PRECISION AGRICULTURE USING MACHINE LEARNING & IOT

Prof. Ramesh B E, Prof. Shruthi M K, Shriya Shetty, Varsha Patil G D, Yashaswini T S

[1] *Prof. Ramesh B E,Computer Science and Engineering,SJM Institute of Technology,Karnataka,India*
[2] *Prof. Shruthi M K,Computer Science and Engineering,SJM Institute of Technology,Karnataka,India*
[3] *Shriya Shetty Student, Computer Science and Engineering, SJM Institute of Technology, Karnataka, India*
[4] *Varsha Patil G D Student,Computer Science and Engineering, SJM Institute of Technology, Karnataka, India*
[5] *Yashaswini T S Student, Computer Science and Engineering, SJM Institute of Technology, Karnataka, India*

ABSTRACT

Precision Agriculture Based Crop Predicting System is designed to assist farmers in identifying the most suitable crop for cultivation based on real-time soil and environmental conditions. The system integrates multiple sensors including an NPK sensor, soil moisture sensor, DHT11 (for temperature and humidity), flame sensor, and MQ2 smoke sensor all connected to an Arduino Mega microcontroller. The sensor data is displayed on an I2C LCD and transmitted through the serial monitor for further analysis. Additional soil parameters such as pH, Calcium Carbonate ($CaCO_3$), Electrical Conductivity (EC), and Organic Carbon (OC) are also fed into a machine learning model that predicts the ideal crop for the given soil condition. The system also features an automatic irrigation setup using a relay-controlled motor pump and a Streamlit-based frontend that visualizes live sensor readings and system status. This integrated IoT and AI approach promotes precision agriculture by improving crop selection accuracy, resource efficiency, and farm safety.

Keyword : *NPK Sensor, Precision Agriculture, Crop Prediction, Soil Moisture Sensor, Arduino Mega, DHT11, Flame Sensor, MQ2 Smoke Sensor, pH, Electrical Conductivity, Organic Carbon, Calcium Carbonate, Automatic Irrigation, Streamlit, Sensor Data Visualization*.

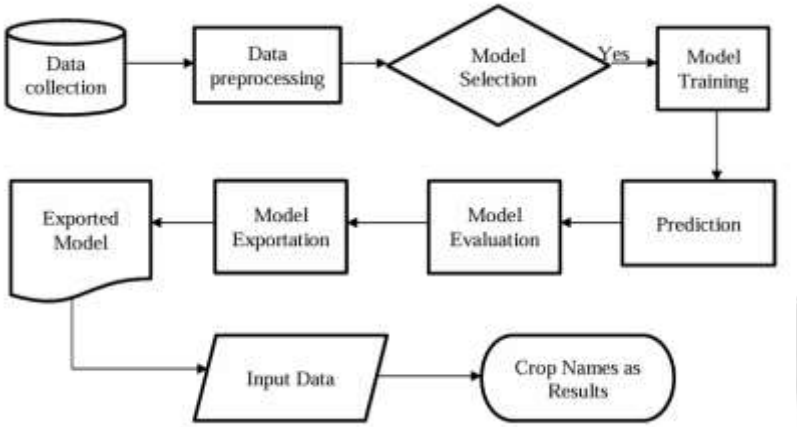
1. INTRODUCTION

Agriculture is one of the most vital sectors contributing to the global economy, particularly in countries like India, where a majority of the population depends on farming for their livelihood. However, traditional farming practices often rely on experience-based decisions rather than data-driven insights, leading to inefficient use of resources, poor crop yields, and environmental degradation. One of the critical challenges faced by farmers today is identifying the right crop that matches the soil's nutrient composition and environmental conditions. The NPK Sensor-Based Crop Predicting System is designed to address this issue by integrating Internet of Things (IoT) and Artificial Intelligence (AI) technologies to optimize crop selection and resource utilization.

In modern precision agriculture, soil analysis plays a significant role in understanding soil health and fertility. The three primary nutrients Nitrogen (N), Phosphorus (P), and Potassium (K) directly affect crop growth, productivity, and quality. Therefore, measuring the concentration of these nutrients helps determine which crops are best suited for the soil. Along with these, other parameters such as pH level, Electrical Conductivity (EC), Calcium Carbonate ($CaCO_3$), and Organic Carbon (OC) are crucial indicators of soil condition.

