<u>ARTIFICIAL INTELLIGENCE IN FARMING</u>

A PROJECT REPORT

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Under the guidance of,
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PRESIDENCY UNIVERSITY

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

This is to certify that the Project report **"ARTIFICIAL INTELLIGENCE IN FARMING"** being submitted by "G SIVA SAI SATHWIK CHOWDARY, B ROSHAN BABU, M YASWANTH, R BHARGAV" bearing roll number(s) "20201CAI0001, 20201CAI0002, 20201CAI0049, 20201CAI0052" in partial fulfillment of the requirement for the award of degree of Bachelor of Technology in Computer Science and Engineering is a bonafide work carried out under my supervision.

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DECLARATION

We hereby declare that the work, which is being presented in the project report entitled **"ARTIFICIAL INTELLIGENCE IN FARMING"** in partial fulfillment for the award of Degree of **Bachelor of Technology** in **Computer Science and Engineering**, is a record of our own investigations carried under the guidance of **Dr. Mrutyunjaya M S, ASST-PROF-SCSE, School of Computer Science and Engineering, Presidency University, Bengaluru.**

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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ABSTRACT

The Indian agricultural sector grapples with challenges such as unpredictable weather, water scarcity, market uncertainties, and limited access to essential inputs. Farmers face difficulties in making informed decisions on crop selection and cultivation timing due to a lack of reliable guidance. Our project "AGRITENCE" is a web-based platform that assists Indian farmers in improving crop productivity and soil health. To deliver individualized recommendations, this unique technology combines Artificial Intelligence with enormous statistics on crops, fertilizers, pesticides, and soil characteristics. The platform's primary functionalities, which include Crop Recommendation, Fertilizer Recommendation, and Pesticide Recommendation, rely on machine learning and deep learning models.

Agritence's major purpose is to address important issues confronting Indian farmers, such as low productivity, improper crop choices based on soil characteristics, limited fertilizer expertise, and considerable crop losses due to pests. Agritence uses precision agriculture techniques to provide exact crop suggestions that are aligned with specific soil conditions, reducing erroneous crop choices and increasing yield.

Agritence ensures accurate crop predictions based on soil variables such as N, P, K, temperature, humidity, rainfall, and pH by utilizing ensemble models and a majority voting technique. Furthermore, it promotes sustainable farming methods by recommending organic fertilizers depending on nutritional values and crop varieties. The platform also uses powerful deep learning models, notably Convolutional Neural Networks (CNNs), to identify pests from uploaded photographs or user selections and recommends appropriate pesticides that comply with ISO standards (ISO 9001, ISO 14001, ISO 17025) for effective pest control.

The proposed solution holds the potential to significantly improve agricultural productivity and resource utilization. By leveraging technology to provide tailored recommendations, our project aims to enhance the decision-making capabilities of farmers, contributing to a more sustainable and economically stable agricultural sector in India.

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CHAPTER-1

INTRODUCTION

India, with a burgeoning population exceeding 1.25 billion, faces an escalating food security crisis, heightening the imperative for robust solutions in the agricultural sector. As a linchpin of the Indian economy, agriculture grapples with multifaceted challenges stemming from a population surge, erratic weather patterns, and volatile market conditions. The necessity for innovative approaches to sustain and enhance agricultural productivity becomes increasingly urgent in the face of these complex and interrelated issues.

This project delves into the heart of India's agricultural challenges, seeking to address the pressing concerns that hinder the sector's efficiency and resilience. With a focus on harnessing technology and artificial intelligence, the project aims to empower farmers by providing tailored recommendations for crop selection, optimal cultivation timing, and resource management. The overarching goal is not only to improve individual farming practices but to contribute to broader objectives of food security and sustainable agriculture. Through collaboration with experts, technological professionals, and government agencies, this initiative aspires to usher in a transformative era for Indian agriculture, leveraging cutting-edge solutions to navigate the intricacies of modern farming.

1.1 Overview:

Agritence is a website that provides farmers with crop suggestions depending on N, P, K, temperature, rainfall, relative humidity, and pH. In general, if the wrong crop is picked, soil degrades and productivity suffers, but Agritence makes it simple by utilizing a machine learning model to make real-time predictions. The second feature is Fertilizer Prediction. If the farmer chooses not to modify the crop depending on the land, he can continue with the same crop but apply fertilizer recommended by Agritence based on N, P, K, and crop values. Finally, a very useful feature has been implemented: Pesticide Recommendation.Pests pose a significant hazard, but they can be eliminated. Farmers simply submit a clear photo of the pest, and Agritence will identify the insect using the DL Model, which is CNN, and will propose the proper pesticide as well as the required dosage to eliminate pests and safeguard the crop. If the farmer is already aware of the pest, he or she can choose it, and the appropriate insecticide will be recommended. Generally, soil testing are done by the Indian government and results come within a few days, but farmers really don't know what to do next, so agriculture is sort of their next step.A simple, intuitive website will allow farmers to quickly track the whereabouts of crops, assisting Agritence in any way it can. As a result, the three modules—Crop, Fertilizer, and Pesticide—are extremely useful and beneficial to farmers.

1.2 Problem Definition:

Agritence aims to help Indian farmers and reduce their hardship. The problems faced by Indian farmers are defined as follows:

i. In order for farmers to earn more money from the same amount of land without causing soil degradation, productivity must be raised.
ii. Indian farmers lack the knowledge necessary to select the best crop for their soil, which is dependent on various elements such as pH, temperature, humidity, rainfall, N, P, and K.
iii. Most farmers are unaware of which fertilizers—standard or organic—to use depending on the needs of their soil.
iv. Soil degradation brought on by insufficient and uneven fertilization is causing nutrient mining and the emergence of second-generation nutrient management issues.
v. The Associated Chambers of Commerce and Industry of India conducted a research that found that bugs cause Rs. 50,000 crore in crop losses per year.

1.3 Objective:

According to the problem statements mentioned above, following are the objectives that "Agritence" is trying to solve:

a. To put precision agriculture into practice (precision agriculture is a modern farming technique that reduces crop selection errors and increases productivity by using research data on soil types, characteristics, and crop yield data collection).
b. To address the issue by putting forth a highly accurate and effective recommendation system for the site-specific parameters using an ensemble model and majority voting technique.
c. To suggest organic fertilizer based on crop and N, P, and K values.

d. To identify the type of pest and suggest a specific pesticide that is accessible in India in accordance with ISO standards (ISO 9001, ISO 14001, ISO 17025).
e. To create a web application to accomplish the aforementioned goals.

1.4 Need Analysis:

The works done in this field of agriculture are disintegrated and no single platform provides all such facilities of crop recommendation, fertilizer recommendation, and pesticide recommendation altogether. “Agritence” is a stop solution to all the problems of the farmers and the feedback system helps to improve and adapt according to the needs of the farmers. The work in the field of pests is only limited to pest detection but “Agritence” extends the idea of pest identification to pesticide recommendation as per the corresponding pest identified which is a practical use of pest detection. Along with that, the dataset is more customized to Indian farms which are unique in themselves. The fertilizers recommended are natural fertilizers and the pesticides are as per ISO standards.

1.5 Outcomes and Deliverables:

The idea is to create a web application that has three major modules namely

1. **Crop Recommendation**
   a. The user will input values of N, P, K, temperature (in °C), relative humidity (in %), rainfall (in mm), and pH.
   b. Output: Prescribed Crop
2. **Fertilizer Recommendation**
   a. The user will input values of N, P, K, and crop.
   b. Output: Corresponding organic fertilizer suggestions.
3. **Pesticide Recommendation**
   a. The user will upload an image that clearly shows the pest on the crop.
   b. Alternatively, the user can also select the pest if the user already knows which type of pest is present in the crop.
   c. Output: Identified pests corresponding with the recommended pesticides available in India as per ISO standards (ISO 9001, ISO 14001, and ISO 17025).

CHAPTER-2

LITERATURE SURVEY

Agriculture is a major source of income in India and one of the primary industries driving economic growth. Farmers mostly deal with crops, fertilizers, pests, and insecticides. As a result, Agritence aims to support Indian farmers through three modules: Crop Recommendation, Fertilizer Recommendation, and Pesticide Recommendation. Crop recommendation has been extensively studied, although all methods differ depending on the factors fed into the Model. The majority of ML models employ Random Forests, others use Decision Trees, and others use Ensemble techniques using a Majority Voting mechanism. Fertilizer recommendation does not work well in the field of AI. The primary issue could be disintegrated data, but Agritence gathered all of the data from numerous sources and combined it to create a well-formed dataset. Third, Pesticide Recommendation is an unexplored area; academics have only focused on Pest Detection, but Agritence expands on the concept of pest identification, as well as a dictionary-based solution for the corresponding pesticide, which is available in India. Pesticide recommendations from Agritence are based on ISO 9001, ISO 14001, and ISO 17025 standards. The majority of pesticides are obtained from the biostat site, which is a popular site for farmers; nevertheless, searching there is difficult, and the largest number of pesticides advised are not available in India. The following sections address several study studies on the services provided by Agritence.

Rajak et al. 951-952 [1] Discuss crop prediction using several learners, including SVM as a classifier, Naive Bayes, Multilayer Perceptron (ANN), and Random Forest. Crop forecast characteristics include pH, depth, water holding capacity, drainage, and erosion.

The rule below demonstrates an example of the proposed recommendation system. If pH is mild alkaline depth is above 90 water holding capacity is LOW drainage is moderate and the erosion is LOW THEN PADDY

Dighe et al. 476-480 [2] We evaluated techniques such as CHAID, KNN, K-means, Decision Tree, Neural Network, Naïve Bayes, C4.5, LAD, IBK, and SVM to create rules for recommendation systems. To pick the most likely crops for plantation, numerous parameters such as soil pH, the month of cultivation, weather in the region, temperature, soil type, and so on were taken into account.

Mokarrama and Arefin [3] The following modules were discussed: location detection, data processing and storage, similar location detection, and recommendation creation. The final crop was calculated using the physiographic database, thermal zone database, crop growth period database, crop production rate database, and seasonal crop database.

Gandge and Sandhya [4] Discuss attribute selection, multiple linear regression, and decision trees with ID3, SVM, Neural Networks, C4.5, K-means, and KNN. The proposed system begins by selecting an agricultural field and then selecting a previously planted crop; it then takes user input and preprocesses it; in the backend, attribute selection is followed by a classification algorithm on data; and finally, the crop is recommended.

Mishra et al. [5]J48, LAD Tree, LWL, and IBK algorithms are utilized. The WEKA tool is used initially, and the LAD tree exhibited the lowest accuracy. However, trimming the tree can reduce errors, and IBK offers good results.

Wu et al. [6] IP102 is a large-scale dataset for insect pest identification that includes over 75,000 photos of 102 insects. In comparison to prior datasets, the IP102 accurately represents several aspects of insect pest dispersal in real-world settings. Meanwhile, they use the dataset to experiment with cutting-edge recognition systems. The results reveal that conventional handmade and deep feature approaches are insufficient for pest identification.

Table 1: Comparative Study for Crop Recommendation

Sr. No.	Name of Researcher, Year of Publication	Paper Title	Parameters Used/ Database Used	Methodology Adopted/ Modules Used
1	Rajak et al. , 2017	Crop Recommendation System to Maximize Crop Yield Using Machine Learning Technique.	pH, depth, water holding capacity, drainage, erosion.	SVM is used as a classifier, Naive Bayes, Multilayer perceptron (ANN), and Random Forest.
2	Dighe et al, 2018	Crop Recommendation System for Precision Agriculture.	pH level of soil, month of cultivation, weather in the region, temperature, type of soil	CHAID, KNN, K-means, Decision Tree, Neural Network, Naïve Bayes, C4.5, LAD, IBK and SVM
3	Mokarrama and Arefin, 2017	RSF: A Recommendation System for Farmers.	Physiographic database, Thermal zone database, Crop growing period database, crop production rate database, and seasonal crop database.	Location Detection, Data analysis, and storage, Similar location detection, and Recommendation generation.
4	Gandge and Sandhya, 2017	A study on various data mining techniques for crop yield prediction.	Agricultural field, Crop previously planted.	Attribute selection, Multiple Linear Regression, Decision Tree using ID3, SVM, Neural Networks, C4.5, K-means, and KNN

5	**Mishra et al., 2018**	**Use of data mining in crop yield prediction**	**Not mentioned**	**J48, LAD Tree, LWL, IBK algorithm.**

Kasinathan et al [7] Using a machine learning and insect pest detection algorithm, various insect datasets were identified and detected, and the results were correlated. ANN, SVM, KNN, Naive Bayes, and the CNN model were used to test classification accuracy between different machine learning techniques. According to the findings, the CNN model has the best classification precision of 91.5 percent and 90 percent for 9 and 24 insect groups, respectively, from the Wang and Xie datasets.

Ding and Taylor [8] describe a tool for automatically tracking pests using photographs from traps. A sliding window-based detection pipeline is proposed, in which a convolutional neural network is applied to image patches at various locations to decrease the success of possessing a particular pest type. To generate the final detections, image patches are filtered using non-maximum suppression and thresholding based on their positions and related confidences.

TÜRKOĞLU and HANBAY [9] For the identification of plant diseases and pests, the different effects are compared of deep feature extraction and transfer learning. Deep features for tuning layers of these deep models were extracted. The resulting deep features were then analyzed using SVM, ELM, and KNN classifiers. Deep models were then fine-tuned with images of plant illnesses and pests. Deep learning models outperformed conventional approaches, according to the evaluation results. Deep feature extraction yielded better results than transfer learning.

(Selvaraj et al.) i.e paper [10] Using a transfer learning approach, massive datasets of expert pre-screened banana disease and pest symptom/damage images were gathered and used to model three distinct convolutional neural network (CNN) architectures for detection. The DCNN proved to be a reliable and simple-to-implement technique for detecting digital banana disease and pests. Deep transfer learning (DTL) uses a pre-trained disease recognition algorithm to create a network that can make reliable predictions, and it was discovered that ResNet50 and InceptionV2-based models worked better than MobileNetV1.

