FarmTech: - Recommendation and Prediction System for Farmers

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Abstract - In 2019, India witnessed over 10,000 farmer suicides, driven by crop failures, overwhelming financial burdens, and debt distress. These tragedies were exacerbated by unpredictable weather patterns, pest infestations, and market volatility, highlighting the vulnerabilities faced by farmers and the lack of access to modern agricultural technologies. To address these issues, we introduce FarmTech: Prediction and Recommendation System for Farmers, a versatile platform designed for farmers through data-driven insights. The platform offers a Fertilizer Recommendation System, which provides optimized solutions to enhance soil health and reduce chemical overuse. The Crop Recommendation System helps farmers select the most suitable crops based on soil conditions and climate. Additionally, FarmTech integrates a Plant Disease Recognition System, employing image processing and machine learning to diagnose crop diseases and enable timely interventions quickly. To further enhance usability, an Interactive Chatbot is included to offer real-time advice and address farmer queries. By leveraging AI-driven technologies and real-time agricultural data, FarmTec aims to tackle the challenges of modern farming, promote sustainable practices, and provide farmers with the tools needed to navigate economic, environmental, and technological hurdles.

Key Words*: *Prediction, Recommendation, soil health, Plant Disease, AI-driven, sustainable, Fertilizer

1. INTRODUCTION

India's economy, which is among the fastest-growing in the world and is currently the fifth largest in terms of nominal GDP, is confronted with considerable obstacles in the agricultural sector. More than 50% of India's workforce is employed in agriculture, which generates 16–17% of the nation's GDP and is mostly dependent on traditional practices. This reliance on primitive methods hinders production and restricts overall economic progress, especially when combined with restricted access to innovative, effective farming technology. As a result, the industry deals with problems like low crop yields, inefficient resource use, and unsustainable farming methods, which strain rural livelihoods and have a wider impact on the national economy, limiting the potential of an industry essential to India's food security and economic stability.

These inefficiencies contribute to severe financial distress among farmers, leading to a tragically high number of farmer suicides. In 2019 alone, over 10,000 farmer suicides were reported, largely due to crop failures, mounting debts, and unpredictable weather conditions. At the core of these challenges is the lack of access to proper farming methods, advanced tools, and timely information, which continues to undermine the growth and sustainability of India's agricultural landscape.

Machine learning (ML) is transformative in shaping various aspects of our lives, from enhancing everyday conveniences to driving innovation in multiple industries. Its ability to process vast amounts of data, recognize patterns, and make intelligent predictions has led to transformative changes in sectors such as healthcare, finance, transportation, and entertainment. Across industries, ML is a crucial tool for improving efficiency, personalizing experiences, and driving breakthroughs. When it comes to agriculture, machine learning has the potential to radically transform farming practices, helping to address many of the challenges faced by farmers today. Agriculture is a data-rich field where decisions about soil management, crop selection, pest control, irrigation, and yield prediction can all benefit from data-driven insights.

Our project aims to address all these issues with FarmTech: Prediction and Recommendation System for Farmers, a platform designed to revolutionize farming practices in India by offering data-driven insights and AI-powered tools. FarmTech integrates a Fertilizer Recommendation System, which provides tailored advice based on soil health to ensure optimal nutrient use, enhancing crop growth and preserving soil quality. The Crop Recommendation System suggests the most suitable crops based on soil composition, climate conditions, and market trends, helping farmers make informed decisions that increase yield potential.

Additionally, FarmTech includes a Plant Disease Recognition System, leveraging image processing and machine learning to quickly diagnose crop diseases and recommend treatments. To further support farmers, an Interactive Chatbot is available for real-time query resolution, offering instant advice on various agricultural practices.

2. Literature survey

2.1 Crop recommendation system

This study aims [1] to assist farmers in selecting appropriate crops based on meteorological conditions and soil factors. Using the Naive Bayes algorithm, the study collects data on temperature, humidity, and moisture content to help farmers choose crops that will yield better outcomes. The article emphasizes the importance of modernizing agricultural practices to address climate change concerns and aims to equip farmers with a mobile application that helps predict crops and boost agricultural production.

The paper [2] highlights the role of machine learning in enhancing agricultural productivity in India, which contributes significantly to the national GDP. It reviews various machine learning techniques for crop yield prediction based on climatic and soil parameters. The study compares algorithms such as SVM, Decision Trees, and Random Forests, concluding that these methods can effectively assist farmers in selecting appropriate crops, thereby improving yields and addressing food security challenges.

