

**CROP RECOMMENDATION SYSTEM USING MACHINE LEARNING AND IOT**

**Mahesh V. Korde<sup>\*1</sup>, Shivam R. Varma<sup>\*2</sup>, Pritesh N. Bhalerao<sup>\*3</sup>, Tanvir T. Shaikh<sup>\*4</sup>,  
Atharv A. Sonawane<sup>\*5</sup>**

<sup>\*1</sup>Professor, Department of Computer Engineering, Sandip Institute of Engineering and Management, Nashik, MH, India.

<sup>\*2,3,4,5</sup>Student, Computer Engineering, Sandip Institute of Engineering and Management, Nashik, MH, India.

DOI : <https://www.doi.org/10.56726/IRJMETS53837>

**ABSTRACT**

This paper is a study of project that integrates IoT with machine learning to provide real-time crop suggestions based on soil characteristics. By analysing a dataset that includes key soil parameters such as nitrogen, potassium, phosphorus, pH, as well as environmental factors like rainfall, humidity, and temperature, this project employs machine learning algorithms to establish relationships among these variables. The goal is to offer personalized crop recommendations to farmers that can adapt to various soil types and changing environmental conditions. Through IoT sensors capable of gathering soil data, this system can swiftly process information and deliver customized crop advice to users. This system aims to empower farmers with valuable insights, helping them make informed decisions about crop selection, resource utilization, and sustainable farming methods. It is designed to be adaptable to fluctuating soil and environmental conditions, making it a scalable solution for precision agriculture. By enabling informed decision-making, this approach contributes to increased agricultural productivity and promotes sustainable farming practices, representing a significant advancement in precision agriculture.

**Keywords:** IoT integrated approach, Machine Learning, Environmental factors, Soil metrics, Crop Recommendation system, Precision agriculture.

**I. INTRODUCTION**

Agriculture stands as a cornerstone of human sustenance, yet it grapples with formidable challenges posed by the evolving landscape of environmental shifts, population growth, and resource limitations, which collectively threaten global food security. Amidst these challenges, precision agriculture emerges as an instrumental solution, poised to revolutionize conventional farming practices by seamlessly integrating cutting-edge technologies with deep agronomic expertise.

The advent of IoT-driven sensor technologies, coupled with the prowess of machine learning algorithms, has redefined the traditional paradigms of farming. Notably, we have witnessed the application of IoT-based systems in irrigation farming and the utilization of drones for precision fertilizer sprinkling. These innovations herald a new era in agriculture, where datadriven insights and automated processes play pivotal roles in enhancing productivity and sustainability.

The genesis of a Smart Crop Recommendation System embodies a pivotal breakthrough in this realm, aligning the insights derived from soil composition and environmental parameters with sophisticated data-driven algorithms to offer real-time, tailored crop suggestions. This system represents a significant departure from conventional approaches, enabling farmers to make informed decisions based on accurate and timely information, thereby optimizing resource utilization and minimizing risks.

Current project initiatives underscore the urgency of developing intelligent systems capable of adapting to the dynamic nuances of soil health and changing climatic patterns. These endeavours not only aim to bridge the gap between traditional agricultural methods and a technologically empowered future but also highlight the imperative of sustainability in agricultural practices.

Recent studies emphasize the potential of such systems to not only optimize crop yields but also foster sustainable agricultural practices by minimizing resource wastage and environmental impact. By leveraging the capabilities of IoT and machine learning, these systems offer a pathway to enhanced efficiency, reduced costs, and improved environmental stewardship in agriculture.

Amidst these advancements, the critical need for robust, scalable, and user-friendly systems that cater to the diverse needs of farmers remains paramount. This paper aims to delve into the intricacies of this burgeoning field, exploring the multifaceted implications of IoT-integrated machine learning models in revolutionizing crop selection, resource management, and the overall trajectory of global agriculture.

This research signifies a significant stride towards sustainable farming practices, facilitating informed decision-making, and ultimately leading to improved yield outcomes and environmental sustainability in the agricultural sector.

