Chapter 1

Introduction

A farmer's decision regarding which crop to cultivate is typically influenced by his knowledge as well as unimportant variables like the desire to make quick money, ignorance of market demand, exaggeration of a soil's ability to support a particular crop, and so forth. The farmer's family's financial situation could be severely strained if he makes the wrong choice. Maybe this is one of the numerous factors contributing to the innumerable farmer suicide cases that the media reports on every day. Such a wrong judgement would have detrimental effects on not only the farmer's family but the entire economy of an area in a country like India, where agriculture and associated sectors contribute to about 20.4% of its Gross Value Added (GVA). Because of this, we have determined that a farmer's decision on which crop to cultivate during a specific season is a very serious one. The urgent requirement is to create a system that might offer Indian farmers predictive information so they could choose which crop to produce with knowledge.

In light of this, we suggest a system, an intelligent system, that would evaluate soil characteristics (pH value, N, P, K, soil type, and nutrients concentration) as well as environmental factors (rainfall, temperature, geographic location in terms of state), before advising the user on the crop that would grow best. Additionally, a fertiliser recommendation based on the ideal nutrients of the produced crops is also made.

1.1 Motivation

As about 70% of the population depends on agriculture, it serves as the economic foundation for developing nations like India. India's economy and employment areheavily reliant on agriculture

Indian farmers frequently struggle with choosing the right crop to support their soil's needs and which fertiliser to utilise for their particular crop.This problem of the farmers has been addressed through precision agriculture

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1.2 Project Scope

1. Crop Advice System: Develop a system that provides advice to farmers on the best crops to grow in the area based on the estimated crop sustainability. The system should be designed to prevent farmers from suffering any losses by providing them with information on the most suitable crops for their specific area.
2. Fertilizer Recommendation System: Develop a system that recommends fertilizers for specific crops based on their chemical properties and the identified soil and climatic conditions. The system should be designed to improve crop yields while minimizing the use of harmful chemicals.
3. Disease Detection System: Develop a system that uses machine learning algorithms to detect common crop diseases based on symptoms and other relevant data. The system should provide recommendations for disease control and prevention.

1.3 Objectives

- To develop a reliable model that can accurately estimate crop sustainability in a given state under specific climatic and soil conditions
- Give advice on the best crops to grow in the area so that the farmer doesn't suffer any losses.
  • Suggest fertilizers for crops with supported chemical properties.

Chapter 2
Literature Review

Low-cost IOT + ML design for smart farming with multiple application paper authors Fahad Kamraan Syed, Agniswar Paul, Ajay Kumar,Jaideep Cherukuri in paper [1] proposed system for water management systems and improve current irrigation methods. An IoT and MLbased farming system always keeps farmers aware of the upcoming weather possibilities and gives them the best suggestions about irrigation methods and crops thereby helping in better yield.

In paper [2] author's proposed a smart system that can assist farmers in crop management by considering sensed parameters (temperature, humidity) and other parameters (soil type, location of farm, rainfall) that predicts the most suitable crop to grow in that environment.

Reference Paper [3] determines real time sampling of soil properties using MODIFIED SUPPORT VECTOR REGRESSION, a popular machine learning algorithm and four modules. The Modules include Sensor interfaced to IoT device, Agri cloud, Analyzing the real time sensor data and Agri user interface (AUI). The first module is portable IoT device (NodeMCU) with soil moisture sensor and pH sensor, environmental sensors. Agri cloud module consists of storage. Analyzing the real time data module is processing of types of crops and small plants suggested using modified support vector machine algorithm. Agri-user interface is a basic web interface. Thus, with the help of soil properties farmer will be able to get types of crops and small plants is grown in farmland with help of Modified support vector machine algorithm.

In paper [4] author's proposed new technologies include the use of Internet of Things (IOT) and Machine Learning. The real time data from the field area can be collected using IOT system. The collected data from the field area is fed to the trained model. The trained model then makes the predictions using the data. The result produced by the model greatly helps is sowing the suitable crops in the particular field area. GHRIET, Department of Computer Engineering 2020-21 10

In Reference paper [5] determines a model is proposed for predicting the soil type and suggest a suitable crop that can be cultivated in that soil. The model has been tested using various machine learning algorithms such as KNN, SVM and logistic regression. The accuracy of the present model is maximum than the existing models.

Aruul Mozhi Varman S proposed an IOT and deep learning based smart agriculture systems. This system monitors and collects the soil parameters from the field with the help of a wireless sensor network. The collected data is then uploaded in the cloud. Finally, the systems suggest best irrigation

practices to the farmers by predicting the crop to be sown for next crop rotation. This information will be sent as an SMS to the farmers. The parameters include soil temperature, atmospheric temperature, and humidity [6]. This system suggests further improving the effectiveness by predicting the suitable time for applying pesticides, fertilizer and manures.

In paper [7] proposed a system would assist the farmers in making an informed decision about which crop to grow depending on a variety of environmental and geographical factors. The ML and IoT based suggestions will significantly educate the farmer and help them minimize costs and make strategic decisions by replacing intuition and passed-down knowledge with far more reliable data-driven ML models. This allows for a scalable, reliable solution to an important problem affecting hundreds of millions of people

In paper [8], proposes a machine learning-based approach for predicting the onset of various diseases based on various features such as NPK value, Temperature, etc. The authors utilize six different machine learning algorithms, including Decision Tree, Random Forest, K-Nearest Neighbor, Naive Bayes, Support Vector Machine, and Logistic Regression. The dataset used for this study includes 768 classes from the Kaggle dataset, and the results show that the Random Forest algorithm achieved the highest accuracy of 77.60%.

In paper [9], proposes a machine learning-based approach for detecting plant diseases using leaf images. The authors utilize three different machine learning algorithms, including Convolutional Neural Network (CNN), Support Vector Machine (SVM), and K-Nearest Neighbor (KNN), to classify healthy and diseased plant leaves based on the image features extracted from them. The results show that the CNN algorithm achieved the highest accuracy of 98.45% in classifying the plant leaves into their respective disease categories.

In paper [10], proposes a data mining-based approach for recommending suitable crops and fertilizers for a particular agricultural region. The authors utilize various data mining techniques, including association rule mining, decision tree, and k-means clustering, to analyze and process the agricultural data. The study also recommends the appropriate fertilizers for the recommended crops based on the association rules mined from the dataset. The study concludes that data mining techniques can effectively assist farmers in making informed decisions about crop selection and fertilizer application, ultimately leading to higher yields and economic benefits.

