REPORT

On

U18IT804: MAJOR PROJECT WORK

KHETI SAHAYAK: THE FUTURE OF FARMING, POWERED BY MACHINE LEARNING, WEB DESIGN AND API

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ABSTRACT

An innovative solution to counter the challenges posed by unpredictable climate changes in Indian agriculture, this research harnesses the potential of machine learning, specifically the Naive Bayes algorithm, to predict crop yields based on vital parameters such as temperature, humidity, moisture, pH, and rainfall. The user-friendly web application "Kheti Sahayak" streamlines data input, enabling farmers to effortlessly provide crucial information for accurate predictions, thus empowering them to make informed decisions and optimize crop productivity. Additionally, integrated features facilitate community collaboration, allowing farmers to share experiences, learn from each other, and collaborate on agricultural projects. By seamlessly integrating technology into agriculture, this research not only addresses climate change's impact but also showcases the potential of machine learning in providing dependable crop yield predictions. Through "Kheti Sahayak" and its comprehensive features, including real-time monitoring, data analysis, personalized recommendations, and community engagement, farmers are equipped with actionable insights. This facilitates effective cultivation practices and informed decision-making to enhance overall crop yields. This research underlines the transformative role of technology in reshaping agricultural practices, offering reliable tools in navigating uncertain conditions and contributing to heightened productivity and sustainable farming methods.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Smart farming, an innovative approach in modern agriculture, has paved the way for transformative solutions to age-old challenges. As we embark on a detailed exploration of the existing method, encapsulated in the base paper and subsequently delve into the proposed solution, the groundbreaking "Kheti Sahayak," we unravel the intricacies, technologies, algorithms, and data sources that collectively contribute to the evolution of smart farming. The base paper acts as a cornerstone, introducing beginners to the realm of computer-assisted crop prediction. At its core lies the Naive Bayes algorithm, a stalwart in the machine learning domain. The fundamental objective is clear, empower farmers with informed decisions based on predictions of crop suitability rooted in weather and soil conditions. The algorithm undergoes a systematic process encompassing data collection, preprocessing, feature extraction, and data prediction.

As we transition to intermediate levels of understanding, the focus intensifies on the Naive Bayes algorithm. Its strengths, namely efficiency and ease of implementation, make it a beacon for those new to machine learning. The paper leaves no stone unturned, addressing every facet from data gathering and preprocessing to feature extraction, model training, and evaluation. The clarion call for refining data and comprehending its limitations echoes through every phase, emphasizing the pivotal role of these steps in achieving accurate predictions. With a profound understanding of the foundational principles, we segue into the proposed solution, the magnum opus that is "Kheti Sahayak." This web-based application, a convergence of Machine Learning (ML) and Deep Learning (DL) techniques, is designed to be a panacea for farmers' woes. Its multifaceted features, including crop recommendation, fertilizer suggestions, and plant disease prediction, herald a new era in smart farming.

1.2 MOTIVATION

Beyond the lines of code and the algorithms humming within Kheti Sahayak lies a deeper narrative, a narrative of empowerment, sustainability, and community. The driving force behind Kheti Sahayak is rooted in addressing the challenges faced by farmers due to a lack of technical familiarity. The complexities of managing weather, labour, and market fluctuations often become daunting hurdles, impacting resource management, crop yield, and overall sustainability. The core philosophy is to equip technology-limited farmers with precise strategies, weather forecasts, crop monitoring, disease detection, and yield predictions. Automation becomes the silent ally, reducing labour needs, while market insights become the guiding light for strategic decisions.

In the Indian agricultural landscape, characterized by erratic climate patterns impacting crop yields, Kheti Sahayak steps in as the guardian against uncertainties. For farmers without access to technological resources, effective management becomes an elusive goal. Limited access to advanced technology and information becomes a bottleneck, hindering the optimization of practices, enhancement of productivity, and assurance of food security. The innovative spirit of Kheti Sahayak lies in its synthesis of machine learning and a user-friendly web application. It is not merely a platform that predicts crop yields or offers personalized recommendations; it is a revolutionary web application that fosters collaboration among farmers. It transforms the isolated landscape of traditional farming into a collaborative community, reminiscent of the forums that define social platforms like Reddit and Facebook.

1.3 MACHINE LEARNING, WEB DESIGN, AND API INTEGRATION

Peeling back the layers of Kheti Sahayak reveals the intricate interplay of machine learning, web design, and API integration. At the heart of this transformation is machine learning, not merely as a technological appendage but as the pulse that propels the platform forward. Machine learning becomes the beacon of predictive analytics, foreseeing the future of crop yields and facilitating informed decision-making. The machine learning algorithms within Kheti Sahayak become the virtual agronomists, leveraging historical and real-time data to provide actionable insights. They become the silent partners, understanding the nuances of soil, weather, and crop conditions to unravel the tapestry of optimized agricultural practices. It is this fusion of technology and agriculture that holds the key to mitigating the impacts of climate change. As Kheti Sahayak harnesses the potential of machine learning, it goes beyond mere prediction. The platform becomes the harbinger of real-time monitoring, data analysis, personalized recommendations, and community engagement.

CHAPTER 2
LITERATURE SURVEY

The exploration of advanced technologies in precision agriculture reveals a compelling narrative that significantly shapes our Kheti Sahayak project. Cited as [1], focusing on the application of deep learning for crop disease detection and plant classification using Convolutional Neural Networks (CNN) and transfer learning, stands out as a pivotal influence. This work has inspired Kheti Sahayak's disease detection capabilities and automated yield estimation, reflecting the efficiencies highlighted in the cited study.

Furthermore, the convergence of Machine Learning (ML), Deep Learning (DL), and the Internet of Things (IoT) in [2] and [3] has left a profound impact on the multifaceted approach integrated into Kheti Sahayak. Addressing aspects such as soil prediction, disease detection, and intelligent farming guidance, our project aligns with the holistic methodologies outlined in these studies. The challenges articulated in [2] and [3], such as a high initial investment and potential data security risks, have steered our project's considerations, ensuring a balanced approach that prioritizes innovation, practicality, and security.

The insights also extend to specific agricultural practices, drawing from the wisdom of [4], which explores fertilizer recommendation practices. Although Kheti Sahayak does not directly implement fertilizer recommendations, the study encourages the recognition of local conditions and optimization of recommendations, shaping the development of tailored features within our application. In essence, these insights underscore the collaborative and interdisciplinary nature of our approach, leveraging methodologies and lessons learned from diverse studies cited as [1], [2], [3], and [4], to create a comprehensive and impactful solution for precision agriculture.

The comprehensive survey on machine learning for the detection and prediction of crop diseases and pests in [5] has contributed to the overarching strategy of leveraging ML and DL techniques in our application. Additionally, [6] has inspired our emphasis on efficient data processing and effective planting management, aligning with the principles of smart farming. The comparative study on Random Forests and Decision Trees in [7] has influenced our considerations in choosing classification algorithms.

Table 2.1 Literature Survey

Sl. No.	AUTHOR	PAPER	METHODOLOGY	ADVANTAGES	DISADVANTAGES
01.	Zeynep Unal	Smart Farming Becomes Even Smarter with Deep Learning a Bibliographical Analysis	Implement deep learning for crop disease detection and plant classification using methods like CNN and transfer learning.	Enhanced disease detection. Automated yield estimation.	Limited specifics on methodologies.
02.	Senthil Kumar Swami Durai Mary Divya Shamili	Smart farming using Machine Learning and Deep Learning techniques	Utilizes IoT, Data Mining, Data Analytics, Machine Learning, and Deep Learning for precision agriculture.	Increased productivity reduced manual labour, smart farming guidance.	High initial investment, dependence on technology, potential data security risks.
03.	Abhinav Sharma, Arpit Jain, Prateek Gupta	ML Applications for Precision Agriculture: A Comprehensive Review	Implement ML, DL, and IoT for soil prediction, disease detection, and intelligent farming.	Enhanced crop yield, smart irrigation, livestock prediction.	Reliance on sensors, potential cost, and data security concerns.
04.	Jakia Sultana, M. N. A. Siddique, Md. Rishad Abdullah	Fertilizer recommendation for Agriculture: practice, practicalities and adaptation in Bangladesh and Netherlands	Literature research combined with personal experience and contact with advisors of BLGG AgroXpertus and SRDI.	Provides insights into the fertilizer recommendation practices in Bangladesh and the Netherlands.	Highlights the need for adjusting and optimizing fertilizer recommendations based on local conditions. Limited information on specific details of fertilizer recommendations.
05.	Tiago Domingue, Tomás Brandão, João C. Ferreira	Machine Learning for Detection and Prediction of Crop Diseases and Pests: A Comprehensive Survey	Implement ML, DL, and IoT for soil prediction, disease detection, and intelligent smart farming using Machine Learning and Deep Learning.	Promotes ML in agriculture for disease and pest detection. Automated yield estimation.	Emphasizes precision farming and smart agriculture. Limited focus on specific ML and DL techniques for smart farming. .

