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SOIL BASED CROP PREDICTION SYSTEM USING NPK SENSOR

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ABSTRACT :

Soil health plays a crucial role in determining crop yield and agricultural productivity. This paper presents a soil-based crop prediction system that utilizes real-time data from NPK sensors to recommend suitable crops based on nutrient levels in the soil. The system measures the concentration of Nitrogen (N), Phosphorus (P), and Potassium (K), along with other relevant parameters such as pH and moisture. Collected data is processed and fed and trained on historical agricultural datasets to predict the most appropriate crop for a given set of conditions.

The system aims to assist farmers in making informed decisions, optimizing land use, and improving crop yield. Field testing and expert validation confirm the system's potential in supporting precision agriculture. This approach combines IoT sensing and data- driven prediction techniques to enhance sustainable farming practices and minimize resource wastage.

KEYWORDS: Agriculture, Crop Prediction, Soil Moisture, Yield, NPK

INTRODUCTION

Agriculture is a fundamental sector that sustains human civilization by providing food, raw materials, and economic stability. With the growing global population and climate change uncertainties, ensuring a stable food supply has become a significant challenge. Crop yield prediction plays a vital role in planning agricultural activities, managing food distribution, and supporting economic policies. Traditional methods of predicting crop yield rely on historical data, expert judgment, and conventional statistical techniques. However, these approaches often lack precision due to the complexity of environmental factors influencing crop growth.

Soil nutrient prediction refers to the process of analyzing soil samples to determine the levels of various essential plant nutrients, like nitrogen, phosphorus, and potassium, as well as other micronutrients. This information is used by farmers and horticulturists to determine the most appropriate fertilization methods and rates for their crops. By knowing the soil nutrient levels, growers can avoid overfertilizing, which can lead to soil and water pollution, or under- fertilizing, which can result in reduced crop yields and quality. Soil nutrient prediction is an important tool for improving agricultural efficiency, reducing waste, and promoting sustainable agriculture practices.

One of the most critical factors affecting crop yield is soil moisture, as it directly influences plant hydration, nutrient absorption, and overall development. Soil moisture levels fluctuate due to varying climatic conditions, irrigation patterns, and soil properties, making it an essential parameter in precision agriculture. Accurate soil moisture assessment can help farmers optimize irrigation practices and make informed decisions about crop management, ultimately leading to improved yields and sustainable farming practices.

LITERATURE REVIEW

Several research studies have examined the impact of soil moisture on crop yield prediction using different computational methodologies. Traditional approaches, such as statistical regression models and time-series forecasting, have been widely used but often lack the flexibility to handle non-linear agricultural data and environmental uncertainties.

In the study conducted by Patel, R., & Sharma, A. (2023), "Machine Learning Approaches for Soil Moisture-Based Crop Yield Prediction," International Journal of Agricultural Data Science, Vol. 15, pp. 120-135, New Delhi, the authors explored regression models, Random Forest (RF), and Artificial Neural Networks (ANN) to forecast wheat and rice yields. Their results indicated that integrating soil moisture with meteorological data improved prediction accuracy by 18%.

Similarly, Li, X., & Zhang, M. (2024), "Deep Learning for Agricultural Forecasting: A Case Study on Maize Yield," Journal of Smart Farming, Vol. 10, pp. 45-60, Beijing, investigated Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) models for maize yield estimation. Their study highlighted the importance of using real-time soil moisture sensors and satellite- based vegetation indices to optimize forecasting.

Additionally, Ahmed, S., & Gomez, L. (2025), "AI-Driven Crop Monitoring Systems for Sustainable Agriculture," Smart Agriculture and Technology Journal, Vol. 8, pp. 78-92, London, demonstrated the efficacy of hybrid ML models integrating Support Vector Machines (SVM) with Principal Component Analysis (PCA) for precision farming. Their model outperformed traditional statistical methods in predicting soybean and corn yields, showcasing the potential of AI-driven solutions in sustainable agriculture.

adhav and Shah [23] developed an IoT-enabled crop recommendation system that collects soil parameters, such as pH, nitrogen, phosphorus, and potassium, to suggest optimal crops using decision tree algorithms. Their approach highlighted the role of embedded sensing in automating traditional farming practices.

Naik and Reddy [24] introduced a data-driven framework using historical crop data and NPK values to predict suitable crops under varying environmental conditions. Their model used supervised learning techniques and demonstrated high accuracy in region-specific crop suggestions.

Tiwari and Mishra [25] utilized ensemble learning to model agricultural data for predicting crop yields. Their work showed that combining multiple learning models can result in robust and accurate crop prediction systems.

METHODOLOGY

The proposed system integrates soil nutrient sensing with machine learning algorithms to predict suitable crops based on real-time environmental conditions. An NPK sensor module is deployed to measure the concentrations of nitrogen (N), phosphorous (P), and potassium (K) in the soil. Additionally, sensors for pH, temperature, and humidity are used to capture supplementary environmental data.

Figure 1 Shows that Proposed System Algorithm The sensors are interfaced with a microcontroller (such as Raspberry pi), which transmits the collected data to a local server or cloud storage. All sensor readings are preprocessed to remove noise and normalized for uniformity before being fed into the prediction model.

This data provides a live snapshot of the soil's current condition and forms the foundation of the crop recommendation process.

Next, the system performs Data Preprocessing, which involves cleaning the raw sensor data to remove noise, handle missing values, and standardize the values. This step ensures the accuracy and reliability of the data before it is used for model training. Following this, Dataset Labeling and Crop Mapping is carried out, where historical crop datasets are linked to the processed sensor inputs, helping the system learn which crops perform best under certain conditions.