In paper [11], proposes a machine learning-based approach for recommending suitable crops for a particular agricultural region. The authors utilize various machine learning algorithms, including K-Nearest Neighbor (KNN), Decision Tree, and Random Forest, to analyze and process the agricultural data. The study also considers various factors such as pH level, rainfall, temperature, and humidity in recommending suitable crops for a particular region. The study concludes that machine learning algorithms can effectively assist farmers in making informed decisions about crop selection, ultimately leading to higher yields and economic benefits.

2.12 Literature Survey Table

No.	Reference	Dataset	Techniques	Results
1.	An IoT Based Smart Farming System Using Machine Learning (researchgate.net)	The data have been collected from 30 US and Canadian Cities, as well as 6 Palestine cities. The dataset contains ~5 years of high temporal resolution (hourly measurements) data of various weather attributes , such as temperature, humidity	Data collection phase using sensors deploying in an agricultural field. Data cleaning and storage phase and predicting processing using some AI methods.	Showed that AI techniques play a pivotal role in agriculture of precision by using machine learning and open sources technologies.
2.	Smart Management of Crop Cultivation using IOT and Machine Learning | IRJET Journal - Academia.edu	-	uses random forest algorithm to predict appropriate crop based on current NPK value of soil. Machine Learning Algorithm(KNN) is used to calculate the crop which is best to grow in the particular field based on the values received at real time.	Using the real time values obtained from the field and running the algorithm on them, the most suitable crop for aparticular land at a given time is predicted
3.	High Resolution Mapping of Soil Properties Using Remote Sensing Variables in South-Western Burkina Faso: A Comparison of Machine Learning and Multiple Linear Regression Models (researchgate.net)	A total of 1104 soil samples (1002 in subwatershed and 102 out-side)		Internal validation was conducted by cross validation while the predictions were validated against an independent set of soil samples considering the modelling area and an extrapolation area.

4.	Internet of things (IoT) applications to fight against COVID-19 pandemic - PMC (nih.gov)	No Dataset information is provided	IoT is used to capture health data from various locations of the infected patient and manage all the data using the virtual management system contact tracing, cluster identification and compliance of quarantine.	By using a statistical-based method, IoT gets helpful to predict an upcoming situation of this disease.
5.	Soil Classification and Crop Suggestion using Machine Learning Techniques by IJRASET - Issuu	They have used a large dataset extracted from the Australian Department of Agriculture and Food(AGRIC) to conduct the research	The model has been tested using various machine learning algorithms such as KNN, SVM and logistic regression.	The accuracy of the present model is maximum than the existing models.
6.	Smart Agriculture Using WSN and IoT: Environment & Agriculture Book Chapter | IGI Global (igi-global.com)	-	This system monitors and collects the soil parameters from the field with the help of a wireless sensor network. The collected data is then uploaded in the cloud. Finally, the systems suggest best irrigation practices to the farmers by predicting the crop to be sown for next crop rotation.	This system suggests further improving the effectiveness by predicting the suitable time for applying pesticides, fertilizer, and manures.
7.	Intelligent Agriculture System To Assist Farmers In Smart Decision (quickcompany.in)	A total of 9 types of soil present in dataset.	The ML and IoT based suggestions will significantly educate the farmer and help them minimize costs and make strategic decisions by replacing intuition and passed-down knowledge with far more reliable data-driven ML models.	provide intelligent agriculture system to assist farmers in smart decision making using IoT data analytics and machin e learning.

8	Disease Prediction From Various feature Using Machine Learning by Rinkal Keniya, Aman Khakharia, Vruddhi Shah, Vrushabh Gada, Ruchi Manjalkar, Tirth Thaker, Mahesh Warang, Ninad Mehendale :: SSRN	The dataset used had more than 230 diseases	The weighted KNN algorithm gave the best results as compared to the other algorithms. The accuracy of the weighted KNN algorithm for the prediction was 93.5 %.	Different machine learning models were used to examine the prediction of disease for available input dataset. We used 11 different ML models for the prediction. Out of the 11 models we managed to get 50 % or above accuracy for 6 models.
9	(PDF) Plant Disease Detection Using Machine Learning (researchgate.net)	No Dataset information is provided	Compared to other machine learning techniques like SVM, Gaussian Naïve bayes, logistic regression, linear discriminant analysis , Random forests gave more accuracy with less number of image data set	Randon Forest gives highest accuracy of 70% and
10	(PDF) Crop Suitability and Fertilizers Recommendation Using Data Mining Techniques (researchgate.net)	No Dataset information is provided	For recommending fertilizer to the farmer, K-means clustering algorithm is used. Crop name and soil contents Nitrogen (N), Phosphorous (P) and Potassium (K) are given as an input to the given algorithm.	Maximum accuracy of random forest is 71%
11	https://ijariie.com/AdminUPI/crop recommendation_System_using_Mchine_Learning_ihariee174.pdf	The dataset contains various parameters like Nitrogen (N), Phosphorous (P), Potassium (K), PH value of soil, Humidity, Temperature, and Rainfall	Various algorithms are used like KNN algorithm, random forest, support vector machine, XGBoost	Maximum accuracy is of Naive bayes 94.72% and minimum accuracy is of AdaBoost classifier with 12%.

Chapter 3

Problem Statement

The overall problem statement is to develop a comprehensive agricultural solution that encompasses crop recommendation, fertilizer recommendation, and disease prediction. The solution should provide accurate and personalized recommendations to farmers based on various environmental variables such as soil type, weather conditions, and historical data. The aim is to help farmers optimize their crop yields and minimize losses due to disease outbreaks or inadequate fertilizer application. The solution should be scalable, cost-effective, and accessible to farmers across different regions and socio-economic backgrounds.

3.1 Drawbacks of Current Solutions

The fact that each author of each publication concentrated on one factor (weather or soil) for predicting the appropriateness of crop development was one weakness we found in all of these important published papers. But in our opinion, the best and most accurate prediction should be made by concurrently taking into account both of these aspects. This happens frequently because even if a particular soil type may be ideal for supporting a certain crop variety, the yield will suffer if the local climate doesn't appear to be favourable for that crop kind.

