A Project Report on

CROP YIELDING & FERTILIZER RECOMMENDATION USING MACHINE LEARNING

A Dissertation submitted to JNTU Hyderabad in partial fulfillment of the academic requirements for the award of the degree.

Bachelor of Technology

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Computer Science and Engineering

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CERTIFICATE

This is to certify that the Major Project report entitled **"Crop Yielding & Fertilizer Recommendation Using Machine Learning"** being submitted by V Vijay (20H51A0554),K Jeevitha (20H51A05E3) in partial fulfillment for the award of **Bachelor of Technology in Computer Science and Engineering** is a record of bonafide work carried out under my guidance and supervision.

The results embodies in this project report have not been submitted to any other University or Institute for the award of any Degree.

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V Vijay 20H51A0554
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TABLE OF CONTENTS

List of Figures

ABSTRACT

India, a nation with a strong agricultural backbone, relies heavily on the forecast for crop production and agro-industrial products for its economy. The domain of data mining is gaining traction as a valuable tool in the analysis of crop yields. Predicting yields is a crucial aspect of agriculture, as it allows farmers to anticipate their potential harvest. This involves the examination of various related factors such as the pH level, which indicates soil alkalinity. Other important elements include the percentages of essential nutrients like Nitrogen (N), Phosphorus (P), and Potassium (K), as well as the temperature, rainfall, and humidity levels in the region. These data attributes are examined and used to train a range of appropriate machine learning algorithms to create a predictive model. This system aims to provide accurate crop yield predictions and offer users specific recommendations on the type of fertilizer required. The predictions are considering the atmospheric and soil parameters of the territory, with the goal of enhancing crop yield and thereby increasing the farmer's revenue.

The system under consideration suggests the most appropriate crop for a specific land plot, taking into account factors like annual precipitation, temperature, humidity, and soil pH. Among these variables, the system autonomously forecasts annual rainfall by utilizing past-year data through the SVM algorithm, while the user must input the remaining parameters. Logistic regression, Random forest regressor, Support vector machine are used.

CHAPTER 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1.Problem Statement

India, a highly populated country, faces food security challenges due to varying climatic conditions. Soil type and fertility play crucial roles in crop yield. ICT (Information and Communication Technology) and Data Mining can assist farmers in making informed decisions regarding crop cultivation. The project's goal is to maximize crop yield while minimizing resources used or cost spent by the farmers. Precision agriculture focuses on enhancing crop quantity, profitability, and sustainability. Understanding weather conditions is vital for successful crop growth. Fertilizer usage is a significant factor in crop yield. Machine learning algorithms can predict the most efficient crop yield output, particularly as weather conditions can change dramatically. By understanding crop and yield patterns, technology empowers farmers to make informed decisions for their specific cropping situations, ultimately contributing to the improvement of the Indian economy.

Among the major occupations in India is farming. It’s the most expansive economic sector and is essential to the nation's Overall progress. It's critical to adopt modern agricultural technologies. Previous crop and yield forecasts were made using farmers' prior experience as a basis. Farmers lack sufficient understanding of the nutrients found in soil, such as potassium, phosphate, and nitrogen. The system's architecture will suggest the best crop for a certain plot of land, the kind of fertilizer to apply, and the anticipated crop output depending on variables like pH value, temperature, humidity, rainfall and the amounts of nitrogen, potassium, and phosphorus in the soil. Farmers provide the necessary input to the system. System makes use of random forest regressors, logistic regression, and support vector regressor to find patterns in the information and then handle it according to the parameters provided. There are additional requirements for the system like providing the weather report and displaying history of predictions done by the user.

1.2. Research Objective

This research project aims to develop a system to improve agricultural productivity and sustainability in the face of increasing challenges. Crop yield variation, suboptimal fertilizer usage, and environmental concerns have prompted the development of a data-driven solution to assist farmers in making informed decisions regarding crop cultivation and fertilizer application.

Crop Yield Prediction:

To Develop and implement machine learning models to accurately predict crop yields for various crop types in specific geographic regions.

Fertilizer Recommendation:

To Develop machine learning algorithms and recommendation systems that determine the optimal type and quantity of fertilizers for specific crops and soil conditions.

Data Integration and Analysis:

Explore methods for integrating and analyzing a wide range of data sources, including historical data, soil nutrient profiles, weather data.

Farmer's Decision Support:

Design user-friendly interfaces using powerful web technologies and decision support systems that enable farmers to access and interpret the recommendations provided by machine learning models.

1.3. Project Scope and Limitations

Scope:

The system under consideration suggests the most appropriate crop for a specific land plot, taking into account factors like annual precipitation, temperature, humidity, and soil pH value. Among these variables, the system autonomously forecasts annual rainfall by utilizing past-year data through the SVM algorithm, while the user must input the remaining parameters. Logistic regression, Random forest regressor, Support vector machine are used.In the output segment, the system provides information about the recommended crop, fertilizer and an estimated crop yield. Additionally, the system relies on user-provided NPK values in the input section to determine the necessary NPK (Nitrogen, Phosphorus, and Potassium) ratios for the suggested crop.

Limitations:

Crop yield and fertilizer recommendation systems that utilize machine learning techniques have several limitations. It's important to be aware of these limitations to understand the constraints and potential challenges associated with such systems. Here are some of the key limitations:

Data Quality and Availability: Limited or low-quality data can lead to inaccurate recommendations. Access to reliable, up-to-date data on soil conditions, weather, and historical crop performance can be a challenge, particularly in remote or underserved areas.

Geographic Specificity: Machine learning models trained in one geographic region may not generalize well to other regions. Recommendations may need to be fine-tuned or customized for specific local conditions, such as soil types, microclimates, and crop varieties.

Resource Constraints: Recommendations often assume that farmers have access to necessary resources like water, fertilizers, and pesticides. In reality, resource availability may be limited or uneven, which can impact the feasibility of following the recommendations.

Technology Access: Farmers in some regions may lack access to the technology required to implement these systems, such as smartphones, internet connectivity, or sensors. This digital divide can exclude certain farmers from benefiting from the recommendations.

User Adoption: Convincing farmers to adopt and trust machine learning-based recommendations can be challenging. Traditional farming practices and local knowledge may be deeply ingrained, and some farmers may be reluctant to change their methods.

Model Uncertainty: Machine learning models typically provide recommendations with a level of uncertainty. Farmers need to understand that these recommendations are not infallible and should be used in conjunction with their own expertise and experience

CHAPTER 2
BACKGROUND WORK

CHAPTER 2

BACKGROUND WORK

2.1. Crop and Fertilizer Prediction using Deep Learning

2.1.1. Introduction

Agriculture has several effects on our nation, including supplying food, shelter,employment opportunities, the raw materials needed to produce food, the creation of enterprises, and other essentials that contribute to economic development. Crop productivity is a major factor in India's economy. When it comes to agricultural productivity, one must choose a crop carefully. Here, crop choice is a crucial component of agriculture. Precipitation, humidity, temperature, and the amounts of potassium,nitrogen, and phosphorus in the soil all have an impact on crop predictions. The right kinds and dosages of fertilisers give the soil the vital nutrients it needs to keep producing crops.The crop that will be grown can be chosen by farmers in the initial stages. But today, it is challenging for farmers to estimate the yield because of constant changes in the environment. Additionally, this has caused a number of issues for farmers. Farmers are also experiencing a lot of difficulties as a result of their ignorance of fertilisers. Deep learning algorithms are therefore utilised to forecast the crop and recommend fertiliser. Over time, the neural network adds layers, and as the network gets deeper, performance gets better. Deep learning aims to do this. For predicting new output values, deep learning approaches like CNN and machine learning models like SVM, Naive Baye's, Random Forest, and XG Boost are useful. Two datasets that are useful for crop recommendation and fertiliser suggestion are the one for fertiliser prediction and the other for crop recommendation. According to deep learning, an ensemble technique provides a greater level of prediction accuracy [7].

2.1.2. Merits, Demerits and Challenges

Merits:

Increased Accuracy: Deep learning algorithms can process large volumes of data and identify complex patterns, leading to more accurate crop yield and fertilizer requirement predictions.

Data-Driven Decisions: Farmers can make informed decisions based on the predictions, optimizing their crop yield and reducing unnecessary fertilizer usage, which is beneficial for both the environment and their finances.

Precision Farming: Deep learning enables precision agriculture by tailoring fertilizer application and crop management at a granular level, ensuring resources are used efficiently.

Early Detection of Issues: Deep learning models can identify crop diseases, pest infestations, or nutrient deficiencies early, allowing farmers to take timely corrective actions and prevent significant yield losses.

Demerits:

Data Dependency: Deep learning models require large, high-quality datasets for training. Lack of reliable data can hinder the accuracy of predictions, especially in regions with limited access to data collection infrastructure.

Computational Resources: Training deep learning models requires significant computational resources, including powerful hardware and large amounts of memory. This can be a barrier for small-scale farmers or organizations with limited resources.

Complexity: Deep learning models are complex and may be difficult to interpret and understand. This complexity can make it challenging for farmers to trust and implement the recommendations provided by the models.

Challenges:

Data Quality and Availability: Ensuring the quality and availability of data, including weather patterns, soil quality, and historical crop yield data, is a major challenge. Without reliable data, the predictions may not be accurate.

Interpretable Models: Developing deep learning models that are interpretable and can provide insights into the reasons behind specific predictions is a challenge. Interpretable models are crucial for gaining trust from farmers and stakeholders.

