A

Major Project report on

Crop Recommendation System Using Machine Learning and IOT

Submitted in partial fulfillment of the requirements
for the degree of
BACHELOR OF ENGINEERING
IN
Computer Science & Engineering
Artificial Intelligence & Machine Learning

by

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2024-2025

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CERTIFICATE

This is to certify that the project entitled "**Crop Recommendation System Using Machine Learning and IOT"** is a bonafide work of Prathamesh Mane (22206003), Sahil Shaikh (22206004), Milind Chavan (22206007), Aryan Bane (22206009) submitted to the University of Mumbai in partial fulfillment of the requirement for the award of **Bachelor of Engineering** in **Computer Science & Engineering (Artificial Intelligence & Machine Learning).**

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Project Report Approval

This Major project report entitled "**Crop Recommendation System Using Machine Learning and IOT**" by **Prathamesh Mane, Milind Chavan, Sahil Shaikh, Aryan Bane** is approved for the degree of ***Bachelor of Engineering*** in ***Computer Science &Engineering***, (AIML) ***2024-25***.

External Examiner: ____________________

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Place: APSIT, Thane

Date:

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ABSTRACT

The Crop Recommendation System using Machine Learning and Internet of Things (IoT) technology is designed to assist farmers in making informed decisions about crop selection to maximize yield and sustainability. By analyzing 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.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

A Crop Recommendation System using Machine Learning and IoT is an innovative approach that addresses the challenges faced by farmers in maximizing crop productivity and ensuring sustainable agricultural practices. Traditional farming methods often rely on experience-based decisions, which may not consider the dynamic environmental conditions and variability in soil properties. This system aims to modernize agriculture by combining data science and smart technology to offer precise and customized crop recommendations.

Machine learning models, trained on vast datasets that include soil health parameters, weather forecasts, enable the system to predict the most appropriate crops for a given piece of land. These models can also consider factors like temperature, humidity, and pH levels, ensuring that the recommendations are tailored to the specific needs of the land and the climate.

The integration of IoT devices further enhances the system's capabilities by providing real-time data collection and monitoring. Sensors deployed in the field can continuously gather data on soil moisture, nutrient levels, and micro-climatic conditions, enabling the system to update its recommendations dynamically. This real-time feedback loop helps farmers to adapt quickly to changing conditions, optimize resource usage, and minimize input costs, ultimately leading to increased crop yield and profitability.

This report delves into the key components, methodologies, and technologies involved in developing a Crop Recommendation System using Machine Learning and IoT. It also discusses the benefits, challenges, and future scope of such systems, emphasizing their potential to transform traditional farming practices and promote sustainable agriculture on a global scale.

CHAPTER 2

LITERATURE SURVEY

2. LITERATURE SURVEY

2.1-HISTORY

The evolution of Crop Recommendation Systems using Machine Learning (ML) and the Internet of Things (IoT) is rooted in the broader development of precision agriculture, which began gaining momentum in the 1980s. Precision agriculture initially relied on technologies such as Geographic Information Systems (GIS), Global Positioning Systems (GPS), and remote sensing to improve farm management practices by providing spatial data on soil and crop conditions.

The advent of machine learning in agriculture emerged in the late 2000s, with researchers and agronomists recognizing the potential of data analytics and predictive modeling to enhance decision-making processes. Early applications focused on analyzing historical crop yield data, soil health parameters, and climatic conditions to build models that could predict suitable crops for specific regions. The increasing availability of agricultural datasets and advancements in computational power facilitated the development of more sophisticated machine learning algorithms capable of handling large, complex datasets.

Around the same time, IoT technology began to influence agriculture, offering new possibilities for real-time data collection and monitoring. IoT devices, such as soil sensors, weather stations, and drones, provided granular data on soil moisture, temperature, humidity, and nutrient levels. By the mid-2010s, the integration of IoT with machine learning created a new paradigm in smart farming, enabling more accurate and dynamic crop recommendations based on real-time environmental data.

In recent years, the convergence of machine learning and IoT has led to the development of comprehensive Crop Recommendation Systems that are increasingly being adopted in both developed and developing countries. These systems are now being enhanced with cloud computing, big data analytics, and artificial intelligence, further improving their accuracy, scalability, and accessibility. The growing interest in sustainable agriculture and the need to address climate change impacts have accelerated the adoption of these advanced systems, positioning them as vital tools in modern farming practices.

2.2-LITERATURE REVIEW

Crop Recommendation with IOT and ML (IEEE EXPLORE 2023) C. V. Neha Niharika; K. Mothish Kumar; K. Harika; V. Venkatesh; A. Yasmine Begum

The Indian economy heavily depends on agriculture. By recommending a better crop to grow in a certain place, we can increase the production of high-quality yields, but farmers nowadays struggle to choose the crop due to significant climatic and soil condition variations. This project's main objective is to offer the crop that will be most acceptable and suitable given the necessary attributes. The majority of crop losses happen from choosing the wrong crops for a specific area of land. Therefore, we have recommended some fertilization methods that enhance soil nutrient management and boost production.