3.2 Solution to the Problem

By proposing an effective crop recommendation system that accounts for all relevant factors, such as temperature, rainfall, location, and soil quality, we hope to eliminate the above shortcomings. Giving farmers crop suggestions is the main task that this system is primarily concerned with carrying out. In order to give the user a simple and trustworthy knowledge of the

insight to determine and plant the crops, we also supply the fertilisers to be used for crops grown in various states.

Chapter 4

Project Design

4.1 Overview

Fig 4.1 shows the architecture of whole system and how the prediction happens from uploading the image to final result.

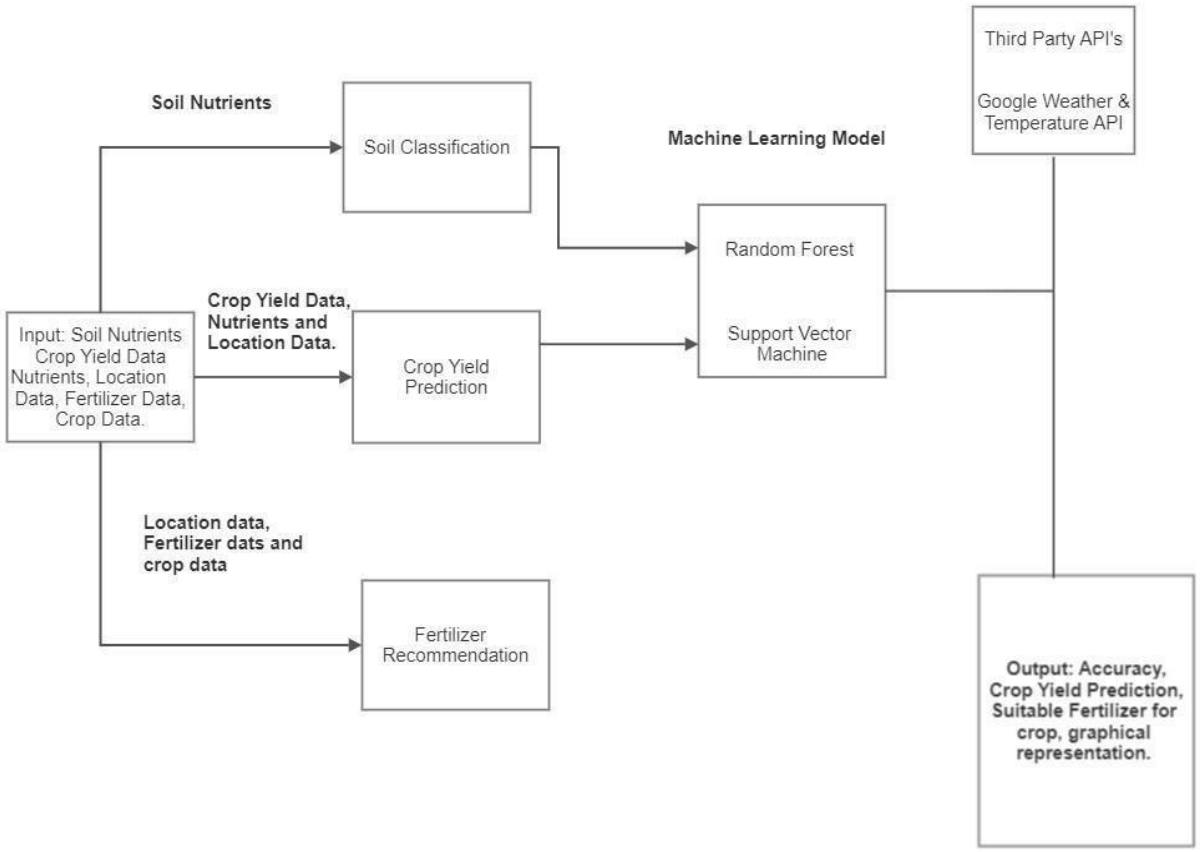


Fig 4.1 Block Diagram for Crop and Fertilizer Recommendation

Crop recommendation, fertiliser recommendation, and disease prediction are the three goals of our method. We are utilising an API key to retrieve the data for the fertiliser recommendation. The system will provide recommendations and predictions based on the nutrients dataset.

4.2 Architecture

Fig 4.2 gives ideas about architecture of system. How data is collected and how models are predicting result based on input data

