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FarmIQ: An Intelligent Agricultural Solution

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Abstract- Agriculture is becoming increasingly vulnerable to changing weather conditions, soil nutrient imbalance, and the rapid spread of crop diseases, all of which place considerable pressure on farmers to make proper decisions with narrowed resources. In many cases, farmers continue to depend on intuition or general advice rather than structured analysis, resulting in poor crop selection, inefficient fertilizer application, and delayed recognition of plant infections. These challenges indicate a rising requirement for smart solution that simplify field-level decision- making while improving precision. This study presents FarmIQ, an integrated Agricultural Decision Support System designed to provide real-time, data-driven guidance for sustainable crop management. The system brings together multiple computational techniques, applying machine learning for crop recommendation, fertilizer optimization, and yield forecasting, along with a deep-learning-based method for automated leaf disease classification. FarmIQ evaluates essential soil and environmental parameters, including npk, pH, temperature, humidity, and rainfall, to find crops that are suitable with current field conditions. A fertilizer module analyzes nutrient deficiencies and generates targeted recommendations to maintain soil health, while yield prediction is done using regression models trained on historical production data. For disease detection, the system uses a fine-tuned VGG16 convolutional neural network capable of identifying common infections in tomato, potato, grape, and corn plants and providing treatment suggestions immediately after classification. All functionalities are delivered through a lightweight Flask based user facing platform to input soil details, upload leaf images, and obtain results instantly and clearly. Experimental evaluation shows that FarmIQ performs reliably across varied agricultural scenarios, demonstrating strong potential for practical use in field environments. The system contributes to improved decision accuracy, reduced dependency on agricultural experts, and more efficient resource utilization. By integrating predictive analytics and automated diagnosis into a unified platform, FarmIQ supports the transition toward data-driven and sustainable agriculture for farmers, students, and researchers.

Keywords: Agricultural Decision Support System, Crop Recommendation, Fertilizer Optimization, Yield Prediction, Leaf Disease Classification, Machine and Deep Learning, Precision Agriculture.

I. INTRODUCTION

Agriculture is the most essential sectors supporting global food security, yet it continues to face increasing pressure from environmental instability, soil degradation, unpredictable pest outbreaks, and the rising demand for higher productivity. Traditional farming practices often depend on experience-based decision-making, that usually does not consider variations in soil composition, climatic conditions, or the early symptoms of plant diseases. As a result, farmers frequently encounter challenges such as incorrect crop selection, improper fertilizer usage, and delayed responses to crop infections, all of which contribute to reduced yield and economic losses.

With the rise of data analytics, machine and deep learning, new techniques have come to introduce intelligent tools that support farmers in making accurate and timely decisions. Recent research shows that predictive modeling, automated disease identification, and real-time advisory systems can significantly improve agricultural efficiency. Since, many available solutions check on isolated tasks—such as only crop prediction or only disease detection—without providing an integrated platform that addresses multiple farming requirements simultaneously.

To mitigate these problems, this work have come up with FarmIQ, a unified ADSS designed to deliver data-driven recommendations using machine and deep learning techniques. The system analyzes soil parameters, environmental factors, and leaf images to support decisions related to crop selection, fertilizer planning, yield forecasting, and disease diagnosis. By offering multiple intelligent services in a single platform, FarmIQ aims to simplify decision-making processes, reduce dependency on expert consultation, and enhance ecologically balanced farming practices. This section introduces the motivation for developing FarmIQ and highlights the growing need for accessible digital tools in modern agriculture.

Problem Statement

Modern agriculture is increasingly affected by climate variations, soil nutrient deficiencies, and the rising incidence of plant diseases, making it a problem for farmers to make consistent and accurate decisions. Many farmers still rely on traditional methods or personal judgment, which often leads to poor crop selection, improper fertilizer use, and delayed identification of field-related issues. Existing digital tools target only isolated tasks and fail to deliver an integrated solution that supports multiple decision-making processes. This creates a significant need for an integrated system capable of analyzing soil parameters, environmental conditions, and plant health indicators to deliver reliable and actionable recommendations for efficient and sustainable farming.

II. RESEARCH BOUNDARIES

This work deals on the design, implementation, and assessment of an integrated ADSS that utilizes deep learning techniques to address key decision-making processes in farming. The work focuses on four essential components: crop recommendation using soil characteristics and climatic parameters, fertilizer optimization through nutrient analysis, yield prediction using regression-based models, and automated identification of leaf diseases through CNN.

The study further includes the implementation of a unified web-based interface to ensure accessibility for end users, along with the evaluation of system performance assessment of the underlying models using standard evaluation metrics. While the system addresses several core aspects of smart agriculture, the scope is limited to selected crops, controlled datasets, and predefined environmental parameters. Broader deployment scenarios, real-time sensor integration, and adaptation to region-specific agricultural practices are identified as potential extensions beyond the current scope of this work.

