

Krishi Drishti- Smart Crop Recommendation And Yield Prediction System

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Abstract: Agriculture is the backbone of India's economy. Still, many farmers depend on gut feelings instead of data for choosing crops and managing soil, which leads to wasted fertilizer, lower yields, and lost income. Here's the thing — the project Krishi Drishti, which means "Agricultural Vision" in Sanskrit, tackles this problem with a real-time, IoT-based Smart Crop Recommendation and Yield Prediction System. It pairs an ESP32 microcontroller with various soil and environmental sensors, like NPK (RS485 Modbus), DHT11, pH, rain, and soil moisture sensors. The sensor data moves through USB serial communication at 115200 baud to a web app built on Streamlit.

This application features a live sensor dashboard with interactive Plotly charts, a crop recommendation engine powered by machine learning, a crop advisor module, and a yield prediction system. Random Forest models handle both classification and regression, trained on agricultural datasets and deployed using Joblib. The system points out the top five crop options based on confidence scores and pairs real-time soil data with ideal crop conditions to offer practical advice.

The yield module calculates production in tons per hectare and estimates revenue in Indian Rupees with interactive visualizations. Sensor stabilization averages readings over 5–30 seconds for better reliability.

Keywords: IoT, ESP32, Machine Learning, Crop Recommendation, Yield Prediction, Streamlit, RS485, NPK Sensor, Random Forest,

I. INTRODUCTION

Agriculture is the backbone of India's economy and the primary livelihood source for nearly 58% of the rural population, contributing significantly to GDP and ensuring food security for over 1.4 billion people. India produces a wide variety of crops across diverse agro-climatic regions, from wheat in Punjab to rice in West Bengal and cotton in Maharashtra, yet farmers face common productivity and income challenges. Traditional farming practices rely heavily on intuition, local habits, and market trends rather than actual soil conditions, leading to mismatched crop selection and inefficient resource use. Climate change further worsens the situation with unpredictable rainfall, extreme temperatures, and unseasonal weather, while poor soil monitoring causes undetected nutrient deficiencies until visible damage occurs. Improper fertilizer use and water mismanagement, including over-irrigation and drought stress, significantly reduce yield and increase financial losses.

Modern agriculture increasingly depends on sensor-based systems that act as a bridge between field conditions and digital decision-making. Sensors such as NPK measure essential nutrients, pH sensors determine soil acidity, DHT11 monitors temperature and humidity, rain sensors estimate rainfall, and soil moisture sensors track water content, providing real-time insights that were previously unavailable without laboratory testing. These parameters directly influence crop growth and productivity, making precise monitoring essential.

Selecting the right crop for specific soil and climate conditions is critical, as incorrect choices can lead to crop failure and financial loss. Traditional selection methods fail to consider real-time farm conditions, whereas data-driven crop recommendation systems analyze sensor inputs and match them with ideal crop requirements, offering accurate suggestions, alternative options, and improvement guidance. Similarly, yield prediction plays a crucial role by estimating production and revenue before planting, enabling better financial and resource planning. Machine learning



models use multiple factors such as crop type, season, rainfall, and input usage to generate farm-specific predictions, helping farmers make informed, science-based decisions and improving overall agricultural efficiency and sustainability.

II. RELATED WORK

- Traditional agricultural practices rely on manual soil testing methods, where soil samples are analyzed in laboratories to determine parameters such as pH and nutrient levels. These methods are accurate but time-consuming, costly, and unsuitable for real-time decision-making.
- Sensor-based agricultural monitoring systems have been developed using devices such as soil moisture sensors, pH sensors, and temperature-humidity sensors. These systems provide continuous observation of field conditions but are often limited to data collection and basic visualization.
- Several studies have applied machine learning algorithms such as Decision Trees, Support Vector Machines, and Random Forest for crop recommendation. These models use soil and environmental parameters to predict suitable crops with high accuracy.
- Random Forest algorithms are widely preferred due to their robustness, ability to handle complex datasets, and reduced risk of overfitting compared to other models. They are commonly used for both classification (crop recommendation) and regression (yield prediction).
- Yield prediction systems have been developed using multiple parameters such as crop type, rainfall, fertilizer usage, and land area. These systems help estimate production in advance but are often developed independently of crop recommendation systems.
- Existing crop recommendation approaches are often based on static datasets or predefined rules, which do not adapt to real-time soil conditions and farm-specific variations.
- Many existing systems focus on either monitoring, recommendation, or prediction individually, lacking integration of all functionalities into a single platform.
- The proposed system addresses these limitations by integrating real-time sensor data analysis with machine learning-based crop recommendation, advisory support, and yield prediction, enabling accurate and data-driven agricultural decision-making.