## **II. OBJECTIVE**

Our primary goal is to develop an advanced Crop Recommendation System that seamlessly integrates Machine Learning (ML) and Internet of Things (IoT) technologies, thereby advancing agricultural practices. By analyzing historical data, real-time sensor inputs, and predictive models, the system aims to improve crop yield optimization through personalized recommendations tailored to specific environmental and soil conditions. This method not only enhances resource efficiency by aligning crop choices with available resources but also promotes sustainable agriculture by minimizing environmental impact. The main objective is to provide farmers with data-driven decision-making tools, enabling informed choices in crop selection, irrigation schedules, and fertilization practices. The system's adaptability ensures resilience to changing environmental factors. Ultimately, the project seeks to revolutionize traditional farming practices, focusing on reducing costs, customization, and scalability to create a more efficient, profitable, and sustainable agricultural ecosystem.

### **MOTIVATION**

The driving force behind creating an advanced Crop Recommendation System that incorporates Machine Learning (ML) and Internet of Things (IoT) technologies stems from the urgent need to modernize and optimize traditional agricultural methods. With the global population on the rise and an increasing demand for food, there is a critical necessity to enhance crop yield and resource utilization efficiency. The idea of leveraging historical data, real-time sensor data, and predictive models is exciting because it holds the promise of providing farmers with personalized recommendations tailored to their specific environmental and soil conditions. Moreover, considering the undeniable environmental impact of agriculture, adopting a sustainable approach is imperative. Our motivation is to contribute to sustainable agriculture by aligning crop choices with available resources, thereby reducing waste and minimizing the overall ecological footprint. Additionally, the desire to mitigate risks associated with crop diseases, pests, and adverse weather conditions drives our efforts, as this not only protects farmers' livelihoods but also promotes a resilient and adaptable agricultural ecosystem. Central to our motivation is empowering farmers with data-driven decision-making tools. Our aim is to offer practical insights and early warnings, enabling farmers to make informed decisions regarding crop selection, irrigation, and fertilization practices. The development of a user-friendly interface further fuels our motivation, ensuring that our technology is accessible and beneficial for farmers with varying technical backgrounds. In essence, our motivation lies in the potential to transform traditional farming practices, reduce expenses, customize agricultural methods, and expand the reach of sustainable and efficient crop management. By addressing these challenges, we strive to contribute to a more productive, profitable, and environmentally conscious agricultural landscape.

## **III. LITERATURE SURVEY**

The following literature surveys delve into innovative solutions for accessible and inclusive human-computer interaction, addressing the diverse needs of individuals with physical disabilities.

[1]"Crop Recommendation system using machine learning techniques"- In this research paper, Machine learning methods like Decision Trees, Random Forest algorithm were implemented on dataset for the crop recommendation purpose.

[2]"Applying Big Data for Intelligent Agriculture-Based Crop Selection Analysis"- This study investigates climate's impact on crops. Employing 3D cluster analysis, it explores environmental data correlations, aiding in crop suitability. Results confirm the feasibility of this method in aligning crop selection with changing environmental conditions.

[3] "Artificial Intelligence Technology in the Agricultural Sector": A Systematic Literature Review"- Survey explores AI facets (machine learning, IoT) in crop monitoring, robotics, predictive analytics. It discusses their impact on data collection, smart robots, crop monitoring, and irrigation. Emphasizes AI's role in bolstering productivity, sustainability, with insights on benefits and challenges in smart farming methodologies.

[4] "Crop Prediction Based on Characteristics of the Agricultural Environment Using Various Feature Selection Techniques and Classifiers"- Agricultural research focuses on crop prediction; machine learning aids due to changing environmental factors. Efficient feature selection enhances ML precision by choosing relevant data attributes. Optimal feature selection ensures model accuracy, with ensemble techniques showing superior prediction accuracy over existing classification methods.

[5] "An IoT Based System for Remote Monitoring of Soil Characteristics"- This research paper includes methods like antimony electrodes for pH, soil resistance for moisture, DS18B20 sensors for temperature enable accurate measurements. Integration with Bluetooth on STM32 Nucleo enhances data transfer for informed decisions and increased productivity.

[6] "Development of a Low-Cost Internet-of-Things (IoT) System for Monitoring Soil Water Potential Using Watermark 200SS Sensors"- This research paper is about soil moisture monitoring which aids irrigation scheduling but faces limited adoption due to cost and data interpretation challenges. Advances in IoT, Arduino, LoRa, and open-source platforms offer cost-effective solutions. This study presents a successful low-cost IoT system using Watermark sensors for widespread farmer adoption.