Table 2: Comparative Study for Pest Detection

Sr. No.	Name of Researcher, Year of Publication	Paper Title	Parameters Used/ Database Used	Methodology Adopted/ Modules Used
6	**Wu et al., 2019**	**A Large-Scale Benchmark Dataset for Insect Pest Recognition**	**Pest identificatio n database IP102**	**handcrafted feature methods and deep feature methods**
7	**Kasinathan et al., 2020**	**Insect classification and detection in field crops using modern machine-learning techniques**	**Different field crops**	**ANN, SVM, KNN, Naive Bayes, and the CNN model**
8	**Ding and Taylor, 2016**	**Automatic moth detection from trap images for pest management**	**commercial codling moth dataset**	**CNN**
9	**TÜRKOĞL U and HANBAY, 2018**	**Plant disease and pest detection using deep learning-based features**	**Plant diseases and pest database**	**SVM, ELM, and KNN classifiers**
10	**Selvaraj et al., 2019**	**AI-powered banana diseases and pest detection**	**Datasets of expert pre-screened banana disease and pest**	**Distinct convolutional neural network, Deep transfer learning algorithm, ResNet50 model, InceptionV2 model, and MobileNetV1 model**

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

The literature analysis reveals that India's agricultural environment has made great achievements in harnessing technology, machine learning (ML), and artificial intelligence (AI) to solve critical areas of farming, such as crop recommendations, fertilizer consumption, and insect management. However, in this field of innovation, various research gaps and undiscovered territories emerge, highlighting prospects for further enhancement and refinement:

1. Integration of Comprehensive Data Sources: This analysis highlights studies on crop advice, fertilizer management, and pest detection. However, a significant gap exists in the integration and complete use of several data sources. Existing approaches frequently rely on small datasets or fail to incorporate multiple sources of information required for exact suggestions. It is still difficult to incorporate real-time, localized, and multidimensional data, such as soil parameters, weather patterns, historical crop yields, and insect profiles. A more comprehensive approach to data aggregation could improve the accuracy and relevance of recommendations.

2. Optimizing Recommendation Algorithms: Many machine-learning algorithms have been used for crop recommendation, fertilizer management, and pest identification. However, there is still room for improvement in accuracy and usability. The present procedures frequently rely on classic algorithms like SVM, Decision Trees, and Ensemble methods. However, a comparative investigation of the efficiency of these algorithms in the context of Indian agricultural settings is lacking. Furthermore, the implementation of cutting-edge techniques such as deep learning and neural networks for these purposes requires further investigation and validation in the Indian agricultural environment.

3. Tailored Recommendations for Agriculture: Given India's different agricultural environments, tailored recommendations are critical. Soil types vary in nutrient composition, ranging from fertile alluvial soils in the Indo-Gangetic plains to red and black soils on the Deccan Plateau, which influences agricultural development. Microclimates are complicated and influenced by factors such as altitude, proximity

to water bodies, and weather patterns.

4. Crop appropriateness varies substantially by area, with crops surviving in Rajasthan's arid zones differing from thoSoil types vary in nutrient composition, ranging from fertile alluvial soils in the Indo-Gangetic plains to red and black soils on the Deccan Plateau, which influences agricultural development. Microclimates are complicated and influenced by factors such as altitude, proximity to water bodies, and weather patterns.

5. in Kerala's tropical environment. Diverse insect characteristics throughout states present various pest management issues. Addressing regional differences through fine-tuned recommendation systems is critical. Precise instruction tailored to area conditions empowers farmers, allowing them to make more informed decisions about improving sustainable agriculture methods.

6. Accessibility and Usability for Farmers: Improving the accessibility and usefulness of agricultural technological solutions is critical to their effective implementation by Indian farmers. The common absence of user-friendly interfaces in existing systems impedes their adoption, particularly among farmers with low technological skills. Simplifying the interface design and optimizing navigation are essential steps towards closing the gap. It is critical to provide intuitive and visually simple interfaces that transcend language boundaries and accommodate farmers with varied levels of literacy and technological proficiency. Furthermore, activities focused on farmer-centric design principles and usability testing suited to local contexts are required to guarantee that these solutions meet the unique needs and preferences of India's diverse farming community. By emphasizing user-centric design and ease of engagement, agricultural technology can become more inclusive, allowing all farmers to reap the benefits of these advances for increased production and sustainable agricultural practices.

7. Validation and Integration of Pest Identification Techniques: Validating pest detection systems under the various field circumstances seen throughout India is critical for their practical application. Field conditions differ greatly among locations due to varying weather, soil types, and cropping patterns, which influence insect

prevalence and behavior. Testing the durability and accuracy of image-based recognition and deep learning approaches in these diverse contexts is critical to ensuring their dependability in real-world situations. Furthermore, while identification is critical, the integration of such identification with precise and accessible pesticide recommendations that meet ISO requirements necessitates further exploration. Bridging this gap will necessitate collaborative efforts in field trials and validation studies to determine the efficacy and dependability of integrated systems. Developing complete systems that smoothly link insect identification to suggested pesticides while adhering to international quality standards will considerably improve Indian farmers' pest control techniques, thereby protecting crop yields and agricultural sustainability.

8. Sustainability and Long-term Impact Assessment: Understanding the long-term implications of recommendation systems for different aspects of agricultural sustainability is critical for making educated decisions. Evaluating the long-term effects on soil health, such as changes in nutrient levels, soil structure, and microbial diversity, is critical for determining the sustainability of recommended measures. Furthermore, analyzing their impact on crop output, pest dynamics, and overall agricultural productivity over time is required to provide a thorough understanding of their effectiveness. Beyond agronomic considerations, investigations should look into the socioeconomic implications for farmer lives, such as income stability and resource management techniques. Researchers can validate the usefulness and durability of these recommendations by undertaking comprehensive, longitudinal studies that include a wide range of agroecological zones and farming practices. This research will not only inform policymakers but will also provide farmers with sustainable methods that promote long-term agricultural resilience and success.

9. Adaptive Feedback Mechanisms: Adding adaptive feedback mechanisms to recommendation systems is critical to increasing their usefulness and relevance in changing agricultural settings. The existing limits of these systems derive from their static character, as they lack mechanisms for learning and adapting in real-time based on farmer feedback. It is critical to develop responsive systems that use real-time data to track the performance and effects of recommendations. These systems can constantly fine-tune their recommendations by adding machine learning algorithms

capable of processing and integrating input. Furthermore, creating a collaborative atmosphere that fosters active engagement and feedback from farmers would help to iteratively enhance these systems. Establishing strong mechanisms for continual learning and adaptation ensures that recommendation systems evolve dynamically, remaining responsive to the changing demands and challenges faced by farmers in their agricultural practices.

CHAPTER-4

PROPOSED METHODOLOGY

The process of creating an AI-driven application designed to support farmers in making well-informed decisions entails a methodical approach that includes problem analysis, identification of user needs, design of the program's architecture, and subsequent implementation of the application. The methodology utilized adheres to a well-defined framework to effectively address the varied requirements of the agricultural sector.

The methodology employed in this project centers on the resolution of issues encountered by farmers using integrating sophisticated technologies and employing data-driven decision-making. The method prioritizes user-centric design and development, aiming to create an intuitive application that addresses the specific needs of farmers. This is achieved by incorporating AI algorithms to provide personalized recommendations.

4.1 Ideology

The design procedure is a systematic approach used to develop and create a product system, or solution. It involves a series of steps.

A. **Problem Analysis:** An extensive examination was undertaken to analyze the various difficulties faced by farmers, encompassing volatile weather patterns, uncertainties in the market, and restricted availability of up-to-date information and professional guidance. The main pain points and gaps in present agricultural practices were identified to establish the basis for the functions of the application.
B. **User Requirements:** The research team actively engaged with farmers, agricultural specialists, and stakeholders to comprehensively comprehend their specific needs, preferences, and limitations. It created an exhaustive inventory of user specifications, considering geographical disparities, crop-specific necessities, market dynamics, and issues related to accessibility.
C. **Architectural Design:** The application architecture was designed with careful consideration given to factors such as scalability, data integration, and user accessibility and developed a comprehensive architecture that incorporates multiple

layers, including data collecting, analysis, artificial intelligence algorithms, and a user-friendly interface.

D. **Application Development:** The Agile technique was utilized to facilitate iterative development, enabling the integration of ongoing feedback from agricultural specialists. The selected programming languages, machine learning libraries, and development frameworks were employed to execute the implementation of data analysis and application interfaces. The primary objective is to develop a user-friendly interface that is intuitive and facilitates efficient navigation for farmers. This interface will be accessible through both web and mobile platforms, ensuring widespread availability.
E. **Implementation of AI Algorithms:** The AI algorithms were developed and deployed to facilitate data analysis, predictive modeling, and the development of personalized recommendations. The utilization of machine learning methodologies was employed to analyze a wide range of data sets, thereby offering customized recommendations and guidance to agricultural practitioners.
F. **Testing and Validation:** A series of comprehensive testing phases were performed to ascertain the functionality, dependability, and accuracy of the application. The application's recommendations were assessed for data accuracy and relevancy by comparing them to real-world events and expert opinions.
G. **Phased Deployment and Iterative Improvement:** The application was deployed in stages, considering user feedback, and implementing iterative enhancements to optimize performance and usability. Implemented a systematic process of ongoing surveillance and revisions to uphold the precision and pertinence of the data.

The technique employed in this study is based on problem analysis, user-centric design, and iterative development. It provides a structured framework for the effective development and implementation of an AI-driven application that helps in predictive modeling. The fundamental goal of this application is to improve farmers' decision-making abilities in the field of agriculture by deploying the problem into three basic components, which are:

- Crop Recommendation
- Fertilizer Recommendation
- Pesticide Recommendation

4.2 Proposed Solution

“Agritence" consists of three modules: crop recommendation, fertilizer recommendation, and pesticide advice. The approaches for each module differ, but the objective is the same: accurate predictions for the user's request.

4.2.1 Crop Recommendation

Step 1: Data Acquisition

The dataset can be obtained from Kaggle and adjusted to meet the project's needs. The dataset comprises crop-specific N, P, K, pH, temperature, humidity, and rainfall variables.

Step 2: Values Input

Users are expected to enter site-specific input parameters such as N, P, and K (all in percentages), temperature (in degrees Celsius), relative humidity (in percent), rainfall (in millimeters), and pH value.

Step 3:ML Model Training and File Creation (.pkl)

The machine learning model is built on ensemble learning approaches, with a majority voting classifier as the primary methodology. The constituent models include:

1. SVM
2. Random Forest.
3. Naive Bayes.
4. kNN

A.pkl file is created once the model has been trained with the data.

Step 4: Crop Recommendation

The .pkl file is loaded to recommend the best crop to farm based on user-specific information.

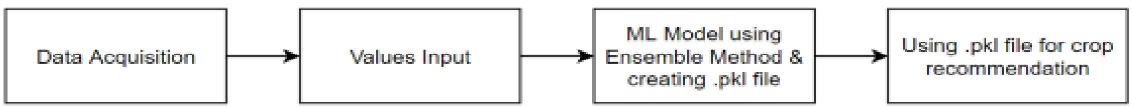

Fig.4.1 – Crop Recommendation Model

4.2.2 Fertilizer Recommendation

Step 1: Data Acquisition

The dataset will be built manually after collecting data from the many trustworthy sources listed below.

1. Fertilizer Association of India.
2. Indian Institute for Water Management
3. Kaggle.

The dataset contains N, P, and K values (all in percentages) together with respective crop labels.

Step 2: Values Input

Users are requested to provide site-specific data such as N, P, and K (all in percentages) as well as the crop to be examined for fertilizer type (from a list of just 22 crops supported).

Step 3:Difference between the desired and actual values.

The difference between the desired value of N, P, and K per crop and the farm's actual value is determined, and the fertilizer outcome is forecasted using this difference. All three nutrients can lead to one of three outcomes:

1. High 2. Low 3. Up to mark

Step 4: Fertilizer recommendation.

A dictionary-based solution (organic fertilizers) will be displayed based on the differences in intended and actual N, P, and K values for the crop.

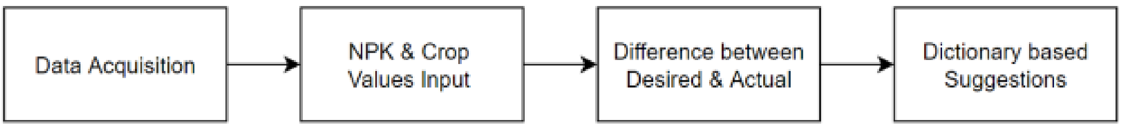

Fig.4.2 – Fertilizer Recommendation Model

4.2.3 Pesticide Recommendation

Step 1: Data Acquisition

The dataset will be created by web scraping of images from Google via automatic script using Selenium and Chrome Driver. Along with that, pest labels will be provided as well.

Step 2: Data Cleaning and Data Augmentation

The dataset obtained from Google needs to be pre-processed manually to get rid of anomalies present in the data. e.g.: In the case of scraping the images of a pest named “beetle” there are also few images of a “car called beetle”. This would result in a reduced accuracy of the model to predict. So, the dataset needs to be pre-processed to increase its variability.

Step 3: DL Model Creation

This involves passing the data as input, model configuration, training the model with the dataset, and evaluation of the model using testing dataset. Later on, a .h5 file will be created to store the model.

Step 4: Pest Identification and corresponding Pesticide Recommendation

.h5 model will be loaded to identify the pest, and later on, based on the result, the corresponding pesticide will be recommended based on a dictionary-based solution.

