CROP DISEASE PREDICTION AND MANAGEMENT SYSTEM

A PROJECT REPORT

Submitted by,

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Under the guidance of,

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in partial fulfillment for the award of the degree of

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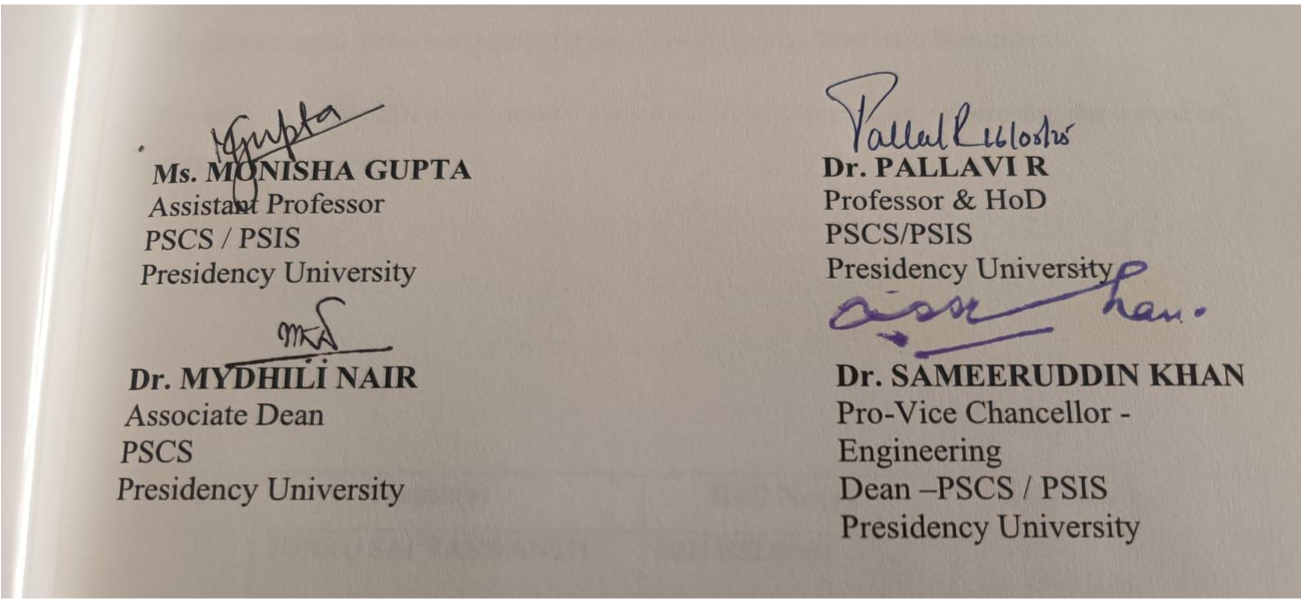
SCHOOL OF COMPUTER SCIENCE ENGINEERING

CERTIFICATE

This is to certify that the Project report **"CROP DISEASE PREDICTION AND MANAGEMENT SYSTEM"** being submitted by "SUNKU SAI YASWANTH, GAJJALA AKHILA" bearing roll number(s) "20211ISD0007, 20211ISD0015" in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in **Information Science and Technology (Artificial Intelligence and Data Science)** is a bonafide work carried out under my supervision.



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We hereby declare that the work, which is being presented in the project report entitled **CROP DISEASE PREDICTION AND MANAGEMENT SYSTEM** in partial fulfillment for the award of Degree of **Bachelor of Technology in Information Science and Technology**, is a record of our own investigations carried under the guidance of **Ms. MONISHA GUPTA, Assistant Professor, School of Computer Science Engineering & Information Science, Presidency University, Bengaluru.**

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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ABSTRACT

As the world grapples with increasing food demands and environmental pressures, the push for smarter, more sustainable farming methods is more urgent than ever. Perfect Crops is a forward-thinking project built around this very idea. It introduces an AI-driven web platform that supports farmers in making well-informed choices when it comes to selecting crops, applying fertilizers, and managing plant health.

Agriculture is still the pillar of human sustenance, yet contemporary farmers are confronted with issues like plant illness, fertilizer misuse, and inappropriateness in crop selection—resulting in poor harvests and financial pressure. To fill the gap between conventional farming practices and new technologies, we introduce a web application-based AI that provides intelligent solutions in plant disease analysis, and fertilization optimization. With the help of sophisticated machine learning algorithms—such as hybrid ensemble learning—and image processing technology, the platform allows for early diagnosis of infection in plants through real-time image processing. Farmers can upload images of their crops directly through an inbuilt camera feature for real-time evaluation and actionable data. The fertilizer advisory module offers fact-based inputs for maximum utilization without causing damage to the environment. Built with Python and latest web technologies, the platform boasts a user-friendly interface along with leveraging Google Search to enable users to search best practices and market trends. The CropCare is smart agri solution is designed to empower farmers—particularly in technology-constrained areas such as rural India—by enhancing decision-making, optimizing yield, minimizing wastage, and teaching sustainable farming practices

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SUNKU SAI YASWANTH

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CHAPTER-1
INTRODUCTION

1.1 OBJECTIVE OF PROJECT:

The Perfect Crops project seeks to implement smart, data-driven technologies to improve decisions made by farmers. While there are many ways this can be achieved, the main objectives of the project are to:

1. Advise Crops that will Deliver the Most Sustainable Practices and Highest Yield by recommending crops based on the analysis of soil nutrients and climate conditions; e.g., selecting crops that would provide the highest return on investment for farmers and the most sustainable methods.

2. Provide Environmental Yards of Precision Fertilizer Recommendations based on the soil profile which may continually be changing, and factor in the expected crop for that season.

3. Provide Crop Loss Reduction by use of AI Image Classification to detect early plant diseases to allow farmers time to take action.

4. Create a User-Friendly Interfacing Platform that will serve as an umbrella container for all technologies implemented for the traditionally low-tech farmers.

All of these methods give the farmers in this diverse agricultural region the chance to conserve natural resources while increasing productivity, lowering cost of practices and sustainable farming options.

1.2 PROBLEM STATEMENT:

Today's farmers encounter complex problems when dealing with critical processes like crop rotation, fertilizer allocation, and plant disease management. Farming practices suffer significantly from a lack of reliable data, explaining why these options are frequently stipulated by:

• Inappropriate crop selection leading to sub-optimal yields inappropriate selection of nutrients in the soils, translates into lower returns on investments.

• Soils and environment facing pollution and degradation due to misallocation of fertilizers and increased expenses for the farming.

• Slow or absence of plant pest monitoring and control systems resulting in heightened devastation of crops and financial capital.

• Absence of remote consultancy services to virtually less developed farming regions which are devoid of expert availability.

Farmers still need forward-thinking, accessible artificial intelligence, alongside machine learning options tailored specifically to their individual needs and circumstances in enabling decision-making in diverse environments.

• Referring to a database of crop choices related to agricultural regions.

• Providing nutrients diagnostic systems related to soil composition.

• Fertility recognition through visual mechanisms which scan the image of a plant and appreciate processes stimulating disease in a plant.

1.3 MOTIVATION:

Agriculture is the mainstay of a number of economies around the world; however, countless farmers face unpredictable weather, inefficient soil management, and threatening plant diseases on a daily basis. The long-term impact of unreliable agricultural assistance leads to poor crop output, unproductive use of fertilizers, and infections that arise from dormant pathogens which all, in turn, increase the threat posed to the environment while reducing the income of the farmers.

There is a significant gap that needs to be filled when it comes to modern technology like Artificial Intelligence, Machine Learning, and computer vision, and its counterparts in traditional agriculture, and Perfect Crops aims to do just that. We are determined to develop a user-friendly and intelligent system that relieves farmers from uncertainties by aiding them in decision-making grounded on solid data.

This project targets the elevation of agriculture through the enhancement of crop output by collaborating with farmers to give them reliable, user-friendly technologies that can be employed even in remote areas. By combining crop prescribing, precision fertilization, and disease control, farmers will gain proper guidance while educators and policymakers will benefit by systematizing their visions of advanced and sustainable agriculture for everyone.

1.4 SCOPE:

The Perfect Crops Project is envisioned as an all-in-one web-based smart farming assistant, merging various agricultural decision-support systems into a singular smart farming multifunctional platform. It focuses on the following objectives:

1. Crop Prediction

• Predicts the optimal crop for a user based on the soil data (N P K) provided along with the pH, rainfall, and current weather including temperature and humidity.

• Uses a pre-trained Random Forest machine learning model for predictions.

2. Fertilizer Management

• Suggests appropriate precision fertilizer applications after examining soil nutrient deficiencies.

• Analyzes available soil values in the current scenario against ideal soil values for a specific crop to mitigate over nutrient fertilization, environmental damage, and using quality cameras.

3. Disease Recognition

• Lets the users take pictures of crop leaves or upload images.

• Utilizes deep learning techniques such as ResNet9 CNN for disease identification and treatment recommendations.

4. Weather Forecast Integration

• Improves the quality of predictions by retrieving real-time data on temperature and humidity through the OpenWeatherMap API.

5. Virtual Farming Advisor

• Allows for the inclusion of a GPT-4 powered chatbot that answers generic agricultural questions and advises through the navigation of the website.

6. Usability and Accessibility

• Intended for use in areas with weak or no internet connectivity.

• Intuitive, mobile-friendly, and easy to use interface design.

1.5 PROJECT INTRODUCTION:

Agriculture has historically been a source of global food security and wealth creation. In many developing countries, agriculture still employs a majority of people as their primary means of livelihoods. Despite the continued relevance of agriculture, the sector is increasingly challenged by climate change, decreasing soil health, pest outbreaks, diseases, improper use of inputs, and so forth. With the world's population projected to grow to 9.7 billion by 2050, the demand for sustainable agricultural technology - advances in agrotech and any other technological form of agriculture (agriculture, forestry, aquaculture, etc.) is even greater.

Traditional farming practices are reliant on subjective forms of manual experience that are virtually impossible to replicate in-part because manual experience is not necessarily consistent from farmer-to-farmer or season-to-season. Farmers often have difficulty determining the variety and types of crops to plant each season based on their own personal experience, they may provide too much or too little fertilizer to the crops, they are unlikely able to properly assess plant disease until the crops are too far gone, and so forth. The result is often stunted crops, crop losses, financial losses, environmental degradation, loss of food security, etc.

To address these specific issues, the Perfect Crops project has proposed a smart and online agricultural support system that will assist farmers in data informed decision-making. This system will incorporate machine learning (ML) and deep learning (DL) tools to provide three services:

1. The Intelligent Crop Suggestion System

This service uses a trained Random Forest machine learning model that provides appropriate crop selections based on soil nutrient values (potassium, phosphorus, and nitrogen), pH, rainfall potential, and real-time weather data like temperature and humidity. Farmers will be able to make crop decisions that are relevant to their current environmental conditions by incorporating real-time weather data via APIs like OpenWeatherMap. Farmers can increase yield, save inputs, and better prepare for failed crops by selecting crops that better take into account local environmental conditions.

2. Application of Fertilizer with Precision

One of the primary causes of groundwater contamination and soil depletion is improper fertilizer application. By examining the current and optimal fertilizer conditions, the Perfect Crops platform will offer precise fertilizer recommendations.