[7] "Big Data in food and agriculture"-The digital transformation in farming sparks concerns over power dynamics in agri-food sectors. Reviewing Big Data applications unveils data ownership dilemmas (e.g., Monsanto's Weed I.D.). Exploring implications from John Deere's data raises privacy issues. Understanding this revolution's impact and limitations aligns data scholarship with food studies, emphasizing societal consequences.

[8] "Crop and Yield Prediction Model"- This paper discusses the necessity of a systematic approach in agriculture for crop prediction to aid farmers' decision-making and improve farming quality and revenue. It highlights the limitations of existing clustering algorithms in crop prediction and proposes the use of a modified K-Means algorithm to enhance accuracy by addressing initial cluster selection.

[9] "Soil conditions and plant growth"- This paper delves into plants' responses to soil conditions, exploring root sensing triggering reactions against dryness, compaction, or infection. However, reactions to extremely soft soil or large pores remain ambiguous. Inhibitory signals impact vital plant processes, revealing a complex interplay of hormonal responses optimizing growth based on environmental cues.

#### IV. METHODOLOGY

This crop recommendation system revolves around the concept of machine learning and IoT. The steps involved for developing this system are:

##### [1]- Data Collection

Gather a comprehensive dataset encompassing soil parameters (nitrogen, potassium, phosphorous, pH levels, humidity and temperature) from diverse geographical locations, incorporating historical records and real-time data.

The dataset should consist of the required parameters along with the corresponding crops suitable for cultivation.

##### [2]- Data Pre-Processing

We will check for the irregularities in data like missing values, outliers, and inconsistencies within the collected dataset which might have caused problems in system training. Extract relevant features, possibly transforming or scaling data to enhance model performance.

##### [3]- Model Development

Implement and train machine learning models (e.g., decision trees, random forests, gradient boosting) to correlate soil and environmental data with recommended crops. Optimize model parameters using techniques like cross-validation to improve predictive accuracy.

#### [4]- System Integration

Establish a system to collect live soil data through IoT sensors, ensuring seamless data transmission to the recommendation system. Develop algorithms to process incoming data in real-time and send this data to the machine learning model we developed for the crop recommendations.

#### [5]- User Interface and Deployment

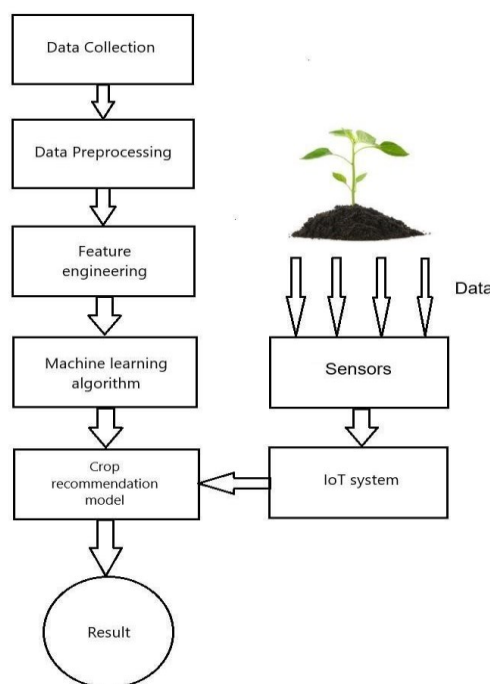
Create a user-friendly interface for farmers to access the system and receive personalized crop recommendations. Implement the system in a scalable and accessible manner.

#### [6]- Evaluation and Refinement

Create a user-friendly interface for farmers to access the system and receive personalized crop recommendations. Implement the system in a scalable and accessible manner.

### V. PROPOSED SYSTEM

The proposed system is consisting of two important parts, first one is development and training of machine learning model and second one is creating an IoT system which is capable of recording required soil parameters directly from soil and finally integration of both.



**Fig.1.** represents the steps involved in development of the proposed system and they are described below:

#### [A]- Data Collection

The data collection is the most important part as the training of the model and produced result will be based on this dataset only, so, we have to select the dataset which consist of required parameters and accurate recommendations, we can refer to several free websites like kaggle for the datasets.

