A Project Report on

Crop Recommendation System Using Machine Learning and Internet of Thing

submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING

In

Computer Science & Engineering Artificial Intelligence & Machine Learning

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CERTIFICATE

This is to certify that the project entitled Crop Recommendation System Using Machine Learning and Internet of Thing 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 fulfilment of the requirement for the award of the degree of **Bachelor of Engineering** in **Computer Science & Engineering (Artificial Intelligence & Machine Learning**).

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Project Report Approval for B.E.

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

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Abstract

The Crop Recommendation System using Machine Learning and Internet of Things (IoT) technology that is designed to assist farmers in taking 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 to 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.

CONTENTS

LIST OF FIGURES

ABBREVAION

AI	*Artificial Intelligence*
ML	*Machine Learning*
IoT	*Internet of Things*
GPS	*Global Positioning System*
GIS	*Geographic Information System*
NPK	*Nitrogen, Phosphorus, Potassium*
ESP32	*Expressif Systems 32-bit microcontroller*
ESP8266	*Expressif Systems Wi-Fi microcontroller*
DHT11	*Digital Humidity and Temperature sensor*
AWS	*Amazon Web Services*
MQTT	*Message Queuing Telemetry Transport*
CNN	*Convolutional Neural Network*
SVM	*Support Vector Machine*
KNN	*K-Nearest Neighbors*
RF	*Random Forest*
LSTM	*Long Short-Term Memory*
XAMPP	*Cross-platform Apache, MySQL, PHP, and Perl*
PHP	*Hypertext Preprocessor*
API	*Application Programming Interface*
SQL	*Structured Query Language*
F1 Score	*Harmonic mean of precision and recall*
UI	*User Interface*

Chapter 1

Introduction

Agriculture has been the backbone of human civilization, providing food security, raw materials, and livelihoods for billions of people worldwide. However, as the global population grows and climate change intensifies, farmers face mounting challenges in sustaining high crop yields while preserving natural resources. Traditional farming practices, often guided by generational knowledge and experience, may not always align with rapidly changing environmental conditions or the evolving needs of modern agriculture. This is where technology can bridge the gap — empowering farmers with data-driven insights to make informed decisions. One such innovation is a Crop Recommendation System using Machine Learning (ML) and the Internet of Things (IoT), which has the potential to revolutionize agriculture by bringing precision, efficiency, and sustainability to the forefront of farming practices

This system is designed to help farmers choose the most suitable crops for their land based on real-time environmental data and historical agricultural patterns. By leveraging machine learning algorithms trained on vast datasets — including soil health parameters, historical crop yields, local weather conditions, and geographical factors — the system can accurately predict the best crops to cultivate in a given region. These models can process complex variables like soil pH, nitrogen-phosphorus-potassium (NPK) levels, temperature, humidity, and rainfall to offer personalized recommendations tailored to the farmer's specific needs. Unlike traditional trial-and-error methods, this approach minimizes risk, conserves resources, and optimizes agricultural output.

The integration of IoT devices enhances the system's capabilities by enabling continuous, real-time data collection and monitoring. In this project, hardware components like the NodeMCU ESP8266, DHT11 sensor (for temperature and humidity), pH sensor, and NPK sensor are used to gather critical soil and environmental data. The sensor readings are sent to a MySQL database in XAMPP via the ESP8266, where they are processed and displayed on a web interface. Additionally, the system uses the Open Weather API to provide live weather forecasting, while a trained machine learning model predicts rainfall in millimeters — a crucial parameter for crop recommendation. By combining sensor data with real-time weather insights, the system can dynamically adjust its recommendations, helping farmers make informed decisions based on changing conditions.

The project also features a user-friendly web interface designed to streamline farmer interactions with the system. After logging in through a secure admin page, farmers can access a navigation bar with key functionalities such as Crop Recommendation, Rainfall Prediction, Weather Forecasting, and Sensor Values. This intuitive design allows users to view live sensor data, get weather updates, and receive crop recommendations all in one place, making advanced agricultural insights accessible even to those with minimal technical knowledge.

This report delves into the core components, methodologies, and technologies involved in developing the Crop Recommendation System using ML and IoT. It explores the entire workflow — from hardware setup and sensor integration to model training and web interface development. The report also highlights the system's broader impact, emphasizing its potential to enhance food security, promote sustainable farming, and support smallholder farmers by reducing guesswork and empowering them with data-driven decision-making tools.

By combining the analytical power of machine learning with the real-time responsiveness of IoT, this system has the potential to transform traditional farming practices and pave the way for a smarter, more resilient agricultural future. It represents a step towards a world where technology and nature work in harmony — where farmers can make decisions with confidence, maximize their yields, and contribute to a more sustainable planet for future generations.

Chapter 2

Literature Survey/ Existing system

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 and positioning them as vital tools in modern farming practices.

LITERATURE REVIEW

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[1].

A. A. Islam Ridoy and other proposed 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[2].

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[3].

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[4].

G. B. P and other proposed 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[5].

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[6].

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 which 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[7].

Agriculture is the backbone of any country's economic 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[8].

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[9].

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[10].

The IoT advancements have majorly influenced in redefining the agricultural field. A reliable remote monitoring system is the need of the hour. In this paper, two objectives are addressed. Firstly an app based solution is presented which helps in displaying the current sensor values that efficiently aid in remotely administrating the field. Secondly an IoT based prototype system for surveillance is proposed that embeds the concept of multi-class classification technique using Machine and Deep Learning for the labels clear farm, horse, cow, wild elephant and wild boar. Support Vector Machines (SVM) and Convolutional Neural Networks (CNN) were analysed for this purpose and the best model was chosen based on accuracy metric[11].

To define the term “smart farming,” this work has used real-time applications over sensors to capture changes in the soil's and the atmosphere's climate. The type of crop being grown is predicted based on weather patterns, soil moisture, nitrogen, phosphorus, potassium, and ph levels, as well as making sure that the farmers are growing the right crops to ensure optimal yield and profits. In this paper, An hardware system using Nodemcu is developed to measure the vitals and is monitored on Thinkspeak and as a result of combining Random Forest, K-Nearest Neighbor, and Logistic Regression, we developed a model that uses many variables to forecast the sort of crop being grown like element levels (Nitrogen, Phosphorus, and Potassium), PH levels, temperature, humidity, and land type, and deployed the best model to a web app using streamlit for real-time usage, the measured vitals from the thinkspeak are manually inputted on the web app and the suitable crop is predicted thus ensuring that the farmer is cultivating the correct crops for maximum profits and the best yield possible. With a validation accuracy of 99.5%, an F1 score of 1.00, and the ability to forecast values that are closer to the real values than other models based on the findings, after comparing the three models the Random Forest ensemble reached the best level[12].

Smart farming allows to analyze the growth of plants and to influence the parameters of our system in real time in order to optimize plant growth and support the farmer in his activity. Internet of Things (IoT) arrangements, based on the application particular sensors data measurements and intelligent processing, are bridging the holes between the cyber and physical worlds. In this paper, we propose the design and the experiment of a smart farming system based on an intelligent platform which enables prediction capabilities using artificial intelligence (AI) techniques. This system is based on the technology of wireless sensor networks and its implementation requires three main phases, i) data collection phase using sensors deployed in an agricultural field, ii) data cleaning and storage phase, and iii) predictive processing using some AI methods[13].

Agriculture balances both food requirement for mankind and supplies indispensable raw materials for many industries, and it is the most significant and fundamental occupation in India. The advancement in inventive farming techniques is gradually enhancing the crop yield making it more profitable and reduce irrigation wastages. The proposed model is a smart irrigation system which predicts the water requirement for a crop, using machine learning algorithm. Moisture, temperature and humidity are the three most essential parameters to determine the quantity of water required in any agriculture field. This system comprises of temperature, humidity and moisture sensor, deployed in an agricultural field, sends data through a microprocessor, developing an IoT device with cloud. Decision tree algorithm, an efficient machine learning algorithm is applied on the data sensed from the field in to predict results efficiently. The results obtained through decision tree algorithm is sent through a mail alert to the farmers, which helps in decision making regarding water supply in advance[14].

Agriculture is a key component of a nation's economy. In the traditional method, farmers rely on experience to determine the ideal climate and environment for a given crop. Technology is advancing, and while the system depends on it to some extent, improvements are still required. This study presents an Internet of Things (IoT) based crop recommendation system that uses Machine learning (ML) to use the value that IoT devices collect from the soil. Initially, we utilized baseline ML classifier models like Support vector machine (SVM), K-Nearest Neighbor(KNN), Random forest (RF), and Random forest (NB).Then we employed an ensemble model to detect the suitable crops. We employed several IoT sensors in our research. The DHT11 sensor collects real-time environmental data, such as temperature and humidity. During crop recording, vital soil parameters like potassium and phosphorus—which are essential for crop growth—are measured using an NPK sensor, a pH sensor, and a rain sensor. These sensors can be seamlessly integrated by the IoT device, offering an effective way to collect crucial agricultural data. The Voting Base Ensemble performs exceptionally well in terms of precision, recall, and F1 score measures. The voting Base Ensemble algorithm improves metrics such as F-score, recall, and precision by up to 98%[15].

Chapter 3

Limitations of Existing system

Despite the remarkable progress in crop recommendation systems powered by IoT and machine learning, several limitations persist, as observed across multiple research studies. These limitations can hinder system effectiveness, accuracy, and real-world applicability, especially in diverse agricultural landscapes. One key issue lies in the reliance on static and incomplete datasets, as seen in studies like [1], [6], and [7]. Many systems depend on historical data without accounting for dynamic environmental changes, making it difficult to adapt to sudden shifts like unexpected rainfall or temperature spikes.

While some research ([3], [5], [10]) integrates IoT sensors, real-time sensing capabilities are often limited. Critical factors like micro-nutrient levels may go unmeasured, and the absence of continuous updates can lead to outdated recommendations. Connectivity constraints also pose a significant barrier, with studies like [2] and [8] highlighting the dependence on cloud services for data analysis and weather forecasts. This reliance becomes problematic in remote areas where internet access is intermittent or unavailable.

Furthermore, several works ([4], [9]) fail to account for localized variability, generalizing recommendations without considering microclimate factors or site-specific soil characteristics. This lack of precision can lead to sub-optimal crop choices, particularly for smaller, fragmented farms. Economic considerations are another overlooked aspect. Studies

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like [1] and [6] prioritize maximizing yields but ignore market dynamics, crop demand, and cultivation costs factors that directly impact farmers' financial viability.

Hardware limitations add another layer of complexity. IoT devices, as described in [5] and [10], often require constant power and regular maintenance, which may not be feasible for small-scale farmers with limited resources. Compounding this challenge, research like [3] and [7] reveals that many systems feature complex user interfaces, making it difficult for farmers to interpret data or navigate technical dashboards without additional training.

Finally, some models ([2], [4]) are trained on limited crop datasets, resulting in biased recommendations that may not generalize well to regions with diverse agricultural practices. This model bias, combined with the other limitations, underscores the need for continuous improvements. Addressing these challenges involves enhancing sensor capabilities, developing offline-compatible systems, designing intuitive interfaces, and expanding training datasets. By doing so, future crop recommendation systems can become more accurate, accessible, and truly trans formative for sustainable agriculture.

Chapter 4

Problem Statement and Objective

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.

- **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.

- **Data Integration and Pre-processing:**

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.

- **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.

- **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 5

Proposed System

A Crop Recommendation System using Machine Learning (ML) and Internet of Things (IoT) is a modern solution designed to help farmers make smarter, data-driven decisions about which crops to grow. By utilizing IoT sensors placed in the field, the system collects real-time data on environmental factors such as soil moisture, temperature, pH levels, and weather conditions. This data is then sent to a cloud platform where machine learning algorithms process it and compare it with historical data to predict the most suitable crops for the given conditions. The system not only suggests the best crop choices but also considers local factors, such as seasonal weather patterns and soil quality, helping farmers optimize yield and reduce resource wastage. This technology empowers farmers to adapt to changing climates, improve productivity, and make informed decisions about planting, irrigation, and crop management. Ultimately, it aims to support sustainable farming practices and improve food security by providing tailored recommendations that fit the unique needs of each farm.

5.1 Block diagram:

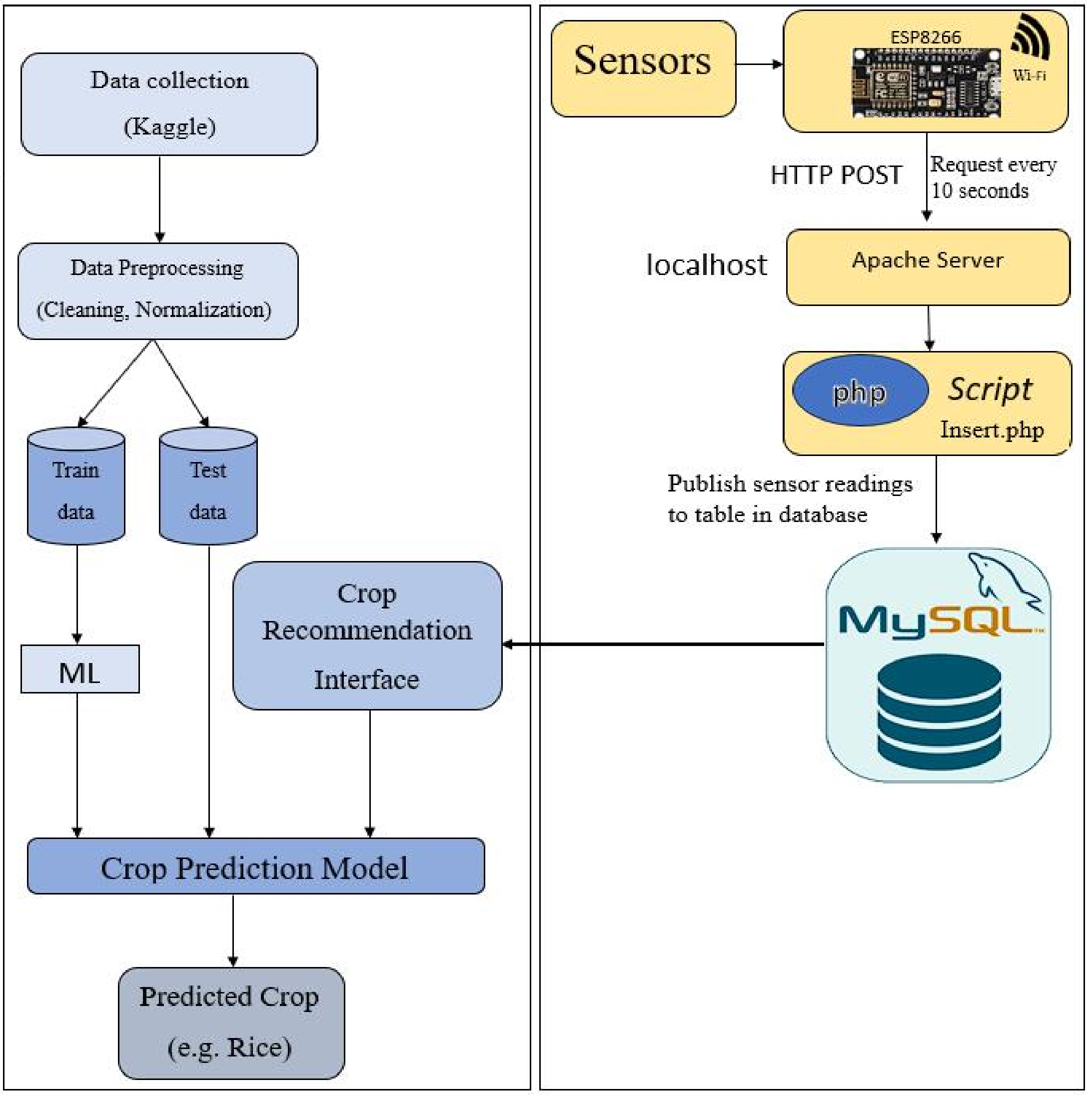

Fig 5.1 Block Diagram

Description of Block Diagram:

1. Data Collection

The system begins with the collection of agricultural datasets, primarily sourced from Kaggle. These datasets contain crucial agricultural parameters such as nitrogen , potassium , phosphorus, temperature, humidity, pH level, rainfall. Accurate and diverse data is essential to ensure the machine learning model can learn and generalize well across different environmental conditions.