06.	Annafi' Franz, Eko Junirianto, Suswanto	Web Design and Application Programming Interface (API) Smart Farming Application	Waterfall Model: Analysis, Design, Coding, Testing, Maintenance.	Efficient data processing, effective planting management, increased productivity.	Requires understanding of REST principles, potential security concerns with data access.
07.	Jehad Ali, Rehanullah Khan, Nasir Ahmad	Random Forests and Decision Trees	Compared Random Forest and J48 for classifying datasets. Used 10-fold cross-validation.	Improved accuracy for large datasets. Handles missing values.	May not perform as well on small datasets. Random Forest complexity.
08.	Kaiming He, Xiangyu Zhang, Shaoqing Ren, Jian Sun	Deep Residual Learning for Image Recognition	Residual learning with shortcut connections, reformulating layers as learning residual functions.	Enables training of very deep networks. Eases optimization with improved accuracy.	Optimization difficulties in deep plain nets. Potential overfitting in aggressively deep models.
09.	Andy Neumann, Nuno Laranjeiro, Jorge Bernardino	An Analysis of Public REST Web Service APIs	Examined Alexa.com's top 4000 sites, identified 500 claiming REST APIs. Analysed 26 features manually, covering compliance, common decisions, and best practices.	Provides insights into REST service compliance, common practices, and best practices. Identifies trends and challenges.	Limited to a subset of web services, potential bias in random selection. Manual analysis may introduce human error.
10.	Aashis Rimal	Developing a Web Application on NodeJS and MongoDB using ES6 and Beyond	Developed a Web Application on NodeJS and MongoDB.	Speedy development with NodeJS. Scalability with MongoDB.	NodeJS limitations in handling complex computations. Challenges in MongoDB's document model.

CHAPTER 3
EXISTING SYSTEM

Utilizing the Naive Bayes algorithm, the existing methodology for addressing challenges in crop selection integrates modern technologies, particularly machine learning, into agricultural practices as proposed in [7]. Recognizing agriculture's pivotal role in global economies, the approach aims to enhance farming practices by leveraging computational techniques for accurate predictions as citied in [1]. The significance of integrating technology into agriculture is emphasized, directly addressing the central problem faced by farmers – optimal crop selection. A historical perspective sheds light on traditional hurdles, setting the stage for the paradigm shift towards computer algorithms as a solution for more precise predictions as citied in [3]. Delving into the Naive Bayes algorithm, a relatable analogy simplifies complex machine learning concepts, ensuring accessibility for readers less familiar with advanced computational techniques. The step-by-step methodology emphasizes the importance of data collection, including weather, soil conditions, and other factors crucial for accurate predictions. Subsequent preprocessing steps tackle data cleaning and organization, preparing the dataset for algorithmic analysis. Feature extraction, a critical stage, distils key factors influencing crop growth, streamlining the dataset and contributing to accurate predictions.

The data prediction elucidates the algorithm's core functionality, relying on historical data for informed predictions about crops likely to thrive in specific environmental conditions. A practical example draws parallels between the algorithm's predictive capabilities and everyday decision-making scenarios, demystifying computational complexity for a broader audience as proposed in [9]. In the application, the focus shifts to the tangible impact of the Naive Bayes algorithm, portraying it as a digital farming assistant that empowers farmers to make informed decisions about crop selection. The mention of a forthcoming mobile app introduces a forward-looking perspective, emphasizing continuous technology integration into agricultural practices as citied in [10]. The conclusion succinctly summarizes key findings, emphasizing the transformative role of the Naive Bayes algorithm in elevating farmers' decision-making processes. Drawing parallels with daily weather forecast use creates a relatable analogy for readers. The potential future directions for research and development, fostering a sense of continuity and ongoing improvement in leveraging the Naive Bayes algorithm and technology for agricultural advancements as citied in [6].

CHAPTER 4
PROPOSED SYSTEM

4.1 DATA SOURCES NURTURING KHETI SAHAYAK

The precision and reliability of Kheti Sahayak are intricately tied to the quality and diversity of these data sources, ensuring a robust foundation for data-driven decision-making. In the grand tapestry of smart farming, Kheti Sahayak emerges as a beacon of innovation, transcending traditional paradigms and embracing a technological revolution. In the crucible of smart farming, Kheti Sahayak is not merely a solution; it is a commitment to uplift farmer livelihoods and contribute to the crescendo of national agricultural growth.

4.1.1 Custom Datasets

The richness of Kheti Sahayak lies in its custom datasets curated for crop recommendation and fertilizer suggestions. These datasets, meticulously crafted, encapsulate a spectrum of environmental factors, fortifying the algorithms with depth and breadth.

4.1.2 Plant Disease Image Dataset

The plant disease prediction module relies on a specialized dataset created through offline augmentation of the original Plant Village Dataset. This dataset, comprising approximately 87,000 RGB images of healthy and diseased crop leaves across 38 different classes, forms the cornerstone of Kheti Sahayak's predictive capabilities. The dataset has been meticulously divided into training and validation sets, maintaining an 80/20 ratio, while a separate directory containing 33 test images has been established for prediction purposes. This augmented dataset plays a pivotal role in training and validating the deep learning models integrated into Kheti Sahayak, ensuring precise identification and prediction of crop diseases from uploaded images.

4.2 ALGORITHMS PERVADING KHETI SAHAYAK

The amalgamation of the following algorithms transforms Kheti Sahayak into a multifaceted solution, addressing the myriad challenges faced by farmers in the agricultural landscape.

4.2.1 Random Forest Algorithm

The Random Forest algorithm is a powerful tool employed in Kheti Sahayak for crop recommendation tasks. Unlike Naive Bayes, Random Forest excels in handling large and complex datasets, making it well-suited for analysing diverse agricultural data sets comprising variables such as weather conditions, soil health, and crop characteristics. By leveraging an ensemble of decision trees, Random Forest can capture intricate relationships between input features and crop yields, enabling more accurate predictions. Additionally, Random Forest is robust to overfitting and noise, ensuring reliable recommendations even in the presence of imperfect or noisy data. Its ability to handle categorical and continuous variables alike further enhances its utility in crop recommendation systems.

4.2.2 Highest Absolute Difference in Soil Nutrient Values (Custom Algorithm)

Kheti Sahayak employs a custom logic to recommend fertilizers based on the highest absolute difference in soil nutrient values. This algorithm calculates the absolute difference in nitrogen (N), phosphorus (P), and potassium (K) levels between the optimal nutrient requirements for a target crop and the actual nutrient levels in the soil. By identifying the most significant disparities in soil nutrient content, the algorithm determines the specific nutrients that need to be supplemented through fertilization. This tailored approach ensures precise fertilizer recommendations tailored to the unique nutrient needs of each crop, optimizing nutrient utilization and enhancing crop productivity.

4.2.3 ResNet9 Image Classifier Algorithm

The ResNet9 Image Classifier Algorithm is instrumental in plant disease detection within Kheti Sahayak. ResNet9, a variant of the Residual Network architecture, is preferred for its ability to effectively learn complex features from image data, making it well-suited for detecting subtle patterns associated with plant diseases. Unlike traditional image classifiers, ResNet9 employs residual connections to facilitate the training of deeper neural networks, enabling the extraction of intricate disease-related features from plant images. By leveraging the deep learning capabilities of ResNet9, Kheti Sahayak can accurately identify and classify various plant diseases, enabling timely interventions and disease management strategies to safeguard crop health and maximize yields.