In [3] they study and investigate the use of the Random Forest algorithm for crop yield prediction, addressing the challenges posed by varying climatic conditions. The authors collect crop growth datasets and apply machine learning techniques to analyze crop production. The Random Forest classifier demonstrates high accuracy in predicting crop yields, suggesting its potential as a reliable tool for farmers to optimize crop production based on current climatic data.

This paper [4] research presents a mobile application designed to help farmers in India predict crop yields and select profitable crops using machine learning algorithms. The system utilizes various algorithms, including Random Forest and SVM, to analyze rainfall, temperature, and soil type. The Random Forest algorithm achieves the highest accuracy of 95%, providing farmers with valuable insights into crop selection and optimal fertilizer usage, thereby aiming to improve agricultural productivity and reduce farmer distress.

In their [5] discusses about the importance of crop yield prediction in India, emphasizing the need for advanced agricultural practices due to the rising food demand from a growing population. It explores various machine learning algorithms applied to agricultural datasets from different states, including Linear Regression, Random Forest, and Gradient Boosting. The study finds that the Gradient Boosting Regressor achieves the highest accuracy of 87.9% for yield prediction, while the Random Forest Regressor excels in predicting crop production with an accuracy of 98.9%. The research aims to assist farmers in maximizing profits and addressing challenges in crop yield.

Table -1: Approach to Crop Recommendation and perdiction system

Author	Proposed Model	Accuracy
M.Kalimuthu et.al (2020) [5]	Naïve Bayes	97%
S Bharath et.al (2020) [9]	Support Vector Machine (SVM), Decision Tree (DT), K-Nearest Neighbor, Random Forest (RF)	99.87% Decision Tree Classifier
V. Geetha et.al (2020) [6]	Naïve Bayes and RF	95% Random Forest Classifier
Shilpa Mangesh P et.al (2021) [7]	SVM, K- Nearest Neighbor, Multivariate Linear Regression, Artificial Neural Network, RF	95% Random Forest Classifier
Payal Gulati and Suman Kumar (2020) [11]	Linear Regression, RF, DT, Gradient Boosting Regression, Ridge Regression, Polynomial Regression	98.9% Random Forest Classifier

From the above table we conclude the comparison of various crop recommendation and prediction systems highlights that ML models such as RF, SVM, and Naïve Bayes are commonly used and effective for this task. Among these models, RF consistently provides high accuracy, with results ranging from 95% to 99.87%, making it a reliable choice for crop prediction.

2.2 Fertilizer recommendation system

This paper [6] discusses about the Machine learning techniques, particularly Support Vector Machines (SVM) and Random Forest, are increasingly utilized for predicting crop yield and recommending fertilizers. These algorithms analyze various data, including soil nutrients and environmental conditions, to optimize agricultural productivity. The proposed system classifies soil types, predicts crop yields, and suggests suitable fertilizers based on historical data. Experimental results indicate that SVM excels in yield prediction with an accuracy of 99.47%, while Random Forest is effective for soil classification at 86.35% accuracy. This approach aims to assist farmers in making informed decisions for better crop management and sustainability.

In the paper [7] In the paper [7] practices are based on machine learning and Internet of Things (IoT) technologies that revolutionized fertilizer prediction and detection in agriculture. A recent study presents a Crop and Fertilizer Recommendation System (CFRS) that employs predictive models to optimize fertilizer use based on specific soil conditions and crop requirements. This system achieves a remarkable 97% accuracy in recommendations, enabling farmers to make informed decisions that enhance productivity and sustainability. By leveraging real-time data from sensors, the CFRS provides tailored guidance on both crop selection and appropriate fertilizer application, addressing the inefficiencies of traditional farming practices and promoting better resource management in regions like Rwanda.

The study from paper [8] The study from paper [8] focuses on predicting and detecting soil nutrient content and fertilizer requirements using machine learning algorithms. It compares the performance of Support Vector Machine (SVM), Decision Tree (DT), and Multilayer Perceptron (MLP) in classifying soil nutrients like nitrogen, phosphorus, and potassium (NPK). MLP outperforms with a 94% accuracy, making it highly effective for fertilizer recommendations. The study emphasizes the importance of optimizing fertilizer use to prevent soil degradation and improve crop yield, addressing the overuse of chemical fertilizers through accurate nutrient analysis.

In [9] we discuss about how the Machine learning and deep learning techniques are increasingly being applied to fertilizer prediction and detection, aiming to optimize agricultural output. Algorithms such as SVM, CNN, and MLP are commonly used to analyze soil nutrient levels and predict the amount of fertilizer required for different crops. These models ensure precise fertilizer recommendations, which prevent overuse and enhance crop yields. Studies show that using such technologies improves accuracy in both fertilizer estimation and crop selection, with some models achieving up to 94% accuracy in predictions.

