

# An IoT-Based Smart Agriculture System for Real-Time Field Monitoring and Crop Prediction

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**Abstract—** Agricultural areas in India are decreasing gradually, which influences the crop yields. The framework overcomes limitation of conventional farming methodology by using water resources productively and furthermore reducing labour costs. A comparative analysis was conducted between the proposed system and existing methods. Recently, recurrent incidents of food quality and security issues have jeopardized individuals' wellbeing and public health systems. The project predicts crops using the plantation based on the sensors and climate values which have been collected from four different sources. This data will be stored on a database server. A model processes this data predict the crops from the values generated. To predict the plantation, we are using a regression model for which trained on with the sensors and plantation data to optimize prediction accuracy for the prediction.

**Index Terms—**Agriculture, IoT, Machine Learning, Regression Model, Smart Farming

## I. INTRODUCTION

The UNFAO predicts a 71% surge in food demand by 2050 to support 9.6 billion people [1]. Thus, boosting crop productivity is critical for farm profitability and economic returns. Unpredictable weather—erratic rainfall, temperature swings, and soil moisture fluctuations—poses the biggest challenge to sustainable farming. IoT, a network of devices with embedded sensors, autonomously monitors field conditions. Unlike manual systems, it reduces labour while adapting to climate shifts—a significant change for small farms. Each device, assigned a unique ID, shares data without human intervention, enabling real-time decisions

## II. LITERATURE SURVEY

According to the view of M. Abdurrahman, et al. a costly commodity was provided for increasing concern for water. The structure made of low-cost actuators is simple hardware to therefore monitor the advancement of a liquid. The humidity and level of climate are further sensed and displayed in the LCD.

This structure provides water to plants as based on the soil moisture level and produce water requirement.

P. A. Bosel and V. V. Bixit's proposal was a local minimal-cost microprocessor-based time-dependent water system scheduler that consists of various actuators for detecting dampness, weather, and wind. The framework identifies correct actuators (hand-off, solenoid valves, engine) based on these attributes.

M. Ramu, CH. Rajendra Prasad suggested computerizing the agricultural system. It is very useful for old-aged people and common people who stay distant from the horticultural region. By keeping cash aside and assisting in the safeguarding of water. The article "Modernization of the Indian agribusiness framework using regulators" with the use of 8051 and GSM aims at automating the horticulture framework to provide government aid to the Indian agrarian structure and, secondly, to provide incredible irrigation especially regions.

The agricultural data cloud is described with different resources to understand the dynamic transmission of asset and load adaptation. Bundles of data received via RFID. Remote communication is handled within the agricultural data cloud. Seen as the control organization and IoT technology for agriculture creation. The author suggested a remote-checking system that supported web and remote communication. The information in the executive's framework is also designed to hold the information. The collected information is often used for farming exploration offices.

## III. OBJECTIVE

The smart agriculture system is a new term that signifies the management of forms with the help of advanced information and communication technologies in order to enhance the quantity as well as the quality of the products. While optimizing the

human labour input. In IOT –based smart agriculture system, a system is developed to monitor the crop field with the assistance of sensors. Sensors employed are soil sensor, PIR sensor, fire sensor, and temp-Humidity sensor. Farmers are able to check the condition of their field from anywhere with the assistance of a smart agriculture system. The IOT-based smart agriculture system is very efficient compared to the traditional method. The smart agriculture system assists in reporting weather conditions and finding the right time to plant and harvest plays a significant role in conserving water. It will reduce the environmental footprint of farming. A smart agriculture system will decrease the use of fertilizers, pesticides, and energy. And enhances the product quality, nutrients, and flavor. And we can save water through soil moisture sensors. Nowadays, India is number two in the world in farming.

#### IV. HARDWARE TOOLS

Arduino mega 2560

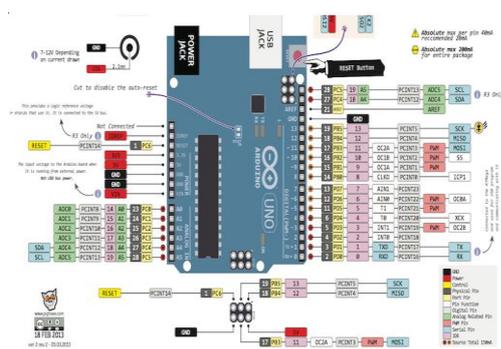


Fig. 1. 1 Arduino Mega 2560 Microcontroller Board.

