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AI POWERED CROP RECOMMENDATION SYSTEM

[1]Dnyaneshwari Madhukar Sawant [2]Prof. Mrs. Rashmi G. Kulkarni
[1]Information Technology Engineering
[1]Siddhant College of Engineering, Sudumbre
[2]Savitribai Phule Pune University

Abstract: Agriculture plays a vital role in economic growth and food security, but farmers often face challenges in crop selection, disease detection, soil analysis, fertilizer management, and yield prediction due to changing environmental conditions and lack of proper agricultural guidance. This project proposes an AI Powered Crop Recommendation System that uses Machine Learning and Deep Learning techniques to support smart and sustainable farming practices. The system analyzes soil properties, weather conditions, and agricultural parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, rainfall, and pH level to recommend suitable crops using Random Forest and XGBoost algorithms. Soil type prediction is performed using a Convolutional Neural Network (CNN) model, while plant disease detection is carried out using a MobileNet-based CNN model that identifies diseases from leaf images and provides fertilizer suggestions along with disease prevention and management strategies. Additionally, crop yield prediction is performed using an LSTM model by considering soil conditions, climatic factors, and geographical location. The proposed system also supports real-time agricultural monitoring and helps farmers optimize the use of water, fertilizers, and other resources efficiently. By integrating Artificial Intelligence, Machine Learning, and Deep Learning technologies into agriculture, the system enables farmers to make accurate and data-driven decisions related to crop selection, disease control, fertilizer usage, and yield optimization. Overall, the project aims to improve agricultural productivity, reduce farming risks, promote sustainable farming practices, enhance farmer profitability, and contribute toward global food security and modern precision agriculture.

Keywords- Artificial Intelligence (AI), Machine Learning, Crop Recommendation, Deep Learning, Soil Analysis, Plant Disease Detection, Crop Yield Prediction, Smart Agriculture, Random Forest.

I. INTRODUCTION

Agriculture plays a vital role in the economy of many countries, especially in developing nations where a large percentage of the population depends on farming for livelihood. Farmers face numerous challenges while selecting the most suitable crop for cultivation due to changing climatic conditions, soil fertility variations, rainfall uncertainty, pest attacks, and lack of proper agricultural guidance. Choosing an unsuitable crop may result in low productivity, financial loss, and inefficient use of resources such as water and fertilizers. With advancements in technology, the integration of Artificial Intelligence (AI) and Machine Learning (ML) in agriculture has opened new opportunities to solve agricultural problems efficiently. AI-powered systems can analyze environmental and agricultural data to make intelligent predictions and recommendations. An AI Powered Crop Recommendation System helps farmers identify the most suitable crop to cultivate based on various parameters such as soil nutrients, weather conditions, humidity, temperature, pH level, rainfall, and geographical conditions. The proposed system aims to utilize machine learning techniques to analyze agricultural datasets and recommend crops that are best suited for cultivation under specific environmental conditions. By using predictive analytics and intelligent algorithms, the system can improve crop yield, reduce farming risks, and assist farmers in making informed decisions. This system contributes to smart farming by providing reliable crop recommendations, thereby increasing productivity and sustainability in agriculture. The system collects agricultural data from reliable datasets and performs data preprocessing to remove inconsistencies and missing values. After preprocessing, machine learning algorithms are trained using historical crop data to classify and predict suitable crops for a given set of environmental conditions. The recommended crops are displayed to users through an interactive interface, helping farmers make data-driven decisions. In modern agriculture, technology-driven farming practices are increasingly necessary due to the growing demand for food production and climate change effects. Therefore, implementing an AI Powered Crop Recommendation System is important to support precision agriculture and promote efficient farming practices.

II. LITERATURE SURVEY

Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) technologies have significantly transformed modern agriculture by improving crop recommendation, plant disease detection, soil analysis, and crop yield prediction. Researchers have developed intelligent agricultural systems to help farmers make accurate and data-driven decisions for improving productivity and sustainability. Deep Learning techniques, especially Convolutional Neural Networks (CNNs), are widely used for plant disease detection and image-based agricultural analysis because they automatically extract features from images without manual intervention. These techniques help identify diseases such as blight, rust, and leaf spot at an early stage, reducing crop loss and improving crop quality. Several studies compared Machine Learning algorithms such as Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Naïve Bayes, Random Forest, AlexNet, and VGGNet for disease detection and crop classification, where Deep Learning models achieved better accuracy and performance.