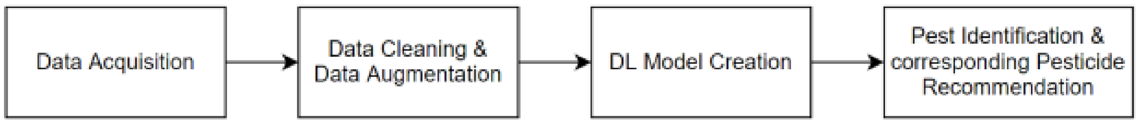

Fig.4.3 – Pesticide Recommendation Model

Hence, the division of "Agritence" into three different modules makes this project more intuitive and provides a better user experience concerning addressing the more specific query of farmers among crop recommendation, fertilizer recommendation, and pesticide recommendation.

CHAPTER-5

OBJECTIVES

Agritence aims to help Indian farmers and reduce their hardship. Agritence's main goal is to provide a web-based solution that can assist farmers by recommending the type of crop to be grown that yields the best output, as well as providing the fertilizers required for the crop based on user-specific input, and even identifying pests and providing the necessary pesticide based on user input. "Agritence" has the following objectives:

i. Precision agriculture is a modern farming strategy that decreases crop selection errors and boosts productivity by collecting research data on soil kinds, characteristics, and crop yields.
ii. To solve the issue, we propose a highly accurate and effective recommendation system for site-specific parameters based on an ensemble learning model and the majority voting technique.
iii. To recommend organic fertilizer based on crop, N, P, and K values.
iv. To identify the type of pest and suggest a specific pesticide that is accessible in India following ISO standards (ISO 9001, ISO 14001, ISO 17025).
v. To create a web application to accomplish the aforementioned goals with Flask.

Some of the other objectives include:

1) Data Integration and Analysis:

a. Comprehensive Data Compilation:

Aggregate data from meteorological agencies, agricultural research organizations, market reports, and soil health evaluations.

b. Integrated Repository:

Combine disparate datasets to establish a comprehensive repository conducive to in-depth study.

c. AI Algorithm Implementation:

Develop and deploy algorithms capable of effectively understanding data, enabling the generation of personalized suggestions.

2) Application Development:

a. User-Friendly Interface:

Design and create an intuitive interface accessible through both mobile and web platforms.

b. Enhanced Accessibility:

Ensure optimal usability for agricultural practitioners, facilitating effortless navigation and interpretation of insights and recommendations.

3) Personalized Recommendations:

a**.** Individualized Guidance:

Provide farmers with personalized suggestions, considering their specific geographic location, historical crop data, current market trends, and up-to-date information.

b. Optimized Agricultural Selection:

Facilitate the identification of suitable crops and optimal cultivation schedules, aiming to enhance agricultural yield and mitigate potential risks.

4) Enhanced Agriculture Practices:

a. Risk Mitigation:

Empower farmers with precise and timely information to effectively mitigate risks arising from volatile weather patterns, market volatility, and limited resource availability.

b. Increased Production:

Strive for heightened agricultural production through well-informed decision-making, contributing significantly to food security and sustainable farming practices.

The refined objectives emphasize the comprehensive strategy driving the AI-driven application, focusing on leveraging technology to deliver tailored recommendations, enhance decision-making, and address contemporary challenges in the agricultural sector.

CHAPTER-6

SYSTEM DESIGN & IMPLEMENTATION

6.1 Tools and Technologies Used:

The list of all the tools and technologies used while implementing the project "Agritence" are listed below:

1. numpy
    a. working with arrays.
2. pandas
    a. working with CSV files.
3. flask
    a. app routing.
    b. web application.
4. pickle
    a. saving Machine Learning model.
5. pymongo
    a. databases for Agritence users.
    b. databases for Agritence feedback.
6. Neural networks like Keras, TensorFlow, CNN
    a. It is used for the classification and training of deep learning models.
7. PyCharm
    a. python offline coding.
8. OS
    a. for manipulating files.
9. Matplotlib. pyplot
    a. plotting graphs for training and testing accuracy.
    b. plotting graphs for training and testing loss.
10. h5
    a. The storage unit of a Deep Learning model.
11. sklearn
    a. it is a classifier

6.2 Implementation Steps:

The steps to implement "Agritence" are divided into several tasks and sub-tasks that effectively complete the project as mentioned below:

1. **Research on project**
    a. Studying Research Papers
    b. Requirement Analysis
    c. Study on crops, fertilizers, pests, pesticides
2. **Project Documentation**
    a. Analysis Modeling
    b. Design Modeling
3. **Crop Recommendation**
    a. Data Acquisition
    b. Values Input
    c. ML model using ensemble method and creating. pkl file
    d. Using .pkl file for crop recommendation
4. **Fertilizer Recommendation**
    a. Data Acquisition
    b. Values Input
    c. Difference between desired and actual
    d. Dictionary-based solution
5. **Pesticide Recommendation**
    a. Data Acquisition
    b. Data Cleaning and Data Augmentation
    c. DL model training
    d. Pest Identification and corresponding Pesticide Recommendation
6. **End-to-End Deployment**
    a. Flask Coding
    b. Front End Design
    c. Integrating all three modules
    d. Deployment

6.3 Workflow Diagrams:

The workflow diagram as shown in Figure 2.1 is for Agritence and all its modules are shown in the below figures, which provide insight into all three different modules present in the project and it also gives the control flow that takes place as per the selected module. The user can choose to explore from any of the three modules. After selecting the individual module, the user will receive the corresponding results from the user-specific query.

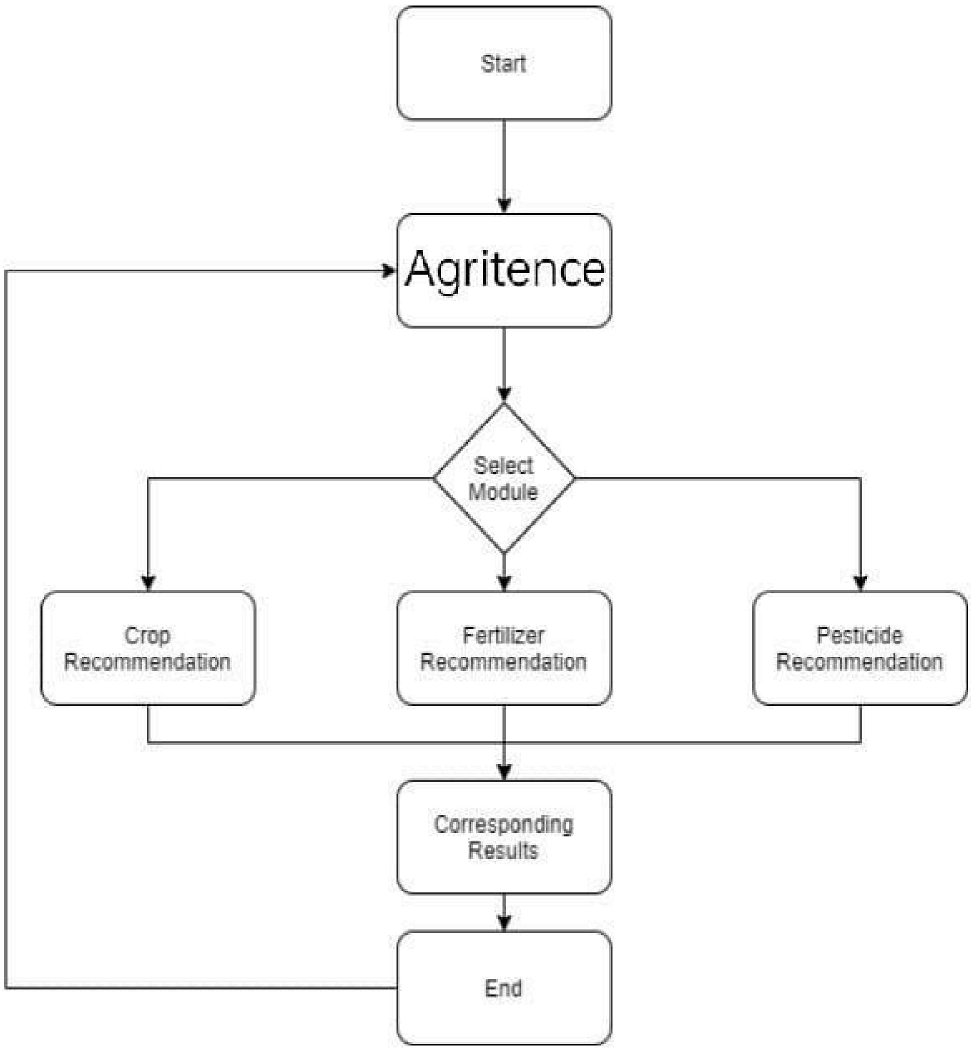

Fig.6.1 - Agritence Workflow Diagram

The diagram below displays the workflow diagram as shown Figure 2.2 for the crop recommendation module of Agritence. The model accepts N, P, K, pH, rainfall, temperature, and relative humidity as inputs and predicts the output only when all of the input fields are within the specified range.

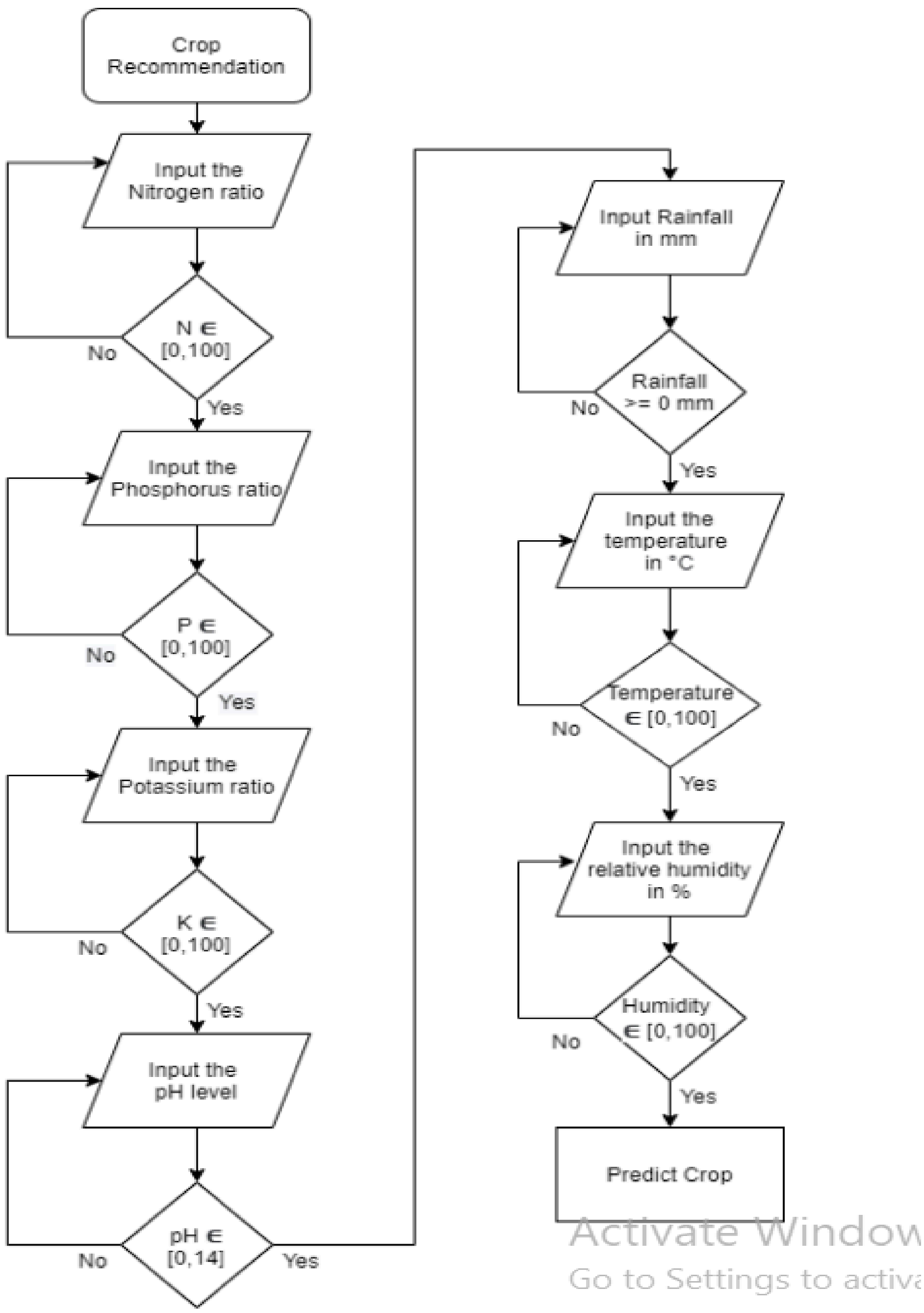

Fig.6.2 - Crop Recommendation Workflow Diagram

The diagram below displays the workflow diagram as Figure 2.3 for the fertilizer recommendation module of Agritence. The model takes the input of Nitrogen, phosphorus, and Potassium as per the given range. The user should also select the type of crop among the limited 22 lists to compare the actual and predicted values of the inputs. The model predicts the output only when all the input fields are filled within the range of their values.