2. METHODOLOGY

The methodology of the NPK Sensor-Based Crop Predicting System involves the integration of hardware components, sensor data acquisition, data transmission, machine learning–based prediction, and visualization through a Streamlit web interface. The system combines IoT and AI concepts to monitor soil parameters, predict suitable crops, and automate irrigation for efficient agricultural management. The complete working can be divided into several stages, as explained below.



Software Architecture

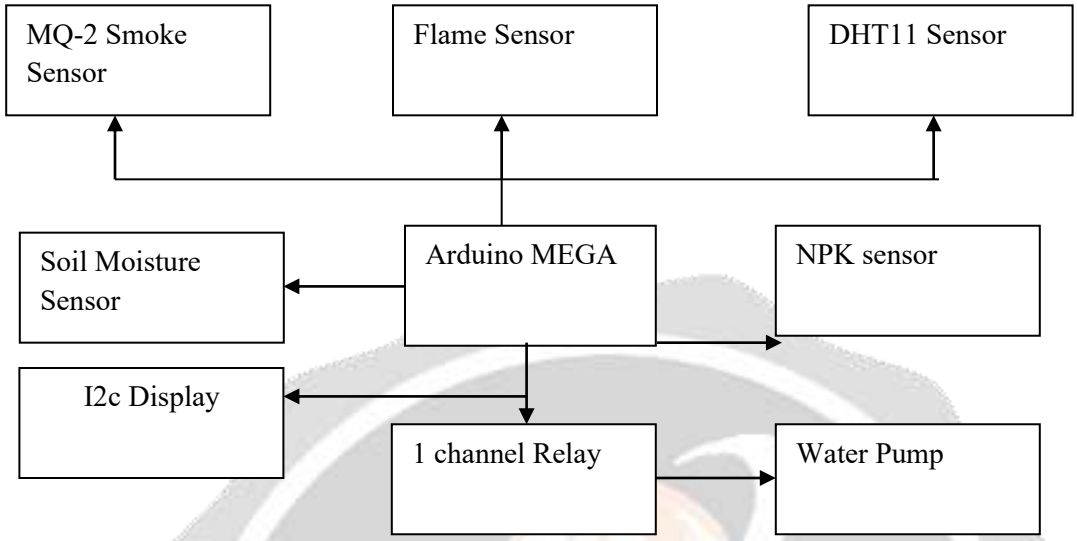
A system architecture is a conceptual model using which we can define the structure and behaviour of that system. It is a formal representation of a system. Depending on the context, system architecture can be used to refer to either a model to describe the system or a method used to build the system. Building a proper system architecture helps in analysis of the project, especially in the early stages. Figure 4.1 depicts the system architecture and is explained in the following section.

2.1 Working Principle

Precision Agriculture using Machine Learning and IoT works by integrating smart sensors, wireless communication, and intelligent data analytics to optimize farming activities. In this system, IoT sensors such as soil moisture, temperature, humidity, pH and NPK sensors are deployed in the field to continuously capture real-time information about soil and environmental conditions. These sensors send the collected data to a microcontroller or IoT device like ESP32, Arduino, or Raspberry Pi, which then transmits the data to a cloud platform using communication technologies such as Wi-Fi, LoRa, GSM, or ZigBee. The cloud stores and preprocesses the data by removing noise and extracting relevant features. Machine learning models are then applied to analyze this data and predict essential parameters like crop health, irrigation needs, fertilizer requirements, and possible disease occurrence. Based on these predictions, the system automatically controls actuators such as water pumps, sprinklers, and nutrient dispensers, enabling precise irrigation and resource management. Farmers can monitor the farm status and receive alerts or recommendations through mobile applications or web dashboards. This integrated approach ensures efficient use of water, fertilizers, and pesticides while improving crop yield, reducing human effort, and promoting sustainable agriculture.