Researchers have also focused on soil analysis and crop recommendation systems using Machine Learning algorithms. Soil plays an important role in agriculture because different soil types have different nutrient compositions and fertility levels that directly affect crop growth. Studies proposed intelligent systems using algorithms such as SVM, Bagged Trees, and k-NN for soil classification and suitable crop recommendation. Experimental results showed that Machine Learning techniques improve soil analysis and help farmers select crops scientifically based on environmental and soil conditions. In addition, image processing and Deep Learning techniques have been applied for soil health prediction, pH estimation, and nutrient analysis. CNN-based soil analysis systems combined with regression models like XGBoost provide high prediction accuracy and reduce the need for laboratory testing.

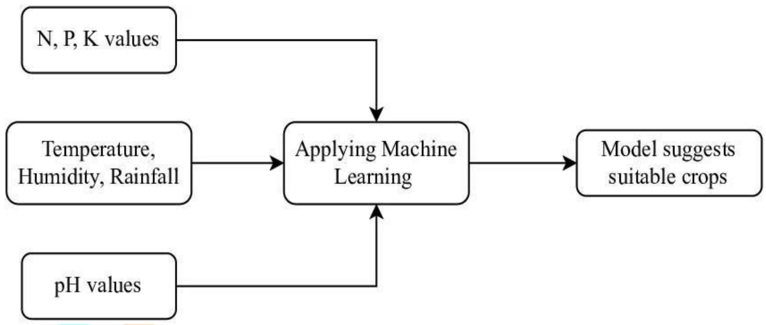
Crop yield prediction is another major research area where Machine Learning and Deep Learning models are extensively used. Researchers reviewed different yield prediction techniques and highlighted the importance of environmental factors such as temperature, rainfall, humidity, and soil fertility in agricultural productivity. Advanced models such as Random Forest, Artificial Neural Networks (ANNs), and Long Short-Term Memory (LSTM) networks are capable of analyzing nonlinear agricultural data and predicting crop yield effectively. LSTM models are especially useful for analyzing sequential and time-series agricultural data. Researchers also explored smart agriculture systems integrating IoT, big data, and Machine Learning for real-time monitoring, automated irrigation, pest detection, and resource management. Although these systems achieved high accuracy and efficiency, challenges such as data scarcity, internet dependency, computational complexity, and lack of user-friendly interfaces still exist. Overall, the literature highlights the growing importance of AI-driven technologies in modern agriculture and their potential to support sustainable farming practices and global food security.

Researchers also explored the integration of Machine Learning in smart agriculture systems for applications such as crop monitoring, automated irrigation, disease prediction, and yield forecasting. IoT sensors are used to collect real-time data like soil moisture, humidity, temperature, and nutrient levels, which are analyzed using Machine Learning algorithms for precision farming and better decision-making. The study also highlighted challenges such as lack of technical awareness, internet connectivity issues, and the need for user-friendly and affordable agricultural technologies for farmers.

III. METHODOLOGY

The AI Powered Crop Recommendation System collects agricultural data such as NPK values, temperature, humidity, rainfall, and pH from a Kaggle dataset. The data is preprocessed by removing missing and duplicate values and scaling features for better accuracy. Machine Learning algorithms like Decision Tree, Random Forest, SVM, KNN, and Naïve Bayes are used for crop prediction and recommendation. CNN models are applied for soil and plant disease detection, while LSTM is used for crop yield prediction. Finally, the system evaluates model performance using accuracy, precision, recall, F1-score, and confusion matrix to provide accurate crop recommendations and farming solutions.

Fig. 1. Data Flow Diagram



A. Data Collection and Preprocessing

The methodology begins with collecting agricultural data from the Kaggle dataset, which contains parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, rainfall, pH level, and crop labels. After data collection, preprocessing techniques are applied to improve data quality. This includes handling missing values, removing duplicate records, converting data into numerical format, feature scaling using normalization or standardization, and encoding categorical crop labels. The dataset is then divided into training and testing sets for model development and evaluation.

B. Segmentation and Feature Extraction

In this stage, the dataset is segmented based on crop categories, soil nutrients, climatic conditions, and pH levels to better understand agricultural patterns. Important features such as NPK values, temperature, humidity, rainfall, and soil pH are extracted because they directly influence crop growth and productivity. Feature extraction helps improve model efficiency by selecting only relevant agricultural parameters and reducing unnecessary complexity in the dataset.

C. Model Training and Crop Recommendation

The processed dataset is used to train multiple Machine Learning algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), K-Nearest Neighbor (KNN), and Naïve Bayes. These models learn the relationship between soil and environmental conditions and suitable crops. Among these algorithms, Random Forest provides better accuracy and reduced overfitting due to its ensemble learning capability. The trained model predicts the most suitable crop based on user input conditions.