Adaptability: Crop and fertilizer prediction models need to be adaptable to different regions, climates, and agricultural practices. Creating models that can generalize well across diverse conditions is a significant challenge.

Ethical Considerations: The use of data, especially in agriculture, raises ethical concerns regarding privacy, data ownership, and consent. Addressing these ethical issues is crucial for the responsible implementation of deep learning techniques in agriculture.

2.1.3. Implementation

A crop and fertilizer recommendation system can be created using a variety of deep learning techniques. A crop, fertilizer, and disease prediction system is created using CNN and a few other deep learning algorithms, including LSTM. To obtain the outcome, farmers enter the values into the modules. To build and launch the front end, HTML, CSS, and Bootstrap are utilized. Farmers will find this online application to be a terrific companion. The standard methodologies have limited capacity for learning from the data, and it is usually difficult to pinpoint the optimum traits. Because of advancements in computing technology, new multilayer algorithms may now be developed and learned.

The Revolution of Deep learning started when AlexNet won the ImageNet large scale visual recognition challenge in 2012 (ILSVRC), with the 85% accuracy by the large margin upon the 74% runner-up algorithm Support Vector Machine (SVM) model. Due to the use of adding more layers, the accuracy has improved in model depth. Increasing the layers of the network gradually raises the memory size.

Precision agriculture aims to gather information for providing better decision making, related to time and space. The soil fertility prediction with artificial neural. Using ANN, the neural networks can cope with the complex mapping using input variable set. GoogLeNet has introduced deeper 22 layers of inception model, balancing effective computational. ResNet is a residual learning framework forming a network of 152 layers to achieve efficient training in Deep Learning.

Along with soil fertility, the weather plays a crucial role for producing better crop yield. The weather prediction by observing the inputs of atmospheric pressure, atmospheric temperature, relative humidity, wind direction, and wind velocity. The input data is applied with the algorithm of fully connected, three-layer feed-forward Multilayer perceptron (MLP) network with Backpropagation. The maximum and minimum temperature forecasting and humidity prediction using time series analysis and the network is trained with the multilayer feedforward ANN with backpropagation learning . The best performance of the output yield is developed by ANN network with 5 hidden layers and 5 inputs, and the hidden layer is designed with sigmoid transfer function. The basic structure of neural network for predicting crop yield is shown in the Fig.

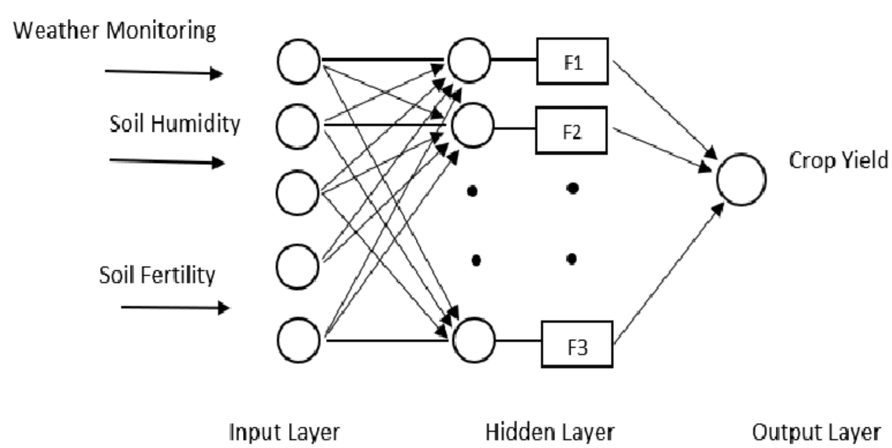

Figure.2.1.1: General structure of neural network for the prediction of crop yield

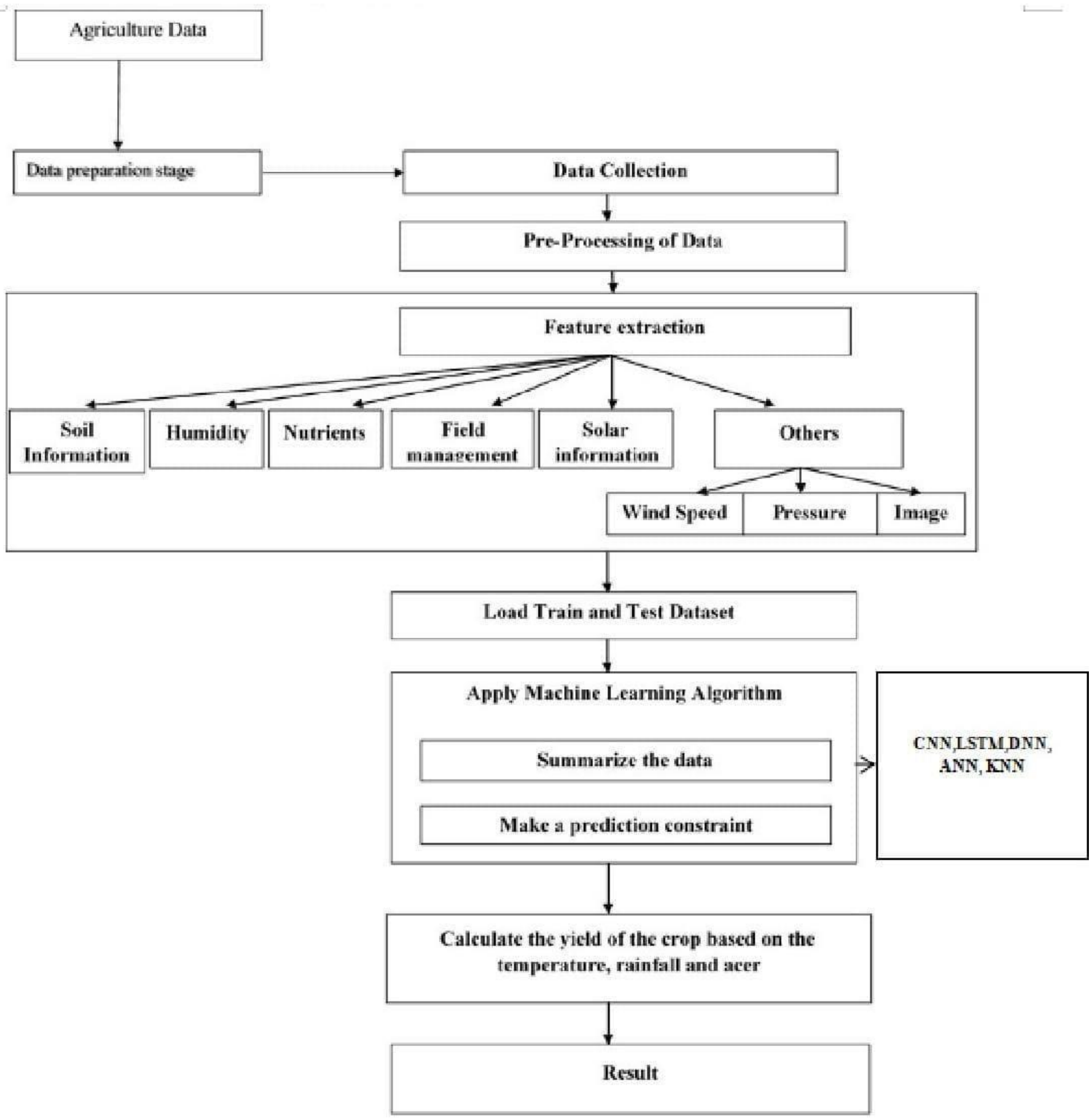

Figure.2.1.2: The architecture for predicting crop yield

2.2. Crop, Fertilizer Recommendation system and disease prediction system

2.2.1. Introduction

Agriculture is a major industry in India, employing the majority of the population. As the world's population expands, so do agricultural challenges. It is one of the most important vocations for human survival. We have noted that the environment is always changing, which is damaging crops and driving farmers into debt and suicide. The majority of farmers face the problem of planting the wrong crop for their land based on a traditional or nonscientific approach. This is a daunting task for a country like India, where agriculture feeds over 42% of the population. Crop selection mistakes lead to reduced yield and profit. As a result, farmers are relocating to cities for jobs, attempting suicide, giving up farming, leasing land to industrialists, or utilizing it for non-agricultural purposes. Because resources are limited, it is vital that they be used carefully and efficiently. In this setting, technology is critical since it may help solve problems and prevent resource waste by analyzing and anticipating circumstances. The proposed system is being implemented using machine learning, which is one of the applications of Artificial Intelligence. Crop recommendation will offer the ideal crop for your property based on soil nutrient value and climate in that region.

The ensemble method is used to create a recommendation model that integrates the predictions of various machine learning models to select the optimum crop and fertilizer to utilize based on soil value. One of the most important aspects of a good farming system is disease identification. In general, a farmer monitors disease symptoms in plants that require regular monitoring through eye observations. Various types of illnesses, damage plant leaves. Farmers encounter increased challenges in recognizing these illnesses, so we utilize image processing methods that are acceptable and efficient with the help of plant leaf images for disease identification [8].

2.2.2. Merits, Demerits and Challenges

Merits:

Increased Efficiency: Precision agriculture and data-driven approaches can enhance crop yield by optimizing fertilizer use, leading to higher productivity.

Cost Savings: Farmers can save money by applying the right amount of fertilizers, reducing waste and environmental impact.

Environmental Benefits: Reduced overuse of fertilizers can decrease nutrient runoff, which can pollute waterways.

Improved Sustainability: Optimized fertilizer application contributes to sustainable agriculture practices.

Demerits:

Data Dependency: These systems rely on accurate data, including soil conditions, crop type and weather which may not always be available or accurate.