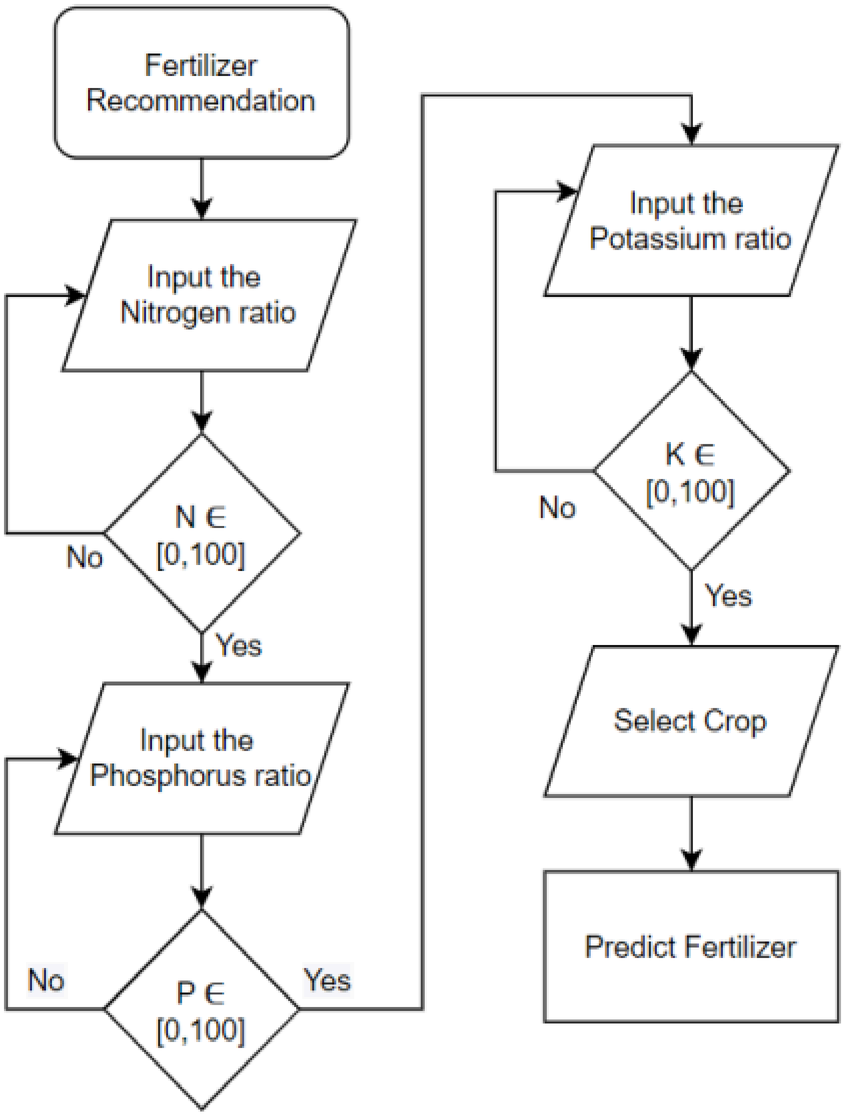

Fig.6.3 - Fertilizer Recommendation Workflow Diagram

The diagram below displays the workflow diagram as Figure 2.4 for pesticide recommendation module of Agritence. There are two ways of finding the pesticide for the required pests namely Identifying the pest and predicting the pesticide or Selecting the pest from the list of options shown. In the first method, the model takes an image file as input. The image file should be ensured to not be blurry or noisy as it will reduce the accuracy of the model. The model identifies the pest based on the image file given as input and recommends pesticide for the corresponding pest identified. In the second method, the user selects the pest from the list of options and the model predicts the corresponding pesticide.

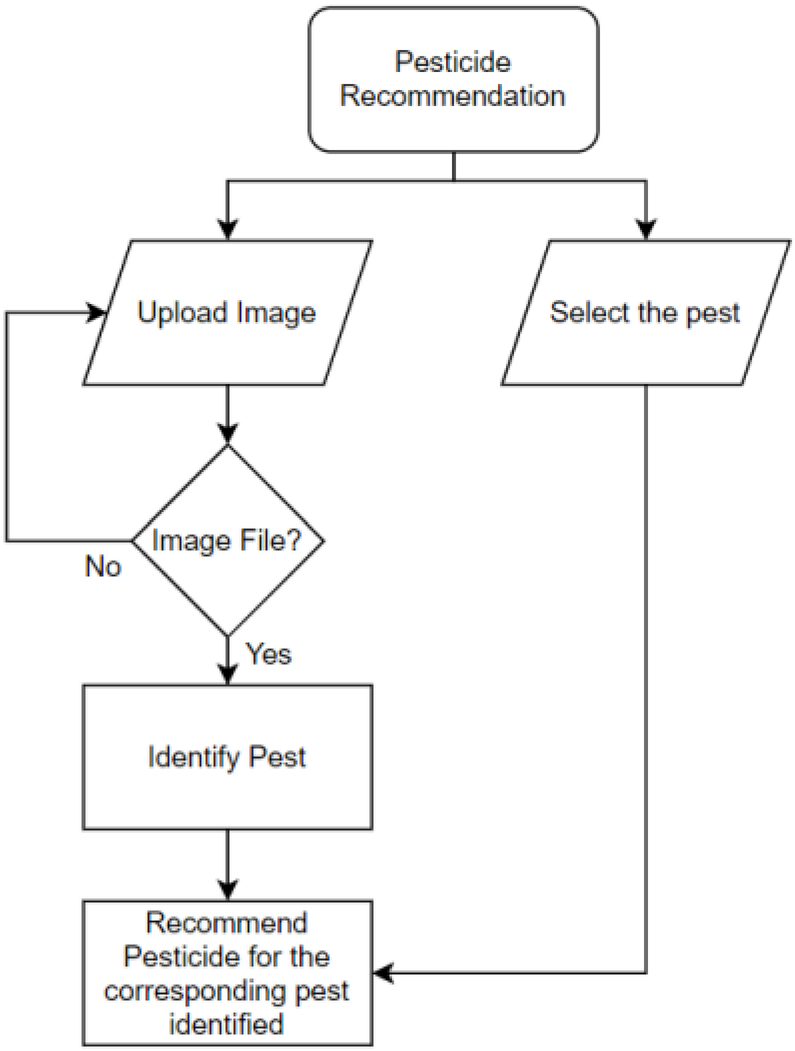

Fig.6.4 - Pesticide Recommendation Workflow Diagram

6.4 System Architecture:

Figure 2.5 shows the layered architecture of the product which consists of several blocks that include:

- Client layer

  This layer consists of web browsing applications like web browsers and mobile browsers.

- Server layer

  This layer consists of the web server.

- Business layer

  This layer covers the project's fundamental features, which include all three modules: crop recommendation, fertilizer recommendation, and pesticide recommendation, as well as all of their associated inputs.

- Persistence layer

  This layer is the logic layer that contains the ML model for prediction.

- Database

  The database is a collection of information and stores data for the model.

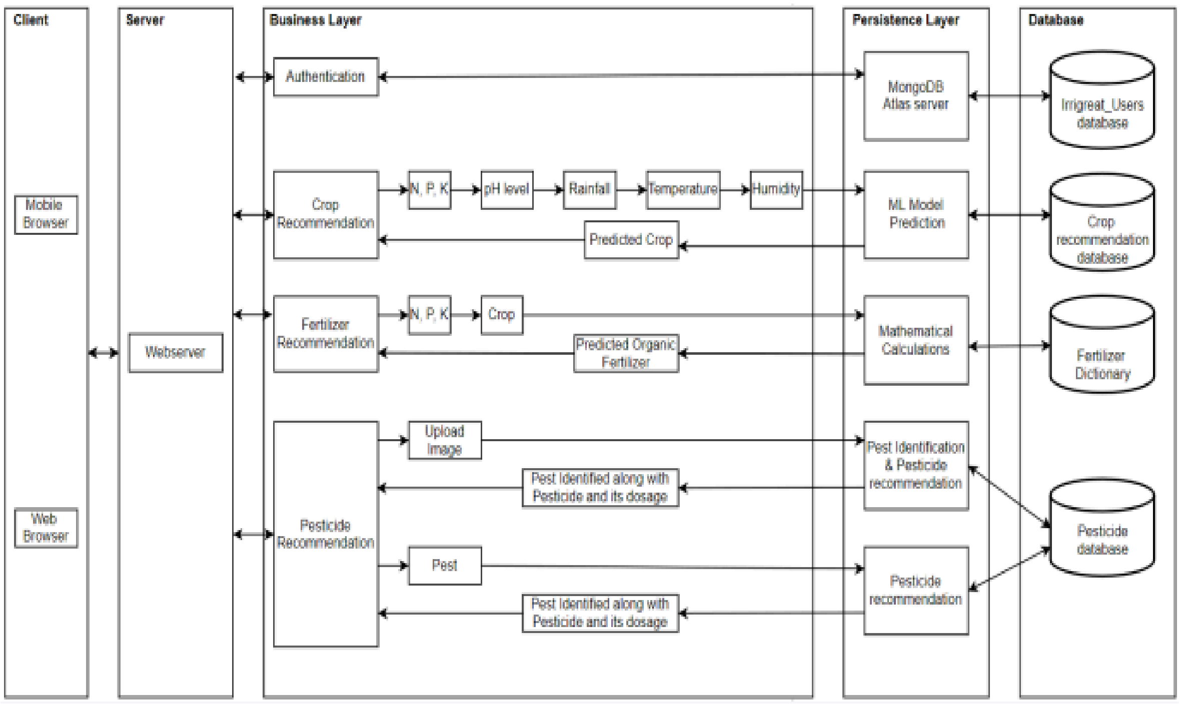

Fig.6.5 - System Architecture of Agritence

CHAPTER-7

TIMELINE FOR EXECUTION OF PROJECT (GANTT CHART)

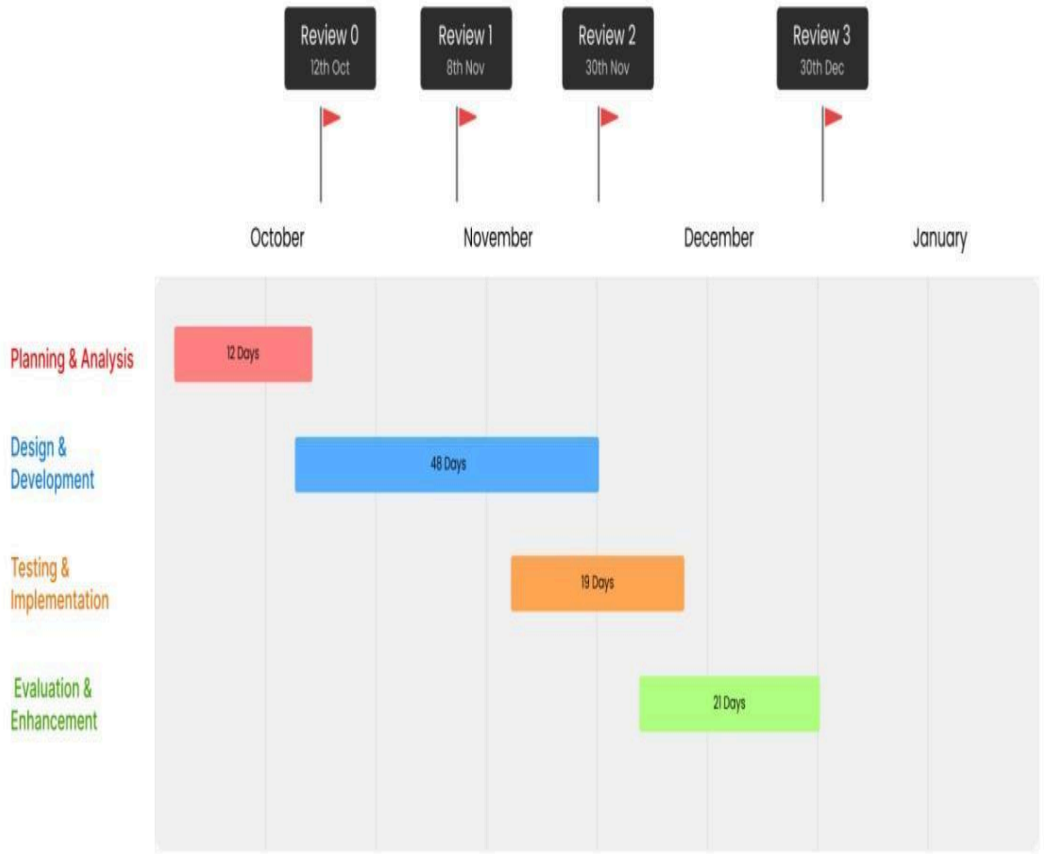

Fig.7.1 - Gantt chart for timeline

CHAPTER-8

OUTCOMES

The ongoing evolution of the AI-powered application designed to support agriculture anticipates achieving impactful results, contributing to advancements in farming techniques and fostering well-informed decision-making for farmers. The expected outcomes encompass various dimensions, including functionality, accessibility, and the overall impact on agricultural productivity.

A. **Tailored Advice:**

- The application aims to provide personalized and real-time advice to farmers regarding optimal crop choices, production timing, and resource management.
- Recommendations will be tailored based on individual geographic areas, prevailing market trends, and specific crop requirements.

B. **Enhanced Decision-Making:**

- Empowering farmers with precise, evidence-based information to facilitate well-informed decision-making.
- Reducing potential risks associated with uncertain weather patterns, market volatility, and resource availability.

C. **Increased Agricultural Productivity:**

- The application's guidance is anticipated to lead to heightened agricultural productivity, translating to enhanced crop yields, minimize losses, and optimized resource utilization.

D. **Improved Accessibility:**

- Key emphasis on a user-friendly design accessible through both mobile and online platforms.
- Addressing the accessibility divide by reaching farmers in diverse regions, irrespective of language proficiency or technological competence.

E. **Promotion of Sustainable Practices:**

- Facilitating the adoption of sustainable agricultural practices through recommendations related to crop diversity, water conservation initiatives, and integrated pest management approaches.

F. **Stakeholder Collaboration:**

- Continuous engagement of agricultural experts, technology professionals, and government entities to foster collaboration.
- Ensuring precision, relevance, and widespread acceptance of the application through ongoing stakeholder involvement.

G. **Validation and Refinement:**

- Implementing a continuous validation process for recommendations using real-time data and expert opinions.
- Iterative enhancements aimed at improving the accuracy and relevance of the application's guidance.