4.3 MODULES ENRICHING KHETI SAHAYAK

The design modules of Kheti Sahayak are not arbitrary; each element is a deliberate choice to empower farmers and reshape Indian agriculture. These features are not just functionalities; they are the building blocks of a future where technology and farming coalesce seamlessly:

1. **Discussion Forums:** The beating heart of community collaboration, reminiscent of platforms like Reddit and Facebook. Discussion forums become the agora where farmers not only share experiences but also collectively chart the course for the future of agriculture.
2. **Prediction of Crop Yields:** The visionary feature that transforms speculation into science. Predictions of crop yields become the lighthouse, guiding farmers through the tumultuous seas of uncertainty.
3. **Personalized Fertilizer Recommendations:** More than a suggestion; it's a prescription for optimal growth. Personalized fertilizer recommendations become the tailored solutions that ensure each crop receives the nutrients it needs.
4. **Detection and Prevention of Crop Diseases:** A proactive stance against potential threats. Using deep learning for image analysis, Kheti Sahayak becomes the vigilant guardian, detecting and preventing crop diseases before they escalate.

These modules are not mere functionalities; they are the strokes on the canvas of a future where farming is not just a traditional practice but a dynamic, data-driven, and collaborative endeavour.

4.4 METHODOLOGY OF KHETI SAHAYAK

4.4.1 Understanding the Concept

The essence of Kheti Sahayak revolves around leveraging machine learning and deep learning techniques to empower farmers with data-driven insights for optimal crop management. Unlike the base paper's Naive Bayes approach, Kheti Sahayak employs a multifaceted solution, including crop recommendation, fertilizer suggestions, and plant disease prediction, contributing to a comprehensive smart farming experience as shown in figure 4.1.

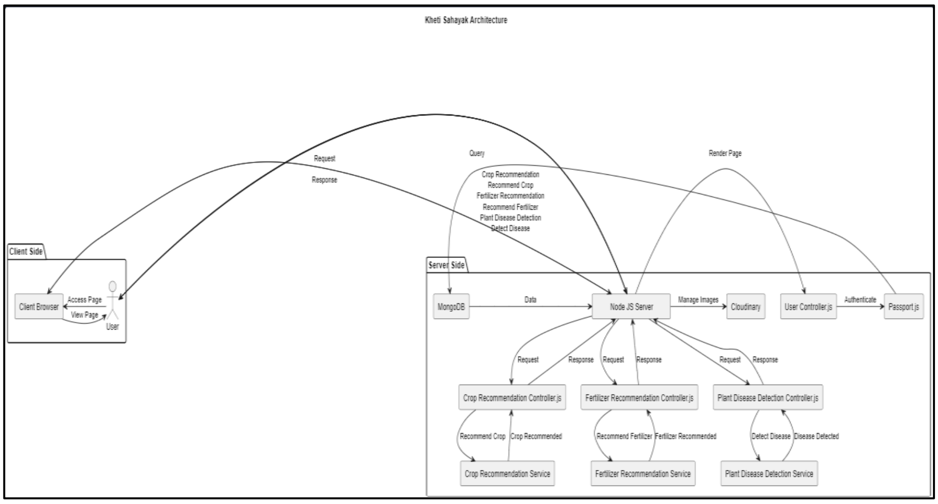

Fig 4.1 Kheti Sahayak Architecture

4.4.2 Data Collection

To train the algorithms within Kheti Sahayak, a diverse and comprehensive dataset is essential. Data is sourced from various channels, including custom datasets for crop recommendation and fertilizer suggestions. Plant disease prediction relies on a specialized image dataset containing images of diseased crops. The datasets aim to encapsulate a wide range of environmental factors crucial for accurate predictions.

4.4.3 Data Preprocessing

Raw data often contains missing values or errors. The preprocessing step involves thorough cleaning and organization of the data. Missing values are filled, and the data is formatted to ensure compatibility with the algorithms. The quality of data significantly impacts the reliability of predictions, making this step crucial.

4.4.4 Feature Extraction

Identifying key factors influencing crop growth is imperative. Kheti Sahayak analyses features such as soil nutrient levels, weather conditions, and crop details. The goal is to determine which features have the most significant impact on predicting suitable crops, contributing to the accuracy of recommendations.

4.4.5 Model Training

The core functionality of Kheti Sahayak lies in training various machine learning and deep learning models using pre-processed and feature-rich data to facilitate accurate predictions, crucial for crop management. These models include Decision Tree, Naive Bayes, SVM, Logistic Regression, Random Forest, and XGBoost. They are trained to classify crops based on features such as soil nutrient levels, temperature, humidity, pH, and rainfall. Gaussian Naive Bayes assumes conditional independence among features given the label, while SVM finds the hyperplane separating crop classes. Logistic Regression models the probability of each crop class, Random Forest uses 20 estimators, and XGBoost boosts decision trees sequentially. The models are evaluated on accuracy, precision, recall, and F1-score to ensure their effectiveness in predicting suitable crops. The best-performing model, Random Forest, is integrated into the Kheti Sahayak platform for real-world deployment and usage by farmers.

Additionally, in line with the comprehensive approach of Kheti Sahayak, the training process encompasses the integration of the ResNet9 Image Classifier Algorithm for plant disease detection. Leveraging the ResNet9 architecture, the model is trained on the augmented dataset comprising images of healthy and diseased crop leaves. By iteratively learning from the intricacies of these images, the ResNet9 algorithm becomes adept at discerning subtle patterns indicative of various plant diseases. During the training phase, the ResNet9 model undergoes iterative optimization to minimize classification errors and enhance its ability to accurately identify and classify crop diseases. This involves adjusting the model's parameters through backpropagation, fine-tuning the neural network layers, and optimizing the learning rate to ensure convergence towards an optimal solution. Furthermore, like the evaluation metrics employed for other machine learning models within Kheti Sahayak, the performance of the ResNet9 classifier is assessed based on key metrics such as accuracy, precision, recall, and F1-score. These metrics provide insights into the model's ability to correctly classify diseased crops and distinguish them from healthy ones, thereby gauging its effectiveness in supporting timely interventions and disease management strategies.

4.4.6 Evaluation and Enhancement

The accuracy of predictions is continually evaluated using testing data that the algorithms haven't encountered before, and the best model for prediction is chosen, as shown in figure 4.2. If the accuracy falls short, enhancements are considered. Refinement of features, obtaining better-quality data, or exploring advanced algorithms may be part of the iterative process to improve prediction accuracy as shown in figure 4.3.