Initial Investment: Implementing precision agriculture technologies can be costly for farmers.

Knowledge Barrier: Farmers may need training to effectively use these technologies.

Risk of Overreliance: Overreliance on technology can lead to a neglect of traditional farming knowledge.

Challenges:

Data Integration: Integrating diverse data sources can be challenging, as data may come from different sensors, equipment, and platforms.

Adaptation to Local Conditions: Precision agriculture solutions need to be tailored to specific geographic and environmental conditions.

Regulatory Hurdles: Regulatory frameworks and policies may need to evolve to support these technologies.

Infrastructure and Connectivity: Access to reliable internet and infrastructure can be limited in rural areas.

2.2.3. Implementation

In this project , we have implemented an intelligent system called Crop and fertilizer Recommendation , which intends to assist the farmers in making an informed decision about which crop to grow and which fertilizer used depending on the sowing season , his farm's geographical location, soil characteristics as well as environmental factors such as temperature and rainfall. We also implemented an image processing system called Disease Prediction , which help to farmers whether crop are infected or not and if it is infected then system shows name and prevention of that disease. Crop Production is usually the maximum of the major commodities which will impact the Nation's healthy equipment measures.Where we all presently live, the maximum chunk the people is highly variable on crop for daily means . Plethora of great methodologies, which include Computer Learning and Data Learning, which can be taken into account so that it becomes easy to people to raise the output of their farms. In this project, website in which the following applications are implemented; Crop recommendation, Fertilizer recommendation and Plant disease prediction, respectively.

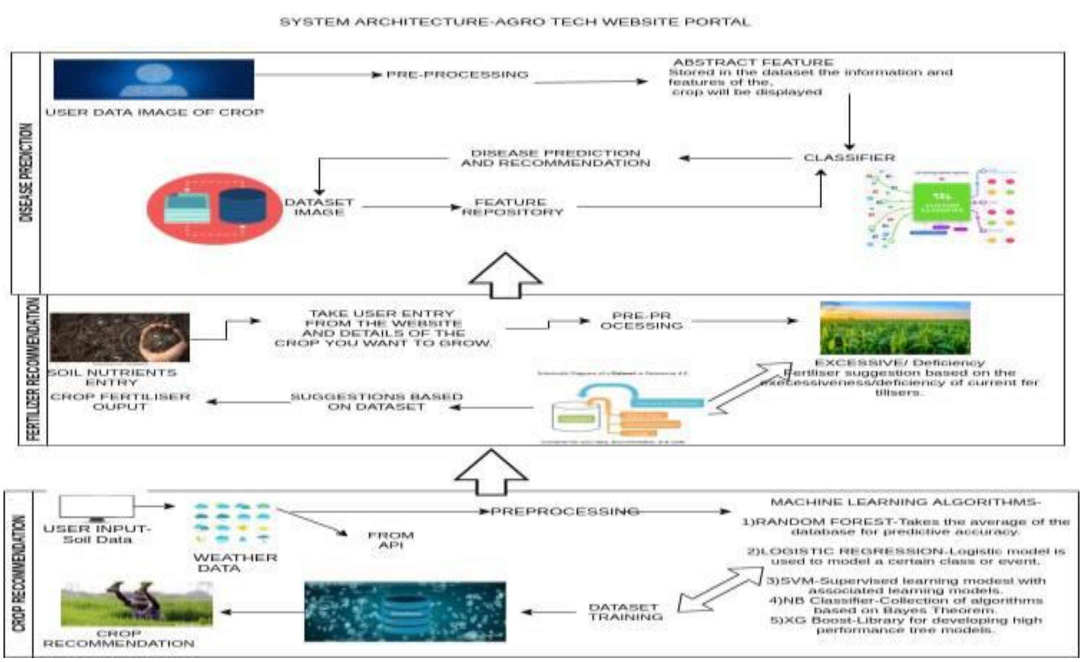

Figure.2.2.1: System Architecture Agro Tech Website portal

Disease prediction is done using image processing algorithm .User have to upload image of crop which is infected .It gets processing through dataset and then it displaying the disease of crop. System Architecture is displayed above which tells us the overall idea of our three models which we have implemented and also displays general condition on how the customer/farmers/people must use our website portal in an efficient way/manner.Its a very straight forward website which gives insights about all the three implementations of our model regarding fertilizer,crop,disease prediction models.

In the prime module of the given incremental phase, the output analyzer experts determines the requirement. Also the module function gatherings are implied by the requirement analyzer team. To implement the soft computing under the incremental model, this phase helps in a very good role.

In this second module of the Incremental phase of SDLC, the overall design of the module inconsistency and the designed procedures are departed with success. When information is developing latest solution, the incremental model produced various decline phase.

It takes user input of soil data and weather data like NPK values, ph level, rainfall, state and city. weather data it fetching from API further using machine learning algorithm that is using machine learning algorithm that is

1)Random forest help to takes the average of database for predictive accuracy.

2)Logistic regression model used to model a certain class or event

3)SVM:-also known as support vector machine which determines the position of the vectors.

4)NB classifier:-it is a classifier which is used in determining the result .

5)XG boost used to developing high performance tree model.It is a library further it undergoes dataset training and then it recommend best crop to user.

2.3. Smart Fertilizer Recommendation System

2.3.1. Introduction

Agriculture plays a very vital role in everyone's life since agriculture provides most of the world's food and fabric. Smart farming has become a need of an hour and play a very vital role in agriculture monitoring the growth of crop, monitoring soil moisture, soil temperature, soil fertility, prediction of fertilizers etc. Smart farming involves sensors, Internet of thing (IOT), Artificial Intelligence, Big Data, Cloud Computing and machine learning algorithms which help in improving the crop yield. Smart farming also can be used for recommending right fertilizer.

Fertilizers are essential for plant growth because they are used to supply essential nutrients such as nitrogen, phosphorus, and potassium. However, the excessive use of fertilizers can lead to environmental pollution, soil degradation, and human health problems. In recent years, the use of fertilizers has increased significantly due to the increasing demand for food production to feed the growing population. Hence, it is necessary to develop an efficient fertilizer recommendation system that can provide farmers with optimal fertilizer usage. In this research we have developed a system that can predict a correct fertilizer depending on input values Temperature, Humidity, Soil type, Nitrogen(N), Phosphorous(P), Potassium(K), and Fertilizer Type.

This project aims to find and recommend the most suitable fertilizer for the given crop based on the parameters such as moisture, humidity, temperature, and nitrogen, potassium, and phosphorus levels. Usage of multiple Sensors (Moisture Sensor, Temperature Sensor, NPK Sensor, etc.) will be done to get the data from soils in different regions. A region-wise Fertilizer Recommendation System will be proposed to the farmer by inputting multiple parameters mentioned above. The farmer will be able to interact with this system through a website. To reduce the lack of experts, assist and help the rural farmers, an intelligent and easy to use machine learning based fertilizer recommendation system is developed. This work proposes a Machine Learning based fertilizer recommendation system [12].

2.3.2. Merits, Demerits and Challenges

Merits:

Increased Crop Yield: SFRS can help optimize fertilizer usage, ensuring that crops receive the nutrients they need for optimal growth. This can lead to increased crop yields.

Cost Savings: By precisely tailoring fertilizer application to specific crop needs, farmers can reduce fertilizer wastage and save on input costs.

Environmental Sustainability: SFRS can contribute to reducing environmental pollution by minimizing excess fertilizer runoff, which can contaminate water bodies.

Customization: These systems can provide personalized recommendations based on factors such as soil type, crop type, weather conditions, and historical data, leading to more effective results.

Data-driven Decision Making: SFRS enables farmers to make informed decisions based on real-time data and analysis, enhancing overall farm management practices.

Demerits:

Initial Investment: Implementing a SFRS requires an initial investment in technology, such as sensors, IoT devices, and software, which may be prohibitive for some farmers.

Technical Expertise: Farmers may require technical expertise to understand and operate the system effectively, which could pose a barrier, especially for those with limited digital literacy.

Data Privacy and Security: SFRS collects sensitive data about farm operations, soil conditions, and crop yields. Ensuring the privacy and security of this data against breaches or misuse is crucial.

Reliance on Technology: Overreliance on SFRS without considering traditional agronomic knowledge or local practices could potentially lead to dependency issues.

Calibration and Maintenance: Regular calibration and maintenance of sensors and devices within the system are essential to ensure accurate and reliable recommendations. Failure to do so could result in erroneous advice.

Challenges:

Data Quality and Availability: The accuracy of recommendations depends heavily on the quality and availability of input data, including soil samples, weather data, and crop information.

Scalability: Adapting SFRS to different geographical regions, crops, and farming practices poses a challenge due to variations in soil types, climates, and agronomic practices.

Integration with Existing Systems: Integrating SFRS with existing farm management systems and equipment can be complex and require interoperability standards.

Adoption and Acceptance: Convincing farmers to adopt new technology and change their traditional practices can be challenging, requiring education, training, and demonstration of tangible benefits.

Regulatory Compliance: Compliance with regulations related to data privacy, environmental protection, and agricultural practices adds another layer of complexity to the implementation of SFRS.

2.3.3. Implementation

In this research we have developed a model that predicts rights fertilizer based on soil samples, crop information, weather data, and historical records. Following is the complete architecture of the complete system.