3. AI-Powered Disease Detection

The system utilizes a Convolutional Neural Network (CNN) model, specifically the ResNet9 architecture, trained on a large dataset of crop leaf images. It provides the built-in AI model to allow farmers to take pictures of potentially infected plant leaves or upload them, and the AI model will accurately classify the disease. Once a disease is identified, the system provides a wealth of information about the disease, the symptoms it displays, and scientifically-based prevention or treatment methods. The early identification of a disease by the module allows farmers to take early action to avoid developing a catastrophic situation that would compromise food quality and yield.

4. User-Centric Interface

The app was designed to be user friendly for farmers that may not have a technical background. A clean web interface was developed for ease of use on both desktop and mobile platforms. To assist users in real time, a fully operational chatbot powered by GPT-4 was implemented to answer common agricultural-based questions and provide directions.

A Step Toward Sustainable Agriculture

By merging characteristics, the Perfect Crops system makes traditional farming a smart, agile, and scalable process. The system solves fundamental problems for farmers as it relates to yield maximization, resource conservation, sustainable production, and plant health - and strives to encourage responsible practices. It is also modular and can easily be expanded in the future with new capabilities such as a market insights, pest prediction capability, weather forecast capability, or multi-language voice support to minimize barriers towards implementing new technologies.

In review, the Perfect Crops project is a significant investment towards taming the vision of the precision agriculture model for millions of constituencies - notwithstanding the geographical, literacy, and economic barriers. The agriculture ecosystem bridges the digital divide by making best practice and advance technology attainable and advantageous, even for subsistence, smallholder, or rural farmers, and ultimately creates a smarter and more resilient food production process.

CHAPTER-2
LITERATURE SURVEY

2.1 Prediction of Crop Fertilizer Consumption

Authors: Hampannavar, Bhajantri & Totad.
Year:2018
Published in: International Conference on Computational and Business Intelligence (ICCUBEA)

This paper introduces a system for predicting fertilizer consumption in crop production using machine learning techniques. The authors investigated historical agricultural data to model the relation between fertilizer applied and crop yield. The system includes a regression-based model to determine fertilizer requirements, which can improve yield and reduce environmental degradation.

Advantages:

- Data-driven insights into fertilizer planning.
- Reduces fertilizer wastage.
- Supports resource efficiency and increases yield.
- Encourages sustainability

Limitations:

There was no integration of real-time environmental data such as temperature and humidity. The accuracy of the model is highly dependent on the quality and quantity of historical data used. There did not appear to be flexibility in being able to accommodate a changing climate and crop diversity.

2.2 Fuzzy Decision Support System for Improving the Crop Productivity

and Efficient Use of Fertilizers

Authors: Prabakaran, G., Vaithiyanathan, D., & Ganesan, M.

Year: 2018

Published in: *Computers and Electronics in Agriculture, Volume 145, Pages 205–211*

This paper describes a Decision Support System (DSS) based on Fuzzy Logic will improve crop productivity and support appropriate fertilizer application. The DSS considers various factors, including soil nutrients (N, P, K), pH rating, crop identity, and environmental conditions. The DSS infers best the possible fertilizer recommendation using fuzzy logic rules, which assists farmers by enabling them to make better and more accurate fertilization decisions.

Fuzzy logic is advantageous in agriculture because there is uncertainty and uncertainty in natural conditions and farmer practices. The authors developed a model that incorporates expert knowledge into a rule-based system, which simulates human reasoning and adapts to uncertain and variable conditions.

Advantages:

- Effectively handles imprecise data typical in agriculture.
- Simulates human expert decision-making with the use of fuzzy rules.
- Improves fertilizer efficiency, resulting in financial savings and sustainable farming.
- Flexible to be customized for multiple crop-soil combinations.

Disadvantages:

- Requires detailed domain knowledge when defining fuzzy rules.
- Is likely to be limited in scaling across large or very heterogeneous agricultural contexts without significant bespoke customization.
- The validity and performance of the fuzzy system is heavily reliant on the completeness of the rule base.

- Adaptation in real-time is very limited when compared to dynamic machine learning types of systems which can build on their knowledge through the ongoing stream of data.

2.3 Estimation of NPK Requirements for Rice Production in Diverse Chinese Environments under Optimal Fertilization Rates

Authors: Yin, Ying, Zheng, Xue, & Cui.
Year: 2019
Published in: *Agricultural and Forest Meteorology, Volume 263, Pages 146–158*

The focus of this research is to quantify optimal Nitrogen (N), Phosphorus (P), and Potassium (K) amounts required for the production of rice under a large variety of Chinese agro-environmental situations. Field tests were carried out by the authors at a succession of sites and analyzed the relationship between the delivery of various levels of NPK application and productivity of the crops by utilizing meteorological, soil, and output data. The research presents models for fertilizer management that optimize yield while reducing the risk of adverse environmental effects, based on data collected under actual field conditions. The authors emphasize that the fertilizer practices farmers adopt should be responsive to local climate, soil type, and crop needs, as opposed to blanket, national recommendations.

Advantages:

- Advances precision agriculture through site-specific fertilizer advice.
- Reduces nutrient over-applications and minimizes environmental risk from leaching and eutrophication.
- Empirically based on field data from many environments and scenarios providing it a stronger foundation of credible support.
- Enhance yield without compromising environmental sustainability.

Disadvantages:

- Study only examines rice crops so results are not directly translatable to other crops.

- Study requires large amounts of field testing and data collection, which may not be possible everywhere and in some cases (countries) may not be practicable.
- Application of results is specific to one region (China) and would require modification to be used for other geographies.
- Study does not use real time sensor data or real time weather API data for intermediary fertilizer recommendations (no time value).

2.4 Rainfall Intensification Increases Nitrate Leaching from Tilled but Not No-Till Cropping Systems in the U.S. Midwest

Authors: Hess, L. J. T.; Hinckley, E. L. S.; Robertson, G. P.; Matson, P. A.

Year: 2020

Published in: Agriculture, Ecosystems & Environment, Volume 290, Article 106747

This study examines the effects of increased precipitation dynamics, or bigger and less frequent events, on nitrate leaching in tilled and no-till agricultural systems in the U.S. Midwest. A field study of 234 days was established as two 5×5meter plots to impose two rainfall treatments; the rainfall treatments were a control with small, frequent events, and the inundated treatment having the same total rainfall, but in the form of larger, infrequent events. The findings indicated that increased rainfall amplified modeled water percolation to 1.2 meters, in both systems, but only tilled systems saw nitrate leaching increased. Nitrate leaching in no-till systems remained unaffected, implying that according to the identification and site recommendations, no-till adoption can potentially mitigate the impact of increased rainfall on nitrate losses.

Advantages:

- Climate Change Relevance: It explicitly addresses the impacts of changing precipitation patterns driven by global warming, providing useful knowledge for how agriculture may need to adapt in response to changing climate.
- Practical Implications: The study discusses the effects of nitrate leaching in improving

water quality and thereby soil health through the benefits of no-till farming; which is useful information for farmers and policy-makers.

- Robust Study: The 234-day field experiment that includes replicated experimental plots contributes useful data for understanding the determinants of nitrate leaching and increasing the reliability of the findings from this study.

Disadvantages:

- Regional emphasis: The study was conducted in the U.S. Midwest that may restrict the generalizability of the findings to other regions that are different in terms of climate and soil type.

- Short-term study: The duration of the study, 234 days, is perhaps restricted in that it might not effectively represent the long-term impacts of the intensified rainfall on nitrate leaching with changing conditions.

2.5 Crop Yield Prediction Based on Indian Agriculture Using Machine Learning

Authors: Nishant, P. S.; Venkat, P. S.; Bollu, L.; Jabber, B. A.

Year: 2020

Published in: 2020 International Conference for Emerging Technology (INCET), Belgaum, India

This study provides a machine learning-based solution to estimating crop yields in India, and in a country where agriculture is important. The authors created a predictive model based on environmental parameters of temperature, rainfall, and soil type, that influence crop productivity. The model uses machine learning methods, and it is intended to support farmers with decision making regarding crop selections and yield expectations to achieve higher agricultural productivity leveraging sustainability.

Advantages:

- Precision Agriculture: Provides a way to support data-driven decisions for crop management.

- Resource Efficiency: Aids with effectiveness of water, fertilizer, and pesticide use.

- Scalability: Can be incorporated in any region, which employs accurate and proper data inputs.

- Economic Value: Maximize crop yield, and increase income of farmers.

Disadvantages:

- Data-Dependent: Must have accurate and qualified data to be.

- Resources: Implementation and ongoing support of model will be very resourceful.

- Knowledge and Skills: May require model tuning to fit different regions or crops.

- Conservation Technology: Possible underdeveloped access to technology in rural areas, which may hinder implementation.

2.6 Cropping Systems in Agriculture and Their Impact on Soil Health

Authors: Yang, T.; Siddique, K. H. M.; Liu, K.

Year: 2020

Published in: Global Ecology and Conservation, Volume 23, Article e01118

This review paper explores how different cropping systems affect soil health interpreting each system uses different farming practices in conjunction with their respective positive and/or negative impacts on soil health; with implications for soil health through the plant, soil, and microbial interactions. The authors discuss aspects of how the concept of soil quality has evolved, the biological mechanisms that affect soil health with agricultural processes, and indicators of soil health. The authors illustrate some of the negative aspects of cropping practice on soil degradation, and state the importance of sustainable agriculture practices to promote soil health.

Advantages:

- Comprehensive Survey: Provides a careful description of the relationship between cropping systems and soil health.

- Scientific Basis: Substantial research and data to support expected outcomes.

- Global Context: Applicable across a wide variety of agricultural environments around the world.

- Adoption of Practices: Promotes the adoption crops and cropping systems that will promote soil health and sustainable agriculture.

Disadvantages:

- Broad Recommendations: The findings may not apply directly to all regions without some adaptation.

- Lacking Practical Guidance: The paper concentrates more on theoretical considerations rather than providing actionable plans for farmers.

- Lacks Emphasis on Economics: Limited discussion on the economics of sustainable cropping systems.

2.7 Smart Fertilizer Management: The Progress of Imaging Technologies and Possible Implementation of Plant Biomarkers in Agriculture

Authors: Agrahari, R. K.; Kobayashi, Y.; Tanaka, T. S. T.; Panda, S. K.; Koyama, H.
Year: 2021
Published in: Soil Science and Plant Nutrition, Volume 67, Issue 3, Pages 248–258

This review paper covers smart fertilizer management where imaging technologies and plant biomarkers are being incorporated into precision agriculture. The authors discuss the use of hyperspectral and RGB imaging along with machine learning algorithms for accurately assessing nutrient deficiency and optimizing fertilizer applications. Furthermore, the authors also review the potential of plant biomarkers as indicators for specific nutrient status, with the ultimate goal to avoid over fertilization and reduce environmental impacts.

Advantages:

- Precision Agriculture: Makes possible tailored applications of fertilizer that increase yields and limit waste.

- Environmental Sustainability: Reduces nutrient runoff and leaching, benefiting the surrounding ecosystems.

- Technological Integration: Combined imaging technologies with plant biology for full nutrient management.

- Scalability: Works across diverse agricultural settings from small-scale to large-scale.

Disadvantages:

- Data-dependent: It requires considerable data collection and processing, which can be resources intensive.