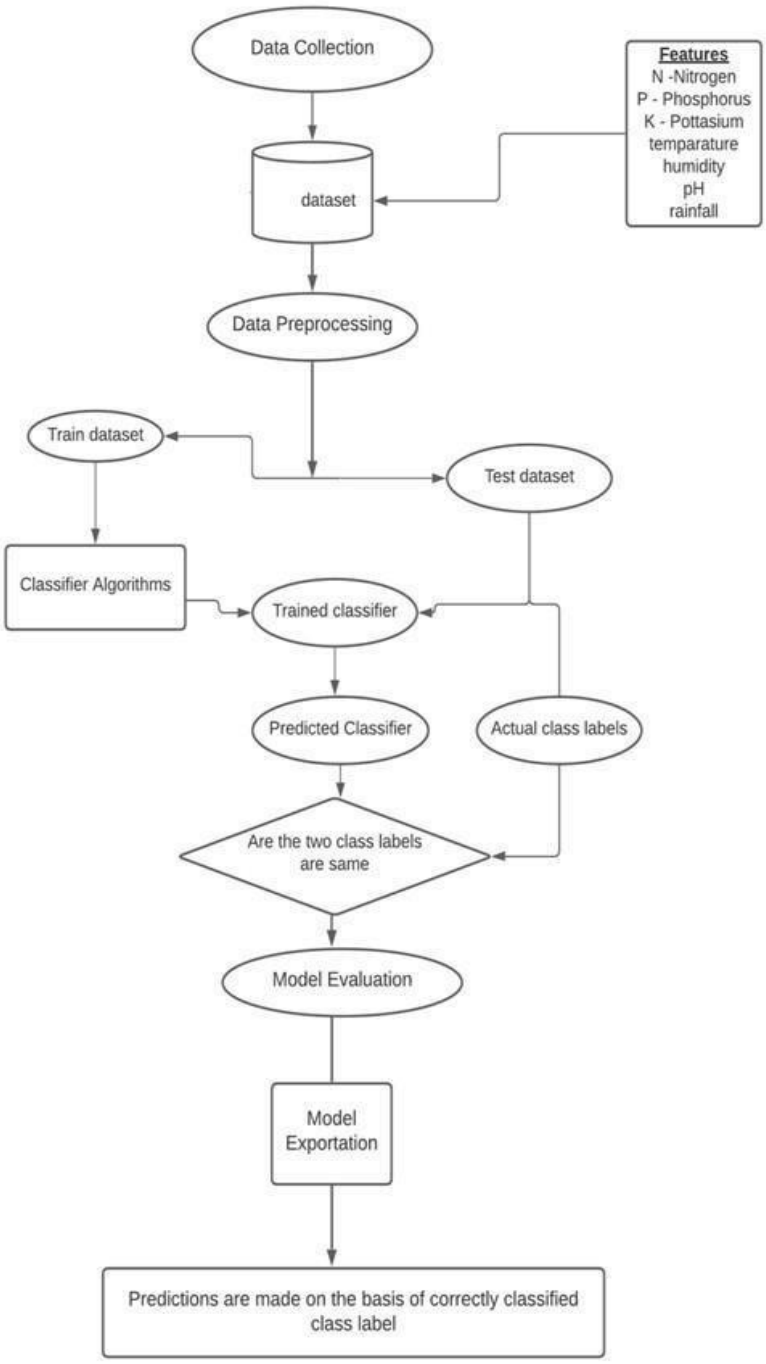


Figure 4.2 : Architecture

4.3 Module Description

Module Description for Crop Recommendation:

The crop recommendation module aims to recommend the most suitable crop to cultivate based on various environmental factors like soil type, climate, and water availability. The module utilizes data analytics and machine learning techniques to analyze data and provide accurate recommendations. The module considers various factors like the current season, crop rotation, and previous crop yield to provide optimal crop recommendations. The module provides farmers with a list of suitable crop options, along with information on their yield potential and growth requirements.

Module Description for Fertilizer Recommendation:

The fertilizer recommendation module aims to suggest the appropriate type and amount of fertilizer to apply to a crop based on various environmental factors like soil type, crop type, and weather conditions. The module utilizes machine learning algorithms to analyze soil samples and recommend the right type of fertilizer. The module also considers the crop's growth stage, previous fertilizer application, and expected yield to provide accurate recommendations. The module provides farmers with detailed instructions on the optimal fertilizer application method and schedule.

Module Description for Disease Prediction:

The disease prediction module aims to forecast the likelihood of crop diseases in a particular region or field. The module utilizes machine learning algorithms to analyze various environmental factors like temperature, humidity, soil moisture, and other indicators to predict the likelihood of disease occurrence. The module also provides farmers with recommendations on preventive measures to reduce the likelihood of disease outbreaks. The module also recommends suitable pesticides and treatments to manage the disease effectively. The module provides farmers with early warning alerts to take timely preventive measures and minimize crop losses due to disease outbreaks.

4.4 Algorithms

4.4.1 Decision Tree

A nonparametric supervised learning technique for classification and regression is called a decision tree (DT). The objective is to learn straightforward decision rules derived from the

data features in order to build a model that predicts the value of a target variable. A fractional approximation of a tree can be thought of. For instance, in the example below, using a series of if-then-else decision rules, decision trees learn from data to approximate a sine curve.

4.4.2 Support Vector Machine

In an N-dimensional space(N being the number of features), the support vector machine algorithm seeks to locate a hyperplane that clearly categorises the data points.

There are a varietyof different hyperplanes that might be used to split the two classes of data points.

Finding a plane with the greatest margin that is, the greatest separation between data points from both classes is our goal.. Maximizing the margin distance adds some support,increasing the confidence with which future data points can be categorised.

4.4.3 Logistic Regression

When classifying observations into a collection of discrete classes, the classification algorithm logistic regression is utilised. Email spam or not spam, online fraud or not fraud, and malignant or benign tumours are a few instances of classification issues.

To convert its output into a probability value, logistic regression uses the logistic sigmoid function.

What are the types of logistic regression

1. Binary (eg. Tumor Malignant or Benign)
2. Multi-linear functions failsClass (eg. Cats, dogs or Sheep's)

The machine learning technique known as logistic regression, which is based on the probability notion and used to solve classification problems, is used to analyse data in a predicted manner.

4.4.4 Random Forest

Supervised machine learning algorithms like random forest are frequently employed in classification and regression issues. On various samples,it constructs vote for regression.

The Random Forest Algorithm's ability to handle data sets with both continuous variables, as regression and categorical variables, as in classification, is one of its most crucial qualities.

In terms of classification issues, it delivers superior outcomes.

To precisely address the issue of high-variance in Decision Trees, Random Forests was created.You're not just training one Decision Tree, as the name implies—you're training an entire forest! A forest of Bagged Decision Trees in this instance.

Random Forests algorithm follows these steps:

1. Starting with the original dataset, generate N bagged samples of size n, where n is the number of samples to be created.
2. With each f the N bagged datasets as input, train a decision tree. Don't, however, look at every feature in the dataset while doing a node split. Choose M features at random from the entire training set of features. Then, using impurity metrics like Gini Impurity or Entropy, choose the optimal split.
3. Combine the outcomes of each decision tree into a single output.
4. If you're working on a regression problem, average the results for each observation, as produced by each tree.
5. If you're working on a regression problem, make a majority decision for each observation across all trees.

4.5 Dataset

Datasets include:-

- Crop Recommendation dataset
- Fertilizer dataset

- Plant Disease dataset
- State -District Wise Crop dataset A brief description of the datasets:
- **Crop Recommendation dataset :** In kg per hectare, this information shows the yield for 18 important crops farmed in every state. When the yield is 0, it means that the crop is not grown in that stage. containing a total of 2201 items in the dataset. It includes 8 parameters i.e N, P, K, Temperature, humidity, pH, rainfall and label.