The overarching objective remains the enhancement of farmers' livelihoods by mitigating risks, increasing crop yields, and promoting sustainable agricultural practices. This contributes significantly to the broader goal of ensuring food security. The projected outcomes underscore the primary goals of the project, centered on leveraging technology to transform agricultural decision-making, empower farmers, and advance sustainable farming practices, ultimately enhancing the resilience and productivity of the agricultural sector.

CHAPTER-9

RESULTS AND DISCUSSIONS

The continuous evolution of AI-powered agricultural applications has led to significant changes in the field, showcasing its potential to revolutionize farming practices and contribute to the overall resilience and productivity of the agricultural sector.

Agritence is an agriculture-based project, hence data is critical in anticipating the exact outcome. In addition, data should be dispersed equitably throughout each crop to ensure that the model is trained equally for all crop labels. The picture below in Figure 4.1 depicts the data distribution of 22 crop kinds in similar proportions, which plays an important role in improving the accuracy of the predictive machine-learning model by training the model evenly for all crop labels.

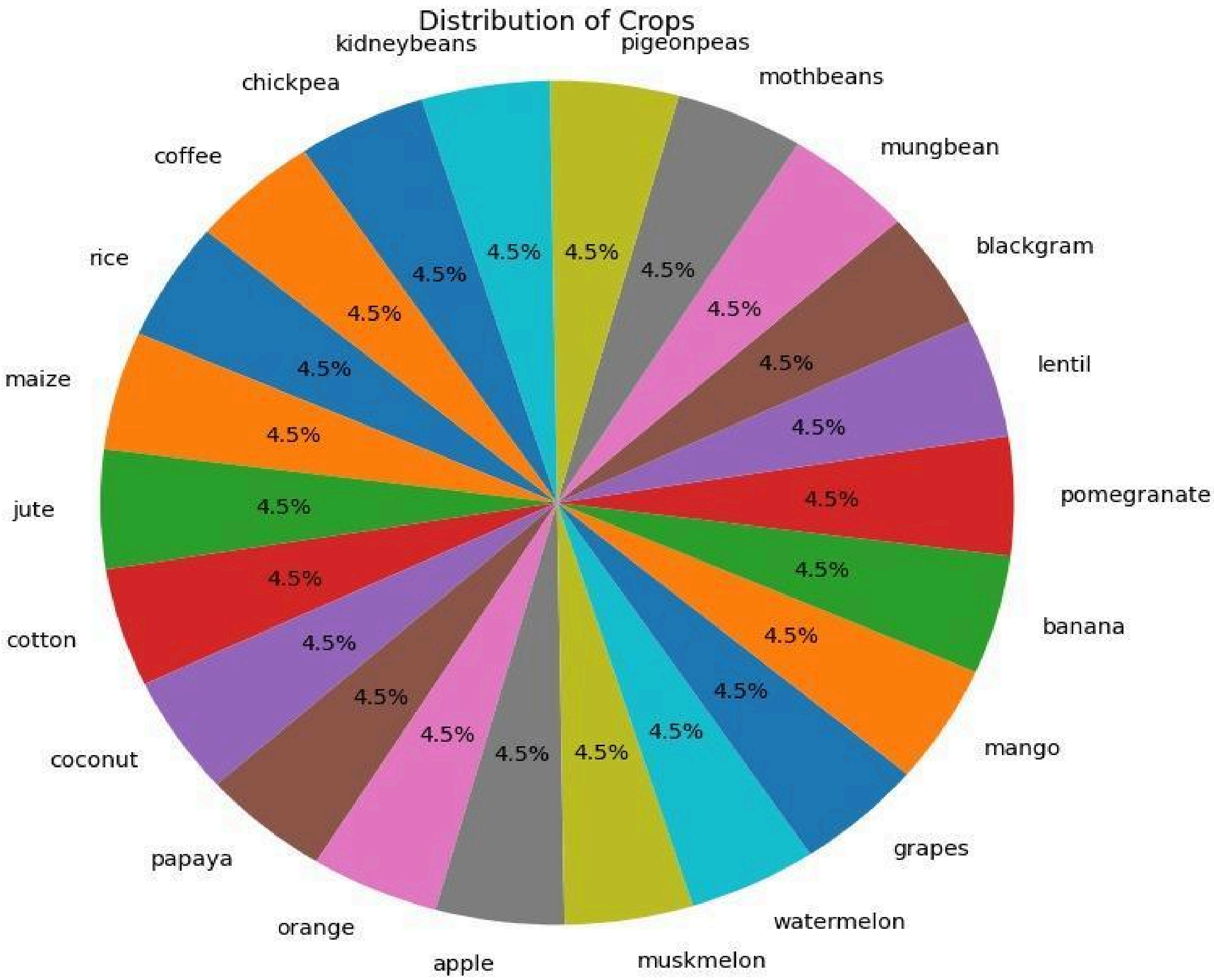

Fig.9.1 - Crop Distribution

A correlation heatmap is a visual representation of the correlation matrix in Figure 4.2, which shows the correlation coefficients between many variables. It is commonly used in data analysis and statistics to quickly identify patterns and relationships between variables in a dataset. It also helps in feature selection and is often used as a diagnostic tool to identify potential issues such as outliers or errors in the dataset. The below figure shows the correlation features of the crop data features.

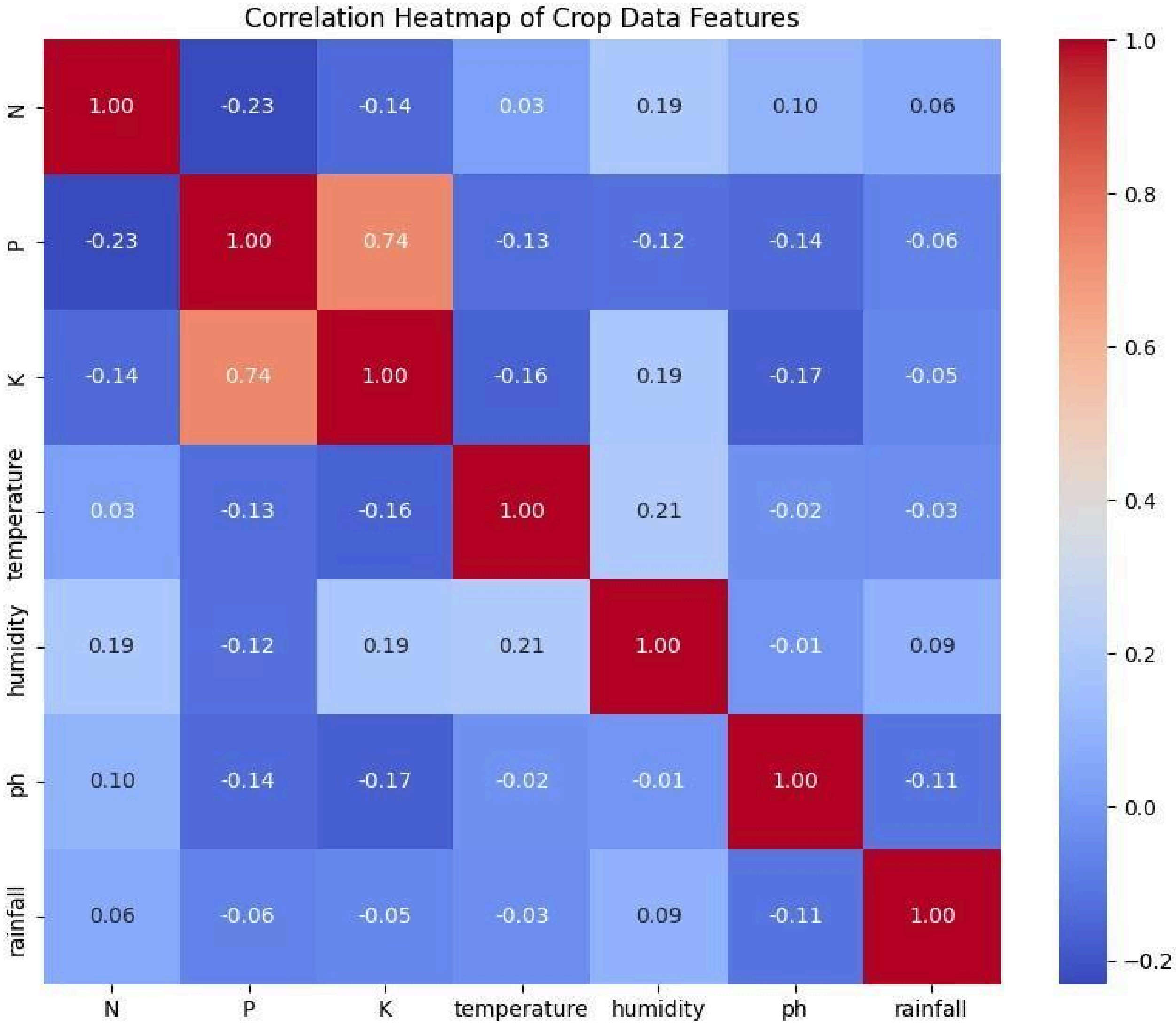

Fig.9.2 - Correlation Heatmap of Crop Data

There are numerous approaches to evaluating the "Agritence" model that have been proposed. First, the crop suggestion accuracy score indicates the solution's success because the machine learning model is utilized to predict the crop that is best suited based on site-specific parameters. The majority voting technique was implemented in an ensemble learning model. The algorithms are namely:

a. Naive Bayes
b. K-Nearest Neighbours
c. SVM
d. Random Forest

The ML model can attain 96.44% accuracy, which is notable given that the accuracy goal was >= 90%.

The comparative graphical figure of the accuracy metrics for all the above learners is shown below in the figure. Naive Bayes outperformed kNN, Support Vector Machines, Random Forest, and other algorithms in terms of accuracy.

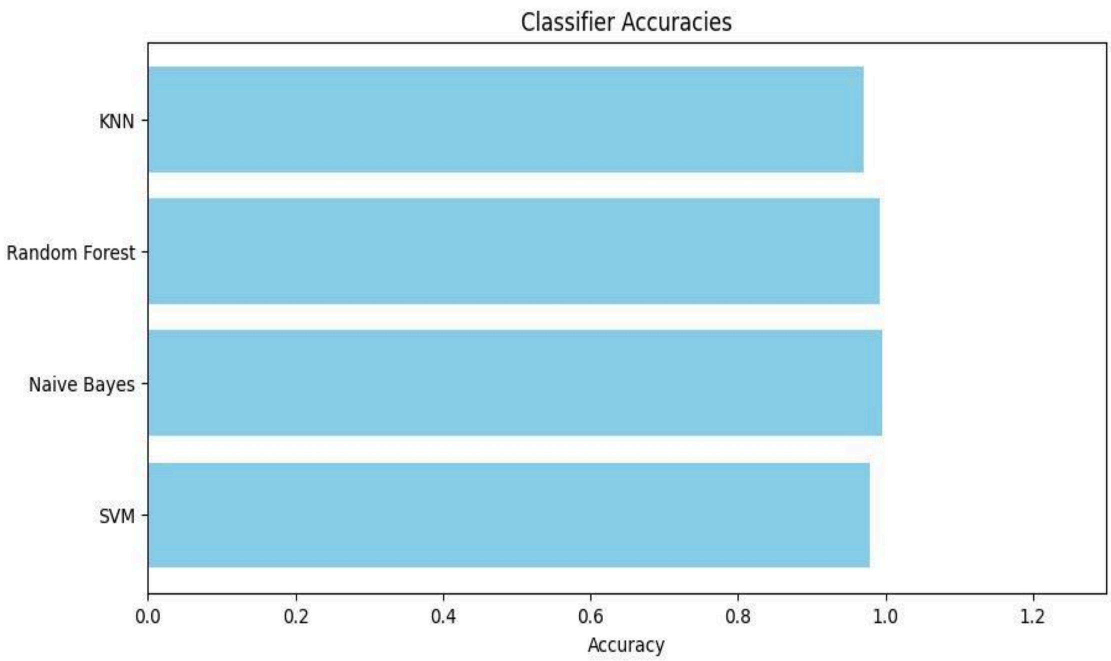

Fig.9.3 - Learners Accuracies

The accuracy of models is noted to be:

- Naive Bayes : 99.54%
- Random Forest : 99.34%
- SVM : 97.95%
- kNN : 97.04%

Fertilizer Recommendation is a dictionary-based method that relies on team members' study. The Pesticide Recommendation module comes last. If the user uploads a snapshot, the pesticide will be advised once the bug has been identified. The CNN-based Deep Learning model is used to detect pests. Performance measures in this scenario include training and validation loss, as well as training and validation accuracy, as shown below.

	ACCURACY	LOSS
TRAINING	0.9699	0.0712
VALIDATION	0.9520	0.4681

The graphs for the same can be seen in the below figures.