Arduino mega 2560 is a micro-controller board in reference to the AT mega 2560 (data sheet).

It possesses 54 digital pins of input/output and 16 analog inputs.

Wi fi- Module (ESP8266)

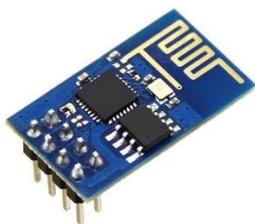


Fig. 1. 2 ESP8266 Wi-Fi Module for Wireless Communication.

The ESP8266 Wi-fi module is a self-contained with an integrated TCP/IP protocol stack that can give any micro-controller access to your Wi-fi network.

Temperature sensor

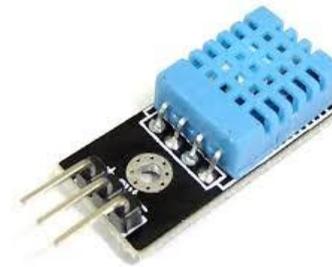


Fig. 1. 3 Temperature Sensor Used for Climate Monitoring.

It is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal temperature changes.

Soil moisture sensor



Fig. 1. 4 Soil Moisture Sensor Used for Irrigation Automation.

Soil moisture transducer senses the condition of the soil whether it is dry or wet and sends the information to the micro-controller.

Humidity sensor

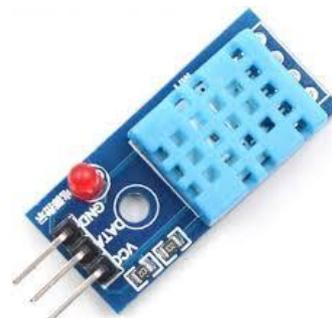


Fig. 1. 5 Humidity Sensor for Atmospheric Moisture Detection.

The humidity sensor will sense the condition of the weather and send the information to the micro-controller. There is a serial communication between the micro controller and GSM.

LDR sensor



Fig. 1. 6 Light Dependent Resistor (LDR) for Light Intensity Monitoring.

Photo resistors, also known as Light Dependent Resistors (LDRs), are light-sensitive instruments that are commonly used to detect the presence or absence of light or to determine the strength of light.

Zero Board

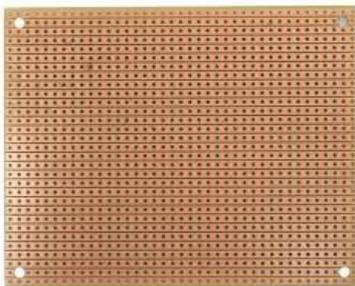


Fig. 1. 7 Arduino Zero Board Used for Advanced Prototyping.

The Zero may be a simple and powerful 32-bit extension of the platform established by the UNO. The Zero board expands the family by providing enhanced performance, sanctioning a spread of project opportunities for devices.

## V. SOFTWARE TOOLS

### ARDUINO IDE

The Arduino Integrated Development Environment (IDE) includes a code editor, a message field, a text console, a toolbar with buttons for basic functions, and a set of menus. It communicates with the Arduino and genuine hardware by connecting to them.

### PROTEUS 7.7

The Proteus design Package is a proprietary software technology tool suite used mainly for electronic design automation. Electronic design engineers and technicians primarily use the software system to create schematics and electronic prints for manufacturing digital circuit boards.

### Thing Speak

ThingSpeak is an open-source IoT platform that enables data collection and communication between internet-connected devices using a simple API.

## VI. IMPLEMENTATION

### A. System Architecture

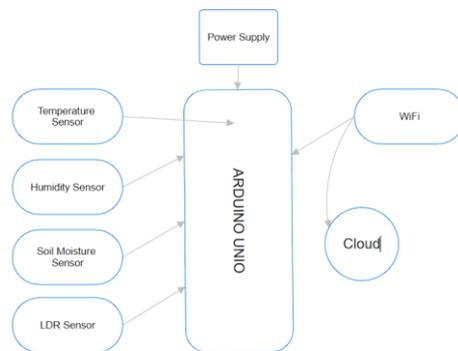


Fig. 2. 1 System Block Diagram of the Smart Agriculture System.