D. Disease Detection and Yield Prediction

The system also includes Deep Learning techniques for soil and plant disease analysis. A CNN-based model is used for soil type prediction and plant disease detection through leaf image analysis. The Mobile Net CNN model identifies diseases such as blight, rust, and leaf spot and provides fertilizer recommendations and disease management strategies. Additionally, an LSTM model is used for crop yield prediction by analyzing soil conditions, environmental factors, and geographical location data.

E. Performance Evaluation and Output Generation

Finally, the performance of the trained models is evaluated using metrics such as accuracy, precision, recall, F1-score, and confusion matrix. These metrics help identify the best-performing algorithm for crop recommendation and prediction. After evaluation, the system generates outputs such as recommended crops, detected plant diseases, fertilizer suggestions, disease prevention methods, and crop yield predictions through a user-friendly interface, helping farmers make accurate and data-driven agricultural decisions.

IV. IMPLEMENTATION

This section describes the practical implementation of the proposed quiz and examination paper generator system. The system is implemented as a full-stack web application with a clear separation between frontend, backend, and processing modules.

A. Dataset Collection

The implementation of the AI Powered Crop Recommendation System begins with collecting the agricultural dataset from Kaggle. The dataset contains important agricultural parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, rainfall, pH level, and crop labels. These parameters are essential for analyzing soil fertility and environmental conditions that affect crop growth and productivity. The dataset is loaded into the Python environment using libraries such as Pandas and NumPy for further processing and analysis. The collected data acts as the foundation for training Machine Learning and Deep Learning models for crop prediction and recommendation. prediction.

B. Data Preprocessing

After loading the dataset, preprocessing techniques are applied to improve data quality and consistency. In this stage, missing values are handled using suitable methods such as replacing null values with mean or median values. Duplicate records are removed to prevent biased predictions and improve model reliability. Feature scaling techniques such as normalization and standardization are used to convert all input values into a uniform range, which improves model performance and convergence speed. Categorical crop labels are encoded into numerical values so that machine learning models can process them efficiently. This preprocessing stage ensures that the dataset is clean, accurate, and ready for training.

C. Feature Selection and Analysis

Feature selection and segmentation play an important role in improving the accuracy and efficiency of the AI Powered Crop Recommendation System. In this stage, the system identifies and selects the most relevant agricultural parameters that directly influence crop growth and productivity. Important features such as Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, rainfall, and soil pH are extracted from the dataset for further analysis and prediction. These parameters are considered essential because they help determine soil fertility, climatic suitability, and environmental conditions required for healthy crop cultivation. Selecting only relevant features reduces unnecessary complexity in the dataset and improves the overall performance of the machine learning models. Segmentation is also performed to organize the dataset into meaningful groups based on crop types, soil conditions, climatic factors, and nutrient levels. This helps the system understand relationships and patterns between environmental conditions and crop suitability more effectively. By grouping similar agricultural conditions together, the system can make more accurate crop predictions and recommendations. Feature extraction and segmentation also help reduce computational time, improve model efficiency, and enhance prediction accuracy for real-world agricultural applications.

D. Model Training and Crop Recommendation

After preprocessing and feature selection, the dataset is divided into training and testing sets, generally using an 80:20 ratio. The training dataset is used to train different Machine Learning algorithms, while the testing dataset is used to evaluate model performance on unseen data. Multiple Machine Learning algorithms such as Decision Tree, Random Forest, Support Vector Machine (SVM), K-Nearest Neighbor (KNN), and Naïve Bayes are implemented for crop recommendation and classification. These algorithms learn patterns and relationships between soil nutrients, environmental conditions, and crop labels from historical agricultural data. Among all the algorithms, Random Forest provides better accuracy and performance because of its ensemble learning capability and reduced overfitting. The trained models analyze input parameters such as NPK values, temperature, humidity, rainfall, and pH level provided by the user and predict the most suitable crop for cultivation. This process helps farmers select crops scientifically rather than relying only on traditional farming knowledge and assumptions. The crop recommendation module improves agricultural productivity, reduces farming risks, and supports data-driven decision-making for sustainable farming practices. conditions.

E. Disease Detection and Yield Prediction

Deep Learning techniques are implemented for soil type prediction and plant disease detection. A Convolutional Neural Network (CNN) model is used to analyze soil and plant leaf images. The Mobile Net-based CNN architecture detects common plant diseases such as blight, rust, and leaf spot from uploaded leaf images. After detecting the disease, the system provides recommendations for fertilizer and disease management strategies to reduce crop damage and improve plant health. This feature enables early disease detection and helps farmers take preventive actions before the disease spreads further.