A Machine Learning-Driven Crop Recommendation System with IoT Integration (IEEE EXPLORE 2024) Al Amin Islam Ridoy; Md. Abu Ismail Siddique; Oishi Joyti

This paper proposes a system that utilizes several types of soil and environmental characteristics to determine the ideal crop for a particular land. Via Internet of Things (IoT) devices, environmental characteristics that include temperature and humidity, as well as soil parameter that is pH will be immediately retrieved from the land, enabling instantaneous data gathering. Using a variety of algorithms, the suggested approach Gaussian Naive Bayes which we got 99.55% validation accuracy, determines which crop would be best for cultivation. Following the integration of the model into an intuitive interface, farmers are provided with a useful tool to improve decision-making and eventually support Bangladeshi agriculture's sustainability.

Design of Crop Recommender System using Machine Learning and IoT (IEEE EXPLORE 2023) Josephine Selle Jeyanathan; B. Veerasamy; B. Medha; G.Tharun Venkata Sai; R.Bharath Kumar; Varsha Sahu

Agriculture is one of the key drivers of Indian economy. The primary problem now confronting Indian farmers is that farmers don't choose the right crop based on their land requirements. A significant decline in production is seen as a result. Precision agriculture will provide the farmers with a solution to this problem. To suggest the optimal crop to farmers based on site-specific criteria, precision agriculture uses research data on soil types, features, and crop yields. With the help of an intelligent system

IoT-Enabled Crop Recommendation in Smart Agriculture Using Machine Learning (IEEE EXPLORE 2023) Gregory Davrazos; Theodor Panagiotakopoulos; Sotiris Kotsiantis; Achilles Kameas

Crop recommendation systems driven by IoT data in smart agriculture is a valuable tool in contemporary farming approaches. Such systems increasingly rely on machine learning techniques to reason over the most suitable crops according to soil, environmental and weather parameters continuously measured by IoT sensors. This paper applies a set of state-of-the-art machine learning models for crop recommendation using an open dataset for multi-class classification. Evaluation results show that Random Forest classifier outperforms all the other models that were employed in our research.

Smart Agriculture System Using IoT and ML (IEEE EXPLORE 2023) R Arthi; S Nishuthan; L Deepak Vignesh

This paper proposes a low-cost system that uses Internet of Things (IoT) and Machine Learning (ML) to maximize crop yield and productivity. The system consists of three key components: an IoT device, a mobile application, and servers. The IoT device uses an expressive System Platform 32(ESP32) microcontroller, a Digital Humidity and Temperature sensor 11 (DHTII) temperature humidity sensor, and a soil moisture sensor to gather data and sends it to the Amazon web services (AWS) IoT via the Message Queuing Telemetry Transport (MQTT) protocol. The IoT device is interfaced with a relay switch to turn ON/OFF water pumps. The mobile application helps us to monitor the temperature, humidity, soil moisture and light intensity in real time.

Crop Recommendation Using Machine Learning (IEEE EXPLORE 2023) Ramachandra A C; Garre Venkata Ankitha; Idupulapati Divya; Parimi Vandana; H S Jagadeesh

One of the key economic drivers in India is agriculture. Farmers now cultivate crops using lessons learned from the previous century. One of the most crucial elements of farm planning is crop selection. Losses are reduced when farmers are well-informed on the crops that will thrive in their soil and climate. Many factors affect crop yield, including specific meteorological conditions and soil characteristics (such as soil N, P, K values, soil moisture, etc.). Various datasets including these traits were gathered and examined. The data analysis process, which evaluates each component of the data using a variety of analyses and logical reasoning, is crucial. Agricultural monitoring and the food business use a variety of models thanks to the development of machine learning algorithms

Crop Recommendation Systems using Machine Learning Algorithms (IEEE EXPLORE 2024) Gokila Brindha P; ReenaSri S; Dhanushree U; Sivadhanu K

Agriculture is the foundation of all the countries. Due to the decreased size of a farming parkland, it has become a most important issue in picking the maximum fitting crop based on current factors in a particular field. The difficulty of young farmers in India to estimate the ideal crop based on their needs is one of the most significant problems they face. This problem arises due to the ecological factors like rainfall, humidity, temperature etc. Machine learning (ML) a branch of AI enables computer to be trained based on the experience being clearly programmed. The goal of ML is to create computer programmers so as to access the data and exploit it to learn for themselves. The crop recommender assistant will suggest the proper crop considering the parameters such as NPK nutrients, humidity, temperature along with pH values with the assistance of Machine Learning algorithms.