2. Data Preprocessing

Once the raw data is collected, it undergoes preprocessing to ensure it is clean and ready for training. Preprocessing includes data cleaning, where missing or inconsistent values are handled, and normalization, where data is scaled to bring all features to a uniform range. These steps help improve the model's performance and ensure it can process different datasets efficiently without being biased toward larger numerical values. Proper preprocessing is crucial to avoiding erroneous predictions and enhancing the accuracy of the crop recommendation system.

3. Machine Learning Model

After preprocessing, the refined dataset is split into two parts: training data and test data. The training data is used to teach the machine learning model how various environmental factors influence crop suitability. The test data is then used to evaluate the model's accuracy . The goal is to develop a robust model that can accurately predict the best crop based on real-time input parameters.

4. Crop Recommendation Model

The trained machine learning model is then transformed into a crop recommendation model. This model takes user input (such as nitrogen, phosphorous, potassium, pH, temperature, and rainfall) and processes it using the trained ML model to generate a predicted crop recommendation. For example, if the environmental parameters match the optimal conditions for rice, the model will suggest rice as the most suitable crop. The system continuously updates and improves its predictions based on newly collected data, making it more adaptive to changing agricultural conditions.

5. Crop Recommendation Interface

The interface acts as the bridge between the user and the prediction model. It allows farmers to input environmental conditions and receive real-time recommendations. This interface is a web application . The interface ensures ease of access and provides a user-friendly experience, allowing farmers to make informed decisions without requiring technical expertise.

6. Sensors for Real-Time Data Collection

To enhance the accuracy of the system, IoT-based sensors are deployed in agricultural fields to collect real-time environmental data. These sensors measure crucial parameters such as temperature, humidity, nitrogen, phosphorous, potassium, and pH levels. The collected data is then transmitted to the system every 10 seconds to ensure the most up-to-date information is used for crop recommendation. The integration of IoT with machine learning allows the system to dynamically adjust crop recommendations based on changing field conditions, improving precision in agricultural planning.

7. ESP8266 Wi-Fi Module

The ESP8266 microcontroller is used to transmit sensor data to a central server. This module connects to the internet via Wi-Fi and sends sensor readings using HTTP POST requests to the server every 10 seconds. The ESP8266 ensures that data is continuously relayed from the sensors to the system, enabling real-time monitoring of environmental conditions. Its low cost and energy efficiency make it an ideal choice for agricultural IoT applications.

8. Apache Server

The Apache server acts as the intermediary between the ESP8266 and the database. It is hosted on a localhost machine and handles incoming sensor data through HTTP requests. Apache ensures that data is properly received, processed, and forwarded to the MySQL database for storage. This server is essential for managing multiple sensor inputs efficiently and ensuring seamless communication between the hardware and software components of the system.

9. PHP Script (Insert.php)

A PHP script (Insert.php) is responsible for inserting the data into the MySQL database. When the Apache server receives sensor readings, it passes them to this PHP script, which formats the data appropriately and updates the database in real time. The script ensures that the database is continuously updated with the latest environmental conditions, allowing the crop recommendation model to make accurate predictions based on fresh data.

10. MySQL Database

The MySQL database stores all collected environmental data and maintains historical records of sensor readings. This allows for long-term analysis and model improvement over time.The database structure is optimized for quick data retrieval, ensuring that sensor data is instantly accessible when needed for prediction.

5.2 FlowChart:

5.2.1 Home Page

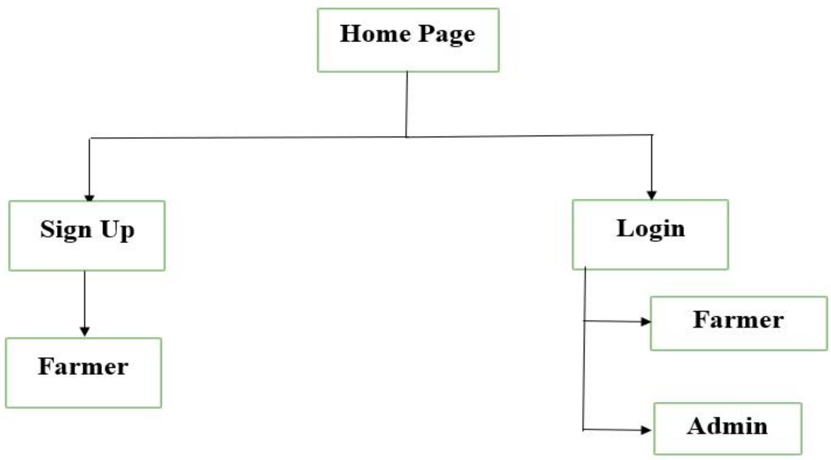

Fig 5.2.1 Flowchart of Home Page

The diagram above illustrates the user access flow for the smart agricultural platform, providing a streamlined experience for both farmers and administrators. The system prioritizes user differentiation, ensuring that each type of user accesses relevant features and modules only.

◆ **Home Page**

The Home Page serves as the primary gateway into the system. It presents two main navigation options:

- Sign Up (for new users)

- Login (for existing users)

This approach ensures clarity and simplicity, allowing users to immediately identify the appropriate action based on their access status.

◆ **Sign Up Process**

1. Purpose: Enables new farmers to register into the smart agriculture platform.

2. User-Friendly Interface: Simple, clean layout with clearly labeled input fields for ease of use.

■ Mandatory Fields Include:

- Farmer Name
- Email Address
- Mobile Number
- Password
- State, District, and City (for location-based services)

■ Additional Details Collected:

- Gender selection via dropdown.
- Date of Birth (DOB) using a date picker input.

5. Location Selection: State and District dropdowns to fetch location-specific agricultural data. Helps in accurate rainfall prediction and crop suggestions.

6. Password Field: Secured and masked password input to maintain user privacy.

7. Validation and Error Handling: Ensures all mandatory fields are filled correctly before submission.

8. Registration Button: A "Register" button submits the form and saves the farmer's data into the system.

9. Navigation Links: Located at the top right, users can easily navigate to Sign Up or Login pages.

◆ **Login Process**

The Login function serves as the main entry point for both Farmers and Admins. Upon selecting the Login option, users are prompted to enter their username and password. Based on the credentials entered, the system performs a role check: If the credentials match a farmer account, the user is redirected to the Farmer Interface. If the credentials belong to an admin, the user is directed to the Admin Dashboard. This role-based routing is essential for security and functional segregation.

◆ **Role-Specific Access**

■ **Farmer Role**

- Once logged in, farmers gain access to:
- Crop recommendation module
- Weather forecasting and rainfall estimation
- Sensor data readings
- Profile management

■ **Admin Role**

- Admins have extended control over:
- User management (e.g., view/delete users)

This ensures that administrative tasks are separated from field-level operations, maintaining a clean separation of concerns within the system.

5.2.2 Farmer Module:

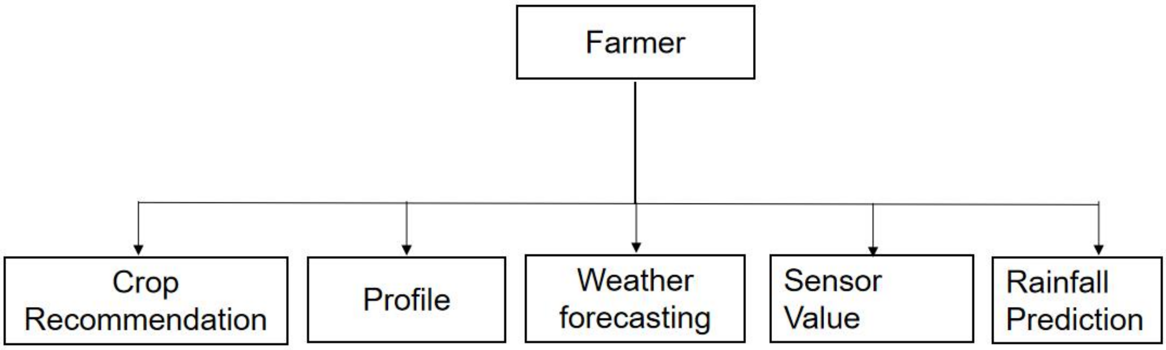

Fig.5.2.2 Flowchart of Farmer Module

The diagram represents a high-level functional structure where the farmer is at the center of a smart agricultural ecosystem, empowered by various intelligent modules. These modules serve distinct yet interconnected purposes to improve decision-making and enhance agricultural productivity through the use of real-time data, machine learning models, and environmental insights. The five main components accessible to the farmer include: Crop Recommendation, Profile Management, Weather Forecasting, Sensor Value Monitoring, and Rainfall Prediction.

- **Crop Recommendation System**

This module is at the core of modern precision agriculture. Based on the input parameters such as soil nutrients pH, temperature, humidity, rainfall, and soil type, the system applies a machine learning model trained on historical agricultural data to suggest the most suitable crop for cultivation. The data can either be entered manually by the farmer or fetched in real-time from sensors deployed in the field.

The goal is to maximize yield and resource efficiency by recommending crops that are best suited to current environmental and soil conditions. By minimizing guesswork, this system supports sustainable agriculture and improves profitability.

- **Farmer Profile Managemen**

The profile section maintains a detailed record of each farmer's data, such as:

- Name
- Contact Information
- Email Address
- Age
- Location

This module serves as a personalized dashboard for farmers, allowing the system to tailor its outputs. Over time, this data also becomes invaluable for improving recommendation accuracy and tracking the impact of AI-assisted decisions.

◆ **Weather Forecasting Integration**

Weather is one of the most critical and uncontrollable variables in agriculture. This module provides real-time and predictive weather information, such as:

- Temperature trends
- Rainfall estimates
- Wind speed and direction
- Humidity levels
- Forecast for next 7–14 days

This information enables farmers to make informed decisions on irrigation schedules, pest control, sowing and harvesting timings. The system may use APIs like OpenWeatherMap or government meteorological databases to fetch data automatically and integrate it within the dashboard.

◆ **Sensor Value Monitoring**

Incorporating IoT (Internet of Things), sensors are installed in the field to capture real-time values such as:

- Temperature
- Humidity
- pH level

These values are transmitted via microcontrollers like ESP8266 to a local server (e.g., Apache) and stored in a database (e.g., MySQL). This data is then processed and visualized for the farmer to monitor environmental conditions, detect anomalies, and trigger automated actions (like turning on irrigation pumps).

◆ **Rainfall Prediction**

Unlike other modules that use machine learning, the rainfall prediction module is based on statistical averaging of historical data sourced from Kaggle datasets. The system calculates the average rainfall values (measured in millimeters) for specific months, seasons, or locations.

This average value is then presented to the farmer as a rough estimate of expected rainfall. While it doesn't involve predictive modeling, it still provides a valuable reference for planning irrigation or determining whether conditions are suitable for planting water-dependent crops. Since it’s grounded in real recorded data, it maintains practical relevance for field decision-making.

Chapter 6

Experimental Setup

6.1 Details of Database and Input to the System

The system utilizes two primary databases: agriculture_portal and weather. These databases store essential data for crop recommendation, weather forecasting, and sensor readings. Below are the detailed structures and purposes of each table.

Tables in the Agriculture Portal Database:

1. admin: Stores admin credentials for managing farmer access.
   - id (INT, PRIMARY KEY)
   - username (VARCHAR)
   - password (VARCHAR)
2. district: Contains district-wise data to tailor recommendations regionally.
   - district_id (INT, PRIMARY KEY)
   - district_name (VARCHAR)
   - state_id (INT, FOREIGN KEY)
3. farmerlogin: Manages farmer login credentials and access.
   - farmer_id (INT, PRIMARY KEY)
   - username (VARCHAR)
   - password (VARCHAR)

- email (VARCHAR)
- phone (VARCHAR)

4. state: Stores state information for location-based insights.
   - state_id (INT, PRIMARY KEY)
   - state_name (VARCHAR)

Tables in the Weather Database:

1. sensor_readings: Stores real-time sensor data.
   - id (INT, PRIMARY KEY)
   - temp (FLOAT) - Temperature reading (in °C)
   - humi (FLOAT) - Humidity percentage
   - ph (FLOAT) - Soil pH value
   - rainfall (FLOAT) - Rainfall in mm
   - time (TIMESTAMP)

This setup enables real-time data collection from sensors connected via NodeMCU ESP8266, sending values to the MySQL database hosted on XAMPP.