F. Crop Yield Prediction and Performance Evaluation

The system also includes crop yield prediction using the Long Short-Term Memory (LSTM) model. LSTM is used because it performs well in analyzing sequential and time-series agricultural data. The model predicts crop yield by considering environmental factors, soil conditions, weather data, and geographical location information. After model training, evaluation metrics such as accuracy, precision, recall, F1-score, and confusion matrix are used to measure model performance and compare different algorithms. These metrics help identify the best-performing model for crop recommendation and agricultural prediction tasks.

G. User Interface and Result Generation

Finally, a user-friendly interface is developed to make the system accessible and easy to use for farmers. Farmers can enter soil parameters, environmental conditions, and upload leaf images through the interface. The system processes the input data using trained Machine Learning and Deep Learning models and generates outputs such as suitable crop recommendations, detected plant diseases, fertilizer suggestions, disease management solutions, and crop yield predictions. The implementation of this intelligent agricultural system supports smart farming practices, improves productivity, reduces farming risks, and promotes sustainable agriculture using Artificial Intelligence technologies.

V. RESULTS AND DISCUSSION

This proposed AI Powered Crop Recommendation System successfully integrated Machine Learning and Deep Learning techniques for soil analysis, crop recommendation, plant disease detection, fertilizer suggestion, and crop yield prediction. The developed web-based interface provided a user-friendly platform where farmers could upload soil and leaf images and receive real-time agricultural insights. The system accurately analyzed soil characteristics such as NPK values, pH level, moisture content, and weather conditions to recommend suitable crops including soybean, wheat, and gram based on environmental suitability.

The CNN and Mobile Net-based models effectively detected plant diseases from leaf images and provided appropriate fertilizer suggestions and disease management strategies. The Random Forest model achieved better performance for crop recommendation due to its high accuracy and reduced overfitting capability. Additionally, the LSTM model successfully predicted crop yield using soil and climatic conditions. Real-time weather integration and soil analysis further improved the prediction quality and supported precision farming practices.

The developed system demonstrated that AI-driven agricultural solutions can help farmers make data-driven decisions, improve crop productivity, reduce farming risks, and support sustainable agriculture. The project also highlighted the importance of integrating IoT, Machine Learning, and Deep Learning technologies for smart farming applications. Although the system produced accurate and efficient results, future improvements can include multilingual support, mobile application integration, larger agricultural datasets, and real-time sensor-based monitoring for better scalability and practical implementation in rural farming-environments.