1	N	P	K	temperatu	humidity	ph	rainfall	label
2	90	42	43	20.87974	82.00274	6.502985	202.9355	rice
3	85	58	41	21.77046	80.31964	7.038096	226.6555	rice
4	60	55	44	23.00446	82.32076	7.840207	263.9642	rice
5	74	35	40	26.4911	80.15836	6.980401	242.864	rice
6	78	42	42	20.13017	81.60487	7.628473	262.7173	rice
7	69	37	42	23.05805	83.37012	7.073454	251.055	rice
8	69	55	38	22.70884	82.63941	5.700806	271.3249	rice
9	94	53	40	20.27774	82.89409	5.718627	241.9742	rice
10	89	54	38	24.51588	83.53522	6.685346	230.4462	rice
11	68	58	38	23.22397	83.03323	6.336254	221.2092	rice
12	91	53	40	26.52724	81.41754	5.386168	264.6149	rice
13	90	46	42	23.97898	81.45062	7.502834	250.0832	rice
14	78	58	44	26.8008	80.88685	5.108682	284.4365	rice
15	93	56	36	24.01498	82.05687	6.984354	185.2773	rice
16	94	50	37	25.66585	80.66385	6.94802	209.587	rice
17	60	48	39	24.28209	80.30026	7.042299	231.0863	rice
18	85	38	41	21.58712	82.78837	6.249051	276.6552	rice
19	91	35	39	23.79392	80.41818	6.97086	206.2612	rice
20	77	38	36	21.86525	80.1923	5.953933	224.555	rice

Fig 4.3 Crop recommendation dataset

- **Fertilizer dataset** : The columns in this dataset have the following attributes: State, Nitrogen, Phosphorous, Potassium, Average Ph Level, and Soil Moisture Content.
  There are 25 total records in the collection.

	Crop	N	P	K	pH	soil_moisture
0	rice	80	40	40	5.5	30
3	maize	80	40	20	5.5	50
5	chickpea	40	60	80	5.5	60
12	kidneybea	20	60	20	5.5	45
13	pigeonpea	20	60	20	5.5	45
14	mothbean	20	40	20	5.5	30
15	mungbean	20	40	20	5.5	80
18	blackgram	40	60	20	5	60
24	lentil	20	60	20	5.5	90
60	pomegran	20	10	40	5.5	30
61	banana	100	75	50	6.5	40
62	mango	20	20	30	5	15
63	grapes	20	125	200	4	60
66	watermelc	100	10	50	5.5	70
67	muskmelo	100	10	50	5.5	30
69	apple	20	125	200	6.5	50
74	orange	20	10	10	4	60
75	papaya	50	50	50	6	20
88	coconut	20	10	30	5	45

Fig 4.4 Fertilizer Dataset

- **Plant Disease dataset:** 76100 items in this dataset include photos of illness leaves and 38 distinct classes.

  For instance, Apple->Apple scab, Apple black rot, and Apple healthy

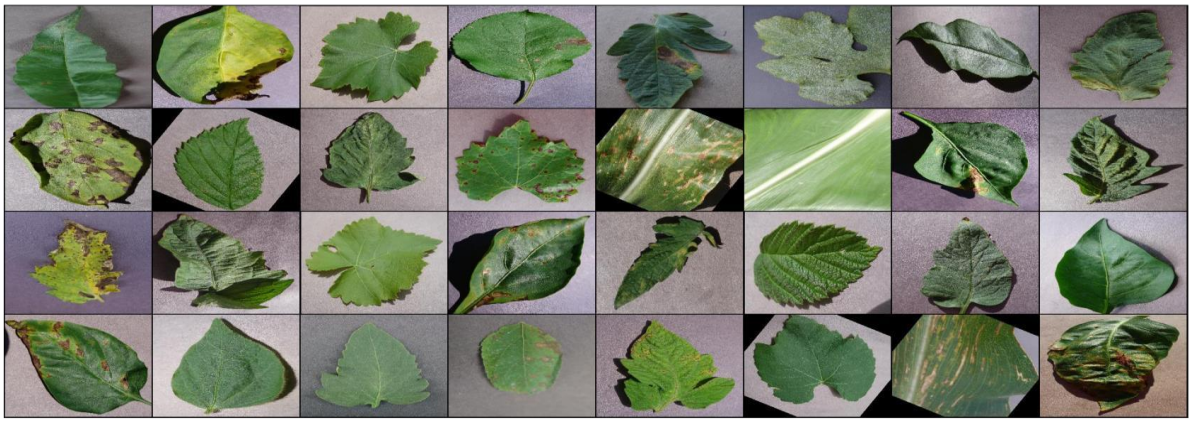


Fig 4.5 Disease Dataset

4.6 UML Diagram

Fig 4.6 visualize the way a system has been designed and structure of a system.