6.2 System Performance Evaluation

The crop recommendation system's performance is evaluated using a combination of classification and regression metrics, depending on the functionality (crop recommendation or rainfall prediction). The evaluation is divided into two aspects: crop recommendation accuracy and rainfall prediction reliability.

Crop Recommendation Model Evaluation:

1. **Accuracy:** Measures the percentage of correctly recommended crops based on environmental parameters (temperature, humidity, pH, rainfall).
2. **Precision:** Evaluates how many of the crops predicted as suitable are actually correct.
3. **Recall:** Measures the system's ability to recommend all relevant suitable crops.
4. **F1-Score:** A balanced metric that combines precision and recall.
5. **Confusion Matrix:** Visualizes the model's prediction results.

System Efficiency Evaluation:

1. **Response Time:** The time taken to fetch sensor data, process it, and generate recommendations.
2. **Database Query Performance:** Speed and efficiency of reading/writing sensor data and retrieving historical weather data.

6.3 Software and Hardware Setup

Software Setup

1. **XAMPP(v8.2.12):**
   XAMPP is used to set up a local server environment. It includes Apache for handling HTTP requests, MySQL for managing the system's databases, and PHP to connect the web interface with backend services. The MySQL database stores sensor readings, user information, and historical weather data for training the machine learning models. XAMPP's control panel allows easy management of server components, simplifying development and testing.
2. **Python(v3.12.6):**
   Python serves as the backbone for machine learning and data processing tasks. It processes sensor data, applies machine learning models for crop recommendation and rainfall prediction, and returns insights to the web interface. The language's rich ecosystem of libraries enables complex computations and rapid prototyping.
3. **Key Python Libraries:**

- **Pandas:** For data manipulation and cleaning.
- **NumPy:** For numerical computing and handling sensor data arrays.
- **Scikit-learn:** For building and training machine learning models.
- **Matplotlib/Seaborn:** For visualizing data and model performance metrics.
- **Flask:** For creating API endpoints to connect Python scripts with PHP.
- **PyMySQL:** For connecting Python scripts to the MySQL database.

4. **Visual Studio Code (VSCode):**
   A lightweight and powerful code editor used for developing Python scripts, PHP files, and frontend components. The editor's extensions for Python, PHP, and MySQL integration enhance productivity and help debug the system smoothly.

5. **Bootstrap4+:**
   Bootstrap powers the system’s responsive web design, making the portal accessible across various devices. It provides pre-built components for navigation, forms, and tables, accelerating frontend development while ensuring a clean, modern UI.
6. **OpenWeatherAPI:**
   This API fetches real-time weather data (e.g., temperature, humidity, wind speed) based on the farmer’s location. The data is stored in the weather database and used as an input feature for the crop recommendation system, enhancing the model's accuracy by incorporating dynamic environmental factors.
7. **ArduinoIDE:**
   The Arduino IDE is used to write and upload firmware to the NodeMCU ESP8266 microcontroller. It facilitates sensor integration and real-time data transmission to the MySQL database, bridging the hardware and software components.

Hardware Setup

1. **NodeMCUESP8266:**
   A low-cost Wi-Fi microcontroller that gathers real-time data from connected sensors and transmits it to the MySQL database via HTTP requests. It acts as the core hardware unit, enabling IoT-based monitoring of environmental parameters.

2. **DHT11 Sensor (Temperature and Humidity):**
   This sensor measures temperature and humidity, critical factors for crop growth. The readings are sent to the database at regular intervals, providing dynamic inputs for the crop recommendation algorithm.

3. **PE03 pH Electrode:**
   The pH sensor measures soil acidity/alkalinity. The pH value directly influences nutrient availability and crop suitability, making this data vital for personalized recommendations.

4. **Breadboard and Jumper Wires:**
   Essential for prototyping and connecting sensors to the NodeMCU. The breadboard allows for easy experimentation and modification of the circuit layout without soldering.

5. **Power Supply (5V):**
   A reliable power source for the NodeMCU and sensors, ensuring continuous data collection and transmission.

6.4 IoT Circuit Diagram for Crop Recommendation System

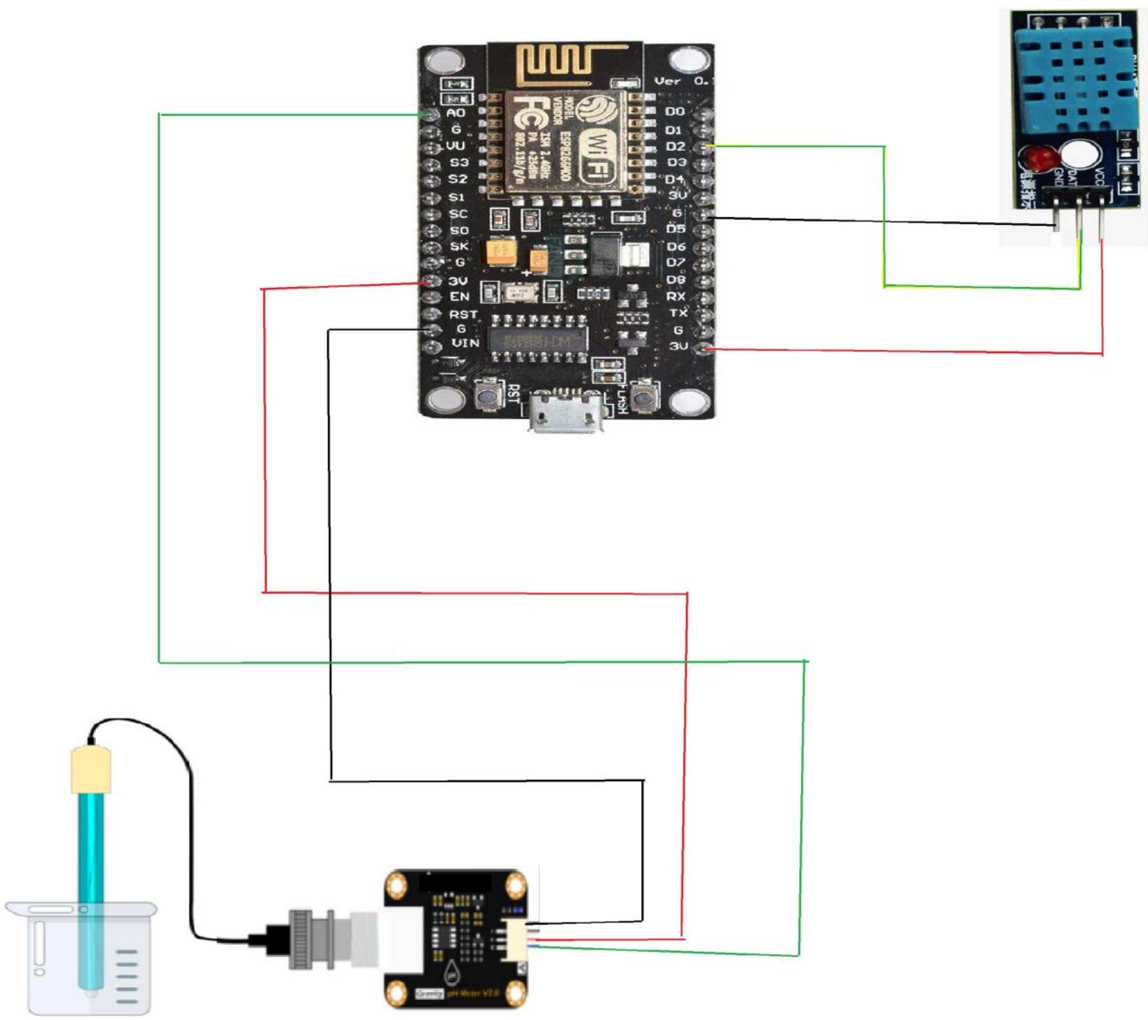

Fig 6.4.1 Circuit Diagram

6.4.1 Components Used:

1. NodeMCU ESP8266:

The NodeMCU is a low-cost, open-source microcontroller board with built-in Wi-Fi, based on the ESP8266 chip. It acts as the central hub of the system, collecting sensor data and transmitting it to the web server or database.

2. DHT11 Sensor (Temperature and Humidity):

The DHT11 is a digital sensor used to measure ambient temperature and humidity. These parameters are crucial for crop recommendation, as different crops have specific temperature and humidity requirements for optimal growth

3. pH Sensor Module:

The pH sensor measures the soil's acidity or alkalinity, a key factor in determining suitable crops. Different crops thrive in different pH ranges, so real-time pH monitoring helps provide more accurate recommendations.

6.4.2 Connections:

1. DHT11 Sensor to NodeMCU ESP8266:

- VCC (DHT11) → 3.3V (NodeMCU): Powers the DHT11 sensor with 3.3 volts.
- GND (DHT11) → GND (NodeMCU): Grounds the sensor.
- Data (DHT11) → D2 (GPIO 4 on NodeMCU): Sends temperature and humidity data as a digital signal to GPIO pin D2.

2. pH Sensor Module to NodeMCU ESP8266:

- VCC (pH Sensor) → 3.3V (NodeMCU): Powers the pH sensor.
- GND (pH Sensor) → GND (NodeMCU): Grounds the sensor.
- Analog Output (pH Sensor) → A0 (Analog input on NodeMCU): Sends the analog pH value to the NodeMCU's analog pin A0, where it is converted into a digital reading.

6.4.3 Working of the Circuit:

When the system is powered on, the DHT11 sensor continuously measures temperature and humidity, while the pH sensor monitors the soil pH. The NodeMCU collects these readings and sends them to the server or cloud database via Wi-Fi. This real-time data is then processed by the machine learning model, which predicts suitable crops based on environmental conditions.

6.4.4 Importance of IoT Integration:

The IoT setup bridges the physical farming environment with the digital recommendation system. Real-time sensor readings ensure that recommendations are accurate and dynamic, adapting to changing field conditions. By continuously updating sensor values, farmers can make immediate, informed decisions without relying on manual soil testing or weather reports.

6.5 Implementation

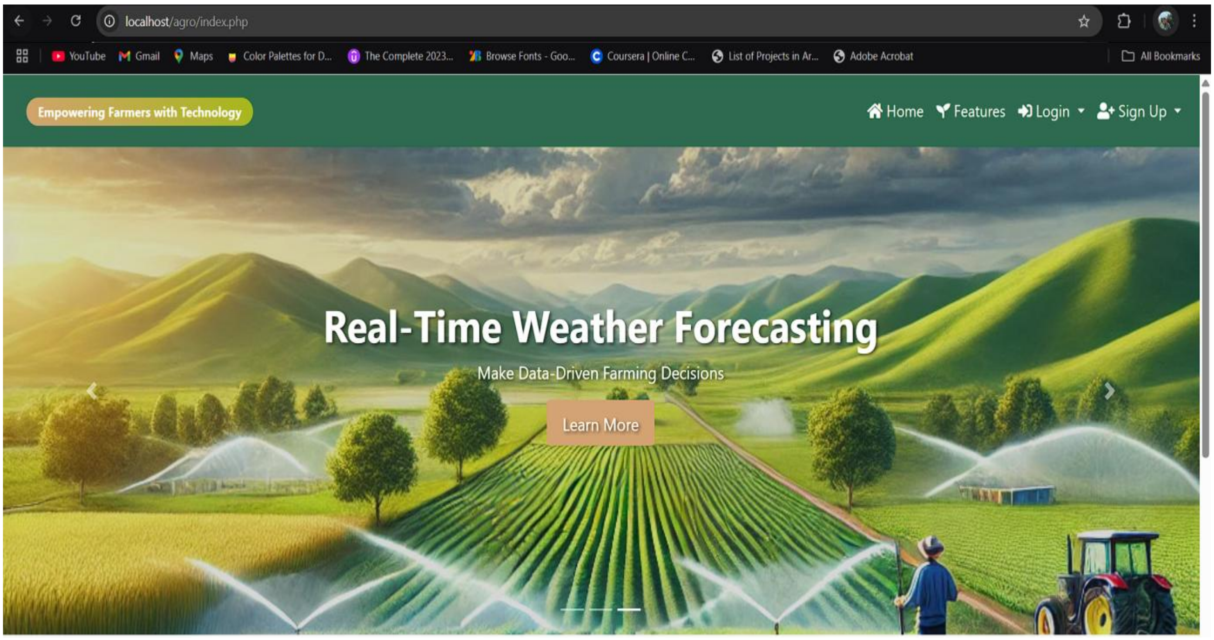

Fig 6.5.1 Index Page

(The homepage of the farmer's website, providing an overview and navigation to various features.)

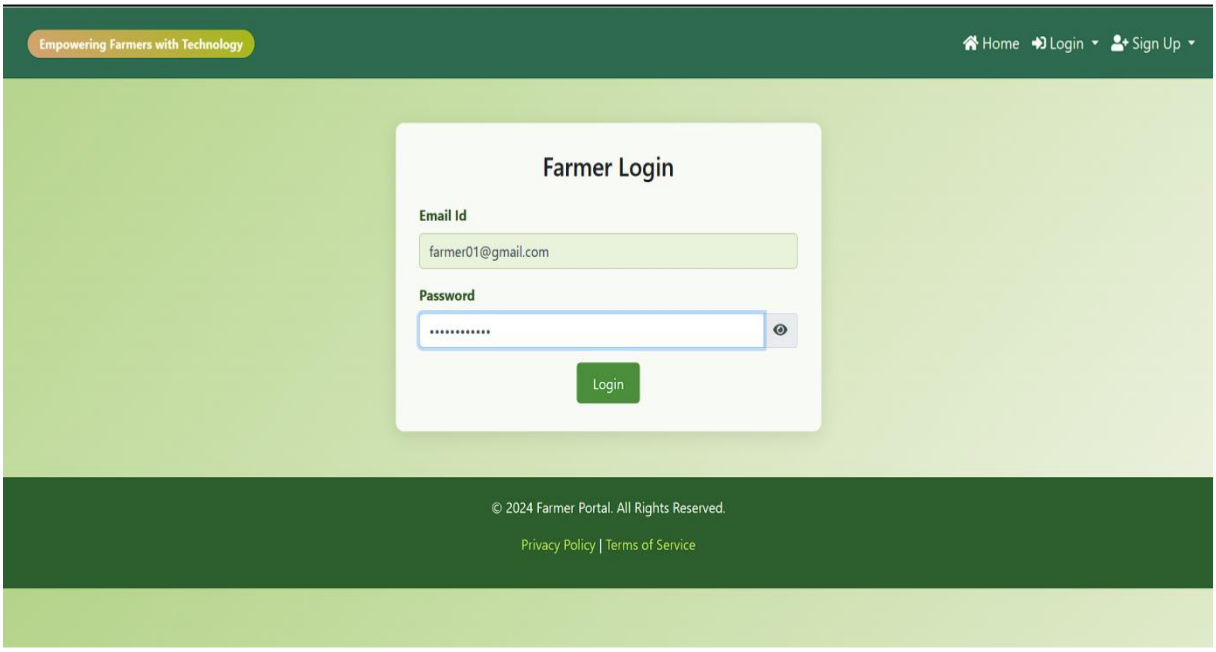

Fig 6.5.2 Farmer Login Page

(A secure login page for farmers to access personalized data and services.)