Appropriate Crop Recommended System for Cultivation using IoT and ML (IEEE EXPLORE 2024) Abdul Kayum; Mohammad Osiur Rahman

Agriculture is the backbone of any country's eco-nomic growth. Agriculture is also essential for achieving both sustainable development and food security. Smart farming uses Internet of Things (IoT) technologies extensively. IoT is currently utilized to improve soil fertility, recommend crops, monitor crops, and improve seed germination. This research mainly focuses on determining crop selection using IoT and machine learning-based crop recommendation systems. Firstly, IoT sensors collect Realtime data on soil temperature, humidity, and moisture levels. Then use various ML algorithms, such as Decision Tree, Random Forest, Bagging Classifier, Extra Trees Classifier, Naive Bayes, and K-Nearest Neighbor, to analyze the data and provide accurate crop recommendations.

A Crop Recommendation System Based on Nutrients and Environmental Factors Using Machine Learning Models and IoT (IEEE EXPLORE 2023) Anishka Chauhan; Anuraag Tsunduru; Kishwar Parveen; Srilatha Tokala; Koduru Hajarathaiah

With the ever-increasing population of the world, enough crop production is the biggest concern for the human race. This issue is more pressing than ever as the world population has surpassed the 8 billion mark. Smart farming has become a popular option as it solves the problem by suggesting ways to increase the quality and quantity of crop yield. It is a term associated with the practice of automating farm-related activities. This paper proposes a crop recommendation system based on machine learning algorithms for agricultural fields in India.

A sensor system is also prepared to collect first-hand data from fields.

Smart Farming System using NPK Sensor (IEEE EXPLORE 2023) Bharadwaj Cheruvu; S. Bhargavi Latha; Mada Nikhil; Hitesh Mahajan; Kongari Prashanth

The human population is only growing, and certain steps are to be implemented to meet the future requirements with respect to food. This paper discusses the implementation of a smart farm using Internet of Thing. IoT has led to a faster form of gathering data and inferring from our surroundings. A farmer, with the help of this smart farm system, will be able to keep track of plant and soil vitals in real-time and use the recommendation system, based on a model trained from a dataset, to suggest the best suitable crop based on sensor values. IoT-enabled Smart Farming will enable growers and farmers to enhance productivity and reduce the wastage of resources. The proposed system is a more reliable concept and can be easily implemented as it consists of sensors that can collect vital information about the environment from soil nutrients, temperature, humidity, and soil moisture regularly which is displayed on an easy-to-understand interface to be interpreted by the growers and farmers to understand the best conditions to give their plants.

CHAPTER 3

PROBLEM STATEMENT

3. PROBLEM STATEMENT

Agricultural productivity is highly dependent on selecting the right crops based on various environmental, soil, and weather conditions. Traditional farming methods often rely on farmers' experience and intuition, which may not be accurate in dynamically changing climatic conditions. Inconsistent crop selection can lead to reduced yield, increased use of fertilizers and pesticides, depletion of soil nutrients, and economic losses for farmers. To address these challenges, a more precise and data-driven approach is required.

The goal is to develop a Crop Recommendation System that integrates Machine Learning (ML) algorithms and Internet of Things (IoT) technologies to provide farmers with precise recommendations for crop cultivation. The system will use real-time and historical data to analyze and predict the most suitable crops to plant in a particular region, aiming to maximize yield, optimize resource use, and ensure sustainable farming practices.

1. IoT Sensors Data Collection:

- Deploy IoT sensors in the field to collect real-time data on soil properties (such as pH level, moisture, temperature, and nutrient content), weather conditions (temperature, humidity, rainfall, etc.), and other environmental factors.

2. Data Integration and Preprocessing:

- Integrate real-time data from IoT sensors with historical agricultural data such as soil type, PH level, moisture, temperature, humidity, and rain-fall.
- Perform data cleaning, normalization, and feature engineering to prepare the dataset for machine learning model training.

3. Machine Learning Model Development:

- Develop and train machine learning models (e.g., Random Forest, Decision Trees) using the integrated dataset to predict the most suitable crops for a given set of environmental and soil conditions.
- Evaluate models based on metrics like accuracy to ensure reliable crop recommendations.