This research [10] uses Machine learning techniques which predict precise fertilizer dosages, such as nitrogen, phosphorus, and potassium, for specific farmlands. By analyzing soil data (e.g., pH, electrical conductivity EC, and nutrient levels) through algorithms like CART regression, models offer tailored recommendations for different crops and zones. These predictions help farmers optimize fertilizer use, reduce environmental impact, and make informed financial decisions based on target yields. This approach enhances precision agriculture, leading to more sustainable farming practices

Table -2: Approach to Fertilizer Recommendation system

Author	Proposed Model	Accuracy
D Bondre et al. (2019) [6]	SVM, RF	99.47% (SVM)
S Reshma Juhi et al. [8]	SVM, DT, Multilayer Perceptron (MLP)	94% Multilayer Perceptron
S Devi et al. [9]	SVM, Convolutional Neural Network (CNN), MLP	94% Multilayer Perceptron
Singh P et al. [10]	Classification and Regression Tree (CART)	90% (Nitrogen)

Hence, Machine learning techniques such SVM, RF, Multilayer Perceptron (MLP), and Convolutional Neural Networks (CNN) have proven highly effective in fertilizer recommendation systems. SVM excels in crop yield prediction with 99.47% accuracy, while MLP achieves 94% accuracy in nutrient classification. Systems like CFRS, with 97% accuracy, show the potential of combining IoT and machine learning to optimize agricultural practices.

2.3 Plant disease detection system

This paper [11] presents an image processing system utilizing Support Vector Machine (SVM) classification to identify and classify two major tea leaf diseases in Bangladesh: brown blight and algal leaf disease. The methodology involves capturing images of tea leaves, followed by preprocessing steps such as normalization and color space conversion to enhance image quality. A total of eleven features are analyzed for classification, with three less effective features eliminated to improve processing speed while maintaining an accuracy of over 90%. The system significantly reduces the processing time per leaf by approximately 300 ms compared to previous methods, enabling more efficient disease detection and classification. This advancement aims to bolster the competitiveness of the tea industry in Bangladesh by minimizing losses from leaf diseases and enhancing overall production rates.

The paper [12] explores the challenge of timely and accurate identification of plant diseases, especially in developing countries where crop production is significantly impacted by late detection. The study leverages machine learning models, including Support Vector Machine (SVM), k-Nearest Neighbors (KNN), Random Forest Classifier (RFC), and Convolutional Neural Network (CNN), to classify and predict plant diseases from images. Haralick texture features, such as contrast, correlation, and entropy, were used for image feature extraction. Among the models tested, CNN achieved the highest accuracy of 97.89%, followed by RFC at 87.43%,

SVM at 78.61%, and KNN at 76.96%. The study underscores the potential of using advanced machine learning techniques to reduce farmers' dependency on field experts and enhance disease detection accuracy.

This study [13] explores the application of machine learning models to detect early and late blight diseases in potato crops. Using image processing techniques, it analyzes potato leaf images, segments disease-affected regions with fuzzy c-means clustering, and extracts texture features from HSV images for classification. The research compares three classifiers—Support Vector Machine (SVM), Random Forest (RF), and Artificial Neural Network (ANN)—with ANN achieving the best accuracy at 92%, followed by SVM at 84%, and RF at 79%. The study underscores the importance of automated disease detection tools to improve crop management and minimize losses for farmers.

The research paper [14] presents a method for detecting and classifying plant leaf diseases using a K-nearest neighbor (KNN) classifier, focusing on five specific diseases: Alternaria alternata, anthracnose, bacterial blight, leaf spot, and citrus canker. The approach involves several key steps: image acquisition, color space conversion to the Lab model, color segmentation using KNN, morphological operations to isolate disease-affected areas, and feature extraction based on texture and color characteristics. The system achieves a high classification accuracy of 96.76% by analyzing a dataset of 237 leaf images. Performance metrics such as the Dice Similarity Coefficient (DSC), Mean Square Error (MSE), and Structural Similarity Index (SSIM) are used to evaluate the effectiveness of the segmentation process, demonstrating strong results in disease detection.

In [15] we focus on detecting and classifying soybean leaf diseases using image processing techniques, combined with multiclass Support Vector Machine (SVM) and K-Nearest Neighbors (KNN) classifiers. The study targets three common soybean diseases: Bacterial Blight, Frogeye Leaf Spot, and Septoria Brown Spot . The images of infected

leaves are processed to enhance quality, remove backgrounds, and segment the diseased regions using the Incremental K-means clustering technique. Color and texture features are extracted from the segmented regions to train the classifiers. The system measures disease severity by calculating the proportion of diseased area relative to the total leaf area. The SVM classifier achieved an accuracy of 87.3%, while the KNN classifier reached 83.4%. The study demonstrates the effectiveness of machine learning in improving disease detection and classification for agricultural applications.