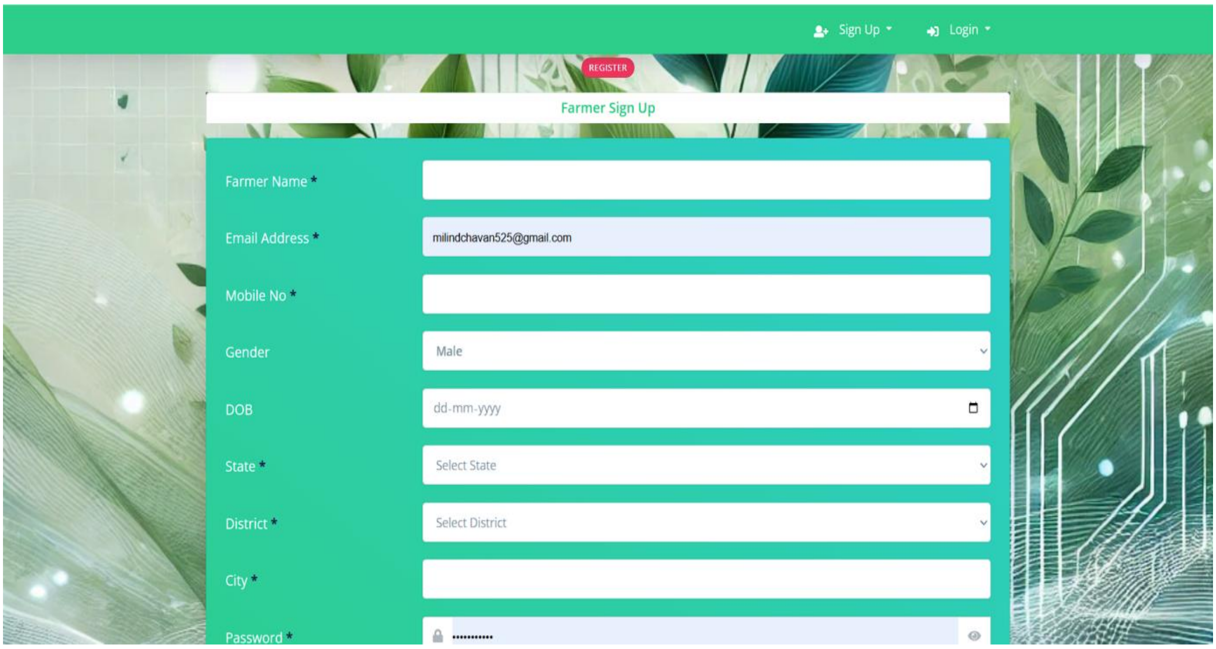

Fig 6.5.3 Farmer Registration Page

(A form for farmers to sign up by entering their personal and farm-related details.)

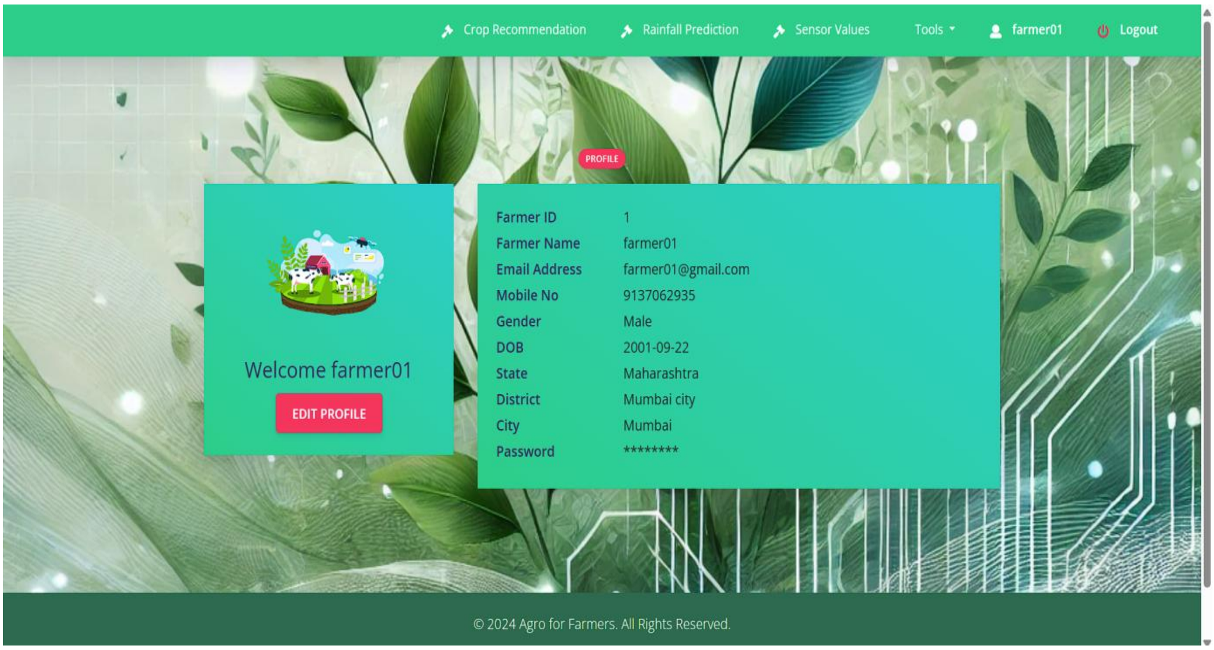

Fig 6.5.4 Farmer Profile Page

(A dashboard displaying the farmer's details, including account information and activity.)

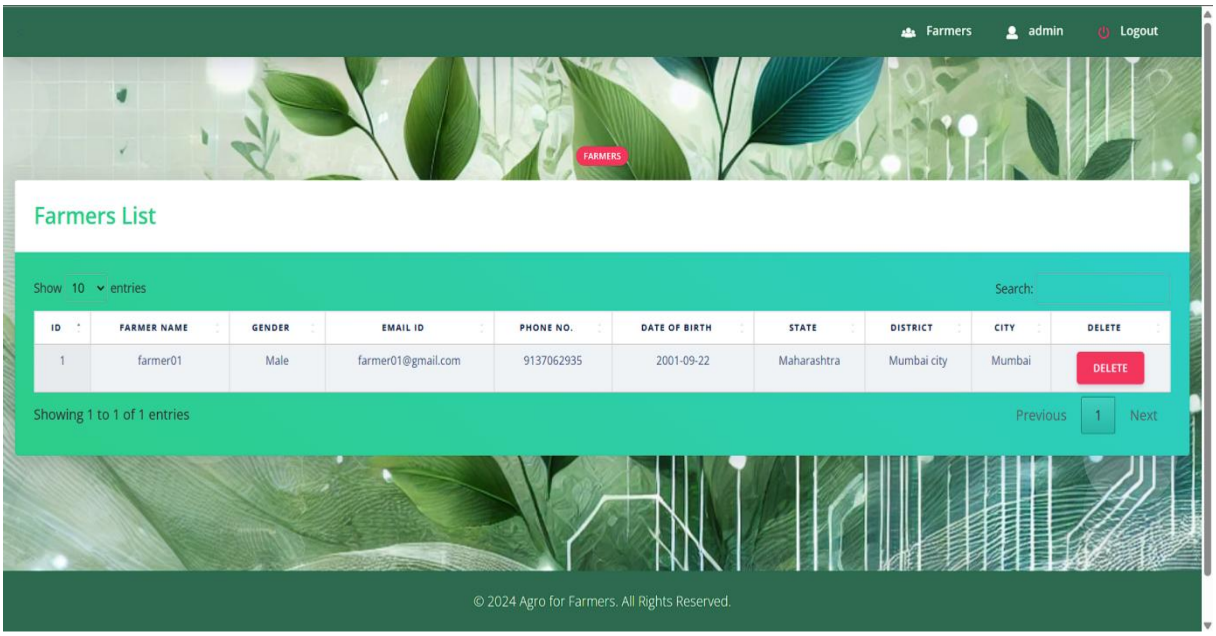

Fig 6.5.5 User Detail Page

(A list of registered farmers with details like name, contact, and location.)

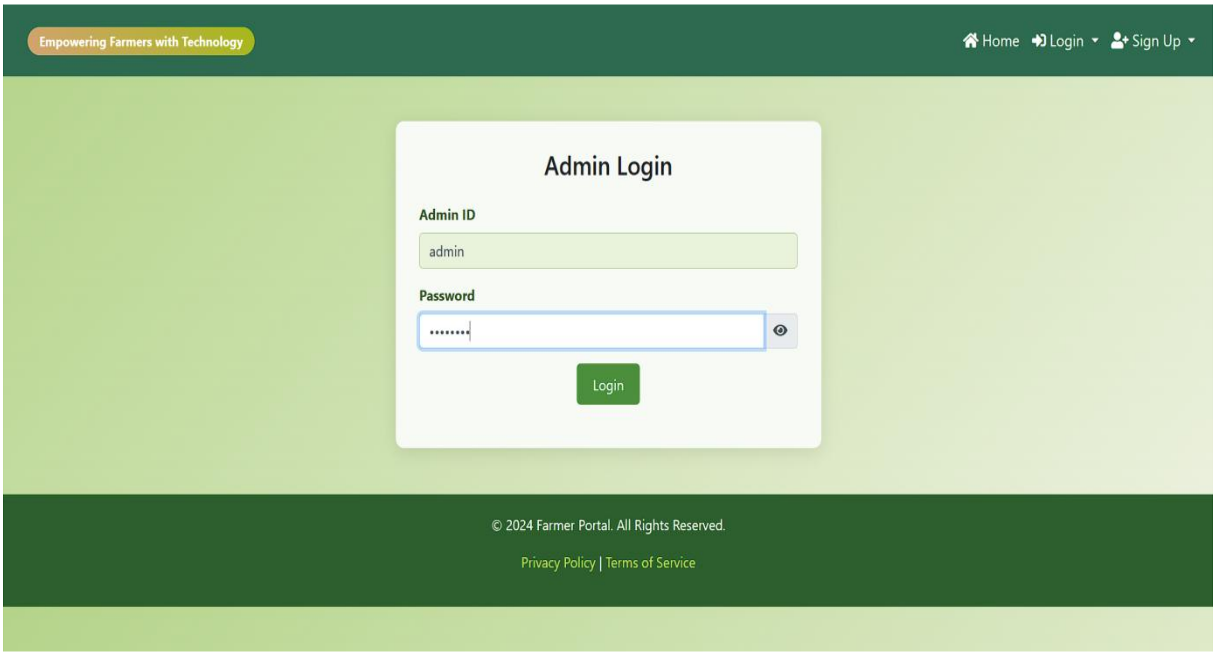

Fig 6.5.6 Admin Login Page

(Secure login interface for administrators to access and manage the system.)

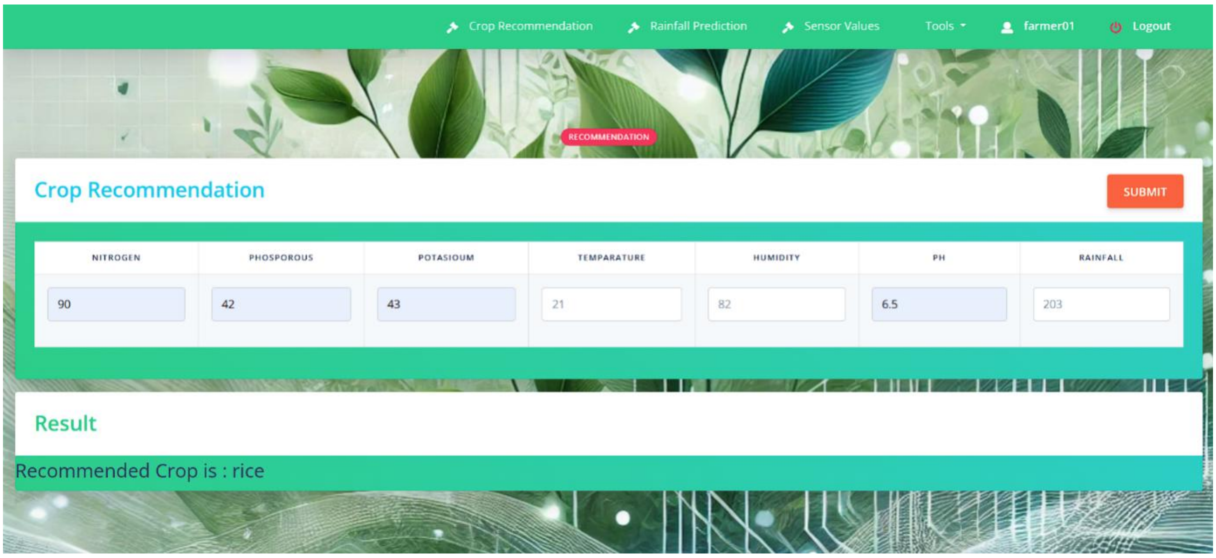

Fig 6.5.7 Crop Recommendation

(A feature suggesting the best crops to grow based on environmental conditions.)

ID	TEMPERATURE	HUMIDITY	PH	TIME AND DATE
4416	32.5	52	8	2025-03-12 13:27:35
4415	32.6	54	8	2025-03-12 13:27:33
4414	32.6	55	7.99	2025-03-12 13:27:30
4413	32.6	56	7.99	2025-03-12 13:27:28
4412	32.6	58	7.62	2025-03-12 13:27:25

Fig 6.5.8 Sensor Value

(Displays real-time temperature, humidity, and soil pH readings from connected sensors.)