4. Crop Recommendation System Interface:

- Design a user-friendly interface (web-based) that allows farmers to input field-specific parameters and receive crop recommendations.
- Crop Prediction, Crop Recommendation, Weather Forecasting, Fertilizer Recommendation

CHAPTER 4

EXPERIMENTAL SETUP

4. EXPERIMENTAL SETUP

4.1 Hardware Setup

NPK Sensor: It is used to measure the concentration of Nitrogen (N), Phosphorus (P), and Potassium (K) in soil, which are essential nutrients for plant growth. Here's a breakdown of how they work and their significance:

Functionality:

1. **Nitrogen (N):** Essential for leaf growth and green coloration. The sensor detects the availability of nitrogen in the soil.
2. **Phosphorus (P):** Critical for root development and flowering. The sensor measures phosphorus concentration.
3. **Potassium (K):** Necessary for overall plant health and resistance to diseases. The sensor tracks potassium levels.

Use in IoT Projects:

1. **Real-time Soil Analysis:** Data from NPK sensors is transmitted via IoT devices to a cloud platform, providing farmers with real-time information on soil nutrient levels.
2. **Automated Fertilization:** Based on sensor readings, automated irrigation systems can adjust the delivery of fertilizers to ensure optimal nutrient levels.
3. **Precision Agriculture:** NPK sensors allow for precise nutrient management, improving crop yield and reducing waste.

DHT11: It is a popular temperature and humidity sensor widely used in IoT and embedded projects due to its affordability and ease of use. Here's key information about it:

Features:

1. Temperature Range: 0°C to 50°C
2. Temperature Accuracy: ±2°C
3. Humidity Range: 20% to 90% RH (Relative Humidity)
4. Humidity Accuracy: ±5% RH
5. Power Supply: 3V to 5.5V
6. Output: Digital signal
7. Sampling Period: 1 reading every 1 second

Advantages:

1. Low cost and widely available.
2. Simple to interface with microcontrollers like Arduino or Raspberry Pi.
3. Provides both temperature and humidity readings in one package.
4. Pre-calibrated, so no additional calibration is needed.

4.2 Software Setup

XAMPP:

1. Version: XAMPP 8.2.12
2. Description: XAMPP is a free and open-source cross-platform web server solution package developed by Apache Friends, consisting mainly of the Apache HTTP Server, MariaDB (MySQL), and interpreters for scripts written in PHP
3. Purpose: Used to set up a local server environment for developing the web application, including PHP scripts for crop recommendation and Python integration.

Python:

1. Version: Python 3.12.6
2. Description: Python is a high-level, interpreted programming language used for a wide range of applications.
3. Purpose: Used to implement the machine learning model for crop prediction and other data processing tasks.

Python Libraries

1. pandas: Used for data manipulation and analysis in Python.
2. NumPy: Provides support for large multi-dimensional arrays and matrices, along with a collection of mathematical functions to operate on these arrays.
3. scikit-learn: Used for machine learning, including the Random Forest Classifier algorithm for training the crop recommendation model.
4. Json: Used to parse the input data from PHP and handle JSON-encoded data.

Web Browser:

1. Browsers: Google Chrome, Mozilla Firefox, or Microsoft Edge
2. Purpose: Used to test and view the web application during development.
3. IDE/Text Editor

Visual Studio Code:

1. Purpose: Used for writing and editing the PHP, HTML, CSS, and Python code.

Bootstrap:

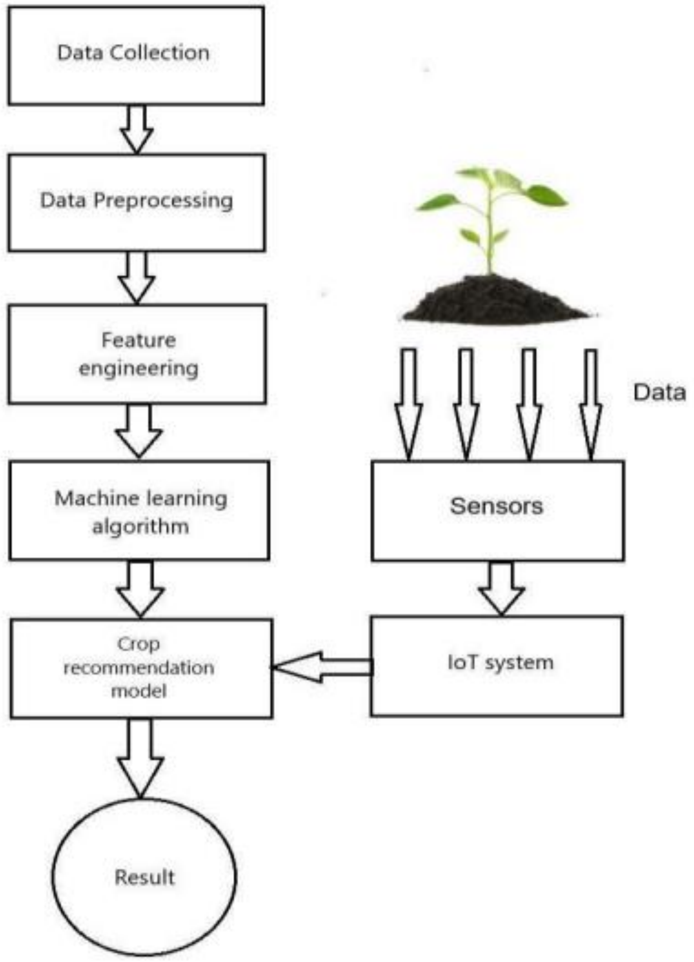
1. Version: Bootstrap 4 or later
2. Purpose: Bootstrap is used for styling the frontend of the web application, ensuring a responsive and mobile-friendly design.