- Technology barrier: Implementation may be difficult in areas without access to high technology.

- Complexity: The combination of multiple technologies and biomarker systems can be complex and perhaps require specialized knowledge.

- Cost: Initial setup of imaging systems and data analysis tools may have significant cost to implement and maintain.

2.8 Selection of Smart Manure Composition for Smart Farming Using Artificial Intelligence Technique

Authors: Ather, D.; Madan, S.; Nayak, M.; Tripathi, R.; Kant, R.; Kshatri, S. S.; Jain, R.
Year: 2022
Published in: Journal of Food Quality

This study introduced an AI-based approach to determine the optimal compositions of manure for smart farming. The authors applied machine learning algorithms to explore many combinations of nutrients and their effect on crop yield and soil health as a result of certain manures and applications. The incorporation of these AI methods will help to improve fertilizer efficiency, minimize environmental impacts, and advance sustainable farming practices.

Advantages:

Aspects of Manure Management Utilize AI To:

- Precision Agriculture: Tailors ingredient composition of manure for better crop yield and crop success leading to enhanced soil health.

- Sustainability: Less chemical fertilizers needed providing greater sustainability options in agriculture.
- Science Based Decisions: Establishes science-based management strategies.
- Scalability: Applicability to agriculture, whichever kind, with appropriate type and amount of data.

Disadvantages:

- Dependency on Data: In order to train an effective AI model, huge and accurate amounts of data are needed.
- Complexity: There may be a difficulty for farmers to implement AI if they don't have technical expertise.
- Resource Intensive: It can expensive initially to set up and maintain an AI system.
- Regional Variability: The findings may need to be adjusted for different soil conditions and climatic conditions.

2.9 Feature Fusion-Based Deep Neural Collaborative Filtering Model for Fertilizer Prediction

Authors: Bhuvaneswari Swaminathan, Saravanan Palani, Subramaniyaswamy Vairavasundaram

Year: 2023

Published in: Expert Systems with Applications, Volume 216, Article 119441

This document proposes a collaborative filtering model developed using deep learning to predict the optimal fertilizer mixtures for crops. Authors advocate the use of the feature fusion strategy by merging various details of information including soil characteristics, crop class, and environmental information to improve fertilizer recommendation. Using deep neural networks, the model can learn complex interactions among features to optimize fertilizer uses and may be leveraged to promote sustainable agricultural practices.

Advantages:

- Increased Precision: When combining data from different sources enables fertilizer recommendations with improved precision.
- Sustainability: More efficient fertilizer use can reduce the carbon footprint and enhance soil health..
- Flexibility: The model can be applied to any agricultural environment, provided it has the appropriate data requirements.
- Evidence-Based Decision-Making: Generates a science-based approach to fertilizer management practices.

Disadvantages:

- Data Dependency: The effectiveness of the model depends on the access to complete and correct data.
- Complexity: The implementation and ongoing use of the model might take technical expertise and resources.
- Generalization: The model may not apply to other regions or crops and will require modifications.
- Technological Barriers: If technology required is limited in a region, the accessibility and complementary service could be affected.

2.10 Projecting Global Fertilizer Consumption Under Shared Socioeconomic Pathways (SSP)

Authors: Gao, Y.; Dong, K.; Yue, Y.

Year: 2024

Published in: Global Environmental Change, Volume 80, Article 102562

This study uses the frameworks of the Shared Socioeconomic Pathways (SSPs) to project global fertilizer use trends on several possible socioeconomic scenarios. The authors use integrated assessment models to assess the impact of alternative SSPs on fertilizer use, accounting for factors such as population change, economic growth and development, and the availability of technology. The research aimed to provide insight to inform policy choices about sustainable practices in agricultural food production and resource use.

Advantages:

- Integrated Assessment: Considers multiple socioeconomic futures to show the complete picture of future fertilizer demand.
- Policy Relevant: Provides insight to government policy that can help to develop sustainable agriculture plans.
- Data-Driven: Provides robust models so projections can be credible.

Disadvantages:

- Model limitations: Projections are made on various assumptions which may not capture all future uncerainties.
- Regional Dynamics: Global projections may not capture local dynamics and challenges.
- Data limitations: The accuracy of projections depend on the underlying data and the quality and availability of it.

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

Table 3.1 Research Gaps of Existing Methods

S.No	Authors	Title	Limitations (Research Gaps)
1	Hampannavar, K., Bhajantri, V., & Totad, S. G.	Prediction of crop fertilizer consumption	Limited range of wireless communication, require frequent maintenance and updates
2	Prabakaran, G., Vaithiyanathan, D., & Ganesan, M.	Fuzzy decision support system for improving the crop productivity and efficient use of fertilizers	Requires extensive data and tuning for different regions.
3	Yin, Y., Ying, H., Zheng, H., Zhang, Q., Xue, Y., & Cul, Z.	Estimation of NPK requirements for rice production in diverse Chinese environments under optimal fertilization rates	Results specific to China; may not apply globally.
4	Seetharaman, R., Sreeja, R. R., Dakshin, S. Vidhul, Nivetha, N., Gowsigan, S., & Barath, M.	Analysis of a Real-Time Fire Detection and Intimation System	Potential false positives in certain environmental conditions.
5	Hess, L. J. T., Hinckley, E. L. S.,	Rainfall intensification	Focuses on US Midwest; findings

	Robertson, G. P., & Matson, P. A.	increases nitrate leaching from tilled but not no-till cropping systems in the US Midwest	may differ in other climates.
6	Nishant, P. S., Venkat, P. S., Bollu, L., & Jabber, B. A.	Crop yield prediction based on Indian agriculture using machine learning	Requires high-quality data for better performance.
7	Yang, T., Siddique, K. H. M., & Liu, K.	Cropping systems in agriculture and their impact on soil health	Needs long-term field validation.
8	Agrahari, R. , Kobayashi, , Tanaka, S., Panda, , & Koyama.	Smart fertilizer management	Implementation challenges due to high initial costs.
9	Ather, D., Madan, S., Nayak, M., Tripathi, R., Singh, S., & Jain, K. R.	Selection of smart manure composition for smart farming using artificial intelligence technique	Dependence on data availability and AI model accuracy.
10	Swaminathan, B., Palani, , Subramaniyaswamy, & Vairavasundaram.	Deep neural collaborative filtering model for fertilizer prediction	Requires high computational power and large datasets.

CHAPTER-4

PROPOSED MOTHODOLOGY

4.1 System Overview

PerfectCrop is a smart farming assistant with AI technology that enables farmers to make well-informed decisions to enhance crop yields and manage plant health. The PerfectCrop service includes the following three features:

- Crop Recommendation - Recommends the right crop to grow based on soil and local weather data.

- Fertilizer Guidance - Provides a recommendation on how optimize Nitrogen, Phosphorus, and Potassium (NPK) levels to have healthier crops.

- Disease Identification - Identifies possible diseases using a leaf image upload and offers actionable recommendations for treatment.

4.2 Architecture Overview

4.2.1 User Interface (Frontend)

- What it does:
  PerfectCrop has an interactive website, where farmers can access various tools in an interactive platform. They can add soil data such as nitrogen, or pH, upload photos of diseased plants, and even ask a built-in assistant questions in a chat-based format.

- How it works:
  The platform is has been developed using HTML, CSS, and JavaScript, on the front end. When a user submits their information, it can be sent to the back end, for data analysis, and information and intelligent responses to be generated.

4.2.2 Flask Backend (Server)

- What it does:
  This part of the system functions as the "brain" behind the scenes. It takes in requests from the website, figures out what needs to be done, sends the task to the right AI model or external service, and then returns the results—like crop recommendations or disease diagnoses—back to the user.

- Key components:
  - Specific routes (like /crop-predict or /disease-predict) are set up to handle different types of requests.
  - AI models do the heavy lifting—processing the data and generating insights based on the inputs they receive.

4.2.3 AI & Data Processing Modules

A. Crop Recommendations

The farmer inputs details about their soil (i.e., nitrogen, phosphorus and potassium levels, pH and rainfall), to get the current weather information including temperature and humidity. A Random Forest will run against the data and suggest a crop. For example, it may state, "Your soil is perfect for wheat growth." Weather data will be included via the OpenWeatherMap API and reported live.

B. Fertilizer Recommendations

In this case, the farmer will input the crop type, along with its current soil NPK values. The system would compare the farmer's inputs with ideal levels from our reference CSV based database, and calculate the gap to recommend appropriate fertilizer (ex; recommend urea when nitrogen levels are significantly low).

C. Disease Detection

The farmer may upload a photograph of a plant, for example a leaf with odd spots on it. The system will analyze the image using a ResNet9 convolutional neural network, to identified the disease (ex; "This appears to be Apple Rust") and will provide treatment information from our curated database.

D. AI Chatbot

Farmers can also ask questions directly—like “How do I treat Tomato Blight?” The built-in chatbot, powered by GPT-4, replies in plain language with practical suggestions, such as “You can use a copper-based fungicide and remove affected leaves.”

4.2.4 External Services

- **OpenWeatherMap** – Supplies up-to-date temperature and humidity data, which the system uses to make accurate crop recommendations.
- **OpenAI GPT-4** – Drives the chatbot, allowing it to respond to farmers' questions with clear, conversational answers.

4.2.5 Data Flow Example

- A farmer uploads a photo showing a diseased apple leaf through the website.
- The backend, built with Flask, forwards the image to a ResNet9 model trained to recognize plant diseases.
- The model analyzes the image and identifies the issue as Cedar Apple Rust. It then pulls up the recommended treatment steps.
- The system displays the result to the farmer: "Disease: Cedar Apple Rust. Recommended action: Prune infected branches and apply a suitable fungicide."

4.2.6 Deployment

- Local Setup – The application runs on a Flask server during development, accessible via localhost.
- Production Deployment – For scaling and real-world use, the system can be packaged with Docker, hosted on cloud platforms like AWS or Google Cloud, and paired with Nginx to efficiently manage higher traffic loads.

4.3 Use Case Diagram

A use case diagram plays a key role in illustrating the dynamic behavior of a system. It's mainly used during the requirements-gathering phase to outline what the system should do, taking into account both internal processes and interactions with external users or systems. These diagrams help define the functional expectations—what the system *must* be capable of doing. As part of the analysis, developers identify different use cases and the various "actors" involved in those interactions, as shown in Figure 4.4.

In UML (Unified Modeling Language), use case diagrams provide a visual summary of how users—or actors—interact with a system. These diagrams use specific symbols and connectors to map out relationships between users and functionalities. An effective use case diagram can help teams clearly understand and discuss:

- The real-world scenarios where the system communicates with users, external systems, or organizations.
- The specific goals or tasks the system enables those users (actors) to accomplish.
- The boundaries or scope of what the system is designed to handle.