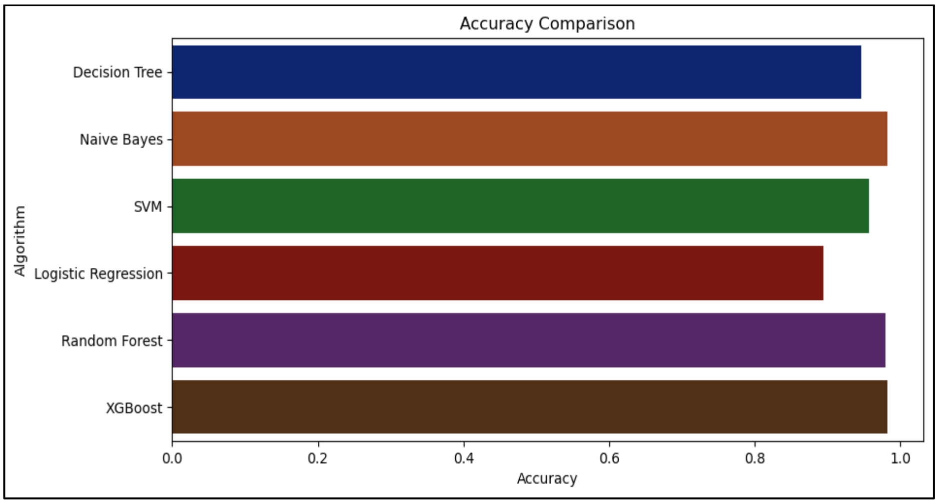

Fig 4.2 Accuracy Comparision of Various Algorithms Used for Crop Recommendation

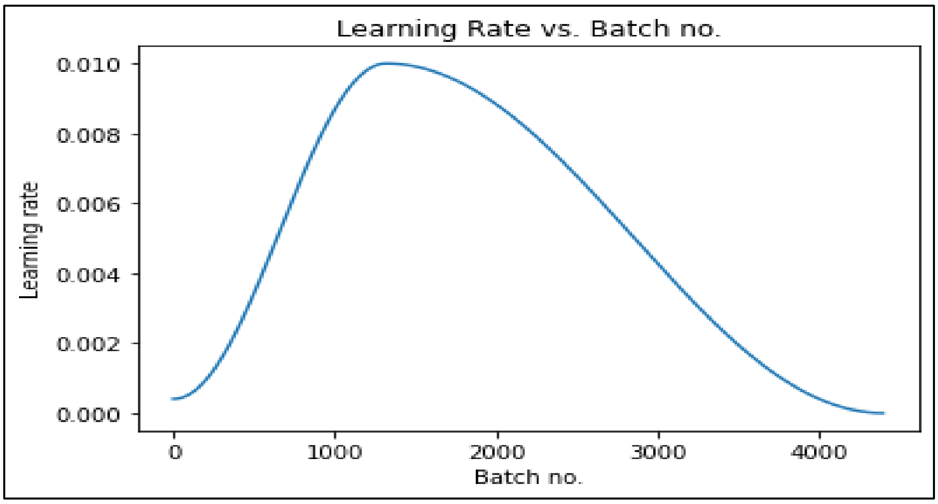

Fig 4.3 Learning Rate of ResNet9 Classifier for Plant Disease Detection

4.4.7 Prediction

Once the algorithms are trained and tested, Kheti Sahayak can make predictions. Users input specific data, such as soil nutrient values, and the application calculates the probabilities for suitable crops, recommends fertilizers, and predicts potential diseases in crops. The predictions guide farmers in making informed decisions for crop management.

4.5 IMPLEMENTATION OF KHETI SAHAYAK

4.5.1 Discussion Forums

Building Discussion Forums is a pivotal aspect of Kheti Sahayak, fostering collaborative engagement among farmers. This stage involves the following steps:

1. **Creating a Simple CRUD Application:** Creating a Simple CRUD Application is the foundational step, involving the configuration of the development environment with tools like Node.js and MongoDB. The backend infrastructure is established using Node.js and Express.js, creating server routes and handlers for basic CRUD operations. Mongoose is integrated for MongoDB data modelling, and database interactions are implemented for efficient data storage and retrieval. Dynamic templating using EJS and styling with Bootstrap v5 enhance the user interface.
2. **Data Validation, User Authentication, and Image/Video Upload:** This stage focuses on ensuring the security and functionality of the application. Data validation using JOI safeguards against vulnerabilities. Passport.js is integrated for user authentication, including login and registration functionalities. Express Middlewares are employed for user authorization, role definition, and access restriction. Users can upload images and videos, with Cloudinary facilitating efficient management.
3. **Enhancing Security, Cloud Database Integration using MongoDB Atlas:** Enhancing Security involves the implementation of the HELMET middleware, securing HTTP headers, and protecting against common web vulnerabilities. The application is integrated with MongoDB Atlas for cloud database functionality, providing scalability and accessibility.

4.5.2 Crop Recommendation System

Developing the Crop Recommendation System is essential for aiding farmers in selecting the most suitable crops for cultivation. The development process involves several key steps:

1. **Server-Side Setup:** Configure the Node.js server to handle crop recommendation requests at the /crops/crop-recommendation endpoint. Establish server routes and handlers to manage incoming requests and responses.
2. **Middleware Integration:** Integrate middleware functions, such as connect(), to facilitate communication between the Node.js server and the Python server responsible for executing the crop recommendation logic.
3. **Python Server Execution:** Upon receiving a recommendation request, the middleware connects to the Python server, which executes the Crop Recommendation CLI (Command Line Interface).
4. **Weather Data Retrieval:** The Crop Recommendation CLI fetches weather data from an external Weather API to incorporate climate conditions into the recommendation process.
5. **Machine Learning Model Integration:** Utilize machine learning algorithms on the Python server to analyse input parameters such as soil composition, temperature, humidity, and rainfall to recommend suitable crops for cultivation.
6. **Result Rendering:** Upon completion of the recommendation process, the recommendation result is returned to the Node.js server, which subsequently renders the output for the user.
7. **User Interface Enhancement:** Dynamically update the user interface to display the recommended crops along with relevant details, enhancing user experience and facilitating informed decision-making by farmers.

4.5.3 Fertilizer Recommendation System

Building the Fertilizer Recommendation System is crucial for optimizing crop yield and health by suggesting appropriate fertilizers based on soil nutrient levels and crop requirements. The development process encompasses the following steps:

1. **Server-Side Configuration:** Configure the Node.js server to handle fertilizer recommendation requests at the /crops/fertilizer-recommendation endpoint. Establish server routes and handlers to manage incoming requests and responses.

2. **Middleware Incorporation:** Integrate middleware functions, such as connect(), to facilitate communication between the Node.js server and the Python server responsible for executing the fertilizer recommendation logic.
3. **Python Server Invocation:** Upon receiving a recommendation request, the middleware connects to the Python server, which executes the Fertilizer Recommendation CLI to determine the most suitable fertilizers for the specified crop.
4. **Custom Logic Execution:** The Fertilizer Recommendation CLI employs custom logic to calculate the absolute difference in nitrogen, phosphorus, and potassium (NPK) levels between the soil and the crop's requirements.
5. **Fertilizer Steps Recommendation:** Based on the calculated differences, the CLI recommends appropriate fertilizer steps using predefined algorithms tailored to specific crops and soil conditions.
6. **Result Rendering:** The recommendation result, including the suggested fertilizer steps, is returned to the Node.js server, which renders the output for the user interface.
7. **User Interface Optimization:** Optimize the user interface to display the recommended fertilizer steps clearly, enabling farmers to implement the recommendations effectively for improved crop nutrition and growth.

4.5.4 Plant Disease Detection System

Creating the Plant Disease Detection System is crucial for early identification and management of plant diseases, thereby minimizing crop losses and ensuring agricultural sustainability. The development process comprises the following steps:

1. **Server-Side Establishment:** Set up the Node.js server to handle plant disease detection requests at the /crops/plant-disease-detection endpoint. Define server routes and handlers to manage incoming image uploads and responses.
2. **Middleware Integration:** Integrate middleware functions, such as connect(), to establish communication between the Node.js server and the Python server responsible for executing the disease prediction logic.
3. **Python Server Invocation:** Upon receiving an image upload for disease detection, the middleware connects to the Python server, which executes the Disease Prediction CLI to analyze the uploaded image.
4. **Pre-trained Model Loading:** Load a pre-trained machine learning model capable of identifying various plant diseases from input images. The model is trained on a diverse dataset of diseased plant samples.

5. **Image Processing and Prediction:** Process the uploaded image and pass it through the loaded model to predict the presence of any diseases. The model outputs the detected disease(s) along with relevant information.
6. **Result Transmission:** Transmit the prediction result, including the detected disease(s) and associated details, back to the Node.js server for further processing and rendering.
7. **User Interface Feedback:** Update the user interface to display the detected disease(s) prominently, along with recommended actions for disease management and mitigation.

4.5.5 Web Integration and Deployment

Web Integration and Deployment mark the final stages of Kheti Sahayak's development, ensuring a seamless user experience. It involves the following steps:

1. **Integrating All Features into One Web Application:** This stage involves the seamless integration of all farming insights features, including discussion forums, crop recommendation, fertilizer recommendation, plant disease detection and security measures, into one cohesive web application.
2. **Deploying Using Render.com:** Finally, the web application is prepared for deployment and deployed using the Render.com platform, ensuring accessibility and online presence.