CHAPTER 5

PROPOSED SYSTEM & IMPLEMENTATION

5. PROPOSED SYSTEM & IMPLEMENTATION

5.1 Block diagram of proposed system



5.2 Description of block diagram

- **Data Collection:**
  Sensors, such as temperature, humidity, soil moisture, and pH sensors, collect real-time environmental data from the field. For instance, DHT11 could be used to gather temperature and humidity data. This step is crucial for understanding the environmental conditions affecting crop growth.

- **Data Preprocessing:**
  Raw data from sensors often needs cleaning to remove noise or outliers. Missing values are handled, and data may be normalized or standardized. This ensures that the data is ready for use in machine learning algorithms.

- **Feature Engineering:**
  Key features are extracted or transformed from the preprocessed data to make it more relevant for predicting crop suitability. For example, combining temperature and soil moisture data to derive a "water stress" feature. The goal is to create meaningful inputs for the machine learning algorithm.

- **Machine Learning Algorithm:**
  This stage uses machine learning models (e.g., decision trees, random forest, neural networks) to analyze the data and recognize patterns that impact crop selection. It predicts the crops that are most suitable for the given environmental conditions.

- **Sensors and IoT System:**
  Sensors: Collect real-time data on various environmental factors (temperature, soil moisture, humidity, etc.). IoT System: Connects sensors to a cloud or local database for remote data access. It also facilitates real-time communication between sensors and machine learning models.

- **Crop Recommendation Model:**
  This model takes the machine learning algorithm's output and integrates it with the IoT system to generate crop recommendations. The IoT system ensures that the recommendation is updated as new data comes in.

- **Result:**
  The result is the recommendation of the most suitable crops to plant based on current and predicted environmental conditions. This final output could be displayed on a dashboard or an app for farmers or users.