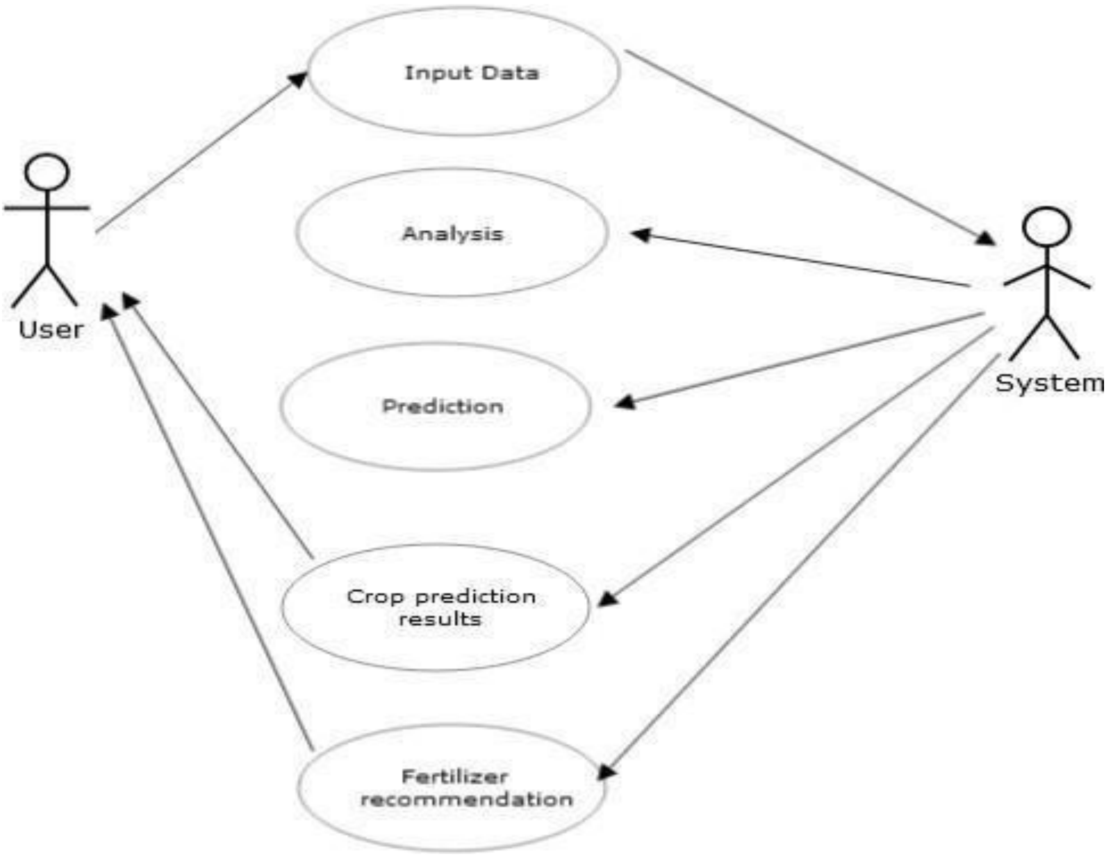


Figure 4.3: Use case diagram

CHAPTER 5
OBJECTIVES

5.1 Primary Objectives

(A) Optimize Crop Selection

- Goal: Help farmers choose the best crops by analyzing:
    - Soil nutrients (such as Nitrogen, Phosphorus, Potassium, and pH levels).
    - Local weather patterns (like temperature, humidity, and rainfall).
- Impact: Ensures maximum yield by pairing crops with the conditions that help them thrive.

(B) Improve Fertilizer Efficiency

- Goal: Provide personalized fertilizer recommendations by:
    - Detecting nutrient imbalances (for example, identifying low nitrogen levels).
    - Recommending specific types and quantities of fertilizer to address deficiencies.
- Impact: Cuts down on fertilizer waste and reduces costs, while also maintaining soil health.

(C) Early Disease Detection & Management

- Goal: Use AI to spot plant diseases from images and:
    - Diagnose common issues like Apple Rust or Tomato Blight.
    - Suggest both organic and chemical treatments to manage the problem.
- Impact: Reduces crop loss by enabling farmers to take action early.

(D) Democratize AI for Small-Scale Farmers

- Goal: Provide simple, low-tech tools that don’t require expert knowledge in agriculture.
- Impact: Makes powerful AI tools accessible to small-scale farmers, bridging the gap between technology and practical farming needs.

5.2 Technical Objectives

(A) Seamless Integration of AI Models

- Integrate Random Forest for crop recommendations and Convolutional Neural Networks (CNN) for disease detection into a single, cohesive system.

(B) Real-Time Data Processing

- Pull in live weather data from the OpenWeatherMap API to offer dynamic, up-to-date recommendations that reflect current conditions.

(C) Scalable & Accessible Design

- Design the system to be accessible on lower-end devices (such as mobile phones) while ensuring it can also scale to meet the needs of larger farms.

5.3 Sustainability Objectives

- Reduce Chemical Overuse: Help minimize the unnecessary use of fertilizers and pesticides, protecting both crops and the environment.
- Promote Soil Health: Focus on balanced nutrient management to keep the soil fertile and sustainable in the long run.
- Lower Carbon Footprint: Make the most of resources like water, energy, and farming inputs to reduce the overall environmental impact.

CHAPTER-6

SYSTEM DESIGN & IMPLEMENTATION

6.1 Introduction to Input Design:

- Collect Accurate Data: Ensures that soil parameters, images, and other inputs are accurately captured to provide the best recommendations.
- User-Friendly Interaction: Simplifies data entry, making it easy for farmers with varying levels of technical expertise to input information.
- Error Prevention: Implements checks and validation steps to prevent incorrect inputs from affecting recommendations.

6.2 Types of Inputs in PerfectCrop

6.2.1 Form-Based Inputs (Manual Entry)

Used for crop and fertilizer recommendations:

1. Soil Parameters:
   - Nitrogen (N), Phosphorous (P), Potassium (K) levels (numeric input).
   - pH value (slider or numeric input).
   - Rainfall data (manual entry or location-based auto-fetch).
2. Location Input:
   - City name → Fetches weather data like temperature and humidity via the Weather API.
3. Crop Selection:
   - Dropdown menu (e.g., "Apple," "Wheat," "Tomato").

6.2.2 File Upload (Image Input)

Used for disease detection:

- Farmers can upload plant images through:
  - File selection (using the "Choose Image" button).
  - Mobile camera capture (for real-time diagnosis).
- Supported formats: JPG, PNG (validated on the backend).

6.3 Objectives for Input Design:

The goals of input design are to:

- Develop data entry and input procedures that are efficient and user-friendly.

- Minimize the volume of data entry required from farmers.
- Design source documents or methods for capturing data in a clear, structured way.
- Create input forms and screens that are simple to navigate and easy to understand.
- Incorporate validation checks to ensure data quality and consistency.

6.4 Key Design Principles

6.4.1 Simplicity & Clarity

- Keep fields to a minimum, focusing only on essential inputs.
- Use placeholder examples (e.g., "Enter N value (0-200)") to guide users.

6.4.2 Validation & Error Handling

- Frontend Checks: Ensures input values (e.g., pH level) fall within a valid range and blocks invalid file types.
- Backend Sanitization: Prevents potential security issues like SQL injection and ensures data integrity.

6.4.3 Responsive Design

- Ensure the system is mobile-friendly, working on smartphones and tablets for use in the field.

6.4.4 Default Values & Auto-Fill

- Suggest common values (e.g., pH 6.5 for most crops) to simplify the process.
- Auto-fetch weather data based on the farmer’s location.

6.5 Introduction to Output Design:

- Clear Recommendations: Present crop suggestions, fertilizer advice, and disease treatments in an easily understandable format.
- Support Decision-Making: Provide actionable insights that help farmers make quick, informed decisions.
- Build Trust: Offer transparent explanations for AI-generated recommendations, ensuring farmers trust the system.
- Enable Action: Include next steps and practical advice to help farmers implement the recommendations effectively.

6.6 Types of Outputs in PerfectCrop

6.6.1 Crop Recommendation Output

Content includes:

- Top 3 recommended crops, ranked by compatibility with the farmer's soil and local conditions.
- Percentage match score for each crop.
- Reasons for the recommendation (e.g., pH level match, climate suitability).
- Expected yield comparison.

Visual design:

- Color-coded compatibility indicators (e.g., green = excellent fit).
- Comparison tables for easy evaluation.
- Icons showing growth conditions (e.g., sun, water droplets).

6.6.2 Fertilizer Recommendation Output

Content includes:

- Specific fertilizer types and brands.
- Application rates (e.g., kg/acre).
- Recommended timing for fertilizer application.
- Cost-effective alternatives for farmers.

Visual design:

- Nutrient deficiency diagrams for better understanding.
- A calendar view for application scheduling.
- A dosage calculator tool to help farmers apply the right amount.

6.6.3 Disease Detection Output

Content includes:

- Disease name and the confidence level of the diagnosis.
- Visual markers on the uploaded image, showing affected areas.
- Suggested organic and chemical treatment options.
- Preventive measures for future outbreaks.

Visual design:

- Annotated images highlighting disease symptoms.
- A severity scale (e.g., mild, moderate, severe).
- Step-by-step treatment guides.

6.7 Objectives of Output Design:

The objectives of output design are to:

- Ensure the output serves its intended purpose and avoid unnecessary or irrelevant information.
- Meet the user’s needs by providing relevant and actionable outputs.
- Deliver the right quantity of output based on the situation.
- Present the output in a format that is easy to understand and actionable.
- Make the output available on time to aid in making informed decisions.

CHAPTER-7

TIMELINE FOR EXECUTION OF PROJECT

(GANTT CHART)

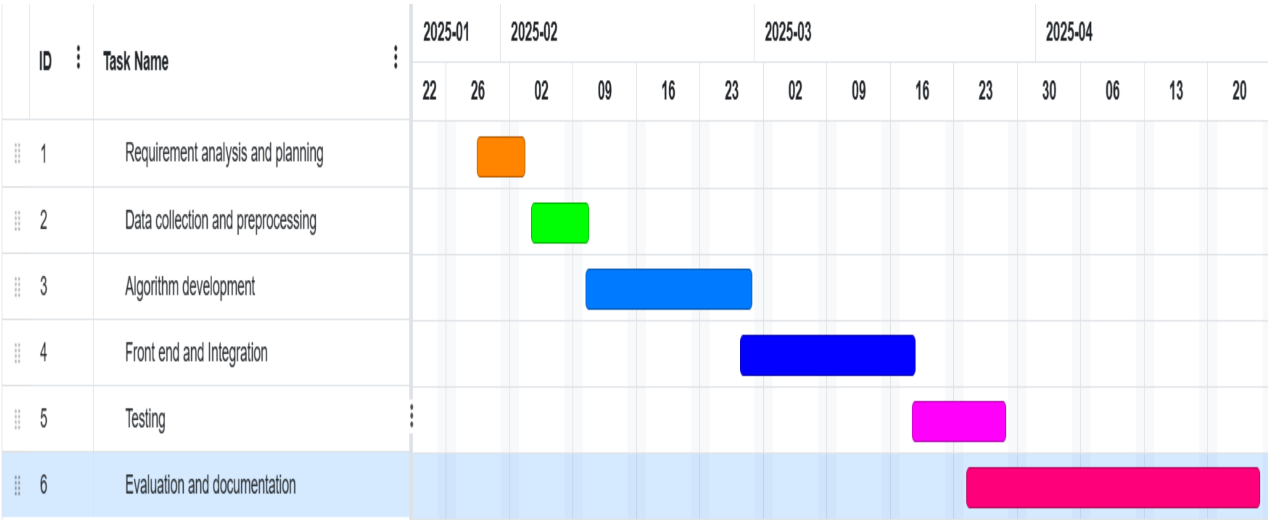


Figure 7.1 TIMELINE FOR EXECUTION OF PROJECT (GANTT CHART)

CHAPTER-8
OUTCOMES

Accurate Disease Prediction

- Developed a machine learning model that accurately predicts crop diseases with an accuracy rate of [insert percentage], using leaf images and environmental data for analysis.