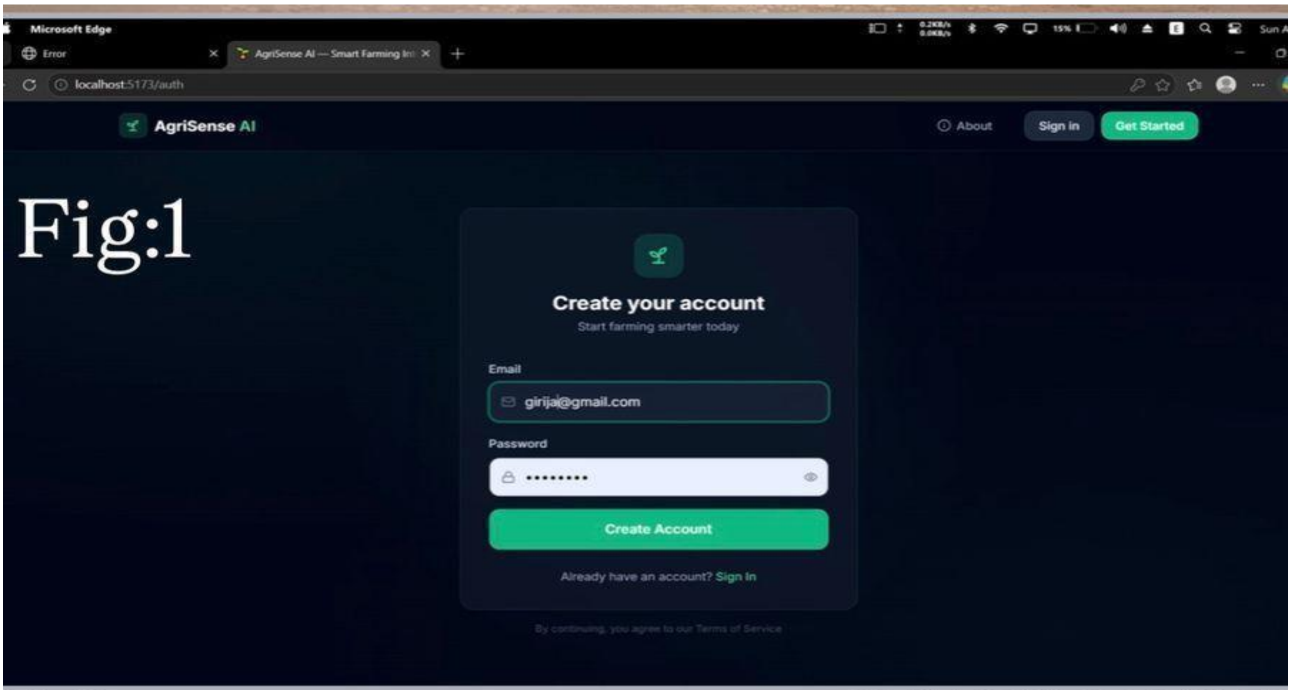


Fig:1
AgriSense AI
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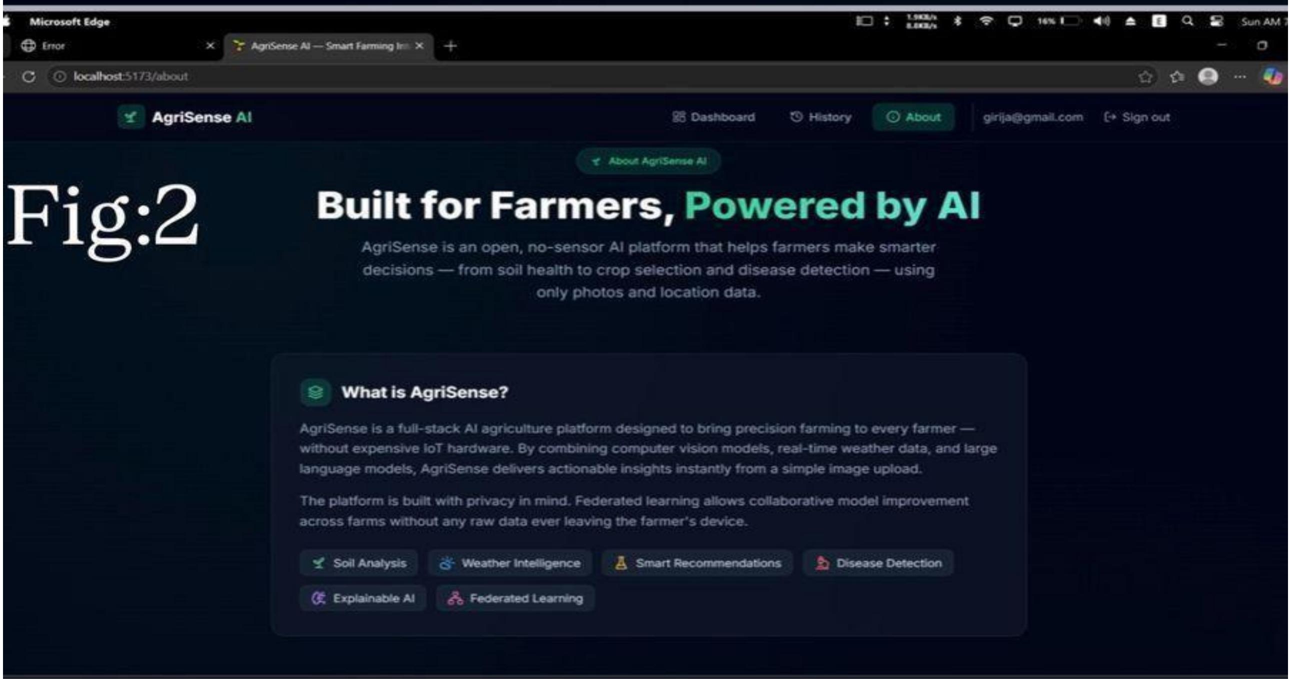
Fig:2
AgriSense AI
Dashboard
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Sign out
About AgriSense AI
Built for Farmers, Powered by AI
AgriSense is an open, no-sensor AI platform that helps farmers make smarter decisions — from soil health to crop selection and disease detection — using only photos and location data.
What is AgriSense?
AgriSense is a full-stack AI agriculture platform designed to bring precision farming to every farmer — without expensive IoT hardware. By combining computer vision models, real-time weather data, and large language models, AgriSense delivers actionable insights instantly from a simple image upload.
The platform is built with privacy in mind. Federated learning allows collaborative model improvement across farms without any raw data ever leaving the farmer's device.
Soil Analysis
Weather Intelligence
Smart Recommendations
Disease Detection
Explainable AI
Federated Learning