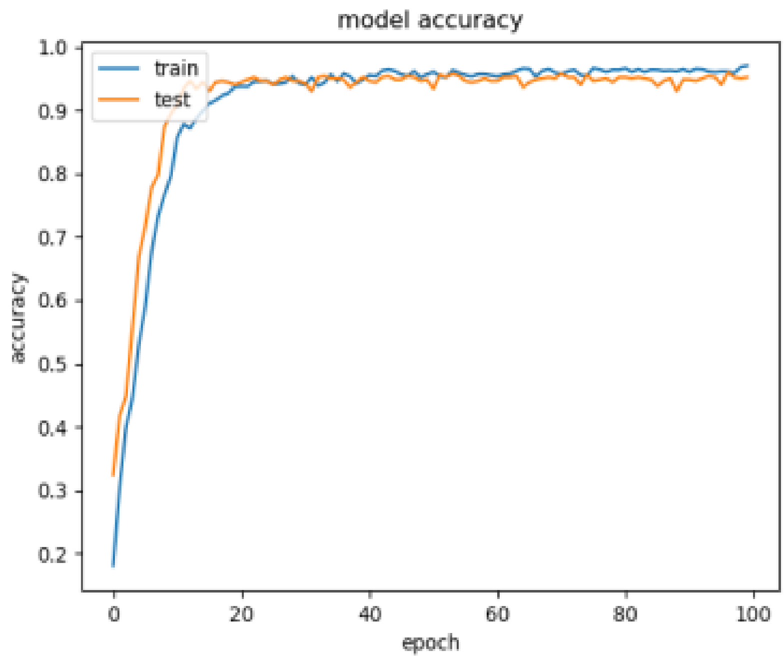

Fig 9.4: Accuracy V/S Epoch

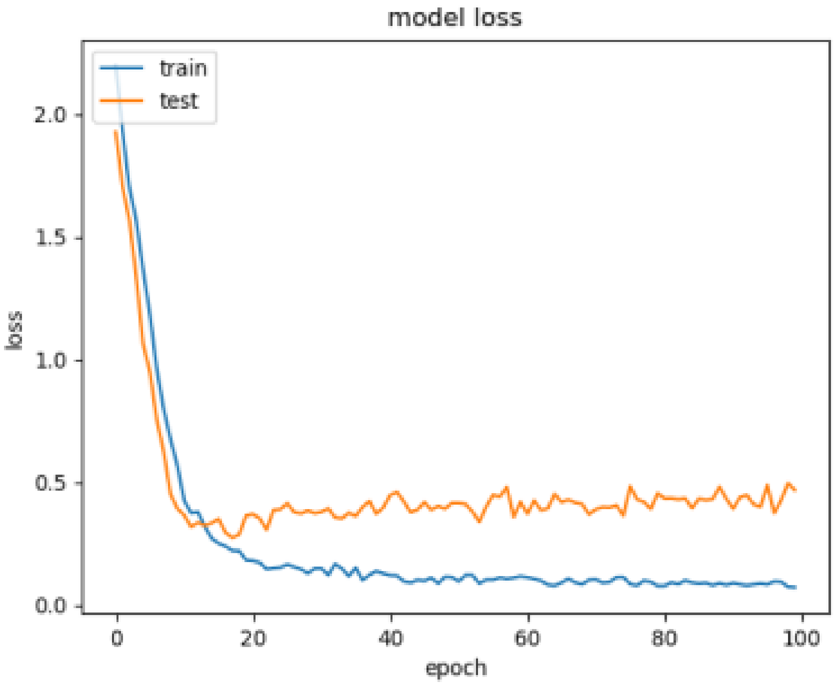

Fig 9.5: Loss V/S Epoch

For pest identification, the Deep Learning model can perform quite well but in some cases, the Deep Learning model identifies “armyworms” as aphids due to close resemblance. Also, the system is not able to perform well with blur images, hence the user must upload the images that clearly show the pest to get accurate predictions.

9.1 Discussion:

The discussion revolves around the transformative impact of the application on agricultural practices. It explores the societal implications of empowering farmers, potential challenges in widespread adoption, and the scalability of the application across diverse agricultural landscapes. Furthermore, the program empowers farmers by giving individualized advice for crop management, fertilization, and pest control, indicating a fundamental change toward more informed and sustainable agricultural practices. However, technological access and infrastructure constraints may limit the general adoption of these novel solutions among farmers in remote or undeveloped areas. However, the application's scalability and flexibility across diverse agricultural landscapes remain promising, providing possible paths for addressing these difficulties and catalyzing a statewide paradigm change toward modernized and resilient farming techniques.

9.2 Transformational Shift in Agricultural Practices:

The results highlight a significant transformation in the way farmers make decisions and conduct farming operations. The application's role in delivering tailored advice, promoting sustainability, and enhancing productivity signifies a paradigm shift in traditional agricultural practices.

Undoubtedly, the application's significance extends beyond mere technical integration, signaling a fundamental shift in farming practices. The tool empowers farmers by giving tailored recommendations for crop selection, fertilization, and pest management, which were previously unavailable in traditional procedures. This shift toward precision agriculture not only improves resource usage but also promotes a more sustainable farming method. Farmers with real-time guidance can make more educated decisions, decreasing resource waste and environmental impact.

Furthermore, the application's emphasis on sustainability reflects current agricultural issues. Its role in encouraging eco-friendly methods, including organic fertilization and targeted pest management, is consistent with worldwide environmental conservation efforts. This revolutionary strategy not only boosts production but also promotes environmental stewardship, ensuring that natural resources are preserved for future generations.

The application's success in transforming farming techniques is dependent on its capacity to adapt and integrate seamlessly into a variety of agricultural environments. While the initial impact is promising, ongoing evolution and adaptation to local situations will be critical. The integration of farmer feedback loops, as well as the application's scalability across areas, will define its long-term influence on agricultural communities, paving the way for a sustainable and resilient future in Indian agriculture.

9.3 Societal Implications and Food Security:

Empowering farmers and enhancing agricultural productivity contribute to broader societal implications, particularly in the context of food security. The application's primary objective aligns with the broader goal of ensuring food security by improving the livelihoods of farmers and optimizing agricultural practices.

The application's function in empowering farmers goes beyond agriculture and intersects with the vital issue of food security. Agricultural production is increased by providing farmers with easily available, data-driven tools for crop management and resource optimization. This not only benefits farmer livelihoods, but it also corresponds with India's national goal of maintaining food security for its people. Integrating technology into decision-making strengthens a robust and sustainable food production system. Increased productivity and improved techniques reduce food scarcity worries, increasing food supply. However, issues remain in guaranteeing fair access for smallholder farmers. Bridging the digital divide and encouraging inclusivity among underprivileged farming communities are vital for properly exploiting these breakthroughs, and strengthening India's road towards sustainable food production.

9.4 Challenges in Adoption and Integration:

While the application has shown promising results, challenges in adoption may exist. Addressing language barriers, ensuring technological accessibility, and tailoring recommendations to diverse farming practices are crucial aspects that need ongoing attention for successful adoption.

Every new learning experience and exploration of previously uncharted territory brings its own set of problems. The performance of "Agritence" is completely reliant on the datasets, ML model, and DL model. Crop recommendation datasets are readily available on Kaggle. Creating a fertilizer glossary was difficult. The dataset for accurate N, P, and K values for the crops was not available in one location, making it difficult to browse through multiple websites while keeping in mind that the sources must be trustworthy and vetted. Another problem was related to the pest dataset. There is no open source dataset available, so the dataset was created by building an automated script that scraped photos from Google using Selenium and the Chrome driver.

Finding herbicides that met ISO criteria was likewise a tough undertaking. Because the model used the CNN algorithm, determining hyperparameters was another step. With a lot of hits and trials, some thumb rules, and hyperparameters, the algorithm was optimized to its full potential. The model suffered from overfitting, which was addressed using the Dropout approach, the next issue that everyone faced was coordination among team members during the Holidays when everyone was at their respective locations; however, working from home was well-versed thanks to technology such as Team Viewer to assist in gaining access to the

PC where the main project is being created, Zoom, and Google Meet for sharing and discussing work progress. Despite the hurdles, it was an incredible experience that taught me a lot about starting from nothing and making things work. The team is the fundamental component that makes everything work.

9.5 Scalability and Future Prospects:

The scalability of the application is a critical factor for its long-term success. As the project aims to utilize technology to transform agricultural decision-making, considerations for scalability across different regions and crops become essential. Continuous innovation and adaptability will be key to addressing diverse agricultural needs.

In conclusion, the achieved outcomes and the ensuing discussion underscore the positive impact of the AI-powered agricultural application on farmers and the agricultural sector. The application's multifaceted approach towards customization, sustainability, and collaboration sets the stage for a resilient and productive future in Indian agriculture.

CHAPTER-10

CONCLUSION AND FUTURE SCOPE

Finally, this project represents a tremendous advancement in harnessing technology to address crucial difficulties in Indian agriculture. The program, which provides individualized advice for crop management, fertilization, and pest control, is a transformative tool that empowers farmers and promotes sustainable practices. However, this is only the start of a path toward agricultural innovation.

The future scope is constantly refined and expanded. It is critical to refine the application's algorithms in response to ongoing feedback, integrate more robust data sources, and react to changing area agricultural dynamics. Furthermore, efforts to improve accessibility among varied farming groups, as well as the incorporation of innovative technologies like IoT and blockchain, have the potential to unlock new levels of efficiency and transparency in agriculture.

Exploring collaborations with government agencies and agricultural research institutions could increase the application's influence and scope. Furthermore, expanding the application's reach across borders to help farmers in similar agro-climatic zones around the world could increase its scope and significance.

In essence, while this project establishes a solid basis, the future beckons with prospects for deeper integration, greater accessibility, and continual innovation in agricultural technology, offering a brighter, more sustainable future for Indian agriculture.

10.1 Work accomplished w.r.t. Objectives

The work accomplished w.r.t. objectives are given below.

a) To apply precision agriculture: a. Using research data on soil properties, soil types, and crop yield data gathering, "Agritence" recommends the best crop for farmers based on site-specific features, reducing crop selection errors and increasing productivity.

b) To overcome the problem, we propose a recommendation system using an ensemble model and a majority vote technique to crop for site-specific factors with high accuracy and efficiency.
   a. Learners employed include kNN, Random Forest, SVM, and Naive Bayes.
   b. Accuracy: 96.44%.

c) To prescribe organic fertilizer based on N, P, and K values, as well as crop. a. The Fertilizer Dictionary was designed for natural fertilizers labeled as NHigh, Nlow, NNo, PHigh, Plow, PNo, KHigh, Klow, and KNo.

d) To recognize pests and prescribe certain pesticides accessible in India following ISO standards. a. Pesticide recommendations are based on ISO 9001, ISO 14001, and ISO 17025.

e) Design a web application to achieve the aforementioned goals.
   a. The website is designed and launched.

10.2 Conclusion

The development of the AI-driven application stands as a significant milestone in the evolution of agricultural practices, poised to bring tangible benefits to farmers and the sector at large. This exhaustive endeavor, characterized by meticulous planning and iterative development, underscores a commitment to addressing prevalent challenges in agriculture.
Throughout the project's duration, the primary emphasis remained on leveraging cutting-edge technology, integrating diverse data sources, and deploying artificial intelligence algorithms. The overarching goal remains steadfast – to empower farmers with informed decision-making capabilities, specifically regarding crop selection, production timing, and resource management.

The methodology employed, encompassing a thorough problem analysis, user-centric design, and iterative development, ensures alignment with the needs of the agricultural community. Stakeholder involvement has been pivotal in ensuring precision, relevance, and widespread adoption of the application.

As the project progresses, the foundational stages of planning, design, and development have laid a robust groundwork. The ongoing comprehensive testing and validation phase, concluding by Week 18, guarantees a meticulous evaluation and enhancement of the application's functionalities before its launch. Subsequent stages prioritize incremental improvements, continuous monitoring, and long-term initiatives, all aimed at ensuring the application's effectiveness and durability.

In its entirety, this project represents a pivotal leap forward in the modernization of agricultural practices, offering a concrete solution to mitigate risks associated with unpredictable weather patterns and market fluctuations. The envisioned application symbolizes ingenuity, providing a technology-driven resolution to empower farmers and promote sustainable agricultural methods. Its potential impact on enhancing the livelihoods of farmers and cultivating a more resilient and productive farming industry is considerable.

10.3 Future Scope

“Agritence” is not limited to current usage, it can be extended to many features as discussed below”:

1. Agritence currently supports 22 crops, including apple, banana, black gram, chickpea, coconut, coffee, cotton, grapes, jute, kidney beans, lentil, maize, mango, mothbeans, mungbean, muskmelon, orange, papaya, pigeon peas, pomegranate, rice, and watermelon. Later on, the administrator can add other crops. Furthermore, in the future, fertilizers can be added as needed. The training included ten pests: aphids, armyworms, beetles, bollworms, earthworms, grasshoppers, mites, mosquitoes, sawflies, and stem borers, with insecticides recommended. In the future, more pests can be trained on, and more pesticides can be applied based on the pests.

2. In Crop Recommendation, the user inputs data such as temperature, humidity, and rainfall. Admins can also utilize a weather API to retrieve real-time parameters by city and state.

3. In Pesticide Recommendation, the uploaded image should be clear for accurate results; otherwise, the algorithm may return incorrect findings, and further filters can be employed to improve results. Furthermore, the system can leverage improved Deep Learning models in conjunction with reinforcement learning to create a robust model with reliable outcomes.

4. In the future, pesticide code can be combined with drone code by integrating computer vision, allowing it to take live photographs of pests and tell farmers about the pests as well as the chemicals by email or mobile.

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APPENDIX-A

PSEUDOCODE

app.py:

1. Load necessary libraries and models.
2. Define a Flask app.
3. Define a function for fertilizer recommendation:
    a) Get user input for crop name, nitrogen, phosphorous, and potassium levels.
    b) Read a CSV file containing NPK values for different crops.
    c) Calculate differences between desired and filled NPK values for the crop.
    d) Determine fertilizer recommendations based on NPK differences.
    e) Return the HTML template with fertilizer recommendations and differences

4. Define a function to predict the pest in an image:
    a) Accept an image file.
    b) Pre-process the image.
    c) Use a pre-trained CNN model to predict the pest in the image.
    d) Return the identified pest.

5. Define routes for different web pages:
    a) Index page.
    b) Crop recommendation page.
    c) Fertilizer recommendation page.
    d) Pesticide recommendation page

6. Define a function to predict the crop based on user input:
    a) Get user inputs for N, P, K, pH, rainfall, temperature, and humidity.
    b) Use a pre-trained crop recommendation model to predict the suitable crop.
    c) Return the HTML template with the predicted crop and an image related to the crop

7. Define a function to predict the pest in an uploaded image:
   a) Receive an image file from the user.
   b) Save the file to a directory.
   c) Use a pre-trained CNN model to predict the pest in the image.
   d) Render a specific HTML template based on the identified pest

8. Run the Flask app

Crop model:

1. Load necessary libraries and datasets.
2. Split the dataset into features (X) and target variables (Y).
3. Define multiple classifiers (SVM, Random Forest, GaussianNB, KNeighbors).
4. Create a Voting Classifier with multiple models for crop recommendation.
5. Train the Voting Classifier on the dataset and evaluate accuracy.
6. Save the trained Voting Classifier model using Pickle.
7. Perform cross-validation for individual models and visualize accuracy scores using Matplotlib.