CHAPTER 5
RESULTS AND DISCUSSION

Kheti Sahayak, a smart farming web application, stands out for its exceptional performance and responsiveness. Leveraging Node.js and Express.js, renowned for their ability to handle concurrent requests, coupled with MongoDB, a robust NoSQL database, the application efficiently manages large datasets. In addition to its robust technological foundation, Kheti Sahayak offers advanced features for crop recommendation, fertilizer recommendation, and plant disease detection using Python. These functionalities utilize machine learning algorithms and data analysis techniques to provide valuable insights to farmers, enhancing agricultural productivity and sustainability. Employing client-side rendering further optimizes data transfer by rendering only essential data on the client-side. These technological choices contribute to Kheti Sahayak's superior performance, making it a standout among similar websites.

In comparison to other platforms, Kheti Sahayak excels with its user-friendly interface, enhancing user navigation and experience. The platform's inclusion of a commenting and reviewing system fosters a collaborative community, assisting users in making informed decisions about which posts to explore. The underlying technology stack, utilizing Node.js, Express.js, and MongoDB, underscores the application's efficiency and power. These technologies are complemented by adherence to software principles like separation of concerns and the MVC architecture, ensuring maintainability and scalability. Kheti Sahayak's performance is bolstered by its advanced features for crop recommendation, fertilizer recommendation, and plant disease detection. Leveraging machine learning algorithms and data analysis techniques, these functionalities provide farmers with valuable insights into crop management practices. By analysing various factors such as soil nutrient levels, weather conditions, and plant health indicators, Kheti Sahayak assists farmers in making data-driven decisions, ultimately improving agricultural productivity and sustainability.

While Kheti Sahayak boasts numerous strengths, it does face certain limitations. The application is currently available only in English, potentially hindering non-English speakers from accessing its benefits. Additionally, its exclusive availability as a web application restricts users from using it offline, posing challenges for those with limited internet access or in areas with poor connectivity.

5.1 CREATION OF A BASIC CRUD WEB APPLICATION

In the initial phase of implementing Kheti Sahayak, the focus was on incorporating CRUD functionality for posts. This involved developing a form that enables users to seamlessly add new posts to the application. The form collected fundamental information about each post, including its name, description, and an image (refer to Fig 5.2). Upon submission, this information was stored in the application's database, thereby adding the new post to the list of available posts. Users gained the ability to peruse a comprehensive list of all added posts, showcasing each post's name and image. Clicking on any specific post allowed users to access more detailed information about it. Furthermore, users were empowered to update and delete posts within the application. For updating a post, users could simply click on the post they intended to modify, redirecting them to a form where they could conveniently edit the existing information (see Fig 5.4). Similarly, to delete a post, users could click on the post and confirm the deletion, streamlining the process (see Fig 5.5). Bootstrap was leveraged to implement the basic styles for the application, providing a set of pre-built components that facilitated the creation of a responsive and visually appealing user interface (as depicted in figures 5.1, 5.2, and 5.3).