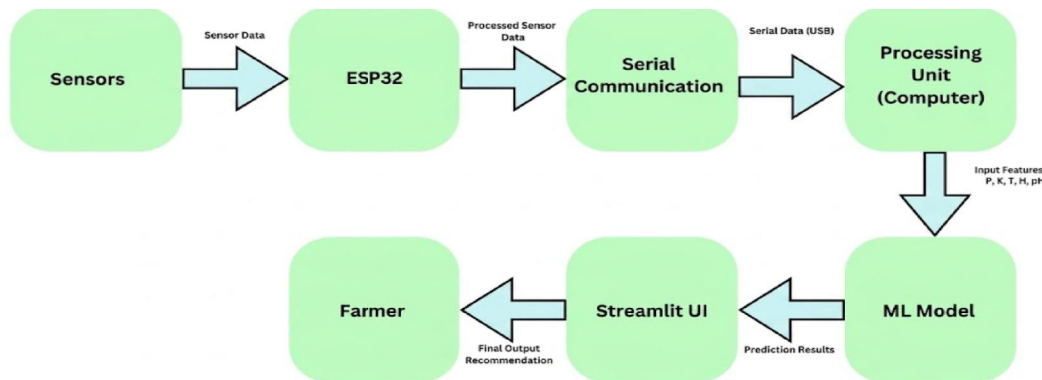
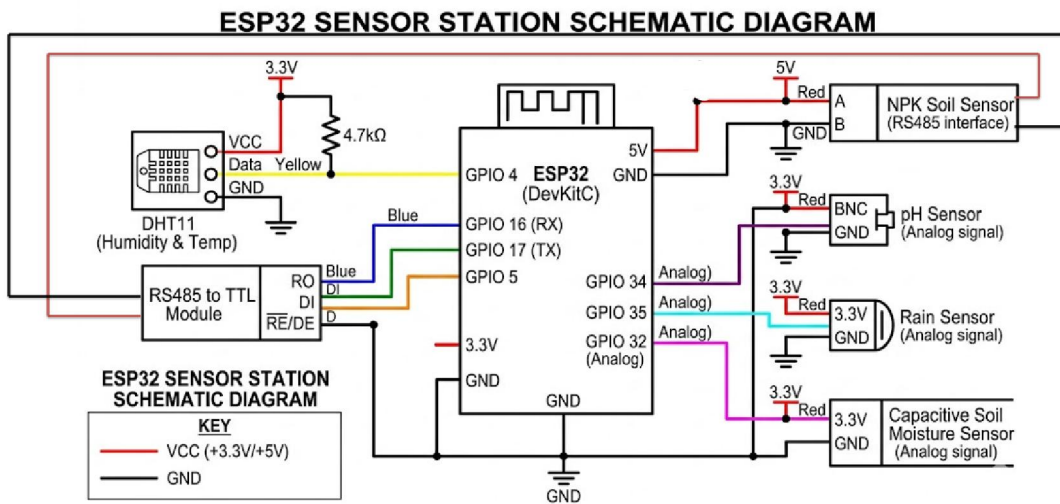
III. METHODOLOGY

- The system is designed as an integrated smart agriculture platform that combines sensor-based data acquisition with machine learning-based decision support. It follows a structured workflow from data collection to final output generation.
- Soil and environmental parameters are collected using multiple sensors, including NPK, pH, temperature, humidity, rainfall, and soil moisture sensors. These sensors continuously monitor field conditions and generate real-time data.
- The ESP32 microcontroller acts as the central processing unit, interfacing with all sensors and reading their values at regular intervals. It ensures synchronized data acquisition and prepares the data for further processing.
- To improve accuracy, sensor stabilization techniques are applied by averaging multiple readings over a defined time window. This reduces noise and fluctuations in sensor outputs.
- The collected sensor data is then processed and formatted into structured values suitable for analysis. These parameters represent the current soil and environmental condition of the farm.
- A machine learning-based crop recommendation model is used to analyze the input parameters and predict the most suitable crops. A Random Forest classifier is employed due to its high accuracy and robustness. The system outputs the top recommended crops along with confidence scores.