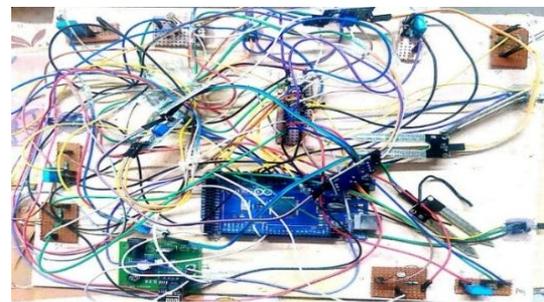


Fig. 2. 1 Assembled Hardware Setup for Sensor and Actuator Integration.

#### 1. Overview of 4-Layered Model

Our major objective of this work is to fashion Associate in Nursing UOI-based acumen cultivation to regulate pumps, playhouse flaps, and alternative high-voltage electronic appliances, while not human mediation relying on natural limits such as mould000000 condition and climate. These limits are units stored on within the cloud for future information exploration. Cultivation is completed at intervals in playhouses for higher regulated setting. The envisioned framework is comprised of varied surfaces as illustrated. It is categorized into four

types: detector surface, Middleware, Communication surface and Cloud & Application surface.

## 2. Detector Surface

The detector surface will be the primary layer of our projected framework. It is answerable for catching and observing completely totally very surprising economic boundaries. For detecting or aggregating the boundaries completely differing types of photo electric cells area units conveyed throughout the horticulture sector. For this analysis job, a pair of kinds of detector have been utilized: ground condition detectors to observe ground condition levels and a climate detector to appear at temperature level at intervals poly homes. These sensors are units connected with an Atmega-based total microprocessor. The microprocessor connected with photoelectric cells intentionally essential IoT objects this area units conveyed throughout the farming field.

## 3. Middleware Surface

Middleware Surface will be the second surface of our projected Framework. The middleware is expected to adjust the cultivating procedure and manage the sensors. It's intended for microprocessors. Identified qualities region unit takes care of in too which the microprocessor depends upon the edge upsides of grouped boundaries of the recognition field it subsequently acts on. This layer stringently screens climate and clay condition size as these a couple of boundaries straightforwardly influence the harvest yield and the following choices' region unit made.

If the soil condition level could be a more modest amount than the verge esteem then the microprocessor would initiate the siphon machine for watering the circle, as insufficient condition content in clay will diminish the yield creation. The verge worth of soil condition context is very surprising for various sorts of photoelectric cell. The embraced edge upsides of clay condition context for various sorts of clay at which the water system happens region units given qualities in accordance with. The projected framework considers V-J Day soil condition content as an edge. When the condition level arrives at the edge, the siphon will naturally defer and afterward keep away from abundant energy utilization.

If the climate size is bigger than the edge esteem then the microprocessor will open the fold of the polyhouse. The projected framework thinks about the 40° C climate as an edge. Expansion in temperature lands in a decrease in crop length and influences the balance between yields and bugs. It can also expand the harvest breath rates and decrease the effectiveness of manures. Other than the prominent sensors, the microprocessor sends the identified data to the trouble Speak cloud from the circle over a dish.

## 4. Transmission Surface

On the transmission surface, the microprocessor speaks with the passage remotely through wireless module because it offers an advantage above Handsfree-Bluetooth. Handsfree-Bluetooth gives shorter shift correspondence than Wi-Fi as passages is furthermore removed from the recognition field. Local space network-based absolute correspondence is kept away because of Brobdingnagian cabling. Here, microprocessor is given actuators conveyed through recognition of the sphere and exacting the recognized clay condition and climate worth to the cloud through a passage. Branch of knowledge put together absolutely convention runs with respect to the section. Microcontroller sends rule solicitation to the trouble Speak Cloud to compose recognized worth to the related rise.