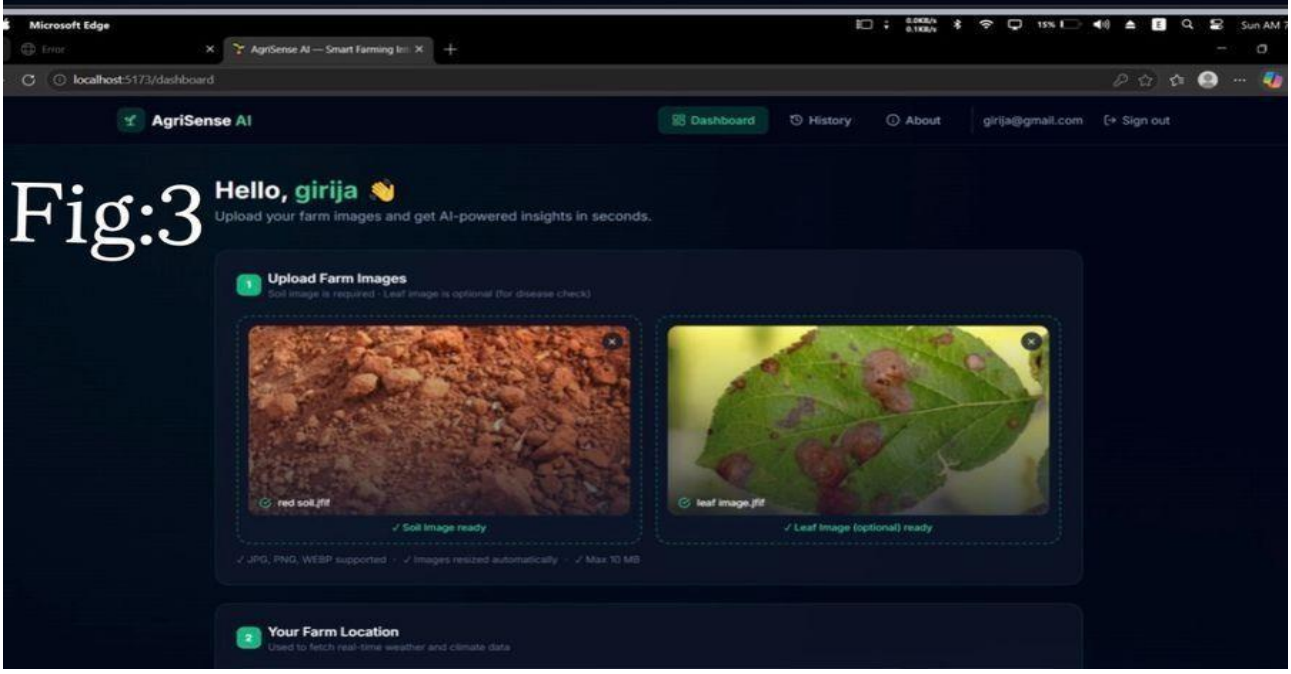
Fig:3
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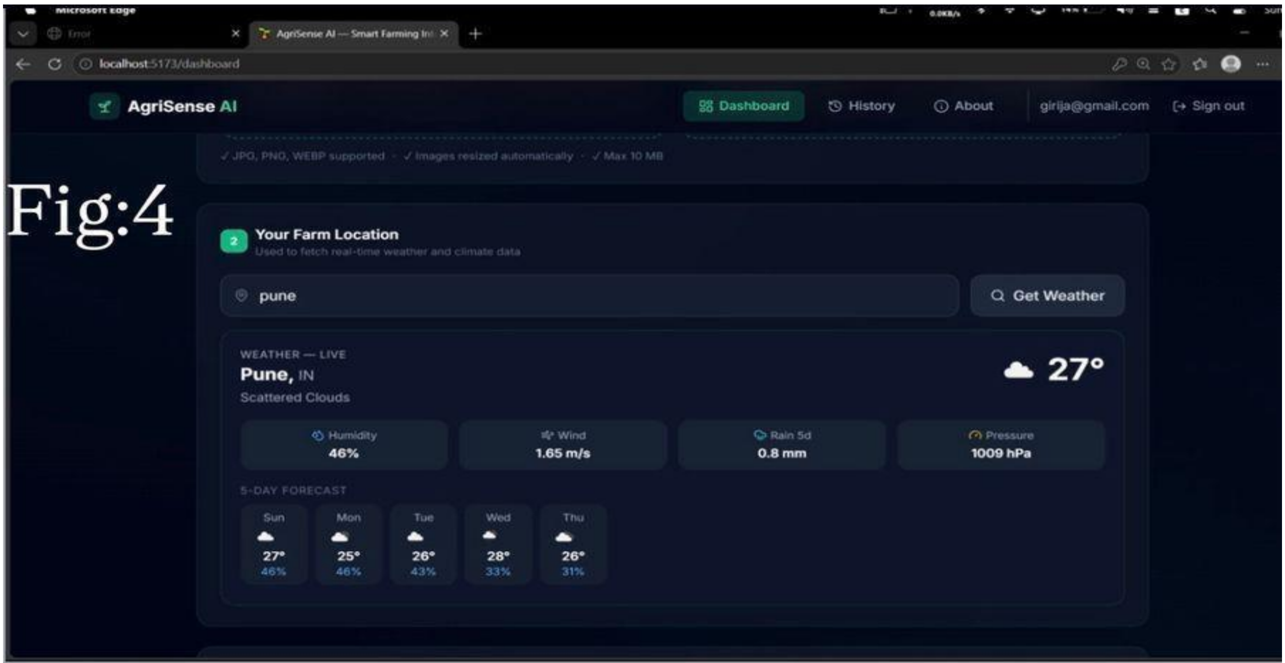