- A crop advisory module compares the real-time sensor values with predefined optimal ranges for different crops. Based on this comparison, it suggests necessary improvements in soil conditions, such as nutrient adjustment, pH correction, or irrigation changes.
- A yield prediction model is implemented using a Random Forest regressor, which estimates expected crop yield based on multiple input factors. The output is generated in terms of tons per hectare.
- The system also calculates expected revenue based on predicted yield and market price assumptions, providing financial insights to the user.
- All results, including sensor readings, crop recommendations, advisory suggestions, and yield predictions, are displayed through an interactive Streamlit-based interface for easy interpretation.

IV. SYSTEM CIRCUIT DIAGRAM



V. HARDWARE COMPONENTS

- DHT11
- NPK Sensor (7-in-1)
- pH Sensor

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- Rain Sensor
- Soil Moisture Sensor
- Esp32 Microcontroller

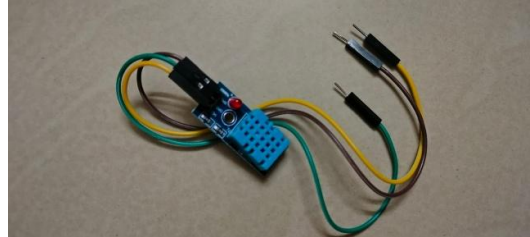


Fig.1 (DHT11 Temperature and Humidity Sensor)

Temperature Range	0–50°C (±2°C accuracy)
Humidity Range	20–80% (±5% accuracy)
Operating Voltage	3–5V
Sampling Rate	1Hz
Output	Digital

• DHT11 (Temperature & Humidity Sensor)

The DHT11 sensor is used for measuring ambient temperature and relative humidity in the agricultural environment. It consists of a capacitive humidity sensing element and a Negative Temperature Coefficient (NTC) thermistor for temperature measurement. The sensor includes an internal analog-to-digital conversion system that processes the measured values and provides calibrated digital output. Monitoring these parameters is essential as temperature and humidity directly influence plant growth, transpiration rate, and disease development.



Measurement	N, P, K, Moisture, Temperature, EC
Communication	RS485 (Modbus Protocol)
Operating Voltage:	5V
Output	Digital (Serial)
Application	Soil nutrient analysis

• NPK Sensor (7-in-1 Soil Sensor)

The NPK sensor is a multi-parameter soil analysis device used to measure key nutrients such as Nitrogen (N), Phosphorus (P), and Potassium (K), which are essential for plant growth. In addition, it measures soil moisture, temperature, and electrical conductivity, providing a comprehensive understanding of soil health. The sensor operates using ion-selective measurement techniques and communicates via the RS485 Modbus protocol, making it suitable for real-time field monitoring. Accurate nutrient measurement helps in optimizing fertilizer usage and improving crop yield.

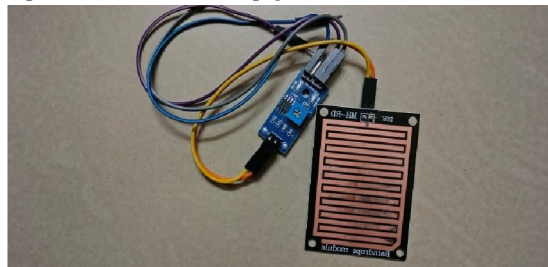




pH Range	0–14
Accuracy	±0.1 pH
Output	Analog
Operating Voltage	3.3–5V
Application	Soil quality monitoring

• **pH Sensor**

The pH sensor measures the acidity or alkalinity of soil, which is a critical factor affecting nutrient availability and microbial activity. It operates on electrochemical principles, where a glass electrode generates a voltage proportional to the hydrogen ion concentration in the soil solution. This voltage is converted into a pH value. Maintaining optimal pH levels ensures better nutrient absorption and healthier crop growth.