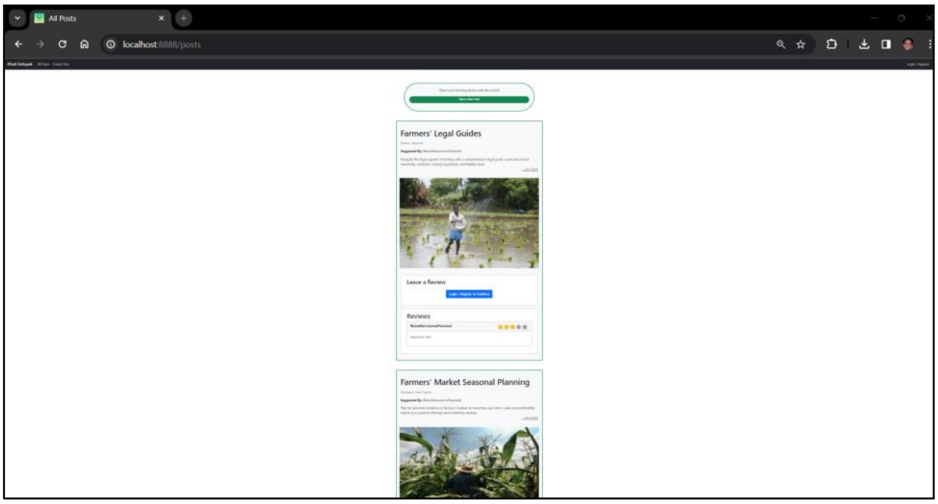

Fig 5.1 All Posts Page

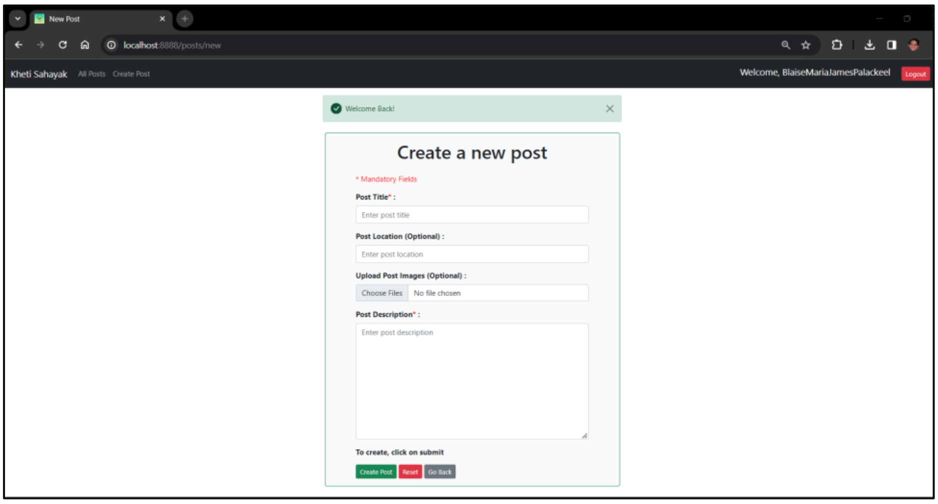

Fig 5.2 New Post Page

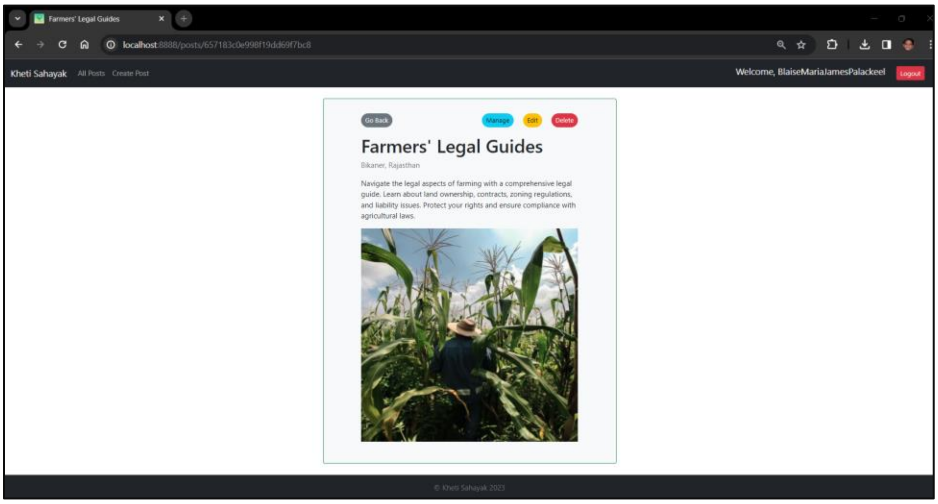

Fig 5.3 View Post Page

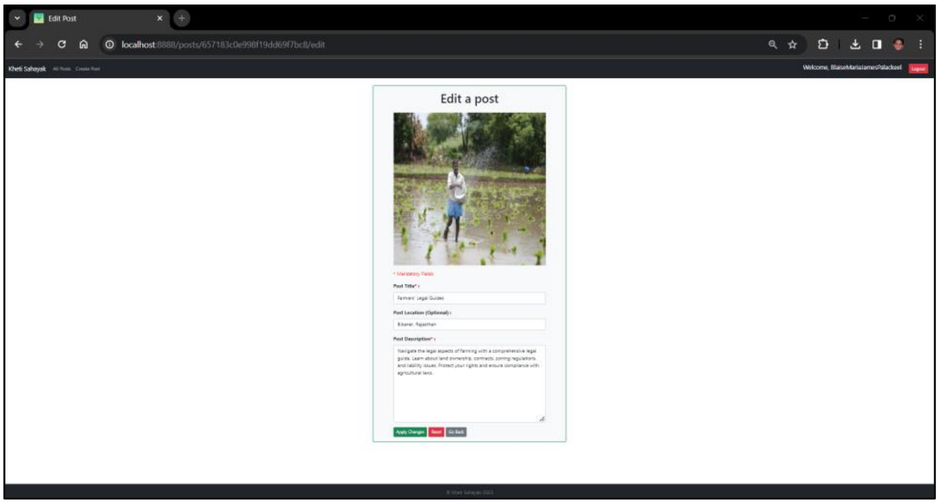

Fig 5.4 Edit Post Page

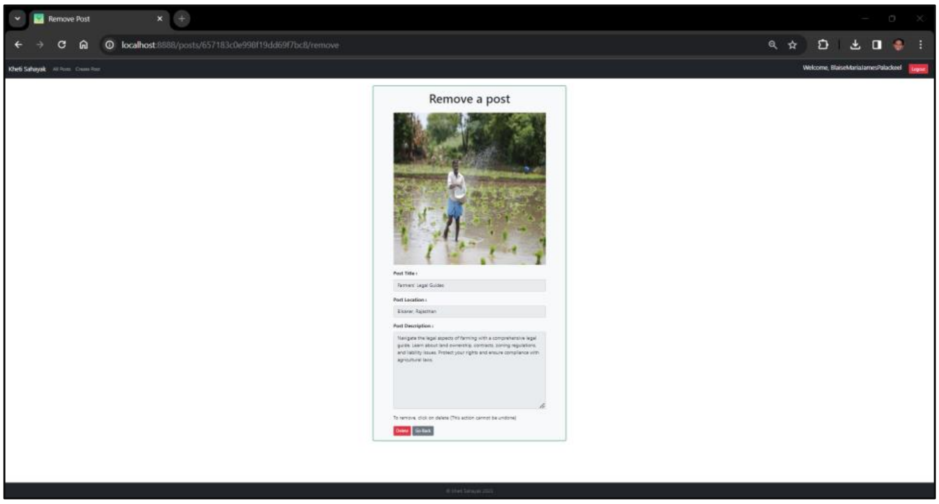

Fig 5.5 Remove Post Page

5.2 AUTHENTICATION AND AUTHORIZATION

The second crucial stage in the implementation process of Kheti Sahayak involved the integration of authentication and authorization into the application. Passport.js, a widely used authentication middleware for Node.js, was employed. It provides a range of authentication strategies for various authentication types, including local authentication and social authentication. Passport.js played a key role in managing the authentication process, validating users' credentials, and creating sessions for authenticated users. Alongside authentication, the implementation introduced authorization to the application through Express middlewares.

Authorization, a critical aspect of web applications, ensures that users possess the necessary permissions to access specific resources or execute actions. Middleware functions were crafted to assess whether a user was authenticated and possessed the required permissions for accessing resources or performing actions within the application, as depicted in figure 5.6. Specific middleware functions were designed to ascertain that only the user who created a post could edit or delete it, exemplifying a fine-grained control mechanism. This reinforced security measures within Kheti Sahayak, aligning with industry best practices for user authentication and authorization.

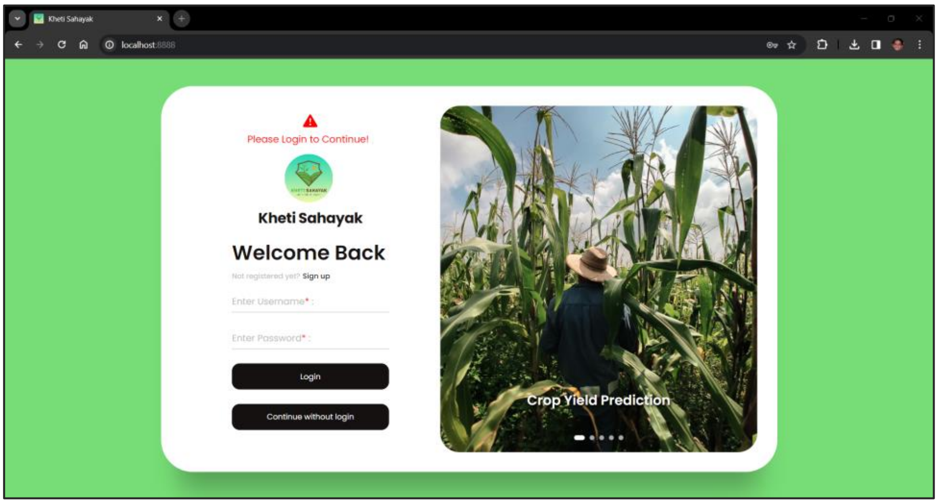

Fig 5.6 Login Signup Page

5.3 MEDIA UPLOAD AND INTEGRATION WITH CLOUD

The third crucial stage in the implementation of Kheti Sahayak involved integrating Cloudinary for media management and MongoDB Atlas for database operations. Cloudinary, a cloud-based platform, facilitated easy media handling through its API, requiring new routes and middleware functions in the application. MongoDB Atlas, a cloud database service, bolstered data storage and retrieval capabilities, enhancing efficiency and security. These integrations streamlined media upload and ensured robust data management within the application as shown in figure 5.7.

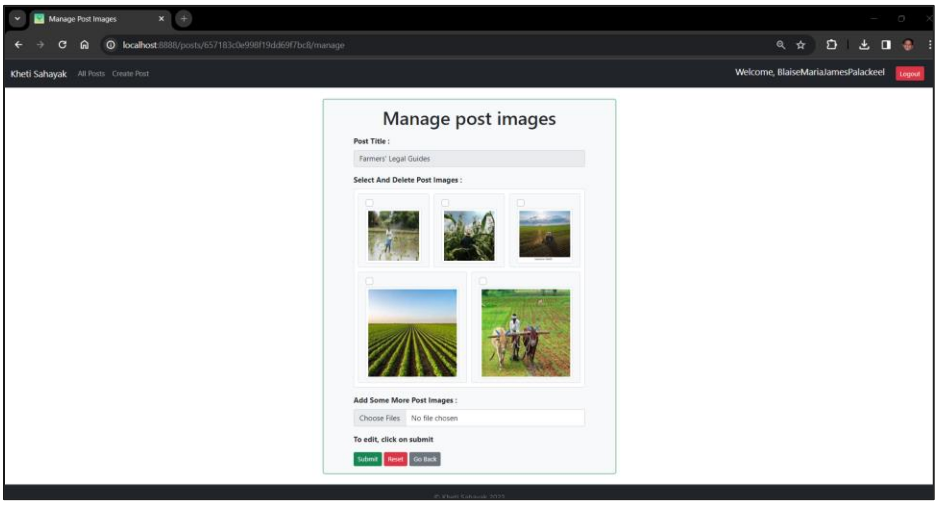

Fig 5.7 Manage Post Images

5.4 CROP RECOMMENDATION USING RANDOM FOREST

The fourth crucial stage in the implementation process for Kheti Sahayak is crop recommendation, utilizing the Random Forest algorithm, a popular machine learning technique known for its robustness and accuracy in classification tasks. This system analyses various factors such as soil type, climate conditions, historical crop yield data, and farmer preferences to suggest the most suitable crops for cultivation in each area as shown in figure 5.8. Leveraging the Random Forest algorithm's ability to handle large datasets and capture complex relationships between input features, Kheti Sahayak provides farmers with valuable insights into crop selection, ultimately enhancing yield and profitability as shown in figure 5.9.

