23 8:00 AM	3/31/23 5:00 PM
20		Frontend	10 days?	4/1/23 8:00 AM	4/14/23 5:00 PM
21		Collecting Data	6 days?	4/15/23 8:00 AM	4/24/23 5:00 PM
22		Developing Algorithms	12 days?	4/25/23 8:00 AM	5/10/23 5:00 PM
23		Database	5 days?	5/11/23 8:00 AM	5/17/23 5:00 PM
24		Backend	21 days?	5/18/23 8:00 AM	6/15/23 5:00 PM
25		Unit Testing	54 days?	4/1/23 8:00 AM	6/15/23 5:00 PM
26		Integration Testing	54 days?	4/1/23 8:00 AM	6/15/23 5:00 PM
27		**Testing**	**16 days?**	**6/16/23 8:00 AM**	**7/7/23 5:00 PM**
28		**System Testing**	**10 days?**	**6/16/23 8:00 AM**	**6/29/23 5:00 PM**
29		Peformance Testing	5 days?	6/16/23 8:00 AM	6/22/23 5:00 PM
30		Function Tsting	5 days?	6/23/23 8:00 AM	6/29/23 5:00 PM
31		Security Testing	6 days?	6/30/23 8:00 AM	7/7/23 5:00 PM
32		**Deployment and Maintena...**	**15 days?**	**7/8/23 8:00 AM**	**7/28/23 5:00 PM**
33		Deployment	8 days?	7/8/23 8:00 AM	7/19/23 5:00 PM
34		Maintenance	7 days?	7/20/23 8:00 AM	7/28/23 5:00 PM
35		Documentation	129 days?	2/1/23 8:00 AM	7/31/23 5:00 PM

Figure 32 - Gantt Chart

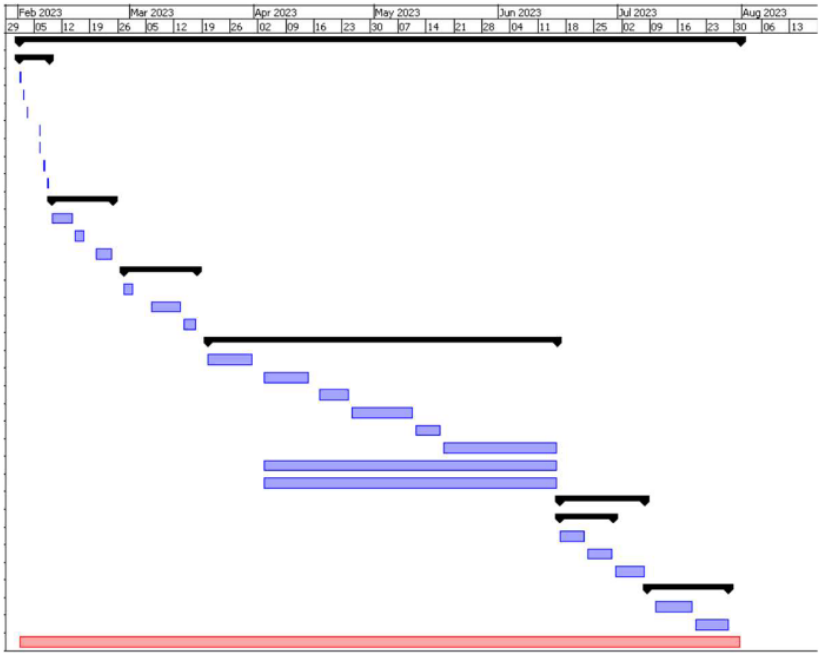


Figure 33- Timeline

This streamlined division of roles and work schedules, including the addition of documentation responsibilities, aimed at maintaining efficiency and clarity within the

team while ensuring all project aspects are well-documented and aligned with the specified requirements.

7.6 Student Outcomes Description and performance Indicators

SO	SO Description	Outcome
1.1	Ability to identify and formulate problems related to computational domain.	Identified challenges in soil and crop analysis, such as data quality, algorithm tuning, and market integration.
2.1	Design computing system(s) to address needs in different problem domains and build prototypes, simulations, proof of concepts, wherever necessary, that meet design and implementation specifications.	Developed a comprehensive e-commerce platform (Farm Fusion) integrating hardware, machine learning models, and user-friendly interfaces.
3.1	Prepare and present a variety of documents such as project or laboratory reports according to computing standards and protocols.	Documented methodologies, algorithms, and project metrics in compliance with standard reporting practices.
3.3	Able to communicate effectively with peers in a well-organized and logical manner using adequate technical knowledge to solve computational domain problems and issues.	Facilitated communication among team members, ensuring effective collaboration and understanding of complex technical aspects.
4.1	Aware of ethical and professional responsibilities while designing and implementing computing solutions and innovations.	Ensured ethical considerations in data handling, algorithmic decision-making, and platform transparency.
4.3	Evaluate computational engineering solutions considering environmental, societal, and economic contexts.	Addressed environmental impact by optimizing resource allocation based on soil quality, contributing to sustainable agriculture.
5.1	Participate in the development and selection of ideas to meet established objectives and goals.	Contributed to the conceptualization and development of the project, aligning with the goals of