5.3 Implementation

Figure 5.3.1 Index page

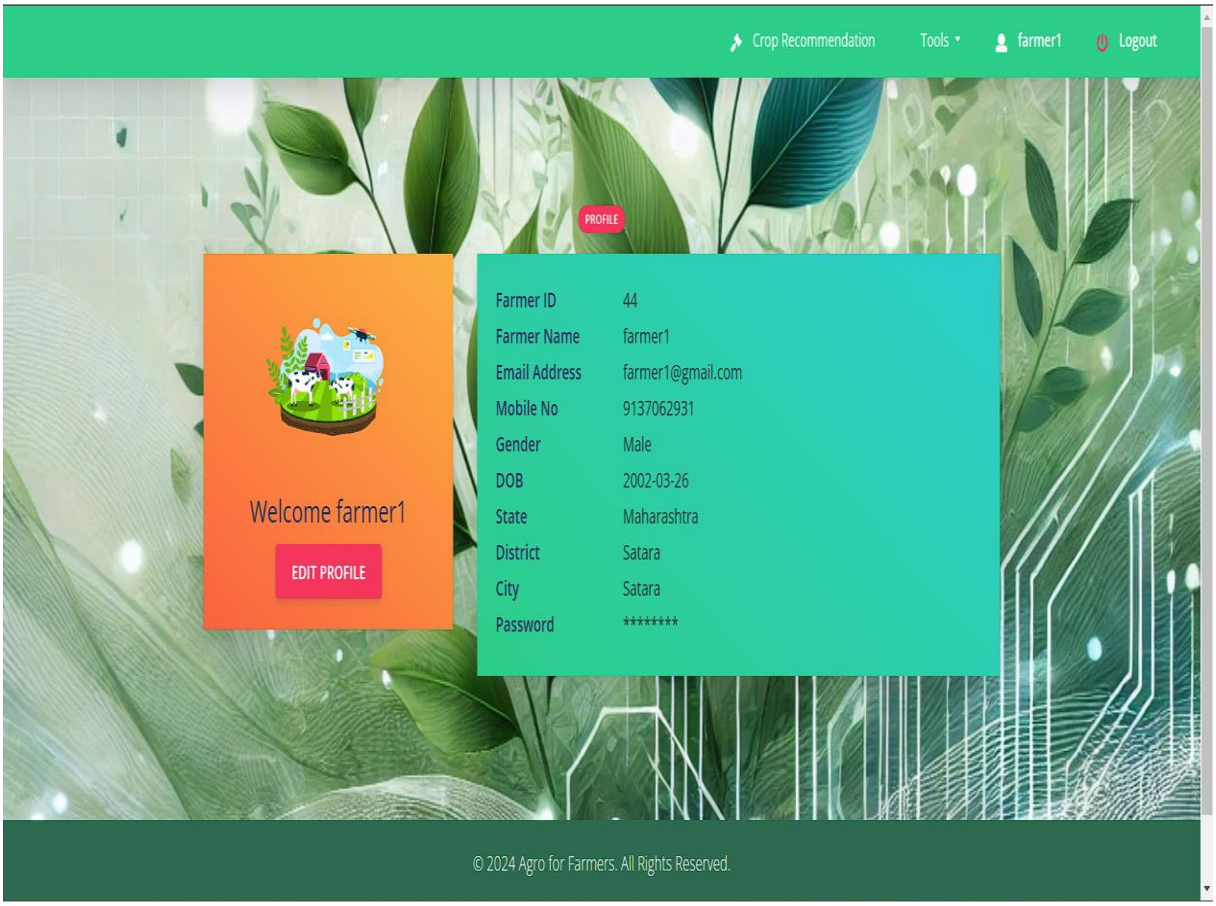


Figure 5.3.2 Farmer profile

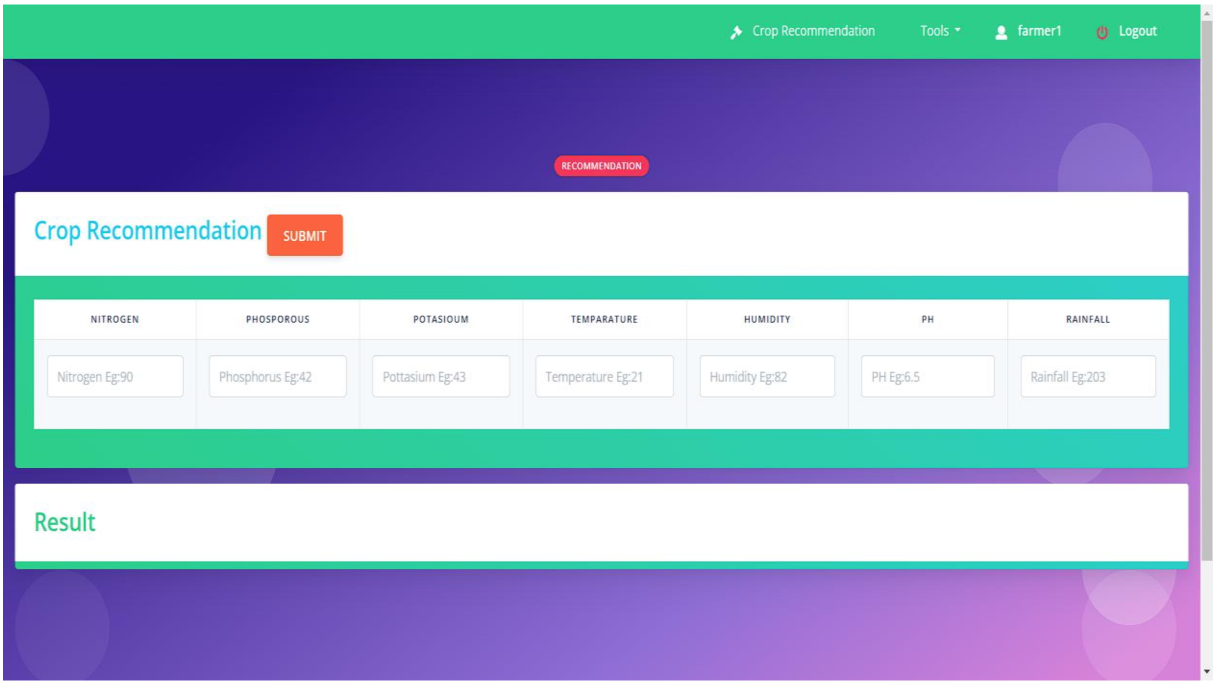


Figure 5.3.3 Crop Recommendation

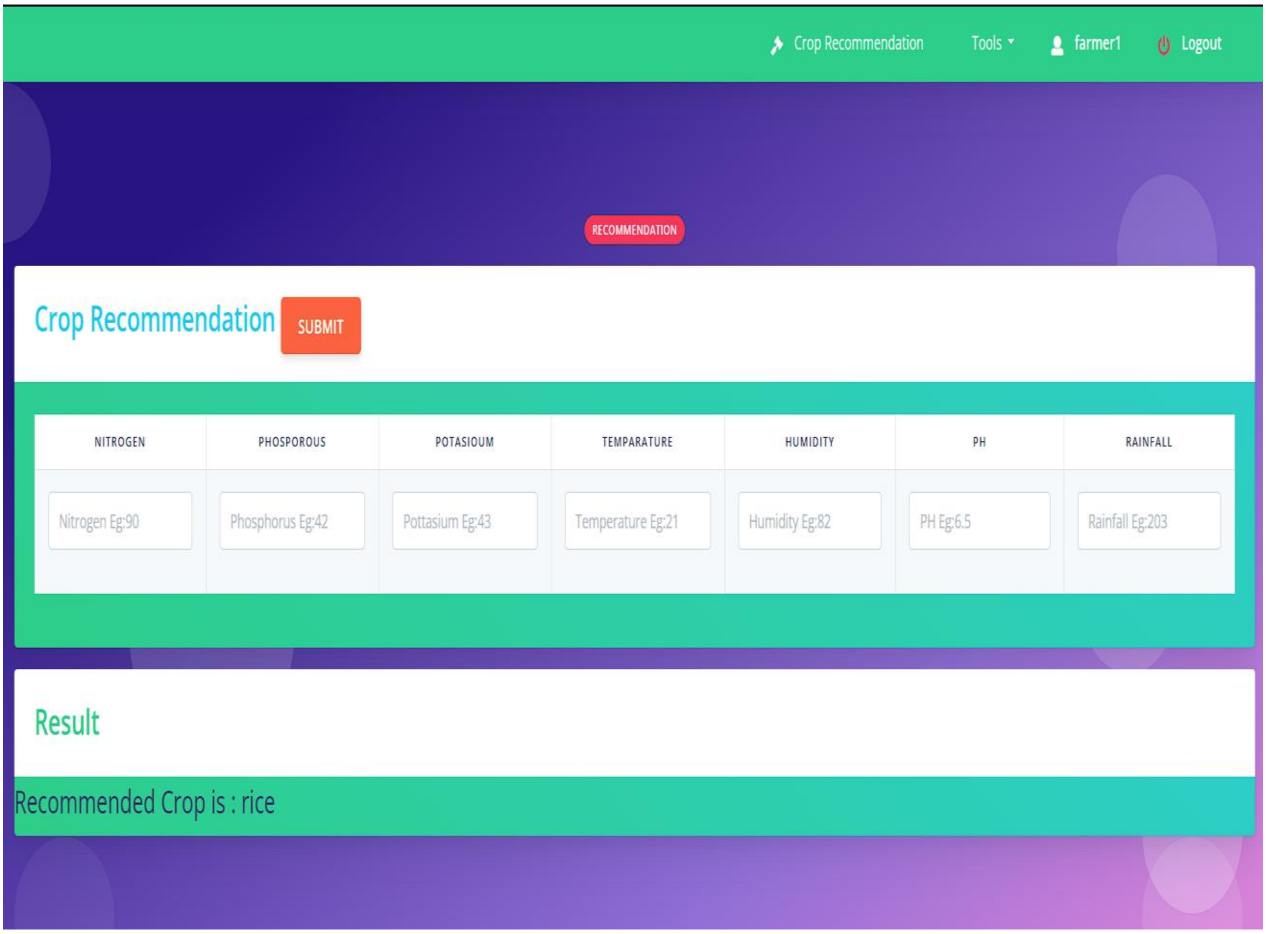


Figure 5.3.4 Recommended Crop

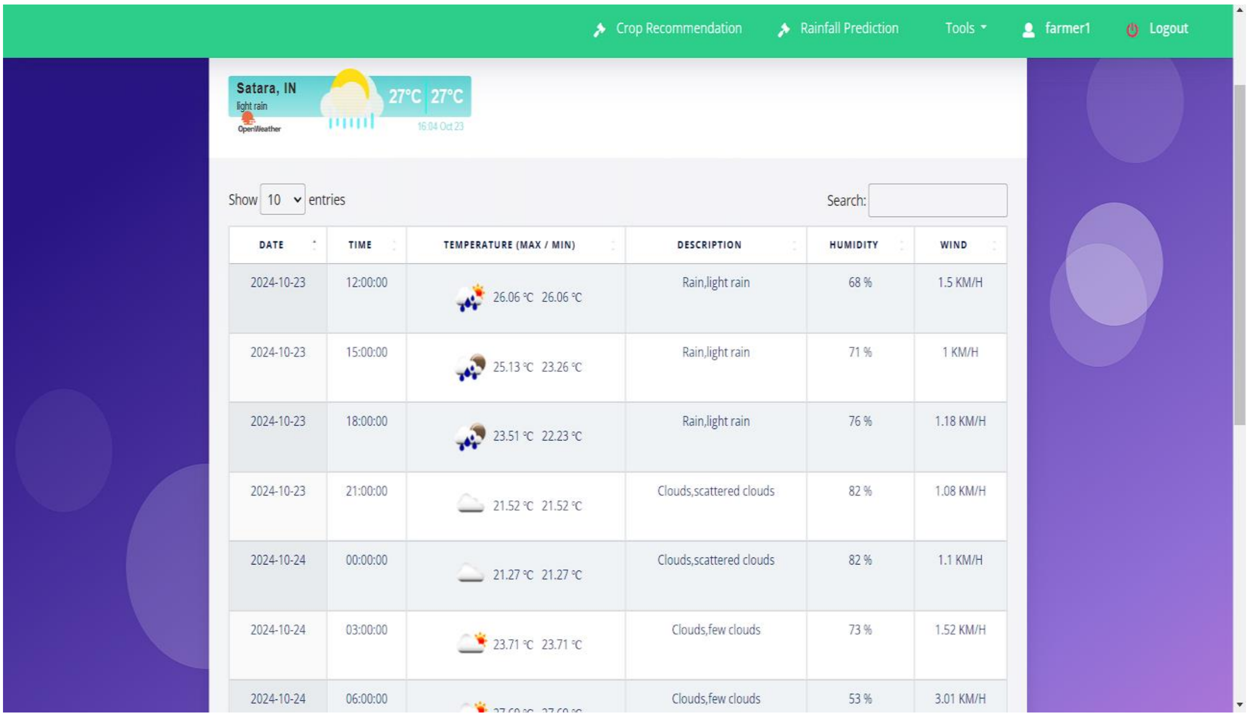


Figure 5.3.5 Weather forecasting

CHAPTER 6

CONCLUSION

6. CONCLUSION

The development of a crop recommendation system using Machine Learning and IoT marks a transformative step in precision agriculture, integrating technology with traditional farming practices to enhance productivity and sustainability. By leveraging real-time data from soil sensors and weather APIs, the system provides tailored crop recommendations based on specific local conditions, helping farmers make informed decisions on crop selection. This data-driven approach reduces risks associated with traditional farming, promotes higher yields, and ensures better resource management. The system's ability to optimize the use of water, fertilizers, and pesticides contributes to cost savings and minimizes environmental impact, addressing