Table -3: Approach to Fertilizer Recommendation system

Author	Proposed Model	Accuracy
Rokeya Mumtahana Mou1 et al. [11]	SVM	97.2% Support Vector Machine (SVM)
B. Hatuwal et al. [12]	RF, KNN, SVM, Convolutional Neural Network	97.89% Convolutional Neural Network (CNN)
Krishnan N et al. [13]	SVM, RF, and ANN in Potato Blight	92% Artificial Neural Network (ANN)
Eftekhar Hossain et.al [14]	KNN Classifier	96.76%
Sachin B. Jadhav et.al (2019) [15]	SVM, and KNN classifier	87.3% Support Vector Machine (SVM)

By observing the above table, we conclude that Convolutional Neural Network (CNN), which achieved the highest accuracy of 97.89% in study. However, SVM also demonstrates strong performance with consistently high accuracy across multiple studies, making it another reliable option.

3. PROPOSED WORK

In the context of FarmTech, machine learning is leveraged in several key areas to empower farmers with intelligent solutions.

- **Crop Recommendation System:** ML models evaluate soil characteristics, weather patterns, and market trends to suggest the most suitable crops for a region. By learning from past data, these models help farmers choose crops that are likely to thrive, maximizing yield and profitability.

- **Fertilizer Recommendation System:** Machine learning algorithms analyze soil data, historical crop yields, and environmental factors to recommend optimal fertilizer usage. This helps reduce the overuse of chemical fertilizers, improving soil health, and ensuring sustainable farming practices.

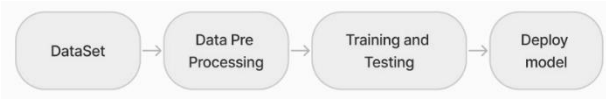

Fig 1 – Crop and Fertilizer recommendation process

- **Plant Disease Recognition System:** One of the most critical uses of machine learning in FarmTech is in plant disease detection. Through image processing and deep learning techniques, the system can analyze images of crops and accurately identify diseases based on visual patterns. This early detection allows for timely intervention, reducing the potential for crop loss.

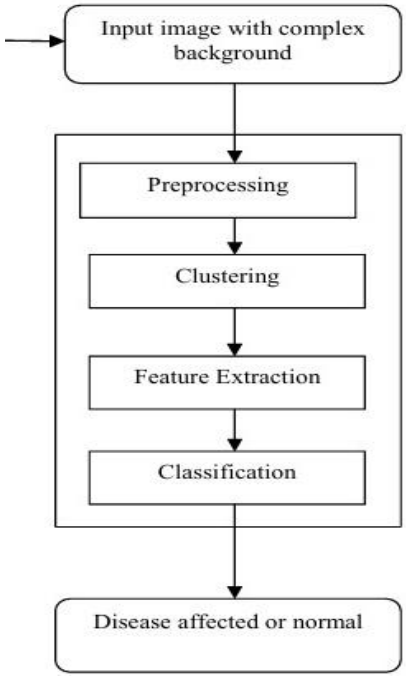

Fig 2 – Plant disease recognition process.

- **Interactive Chatbot:** The chatbot utilizes natural language processing (NLP), a branch of machine learning, to understand farmer queries and provide relevant solutions in real time. It can learn from previous interactions, improving its ability to assist farmers with personalized recommendations and problem-solving.
  By incorporating machine learning, FarmTech provides farmers with predictive, personalized, and scalable solutions that optimize farming practices, mitigate risks, and contribute to more sustainable agriculture. AI ensures that farmers can make data-backed decisions, reducing guesswork and improving outcomes across various farming activities.

4. CONCLUSIONS

The FarmTech: Prediction and Recommendation System for Farmers is a noteworthy development in tackling the various issues that Indian farmers confront. FarmTech boosts agricultural output and encourages sustainable practices, which are essential for farming's long-term sustainability, by fusing machine learning and data-driven insights. The system's several parts—from crop and fertiliser recommendations to the identification of plant diseases—give farmers the critical information they need to make wise decisions, reducing the likelihood of crop failures and subsequent financial hardship. In the end, this platform represents a proactive approach to contemporary farming, giving farmers the ability to successfully negotiate the complicated rules of their surroundings and enhance India's agricultural landscape.

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