SENSOR ASSISTED INTELLIGENT PLATFORM FOR ENHANCING BANANA CROP YIELD

ABSTRACT

Aims: Smart farming and precision agriculture have emerged as transformative paradigms in modern agricultural practices, leveraging technological innovations to enhance productivity, sustainability, and efficiency in food production. This paper provides a comprehensive review of the concepts and technologies related to smart farming. The work proposed implements a sensor assisted IoT based model to enhance the overall yield of banana crop, by monitoring the current conditions existing at the site and predicting the alterations to achieve optimal conditions for conducive and healthy growth, further early identification and prediction of infection causing pathogens to have also been embedded in the model. Model designed has been tested on the farm field of banana crop located in the premises of Amity University Lucknow Campus equipped with moisture and humidity sensors (DHT11), NPK soil nutrient sensor, PIR motion sensor (HC-SR501), pH Sensor (pH -450), rain drop sensor along with camera installed drone for infection identification. Data from sensors and drone camera were monitored at regular intervals for future predictions about health and productivity estimate of the crop.

Keywords: Smart farming, Precision agriculture, Internet of Things (IoT), Drones, Artificial Intelligence (AI), Big data analytics, Remote sensing, Sustainable agriculture, Food security

1. INTRODUCTION

Banana is the second most important crop after mango. It is favoured for table and processing purposes due to its year-round availability, affordability, Flavors, numerous varieties, nutritional value, and health benefits. Additionally, it holds significant export potential both as a fruit and in processed forms, such as banana pulp or juice. Despite our widespread consumption of bananas, many may not be aware of the vast array of varieties available. Globally, there are approximately 300 cultivated varieties of bananas. However, in India, only 15-20 banana varieties are commercially cultivated. [1-3]

1.1 Banana production In India

Bananas are a major fruit crop in tropical and subtropical regions, including India. The country's banana production has witnessed steady growth since 2005, with total production exceeding 30 million metric tons (MT) in 2017. India ranks among the top banana-producing nations globally, alongside the Philippines, China, Ecuador, Brazil, and Indonesia. Significant contributors to India's banana production include Tamil Nadu, Andhra Pradesh, Maharashtra, and Karnataka.

Andhra Pradesh leads as the largest banana-producing state in India, accounting for 16.27% of the total production. Gujarat and Maharashtra follow closely as the second and third largest producers, with shares of 14% and 13%, respectively. The production of bananas in India has experienced a notable increase over the years, with a remarkable surge of 1477% recorded in 2010-11 compared to 2005-2006. The flow chart depicts the distribution of banana production across different states in India for the year 2017-2018.Top of Form

1.2 Parameters for Banana Crop

Here are some parameters and specifications for banana crop cultivation:

i. **Climate Requirements**:

Bananas thrive in tropical and subtropical climates. Optimal temperature range: 24°C to 30°C (75°F to 86°F). Minimum temperature for sustainability: 15°C (59°F). They require well-distributed rainfall or irrigation, with an annual rainfall of 1000 to 2500 mm.

ii. **Soil Conditions**:

Preferably deep, well-drained, fertile soils with a pH range between 6.0 to 7.5. Sandy loam or loamy soils are suitable for banana cultivation. Good organic matter content in the soil is beneficial.

iii. **Planting Material**:

Use healthy, disease-free suckers (shoots arising from the base of the parent plant). Suckers should be about 1.5 to 2.0 meters tall with a minimum of 4-5 leaves. Tissue-cultured plants are also increasingly used for their uniform growth and disease-free nature.

iv. **Planting Time**:

Planting can be done throughout the year in tropical regions. In subtropical regions, it's best to plant during the warmest months.

v. **Spacing**:

Recommended spacing is typically 2 to 3 meters between plants and 2 to 3 meters between rows. Adjust spacing based on the variety, soil fertility, and local conditions.