#### [B]- Data Pre-processing

Data pre-processing is a crucial step as collected dataset may involve a lot of irregularities like missing data, noisy data and outliers, which can cause problems during the training of the model. So, it is better to arrange the data in a format which is suitable for analysis and training. The methods which are used for data pre-processing are data cleaning, data transformation, normalization, data reduction etc.

#### [C]- Feature Engineering

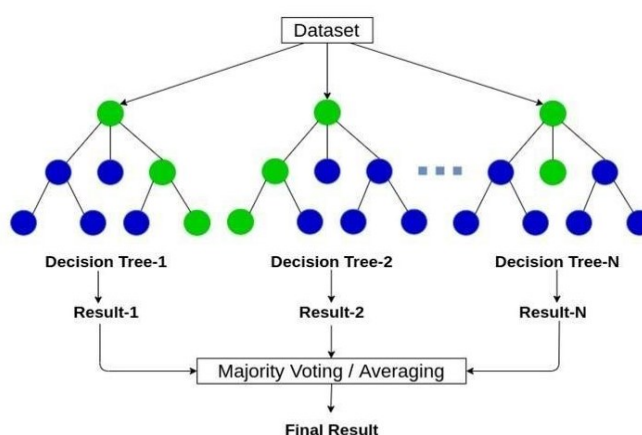
Feature engineering is a way of creating & extracting new features and utilise them in order to improve the performance of the machine learning model. It is an essential step and generally that features are taken into consideration which affects the recommendation.

### [D]- Machine Learning Algorithm

Machine learning algorithms are computational model that enables computers to learn patterns and make decisions or predictions without being explicitly programmed. The dataset is split into two parts, training and testing dataset. According to a standard rule, 80% of dataset is used for training while 20% will be used for testing and validation. There are different machine learning algorithms which are useful for the recommendation system but we have to choose the algorithm with high accuracy. The algorithms with higher accuracies are described below:

#### Random Forest Algorithm

Random forest is an ensemble algorithm which is based on the concept of decision trees. But, instead of one decision tree, multiple decision trees are deployed in the backend which produces individual results and the final result is decided on the basis of majority voting. The random forest also has higher accuracy and is faster as compared to gradient boosting.



**Fig 2:** Random forest algorithm

### [E]- Crop Recommendation system

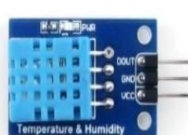
After training is complete, the model is tested on testing dataset and the results are validated. After the validation the model is ready for the usage and the function is created which will take soil parameters as input and output the desired results using ML model. The data from IoT system will be passed on to this function in order to produce the result.

#### [F]- Data from Sensors

Sensors are the most important building block of the IoT system as it is responsible for the collection of data from the soil. There are total seven parameters which our crop recommendation will require and that is Nitrogen (N), Potassium (K), Phosphorous (P), Humidity, Temperature, Rainfall and pH level. To record the NPK values, there is three pin sensors called NPK sensor which is to be used and to record temperature and humidity, DHT11 sensor is used.



**Fig 3:** NPK sensor



**Fig 4:** DHT11 sensor



**Fig 5:** pH sensor



## [G]- IOT System

In our crop recommendation framework, the Internet of Things (IoT) system relies on a network of strategically positioned sensor nodes within agricultural fields. These nodes actively gather real-time data related to critical environmental factors such as soil moisture, temperature, humidity, pH and NPK levels. The collected data undergoes transmission to a central data acquisition layer, functioning as a gateway for preprocessing and filtering. Efficient data transfer is facilitated through connectivity options such as Wi-Fi or cellular networks. Computing devices like NodeMCU are situated near the sensor nodes which can perform initial data processing. Subsequently, the preprocessed data is dispatched to machine learning models which analyze it to generate crop recommendations based on historical and real-time insights.

### Why NodeMCU?

NodeMCU is an open source IoT platform that is based on ESP8266 Wifi module. It combines the capabilities of the ESP8266 microcontroller with the simplicity and ease of use of the Lua scripting language. Due to its Wifi compatibility, the data collected from sensor nodes can directly be transferred to cloud server using internet which provides an edge in data transmission as compared to other microcontroller boards like Arduino, raspberry pi etc.