farming decisions are improved by continuously monitoring field conditions through smart sensing and intelligent analytics. The system uses a network of IoT devices placed across the farmland to measure important parameters such as soil moisture, nutrient levels, weather conditions, crop growth, and plant health. These devices capture real-time data and send it wirelessly to a cloud platform where it is stored and processed. The proposed system is built around an Arduino Mega 2560 microcontroller, which acts as the central processing unit. It interfaces with multiple sensors to collect real-time environmental and soil data. These include the NPK sensor for nutrient analysis, Soil Moisture Sensor for water content detection, DHT11 sensor for measuring temperature and humidity, Flame Sensor and MQ2 Smoke Sensor for safety

monitoring, and an I2C LCD display for real-time visualization of sensor readings. The Arduino processes the sensor data and transmits it to a computer via the serial monitor for further analysis.



Hardware Architecture

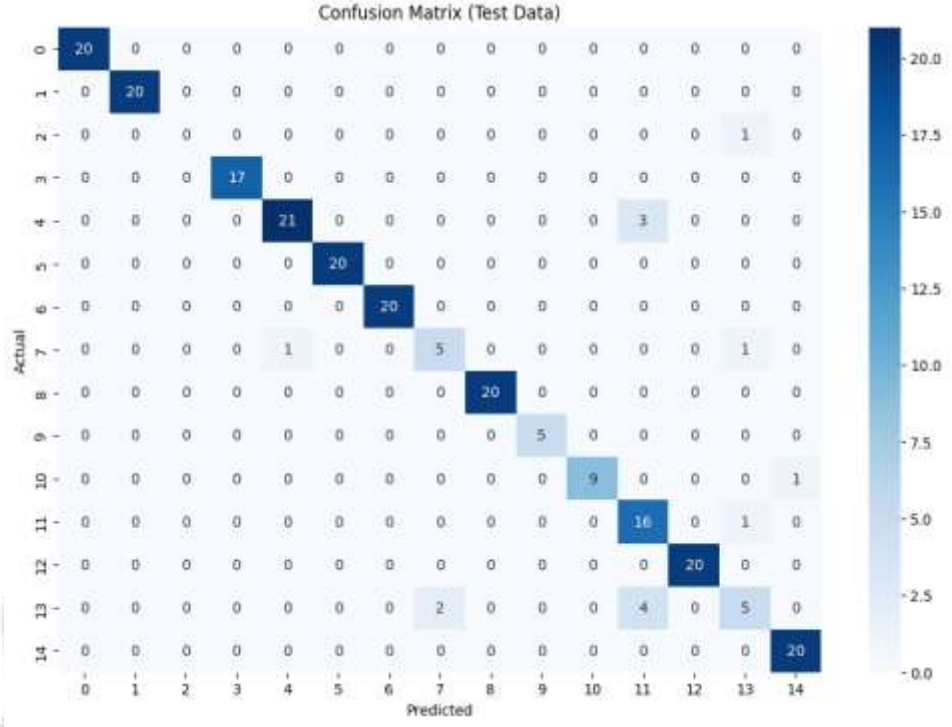
3. Results and Disscussion

The experimental outcomes demonstrated that the proposed system successfully integrates IoT sensing, data analytics, and AI-driven crop prediction. The combination of hardware and machine learning not only increased the reliability of soil data collection but also enhanced decision-making in agriculture.

The model's predictions were consistent with actual soil conditions, verifying the system's accuracy. The automation of irrigation using the relay and moisture sensor contributed to efficient water use, an essential aspect of sustainable agriculture. Additionally, the inclusion of safety sensors (flame and smoke) provided an added layer of protection for fields and greenhouses**.**