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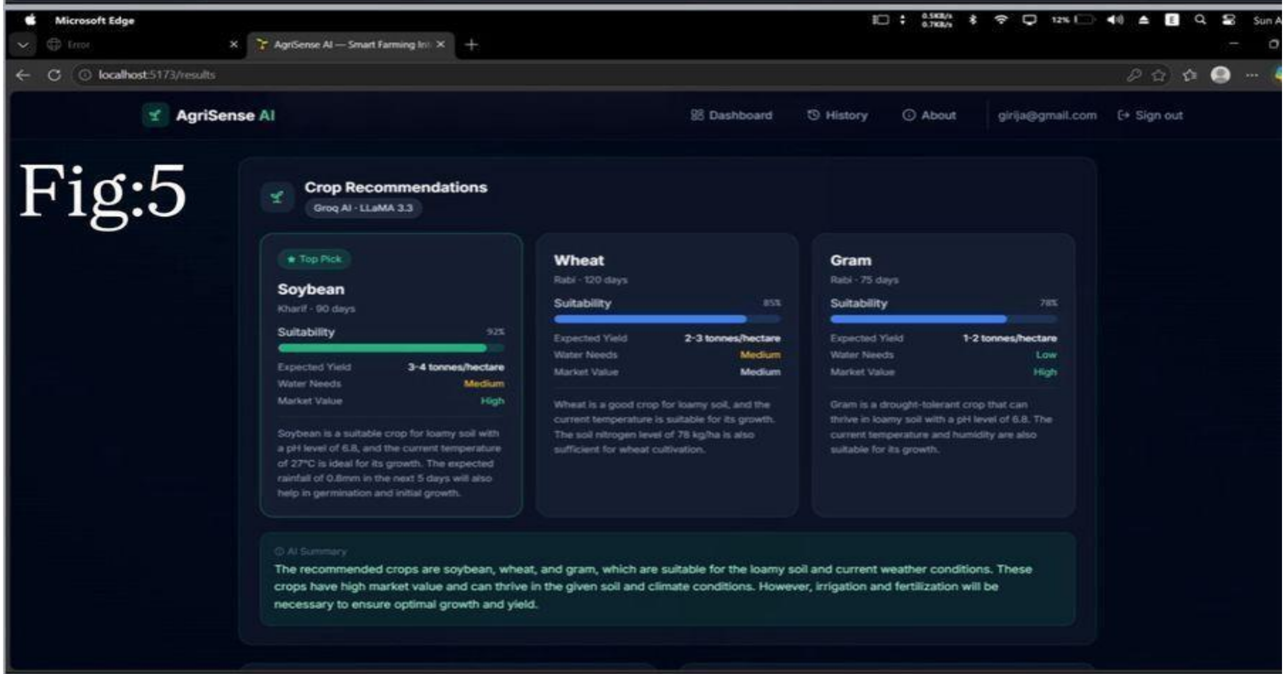