Fig.1 Banana Plants Spacing

vi. **Fertilization**: Apply balanced fertilizers rich in potassium, phosphorus, and nitrogen. Regular fertilization is necessary for healthy growth and high yields.

vii. **Irrigation**: Bananas require regular watering, especially during dry periods. Drip irrigation or furrow irrigation is preferred to avoid waterlogging.

viii. **Weed Control**: Keep the plantation free from weeds, especially during the initial stages of growth. Mulching can help suppress weed growth and retain soil moisture. [4 - 6]

1.3 DISEASES INFECTING BANANA CROP

Major diseases are:

i. Fusarium (dessert types)
ii. Sigatoka (Cooking bananas)
iii. Cigar end rot
iv. Banana Bunchy Top Virus (BBTV)
v. Banana Streak Virus (BST)
vi. Bacterial wilt (BW)

Regular monitoring for pests and diseases is essential. Common diseases include Panama disease, Sigatoka leaf spot, and Fusarium wilt. Use of disease-resistant varieties, proper sanitation, and cultural practices can help manage diseases effectively. [7,8]

Fig.2 Panama Disease

i. Fusarium Wilt

Fusarium wilt affects dessert bananas, causing yellowing and dropping of leaves (Fig. 3),

Fig.3 Fusarium wilt

failure to fruit, and eventual plant drying. Infected plants show brown discolorations in the corm with a foul smell. Uprooting infected plants and careful handling of implements are crucial for control. Resistant varieties like FHIA types offer a solution against this disease. [9-11]

ii. **Cigar end rot**: Fungal disease causing darkened, rotting tips on banana fruits.

iii. **Banana Bunchy Top Virus (BBTV):** Viral infection leading to stunted growth, bunchy appearance, and yellowing of banana leaves.

iv. **Banana Streak Virus (BST):** Viral disease-causing streaks or bands of discoloration on banana leaves and fruit.

v. **Bacterial wilt (BW):** Bacterial infection resulting in wilting, yellowing, and eventual death of banana plants.

1.4 Use of drones to Monitor the Field

i. **Crop Monitoring and Management**: Drones enable farmers to monitor crops more efficiently and effectively compared to traditional ground-based methods. They can quickly survey large areas of farmland and identify problems such as water stress, weed encroachment, and disease outbreaks. This allows for timely intervention and targeted management practices, such as variable rate application of fertilizers or pesticides.

Fig 4. Agricultural Fields

ii. **Precision Spraying and Application**: Some drones are equipped with payload systems capable of precision spraying or application of agricultural inputs such as fertilizers, pesticides, or herbicides. By precisely targeting areas of need, drones can reduce chemical usage, minimize environmental impact, and optimize resource efficiency. This approach is particularly useful for inaccessible or uneven terrain where traditional machinery may struggle to operate efficiently.

iii. **Drones as Alarm**: The drones can Act as alarm as when mobile phone of a individual person is attaches to a drone, It can play some tunes that can distract the birds and make them leave the Field. In agriculture field of Rice, the seeds floats on water in the field. The birds used to destroy the field by eating it. This flying alarm can help them by flying in Air with mobile phone with tunes.

Fig. 5 Drone carrying mobile phone as alarm.

iv. **Checking Crop Density:** Using drones equipped with cameras to assess crop density involves capturing aerial images of agricultural fields. These images are then analysed to determine the distribution and density of crops throughout the field. This method allows farmers to efficiently monitor crop health, identify areas of overgrowth or undergrowth, and make informed decisions regarding irrigation, fertilization, and pest management. [12-15]

2. Data set:

My work focuses on enhancing banana farming in the Amity field, comprising 300 banana plants. Through systematic data collection and analysis, we aim to optimize various aspects of banana cultivation. This includes monitoring plant growth, assessing fruit production and quality, analysing soil conditions, managing pests and diseases, evaluating yield per plant, and conducting cost analysis. By leveraging this comprehensive dataset, our project aims to provide valuable insights and recommendations to enhance banana farming practices and ultimately improve yields and profitability in the Amity field.

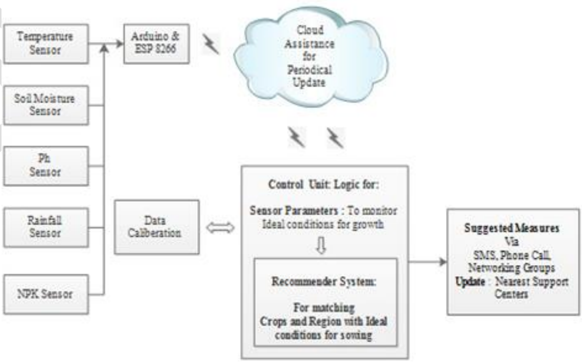


Fig. 6. Generalized Block diagram of Proposed Platform

2.1 Detailed Hardware Components and Sensor Implementation

i. Arduino UNO Board: Central to our setup, the Arduino UNO collects and processes data from all connected sensors. Its programmability allows for customized data reading schedules and logic to act on sensor inputs, making it ideal for our application.