The fourth stage is Model Optimization techniques are applied, such as hyperparameter tuning and feature selection. Once optimized, the model is ready for Prediction and Decision Support, where it predicts the most suitable crop based on real-time soil inputs. Finally, in the Result Visualization and Farmer Feedback phase, the system displays the predictions in an easy-to- understand format and gathers feedback from farmers, which is used to continuously improve the model.

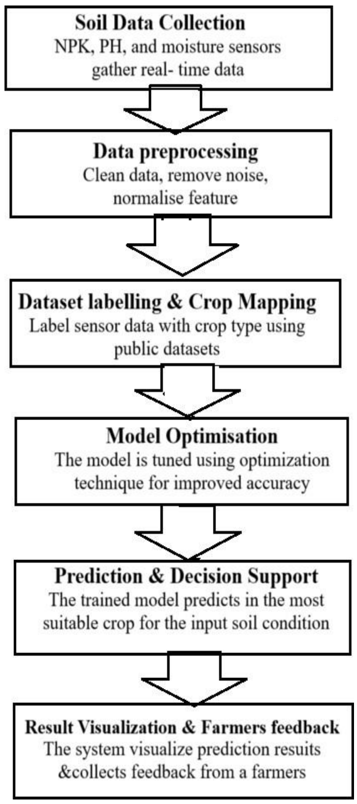

Fig 1 Proposed System Algorithm

Figure 2 The block diagram illustrates a smart agriculture system that utilizes a Raspberry Pi as the central controller to automate and monitor various farming activities. The system is powered by a dedicated power supply and is connected to multiple sensors for real-time data collection. A soil moisture sensor detects the water content in the soil, helping to determine when irrigation is needed. A temperature and humidity sensor monitors the atmospheric conditions, while a pH sensor checks the soil's acidity or alkalinity, both of which are vital for healthy crop growth. Additionally, an NPK sensor measures the levels of nitrogen, phosphorus, and potassium in the soil—key nutrients required for plant development.

The Raspberry Pi processes data from these sensors and sends relevant information to a mobile device, enabling farmers to remotely monitor their fields. Based on the data received, the Raspberry Pi can trigger a relay module that controls the motor and water pump, automatically irrigating the field when necessary. This smart system helps in efficient water usage, soil health management, and remote farm monitoring, making it highly beneficial for modern agricultural practices.

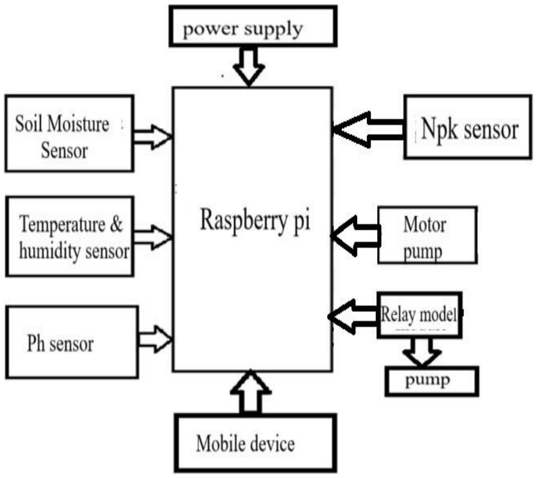

Fig 2 Block diagram

RESULT

The proposed crop prediction system was tested on ten distinct soil samples from different agricultural regions. For each sample, NPK values, pH, humidity, and temperature were recorded and processed. The system recommended suitable crops based on these inputs. A trained Random Forest model was used to generate predictions.

Additionally, farmers involved in the pilot trial found the system user-friendly and responsive, with an average prediction time of under 8 seconds. The interface, designed for mobile devices, helped simplify the interpretation of soil data. Overall, the system proved effective in supporting precision agriculture, offering both environmental and economic advantages by optimizing crop selection based on actual soil health.

TABLE 1:THE TABLE ILLUSTRATES THE CROP DATASET

Crop	Soil pH Range	Humid ity Range	Temp eratu re Rang e(Â°C)	Croppin g K2 O Ratiorecomm endation System (N - P2 O5 - K2 O kg/ ha)
Rice	5.5-7.0	70-80%	20-35°C	120-30-30
wheat	6.0-7.0	60-70%	10-25°C	120-60-30
Maize	6.0-7.5	65-75%	18-27°C	80-40-20
Sugar cane	5.5-8.0	70-80%	20-38°C	150-60-60
Cotton	5.0-7.5	50-60%	21-30°C	150-50-0
Groun dnut	6.0-6.5	60-70%	25-30°C	20 -40 - 40
Soyab ean	6.5-7.5	65-75%	20-30°C	20 -60 - 40

Mustard	**6.5-7.5**	**50-60%**	**10-25°C**	**100-30-15**
Potato	**4.8-5.4**	**60-80%**	**15-25°C**	**150 - 100 - 100**

Fig 3 Project demonstration

Fig 4 Output 1

Fig 5 Output 2

This study presents an effective approach to crop prediction by leveraging soil nutrient parameters specifically nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O). By analyzing these macronutrients, the system can recommend crops best suited to the nutrient profile of the soil, thereby promoting optimal agricultural productivity. The integration of machine learning models further enhances prediction accuracy by learning patterns between soil fertility and suitable crops. This system can be a valuable tool for farmers, agronomists, and agricultural planners, enabling data-driven decisions that improve yield, reduce input costs, and promote sustainable farming. Future work may include incorporating real-time weather data, micronutrient levels, and geographic variables to further refine predictions and make the system more robust and adaptive to diverse agro-climatic zones.

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