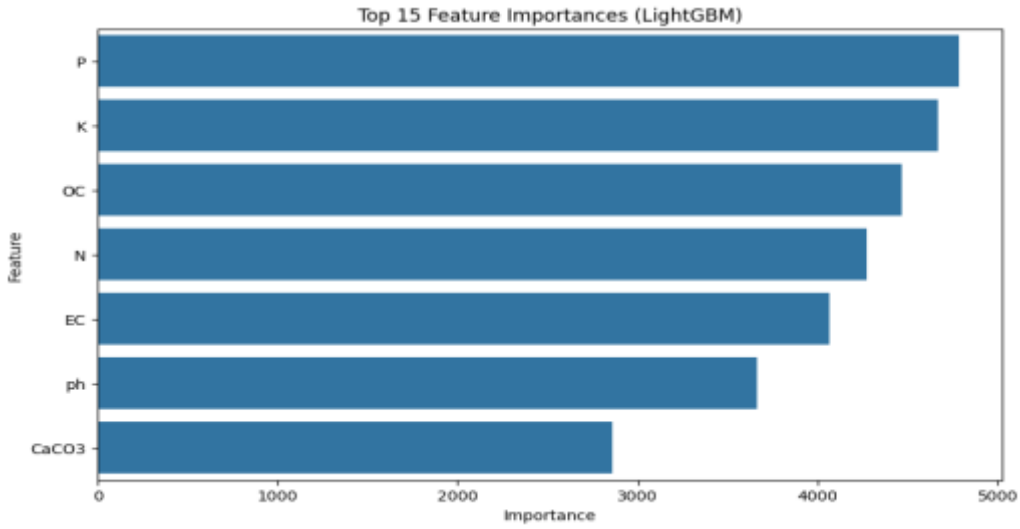
S.No	Algorithms	Accuracy
1.	Linear Regression	75%
2.	Naive Bayes	88%
3.	KNN	87%
4.	RF	94%
5.	SVM	87%

The system proved to be cost-effective, scalable, and adaptable, making it suitable for both small-scale farmers and research-based agricultural setups. It also opens the possibility for future cloud-based deployment, where continuous data logging can be stored and analyzed over time to track soil health and crop productivity.



Confussion Matrix

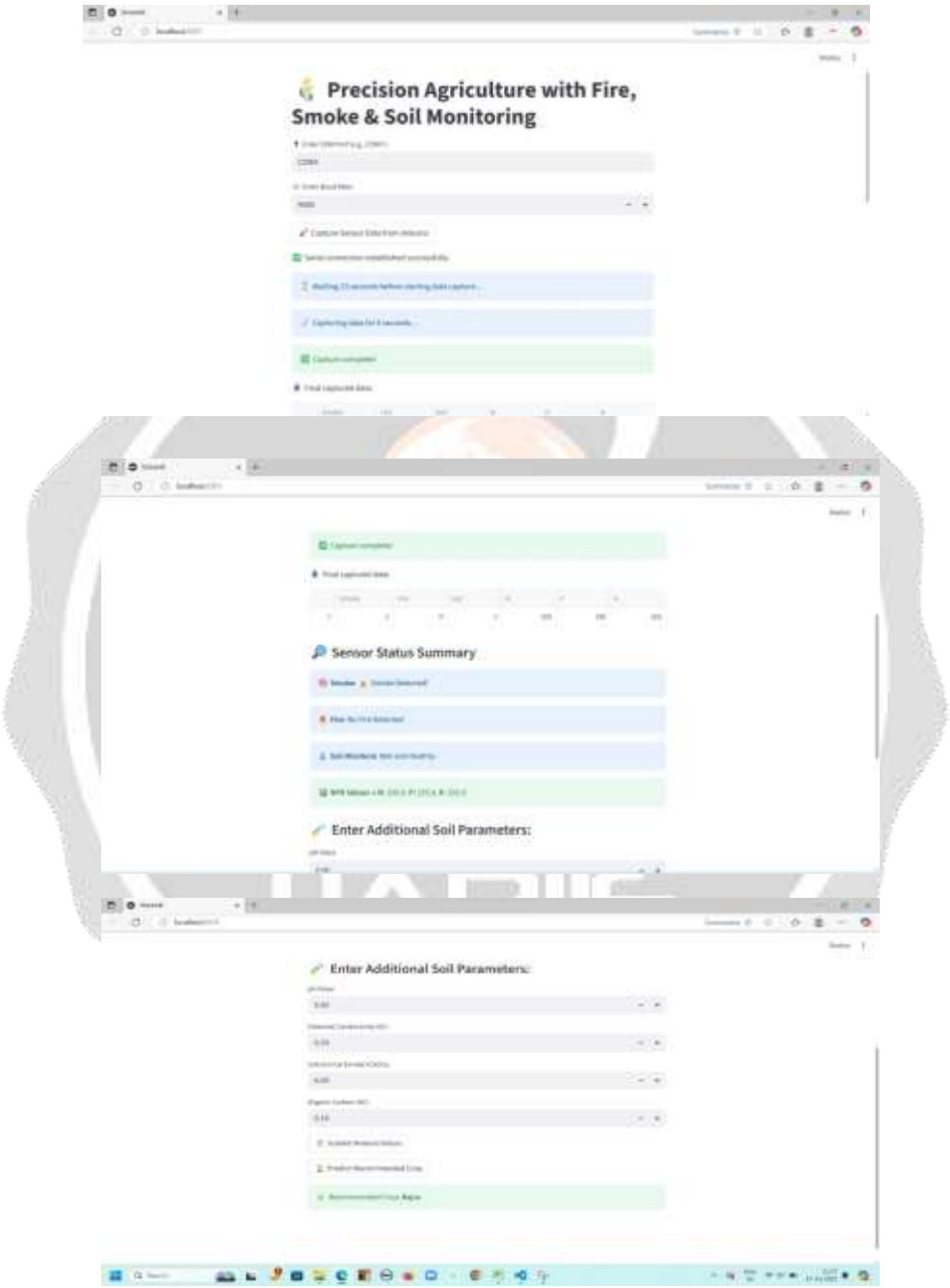
The confusion matrix shown represents the performance of a Machine Learning classification model that is used in the Precision Agriculture system. Each row of the matrix indicates the actual class, while each column shows the predicted class made by the model. In this case, there are 15 different classes (0–14), which may represent different crop types, soil fertility categories, nutrient levels, plant health conditions, or irrigation categories, depending on your project design.