## 5. Cloud & Application Layer

Distributed computing is Associate in Nursing rising innovation and can be utilized adequately in keen cultivating. The projected model utilizes the distributed computing stage for recording entirely unexpected farming sector data. All through this surface very surprising channels space units are made, each compared to an explicit boundary field inside the troubled Speak cloud to put away from areas of activity (climate, clay dampness). The microprocessor sends the identified facts to the many ducts intermittently over the correspondence convention. These data (soil condition esteem, temperature esteem) space units planned with association time can be used for future investigation. Horticultural area standing (climate, clay dampness) territory unit generally observed distantly, as far as the chart in issue Speak web administration. Applications region unit as a rule made identified with cultivating that is conveyed inside the cloud and can be utilized by ranchers or scientists.

The justification for the AT-MEGA is that it interfaces with every single one of the components associated with the occasion pack. The scope of pins during this process is 64. Each stick is consigned with an explicit period of the unit for performing expression's explicit ability. The sting assessment of the sensors is tied in with this AT-MEGA, which is liable of the customized ON and OFF the motor that is joined with the siphon for controlling water in the farming area. As far as possible, regard is revitalized to the worker or system, through IoT for each moment from the joined progression pack. LM35 temperature sensors use speaker at the right allies altogether temperature (assessed in Kelvin) into conjointly physicist or Celsius swear driving game plans. The two resistors are changed inside the line to frame partner degree passing the exact temperature-detecting component. The organized start peruses the information preparing for detecting component is temperature/the wetness regards in go is that the water regards in run Motor on STOP NO agreed data worker (IoT entry) circuit has various semiconductors in it - 2 inside the middle, numerous in each escalated, numerous inside the reliable stream supply, and a few others inside the curve give circuit. The sting regard is accomplished (1 Rh neutralizer 100 RH%). These limits might be set inside the microcontroller if it goes on top of the past ten RH%. The conditions are unprecedented. Generally, clammy levels are at standard conditions. The characteristics will be revived to structure through IoT entry. The features of the viscousness-detecting component are brilliant one-dimensionality, low force usage, wide assessment expansion, speedy response against tainting, high unwavering quality, and first-class worthwhile extent. A water level pointer is utilized to evaluate the water level in the water framework showing. Inside the water level, the detecting component regards life by using a scale level, and its address in cm. On the off likelihood that the water level accomplishes the lower part of the square of metal, it exhibits exceptional condition and, furthermore, the company can thus initiate the motor. On the occasion that the water exceeds the exact level, the motor might be slaughtered normally. These situations will be interminably restored to the construction exploitation IoT. The net of things (IOT) would be the internetworking associated with savage hardware, travel, planning and going things inserted with instrumentality, programming, sensors, actuators, and structures put together that

interface these articles to amass and trade data. These contraptions crowd indispensable data with the help of existing advances and then uninhibitedly stream the information between different gadgets.

B. Flow and Sequence Diagrams

1. Flowchart for Sensor-Based Decision

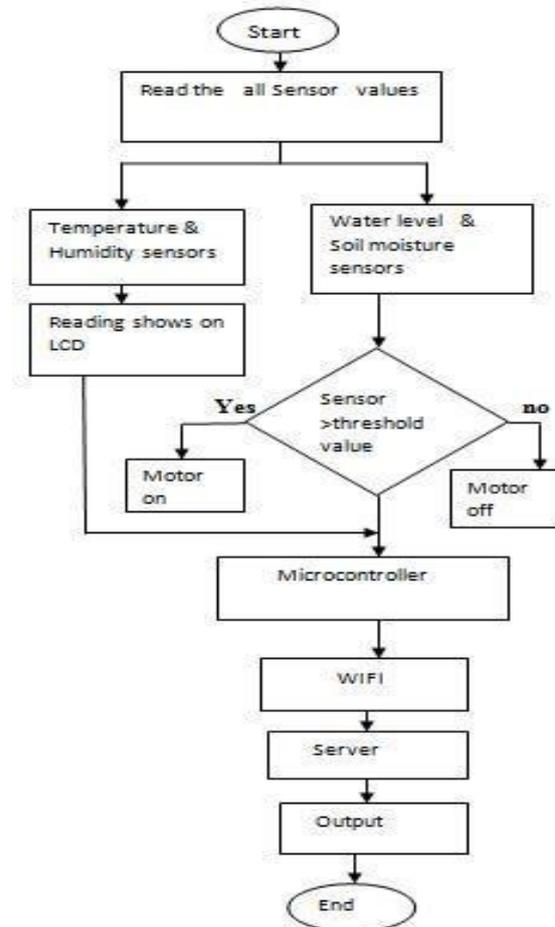


Fig. 3. 1 Flowchart Illustrating Sensor-Based Automation Logic.