III. LITERATURE SURVEY

Recent developments in agricultural informatics have highlighted the effectiveness of machine and deep learning to address key challenges faced by farmers. A lot of work have identified many crop recommendation methods using algorithms such as, showing that soil parameters and climatic factors can be effectively analyzed to suggest suitable crops for different regions. Research on fertilizer optimization highlights the importance of nutrient-based recommendation systems that use soil test reports to identify deficiencies and compute balanced fertilizer dosages. Yield prediction has been studied using regression models and combined methods, with findings indicating that combining past yield information with environmental parameters improves forecasting accuracy. CNN such as VGG16, ResNet, and Inception, has shown strong success in image- based plant disease classification, enabling early detection and treatment suggestions. While these studies indicate important progress, most existing systems address only individual tasks rather than providing an integrated framework. This gap highlights the necessity for a system like FarmIQ, which unifies multiple predictive and diagnostic capabilities to help agricultural practices.

System Architecture and Design

The FarmIQ system is being designed as a multi-component decision support platform incorporating machine learning methods to assist in most of the agricultural decision-making. The architecture is structured into four primary modules: the crop recommendation module, the fertilizer optimization module, the yield prediction module, and the leaf disease detection module. Each module processes specific input parameters and provides targeted outputs to support data-driven farming practices.

The system follows a layered architectural approach. The data layer consists of soil datasets, environmental factors, and curated leaf image datasets used for model training. The processing layer consists of the ML based models that perform the analyzing of soil features and predicting crop suitability, nutrient requirements, and potential yield values. The deep learning component, implemented using a fine-tuned VGG16 network, performs image-based disease classification. The application layer combines these models into a unified workflow that handles user inputs and produces relevant recommendations. The next presentation layer is implemented through a Flask-based system that help users to enter soil parameters, upload leaf images, and view results instantly.

This modular and layered design ensures scalability, flexibility, and ease of maintenance, while enabling seamless integration of additional models or features in future enhancements.

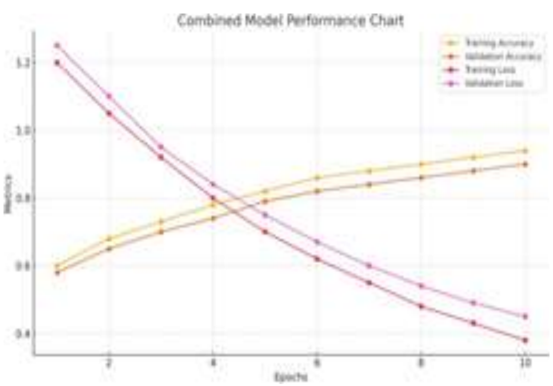

Chart -1: Model Performance Overview

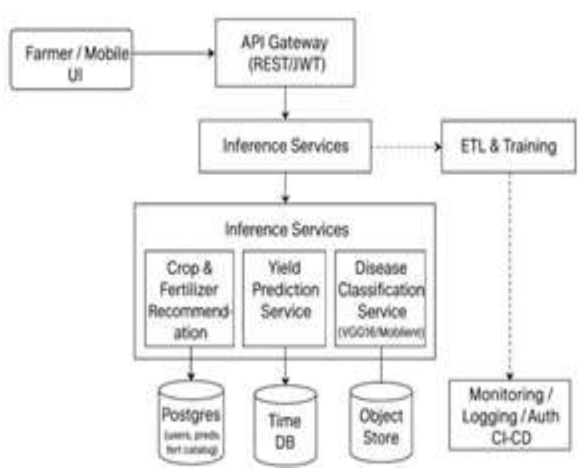

Figure 1: Architecture of the proposed FarmIQ system

Figure 2: Home Dashboard

Figure 3: Output of the proposed FarmIQ system showing leaf disease detection and recommended treatment

CONCLUSION

The FarmIQ system presents an integrated approach to addressing several key challenges in new agriculture by putting together ML, and data-driven analysis within a single platform. The system successfully provides intelligent crop recommendations, optimized fertilizer guidance, accurate yield predictions, and reliable leaf disease detection, helping farmers in making well data supported decisions with greater confidence. The performance evaluation demonstrates that the implemented models achieve high accuracy and stable learning behavior, indicating their suitability for real-world agricultural applications. By offering an accessible and user-friendly interface, FarmIQ reduces the reliance on expert consultation and supports efficient resource utilization, ultimately contributing to increased crop yield and sustainable farming practices. Future improvements include integrating additional crop varieties, expanding disease categories, integrating real-time sensor data, and enabling large-scale deployment for wider agricultural use.

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