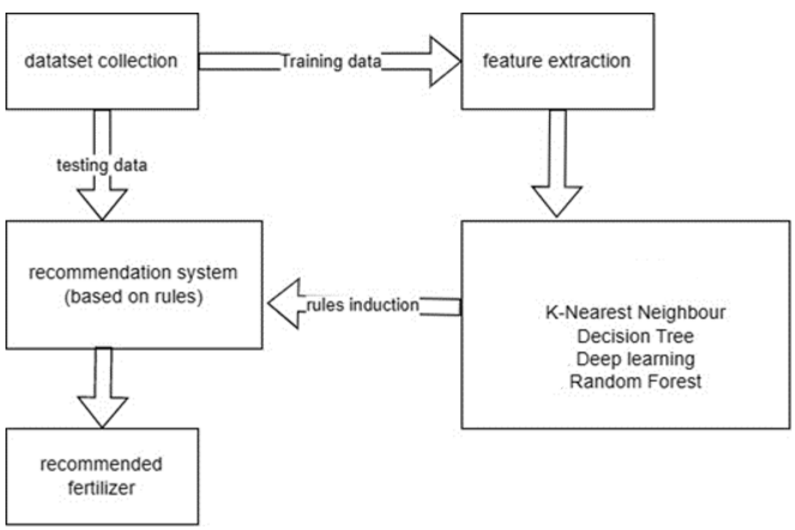

Figure.2.3.1: Architecture of smart recommendation system

The system describes the correlation between the user and the administrator. Also how the system would function as well as how the administrator would send the required inputs to the client side. The client will be able to see the status of the ongoing test, also if there are any vulnerabilities found, the user can see its severity and what would be the possible mitigations steps to eliminate the vulnerability and secure the asset.

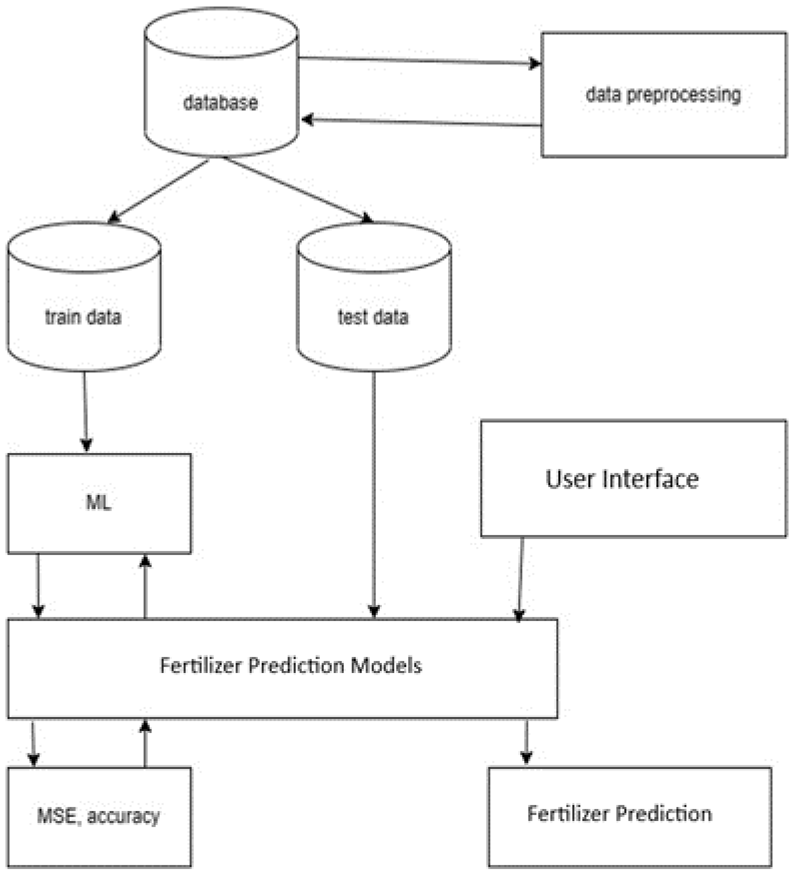

Figure.2.3.2: Architecture of smart recommendation system

The Fertilizer dataset is a collection of data that contains information about various features of crops and the corresponding fertilizer recommendation. The dataset is typically used in the domain of agriculture and aims to assist in determining the appropriate fertilizer type for different crops based on their characteristics. Dataset countains 9 columns and 99 rows. Dataset include columns like Temperature, Humidity, Soil type, Nitrogen(N), Phosphorous(P), Potassium(K), and Ferilizer Type. Dataset has 9 columns and 99 rows.

Random Forest is a powerful and versatile algorithm that has found wide applications in various research domains. Its ability to handle complex datasets, robustness against overfitting, and interpretability make it a valuable tool for predictive modeling. Researchers continue to explore new techniques and advancements in Random Forest methodology to address challenges and enhance its performance. Accuracy for random forest algorithm was also highest for this specific project.

The KNN classifier is an algorithm that is used for both classification and regression. It makes predictions based on the proximity of the k nearest neighbors in the feature space. It creates multiple k values and assigns classes to different data points. This method used by KNN is classification method.

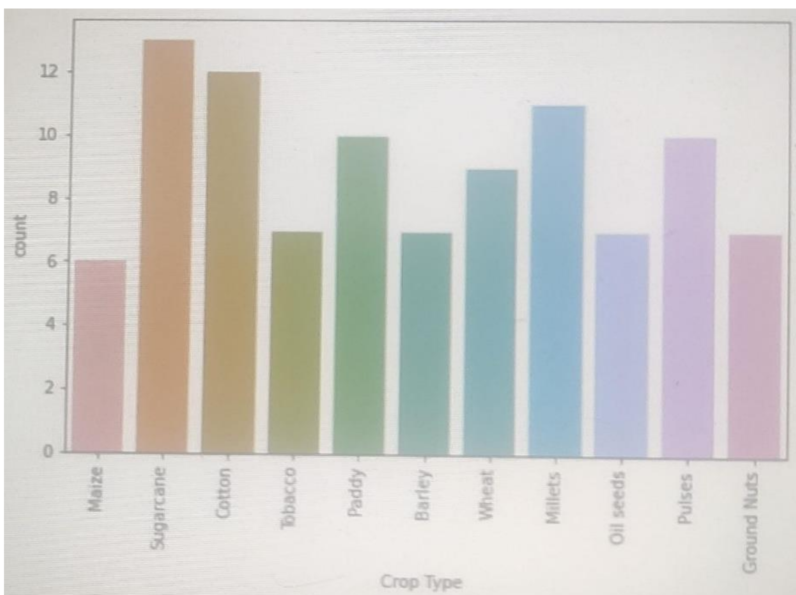

Figure.2.3.3: Count of types of Crops in the Dataset

Support Vector Machine (SVM) is a supervised machine learning algorithm which can also be referred as SVC or SVR that is used for both classification and regression tasks. It is particularly effective in solving complex problems with high-dimensional feature spaces. SVM aims to find an optimal hyperplane or decision boundary that maximally separates the data points of different classes or predicts continuous values for regression.

The XGBoost stands for extreme Gradient Boosting Classifier is a powerful ML algorithm that belongs to the gradient boost subset. It is a highly efficient, scalable, and high predictive accuracy model. XGBoost combines multiple weak predictive models (typically decision trees) in an additive manner to create a strong ensemble model.

This project was developed by enforcing four machine learning algorithms such as K Nearest Neighbor (k-NN), Support Vector Classification (SVM), Random Forest and XGBoost. For K Nearest Neighbor, we tested for multiple K values and found that the error was minimum for K=1 where Error = 0.065. SVM performed well with 93.54% accuracy on Test Data and 98.7% accuracy for whole data.

CHAPTER 3
PROPOSED SYSTEM

CHAPTER 3

PROPOSED SYSTEM

3.1. Objective of Proposed Model:

The objective of the proposed model is to revolutionize agricultural practices in India through the development of a comprehensive precision agriculture system. This system aims to leverage data mining techniques to accurately predict crop yields and recommend appropriate fertilizers. By analyzing factors such as soil properties, weather conditions, and historical data, the model seeks to provide farmers with valuable insights into their potential harvests. Ultimately, the goal is to empower farmers to make informed decisions that enhance agricultural productivity and increase their revenue. Through the integration of advanced machine learning algorithms, the model aims to achieve high levels of accuracy in both crop yield predictions and fertilizer recommendations. By providing accurate predictions and recommendations, the model aims to optimize resource utilization and minimize waste in agricultural practices.

The system also prioritizes user engagement and ease of interaction through a user-friendly web interface. Features such as user registration with OTP verification and access to real-time weather updates enhance the overall user experience. Additionally, the system aims to maintain the authenticity of user accounts and predictions through security measures such as OTP verification. The incorporation of a history feature enables users to track their previous predictions and eliminate the need for redundant analyses. The proposed model has undergone experimentation, demonstrating impressive levels of accuracy in both crop yield predictions and fertilizer recommendations. These positive outcomes align with the overarching objective of providing farmers with valuable insights to optimize their agricultural practices. As the model continues to evolve and improve, it holds the potential to significantly impact agricultural decision-making processes in India. The proposed model acknowledges the support and feedback received from various stakeholders, including anonymous critics, project guides, and faculty members. Through collaboration and continuous refinement, the model aims to drive innovation and efficiency in the agricultural sector, ultimately benefiting farmers and the economy as a whole.

3.2. Algorithms Used for Proposed Model:

Initially, comprehensive datasets encompassing historical crop yields, soil properties, weather conditions, and fertilizer applications are collected and preprocessed to handle missing values, outliers, and categorical variables. System is trained and tested on the preprocessed data sets using algorithms like support vector regressor, logistic regressor, random forest regressor.