CNN Model:

1. Import necessary libraries and packages for CNN model creation.
2. Define a Sequential model for a Convolutional Neural Network (CNN).
3. Add Convolutional, Pooling, Flattening, and Dense layers to the model.
4. Compile the CNN model with optimizer, loss function, and metrics.
5. Prepare image data using ImageDataGenerator for training and testing.
6. Fit the CNN model to the training data and validate it on the test set.
7. Save the trained CNN model as an H5 file.
8. Visualize model training history using matplotlib for accuracy and loss.

APPENDIX-B

SCREENSHOTS

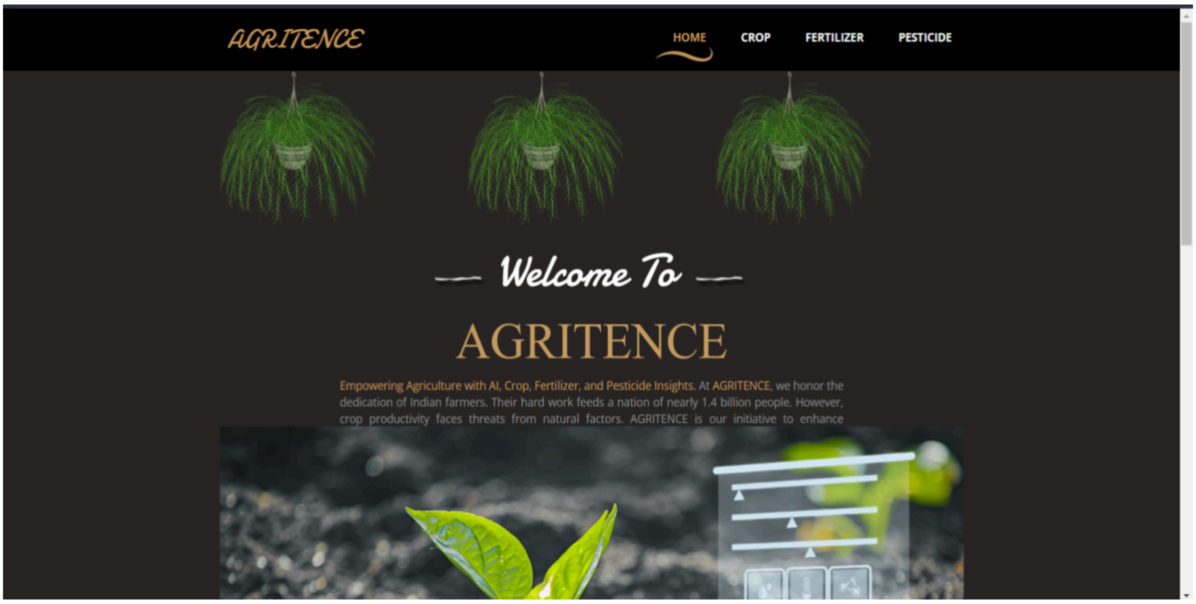

Fig. 13.1 - Landing page

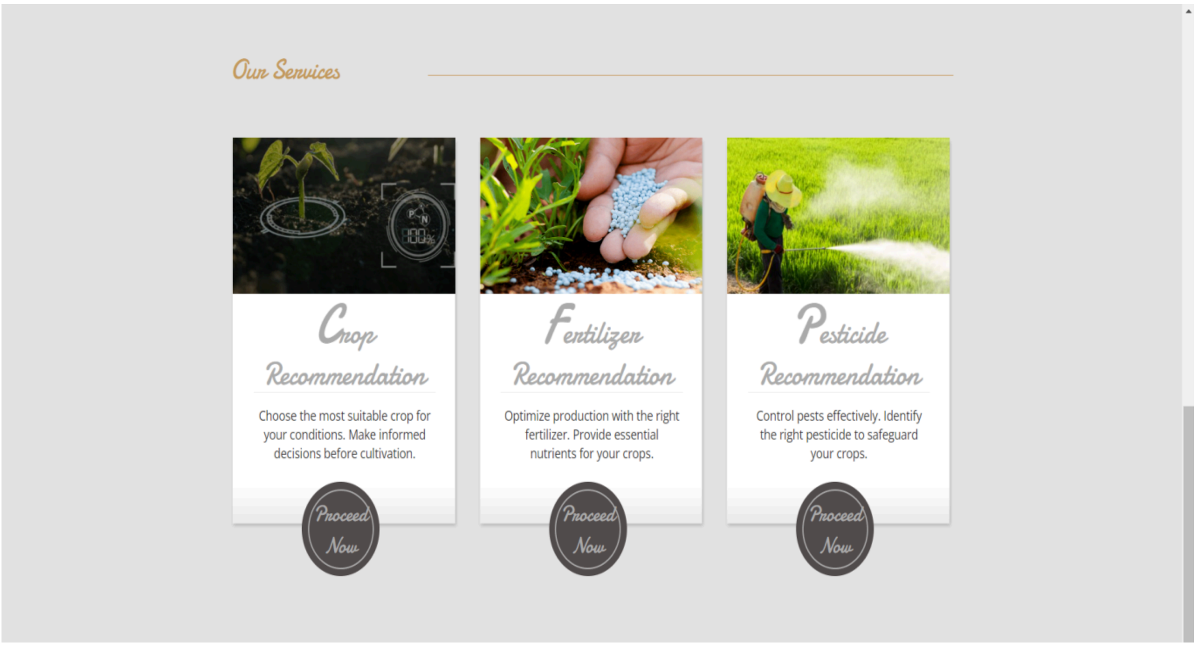

Fig. 13.2 - Services offered

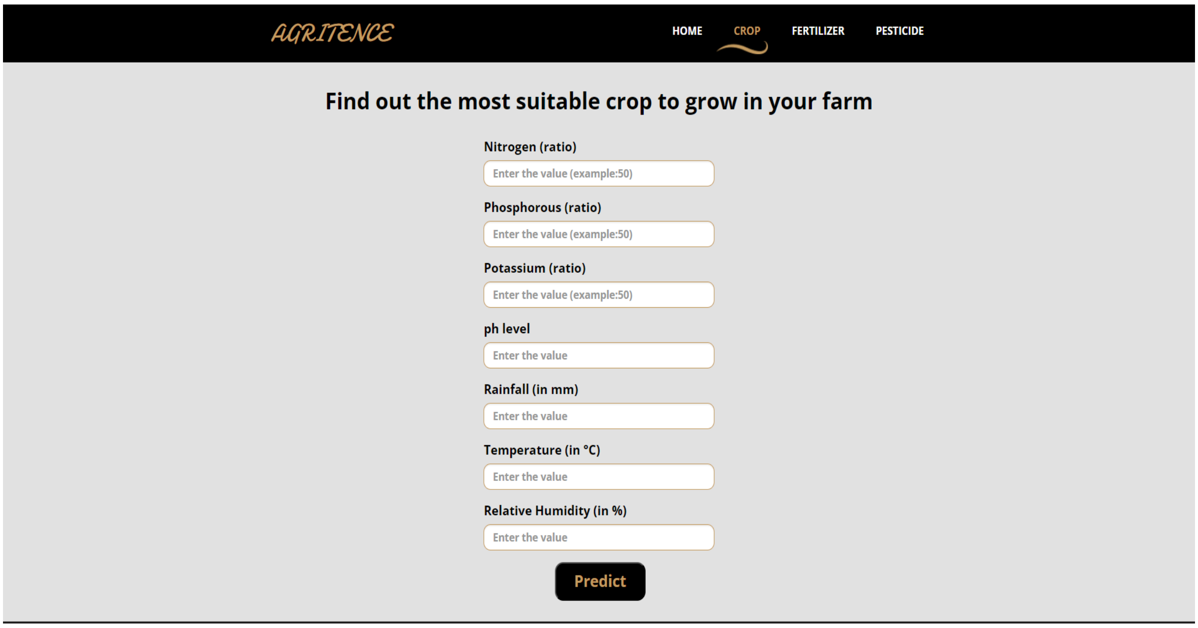

Fig. 13.3 - Crop Recommendation

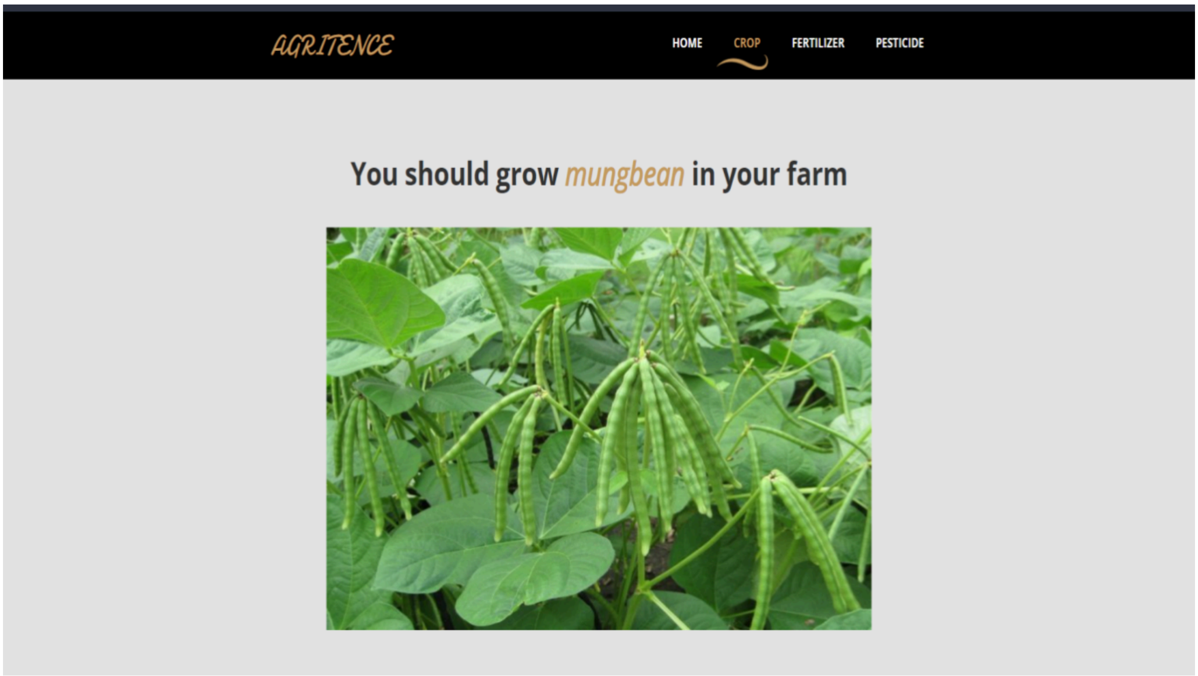

Fig. 13.4 - Recommended crop

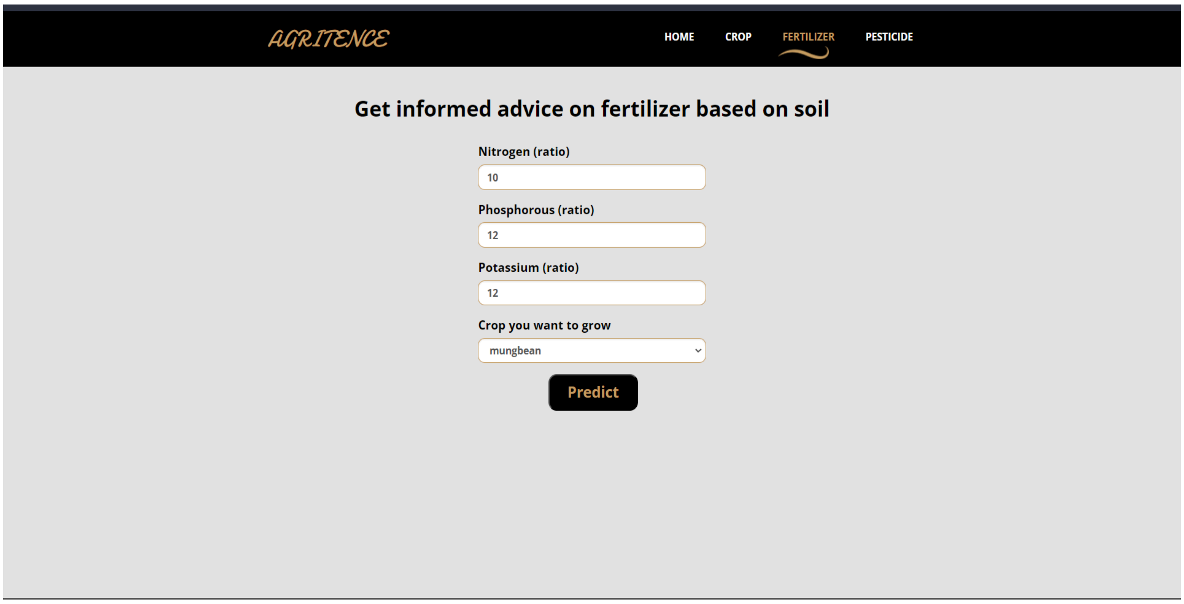

Fig. 13.5 - Fertilizer Recommendation

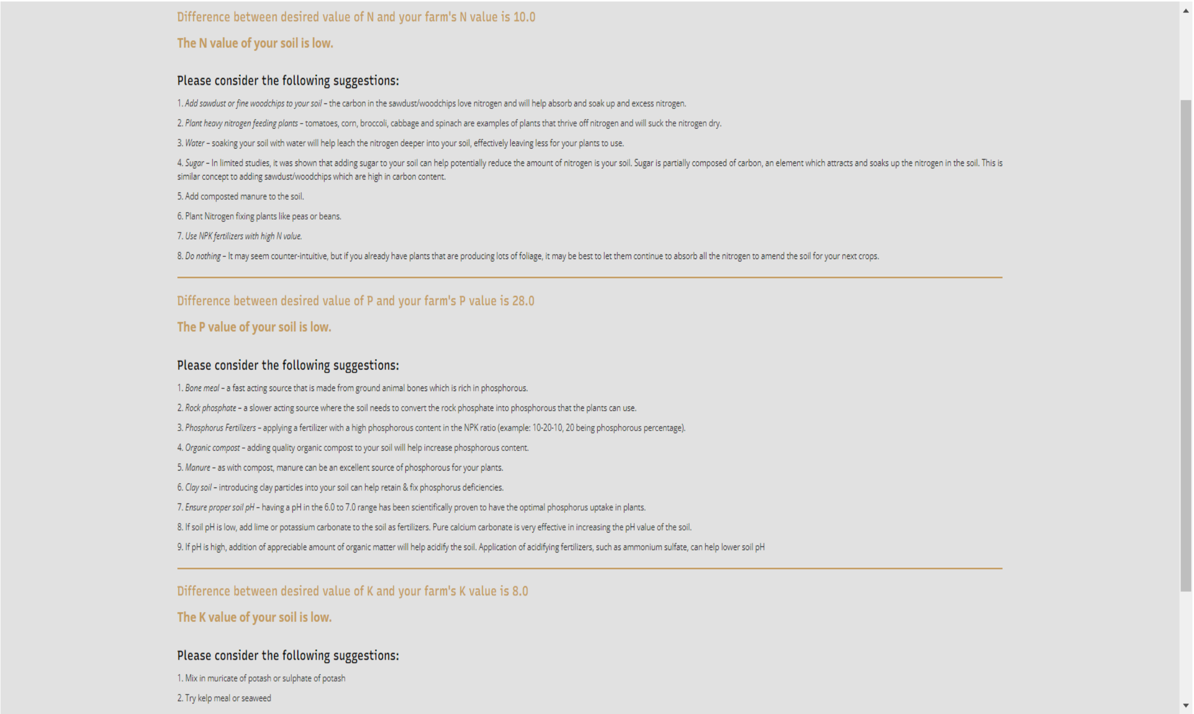

Fig. 13.6 - Recommended suggestions

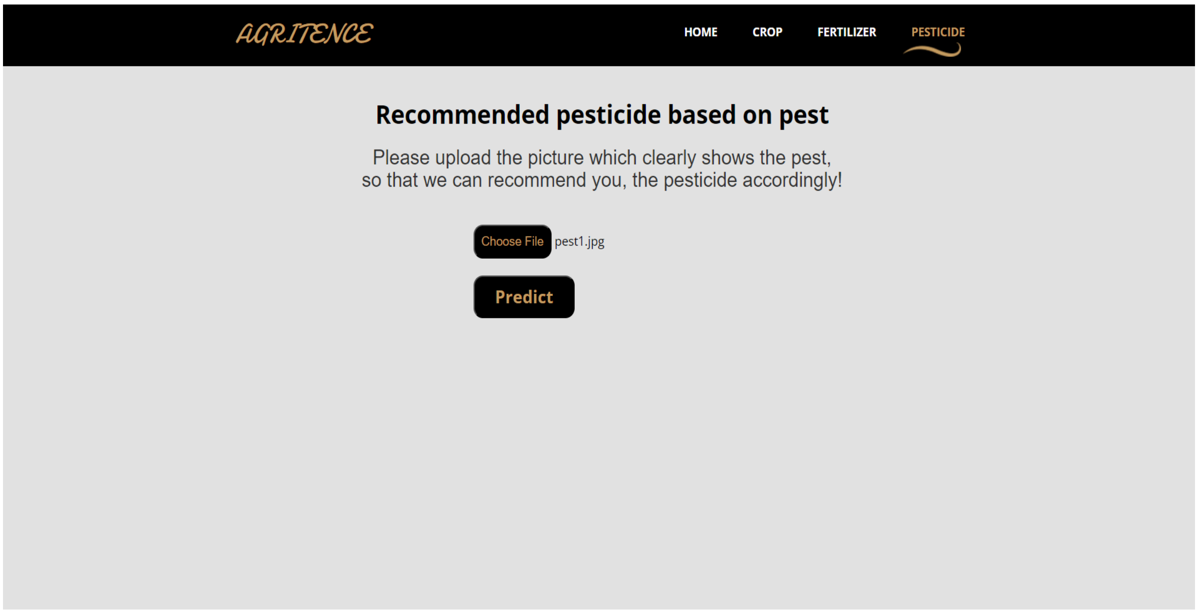

Fig. 13.7 - Pesticide Recommendation

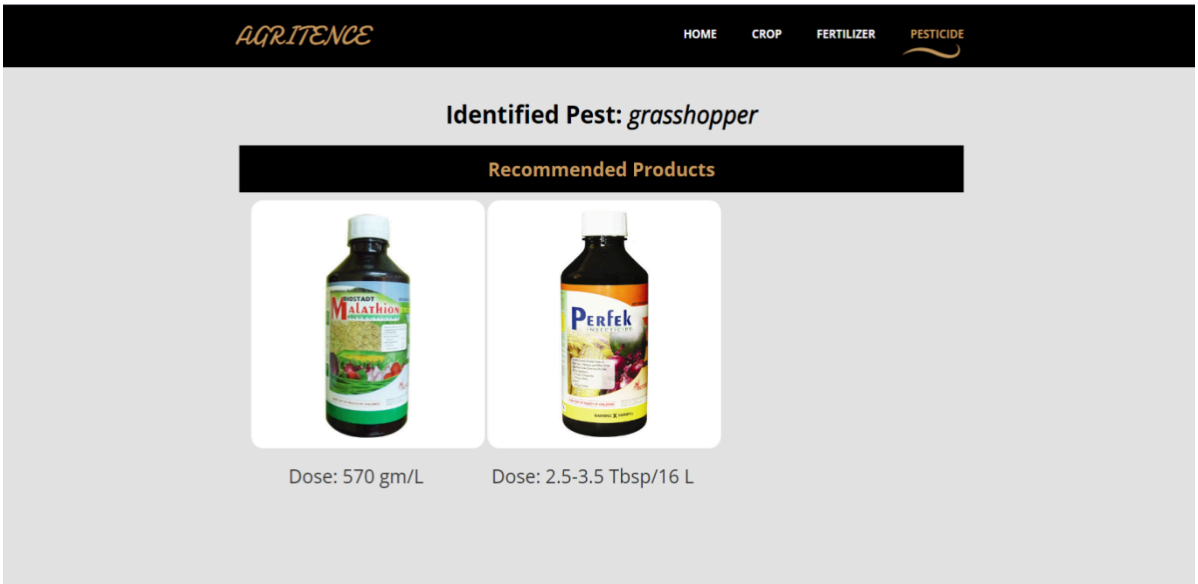

Fig. 13.8 - Recommended Pesticide with dosage

APPENDIX-C

ENCLOSURES

Plagiarism:

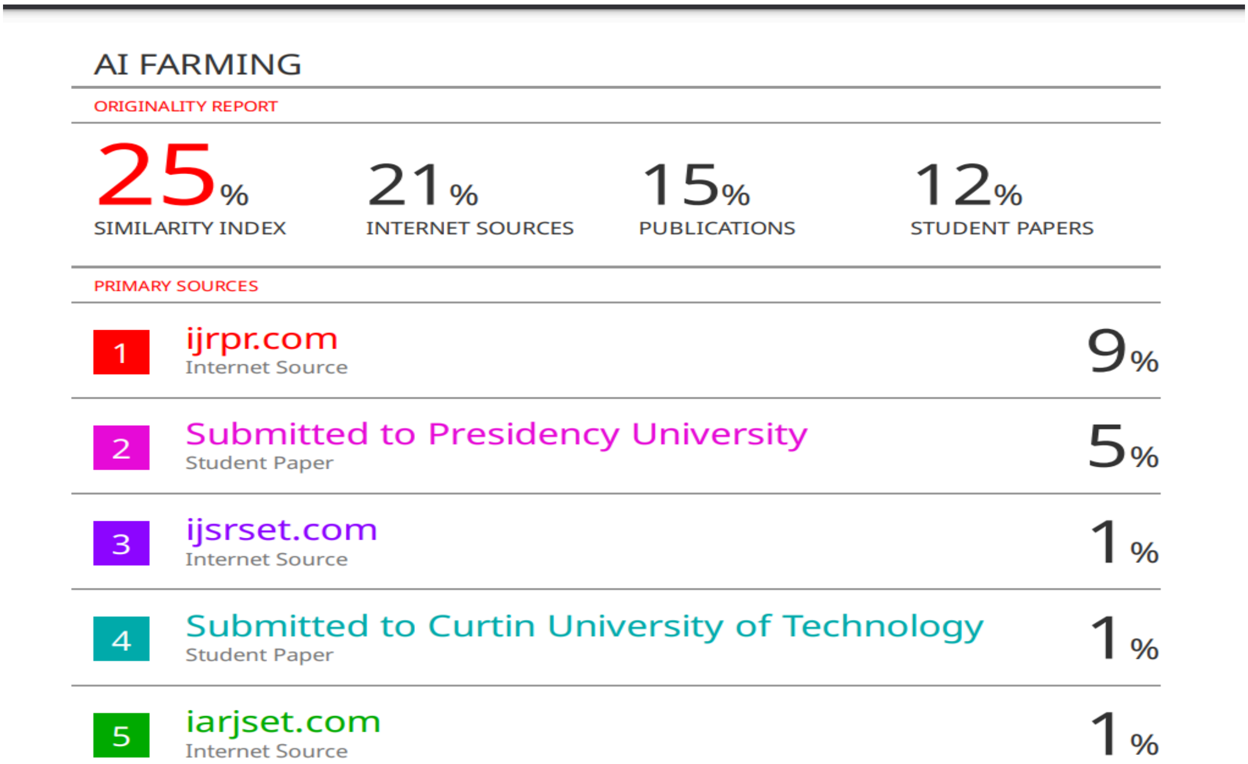

Fig. 14.1 – Plagiarism Detection

Journal Confirmation:

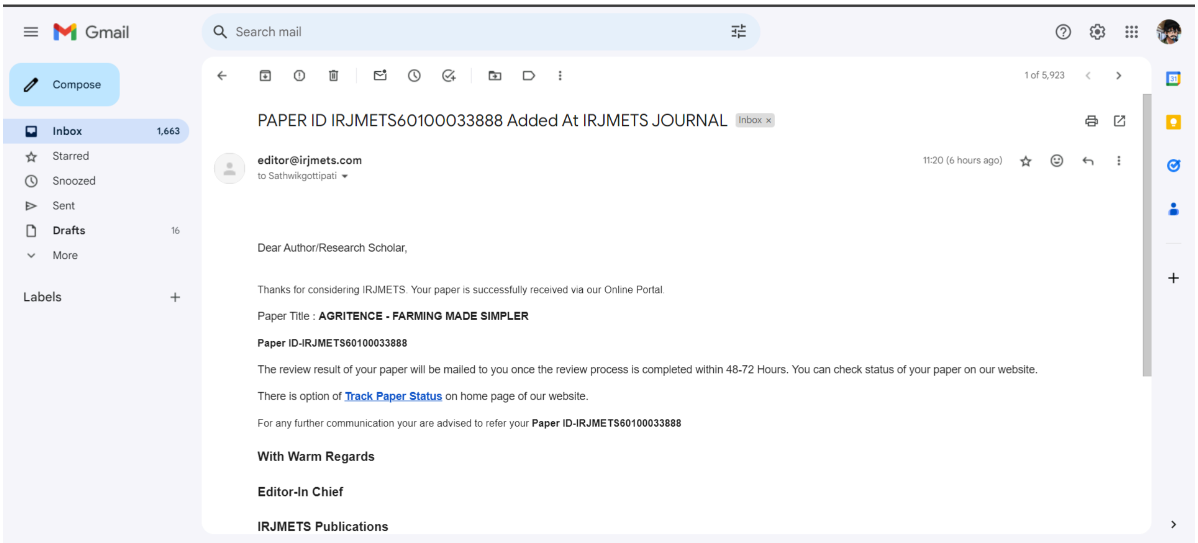

Fig 14.2 – Journal Confirmation

Fig 15.1 Sustainable Development Goals