critical sustainability concerns. It empowers farmers to adapt to changing climatic conditions and supports biodiversity, making agriculture more resilient to the challenges of climate change. With a user-friendly online platform and scalable architecture, the system is accessible to farmers, offering real-time updates and fostering a collaborative community for knowledge sharing. In conclusion, this innovative crop recommendation system not only enhances agricultural productivity but also empowers farmers to secure their livelihoods and contribute to a more sustainable future. The integration of Machine Learning and IoT in farming practices represents a crucial advancement in the pursuit of smarter, more resilient agriculture.

REFERENCE

Research paper

[1] Crop Recommendation with IOT and ML (IEEE EXPLORE 2023) C. V. Neha Niharika; K. Mothish Kumar; K. Harika; V. Venkatesh; A. Yasmine Begum

[2] A Machine Learning-Driven Crop Recommendation System with IoT Integration (IEEE EXPLORE 2024) Al Amin Islam Ridoy; Md. Abu Ismail Siddique; Oishi Joyti

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[4] IoT-Enabled Crop Recommendation in Smart Agriculture Using Machine Learning (IEEE EXPLORE 2023) Gregory Davrazos; Theodor Panagiotakopoulos; Sotiris Kotsiantis; Achilles Kameas

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[6] Crop Recommendation Using Machine Learning (IEEE EXPLORE 2023) Ramachandra A C; Garre Venkata Ankitha; Idupulapati Divya; Parimi Vandana; H S Jagadeesh

[7] Crop Recommendation Systems using Machine Learning Algorithms (IEEE EXPLORE 2024) Gokila Brindha P; ReenaSri S; Dhanushree U; Sivadhanu K

[8] Appropriate Crop Recommended System for Cultivation using IoT and ML (IEEE EXPLORE 2024) Abdul Kayum; Mohammad Osiur Rahman

[9] A Crop Recommendation System Based on Nutrients and Environmental Factors Using Machine Learning Models and IoT (IEEE EXPLORE 2023) Anishka Chauhan; Anuraag Tsunduru; Kishwar Parveen; Srilatha Tokala; Koduru Hajarathaiah

[10] Smart Farming System using NPK Sensor (IEEE EXPLORE 2023) Bharadwaj Cheruvu; S. Bhargavi Latha; Mada Nikhil; Hitesh Mahajan; Kongari Prashanth

URL: https://www.kaggle.com/datasets/atharvaingle/crop-recommendation-dataset