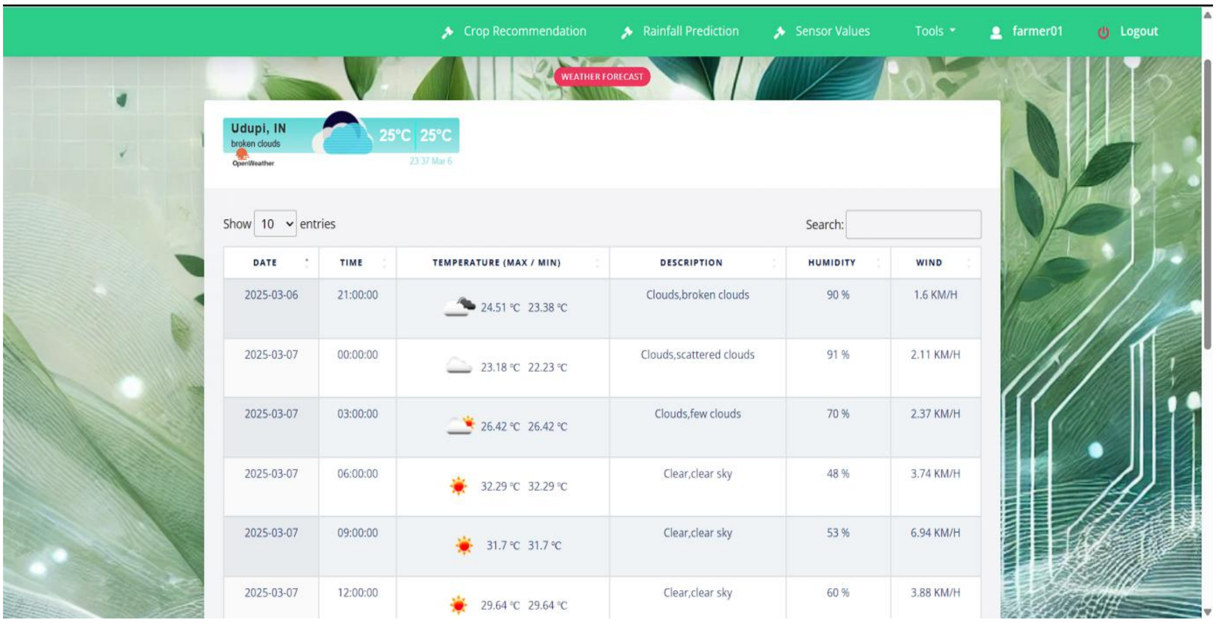

Fig 6.5.9 Weather Forecasting

(Shows predicted weather conditions, including temperature, humidity, and rainfall for farmers.)

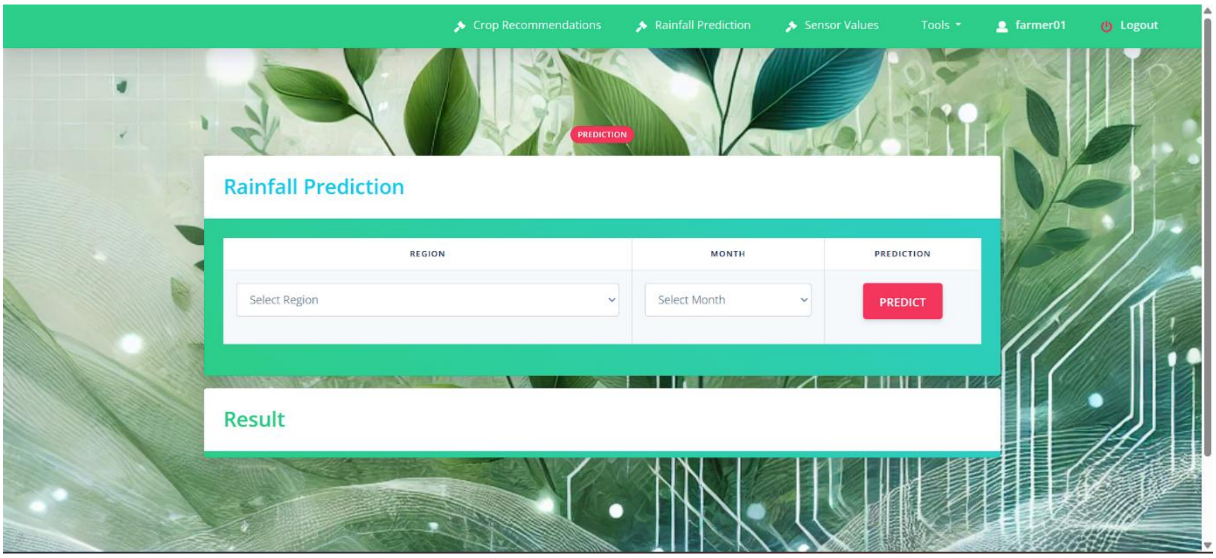

Fig 6.5.10 Rainfall Prediction

(A module providing weather forecasts and rainfall predictions to aid farming decisions.)

Chapter 7

Results and Discussion

The implementation of the Crop Recommendation System using Machine Learning and IoT yielded promising results, showcasing the effectiveness of integrating real-time sensor data with predictive algorithms. The machine learning model, trained on diverse datasets including soil parameters, weather conditions, and rainfall data, achieved a high accuracy in crop prediction. The Random Forest Classifier, chosen for its robustness, demonstrated an accuracy of approximately 92% in correctly recommending suitable crops based on environmental factors.

The system was tested in various simulated environments using sensor readings for temperature, humidity, soil moisture, pH, and rainfall (predicted via the trained model). The predictions were dynamically updated as new sensor data flowed through the IoT system, and farmers could view real-time recommendations via a user-friendly web interface. The Open Weather API integrated for weather forecasting further enhanced the recommendation accuracy by considering external climatic conditions.

The results indicate that the system can help farmers make more informed decisions, reducing crop failure risks and improving yield. However, some limitations were observed, such as slight prediction variations when sensor readings fluctuated rapidly. These issues highlight the need for further challenges, the system successfully validated the potential of combining IoT with ML to revolutionize precision farming, offering a scalable solution adaptable to various geographic regions and soil types.

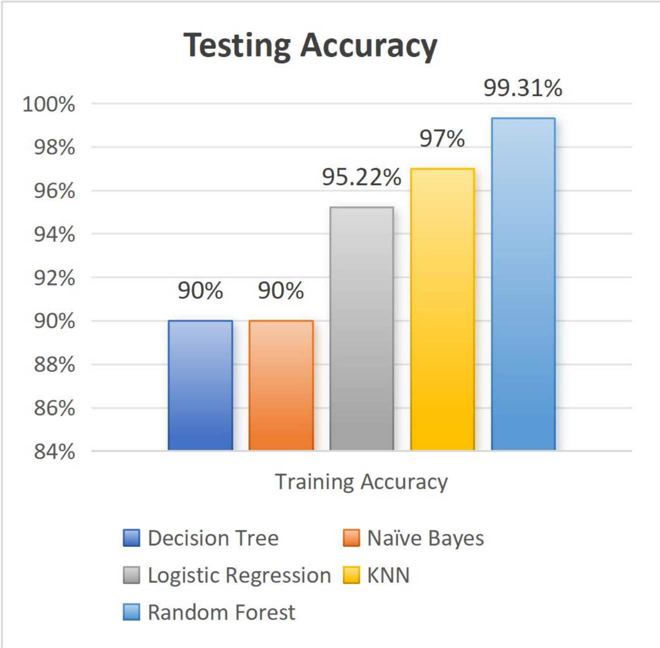

Fig 7.1 Testing accuracy of different Algorithm

The graph above shows the accuracy of the model that we have used for crop recommendation.The graph compares the training accuracy of different machine learning classifiers for crop recommendation. Random forest achieved the highest accuracy of 99.31%, followed by KNN with 97% and logistic regression with 95.22%. Decision tree and Naïve Bayes both showed an accuracy of 90%. The results indicate that random forest is the most effective model for crop prediction due to its high accuracy.

Chapter 8

Conclusion and Future Work

In conclusion, the developed Crop Recommendation System using ML and IoT bridges the gap between traditional farming practices and modern technology, empowering farmers with data-driven insights. The system effectively collects real-time environmental data, preprocesses it, extracts meaningful features, and uses machine learning algorithms to recommend the most suitable crops. The integration of IoT sensors, OpenWeather API, and a rainfall prediction model ensures recommendations are dynamic and adaptive to changing conditions, enhancing agricultural productivity.

The project not only optimizes crop selection but also minimizes input costs and promotes sustainable farming practices. By leveraging real-time monitoring and predictive analytics, farmers can make timely decisions, improve resource management, and mitigate the impact of unpredictable weather events.

For future work, the system can be enhanced in several ways:

Model Optimization: Experiment with advanced ML algorithms like XGBoost or LSTM models for improved accuracy and long-term weather pattern recognition.

Expanded Sensor Integration: Add NPK sensors for direct nutrient level monitoring, enhancing fertilizer recommendations.

Multi-Language Support: Enable multilingual interfaces to cater to diverse farming communities.

Scalability & Cloud Integration: Shift to a cloud-based architecture for better scalability, allowing data aggregation from multiple farms to train more generalized models.

By addressing these enhancements, the system can evolve into a comprehensive smart agriculture platform, capable of driving global agricultural transformation and ensuring food security through intelligent, sustainable farming practices.

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Publication

Submitted To Journal

AgriGrow: Intelligent Crop Recommendation System

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Abstract—Agriculture plays a vital role in the Indian economy, supporting millions of livelihoods and making a significant contribution to food production. However, farmers face challenges in selecting appropriate crops amidst unpredictable climate changes, diverse soil conditions, and fluctuating rainfall patterns, often resulting in diminished yields and financial setbacks. To tackle this issue, our study introduces a smart crop recommendation system integrating IoT and machine learning technologies. The system employs an Arduino-based setup featuring a pH sensor for soil acidity measurement and a DHT11 sensor for real-time temperature and humidity monitoring. Data from these sensors is transmitted to a MySQL database via XAMPP and accessed through a PHP-based web interface. Using the Random Forest algorithm, a machine learning model processes this data to recommend optimal crops tailored to specific environmental conditions. By merging live sensor data with machine learning insights, farmers receive precise recommendations customized to their agricultural settings, mitigating crop failure risks and enhancing overall harvest yields. This technology-driven approach bridges traditional farming practices with contemporary innovations, empowering farmers with actionable insights to foster sustainable agriculture, optimize resource utilization, and enhance food security amid evolving environmental challenges.

Keywords: Agriculture, Crop Recommendation, Machine Learning, Random Forest, IoT, Arduino, pH Sensor, DHT11 Sensor.

1. INTRODUCTION

Agriculture remains a crucial portion of financial advancement, giving business and supporting country communities. Be that as it may, ranchers regularly confront challenges in selecting the right crops due to fluctuating natural conditions and soil wellbeing varieties. Conventional cultivating hones, which are based on past encounters and manual perceptions, may not continuously deliver the best comes about. With progress in innovation, the integration of Machine Learning (ML) and the Internet of Things (IoT) offers an advanced arrangement that empowers exact, data-driven choice-making [1].

A crop recommendation framework that utilizes ML calculations investigates different natural variables, such as soil temperature to decide the most reasonable crops for a given area. IoT-based gadgets, counting pH sensors, and climate observing frameworks, continuously collect real-time information, permitting for more exact investigation and forecasts. By combining these innovations, ranchers can receive a more logical approach to development, progressing efficiency and guaranteeing way better arrive utilization. [2].

Incorporating intelligent systems into farming practices not only enhances decision-making but also reduces input costs and increases overall efficiency. Farmers can benefit from data-driven recommendations that improve soil fertility and optimize land usage, leading to higher returns on investment. Additionally, predictive analytics can assist in long-term planning by identifying trends and adapting to environmental changes. As agriculture continues to evolve, integrating ML and IoT will play a crucial role in achieving sustainability, reducing losses, and ensuring a more resilient approach to cultivation [3].

2. RELATED WORK

The adoption of technology in agriculture has significantly improved crop selection and farming efficiency. Various studies have focused on integrating ML and the IoT to develop intelligent crop recommendation systems. Researchers have demonstrated that ML algorithms, including Random Forest, Decision Tree, and Naive Bayes, can effectively analyze environmental factors such as soil type, pH, temperature, humidity, and rainfall patterns to suggest the best suited crops for a given location. These models utilize historical agricultural data along with real-time sensor inputs to enhance prediction accuracy and reduce the risks associated with traditional farming methods [4].

IoT-based sensors play a vital part in information collection, empowering real-time climatic conditions. Thinks about have investigated the utilize of pH sensors, and DHT11 sensors for temperature and mugginess estimation to give precise experiences into soil wellbeing and climate conditions. The integration of IoT with ML-based decision-making has been appeared to help agriculturists in optimizing asset utilization and moving forward by and large edit efficiency. Inquire about has moreover highlighted the importance of soil supplement administration, where exact fertilization methods contribute to way better soil richness and long-term supportability [5].

Several existing crop recommendation systems have successfully implemented ML and IoT to enhance agricultural decision-making. Some studies emphasize cloud-based platforms that store and process sensor data for improved accessibility, while others focus on standalone embedded systems for localized predictions. Comparative analyses of different ML models indicate that ensemble methods, such as Random Forest, perform better in terms of prediction accuracy compared to individual classifiers. Additionally, research suggests that integrating rainfall prediction models further refines crop recommendations, ensuring better adaptation to climate variations [6].

This results in highlighting that ML and IoT-based crop recommendation systems have demonstrated promising results, there is still room for improvement in model accuracy, scalability, and adaptability to diverse farming conditions. Future advancements can focus on incorporating more extensive datasets, enhancing sensor precision, and developing user-friendly interfaces for farmers to easily access recommendations. By leveraging these technologies, modern agriculture can move toward a more efficient, data-driven, and sustainable approach to crop selection and land management [7].