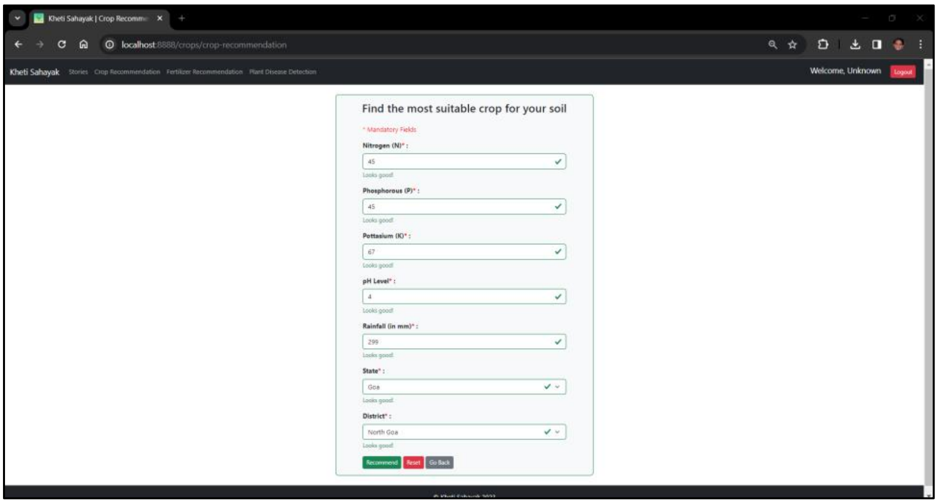

Fig 5.8 Crop Recommendation Form

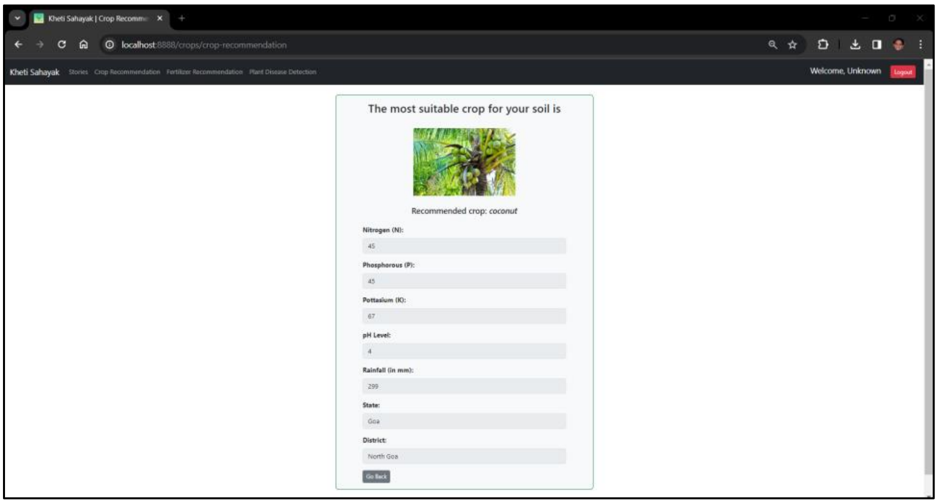

Fig 5.9 Crop Recommendation Result

5.5 FERTILIZER RECOMMENDATION USING CUSTOM LOGIC

The fifth crucial stage in the implementation process for Kheti Sahayak is optimal fertilizer application, ensuring healthy crop growth and maximizing yields. By integrating a fertilizer recommendation system, Kheti Sahayak utilizes data-driven approaches to suggest suitable fertilizer types and application rates for different crops and soil conditions as shown in figure 5.10. Analysing factors like soil nutrient levels and crop requirements, personalized recommendations are generated to aid farmers in informed decision-making. Leveraging machine learning algorithms and agronomic principles enhances nutrient management practices and crop productivity as shown in figure 5.11.

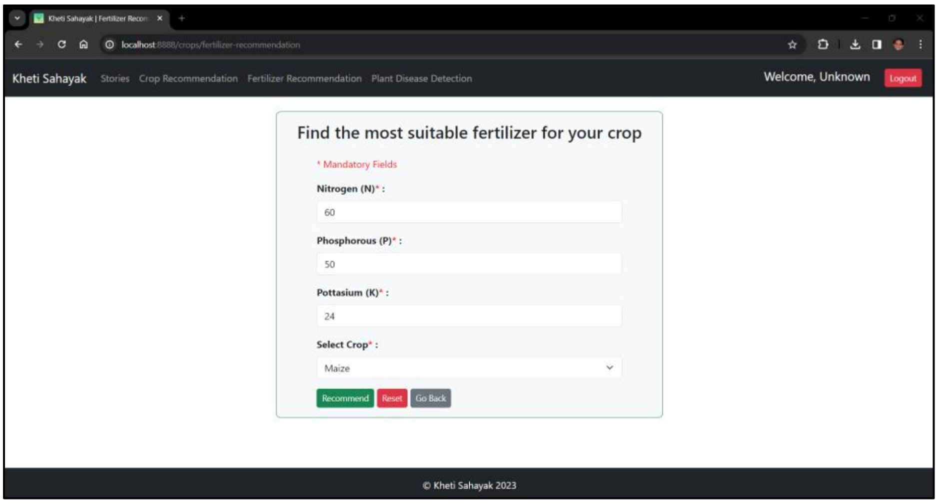

Fig 5.10 Fertilizer Recommendation Form

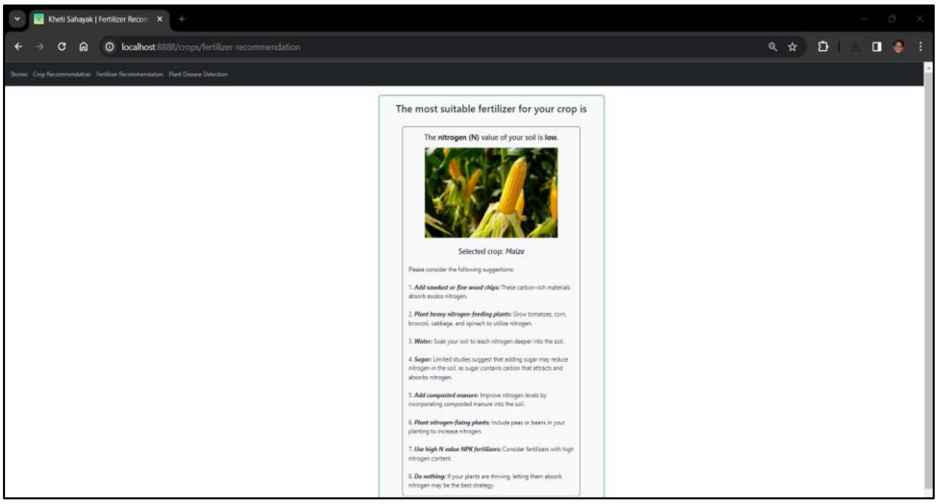

Fig 5.11 Fertilizer Recommendation Result

5.6 PLANT DISEASE DETECTION USING RESNET9 CLASSIFIER

The sixth crucial stage in the implementation process for Kheti Sahayak is a plant disease detection system based on the ResNet9 classifier, a deep learning architecture renowned for its accuracy in image classification tasks. By leveraging the ResNet9 classifier's ability to learn intricate patterns and features from image data, Kheti Sahayak provides farmers with timely and accurate diagnoses of plant diseases as shown in figure 5.12. This enables proactive management strategies, such as targeted pesticide application or crop rotation, to mitigate disease outbreaks and minimize yield losses as shown in figure 5.13.