		revolutionizing agriculture through innovation.
5.2	Able to plan, share and execute task responsibilities to function effectively by creating a collaborative and inclusive environment in a team.	Collaboratively executed tasks, promoting a team-oriented environment and ensuring the success of the integrated system.
6.1	Ability to perform experimentation and further analyze the obtained results.	Conducted experiments with soil and crop data, refining algorithms and models for accurate predictions and recommendations.
6.2	Ability to analyze and interpret data, make necessary judgments, and draw conclusions.	Analyzed diverse datasets, interpreting soil and crop information to derive meaningful insights for farmers and consumers.
7.1	Able to explore and utilize resources to enhance self-learning.	Demonstrated a proactive approach in exploring resources to address challenges, enhance skills, and contribute to continuous learning.

7.7 Brief Analytical Assessment

The Farm Fusion project is an example of an innovative and comprehensive strategy for bringing technology, e-commerce, and data-driven decision-making into agriculture today. Here's a concise analytical assessment:

Strengths:

- **Holistic Vision:** The project provides a holistic solution for farmers and customers by addressing several aspects of agriculture, such as crop quality evaluation, soil quality detection, and market forecasts.
- **Interdisciplinary Collaboration:** The group's wide range of experience in design, computer science, hardware engineering, and agricultural allows for a well-rounded strategy that guarantees that different project components are managed competently.

- **User-Centric Focus:** An effort to improve the user experience for both farmers and customers is demonstrated by the integration of an easy-to-use e-commerce platform and intuitive UI/UX design.
- **Innovative Technology Integration:** A creative and progressive approach to tackling agricultural difficulties is demonstrated by the application of e-commerce technology, hardware sensors, and machine learning algorithms.
- **Sustainability Considerations:** The project's focus on environmental effect is in line with current concerns for environmentally friendly solutions. This is demonstrated by the responsible use of technology and sustainable agricultural techniques.

Opportunities:

- **Continuous Improvement:** There is always room to improve the project's efficacy and relevance thanks to the iterative approach to fine-tuning algorithms and the platform in response to user input and technical developments.
- **Market Expansion:** Growing the e-commerce platform has the potential to give farmers more access to markets and give consumers a wider audience, which would boost the economic opportunity for all parties involved.
- **Education and Training:** To guarantee that the platform is widely used and that its advantages are realized, efforts to educate farmers—especially those who are less tech-savvy should be investigated.

Challenges:

- **Adoption of Technology:** One of the project's challenges is getting farmers, particularly those with low tech literacy, to use technology. It could be essential to concentrate on user education and training.
- **Data Quality Assurance:** The project's success depends on ensuring that the data is accurate and comprehensive for the e-commerce platform and machine learning models. Processes for rigorous data quality assurance should be put in place.
- **Real-time Communication:** It's critical that administrators and farmers communicate with each other promptly. Ensuring that there are no communication hiccups or delays can improve customer experience.

Conclusion:

The Farm Fusion initiative has the ability to completely transform the agriculture sector by giving farmers useful information, expanding their access to markets, and encouraging ethical and sustainable farming methods. The project is positioned for success due to the team's collaborative efforts and dedication to continuous development; yet, overcoming obstacles will call for smart interventions and a user-focused strategy. All things considered, the concept is a promising attempt to combine technology with agriculture.

APPENDIX A: REFERENCES

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APPENDIX B: PLAGARISM REPORT

Capstone Project Plagiarism Report

ORIGINALITY REPORT

14 %	11 %	8 %	10 %
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Thapar University, Patiala Student Paper	6%
2	www.scribd.com Internet Source	2%
3	forum.arduino.cc Internet Source	1%
4	www.scilit.net Internet Source	1%
5	www.researchgate.net Internet Source	1%
6	ieeexplore.ieee.org Internet Source	1%
7	link.springer.com Internet Source	1%
8	M. Sobhana, Pranathi Dabbara, Girija Ravulapalli, Krishna Sahithi Kakunuri. "Seed Quality Prediction using Computer Vision and Convolutional Neural Networks", 2022 4th International Conference on Inventive	1%