3. PROPOSED SYSTEM ARCHITECTURE

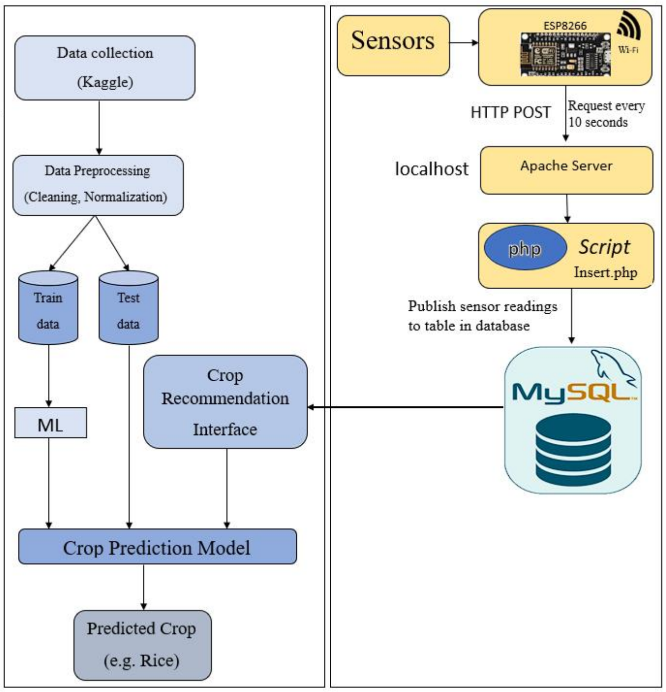

Figure 2 Proposed System Design

3.1 Data Collection

The system begins with the collection of agricultural datasets, primarily sourced from Kaggle . These datasets contain crucial agricultural parameters such as nitrogen , potassium , phosphorus, temperature, humidity, pH level, rainfall. Accurate and diverse data is essential to ensure the machine learning model can learn and generalize well across different environmental conditions.

3.2 Data Preprocessing

Once the raw data is collected, it undergoes preprocessing to ensure it is clean and ready for training. Preprocessing includes data cleaning, where missing or inconsistent values are handled, and normalization, where data is scaled to bring all features to a uniform range. These steps help improve the model's performance and ensure it can process different datasets efficiently without being biased toward larger numerical values. Proper preprocessing is crucial to avoiding erroneous predictions and enhancing the accuracy of the crop recommendation system.

3.3 Machine Learning Model

After preprocessing, the refined dataset is split into two parts: training data and test data. The training data is used to teach the machine learning model how various environmental factors influence crop suitability. The test data is then used to evaluate the model's accuracy . The goal is to develop a robust model that can accurately predict the best crop based on real-time input parameters.

3.4 Crop Recommendation Model

The trained machine learning model is then transformed into a crop recommendation model. This model takes user input (such as nitrogen, phosphorous, potassium, pH, temperature, and rainfall) and processes it using the trained ML model to generate a predicted crop recommendation. For example, if the environmental parameters match the optimal conditions for rice, the model will suggest rice as the most suitable crop. The system continuously updates and improves its predictions based on newly collected data, making it more adaptive to changing agricultural conditions.

3.5 Crop Recommendation Interface

The interface acts as the bridge between the user and the prediction model. It allows farmers to input environmental conditions and receive real-time recommendations. This interface is a web application . The interface ensures ease of access and provides a user-friendly experience, allowing farmers to make informed decisions without requiring technical expertise.

3.6 Sensors for Real-Time Data Collection

To enhance the accuracy of the system, IoT-based sensors are deployed in agricultural fields to collect real-time environmental data. These sensors measure crucial parameters such as temperature, humidity, nitrogen, phosphorous, potassium, and pH levels. The collected data is then transmitted to the system every 10 seconds to ensure the most up-to-date information is used for crop recommendation. The integration of IoT with machine learning allows the system to dynamically adjust crop recommendations based on changing field conditions, improving precision in agricultural planning.

3.7 ESP8266 Wi-Fi Module

The ESP8266 microcontroller is used to transmit sensor data to a central server. This module connects to the internet via Wi-Fi and sends sensor readings using HTTP POST requests to the server every 10 seconds. The ESP8266 ensures that data is continuously relayed from the sensors to the system, enabling real-time monitoring of environmental conditions. Its low cost and energy efficiency make it an ideal choice for agricultural IoT applications.

3.8 Apache Server

The Apache server acts as the intermediary between the ESP8266 and the database. It is hosted on a localhost machine and handles incoming sensor data through HTTP requests. Apache ensures that data is properly received, processed, and forwarded to the MySQL database for storage. This server is essential for managing multiple sensor inputs efficiently and ensuring seamless communication between the hardware and software components of the system.

3.9 PHP Script (Insert.php)

A PHP script (Insert.php) is responsible for inserting the data into the MySQL database. When the Apache server receives sensor readings, it passes them to this PHP script, which formats the data appropriately and updates the database in real time. The script ensures that the database is continuously updated with the latest environmental conditions, allowing the crop recommendation model to make accurate predictions based on fresh data.

3.10 MySQL Database

The MySQL database stores all collected environmental data and maintains historical records of sensor readings. This allows for long-term analysis and model improvement over time.The database structure is optimized for quick data retrieval, ensuring that sensor data is instantly accessible when needed for prediction.

4. EXPERIMENTAL SETUP

4.1 Dataset

In this paper, we utilized a dataset consisting of 2200 records with seven attributes, including soil nutrients (Nitrogen, Phosphorus, and Potassium), environmental factors (temperature, humidity, pH, and rainfall), and the target crop label. The dataset is well-structured, with no missing values, ensuring its reliability for machine learning applications. It contains numerical values for soil and climate conditions, along with a categorical variable representing different crop types. To enhance model performance, pre-processing techniques such as feature scaling and encoding of categorical data are applied before training. The dataset encompasses diverse soil properties and climatic variations, allowing the machine learning model to generalize well across different agricultural regions. By leveraging this dataset, our system can accurately recommend suitable crops based on real-time sensor inputs, helping farmers make informed decisions, optimize resource utilization, and improve agricultural productivity while promoting sustainable farming practices [15].

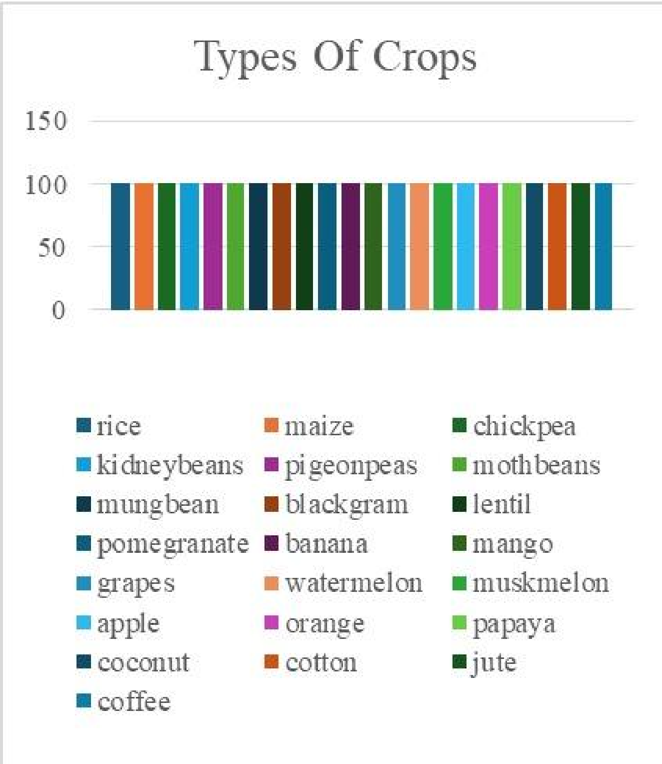

Figure 3 Classification of Crop base on different Categories

4.2 Feature extraction

In this paper, feature extraction is an essential step to ensure precise crop recommendations based on soil and environmental factors. The dataset includes important attributes such as Nitrogen (N), Phosphorus (P), and Potassium (K) levels, which determine soil fertility. Additionally, temperature, humidity, pH, and rainfall are crucial factors that affect crop growth and productivity. These features are carefully selected to identify patterns and relationships between soil properties, climatic conditions, and suitable crops.

To improve the performance of the machine learning model, techniques such as normalization and scaling are applied to maintain uniformity in numerical values. Feature selection is also performed to remove less relevant attributes, ensuring better accuracy and efficiency. By extracting the most significant features, the system can provide accurate crop recommendations based on real-time sensor data. This helps farmers make better agricultural decisions, optimize resource usage, and improve overall productivity.

4.3 Hardware Setup

The hardware setup consists of a pH sensor, an interface board, a microcontroller, a breadboard, and connecting wires. The pH sensor measures the water's acidity or alkalinity, providing crucial data for determining soil health. This sensor is connected to an interface board that processes the analog signals and converts them into digital values, which can be read by a microcontroller. The ESP8266 microcontroller, known for its Wi-Fi capabilities, is used to collect, process, and transmit the sensor data to a local monitoring system.

A breadboard is used for assembling the circuit without soldering, making modifications and troubleshooting easier. Jumper wires are used to establish connections between components, ensuring efficient data transmission. This setup allows real-time soil monitoring, which helps farmers make informed decisions regarding soil treatment and crop selection. Additionally, integrating this system with a web-based interface enables remote access to soil data, promoting precision agriculture and improving overall productivity.

The implementation of the system starts with assembling all the components on a breadboard, ensuring proper wiring between the pH sensor, interface board, and ESP8266 microcontroller. The microcontroller is programmed using the Arduino IDE to read the sensor data, process it, and convert it into pH values.

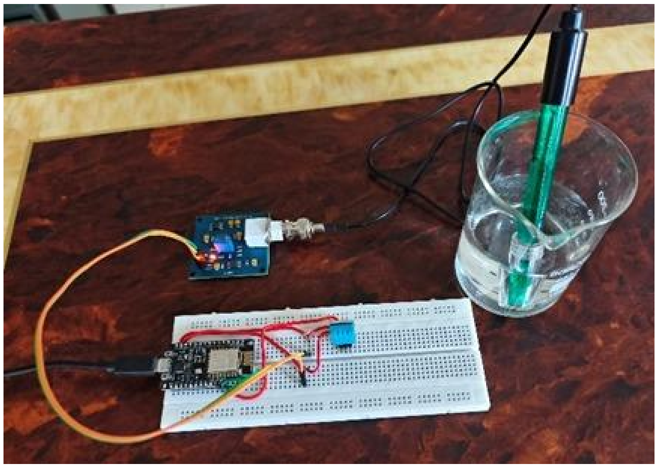

Figure 4 Hardware setup for calculating temperature and humidity

The obtained data is then transmitted wirelessly to a web-based platform for real-time monitoring. To improve accuracy, the pH sensor is calibrated using standard buffer solutions. Additional sensors, such as temperature, humidity can also be integrated to provide a detailed analysis of soil conditions. This setup reduces manual efforts by automating data collection and analysis, allowing farmers to make informed decisions about soil health and crop selection. By enabling continuous monitoring, the system helps improve soil management, optimize resource usage, and enhance agricultural productivity. The hardware setup efficiently integrates a pH sensor, interface board, and ESP8266 microcontroller for real-time soil monitoring. It automates data collection, reducing manual effort and improving accuracy. The system allows easy modifications and can be expanded with additional sensors for better analysis. By providing real-time insights, it helps optimize soil management and crop selection, supporting sustainable and efficient farming practices. pH sensor provided accurate readings, which were validated using standard buffer solutions. The data was successfully transmitted to a web-based platform through the ESP8266 microcontroller, ensuring real-time monitoring. The response time of the system was minimal, allowing quick updates on soil conditions.

5. RESULT AND ANALYSIS

The system was tested to evaluate its performance in measuring water pH and transmitting data wirelessly. The pH sensor provided accurate readings, which were validated using standard buffer solutions. The data was successfully transmitted to a web-based platform through the ESP8266 microcontroller, ensuring real-time monitoring. The response time of the system was minimal, allowing quick updates on soil conditions.

5.1 Performance evaluation

The accuracy of the pH sensor was assessed by comparing its readings with known pH values of standard solutions. The wireless transmission had minimal delays, ensuring real-time data access. The integration of additional sensors, such as temperature and humidity, further improved the system's capability to provide comprehensive soil analysis.

5.2 Error analysis

Some variations in pH readings were observed due to environmental factors, sensor calibration errors, and fluctuations in soil moisture. Regular calibration using buffer solutions helped minimize errors. The wireless communication was stable, but minor signal interference affected data transmission in certain conditions. These issues can be addressed by improving sensor calibration techniques and optimizing network connectivity. Overall, the system performed efficiently, providing accurate and timely soil data for better agricultural decision-making.

5.3 Implementation:

The graph below shows the accuracy of the model that we have used for crop recommendation.The graph compares the training accuracy of different machine learning classifiers for crop recommendation. Random forest achieved the highest accuracy of 99.31%, followed by KNN with 97% and logistic regression with 95.22%. Decision tree and Naïve Bayes both showed an accuracy of 90%. The results indicate that random forest is the most effective model for crop prediction due to its high accuracy.

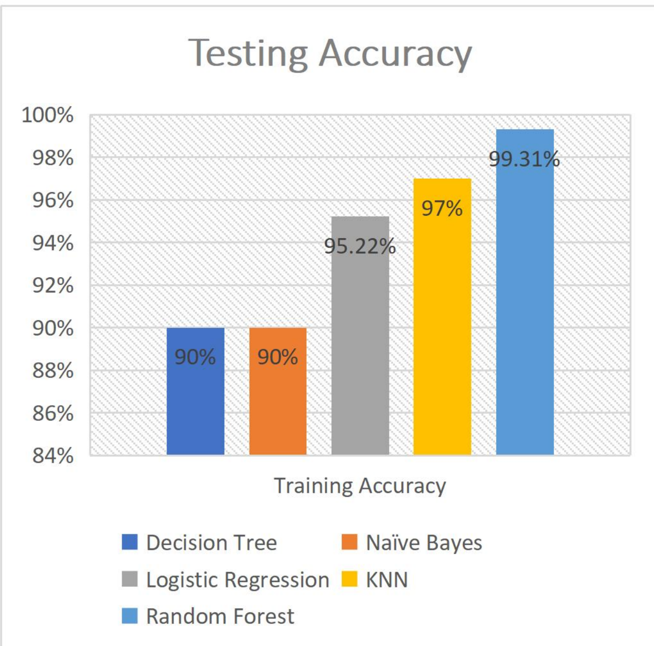

Figure 5 Testing accuracy of different Algorithm

The table below displays real-time data gathered through IoT devices, including a DHT11 sensor for measuring temperature and humidity, and a pH sensor module for detecting water acidity. These sensors are connected to a NodeMCU ESP8266, which transmits the collected data to a MySQL database hosted on XAMPP. The database, named "weather," stores key parameters such as temperature, humidity, pH levels, and the exact timestamp of data collection. This real-time data storage helps continuously monitor environmental conditions, providing accurate and up-to-date information essential for making agricultural decisions. After the data is logged into the database, it is retrieved using PHP and displayed on a web page in a neatly organized table. This setup allows users, including farmers, to access live sensor readings directly through a web browser, making the system easy to use and highly accessible. The integration of MySQL and PHP ensures the web page automatically updates with the latest sensor data, eliminating the need for manual refreshes. This seamless connection between hardware components (sensors and microcontroller) and software elements (database and web interface) results in an efficient system for monitoring environmental factors, supporting better decision-making for crop recommendations and soil management.