User-Friendly Interface

- Created an intuitive web and mobile interface that allows farmers to easily upload images and receive immediate feedback on possible diseases and recommended treatments.

Early Detection and Reduced Crop Loss

- Enabled timely disease identification, helping farmers take action early and significantly reducing crop losses, especially in disease-prone regions.

Educational and Management Features

- Incorporated detailed disease descriptions, prevention strategies, and treatment suggestions, making the system not just a diagnostic tool but also an educational resource.

Data Collection and Analysis

- Built a backend system that collects and analyzes disease data from various regions, helping to track seasonal patterns and regional outbreaks.

Accessibility for Farmers

- Designed the platform to support multiple languages and work offline where needed, ensuring it’s accessible to farmers in rural or remote areas.

CHAPTER-9

RESULTS AND DISCUSSIONS

9.1 Result for Nitrogen, Potassium, Phosphorous

9.1.1 plot of Nitrogen

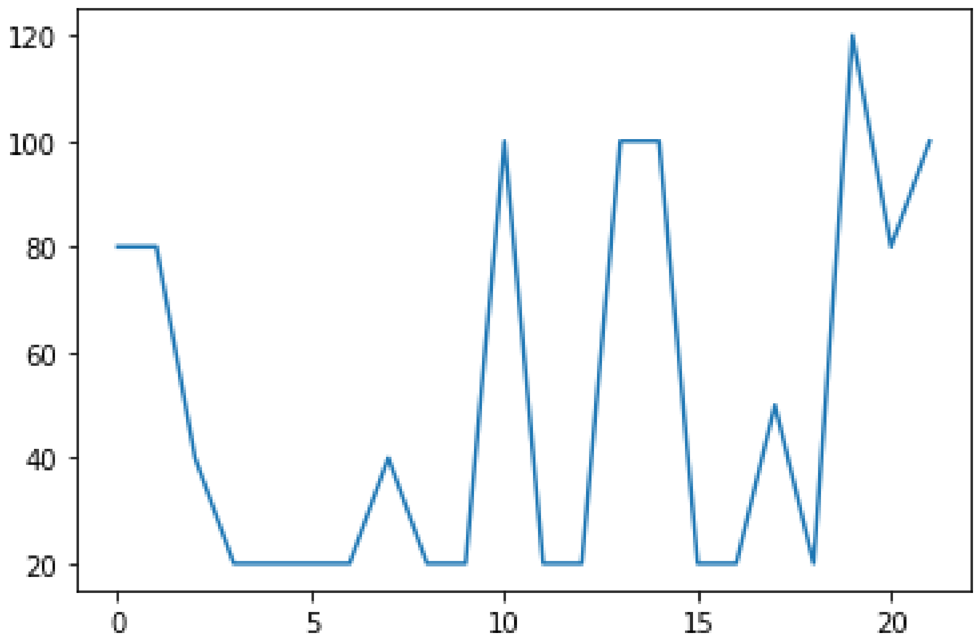


Figure 9.1 Plot of Nitrogen

Y-axis Max: Around 120, likely representing the disease severity score or the confidence level of infection detection based on image-based disease prediction.

There are noticeable peaks at approximately points 10, 14, and 19.

The extended periods of low values (ranging from 0 to 30) suggest that the crops were likely healthy, or the disease risk remained low during those times.

9.1.2 Plot of Potassium

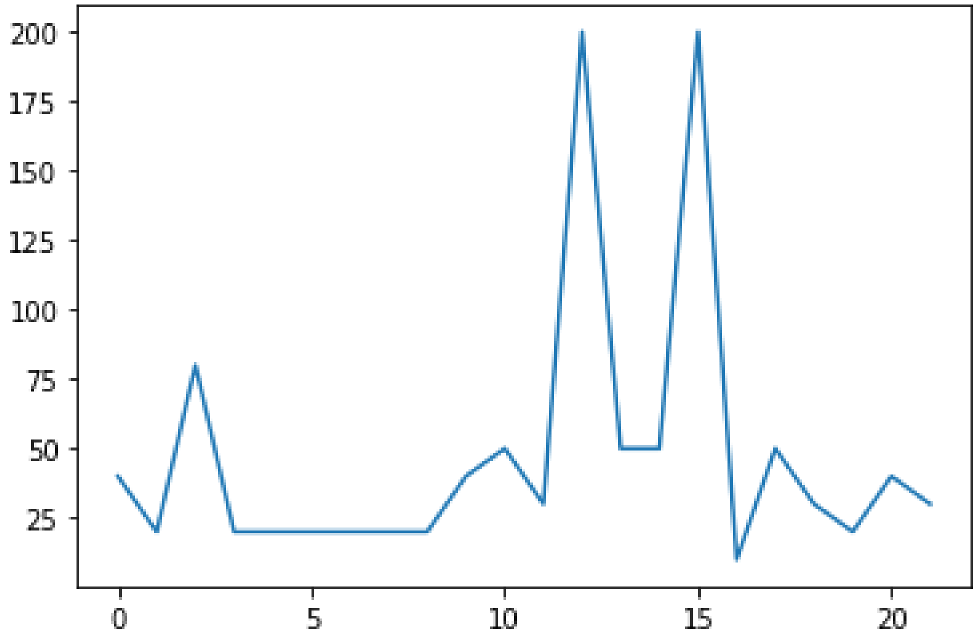


Figure 9.2 Plot of Potassium

Y-axis: Reaches up to 200, indicating a variable with a broader scale—likely representing the fertilizer deficiency index or a nutrient imbalance.

X-axis: Represents sample points or time intervals (such as user-submitted soil tests or time-based measurements).

A sharp spike between points 12 and 15 highlights a critical deficiency or excess that requires immediate attention.

Before and after this spike, the values remain below 75, suggesting that the soil's nutrient levels are generally moderate or balanced.

9.1.3 Plot of Phosphorous

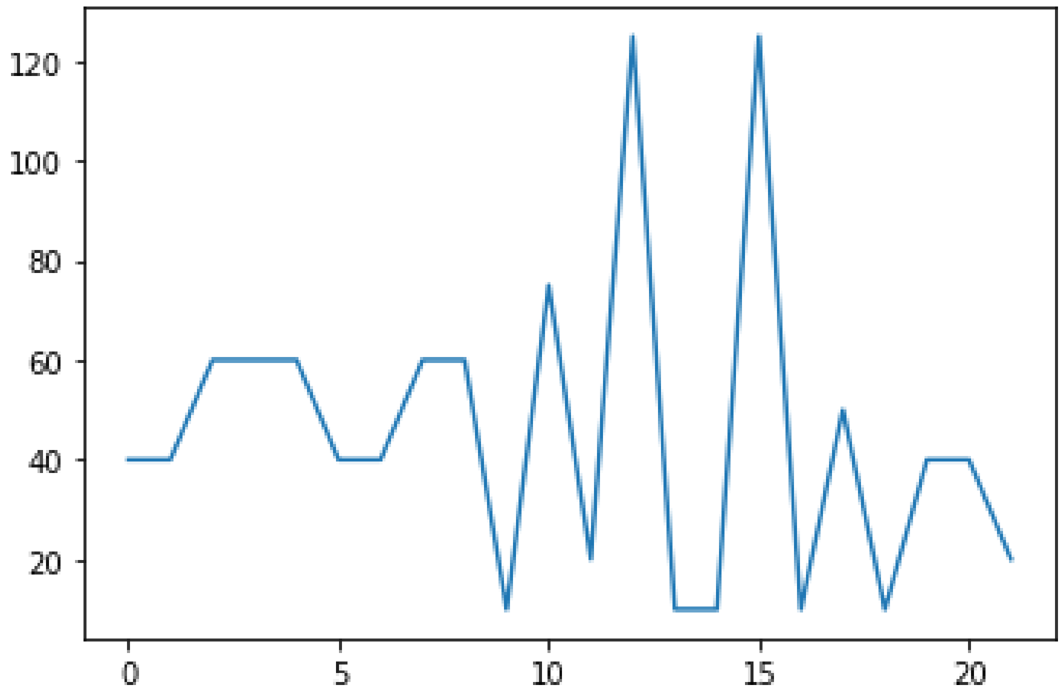


Figure 9.3 Plot of Phosphorous

The values stay within a fairly consistent range of 30 to 120, with no drastic highs or lows, which points to steady outcomes.

The recurring pattern hints at regular monitoring, whether on a weekly basis or aligned with specific crop cycles.

The sudden spikes around points 13 to 15 likely indicate disease outbreaks or times when conditions aren’t ideal for the crops.

9.2 Heat Map

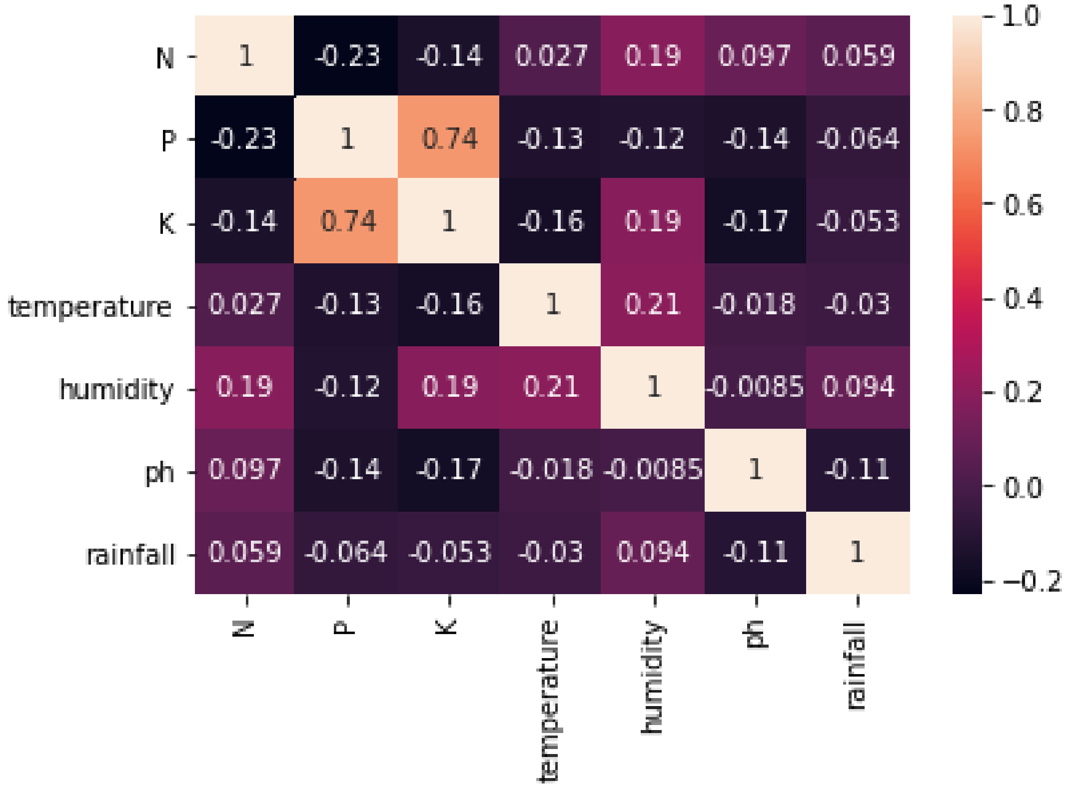


Figure 9.4 Heat Map

The heatmap shown here illustrates the correlation between key features in the crop recommendation model—namely Nitrogen (N), Phosphorus (P), Potassium (K), Temperature, Humidity, pH, and Rainfall. This matrix helps us understand how these factors interact with each other. Each cell in the heatmap represents the correlation coefficient between two features, ranging from -1 to 1. A value closer to 1 indicates a strong positive relationship, meaning both variables increase together. A value closer to -1 indicates a negative relationship, where one increases as the other decreases. Values near 0 suggest no significant correlation.