The Sustainable Development Goals that the project " **ARTIFICIAL INTELLIGENCE IN FARMING** " directly supports are

1. Goal 2: Zero hunger

   AGRITENCE strives to increase crop yield and reduce pest-related crop losses, thereby contributing directly to food security and hunger eradication.

2. Goal 9: Industry, Innovation, and Infrastructure

   AGRITENCE uses new technology, such as artificial intelligence, to create creative agricultural solutions that promote sustainable infrastructure development.

3. Goal 12: Responsible consumption and production

   AGRITENCE encourages responsible agricultural practices by suggesting organic fertilizers and adhering to ISO pesticide regulations, contributing to sustainable consumption and production patterns.

4. Goal 13: Climate Action.

   AGRITENCE assists farmers in adapting to climate change and mitigating its impact on agriculture by leveraging precision agriculture techniques to deliver accurate crop recommendations based on soil conditions and meteorological variables.

5. Goal 15: Life on Land.

   AGRITENCE's emphasis on sustainable farming techniques, soil health improvement, and reduced pesticide use is consistent with protecting, restoring, and promoting the sustainable use of terrestrial ecosystems.

AGRITENCE's goal is to improve agricultural practices, resource utilization, and economic stability directly contributes to these Sustainable Development Goals, demonstrating its ability to promote good change in agriculture while tackling larger global concerns.