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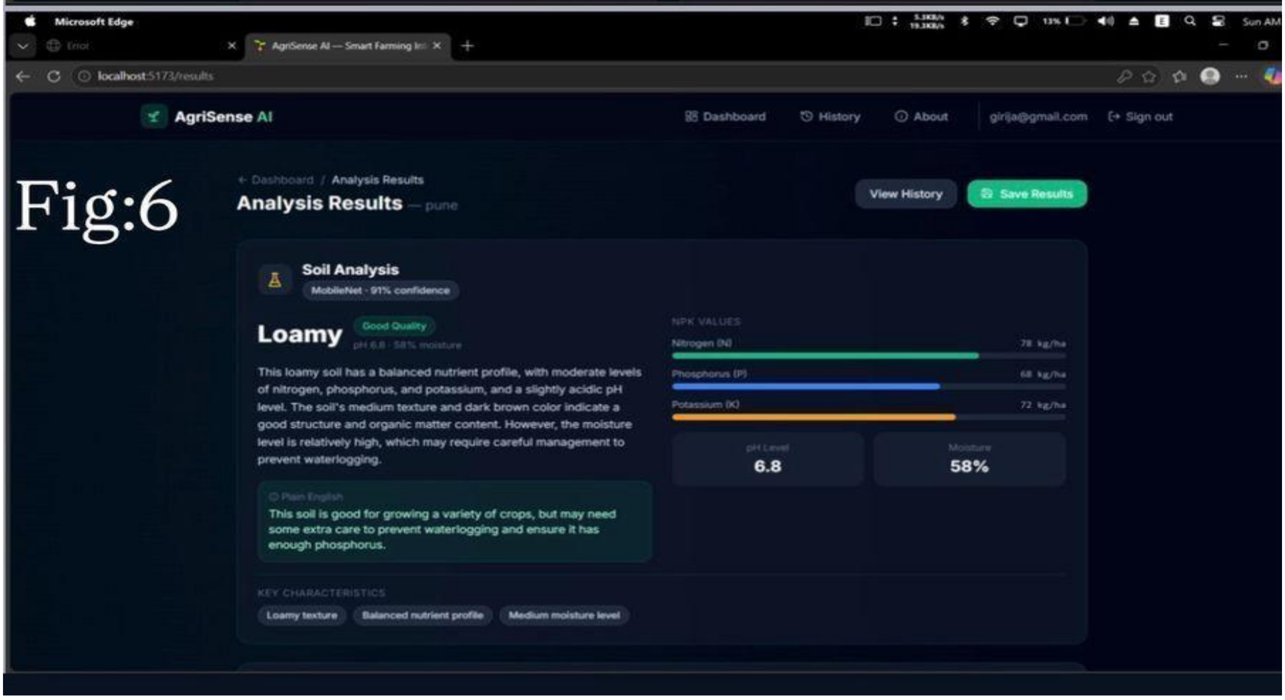

Fig:6

VI. CONCLUSION

The AI Powered Crop Recommendation System successfully demonstrates the use of Artificial Intelligence and Machine Learning in improving modern agricultural practices. The system analyzes important agricultural parameters such as soil nutrients (NPK), temperature, humidity, rainfall, and pH level to recommend the most suitable crop for cultivation. Multiple machine learning algorithms including Decision Tree, Random Forest, SVM, KNN, and Naïve Bayes were implemented and compared, where Random Forest achieved the best performance and prediction accuracy. The developed system helps farmers make scientific and data-driven decisions, reduces the risk of crop failure, improves agricultural productivity, and promotes sustainable farming practices. Additionally, the integration of features such as soil analysis, disease detection, and weather monitoring makes the system more effective and practical for real-world agricultural applications. Overall, the project proves that AI-based technologies can play a significant role in smart farming, resource optimization, and enhancing farmers' economic growth and food security. The AI Powered Crop Recommendation System successfully demonstrates the use of Artificial Intelligence and Machine Learning in improving modern agricultural practices. The system analyzes important agricultural parameters such as soil nutrients (NPK), temperature, humidity, rainfall, and pH level to recommend the most suitable crop for cultivation. Multiple machine learning algorithms including Decision Tree, Random Forest, SVM, KNN, and Naïve Bayes were implemented and compared, where Random Forest achieved the best performance and prediction accuracy. The developed system helps farmers make scientific and data- driven decisions, reduces the risk of crop failure, improves agricultural productivity, and promotes sustainable farming practices. Additionally, the integration of features such as soil analysis, disease detection, and weather monitoring makes the system more effective and practical for real-world agricultural applications. Overall, the project proves that AI-based technologies can play a significant role in smart farming, resource optimization, and enhancing farmers' economic growth and food security.

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