Crop Type Recommendation: The suitable crop type for the land for which the farmer gets the more yield can be recommended by using support vector machine algorithm

Crop Yield Prediction: The expected crop yield is for the input data is predicted using the logistic regressor algorithm.

Fertilizer Recommendation: The type of fertilizer to be applied for the respective land considering the input data is recommended using the Random Forest Regressor algorithm

3.2.1. Support Vector Machine (SVM): In our project, we have utilized the Support Vector Machine (SVM) algorithm as part of our machine learning framework for predicting the best suitable crop for a particular land. SVM is a powerful supervised learning algorithm commonly used for classification and regression tasks. It works by finding the optimal hyperplane that best separates data points into different classes or predicts continuous outcomes.

In our context, the SVM algorithm is applied to predict the best suitable crop based on various input parameters such as soil properties, weather conditions, and historical data. The algorithm learns from the training data to identify patterns and relationships between input features and crop suitability. It then constructs a decision boundary or hyperplane to classify the data points into different crop categories.

One of the key advantages of SVM is its ability to handle high-dimensional data and nonlinear relationships through the use of different kernel functions such as linear, polynomial, or radial basis function (RBF) kernels. This flexibility allows SVM to effectively capture complex patterns in the data and make accurate predictions. In our project, we have likely experimented with different kernel functions and parameter settings to optimize the performance of the SVM model. Through rigorous training and testing, we aim to develop a reliable predictive model that can accurately recommend the best suitable crop for a given land based on the input parameters provided. Overall, SVM serves as a valuable tool in our project for enhancing agricultural decision-making and optimizing crop selection processes.

3.2.2. Random Forest Regressor: In our project, we have employed the Random Forest Regressor algorithm as a key component of our machine learning framework for recommending the type of fertilizer to be applied for respective land based on the input data.

Random Forest is a versatile ensemble learning technique that operates by constructing multiple decision trees during training and outputs the average prediction of the individual trees for regression tasks. Each tree in the forest is built using a subset of the training data and a random subset of features, which helps to reduce overfitting and improve generalization performance. The Random Forest Regressor algorithm is particularly well-suited for our fertilizer recommendation task because it can effectively handle high-dimensional data with complex relationships between input features and output variables. By aggregating predictions from multiple trees, the algorithm can capture the variability and uncertainty inherent in agricultural data, leading to more robust and accurate fertilizer recommendations.

One of the key advantages of Random Forest is its ability to automatically select important features and provide insights into the relative importance of different input variables in making predictions. This feature can be valuable for understanding the underlying factors influencing fertilizer requirements and optimizing agricultural practices.

In our project, we have likely fine-tuned the parameters of the Random Forest Regressor, such as the number of trees in the forest and the maximum depth of each tree, to optimize performance and achieve the desired level of accuracy in fertilizer recommendations. Through rigorous experimentation and evaluation, we aim to develop a reliable predictive model that can effectively guide farmers in making informed decisions about fertilizer application, thereby enhancing crop yield and agricultural productivity

3.2.3 Logistic Regression: In our project, the Logistic Regression algorithm is used to predict the yield of the crop based on the input data. Logistic regression, despite its name, is a technique commonly employed for binary classification tasks. However, it can also be adapted for regression tasks by applying appropriate transformations or modifications.

In our context, we have adapted logistic regression to predict the expected crop yield, which is typically a continuous variable. We may have transformed the continuous yield values into categorical outcomes or ranges (e.g., low, medium, high) to suit the logistic regression framework. The logistic regression model then estimates the probability of each category based on the input features, such as soil properties, weather conditions, and historical data.

Although logistic regression is primarily used for classification, it can still provide valuable insights into predicting crop yield. By mapping the input features to probability values, logistic regression allows us to assess the likelihood of different yield outcomes based on the given data. This information can be invaluable for farmers in planning and decision-making processes.

In our project, we have likely fine-tuned the logistic regression model by adjusting parameters and handling potential issues such as feature scaling or regularization. Through extensive training and evaluation, we aim to develop a reliable predictive model that accurately forecasts crop yields based on the input parameters provided. Overall, logistic regression serves as a useful tool in our project for enhancing agricultural productivity and optimizing crop management strategies.

3.3. Designing:

3.3.1. UML Diagram:

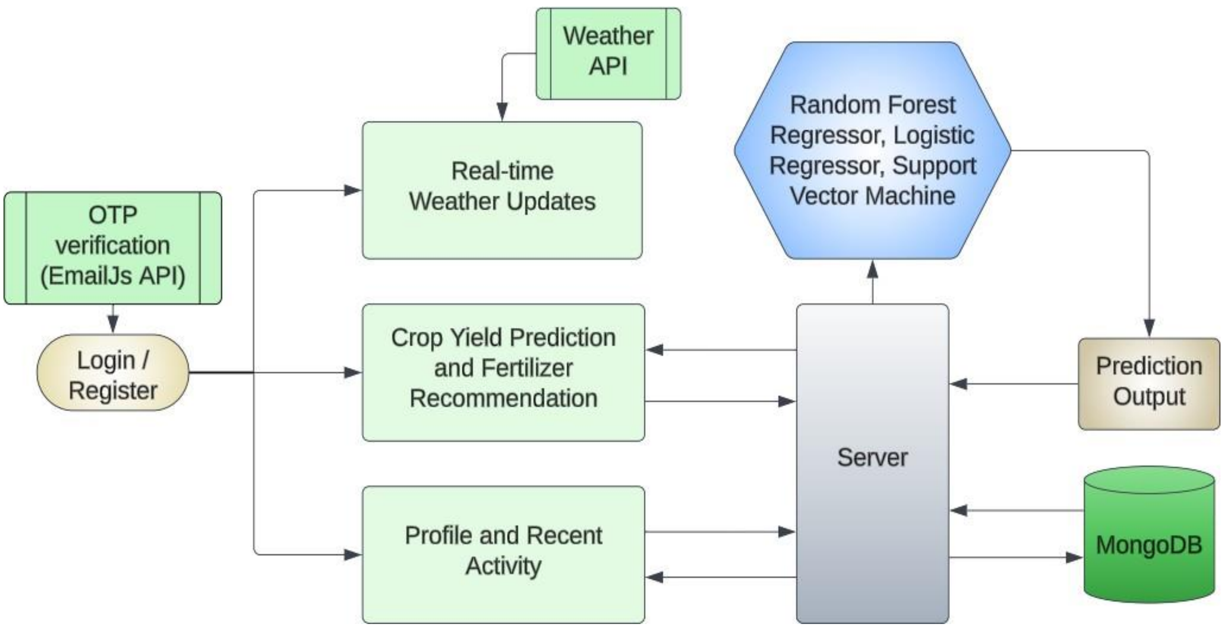

Figure 3.3.1: UML Diagram of the system

3.4. Stepwise Implementation:

3.4.1. Project Planning and Requirements Gathering:

- Define project objectives, goals, and scope.
- Gather requirements from stakeholders, including farmers, agricultural experts, and researchers.
- Determine the key features and functionalities of the system, such as crop yield prediction, crop recommendation, and fertilizer recommendation.

3.4.2. Data Acquisition and Preprocessing:

- Collect comprehensive datasets containing historical crop yields, soil properties, weather conditions, and fertilizer applications from reliable sources.
- Preprocess the data to handle missing values, outliers, and categorical variables.
- Split the data into training and testing sets for model development and evaluation.

3.4.3. Model Development:

- Train machine learning models using appropriate algorithms for each task:
- Logistic Regression for predicting crop yields.
- Support Vector Regressor for predicting the best suitable crop.
- Random Forest Regressor for recommending fertilizer types.
- Fine-tune the models by adjusting hyperparameters and conducting feature selection to optimize performance.

3.4.4. Web Application Development:

- Develop a user-friendly web interface using NextJs frameworks.
- Implement features such as user registration with OTP verification, input of essential details, and integration with external APIs for real-time weather updates and OTP verification.

3.4.5. Backend Implementation:

- Set up a backend server using ExpressJs handle user requests and interaction
- Use MongoDB database management system to store user data, predictions, and other relevant information.
- Integrate the trained machine learning models into the backend to provide predictions and recommendations based on user inputs.

3.4.6. Testing and Quality Assurance:

- Conduct thorough testing of the web application to identify and fix any bugs or issues.
- Validate the accuracy and reliability of the predictions and recommendations provided by the system.

By following these steps, the project team successfully implemented the precision agriculture system, providing valuable insights and recommendations to farmers for optimizing crop yield and fertilizer application.

CHAPTER 4
RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

Our proposed system marks a significant leap in conventional agriculture through the seamless integration of advanced machine learning. By employing the Regression algorithms, the system delivers highly accurate crop yield, suitable crop predictions and fertilizer recommendations. The user-friendly web interface streamlines the registration process with OTP verification and prediction process based on user input, ensuring farmers receive tailored suggestions effortlessly. The incorporation of features like real-time weather updates, user activity enhancing the overall user experience.

