Soil Analysis and Health Evaluation System for Smart Agriculture

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Abstract- ***This paper presents a smart agriculture system that integrates soil analysis with real-time monitoring to improve farming decisions. The system utilizes a dataset containing soil nutrients such as Nitrogen (N), Phosphorous (P), Potassium (K), and pH values to evaluate soil health and recommend suitable crops. In addition, real-time data from soil moisture and rain sensors is collected using an Arduino-based system and processed through a Flask server. The processed data is displayed on a web-based dashboard, which provides irrigation decisions and pest risk predictions. The proposed system aims to improve crop productivity, optimize water usage, and support sustainable farming practices.***

Index Terms — Smart Agriculture, Soil Analysis, Crop Recommendation, Arduino, IoT, Real-Time Monitoring

I. INTRODUCTION

Agriculture plays an important role in food production and economic development. Traditional farming methods often depend on manual observation, which can lead to inefficient use of resources and reduced crop yield. With the advancement of technology, smart agriculture systems can improve decision-making through data analysis and real-time monitoring.

This paper presents a system that integrates dataset-based soil analysis with sensor-based monitoring. The system evaluates soil health, recommends suitable crops, and provides irrigation and pest-related decisions to support efficient farming.

II. LITERATURE REVIEW

Recent agricultural systems use sensors and data analysis to improve farming practices. Sensor-based systems provide real-time environmental data but lack decision-making capabilities. Data-driven approaches offer crop recommendations based on soil parameters but do not consider real-time conditions. IoT-based irrigation systems help in water management but operate with limited intelligence. The proposed system combines soil analysis with real-time monitoring to provide better decision support.

III. PROPOSED SYSTEM

The proposed system consists of two main modules:

1. Dataset-Based Soil Analysis
   - Analyzes soil nutrients (N, P, K)
   - Determines pH level
   - Evaluates soil health
   - Recommends suitable crops
2. Real-Time Monitoring System
   - Uses soil moisture and rain sensors
   - Collects real-time data via Arduino
   - Sends data to Flask server
   - Displays results on dashboard

The integration of both modules provides a complete smart agriculture solution.

IV. METHODOLOGY

The system uses a frequency-based approach for crop recommendation, where the most frequent crop in the selected district is considered as the best suitable crop.

The working of the system is as follows:

1. Load dataset and clean data
2. User selects district
3. Analyze soil parameters (N, P, K, pH)
4. Evaluate soil health using scoring method
5. Recommend best crop based on dataset
6. Read sensor data (soil moisture, rain)
7. Send data to Flask server using serial communication
8. Dashboard fetches data from server
9. Apply decision logic:
   - Irrigation control
   - Pest risk prediction
10. Display results on dashboard

Fig. 1. Data Flow Diagram

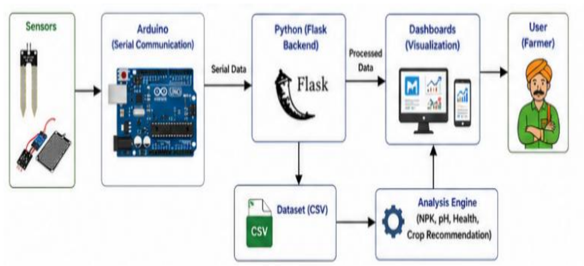
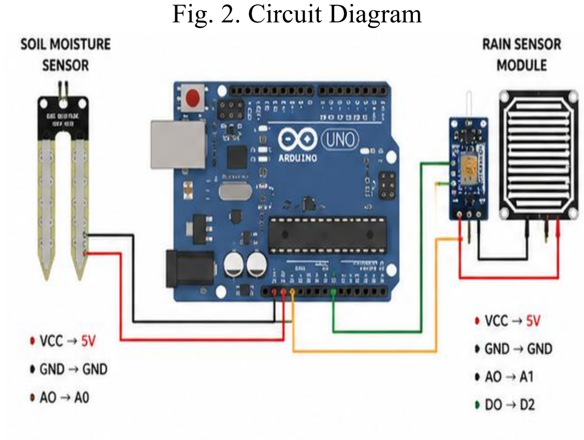


Fig. 2. Circuit Diagram



V. RESULTS AND DISCUSSION

Since the system is based on dataset frequency and rule-based logic, traditional accuracy metrics are not applicable. However, the system provides reliable and consistent recommendations for practical agricultural use.

The system provides real-time visualization of soil and environmental conditions through a dashboard. It successfully classifies soil health and recommends suitable crops based on dataset analysis. The irrigation system helps in conserving water, and pest prediction provides early warning for crop protection.

The integration of dataset analysis and sensor data improves decision-making and increases efficiency compared to traditional farming methods.

As shown in Fig. 3 and Fig. 4, the dashboard provides real-time visualization of system outputs.

Fig. 3. Output Dashboard 1

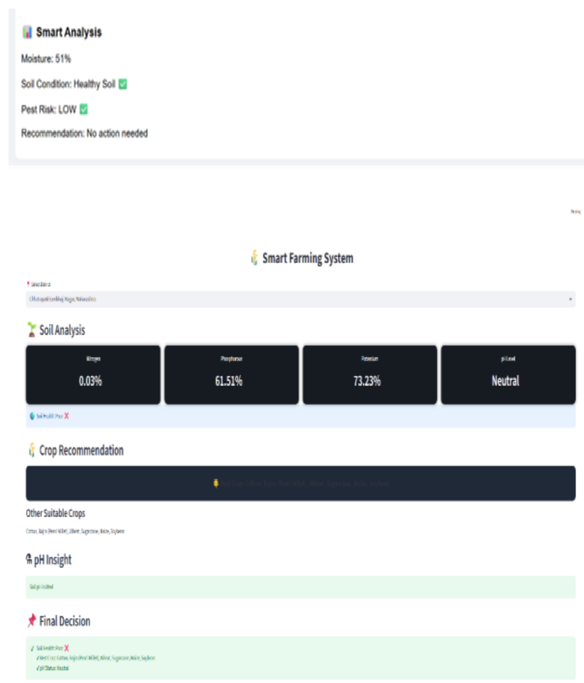
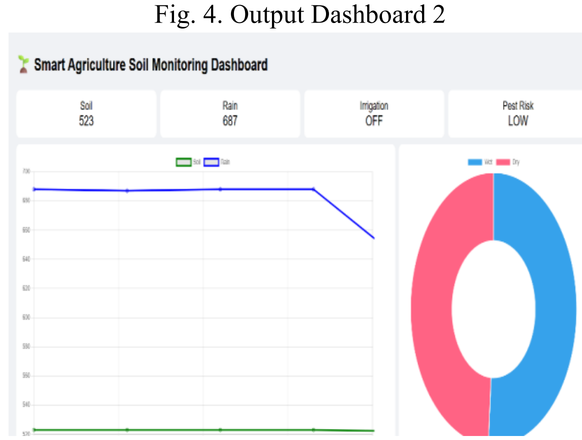


Fig. 4. Output Dashboard 2



VI. CONCLUSION

The proposed system effectively combines soil analysis and real-time monitoring to support smart agriculture. It improves crop productivity, reduces water wastage, and provides useful recommendations for farmers. The system is cost-effective and easy to implement, making it suitable for practical applications. Future work can include integration of machine learning models for improved prediction accuracy.

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