The system follows a rule-based decision model. Each sensor reading (temperature, soil moisture, humidity, LDR) is compared to pre-defined threshold values. If any value exceeds its threshold, the microcontroller triggers the corresponding actuator — such as activating a water pump or adjusting greenhouse flaps. This real-time logic minimizes human intervention and optimizes resource usage.

2. Sequence Diagram for Data Transfer & Motor Control

The sequence diagram shows the communication between system components during sensor data acquisition, assessment, and actuation. Sensor

readings are sent to the Arduino Mega 2560, and conditional logic checks if actuators need to be activated. At the same time, sensor values are sent to the cloud through the ESP8266 Wi-Fi module, allowing remote monitoring and future analysis.

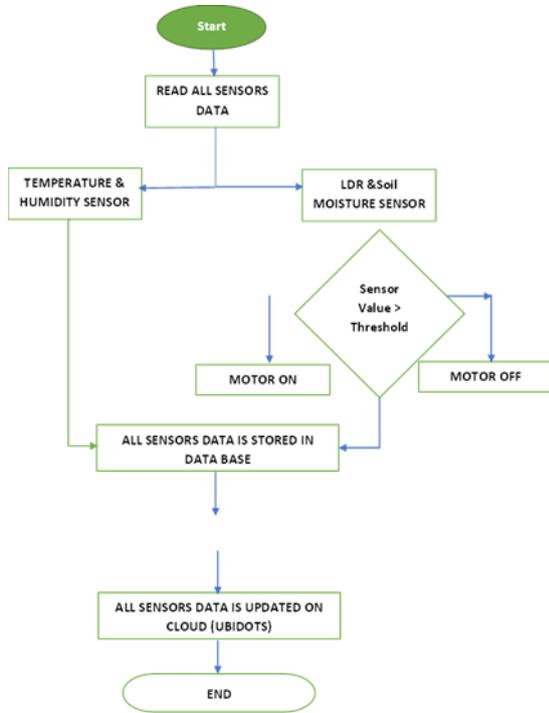


Fig. 3. 2 Sequence Diagram of Sensor Data Transfer and Motor Control.

### C. Mobile Application Integration

#### 1. Android-Based Monitoring

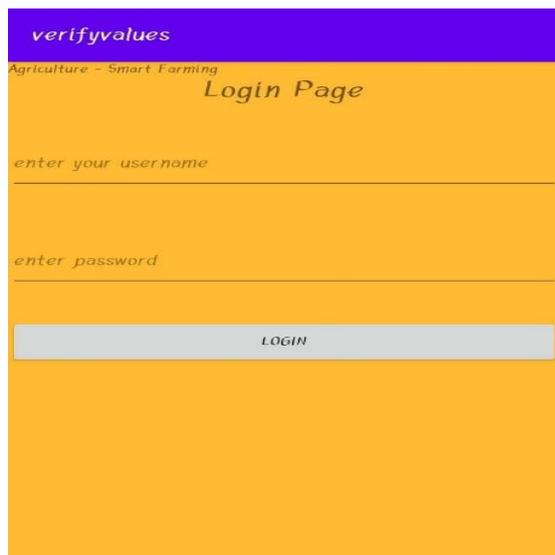


Fig 4. 1 Login Page.

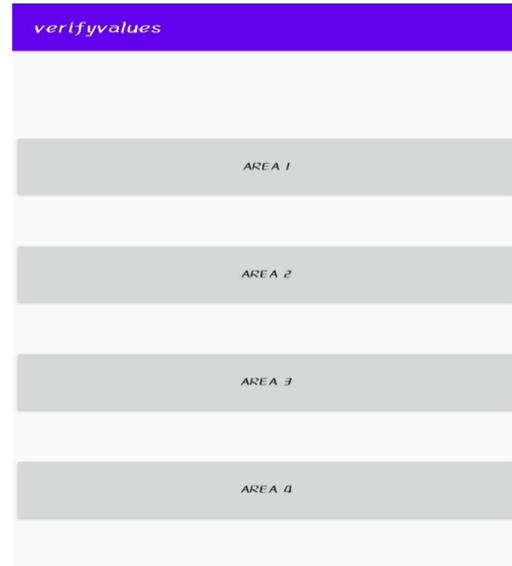


Fig 4. 2 Area 1-4.