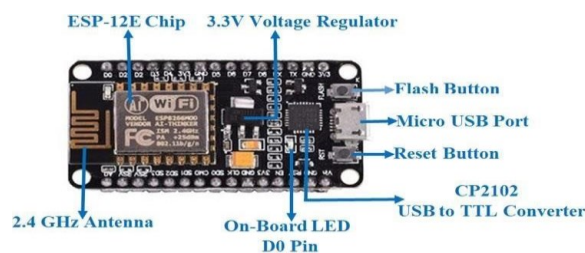


Fig 6:NodeMCU board

## SYSTEM ARCHITECTURE

The system architecture of our advanced Crop Recommendation System, which seamlessly integrates Machine Learning (ML) and Internet of Things (IoT) technologies, plays a crucial role in delivering accurate and personalized recommendations to farmers. At its core, the architecture comprises three main components: data collection and preprocessing, machine learning algorithms, and the user interface. Each component is intricately designed to work in tandem, leveraging data analytics and automation to empower farmers with actionable insights for optimized crop management.

The system architecture discusses about the detailed description and overall structure of system. In system architecture, we will describe about how the IoT system is arranged and is working. Fig.7. represents the system architecture of Crop recommendation system.

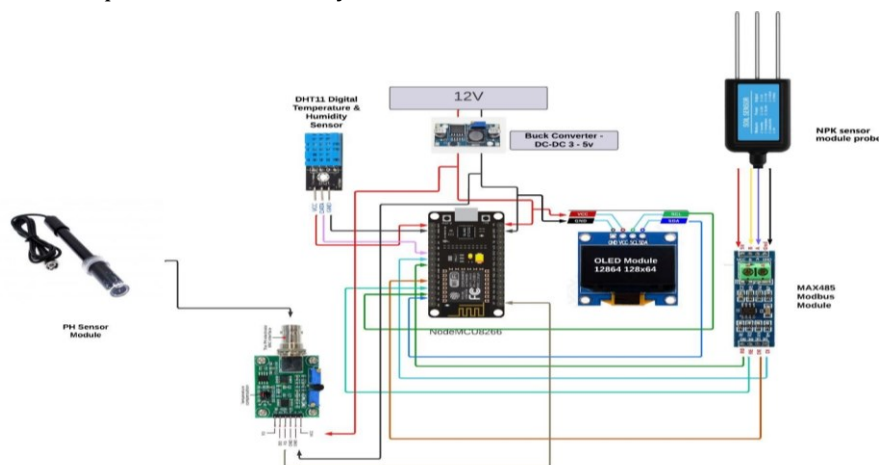


Fig 7: System Architecture

Starting with the sensors, the system incorporates a pH sensor module to measure soil acidity levels accurately. This sensor is crucial as soil pH plays a significant role in determining nutrient availability and overall soil health. Additionally, the system integrates a DHT11 sensor to monitor temperature and humidity levels in the environment, providing insights into climate conditions that directly impact crop growth and development. Furthermore, an NPK sensor module is included to measure nitrogen, phosphorus, and potassium levels in the soil, essential nutrients for plant growth and yield.

The NodeMCU8266 acts as the central processing unit and communication hub within the system. It orchestrates data collection from the sensors, processes the raw data into meaningful information, and facilitates communication with external servers and modules. The NodeMCU8266 also plays a crucial role in power management, ensuring efficient energy utilization through the incorporation of a buck converter, which adjusts the input voltage to power the system components optimally.

Once the data from the sensors is collected and processed by the NodeMCU8266, it is displayed in real-time on an OLED (12864 128X64) module. This module serves as the user interface, providing farmers with immediate access to critical information such as pH levels, temperature, humidity, and NPK levels. This real-time monitoring capability empowers farmers to make timely decisions regarding crop management practices, irrigation scheduling, and fertilizer application.

Simultaneously, the NodeMCU8266 establishes a connection to a WiFi network, enabling seamless data transmission to the ThingSpeak server—a cloud-based platform designed for data storage, analysis, and integration with external services. Within the ThingSpeak environment, a pre-trained machine learning model is deployed to generate crop recommendations based on the collected data.

The machine learning model utilizes sophisticated algorithms and historical data patterns to analyze soil composition, environmental conditions, and nutrient levels. It then generates personalized crop recommendations tailored to the specific needs of the farming operation. These recommendations encompass optimal crop varieties, planting schedules, irrigation regimes, and nutrient management strategies, aiming to maximize crop yields while minimizing resource wastage.