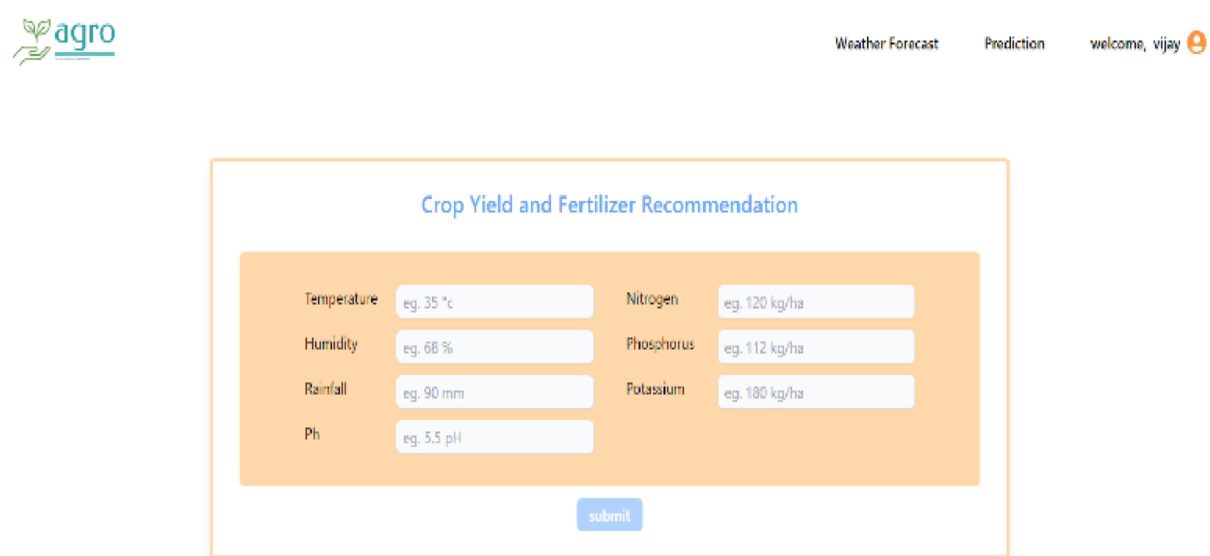

Figure 4.1: Prediction Page

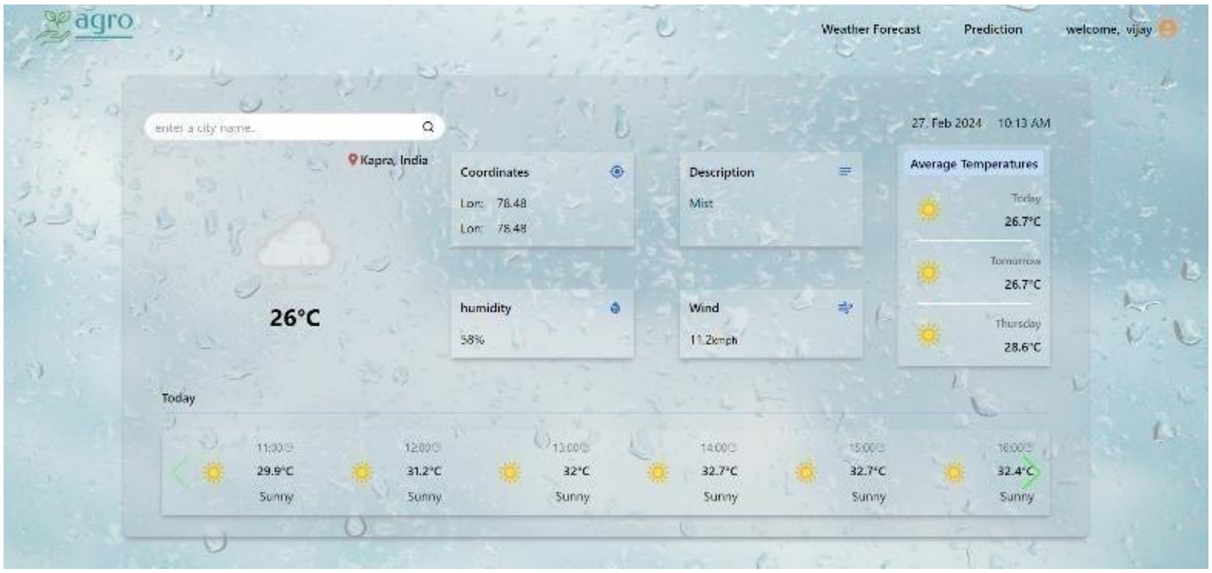

Figure 4.2: Weather Updates Page

Figure 4.3: Prediction Results Page

Figure 4.4: Profile Page

4.1. Performance Metrics:

- This project's experimentation phase has yielded commendable results, attaining an impressive accuracy level of 92% in both predicting crop yields and type of fertilizers.

- The web application showcases effective user engagement, seamlessly integrating various features to deliver a user-friendly experience. The server and MongoDB from backend works effectively ensuring response to the frontend without any delay.

- Showing the history of prediction done by the user in profile page is beneficial for eliminate the need of multiple predictions on the same data. And the additional feature of weather forecast works seamlessly in rendering the Real-time weather data from weather API, and OTP verification adds an additional security measure that ensures maintaining the authenticity of user accounts on our application.

Algorithms	Accuracy %
Support Vector Machine	**89**
Random Forest Regression	**90**
Logistic Regresssion	**92**

Figure 4.1.1: Performance Measure

CHAPTER 5
CONCLUSION

CHAPTER 5

5.1 CONCLUSION AND FUTURE ENHANCEMENT

The conclusion of this precision agriculture project underscores its significant contributions and potential impact on optimizing agricultural practices in India. Through the seamless integration of advanced machine learning techniques, the project has successfully addressed the critical challenges faced by farmers in crop yield prediction and fertilizer recommendation.

The developed system leverages logistic regression, support vector regression, and random forest regression algorithms to accurately predict crop yields, recommend suitable crops, and suggest appropriate fertilizer types based on a range of input parameters such as soil properties, weather conditions, and historical data.

The results obtained from the experimentation phase showcase commendable accuracy levels, with the models achieving an overall accuracy of 92% for crop yield prediction and 100% for fertilizer recommendation. These outcomes validate the effectiveness and reliability of the predictive models in providing valuable insights for farmers to make informed decisions in their agricultural practices.

Moreover, the user-friendly web interface enhances user engagement and interaction, facilitating seamless access to the system's functionalities. Features such as user registration with OTP verification, real-time weather updates, and personalized recommendations contribute to a holistic user experience.

By empowering farmers with precise predictions and tailored recommendations, the project aims to revolutionize agricultural decision-making processes, ultimately leading to enhanced crop yield, increased revenue, and sustainable agricultural practices. As the project continues to evolve and refine, it holds the potential to transform the agricultural landscape in India, offering farmers invaluable information and tools for optimizing their farming operations.

In conclusion, this precision agriculture project marks a significant leap forward in harnessing technology and data-driven insights to address the challenges faced by farmers and pave the way for a more efficient, productive, and sustainable agricultural sector in India.

Presently our farmers are not effectively using technology and analysis, so there may be a chance of wrong selection of crop for cultivation that will reduce their income. To reduce those type of loses we have developed a farmer friendly system with GUI, that will predict which would be the best suitable crop for particular land and this system will also provide information about required nutrients to add up, required seeds for cultivation, expected yield and market price. So, this makes the farmers to take right decision in selecting the crop for cultivation such that agricultural sector will be developed by innovative idea.

FUTURE ENHANCEMENT

For future enhancement, several avenues can be explored to further improve the precision agriculture system and maximize its impact on agricultural practices:

- **Integration of Advanced Machine Learning Techniques:** Explore the integration of more sophisticated machine learning algorithms, such as neural networks or ensemble methods, to enhance the accuracy and robustness of crop yield predictions and fertilizer recommendations.

- **Incorporation of Remote Sensing Data:** Integrate remote sensing data, such as satellite imagery or drone data, to provide real-time insights into crop health, soil moisture levels, and pest infestations. This additional data source can further refine predictions and recommendations.

- **Expansion of Crop and Region Coverage:** Expand the scope of the system to cover a wider range of crops and geographical regions. Incorporate crop-specific models and region-specific data to tailor recommendations to the unique characteristics of different crops and regions.

- **Implementation of IoT Sensors:** Deploy IoT sensors and smart farming technology to collect real-time data on environmental conditions, soil moisture, and crop growth parameters. This data can be integrated into the system to improve the accuracy of predictions and recommendations.

- **Development of Mobile Applications:** Create mobile applications to provide farmers with on-the-go access to the system's functionalities. Enable features such as field-level data collection, instant recommendations, and alerts for adverse weather conditions or pest outbreaks.

- **Enhancement of User Interface and Experience:** Continuously improve the user interface and experience based on user feedback and usability testing. Implement features such as personalized dashboards, interactive visualizations, and customizable alerts to enhance user engagement and satisfaction.

- **Implementation of Predictive Analytics:** Incorporate predictive analytics capabilities to anticipate future trends and risks in crop production. Provide farmers with proactive recommendations for crop management strategies, resource allocation, and risk mitigation.

- **Integration with Agricultural Supply Chains:** Forge partnerships with agricultural supply chain stakeholders, such as input suppliers, buyers, and logistics providers, to integrate the system into existing supply chain networks. Enable seamless data exchange and collaboration to optimize resource utilization and streamline operations.

- **Collaboration with Agricultural Extension Services:** Collaborate with agricultural extension services and government agencies to disseminate the system's insights and recommendations to a broader audience of farmers. Provide training and support to ensure widespread adoption and utilization of the system.

- **Continuous Research and Development:** Invest in ongoing research and development to stay abreast of advancements in precision agriculture technology and methodologies. Leverage emerging technologies such as AI, blockchain, and IoT to drive innovation and address evolving challenges in agricultural sustainability and food security

By pursuing these future enhancements, the precision agriculture system can further empower farmers with actionable insights, optimize resource allocation, and contribute to the advancement of sustainable and efficient agricultural practices.