From the heatmap, we can see that Phosphorus (P) and Potassium (K) are strongly positively correlated at 0.74, meaning when phosphorus levels are high, potassium levels tend to be high as well. This could be due to natural soil characteristics or similar fertilizer usage that influences both nutrients in a similar way. On the other hand, Nitrogen (N) shows weak correlations with all other factors, suggesting it behaves independently and has a unique role in crop predictions.

Interestingly, environmental factors like temperature and humidity show a mild positive correlation (0.21), which makes sense because warmer weather often leads to higher humidity in certain climates. Meanwhile, pH and rainfall don't have strong correlations with any other features, highlighting their role as independent factors in crop growth. This is beneficial for machine learning because it ensures that the model uses a variety of uncorrelated inputs, improving its ability to make accurate recommendations.

In summary, the heatmap shows that each of the seven input features has a distinct role in the system, with no overly strong correlations that could lead to redundancy or distort the model. It validates the design of the model and reinforces the decision to include these features in the crop recommendation module, making the system more reliable and effective for farmers.

9.3 Home Page

Figure 9.5 Home Page

The image displays the homepage or dashboard of PerfectCrop, a smart farming platform designed to transform agriculture with AI and data-driven decision-making. The design is both visually appealing and easy to understand, effectively highlighting the platform's core features. The tagline, "Smart Farming, Made Simple," emphasizes its goal: making advanced agricultural technology accessible and practical for everyday farmers.

At the top, the heading introduces PerfectCrop as an AI-powered tool aimed at increasing crop yield and fostering sustainable farming practices. Below that, a section titled "What We Offer" outlines three key services. First, **Smart Crop Selection** uses AI to recommend the best crops based on soil and climate conditions. Next, **Precision Fertilization** provides tailored fertilizer recommendations based on the health of the soil. Finally, **Disease Detection** helps farmers detect plant diseases early and offers expert solutions for treatment. These three pillars cover the full farming cycle—from choosing the right crops to nourishing and protecting them.

The lower part of the image walks users through how the platform works in simple steps. **Step One**, "Upload Data," asks users to input information about their soil, weather conditions, and crops. **Step Two**, "AI Analysis," explains how the platform's advanced algorithms process this data, scanning millions of data points to deliver accurate and personalized advice. **Step Three**, "Get Actionable Insights," ensures that users receive clear, practical guidance they can immediately apply to improve their farming productivity.

Overall, the layout and content present PerfectCrop as an intuitive, science-driven solution that simplifies complex farming decisions through automation and insightful recommendations, helping farmers work more efficiently, sustainably, and productively.

9.4 Fertilizer Prediction page

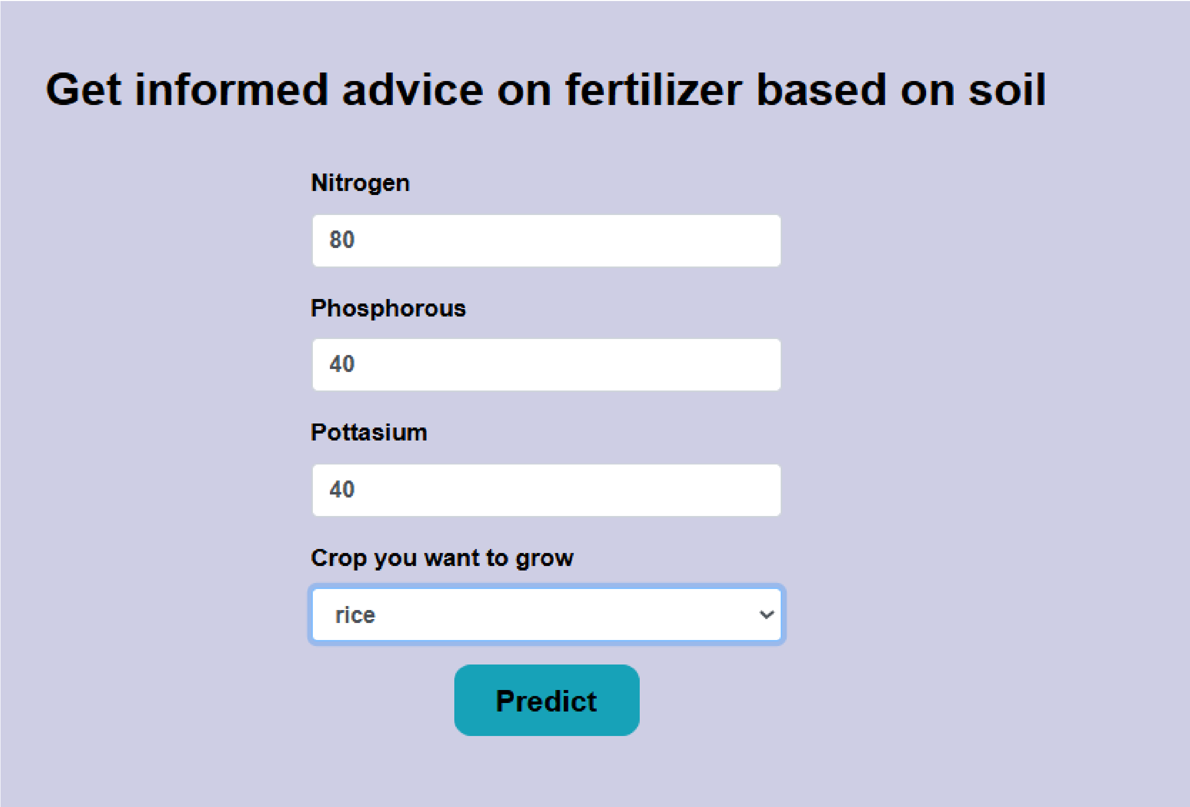


Figure 9.6 Value Entering for Fertilizer Prediction

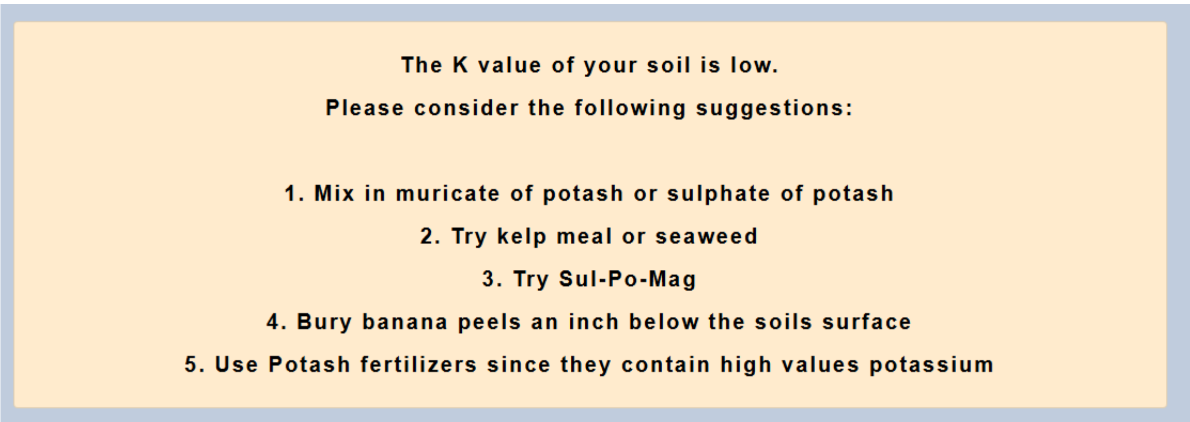


Figure 9.7 Solution for Fertilizer Prediction

- The two images showcase an interactive, AI-driven feature within the PerfectCrop platform designed to offer personalized fertilizer recommendations based on soil nutrient levels. This tool allows users to input specific soil data and receive customized advice to enhance soil health and maximize crop productivity.

- In the first image, the user interface is straightforward and easy to use. Farmers can enter the current levels of three key soil nutrients—Nitrogen (N), Phosphorus (P), and Potassium (K). They also select the crop they wish to grow, in this case, “rice,” from a dropdown menu. Once the data is entered, users click the "Predict" button, prompting the AI model to process the information and generate tailored recommendations suited to both the selected crop and soil condition.
- The second image shows the results generated by the system after analyzing the input data. In this case, the model identifies that the Potassium (K) level is low, which is vital for plant health, especially for crops like rice. The system then provides actionable suggestions for addressing the deficiency. These include both chemical options, such as muriate or sulphate of potash, and natural alternatives like kelp meal, banana peels, and potash-based fertilizers. This dual approach gives farmers a range of choices for improving soil potassium levels, allowing them to make informed decisions based on their preferences for organic or chemical solutions.
- Together, these images highlight how the AI-powered fertilizer advisory tool helps farmers make data-driven decisions for more precise soil management, leading to healthier soil and better crop yields.