Fig.7 Arduino Board

ii. **SIM900 GSM Module:** For remote communication, the SIM900 GSM module connects our system to the cellular network. This module enables the transmission of sensor data to our server and allows for remote monitoring and control, crucial for farms located in areas with limited internet infrastructure.

Fig.8 SIM900 GSM Module

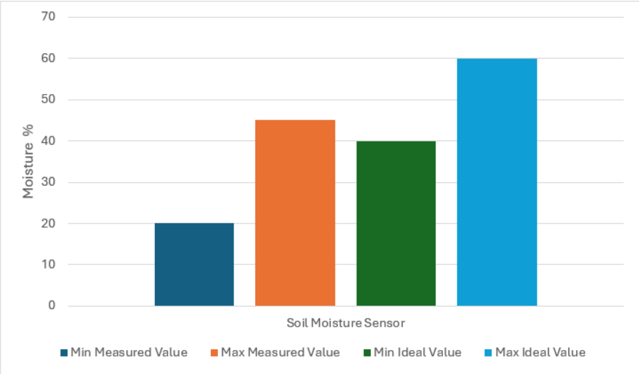
iii. **Soil Moisture Sensors:**

Soil moisture sensors are installed at strategic locations within the field to measure the moisture content of the soil at various depths. These sensors can be inserted into the soil profile or buried at specific depths depending on the crop's root zone.

iv. **Continuous Monitoring**:

Soil moisture sensors continuously monitor the moisture levels in the soil, providing real-time data on the water status of the crop's root zone. Some sensors may also measure other parameters such as temperature and electrical conductivity to provide additional insights into soil conditions. [16-18]

Fig.9 Moisture sensor



Soil Moisture Sensor Reading Graph

2.2 Other Sensor Implementation:

i. DHT22 Temperature and Humidity Sensor:

- The DHT22 is a digital sensor used for measuring temperature and humidity. Here are some brief details about it:
- **Functionality**: The DHT22 sensor is capable of measuring both temperature and humidity levels in the surrounding environment.
- **Accuracy**: It provides fairly accurate readings, with a typical accuracy of ±0.5°C for temperature and ±2-5% for humidity.
- **Interface**: It operates via a digital interface, making it easy to integrate with microcontrollers like Arduino and Raspberry Pi.
- **Operating Range**: The DHT22 can measure temperatures ranging from -40°C to 80°C (-40°F to 176°F) and humidity levels from 0% to 100%.
- **Output**: The sensor provides digital output, simplifying the process of reading data.
- **Application**: It's commonly used in various applications such as weather stations, HVAC systems, incubators, and environmental monitoring systems.
- **Reliability**: While the DHT22 is relatively reliable, it's worth noting that calibration may be required for precise measurements, and it may not be as robust as some higher-end sensors in extreme conditions.

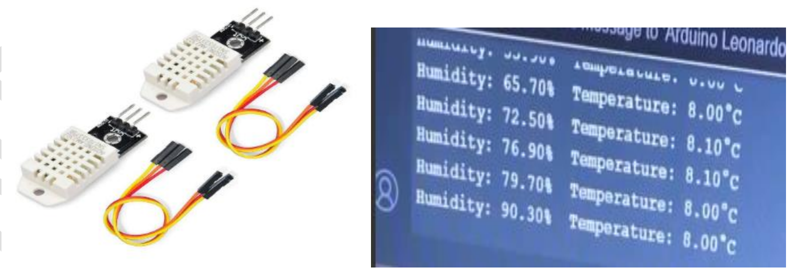


Fig.10 DHT22 Temperature and Humidity Sensor

ii. NPK Soil Nutrient Sensor

The NPK soil nutrient sensor measures soil nitrogen, phosphorus, and potassium levels, aiding precise fertilizer application in agriculture. It employs various techniques for measurement, providing digital output for easy integration, and finds applications in optimizing plant growth and environmental monitoring.