The system has an Android application for end-users to remotely monitor agricultural zones. The app is comprised of a secure login page, followed by an interface for choosing specific areas (Area 1 to 4). All areas have sensors (temperature, humidity, soil moisture, LDR) whose readings are displayed in embedded ThingSpeak graphs.

#### 2. Real-time Visualisation using ThingSpeak

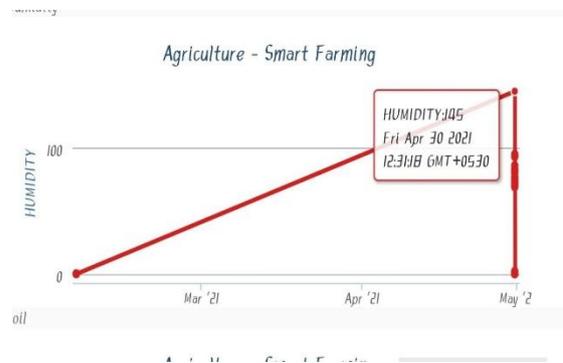


Fig 4. 3 ThingSpeak Visualization of Humidity – Area 1.

ThingSpeak serves as the cloud visualization platform, where every sensor channel is set to get real-time data from the microcontroller. Charts are automatically updated and embedded in the Android application via public channel URLs. This makes it possible for farmers to see trends and make intelligent agricultural decisions on the move.

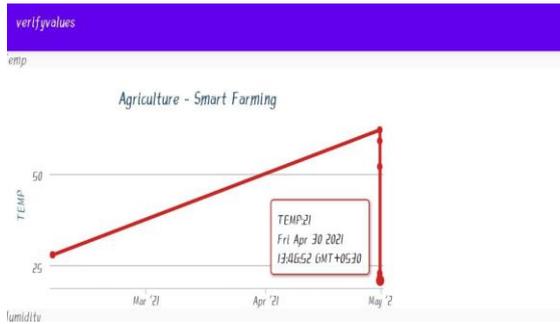


Fig 4. 4 ThingSpeak Visualization of Temperature – Area 1.



Fig 4. 5 ThingSpeak Visualization of Soil Moisture – Area 1.

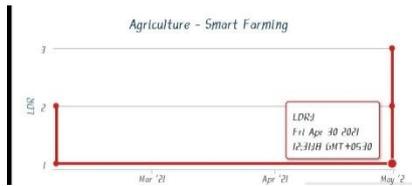


Fig 4. 6 ThingSpeak Visualization of LDR – Area 1.

Owing to space constraints, the graphs presented here reflect Area 1. The same design and visualization were applied for Areas 2, 3, and 4, with real-time updating through the Android app using ThingSpeak charts.

## VII. TESTING AND RESULTS

### A. Plantation Prediction Using ML Models

#### 1. Data Preprocessing

The dataset used for plantation prediction includes sensor readings such as temperature, humidity, soil moisture, and LDR values. During preprocessing, any zero values in the dataset were considered as missing or faulty readings and were replaced with the mean of the respective column. This ensured that the model was trained on consistent and valid data.

#### 2. Model Training and Testing

Two supervised machine learning models were used: Support Vector Machine (SVM) and Random Forest Classifier. The data was split with a standard

70-30 train-test split. Sensor readings were used as features, and the crop type (label-encoded) as the target to predict.

Tech stack used:

Python

Scikit-learn (sklearn)

OrdinalEncoder for label encoding

### 3. Accuracy Results and Comparison (SVM vs Random Forest)

After training and testing, the following accuracy scores were observed:

Model	Accuracy
SVM	58.3%
Random Forest	87.5%

The Random Forest model outperformed SVM in both accuracy and generalization ability, and hence was selected for final deployment.

### 4. Confusion Matrix Outputs

The confusion matrix results for both models are as follows. Each cell represents the number of correctly and incorrectly predicted instances for various crop classes.