The generated crop recommendations are relayed back to the NodeMCU8266, which in turn displays them on the OLED module for user interaction. Farmers can review the recommendations, adjust parameters as needed, and implement data-driven strategies to optimize their crop production processes effectively.

In summary, the detailed system architecture integrates a comprehensive array of IoT components, including sensors, processing units, communication modules, and cloud-based services. This integration facilitates real-time monitoring, data analysis, and decision support, ultimately empowering farmers with actionable insights to enhance crop productivity, resource efficiency, and sustainability in agriculture.

## **VI. RESULTS**

Below are the screenshots of the physical system developed and the output which is generated for a random example.



**Fig.8.** represents the physical IoT system developed for detecting real time soil values.

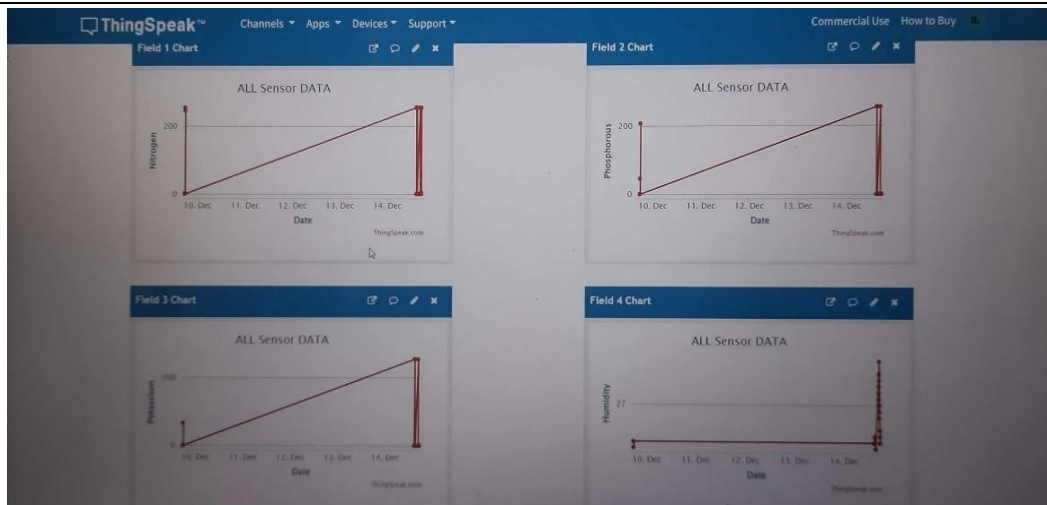


Fig 9: Sensors' data on ThingSpeak server

Fig.9,10. represents the graph of data collected through sensors on ThingSpeak server.