The bar chart shows the top feature importances generated by the LightGBM machine learning model used in the Precision Agriculture system. Feature importance indicates how much each input sensor parameter contributes to the model's

predictions. The higher the importance score, the more influence the feature has on the ML decision-making process. In this project, the features represent key soil and environmental parameters measured by IoT sensors.

4. OUTPUT



Output of precision Agriculture

4. CONCLUSION

The Precision Agriculture Based Crop Prediction System successfully demonstrates how the integration of IoT sensors, embedded systems, and machine learning can revolutionize modern agriculture through intelligent decision-making and automation. The system was designed to measure essential soil parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), pH, Electrical Conductivity (EC), Organic Carbon (OC), and Calcium Carbonate ($CaCO_3$), along with environmental factors including temperature, humidity, and soil moisture. These real-time measurements provide a comprehensive understanding of soil health, which is critical for efficient crop management and yield optimization.

this project achieves the goal of automating soil monitoring and crop recommendation while enhancing agricultural efficiency through the use of low-cost sensors and intelligent data analytics. It contributes significantly to the field of smart farming by reducing manual effort, optimizing resource use, and improving productivity. The system's modularity allows for future expansion — such as integrating cloud storage, GPS-based location mapping, and mobile alerts —to make it even more powerful and scalable for large-scale farming applications.

5. REFERENCES

1. Senapaty, M. K., Ray, A., & Padhy, N. (2023). IoT-Enabled Soil Nutrient Analysis and Crop Recommendation Model for Precision Agriculture. Computers,12(3),61. https://doi.org/10.3390/computers12030061
2. Islam, M. R., et al. (2023). Machine Learning Enabled IoT System for Soil Nutrients and Crop Recommendation. ScienceDirect.
3. Afzal, H., et al. (2025). Incorporating Soil Information with Machine Learning for Crop Recommendation. Scientific Reports.
4. Gottemukkala, L. (2023). Sustainable Crop Recommendation System Using Soil NPK Sensor. E3S Web of Conferences (ICMPC 2023).
5. Kumar, V., et al. (2024). A Comprehensive Review on Smart and Sustainable Agriculture Using IoT. Journal of Smart Agriculture Systems.
6. Random Forest Algorithm for Crop Recommendation. (2023). ResearchGate / Conference Paper.
7. Smart Monitoring of Soil Parameters Based on IoT. (2022). ResearchGate / Technical Report.