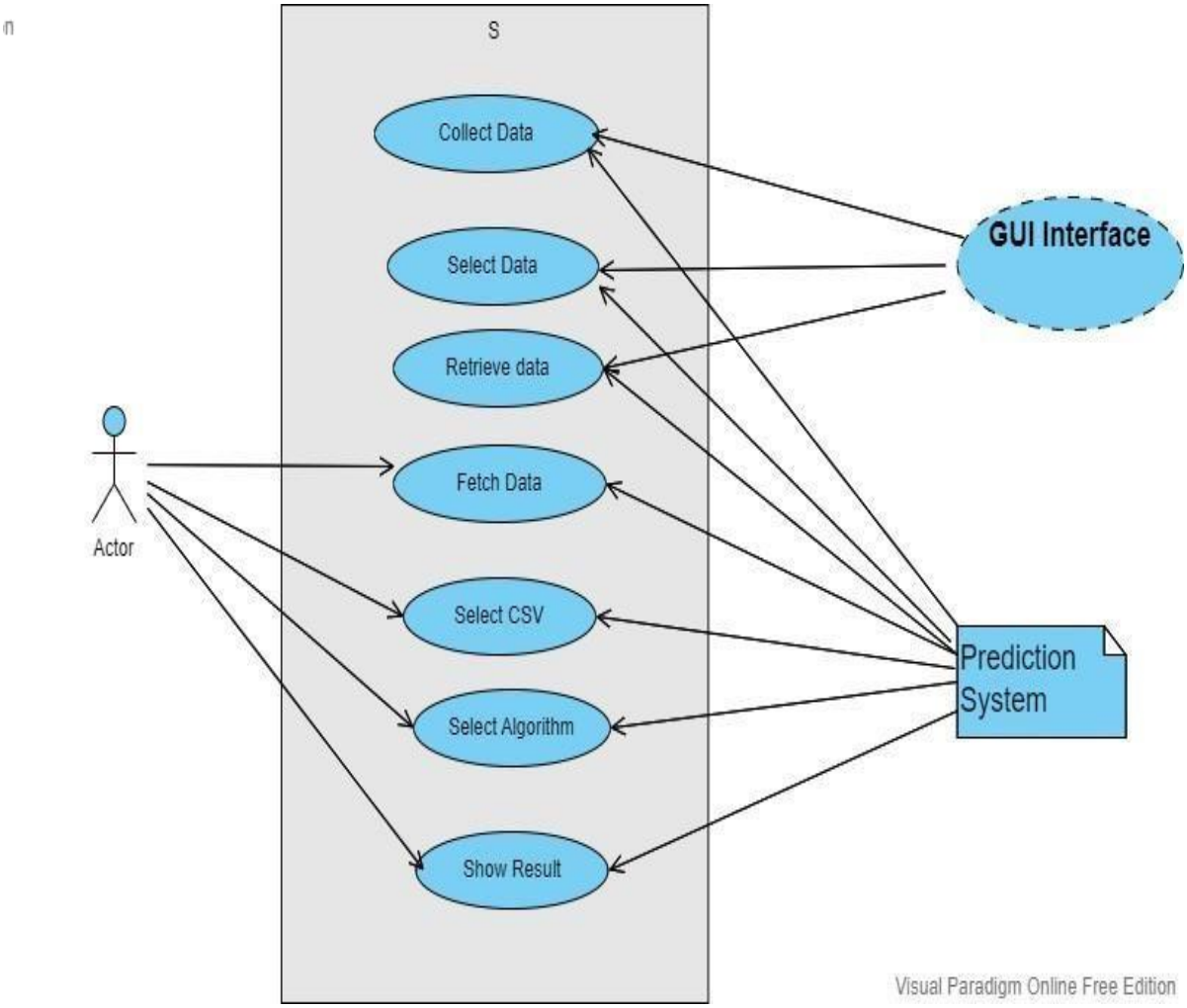


Fig 4.6 UML Diagram

4.6.1 Disease Prediction Diagram

Fig.4.7 shows the flow of the disease prediction process.

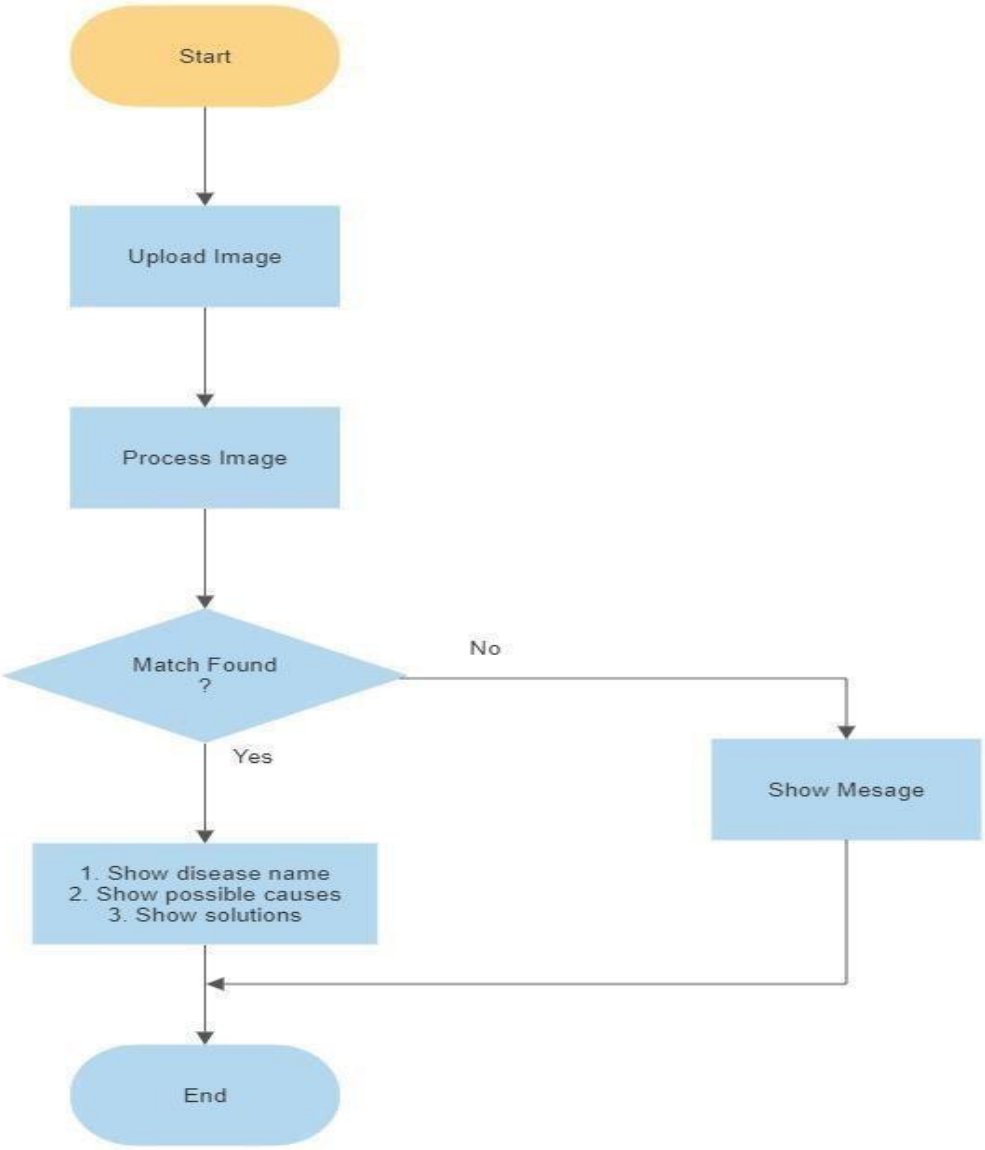


Fig. 4.7 Disease Prediction

4.6.2 Crop Recommendation Diagram

Fig 4.8 shows the flowchart of Crop Recommendation System, It includes the step by step representation of process.