ID	TEMPERATURE	HUMIDITY	PH	TIME AND DATE
4416	32.5	52	8	2025-03-12 13:27:35
4415	32.6	54	8	2025-03-12 13:27:33
4414	32.6	55	7.99	2025-03-12 13:27:30
4413	32.6	56	7.99	2025-03-12 13:27:28
4412	32.6	58	7.62	2025-03-12 13:27:25

Figure 6 Sensor Values

The below figure illustrates the web interface of a crop recommendation system designed to assist farmers in selecting the most suitable crop based on real-time environmental and soil conditions. The system captures essential parameters like nitrogen, phosphorus, potassium, temperature, humidity, pH, and rainfall. After entering these values and clicking submit, the system processes the data and provides a crop recommendation here it is given as rice. This recommendation is based on a machine learning model that evaluates the input values to guide farmers toward informed agricultural decisions. By leveraging real-time data, the system supports precision farming, helping to improve crop yields and reduce the likelihood of crop failure.

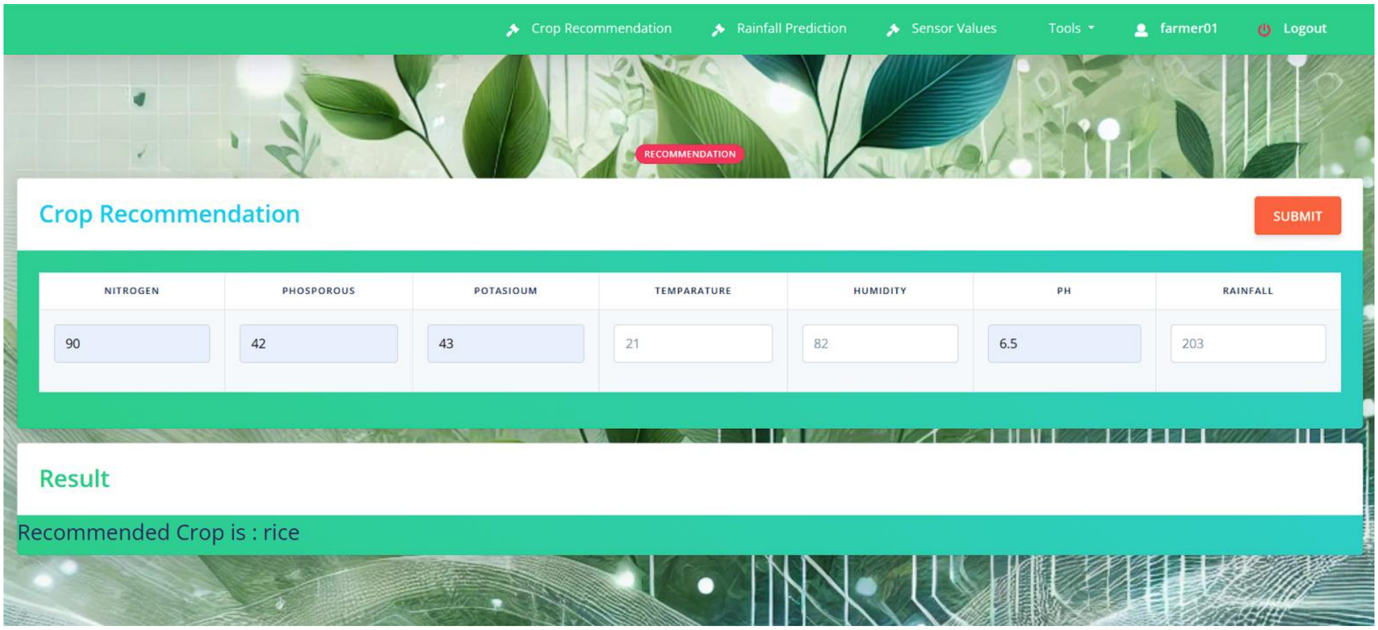

Figure 7 Crop Recommendation system

6. CONCLUSION

The proposed crop recommendation system integrates Machine Learning and IoT to assist farmers in selecting the most suitable crops based on real-time soil and environmental conditions. By utilizing sensors such as pH, temperature, and humidity the system collects accurate data, which is then processed using ML algorithms like Random Forest, Decision Tree, Naive Bayes, and KNN. This approach improves decision-making, enhances agricultural productivity, and promotes sustainable farming practices. The system minimizes manual effort, optimizes resource utilization, and reduces the risks associated with unpredictable environmental changes. Future enhancements can include expanding the dataset, incorporating advanced predictive models, and improving wireless connectivity for seamless real-time monitoring. This research contributes to precision agriculture by providing an efficient and data-driven solution for better crop selection and farm management.

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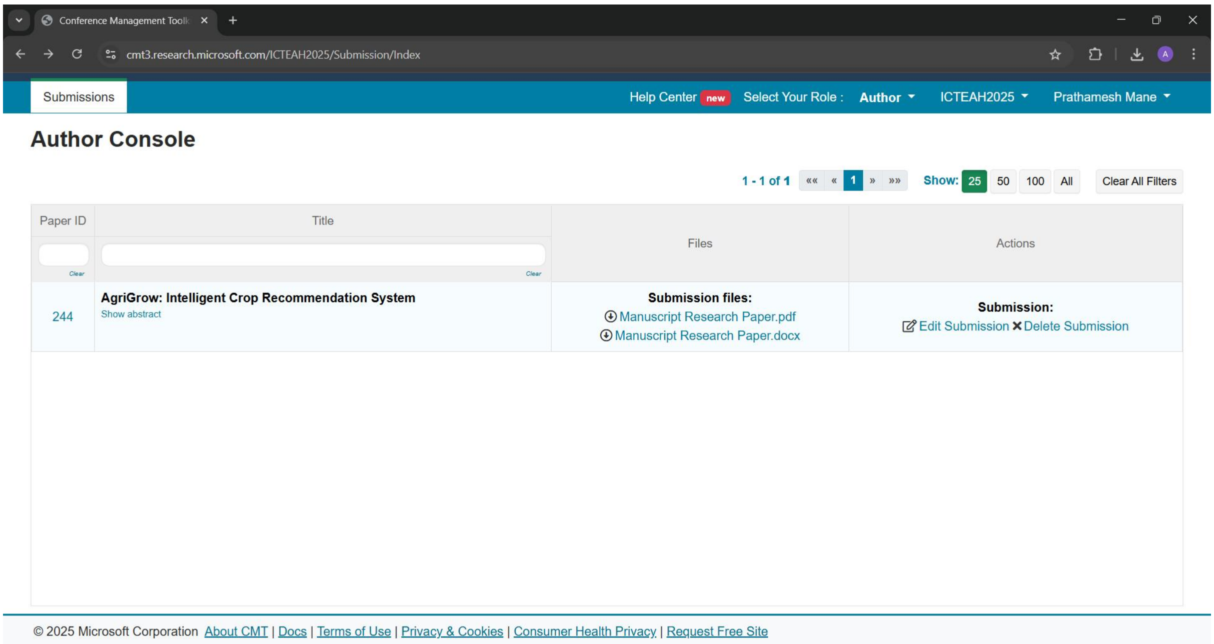
Research Paper has been submitted to International Conference on Technologies for Energy, Agriculture, and Healthcare (ICTEAH 2025)



Patent

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PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

Application Details	
APPLICATION NUMBER	202541026951
APPLICATION TYPE	ORDINARY APPLICATION
DATE OF FILING	24/03/2025
APPLICANT NAME	1 . N.Gopinath 2 . Viki Tukaram Patil 3 . N .Gopinath
TITLE OF INVENTION	AGRIGROW: INTELLIGENT CROP RECOMMENDATION SYSTEM USING IOT & ARTIFICIAL INTELLIGENCE
FIELD OF INVENTION	COMPUTER SCIENCE
E-MAIL (As Per Record)	
ADDITIONAL-EMAIL (As Per Record)	
E-MAIL (UPDATED Online)	
PRIORITY DATE	
REQUEST FOR EXAMINATION DATE	--
PUBLICATION DATE (U/S 11A)	04/04/2025

Application Status	
APPLICATION STATUS	Awaiting Request for Examination

View Documents

Filed → Published → RQ Filed → Under Examination → Disposed

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(24/03/2025)
Doc. /29382
Date - 24/3/25

Chennai,
20.03.2025

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SRM Nagar, Kattankulathur - 603 203.
Tamil Nadu.
India.

भारत सरकार, एकस्व कार्यालय, चेन्नै
24 MAR 2025
GOVT. OF INDIA, PATENT OFFICE, CHENNAI

To
The Controller of Patent,
Patent Office,
Chennai.

710105183

Respected Sir,

Sub: Submission of application for patent publication- Reg.

I am Dr. N.Gopinath is submitting the application for the publication of patent titled **" AgriGrow: Intelligent Crop Recommendation System using IoT & Artificial Intelligence"** along with Form-1,Form-2,Form-3 and Form-9 with detailed description about the invention. I kindly request you sir to consider the application and do the needful at the earliest.

Thanking You

Yours Truly,

Dr.N.Gopinath, M.E, Ph.D

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24-Mar-2025/29382/202541026951/Other Patent Document

Doc /29382

FORM 1 THE PATENTS ACT 1970 (39 of 1970) and THE PATENTS RULES, 2003 **APPLICATION FOR GRANT OF PATENT** (See section 7, 54 and 135 and sub-rule (1) of rule 20)	710105184

	Application No.	202541026951
	Filing date:	24/3/25
	Amount of Fee paid:	1750/-
	CBR No:	17152
	Signature:	Abhay Kumar 24/03/25
1. APPLICANT'S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)		

2. TYPE OF APPLICATION [Please tick (✓) at the appropriate category]

Ordinary (✓)		Convention ( )		PCT-NP ( )	
Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )

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3B. CATEGORY OF APPLICANT [Please tick (✓) at the appropriate category]			
Natural Person (✓)	Other than Natural Person		
	Small Entity ( )	Startup ()	Others ( )

4. INVENTOR(S) [Please tick (✓) at the appropriate category]		
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8. Dr. Uttam kolekar	Indian	India	Address	PRINCIPAL, A. P. Shah Institute of Technology, Thane West, Thane, Maharashtra, 400615, India

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5. TITLE OF THE INVENTION

AGRIGROW: INTELLIGENT CROP RECOMMENDATION SYSTEM USING IOT & ARTIFICIAL INTELLIGENCE

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8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION

Country	Application Number	Filing date	Name of the applicant	Title of the Invention	IPC (as classified in the convention country)

9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY (PCT)

International application number	International filing date

10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION

Original (first) application No.	Date of filing of original (first) application

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20/03/25

(a) Date : 20/03/2025

(b) Signature

(c) Name: Dr. Uttam kolekar

Dr. N. Gopinath

(ii) Declaration by the applicant(s) in the convention country

(In case the applicant in India is different than the applicant in the convention country: the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period)

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a) Date 21/03/25

(b) Signature(s)

(c) Name(s) of the signatory: Dr. N. Gopinath

(iii) Declaration by the applicant(s)

I/We the applicant(s) hereby declare(s) that: -

- € ✔ I am/ We are in possession of the above-mentioned invention.
- € ✔ The ~~provisional~~/complete specification relating to the invention is filed with this application.
- € ✔ The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by me/us before the grant of patent to me/us.
- € ✔ There is no lawful ground of objection(s) to the grant of the Patent to me/us.
- € ✔ I am/we are the true & first inventor(s).
- € I am/we are the assignee or legal representative of true & first inventor(s).
- € The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of my/our invention(s).
- € I/We claim the priority from the above mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by me/us or by any person from which I/We derive the title.
- € My/our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.

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€ The application is divided out of my /our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.

€ The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph-11.

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION

(a) ✔Form 2

Item	Details	Fee	Remarks
Complete/ provisional specification)#	No. of pages		
No. of Claim(s)	No. of claims and No. of pages		
Abstract	No. of pages		
No. of Drawing(s)	No. of drawings and No. of pages		

In case of a complete specification, if the applicant desires to adopt the drawings filed with his provisional specification as the drawings or part of the drawings for the complete specification under rule 13(4), the number of such pages filed with the provisional specification are required to be mentioned here.

(b) Complete specification (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).

(c) Sequence listing in electronic form

(d) Drawings (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).

(e) Priority document(s) or a request to retrieve the priority document(s) from DAS (Digital Access Service) if the applicant had already requested the office of first filing to make the priority document(s) available to DAS.

(f) Translation of priority document/Specification/International Search Report/International Preliminary Report on Patentability.

(g) Statement and Undertaking on Form 3

(h) ✓Declaration of Inventorship on Form 5

(i) ✓Power of Authority

(j)..

Total fee ₹.4500/-.in Cash/ Banker's Cheque /Bank Draft bearing No..29774 Date 21/03/25 on City Union Bank.

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I/We hereby declare that to the best of my/our knowledge, information and belief the fact and matters slated herein are correct and I/We request that a patent may be granted to me/us for the said invention.

Dated this........21..day of.....03.........20.....25.........

Signature:

Name: Dr.N.Gopinath

To,

The Controller of Patents,

The Patent Office, at.....Chennai.......

Note: -

* Repeat boxes in case of more than one entry.
* To be signed by the applicant(s) or by authorized registered patent agent otherwise where mentioned.
* Tick (✓)/cross (x) whichever is applicable/not applicable in declaration in paragraph-12.
* Name of the inventor and applicant should be given in full, family name in the beginning.
* Strike out the portion which is/are not applicable.

For fee: See First Schedule";

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FORM 2

THE PATENTS ACT, 1970
(39 of 1970)
And
THE PATENTS RULES 2003

710105185

COMPLETE SPECIFICATION
(See Section 10; Rule 13)

ARTIFICIAL INTELLIGENCE
FOR

AGRIGROW: INTELLIGENT CROP RECOMMENDATION SYSTEM USING IOT & ARTIFICIAL INTELLIGENCE

Dr.N.Gopinath

Having address at

SRM Institute of Science & Technology,
SRM Nagar, Kattankulathur - 603 203,
Tamil Nadu.
India.