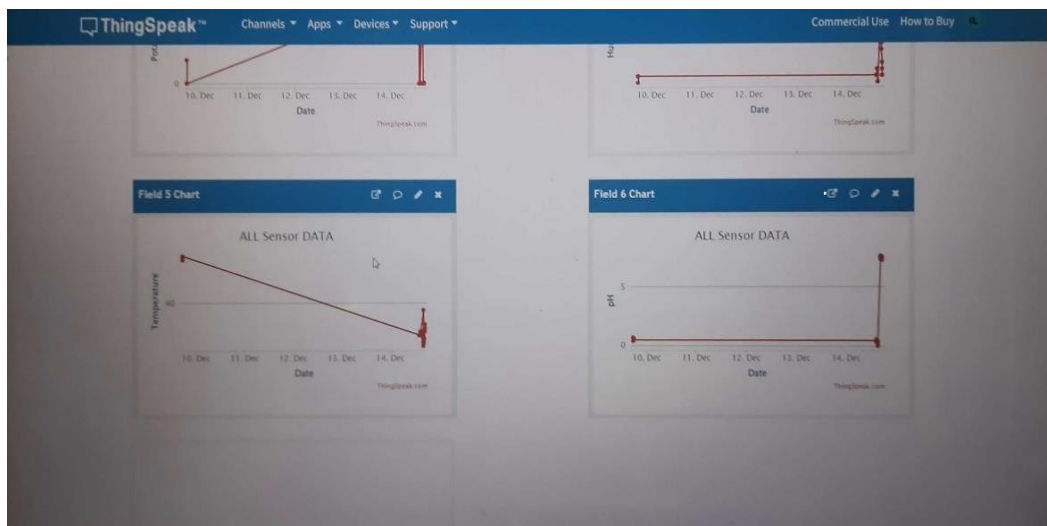


Fig 10: Sensor's data on ThingSpeak server

```
C:\Codes_Files\zip run test\venv\Lib\site-packages\sklearn\base.py:348: InconsistentVersionWarning: Trying to unpickle
https://scikit-learn.org/stable/model_persistence.html#security-maintainability-limitations
warnings.warn(
C:\Codes_Files\zip run test\venv\Lib\site-packages\sklearn\base.py:348: InconsistentVersionWarning: Trying to unpickle
https://scikit-learn.org/stable/model_persistence.html#security-maintainability-limitations
warnings.warn(
Entry ID: 794
Nitrogen: 4
Phosphorous: 1
Potassium: 2
Humidity: 26.30
Temperature: 36.00
pH: 7.31
-----
Predicted Crop: Orange
Process finished with exit code 0
```

Fig 11: Output

Fig.11. represents the output of a random example by crop recommendation system.



## **VII. CONCLUSION**

The Smart Crop Recommendation System exemplifies the transformative power of technology in agriculture. By integrating IoT sensors, machine learning algorithms, and usercentric design, this project presents a dynamic solution to the enduring challenge of selecting the most suitable crops based on soil composition and environmental conditions. By leveraging real-time data on soil parameters and weather patterns, this system equips farmers with actionable insights, empowering them to make informed decisions in crop cultivation. The seamless incorporation of IoT sensors allows for continuous data collection, feeding into an advanced recommendation engine that generates personalized crop recommendations.

This initiative not only represents a significant advancement in precision agriculture but also emphasizes the importance of utilizing data-driven approaches to improve agricultural productivity. The scalability, adaptability, and user-friendly interface of the system indicate a promising path towards sustainable farming practices. In the face of escalating agricultural challenges, the Smart Crop Recommendation System serves as a beacon of hope, demonstrating the potential for technology to transform farming methods. With ongoing refinements, continual enhancements, and broader adoption, this system sets the stage for a more efficient, sustainable, and yield-optimized future in agriculture.

## **VIII. REFERENCES**

- [1] "Crop recommendation using Machine learning techniques"-Shafiulla sharif, Shwetha R.B., Ramya O.G., Pushpa H. , Pooja H.R. – 2022.
- [2] "Applying big data for Intelligent agriculture-based crop selection analysis"-Fan-Hsun Tseng, Hsin-Hung Cho, Hsin-Te Wu-September 2019.
- [3] "Artificial Intelligence Technology in the Agricultural Sector: A Systematic Literature
- [4] Review"-Ersin Elbasi, Nour Mostafa , Zakwan Alternout -2022
- [5] "Crop Prediction Based on Characteristics of the Agricultural Environment Using Various Feature Selection Techniques and Classifiers"-S. P. Raja, Barbara Sawicka, Zoran Stamenkovic, G. Mariammal-March 2022.
- [6] "An IoT Based System for Remote Monitoring of Soil Characteristics"-Abdullah Na,
- [7] William Isaac, Shashank Varshney, Ekram Khan-2016
- [8] "Development of a Low-Cost Internet-of-Things (IoT) System for Monitoring Soil Water Potential Using Watermark 200SS Sensors"-José O. Payero, Ali Mirzakhani-Nafchi, Ahmad Khalilian, Xin Qiao, Rebecca Davis-2017.
- [9] "Big Data in food and agriculture"-Kelly Bronson and Irena Knezevic-2016.
- [10] "Crop and Yield Prediction Model"-Shreya S. Bhanose , Kalyani A. Bogawar , Aarti G. Dhotre , Bhagyashree R. Gaidhani-2016.
- [11] "Soil conditions and plant growth"-J. B. Passioura-2020.
- [12] [10]"Crop recommendation system using Machine Learning and IoT"-Mahesh V. Korde, Shivam R. Varma, Pritesh N. Bhalerao, Tanvir T. Shaikh, Atharv A. Sonawane-2024.