Fig.11 NPK Soil nutrient sensor

iii. HC-SR501 PIR Motion Sensor

The HC-SR501 PIR motion sensor detects infrared radiation emitted by moving objects within its range. Commonly utilized in security systems, lighting control, and automation projects, it triggers an output signal when motion is detected. Operating on low power, it's suitable for battery-operated devices. With adjustable sensitivity and time delay settings, it offers flexibility for various applications. Easy to integrate with microcontrollers like Arduino, it's widely accessible for hobbyists and professionals alike, enhancing the functionality of projects requiring motion detection.

Fig.12 PIR Motion Sensor with its readings

iv. pH-4502C pH Sensor

The pH-4502C pH sensor is a specialized device for measuring the acidity or alkalinity of a solution. It features a glass electrode that generates a voltage proportional to the hydrogen ion concentration in the solution. Commonly used in laboratories, industrial processes, and environmental monitoring, it provides accurate pH readings for quality control and analysis purposes. pH-4502C sensors typically require calibration and maintenance to ensure precision and longevity.

Fig.13 pH-4502C pH Sensor

v. Raindrop Sensor Module

The Raindrop Sensor Module is crucial for farmers to monitor rainfall levels in their fields. By detecting rain or moisture, it helps determine irrigation needs, preventing overwatering or under-watering. Integrated with irrigation systems, it ensures optimal water usage, conserving resources and maximizing crop yield. Farmers can adjust its sensitivity to suit their specific crops and environmental conditions. When connected to microcontrollers, it enables automated responses such as activating irrigation pumps or sending alerts to farmers' mobile devices, facilitating efficient and timely management of agricultural operations.

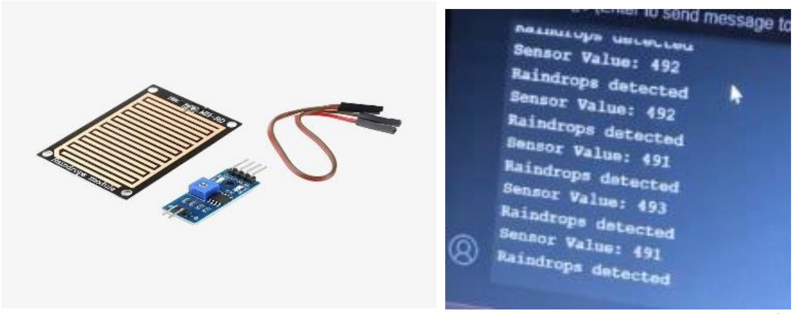


Fig.14 Raindrop Sensor with its results

2.3 connectivity and Data Transmission:

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2.4 Software Integration:

The Arduino Integrated Development Environment (IDE) played a crucial role in implementing our IoT-connected smart farming system. This open-source platform streamlined the programming of the Arduino UNO board, which served as the central component of our system. Using the IDE, we developed custom scripts to initialize sensors, gather and process data periodically, and handle data transmission via a GSM module to a cloud server. This setup facilitated real-time monitoring and analysis of environmental conditions, allowing for precise irrigation and fertilization in agriculture. The IDE's user-friendly interface and debugging tools were invaluable in refining our code for reliable system performance. Moreover, its extensive library support simplified the integration of various sensors, showcasing the IDE's adaptability in IoT applications for farming. This software integration underscores the practical application of programming skills and IoT technology in addressing modern farming challenges sustainably. [6, 17]

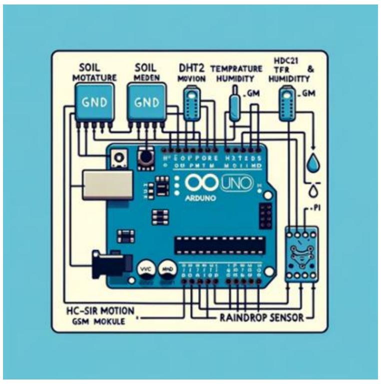

Fig.15 Block Diagram of sensors

2.5 Ideal conditions for Banana crop growth

In India, optimal banana crop growth relies on maintaining specific environmental and soil conditions. The pH level of the soil should fall within a certain range, providing an ideal balance for nutrient uptake.