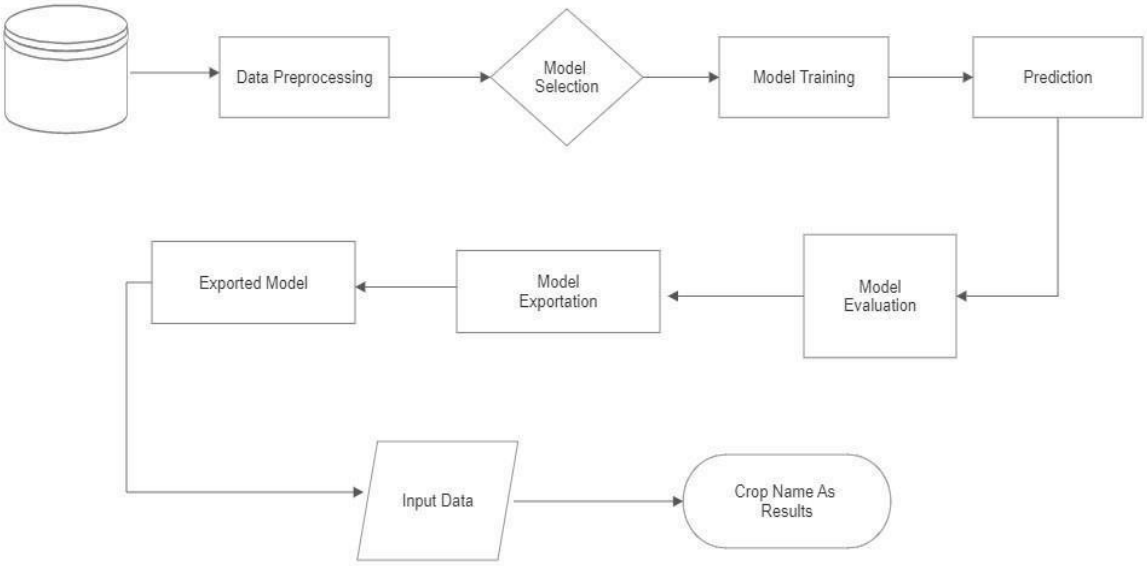


Fig. 4.8 Crop Recommendation

4.6.3 DFD Level 0 and DFD Level 1

Fig 4.4 shows data flow process of the system.

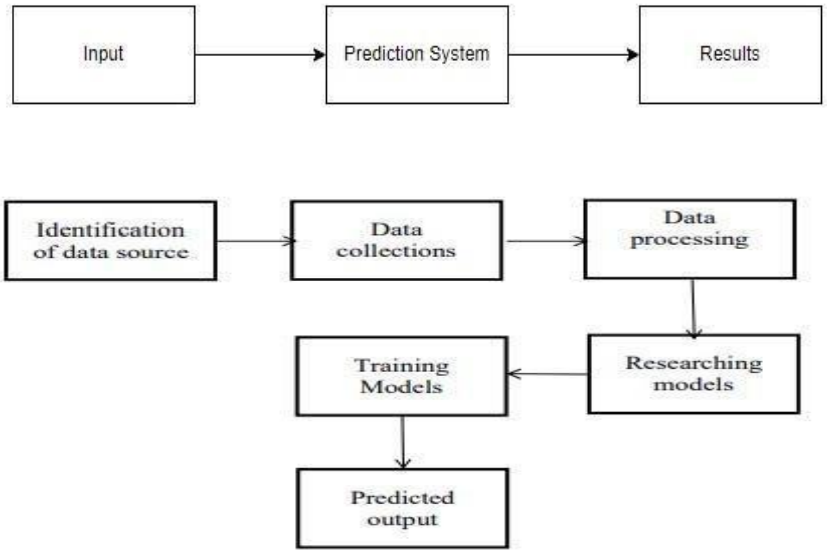


Fig. 4.9 DFD Level 0 and DFD Level 1

Chapter 5

Implementation Details

5.1. Crop Recommendatio

The implementation of the crop recommendation module involves several steps, including data collection, preprocessing, feature engineering, model training, and validation. The following are the implementation details of the crop recommendation module:

1. Data Collection: The first step is to collect relevant data from various sources, including soil samples, weather data, crop yield data, and other environmental variables. The data should cover a broad range of factors that influence crop growth and yield.

2. Preprocessing: The collected data needs to be preprocessed to remove outliers, missing values, and noise. The preprocessing step also involves scaling and normalization of the data to ensure that all features have a similar range and distribution.

3. Model Training: The next step is to train a machine learning model using the preprocessed and engineered features. The model should be able to learn the relationship between various environmental factors and crop yield. The model can be a supervised or unsupervised learning algorithm, depending on the availability of labeled data.

5.2. Fertilizer Recommendation

The implementation of the fertilizer recommendation module involves several steps, including data collection, preprocessing, feature engineering, model training, and validation. The following are the implementation details of the fertilizer recommendation module:

1. Data Collection: The first step is to collect relevant data from various sources, including soil samples, weather data, crop type, and fertilizer usage. The data should cover a broad range of factors that influence fertilizer application and crop yield.

2. Preprocessing: The collected data needs to be preprocessed to remove outliers, missing values, and noise. The preprocessing step also involves scaling and normalization of the data to ensure that all features have a similar range and distribution.

3. Model Training: The next step is to train a machine learning model using the preprocessed and engineered features. The model should be able to learn the relationship between various environmental factors, crop type, and fertilizer application. The model can be a supervised or unsupervised learning algorithm, depending on the availability of labeled data.

Once the model is trained and validated, the fertilizer recommendation module can be deployed to provide farmers with accurate and personalized recommendations on the appropriate type and amount of fertilizer to apply to their crops. The module can also provide farmers with additional information on the optimal fertilizer application method, schedule, and expected yield for each recommended crop.

5.3. Disease Prediction

Disease prediction using ResNet models typically involves the following implementation steps:

1. Data Preparation: The first step is to collect a dataset of images that represent different diseases. This dataset can be either pre-existing or you can collect it yourself. You need to ensure that the images are of high quality and have appropriate labeling.

2. Data Preprocessing: Once the dataset is ready, the next step is to preprocess it. This includes resizing the images to a standard size, normalizing the pixel values, and splitting the dataset into training, validation, and testing sets.

3. Model Architecture: ResNet(Residual Network) is a deep learning architecture that has shown great success in image recognition tasks. There are several versions of ResNet, such as ResNet-18, ResNet-34, ResNet-50, etc. You can choose the appropriate version based on the complexity of your problem.

4. Model Training: The next step is to train the ResNet model using the training set. This involves feeding the images into the model and updating the weights using backpropagation. You can use a cross-entropy loss function to measure the difference between the predicted and actual labels.