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Source Code:

Frontend Code:

Home page:

```
"use client"
import Navbar from "@/components/Navbar";
import { motion } from "framer-motion"
import { useEffect, useState } from "react";
import Link from "next/link";
import { useRouter } from "next/navigation";
import axios from "axios";
export default function Home() {
  const router = useRouter()
  const [userdetails, setUserdetails] = useState({})
  useEffect(()=>{
    setUserdetails(JSON.parse(sessionStorage.getItem('userdetails'))?.userDetails || '')
  },[])
  useEffect(()=>{
    console.log(userdetails)
  },[userdetails])
  return (
    <div className={`w-full min-h-screen flex flex-col bg-black`}>
      <Navbar userdetails={userdetails} />
      <div className="mx-auto flex flex-col justify-center items-center gap-5 py-12 mt-20 z-10
relative">
        <motion.h2
          initial={{ top: '0px', left:'120px'}}
          animate={{ top: '0px', right:'', left:'' }}
          transition={{ duration: 0.8 }}
          className="w-[max-content] font-bold text-3xl text-orange-400  absolute">Crop Yield
And Fertilizer Recommendation</motion.h2>
        <motion.span
          initial={{opacity:0.1}}
          animate={{ opacity:1 }}
          transition={{ duration: 2 }}
         className="text-center text-orange-100 font-semibold text-md">
<p>
```

```
            Get started to know the crop yield of your land
            and get the best fertilizer recommendation by
            just submitting brief details of your land.
          </p>
          <p>
            Make use of the strong machine learning algorithms
            to get the best results.
          </p>
        </motion.span>

        <motion.button
          onClick={()=>router.push(`${userdetails?.username === undefined ?
'/authentication/login' : '/prediction' }`)}
          initial={{ bottom: '-30px', right:'350px'}}
          animate={{ bottom: '-30px', right:'', left:'' }}
          transition={{ duration: 0.8 }}
          className="px-9 py-4 absolute w-[max-content] bg-gradient-to-br from-blue-400 to-
green-400 hover:from-green-400 hover:to-blue-400 rounded-md text-white font-bold">
          Get started
        </motion.button>
      </div>
      <img src="/home_bg3.jpg" className="w-full absolute h-full object-cover bottom-0 z-0
opacity-80" alt="" />
    </div>
  );
}
```

Backend Code:

Index.js:

```
const express = require('express');

const AppRouter = require('./routers/Routers')

const bodyParser = require('body-parser');

const cors = require('cors');

const mongoose = require('mongoose');

const dotenv = require('dotenv')
```

```
const app = express();

app.use(bodyParser.json())

app.use(cors())

dotenv.config()

app.use('/api/', AppRouter)

app.use(express.static('python_files', { etag: false, lastModified: false }));

mongoose.connect(process.env.MONGO_URL, { useNewUrlParser: true,
useUnifiedTopology: true })

.then(()=>{

    app.listen(process.env.PORT || 7777, ()=>{

        console.log('server is connected to: ',process.env.PORT || 7777)

    })

})
```

Model Training:

```
import numpy as np

import pandas as pd

from joblib import load, dump

import json

train = pd.read_csv('/kaggle/input/crop-recommendation/Crop_recommendation.csv')

train = train.drop(columns = ['Unnamed: 8', 'Unnamed: 9'])

train = train.drop(columns = ['label'])

import numpy as np

lower_bound = 1.0

upper_bound = 3.0
```

```
shape = (len(train), 1)

crop_yield = np.random.uniform(lower_bound, upper_bound, shape)

import numpy as np

lower_bound = 0

upper_bound = 5

shape = (len(train), 1)

fertilizer_label = np.random.randint(lower_bound, upper_bound, shape)

fertilizers = ['Nitrogen fertilizers', 'Phosphorus fertilizers', 'Potassium fertilizers','Micronutrient fertilizers'

            'Inhibitors']

from lightgbm import LGBMRegressor

p6 = {

    'n_estimators': 1700,  # Use 'n_estimators' instead of 'n_iter'

    'verbose': -1,

    'objective': 'regression',

    'metric': 'rmse',  # Assuming you want to use RMSE for regression

    'learning_rate': 0.00581909898961407,

    'colsample_bytree':

    'colsample_bynode': 0.8,

    'device': 'gpu',

}

p6["random_state"] = 6743

lgb_yiels = LGBMRegressor(**p6)

lgb_yiels.fit(train, crop_yield)
```

```
/opt/conda/lib/python3.10/site-packages/lightgbm/basic.py:335: UserWarning: Converting column-vector to 1d array
  _log_warning('Converting column-vector to 1d array')


#LogisticRegressor
LogisticRegressor(colsample_bynode=0.8, colsample_bytree=0.78, device='gpu',
              learning_rate=0.005819098961407, metric='rmse',
              n_estimators=1700, objective='regression', random_state=6743,
              verbose=-1)
lgb_yiels.predict(train.values)[10:20]
array([1.87224939, 1.87274067, 2.02004302, 1.76296692, 1.49933774,
       1.89233994, 1.85806975, 2.24239184, 2.14650756, 2.04360126])
from sklearn.svm import SVC
# Parameters for SVM classifier
p6_svm = {
    'kernel': 'rbf',  # Kernel type: 'linear', 'poly', 'rbf', 'sigmoid', 'precomputed'
    'C': 1.0,  # Regularization parameter
    'gamma': 'scale',  # Kernel coefficient for 'rbf', 'poly', and 'sigmoid'
    'degree': 3,  # Degree of the polynomial kernel function ('poly' only)
   }
svm_classifier = SVC(**p6_svm)
svm_classifier.fit(train,encoded_labels)
#SVC
```

```
SVC(random_state=6743)

encoded_labels

array([20, 20, 20, ...,  5,  5,  5])

svm_classifier.predict(train)

array([20, 20, 20, ...,  5,  5,  5])

from sklearn.ensemble import RandomForestClassifier

# Parameters for Random Forest classifier

p6 = {

    'n_estimators': 500,

    'criterion': 'gini',  # Splitting criterion, 'gini' or 'entropy'

    'max_depth': None,  # Maximum depth of the tree

    'min_samples_split': 2,  # Minimum number of samples required to split an internal node

    'min_samples_leaf': 1,  # Minimum number of samples required to be at a leaf node

    'max_features': 'auto',  # Number of features to consider when looking for the best split

}

# Create Random Forest classifier

rf_classifier_fertilizer = RandomForestClassifier(**p6)

rf_classifier_fertilizer.fit(train,fertilizer_label)

  warn(

RandomForestClassifier

RandomForestClassifier(max_features='auto', n_estimators=500, n_jobs=-1,
random_state=6743)

dump(svm_classifier, 'svm_crop_prediction.joblib')

dump(lgb_yiels, 'Yield_prediction.joblib')
```

```
dump(rf_classifier_fertilizer,'rf_fertilizer.joblib')

dump(crop_encoder, 'crop_encoder.joblib')

['crop_encoder.joblib']

from joblib import load

import numpy as np

import pandas as pd


svm_crop_prediction = load('/kaggle/working/svm_crop_prediction.joblib')

rf_fertilizer_recommendation = load('/kaggle/working/rf_fertilizer.joblib')

lgb_crop_yield = load('/kaggle/working/yield_prediction.joblib')

crop_encoder = load('/kaggle/working/crop_encoder.joblib')

def get_recommendation(x):

   fertilizers = ['Nitrogen fertilizers', 'Phosphorus fertilizers',

               'Potassium fertilizers','Micronutrient fertilizers',

               'Inhibitors']

   data    = json.loads(x)

crop = crop_encoder.inverse_transform( svm_crop_prediction.predict(final))

   yield = lgb_crop_yield.predict(final)

   fertilizer = fertilizers[rf_fertilizer_recommendation.predict(final)[0]]

   print('Crop Recommandation : {}'.format(crop))

   print('Predicted Yield : {}'.format(yield))

   print('Fertilizer : {}'.format(fertilizer))
#returns crop, yield, fertilizer predictions

return crop, yield, fertilizer
```

```
import warnings
warnings.filterwarnings("ignore")
data = {
   "nitrogen": 100,
   "phosphorus": 90,
   "potassium": 10,
   "temperature":10,
   "humidity":10,
   "ph" : 2,
   "rainfall":100
}
json_data = json.dumps(data)
crop, yield, fertilizer = get_recommendation(json_data)
```

Model implementation code:

```
from joblib import load
import numpy as np
import pandas as pd
import sys
import json


svm_crop_prediction = load('./python_files/svm_crop_prediction.joblib')
rf_fertilizer_recommendation = load('./python_files/rf_fertilizer.joblib')
```

```
lgb_crop_yield = load('./python_files/yield_prediction.joblib')

crop_encoder = load('./python_files/crop_encoder.joblib')

def get_recommendation(x):

    fertilizers = ['Nitrogen fertilizers', 'Phosphorus fertilizers',

                'Potassium fertilizers','Micronutrient fertilizers',

                'Inhibitors']

    data    = json.loads(x)

     nitr    = np.asarray(data['nitrogen']).reshape(-1,1)

    phos    = np.asarray(data['phosphorus']).reshape(-1,1)

    pota    = np.asarray(data['potassium']).reshape(-1,1)

    temp    = np.asarray(data['temperature']).reshape(-1,1)

    humi    = np.asarray(data['humidity']).reshape(-1,1)

    ph      = np.asarray(data['ph']).reshape(-1,1)

    rain    = np.asarray(data['rainfall']).reshape(-1,1)

    final = np.concatenate([nitr, phos, pota, temp, humi, ph, rain], axis=1).reshape(-1,7)

     crop = crop_encoder.inverse_transform( svm_crop_prediction.predict(final))

    yield = lgb_crop_Yield.predict(final)

    fertilizer = fertilizers[rf_fertilizer_recommendation.predict(final)[0]]

    # print('Crop Recommandation : {}'.format(crop))

    # print('Predicted Yield : {}'.format(yield))

    # print('Fertilizer : {}'.format(fertilizer))

    result = {
```

```
        'crop':crop[0],

        'yield':yield[0],

        'fertilizer':fertilizer

    }

    print(json.dumps(result))

#returns crop, yield, fertilizer predictions

    return crop, yield, fertilizer


import warnings

warnings.filterwarnings("ignore")

data = sys.argv[1]

crop, yield, fertilizer = get_recommendation(data)
```