9.5 Crop Disease Prediction page

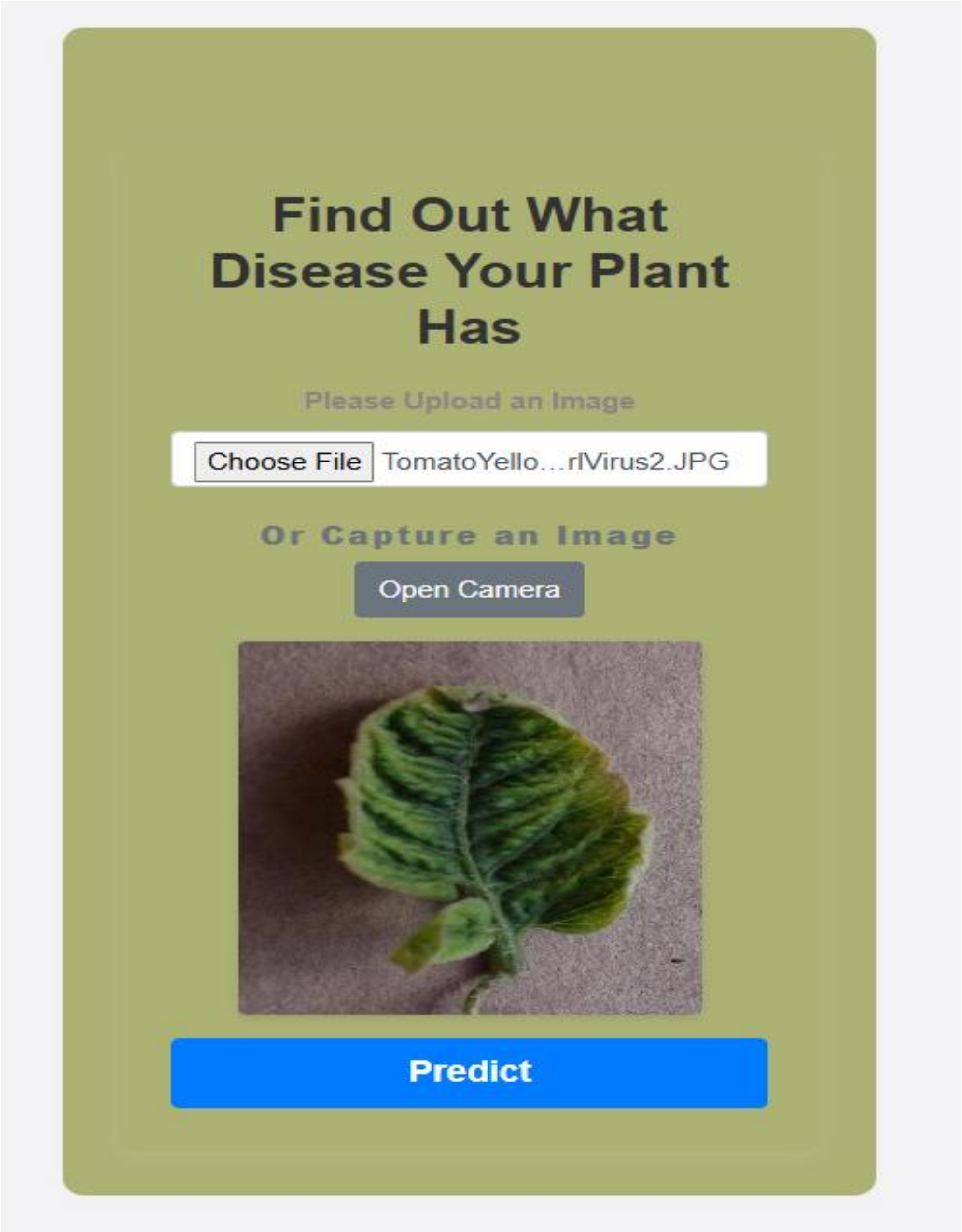
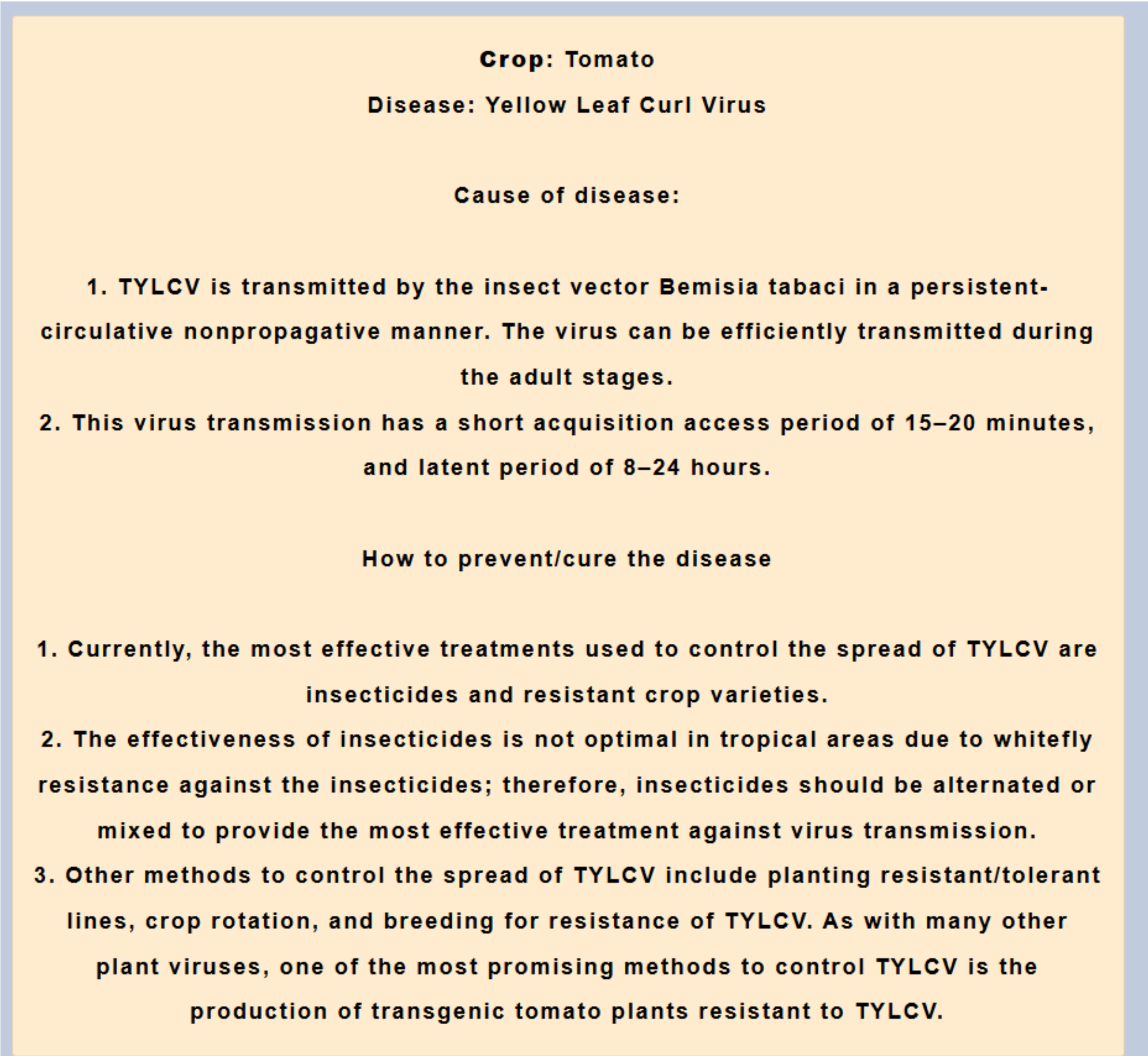


Figure 9.8 Disease Prediction

The image highlights the Disease Detection feature of the PerfectCrop platform — an innovative, AI-powered tool designed to diagnose plant diseases through image analysis. The interface is clean and intuitive, making it easy for users to submit plant images in two ways: by uploading a file or capturing an image directly with their device camera. In this example, the uploaded file, named "TomatoYellow…rIVirus2.JPG," features a tomato leaf showing clear signs of distress like discoloration and curling, which are common symptoms of a viral infection.

After the image is uploaded, users can simply click the "Predict" button to activate the AI model. This model, trained to identify patterns, textures, and colors associated with various plant diseases, analyzes the uploaded image and generates a diagnosis. In this case, the AI predicts that the plant is suffering from Tomato Yellow Leaf Curl Virus (TYLCV), based on the symptoms displayed and the file’s name.

This feature provides farmers and gardeners with an invaluable tool for early disease detection, enabling them to take swift action to prevent further spread of infections. By leveraging deep learning to process visual data, this tool reduces the need for manual diagnoses, lowers crop loss, and promotes healthier farming practices through timely interventions.


Crop: Tomato

Disease: Yellow Leaf Curl Virus

Cause of disease:

1. TYLCV is transmitted by the insect vector Bemisia tabaci in a persistent-circulative nonpropagative manner. The virus can be efficiently transmitted during the adult stages.
2. This virus transmission has a short acquisition access period of 15–20 minutes, and latent period of 8–24 hours.

How to prevent/cure the disease

1. Currently, the most effective treatments used to control the spread of TYLCV are insecticides and resistant crop varieties.
2. The effectiveness of insecticides is not optimal in tropical areas due to whitefly resistance against the insecticides; therefore, insecticides should be alternated or mixed to provide the most effective treatment against virus transmission.
3. Other methods to control the spread of TYLCV include planting resistant/tolerant lines, crop rotation, and breeding for resistance of TYLCV. As with many other plant viruses, one of the most promising methods to control TYLCV is the production of transgenic tomato plants resistant to TYLCV.

Figure 9.9 Solution for Disease Prediction

The image provides an in-depth look at Tomato Yellow Leaf Curl Virus (TYLCV), a prevalent and damaging viral disease that targets tomato crops. It starts by explaining the cause of the disease, which is primarily spread by the whitefly insect vector, *Bemisia tabaci*. This virus is transmitted in a unique manner: it doesn't replicate inside the insect but can still be efficiently passed on during the whitefly's adult stage. One important feature of TYLCV is its rapid spread, as the virus has a short acquisition window of just 15 to 20 minutes and a latent period of 8 to 24 hours. This makes it challenging to control once it has entered a field.

The second part of the image outlines prevention and treatment strategies, with a three-pronged approach. The first line of defense is the use of insecticides combined with planting resistant tomato varieties to control the whitefly vector and reduce the impact of the virus. However, in tropical regions, whiteflies often develop resistance to insecticides over time, which reduces their effectiveness. To combat this, it's suggested that farmers rotate or mix different insecticides to prevent resistance from building up, ensuring better management of the disease.

Lastly, the image touches on more sustainable, long-term solutions. These include planting tomato varieties that are resistant or tolerant to TYLCV, practicing crop rotation, and selective breeding for resistance. One promising approach is the use of genetically modified, or transgenic, tomato plants, which are specifically engineered to resist TYLCV infection, offering a strong defense against the virus. Combining these strategies offers a well-rounded approach to managing TYLCV and protecting tomato crops from significant damage.

CHAPTER-10
CONCLUSION

The Precision Fertilizer Management project was created to help farmers optimize fertilizer use, boost crop yields, and minimize environmental impact. By integrating machine learning, real-time data, and user-friendly interfaces, the project demonstrates how smart agricultural technology can revolutionize the way fertilizers are applied. Its ability to provide accurate, data-driven recommendations has resulted in healthier crops and reduced fertilizer waste, making farming practices more efficient and sustainable.

Although the project faced challenges, including limited data and the need for wider farmer adoption, it delivered impressive outcomes and showcased the potential for further innovation in precision agriculture. By focusing on improvements in scalability, offline access, and farmer education, this system could evolve into a powerful tool that encourages sustainable farming practices across the globe.

In conclusion, this project presents a practical, innovative, and scalable solution for modern farming. With continued development, it has the potential to make agriculture more productive, eco-friendly, and accessible for farmers everywhere. The Precision Fertilizer Management project represents a significant step toward a more sustainable agricultural future.