Actual \ Predicted	0	1	2	3	4	5	6	7	8	9
0	4	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	0	0	0	0	0	0
3	0	0	0	0	0	1	0	0	0	0
4	0	0	0	0	1	2	0	0	0	0
5	0	0	0	0	0	5	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	2	0	0	0	0	0	0	3	0	0
8	0	0	0	0	0	1	0	0	0	0
9	0	2	0	0	0	0	0	0	0	0

Fig 5. 1 Confusion Matrix of SVM Classifier for Crop Prediction.

The Support Vector Machine (SVM) classifier achieved an accuracy of 58.3%, as shown in Fig. 6.1. Although it performed well on certain classes, it showed higher misclassification rates compared to the Random Forest Classifier, especially in classifying crops such as Onion (class 9) and Jowar (class 7).

Actual \ Predicted	0	1	2	3	4	5	6	7	8	9
0	4	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	0	0	0	0	0	0
3	0	0	0	0	0	1	0	0	0	0
4	0	0	0	0	1	2	0	0	0	0
5	0	0	0	0	0	5	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	2	0	0	0	0	0	0	3	0	0
8	0	0	0	0	0	1	0	0	0	0
9	0	2	0	0	0	0	0	0	0	0

Fig 5. 2 Confusion Matrix of Random Forest Classifier for Crop Prediction.

The confusion matrix shown in Fig. 6.2 represents the classification accuracy of the Random Forest model across 10 crop categories. Diagonal entries represent correct predictions, while off-diagonal values indicate misclassifications. The model achieved an accuracy of 87.5%, making it the most effective among tested algorithms.

**B. Model Performance Summary**

**1. Accuracy Metrics**

The Random Forest Classifier achieved a significantly higher accuracy and lower overfitting compared to SVM. The evaluation was done using accuracy score from sklearn. metrics. This validated the model’s suitability for plantation prediction based on sensor data.

**2. Crop Classification Mapping Table**

The crop types used in prediction were label-encoded for compatibility with machine learning algorithms. Below is the mapping between crop names and assigned class IDs:

Crop Name	Crop ID
Black Gram	0
Capsicum	1
Carrot	2
Cinnamon	3
Corn	4
French Beans (Farasbi)	5
Gooseberry (Amla)	6
Jowar	7
Mustard Seeds	8
Onion	9
Potato	10
Rice	11
Soybean	12

Crop Name	Crop ID
Tea	13
Tobacco	14
Wheat	15

Table 1 Crop Name to Class ID Mapping for Machine Learning.

**VIII. CONCLUSION**

The whole system gives the realm of automation in agriculture, which simplifies farmers' work. It assists in enhancing agricultural production and saves the farmer's time and money. The top side is useful for small farms since it is costly to adopt. Graphs area unit want to analyse gift conditions and take necessary actions in future.

**IX. MERGED FUTURE SCOPE AND APPLICATIONS**

The future scope of this project could be as well as kinds of soil detectors, like pH sensors, rain detector so grouping and storing the info on cloud server. This may build the predicting and analysing processes a lot of correct. It additionally includes making different data processing algorithms suitable for knowledge analysis in agriculture.

The envisaged IoT-enabled smart agriculture system can be customized for different sectors of contemporary agriculture. Through real-time sensing, cloud computing, and machine learning, the system facilitates several forms of agricultural innovation that enhance yields, minimize manual labour, and maximize resources.

**A. Precision Farming**

It makes agricultural practices far more precise and controlled when it comes to cultivating crops and rearing livestock. Numerous organizers are investing in this system because it is one of the most well-known IOT applications in the agriculture industry.

**B. Smart Greenhouses**

Greenhouse agriculture may be a system for increasing the yield of vegetables, fruits & crops. It controls the environmental parameters through manual intervention or a proportional management mechanism.

**C. Agricultural Drones**

Drones are being used in agriculture to boost varied agricultural practices like crop health imaging,

integrated GIS mapping, ease of use, saving time, and have the potential to extend yields.

#### D. Livestock Monitoring

Wireless IOT apps for large farmhouse owners can be used to collect data concerning locations, well-being, and ox welfare. Together with IOT-dependent mainly dependent sensors, it reduces labour prices because ranchers can find their birds.

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