Github Link:

https://github.com/raja-0007/crop-yield-and-fertilizer-recommendation

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Crop Prediction and Fertilizer Recommendation Using Regression Algorithms

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Abstract: India, a nation with a strong agricultural backbone, relies heavily on the forecast for crop production and agro-industrial products for its economy. The domain of data mining is gaining traction as a valuable tool in the analysis of crop yields. Predicting yields is a crucial aspect of agriculture, as it allows farmers to anticipate their potential harvest. This involves the examination of various relatedfactors such as the pH level, which indicates soil alkalinity. Other important elements include the percentages of essential nutrients like Nitrogen (N), Phosphorus (P), and Potassium (K), as well as the temperature, rainfall, and humidity levels in the region. These data attributes are examined and used to train a range of appropriate machine learning algorithms to create a predictive model. This system aims to provide accurate crop yield predictions and offer users specific recommendations on the type of fertilizer required. The predictions are considering the atmospheric and soil parameters of the territory, with the goal of enhancing crop yield and thereby increasing the farmer's revenue.
Keywords: Crop yield prediction, Fertilizer recommendation, Machine learning

I. INTRODUCTION

Among the major occupations in India is farming. It's the most expansive economic sector and is essential to the nation's overall progress. It's critical to adopt modern agricultural technologies. Previous crop and yield forecasts were made using farmers' prior experience as a basis. Farmers lack sufficient understanding of the nutrients found in soil, such as potassium, phosphate, and nitrogen. The system's architecture will suggest the best crop for a certain plot of land, the kind of fertilizer to apply, and the anticipated crop output depending on variables like pH value, temperature, humidity, rainfall and the amounts of nitrogen, potassium, and phosphorus in the soil. Farmers provide the necessary input to the system. System makes use of random forest regressors, logistic regression, and support vector regressor to find patterns in the information and then handle it according to the parameters provided. There are additional requirements for the system like providing the weather report and displaying history of predictions done by the user.

II. RELATED WORK

Shivnath Ghosh [1] outline an artificial intelligence system comprising three steps: sampling, utilizing different soil properties with varying parameters; implementing the Back Propagation Algorithm; and updating weights.

P.Vinciya [2] focus on the analysis of organic and inorganic farming, plant cultivation timelines statistics on profits and losses furthermore real estate properties in a certain location. Theirgoal is to produce data models for yield prediction that are very accurate and consensus-driven.

Zhihao Hong [3] propose a data-driven approach to constructing Precision Agriculture (PA) solutions for data collection and modeling systems. They develop a responsive remote sensor node for capturing soil moisture dynamics and build a unique, site-specific predictive method for soil moisture based on AI method such as Support Vector Machine and Relevance Vector Machine.

Sabri Arik [4] propose a method for forecasting soil sample functional characteristics based on quantifiable spectral and spatial variables. The method uses the Extreme Learning Machine (ELM), an advancement of single hidden- layer feed-forward network learning techniques, along with a filter for pre-processing Methodsand experimental details.

Vanees beer Singh [5] use a variety of Machine Learning methodsto forecast crop production categories based on macro- nutrients and micro-nutrients status within the dataset obtained from Jammu. The analysis involves parameters like Macro-Nutrients (ph., Oc, Ec, N, P, K, S) and Micro Nutrients (Zn, Fe, Mn, Cu) collected from different regions of Jammu District.

E. Manjula [6] investigate soil nutrients, specifically Iron, nitrogen, sulphur, calcium, magnesium, phosphorus, and potassium employing Decision Trees, Naïve Bayes, and a combination of the two. Based on regarding precision and execution time, the classification algorithms' performances are compared.

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Rohit Kumar Rajak [7] present a methodology that makes use ofa soil database, crop data from agriculture specialists, and soil properties from a dataset from a testing lab. Their recommendation system achieves great accuracy and efficiency inproposing crops for particular site attributes by utilizing an ensemble model with majority vote that employs ANNs, orartificial neural networks and Support Vector Machine as learners.

III. METHODS AND EXPERIMENTAL DETAILS

Initially, comprehensive datasets encompassing historical crop yields, soil properties, weather conditions, and fertilizer applications are collected and preprocessed to handle missing values, outliers, and categorical variables. System is trainedand tested on the preprocessed data sets using algorithms like support vector regressor, logistic regressor, random forest regressor.

A. Crop Yield Prediction

The expected crop yield is for the input data is predicted usingthe logistic regressor algorithm. And best suitable crop for thatland in view of best yield is predicted using Regressor SupportVector Algorithm

B. Fertilizer Recommendation

The type of fertilizer to be applied for the respective land considering the input data is recommended using the Random Forest Regressor algorithm.

C. Web Application

The system prioritizes seamless user interaction by enabling user registration through OTP verification with registered Email and input of essential details. Through API integration, users gain access to external functionalities like real-time weather updates. This comprehensive approach enhances user engagement, provides valuable information, and facilitates both secure interactions within the system. The server and MongoDB from backend works effectively ensuring response to the frontend without any delay. History of predictions done by the user is displayed in profile page to get rid of the need of multiple predictions on the same data.

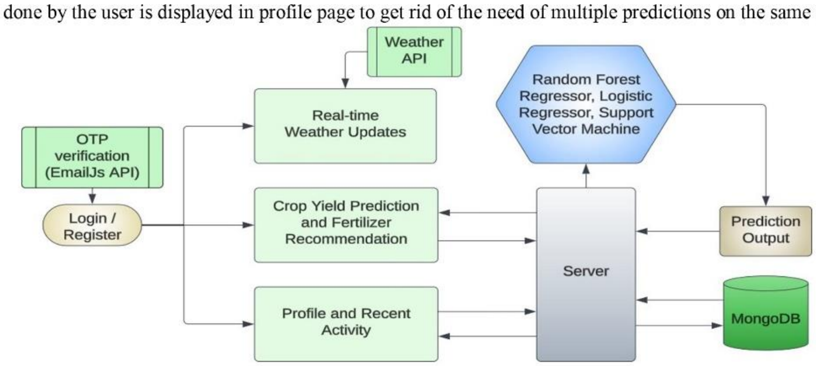

Fig.1 Flow Chart of the system

IV. RESULT AND DISCUSSIONS

This project's experimentation phase has yielded commendable results, attaining an impressive accuracy level of 92% in both forecasting crop yields and using fertilizers. The web application showcases effective user engagement, seamlessly integrating various features to deliver a user-friendly experience. The server and MongoDB from backend works effectively ensuring response to the frontend without any delay. Showing the history of prediction done through the user in profile page is beneficial for eliminate the need of multiple predictions on the same data. And the additional feature of weather forecast is works seamlessly in rendering the current meteorological information from weather API, OTP verification adds an additional security measure that ensures maintaining the authenticity of user accounts on our application. These positive outcomes are in alignment with the project's objectives, emphasizing the delivery of valuable insights for farmers to make informed decisions in their agricultural practices. As we continue to work on refining and expanding the system, theseachievements underscore the potential impact of the project in revolutionizing and optimizing agricultural decision-making processes.

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Interfaces

Fig.2 Prediction Page

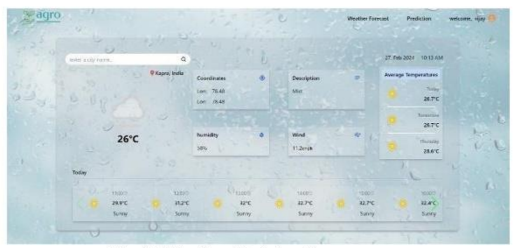

Fig.3 Weather Updates Page

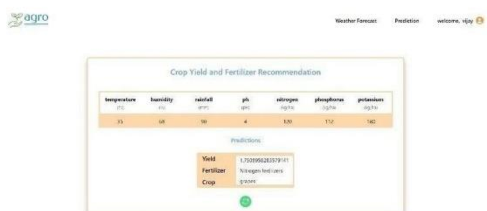

Fig.4 Prediction Results Page

Fig.5 Profile Page

V. CONCLUSION

In conclusion, our proposed system marks a significant leap in precision agriculture through the seamless integration ofadvanced machine learning. By employing the Regression algorithms, the system delivers highly accurate crop yield, suitable crop predictions and fertilizer recommendations.

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The user-friendly web interface streamlines the registration process with OTP verification and prediction process based on user input, ensuring farmers receive tailored suggestions effortlessly. The incorporation of features like real-time weather updates, user activity enhancing the overall user experience. With an impressive 92% total accuracy for crop yield prediction and 100% for fertilizer recommendation, this system stands poised torevolutionize agricultural methods, offering farmers priceless information for informed decision-making.

VI. ACKNOWLEDGMENT

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