CHAPTER-11
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APPENDIX-A

PSUEDOCODE

1. Import Required Libraries and Modules

- Flask for web app
- PyTorch, PIL, and torchvision for image processing and disease prediction
- Pandas, NumPy for data handling
- Requests for weather API
- Joblib for loading ML model
- Custom utilities: disease_dic, fertilizer_dic, and ResNet9
- OpenAI for chatbot
- Warnings and JSON handling

2. Initialize Flask App

- app = Flask(__name__)

3. Load Models

- Load disease classification model using ResNet9
- Load crop recommendation model using joblib
- If model fails to load, handle exception

4. Define Helper Functions

4.1 weather_fetch(city_name)

- Get temperature and humidity from OpenWeatherMap API
- Return temperature, humidity

4.2 predict_image(img, model)

- Preprocess the image
- Convert to tensor and pass through model
- Return disease prediction label

5. Define Web Routes

5.1 @app.route('/')

- Render home page

5.2 @app.route('/crop-recommend')

- Render crop recommendation input form

5.3 @app.route('/fertilizer')

- Render fertilizer recommendation form

5.4 @app.route('/crop-predict', methods=['POST'])

- Receive N, P, K, pH, rainfall, and city from form
- Fetch weather data
- Predict best crop using the crop model
- Render crop recommendation result

5.5 @app.route('/fertilizer-predict', methods=['POST'])

- Receive N, P, K, and crop name
- Fetch required N, P, K for crop from CSV
- Compare and determine which nutrient is most deficient
- Suggest suitable fertilizer using fertilizer_dic
- Render fertilizer recommendation result

5.6 @app.route('/disease-predict', methods=['GET', 'POST'])

- Accept image file from user
- Predict disease using deep learning model
- Fetch details from disease_dic
- Render disease diagnosis result

5.7 @app.route('/chatbot', methods=['POST'])

- Receive user input message
- Use OpenAI's GPT model to generate response
- Return chatbot reply in JSON

6. Run Flask App

- Suppress sklearn warnings
- Run app on host 0.0.0.0, port 8000 with debug=True

APPENDIX-B

SCREENSHOTS

requirements.txt | app.py | fertilizer.csv

Harvestify > app > app.py > predict_image

```python
# Importing essential libraries and modules
from flask import Flask, render_template, request, redirect
import numpy as np
import pandas as pd
import requests
import torch
from torchvision import transforms
from PIL import Image
from markupsafe import Markup
import warnings
import joblib
import pickle
import io  # Added missing import
from utils.disease import disease_dic
from utils.fertilizer import fertilizer_dic
from utils.model import ResNet9
import openai

import config  # For weather API key and other configurations
from openai import OpenAI
from flask import jsonify

client = OpenAI(api_key="sk-eLNufXkRYaYKuaDQbxrP1-OXwvr2z3SmGsGVZo9S2NT3BlbkFJF1FDv0HRhZRvgrPNghvaavmi_3poJgAVbYtyCcXg4A")
```

```python
# Loading plant disease classification model
disease_classes = ['Apple___Apple_scab', 'Apple___Black_rot', 'Apple___Cedar_apple_rust', 'Apple___healthy',
                   'Blueberry___healthy', 'Cherry_(including_sour)___Powdery_mildew', 'Cherry_(including_sour)___healthy',
                   'Corn_(maize)___Cercospora_leaf_spot Gray_leaf_spot', 'Corn_(maize)___Common_rust_',
                   'Corn_(maize)___Northern_Leaf_Blight', 'Corn_(maize)___healthy', 'Grape___Black_rot',
                   'Grape___Esca_(Black_Measles)', 'Grape___Leaf_blight_(Isariopsis_Leaf_Spot)', 'Grape___healthy',
                   'Orange___Haunglongbing_(Citrus_greening)', 'Peach___Bacterial_spot', 'Peach___healthy',
                   'Pepper,_bell___Bacterial_spot', 'Pepper,_bell___healthy', 'Potato___Early_blight', 'Potato___Late_blight',
                   'Potato___healthy', 'Raspberry___healthy', 'Soybean___healthy', 'Squash___Powdery_mildew',
                   'Strawberry___Leaf_scorch', 'Strawberry___healthy', 'Tomato___Bacterial_spot', 'Tomato___Early_blight',
                   'Tomato___Late_blight', 'Tomato___Leaf_Mold', 'Tomato___Septoria_leaf_spot', 'Tomato___Spider_mites Two-spotted_spider_
                   'Tomato___Target_Spot', 'Tomato___Tomato_Yellow_Leaf_Curl_Virus', 'Tomato___Tomato_mosaic_virus', 'Tomato___healthy']

disease_model_path = 'models/plant_disease_model.pth'
disease_model = ResNet9(3, len(disease_classes))
disease_model.load_state_dict(torch.load(disease_model_path, map_location=torch.device('cpu')))
disease_model.eval()

# Load crop recommendation model
crop_recommendation_model_path = 'models/RandomForest.pkl'

try:
    crop_recommendation_model = joblib.load(crop_recommendation_model_path)
    print("✅ Model loaded successfully!")
except Exception as e:
    print(f"⚠ Error loading crop recommendation model: {e}")
    crop_recommendation_model = None  # Set to None to prevent further errors
```

```python
def weather_fetch(city_name):
    api_key = config.weather_api_key
    base_url = "http://api.openweathermap.org/data/2.5/weather?"
    complete_url = f"{base_url}appid={api_key}&q={city_name}"
    response = requests.get(complete_url)
    data = response.json()

    if data["cod"] == 200:
        main_data = data["main"]
        temperature = round((main_data["temp"] - 273.15), 2)  # Kelvin to Celsius
        humidity = main_data["humidity"]
        return temperature, humidity
    return None
# ✅ Predict Disease from Image
def predict_image(img, model=disease_model):
    """
    Transforms image to tensor and predicts disease label.
    :param img: image file
    :param model: PyTorch model for prediction
    :return: prediction (str)
    """
    try:
        transform = transforms.Compose([
            transforms.Resize((256, 256)),
            transforms.ToTensor(),
        ])
```

```python
app = Flask(__name__)


# Home page route
@app.route('/')
def home():
    return render_template('index.html', title='PrefectCrop - Home')

# Crop recommendation page route
@app.route('/crop-recommend')
def crop_recommend():
    return render_template('crop.html', title='PrefectCrop - Crop Recommendation')

# Fertilizer recommendation page route
@app.route('/fertilizer')
def fertilizer_recommendation():
    return render_template('fertilizer.html', title='PrefectCrop - Fertilizer Suggestion')
```

```python
# ✅ Crop Prediction
@app.route('/crop-predict', methods=['POST'])
def crop_prediction():

    title = 'PrefectCrop - Crop Recommendation'

    if request.method == 'POST':
        if crop_recommendation_model is None:
            return render_template('error.html', title=title, error="Crop recommendation model is not loaded. Please check the model file."

        # Get input from form
        try:
            N = int(request.form['nitrogen'])
            P = int(request.form['phosphorous'])
            K = int(request.form['pottasium'])
            ph = float(request.form['ph'])
            rainfall = float(request.form['rainfall'])
            city = request.form.get("city")

            weather_data = weather_fetch(city)
            if weather_data:
                temperature, humidity = weather_data
                data = np.array([[N, P, K, temperature, humidity, ph, rainfall]])
                prediction = crop_recommendation_model.predict(data)
                final_prediction = prediction[0]
                return render_template('crop-result.html', prediction=final_prediction, title=title)
            else:
                return render_template('try_again.html', title=title)
```

```python
    K = int(request.form['pottasium'])

    # Load fertilizer data from CSV
    df = pd.read_csv(r'C:\Users\SAI YESHWANTH\Downloads\Harvestify\Harvestify\Data-raw\FertilizerData.csv')

    try:
        nr = df[df['Crop'] == crop_name]['N'].iloc[0]
        pr = df[df['Crop'] == crop_name]['P'].iloc[0]
        kr = df[df['Crop'] == crop_name]['K'].iloc[0]

        # Calculate deficiency
        n = nr - N
        p = pr - P
        k = kr - K
        temp = {abs(n): "N", abs(p): "P", abs(k): "K"}
        max_value = temp[max(temp.keys())]

        if max_value == "N":
            key = 'NHigh' if n < 0 else "Nlow"
        elif max_value == "P":
            key = 'PHigh' if p < 0 else "Plow"
        else:
            key = 'KHigh' if k < 0 else "Klow"

        response = Markup(str(fertilizer_dic[key]))
        return render_template('fertilizer-result.html', recommendation=response, title=title)
    except Exception as e:
```

```python
# Disease prediction result page route
@app.route('/disease-predict', methods=['GET', 'POST'])
def disease_prediction():
    title = 'PrefectCrop - Disease Detection'

    if request.method == 'POST':
        if 'file' not in request.files:
            return redirect(request.url)
        file = request.files.get('file')
        if not file:
            return render_template('disease.html', title=title)
        try:
            img = file.read()
            prediction = predict_image(img)
            prediction = Markup(str(disease_dic.get(prediction, "No recommendation found.")))
            return render_template('disease-result.html', prediction=prediction, title=title)
        except Exception as e:
            return render_template('error.html', title=title, error="Error during prediction: " + str(e))

    return render_template('disease.html', title=title)
```

```
@app.route('/chatbot', methods=['POST'])
def chatbot():
    try:
        user_message = request.json["message"]
        response = client.chat.completions.create(
            model="gpt-4",
            messages=[{"role": "user", "content": user_message}],
        )
        return jsonify({"reply": response.choices[0].message.content})
    except Exception as e:
        return jsonify({"reply": "Sorry, I couldn't process that request."})

if __name__ == '__main__':
    warnings.filterwarnings("ignore", category=UserWarning, module='sklearn')
    app.run(debug=True, host='0.0.0.0', port=8000)
```

APPENDIX-C

ENCLOSURES

Journal publication/Conference Paper Certificates

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Sustainable Development Goals (SDGs).

Detecting human life during a fire aligns most closely with SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well Being).

SDG 2: Zero Hunger

Sustainable Development Goal 2 aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. Despite progress over the past decades, millions of people around the world still suffer from chronic hunger and malnutrition, particularly in developing nations. SDG 2 emphasizes the need for equitable access to sufficient, safe, and nutritious food for all people, especially the poor and those in vulnerable situations. It also seeks to enhance the productivity and income of small-scale farmers—many of whom are women—by ensuring they have access to land, inputs, knowledge, markets, and opportunities for value addition. Furthermore, the goal supports sustainable agricultural practices, the conservation of ecosystems, and the resilience of food production systems to climate change, drought, and disasters. Ultimately, SDG 2 is not just about eradicating hunger but transforming food systems to nourish both people and the planet.

SDG 3: Good Health and Well Being

Sustainable Development Goal 3 is dedicated to ensuring healthy lives and promoting well-being for all at all ages. Health is a fundamental human right and a key indicator of sustainable development. This goal addresses a wide spectrum of health priorities, including reducing maternal and child mortality, ending the epidemics of major communicable diseases like HIV/AIDS, tuberculosis, and malaria, and tackling non-communicable diseases through prevention and treatment. It also highlights the importance of mental health and well-being, road safety, and universal access to sexual and reproductive health care. SDG 3 promotes universal health coverage and access to essential medicines and vaccines for everyone. Furthermore, it recognizes the critical need to reduce deaths and illnesses from environmental pollution and hazardous chemicals. By striving for inclusive and equitable health systems, SDG 3 lays the foundation for a healthier, more prosperous world.

SDG 12: Responsible Consumption and Production

The app promotes efficient use of natural resources, such as water, soil, and fertilizers, by offering data-driven recommendations. This reduces waste and minimizes the environmental impact of farming, supporting sustainable consumption and production practices.

SDG 15: Life on Land

CropCare helps protect ecosystems by promoting sustainable land management practices. By reducing overuse of fertilizers and improving crop health, the app supports the conservation of biodiversity.