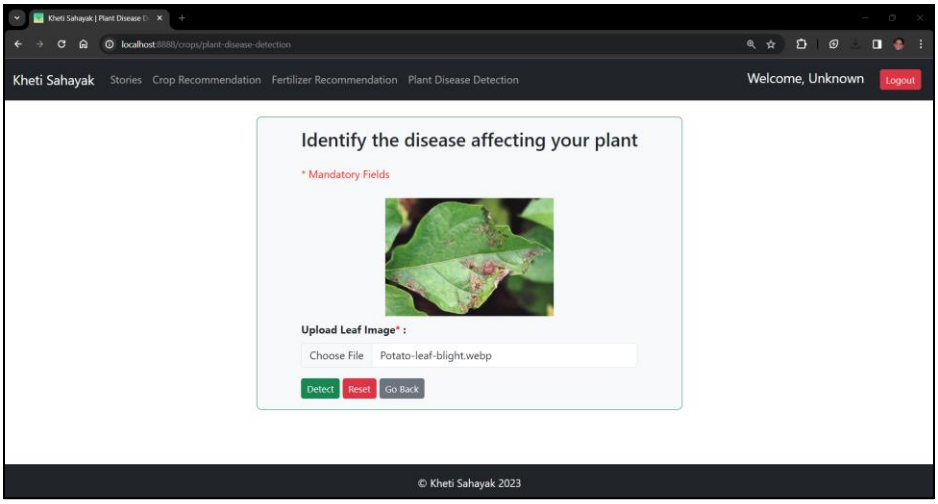

Fig 5.12 Plant Disease Detection Form

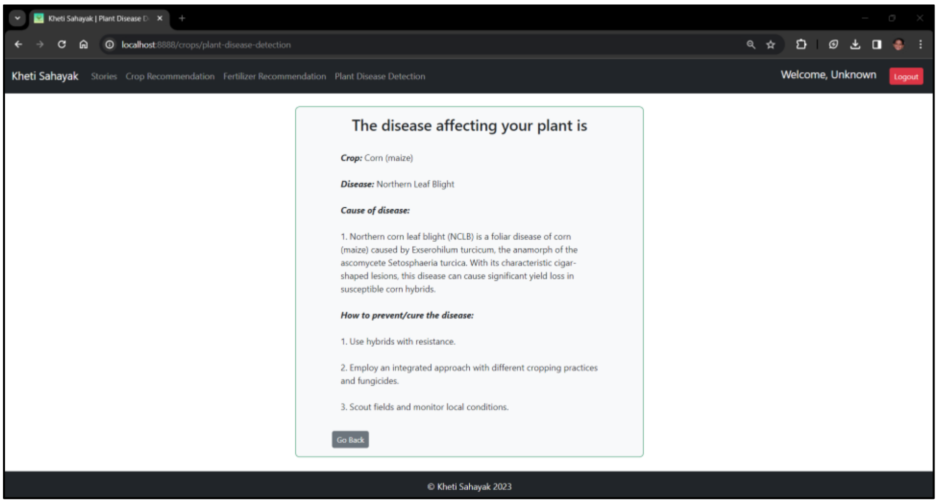

Fig 5.13 Plant Disease Detection Result

5.7 ENHANCING WEB SECURITY AND DEPLOYMENT

The final phase of the Kheti Sahayak project focused on enhancing web security and streamlining deployment. Employing the Helmet.js middleware, the project took measures to bolster web security by configuring various HTTP headers, fortifying the overall resilience of the application. In terms of deployment, a systematic approach was adopted. The codebase underwent integration with a GitHub repository, and subsequently, Render.com was utilized for the deployment process. The Render.com platform seamlessly identified the Node.js application, establishing a conducive build environment. Upon successful completion of the build, the application was deployed on a cloud server, marking its accessibility to the public. The entire deployment process was transparently documented on GitHub, providing a comprehensive overview of the deployment pipeline, as illustrated in Fig 5.14.

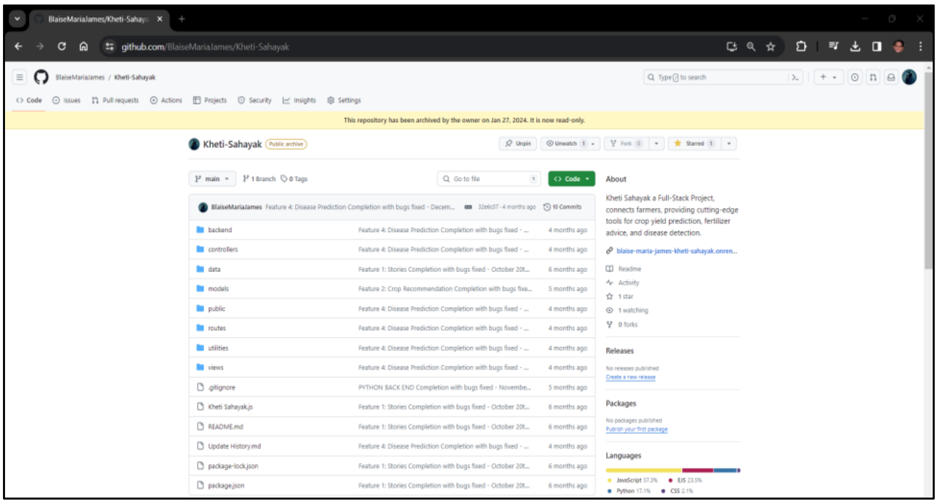

Fig 5.14 Kheti Sahayak GitHub Repository

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

Kheti Sahayak stands as a pioneering solution at the intersection of agriculture and technology. By seamlessly integrating predictive algorithms, real-time communication, and collaborative features, the application brings a paradigm shift to traditional farming practices. Its user-friendly interface and unique offerings, such as personalized recommendations and proactive disease detection, showcase a commitment to empowering farmers with data-driven insights. Despite its achievements, linguistic barriers and limited accessibility present challenges that can be addressed to enhance the application's impact. Kheti Sahayak's successful fusion of technology and agriculture positions it as a catalyst for transformative change in the farming landscape.

Looking ahead, the future scope of Kheti Sahayak holds promising avenues for expansion and refinement. Multilingual support and the development of a dedicated mobile application could significantly broaden the user base, making agricultural insights more accessible. Integration with emerging technologies, such as IoT devices and sensors, offers the potential for enhanced data precision and real-time monitoring. Continuous learning through machine learning models, coupled with collaborations with research institutions and industry stakeholders, could lead to more sophisticated algorithms and comprehensive agricultural solutions. The application's evolution towards fostering a vibrant, interconnected farming community and embracing cutting-edge technologies underscores its potential to shape the future of smart farming on a broader scale.

REFERENCES

[1] Ünal, Z. (2020). "Smart Farming Becomes Even Smarter with Deep Learning: A Bibliographical Analysis." IEEE Access, 8, 85383-85396.

[2] Swami Durai, S. K., & Shamili, M. D. (2022). "Smart farming using Machine Learning and Deep Learning techniques." Decision Analytics Journal, 3, 100041.

[3] Sharma, A., Jain, A., Gupta, P., & Chowdary, V. (2020). "Machine Learning Applications for Precision Agriculture: A Comprehensive Review." IEEE Access, 8, 2248-2268. DOI: 10.1109/ACCESS.2020.3048415

[4] Sultana, J., Siddique, M. N. A., & Abdullah, M. R. (2015). "Fertilizer recommendation for Agriculture: practice, practicalities and adaptation in Bangladesh and Netherlands." International Journal of Business, Management and Social Research. DOI: 10.18801/ijbmsr.010115.03

[5] Domingues, T., Brandão, T., & Ferreira, J. C. (2020). "Machine Learning for Detection and Prediction of Crop Diseases and Pests: A Comprehensive Survey." Instituto Universitário de Lisboa (ISCTE-IUL).

[6] Franz, A., Junirianto, E., & Suswanto. (n.d.). "Web Design and Application Programming Interface (API) Smart Farming Application." Agricultural Polytechnic of Samarinda, Samarinda, Indonesia.

[7] Ali, J., Khan, R., & Ahmad, N. (2012). "Random Forests and Decision Trees." Ajou University, Qassim University, University of Engineering and Technology, Peshawar.

[8] He, K., Zhang, X., Ren, S., & Sun, J. (2016). "Deep Residual Learning for Image Recognition." Microsoft Research.

[9] Neumann, A., Laranjeiro, N., & Bernardino, J. (n.d.). "An Analysis of Public REST Web Service APIs."

[10] Rimal, A. (n.d.). "Developing a Web Application on NodeJS and MongoDB using ES6 and Beyond." Thesis Paper.