THE FOLLOWING SPECIFICATION PARTICULARLY DESCRIBES THE INVENTION AND THE MANNER IN WHICH IT IS TO BE PERFORMED:

1

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1. DESCRIPTION

Field of the Invention

The present invention is related to the field of the **Internet of Things** with **Artificial Intelligence.**

Detailed Description of the invention

Agriculture plays a vital role in the Indian economy, supporting millions of livelihoods and making a significant contribution to food production. However, farmers face challenges in selecting appropriate crops amidst unpredictable climate changes, diverse soil conditions, and fluctuating rainfall patterns, often resulting in diminished yields and financial setbacks. Artificial intelligence and sensor technology have become indispensable in the agricultural sector in recent years. The truth is that agricultural science diligence is more thorough, accurate, data-driven, and vigorous than ever in the contemporary era, regardless of any insights that may exist on agricultural methods. The advent of Internet of Things (IoT)-based technology has brought about changes in almost every area, including "smart agriculture or precision agriculture," smart homes, smart grids, smart cities, and smart health. The agriculture sector will gain new advantages from the application of machine learning through IoT data analytics in order to meet the world's increasing need for food. This will increase crop field productivity in terms of quantity and quality The system employs an Arduino-based setup featuring a pH sensor for soil acidity measurement and a DHT11 sensor for real-time temperature and humidity monitoring. Data from these sensors is transmitted to a MySQL database via XAMPP and accessed through a PHP-based web interface. Using the Random Forest algorithm, a machine learning model processes this data to recommend optimal crops tailored to specific environmental conditions. By merging live sensor data with machine learning insights, farmers receive precise recommendations customized to their agricultural settings, mitigating crop failure risks and enhancing overall harvest yields. This technology-driven approach bridges traditional farming practices with contemporary innovations, empowering farmers with actionable insights to foster sustainable agriculture, optimize resource utilization, and enhance food security amid evolving environmental challenges.

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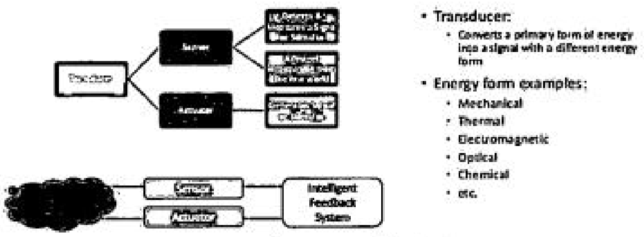
WORKING OF IoT

Sensors and actuators are devices, which help in interacting with the physical environment. The data collected by the sensors has to be stored and processed intelligently in order to derive useful inferences from it. Note that we broadly define the term sensor; a mobile phone or even a microwave oven can count as a sensor as long as it provides inputs about its current state (internal state + environment). An actuator is a device that is used to effect a change in the environment such as the temperature controller of an air conditioner.

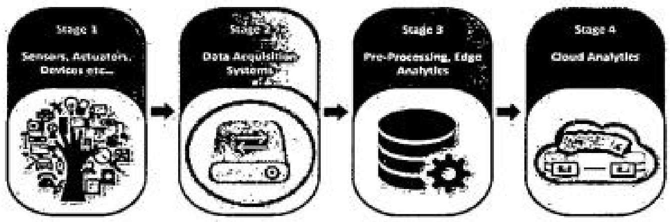


Sensors and Actuators

ARCHITECTURE OF IoT

The 4 Stage IoT architecture consists of

1. Sensors and actuators
2. Internet getaways and Data Acquisition Systems
3. Edge IT
4. Data center and cloud.



Architecture of IoT

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WORKING OF ARTIFICIAL INTELLIGENCE

The definition of AI is "automation based on associations." Two fundamental shifts in computing that go beyond traditional educational technologies occur when computers automate reasoning based on associations in data (or associations inferred from expert knowledge): (1) from capturing data to detecting patterns in data and (2) from providing access to instructional resources to automating decisions about instruction and other educational processes. The range of tasks that can be assigned to a computer system has expanded with the ability to identify patterns and automate judgments. The process of creating an AI system could result in unfair decision-making and biased pattern recognition. As a result, the use of AI systems in education must be regulated. This study outlines opportunities for utilizing AI to enhance education, acknowledges potential difficulties, and formulates suggestions to direct future policy development.

DEEP LEARNING

Deep learning is a part of machine learning. Contrary to traditional machine learning algorithms, many of which have a finite ability to learn regardless of the quantity of data they get, deep learning systems can perform better with access to more data, which is the machine equivalent of more experience. Once they have accumulated enough experience through deep learning, machines can be trained to perform specific tasks like driving a car, identifying weeds in a field of crops, diagnosing diseases, looking for weaknesses in machinery, and other duties. Deep learning networks learn by spotting intricate patterns in the material they analyse. In order to describe the data, the networks can achieve various levels of abstraction by building computational models that are composed of several processing layers.

For example, a convolutional neural network, a sort of deep learning model, can be trained using numerous (hundreds of thousands or millions) of images, such as ones of cats. This particular neural network frequently gathers data from the pixels in the images it collects. With sets like claws, ears, and eyes indicating the presence of a cat in a photo, it has the capacity to classify sets of pixels that are typical of cat characteristics. There are significant differences between deep learning and conventional machine learning. In order to recognize the traits of a cat in this scenario, a domain expert would have to put a lot of effort into creating a standard machine learning system. With deep learning, all that is necessary to teach the system the characteristics

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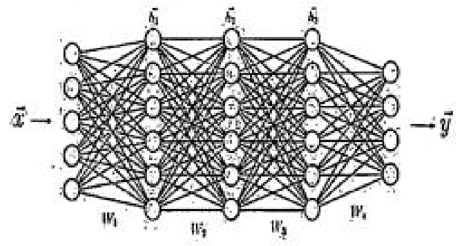
of a cat is to feed it a very large number of images of cats. For many tasks, such as computer vision, speech recognition (also known as natural language processing), machine translation, and robotics, deep learning systems outperform typical machine learning systems by a large margin. This does not imply that creating regular machine learning systems is easier than creating deep learning systems.

ARCHITECTURE OF DEEP LEARNING

Deep learning is a subset of machine learning, which is a subset of artificial intelligence. Generally speaking, "artificial intelligence" refers to techniques that enable computers to mimic human behavior. Machine learning, a group of algorithms that have been taught on data, enables all of this. Deep learning is just one type of machine learning that models the structure of the human brain.

Architecture of Deep Learning

Using a predetermined logical structure, deep learning algorithms continuously examine data in an effort to come to conclusions that are akin to those made by people. Neural networks, a multi-layered structure of algorithms, are used by deep learning to do this.



Architecture of Neural Network

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The architecture of the neural network was inspired by the structure of the human brain. Similar to how human brains automatically recognize patterns and group different types of information, neural networks may be trained to do the same. Using the distinct neural network layers as a form of filter that goes from coarse to fine increases the likelihood of recognizing and generating an appropriate outcome. The human brain acts in a similar manner. Every time we receive new knowledge, the brain tries to draw parallels with familiar objects. The same concept is also used by deep neural networks. Neural networks can be used for a range of tasks, such as grouping, classification, and regression.

DESCRIPTION OF DRAWINGS

FIG 1: ARCHITECTURE OF SENSORS AND ACTUATORS

FIG 2: ARCHITECTURE OF IOT

FIG 3: ARCHITECTURE OF DEEP LEARING

FIG 4: ARCHITECTURE OF NEURAL NETWORK

FIG 5: ARCHITECTURE OF AGRIGROW: INTELLIGENT CROP RECOMMENDATION SYSTEM USING IOT & ARTIFICIAL INTELLIGENCE

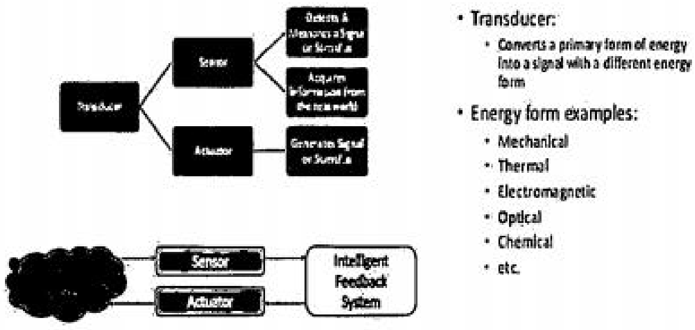

FIG 1: ARCHITECTURE OF SENSORS AND ACTUATORS

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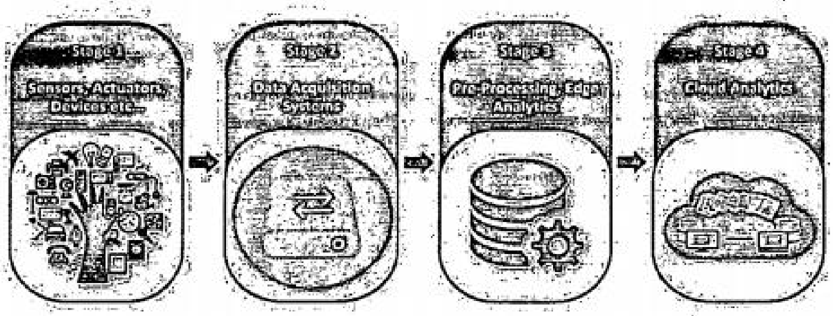

FIG 2: ARCHITECTURE OF IOT

FIG 3: ARCHITECTURE OF DEEP LEARING

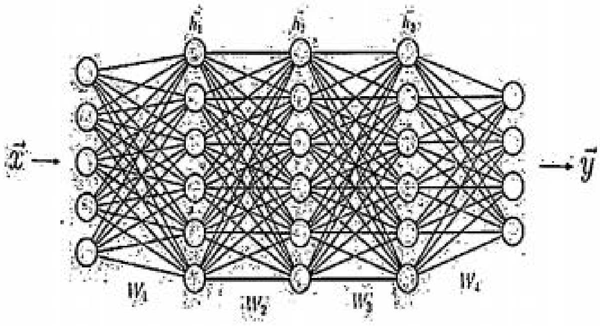

FIG 4: ARCHITECTURE OF NEURAL NETWORK

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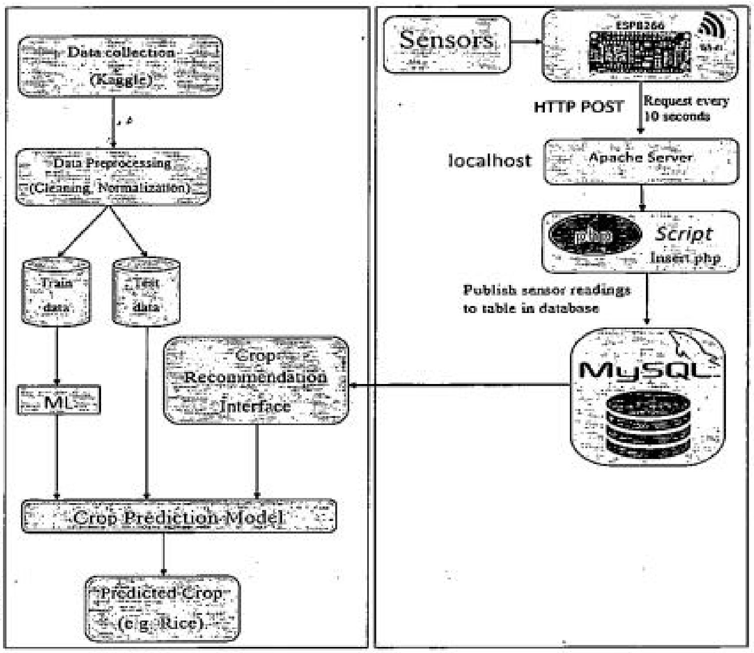

FIG 5: AGRIGROW: INTELLIGENT CROP RECOMMENDATION SYSTEM USING IOT & ARTIFICIAL INTELLIGENCE

CLAIMS

We Claim:

a. Agrigrow: Intelligent Crop Recommendation System Using Iot & Artificial Intelligences uses high speed network connections to communicate between the smart farm and the farmer. Here, a person does not require carrying any physical gadgets.

b. Agrigrow: Intelligent Crop Recommendation System Using Iot & Artificial Intelligences uses deep learning and machine learning methods, also it includes Digital Camera, Sensors, and communicating module with high speed network.

c. b. Agrigrow: Intelligent Crop Recommendation System Using Iot & Artificial Intelligences using live camera device, sensors which share the images of farm field. This device requires embedded devices like Digital camera,Sensors, location tracker etc.

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AGRIGROW: INTELLIGENT CROP RECOMMENDATION SYSTEM USING IOT & ARTIFICIAL INTELLIGENCE

ABSTRACT

Agriculture plays a vital role in the Indian economy, supporting millions of livelihoods and making a significant contribution to food production. However, farmers face challenges in selecting appropriate crops amidst unpredictable climate changes, diverse soil conditions, and fluctuating rainfall patterns, often resulting in diminished yields and financial setbacks. Artificial intelligence and sensor technology have become indispensable in the agricultural sector in recent years. The truth is that agricultural science diligence is more thorough, accurate, data-driven, and vigorous than ever in the contemporary era, regardless of any insights that may exist on agricultural methods. The advent of Internet of Things (IoT)-based technology has brought about changes in almost every area, including "smart agriculture or precision agriculture," smart homes, smart grids, smart cities, and smart health. The agriculture sector will gain new advantages from the application of machine learning through IoT data analytics in order to meet the world's increasing need for food. This will increase crop field productivity in terms of quantity and quality The system employs an Arduino-based setup featuring a pH sensor for soil acidity measurement and a DHT11 sensor for real-time temperature and humidity monitoring. Data from these sensors is transmitted to a MySQL database via XAMPP and accessed through a PHP-based web interface. Using the Random Forest algorithm, a machine learning model processes this data to recommend optimal crops tailored to specific environmental conditions. By merging live sensor data with machine learning insights, farmers receive precise recommendations customized to their agricultural settings, mitigating crop failure risks and enhancing overall harvest yields. This technology-driven approach bridges traditional farming practices with contemporary innovations, empowering farmers with actionable insights to foster sustainable agriculture, optimize resource utilization, and enhance food security amid evolving environmental challenges.

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