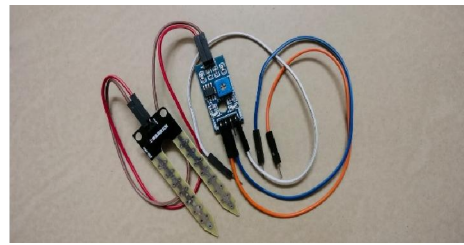
Output	Analog/Digital
Operating Voltage	3.3–5V
Function	Rain detection
Sensitivity	Adjustable

• **Rain Sensor**

The rain sensor is used to detect the presence and intensity of rainfall in the field. It operates based on the principle of electrical conductivity, where water droplets on the sensor surface create a conductive path between traces, altering the output signal. This information can be used to control irrigation systems and prevent overwatering. It plays an important role in water resource management.



Soil Moisture Sensor



Output	Analog
Operating Voltage	3.3–5V
Measurement	Soil water content
Application	Irrigation control

The soil moisture sensor measures the volumetric water content present in the soil. It works either on a resistive or capacitive principle, where the electrical properties of the soil change with moisture level. The sensor provides real-time data that helps in efficient irrigation management by preventing both overwatering and drought stress. Maintaining proper soil moisture is essential for optimal crop growth and yield.



CPU	Dual-core 32-bit
Clock Speed	up to 240MHz
Operating Voltage	3.3V
Interfaces	UART, SPI, I2C, ADC, PWM
Connectivity	Wi-Fi & Bluetooth
Memory	~520KB SRAM

• ESP32 Microcontroller Unit (MCU)

The ESP32 microcontroller serves as the central processing unit of the system. It interfaces with all sensors, collects real-time data, performs basic processing, and transmits the data for further analysis. It features a dual-core processor,



multiple communication interfaces, and built-in Wi-Fi and Bluetooth capabilities. Its high processing speed and low power consumption make it ideal for IoT-based smart agriculture applications.

V. SOFTWARE REQUIRED

- Arduino IDE
- Python
- Streamlit
- Arduino IDE



Arduino IDE is an open-source development environment used for writing, compiling, and uploading code to microcontrollers such as ESP32. It supports C/C++ programming and provides built-in libraries for sensor interfacing. Used to program the ESP32 microcontroller for reading sensor data and serial communication.

- Python



Python is a high-level programming language widely used for data processing, machine learning, and application development. It provides extensive libraries for scientific computing and automation. Used for backend processing, data handling, and integration of machine learning models.

- Streamlit



Streamlit is a Python-based framework used to develop interactive web applications with minimal coding. It allows real-time data visualization and user-friendly interface design.

Used to create the user interface for displaying sensor data, crop recommendations, and predictions.

- VS Code (Visual Studio Code)



VS Code is a lightweight and powerful code editor developed by Microsoft that supports multiple programming languages and extensions. It provides features such as debugging, syntax highlighting, and integrated terminal. Used for writing, editing, and managing Python code and project files efficiently.



VI. CONCLUSION

The proposed system Krishi Drishti presents an effective integration of IoT and machine learning technologies to address key challenges in modern agriculture. By utilizing multiple soil and environmental sensors, the system enables real-time monitoring of critical parameters such as nutrient levels, temperature, humidity, soil moisture, and pH. This real-time data collection eliminates the dependency on traditional manual soil testing methods, which are time-consuming and often impractical for frequent analysis.

The use of the ESP32 microcontroller ensures efficient data acquisition and processing, while maintaining a low-cost and scalable solution suitable for practical deployment. The incorporation of machine learning techniques, specifically Random Forest algorithms, allows the system to provide accurate crop recommendations based on current soil conditions. Additionally, the yield prediction model helps estimate expected production and revenue, enabling better planning and resource management for farmers.

The crop advisory module further enhances the system by comparing real-time sensor data with optimal crop requirements and suggesting necessary improvements in soil conditions. This assists farmers in making precise adjustments to maximize productivity. The Streamlit-based interface ensures that all outputs are presented in a clear and interactive manner, making the system user-friendly and accessible even to non-technical users.

Overall, the system transforms agriculture from a traditional experience-based approach to a data-driven decision-making process. It contributes to improved crop selection, optimized use of fertilizers and water, and increased agricultural productivity. The solution is cost-effective, efficient, and adaptable to different farming conditions.

Future enhancements of the system may include the integration of additional parameters, improvement in model accuracy using larger datasets, and extension of the system to support a wider variety of crops and regional conditions.

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