Similarly, soil nutrient levels, measured by NPK sensors, must be carefully managed to support healthy plant growth. Adequate soil moisture content is crucial, ensuring plants receive sufficient water without becoming waterlogged. Consistent rainfall throughout the year contributes to overall plant health and development. Temperature plays a significant role, with moderate warmth favoring optimal growth. Additionally, humidity levels should remain within a certain range to prevent stress on the plants. By adhering to these ideal conditions, banana farmers can promote robust growth and maximize yields in their crops.

Parameter	Ideal Value
pH (Soil)	6.0 - 7.0
NPK (Soil)	N: 100-150 ppm
	P: 40-60 ppm
	K: 150-200 ppm
Soil Moisture	60% - 80%
Rainfall	1000 - 2000 mm/year
Temperature	25°C - 30°C
Humidity	60% - 80%

Fig.16 Optimal Parameters for healthy growth of the crop

2.6 Implementation

The values which are being mentioned below are taken from the sensors and are collected from the Banana field which is in Amity campus.

The recorded sensor values for banana crop growth in India are within acceptable ranges but not precisely at ideal levels. The soil pH is measured at 6.5, while soil NPK levels show nitrogen at 120 ppm, phosphorus at 50 ppm, and potassium at 180 ppm. Soil moisture content is at 70%, with annual rainfall at 1500 mm. Temperature reads 28.5°C, and humidity stands at 65%. These values indicate conditions that support healthy banana growth, though slight adjustments may optimize crop yield further.

Fig.17 Banana field in Amity University

pH (Soil)	6.5
N (Soil)	120 ppm
P (Soil)	50 ppm
K (Soil)	180 ppm
Soil Moisture	70%
Rainfall	1500 mm/year
Temperature	28.5°C
Humidity	65%

Fig.18 Parameters from the proposed site

3 Results:

The Smart Agricultural Monitoring System effectively collects data from all the sensors in real-time. This data is processed by the Arduino Uno and transmitted to the farmer's mobile phone via the GSM module. Farmers receive timely alerts and notifications regarding soil moisture levels, rainfall, nutrient status, and any detected motion in the field. This enables them to take immediate action such as irrigating the field, applying fertilizers, or deploying pest control measures. Furthermore, the system allows farmers to remotely monitor their fields, providing them with valuable insights even when they are not physically present on the farm.

i. **Soil Moisture Sensor:** The soil moisture sensor effectively measures the moisture content in the soil. By interfacing it with the Arduino Uno, you can accurately monitor the soil's moisture level, which is crucial for proper irrigation scheduling.
ii. **PIR Motion Sensor:** The PIR motion sensor detects motion within its range. When interfaced with the Arduino Uno, it can trigger actions based on detected motion, such as activating an alarm or recording data.
iii. **Rain Drop Sensor:** The rain drop sensor detects rainwater. When integrated with the Arduino Uno, it can provide real-time data on rainfall intensity, aiding in weather monitoring and irrigation control.
iv. **NPK Soil Nutrient Sensor:** The NPK soil nutrient sensor measures the levels of nitrogen, phosphorus, and potassium in the soil. By connecting it to the Arduino Uno, you can monitor soil nutrient levels and adjust fertilization practices accordingly for optimal plant growth.
v. **pH Sensor:** The pH sensor measures the acidity or alkalinity of the soil. Interfacing it with the Arduino Uno allows for continuous monitoring of soil pH levels, essential for maintaining soil health and ensuring proper nutrient uptake by plants.
vi. **SIM900 GSM Module:** The SIM900 GSM module enables communication via GSM networks. When coupled with the Arduino Uno, it allows for remote monitoring and control of the sensors' data, providing real-time updates and alerts to the user's mobile phone.

4 Conclusion:

The Smart Agricultural Monitoring System presented in this project offers an efficient and cost-effective solution for modern farming practices. By leveraging sensor technology and GSM communication, the system empowers farmers with real-time data and actionable insights, ultimately leading to improved crop yield and resource utilization. Future enhancements may include integration with weather forecasting systems and the development of predictive analytics algorithms for advanced decision support. Adding drones to our farming system makes things even better. Drones are like flying robots that can do cool stuff like spraying pesticides on crops and checking how they're doing from the sky. By connecting drones to our phones, we can control them and see what's happening in our fields, even when we're not there. This helps us quickly spot any problems, like pests or bad weather, and deal with them fast. With drones helping, farming becomes smarter, and we can grow more food while taking care of the environment. It's like having superheroes watching over our crops, making sure they grow strong and healthy.

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