5. Model Testing: Once you are satisfied with the performance of the model on the validation set, you can test it on the testing set. This involves measuring the same metrics as in step 5.

6. Model Deployment: Finally, you can deploy the model to predict diseases in new images. This involves preprocessing the new images and feeding them into the model to obtain the predicted label.

In summary, disease prediction using ResNet models involves data preparation,data preprocessing, model architecture, model training, model evaluation, model testing, and model deployment. Each step requires careful attention to ensure that the model performs well on the given task.

5.4 Parameters

The parameters nitrogen, phosphorus, and potassium are essential macronutrients required by plants for their growth and development. They are often referred to as NPK and are the three numbers that you commonly see on fertilizer packaging. Each nutrient has a specific role in plant growth. Nitrogen is responsible for leaf growth, phosphorus promotes root growth and potassium helps with the overall health and vigor of the plant.

Soil type is another important parameter that affects plant growth. Different types of soil have different physical and chemical properties that can affect nutrient availability, water retention, and aeration. For example, sandy soil drains quickly and can be deficient in nutrients, while clay soil retains water but can be too heavy for plants to grow well. Loamy soil is considered the ideal soil type for most plants as it has a good balance of water retention, aeration, and nutrient availability.

Humidity is the amount of water vapor present in the air. It can have a significant impact on plant growth as it affects the rate of transpiration, which is the process by which plants lose water through their leaves. High humidity can reduce the rate of transpiration, which can be beneficial for plants in dry conditions as it helps them conserve water. However, high humidity can also create conditions that are conducive to fungal diseases, which can be harmful to plants. Low humidity, on the other hand, can increase the rate of transpiration, which can be beneficial in humid conditions as it helps plants cool down and prevents fungal diseases.

In summary, nitrogen, phosphorus, and potassium are essential nutrients required for plant growth, soil type affects nutrient availability, water retention, and aeration, and humidity affects the rate of transpiration and can create conditions that are conducive to fungal diseases. All of these parameters are important to consider when growing plants as they can have a significant impact on plant health and growth.

4.4 Hardware and Software

- Hardware System Configuration:

➢ Processor: 2 gigahertz (GHz) or faster processor.

➢ RAM: 4 gigabyte (GB) for 32-bit or 4 GB for 64-bit.

➢ Hard disk space: => 16GB.

- Software Configuration:

➢ Operating System: Windows XP/7/8/8.1/10, Linux and Mac

➢ Coding Language: Python.

➢ Tools: Pandas, Numpy ,Seaborn , Pickle,Scikit-learn, Pytorch & ResNet.

➢ Framework: Flask.

➢ Other Tools : HTML, CSS, Bootstrap.

- Tools and Library used

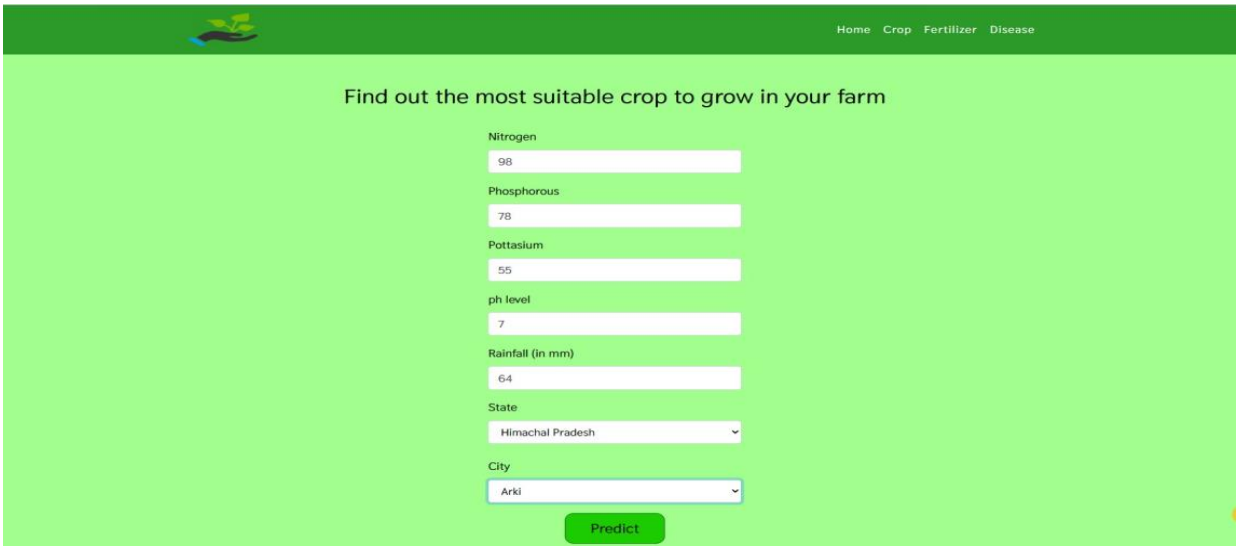
➢ Library-torch, Pandas, Numpy, Matplotlib, Seaborn, Pickle, Scikitlearn, Pytorch and resnet.

➢ Tool- Flask

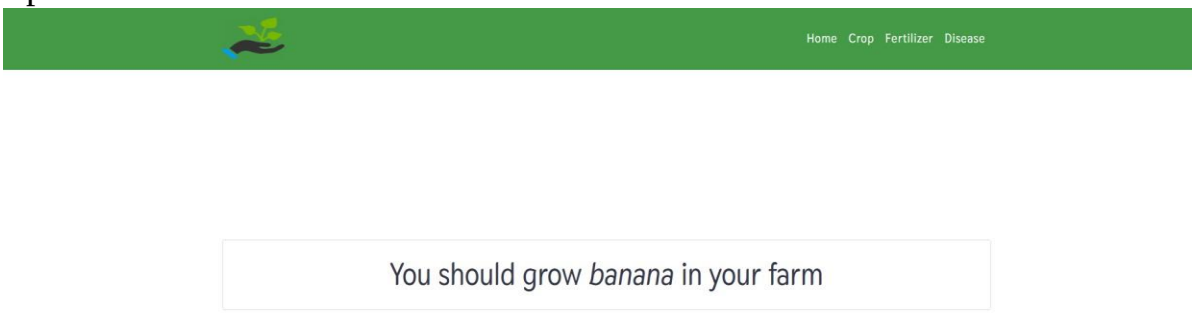
Chapter 6

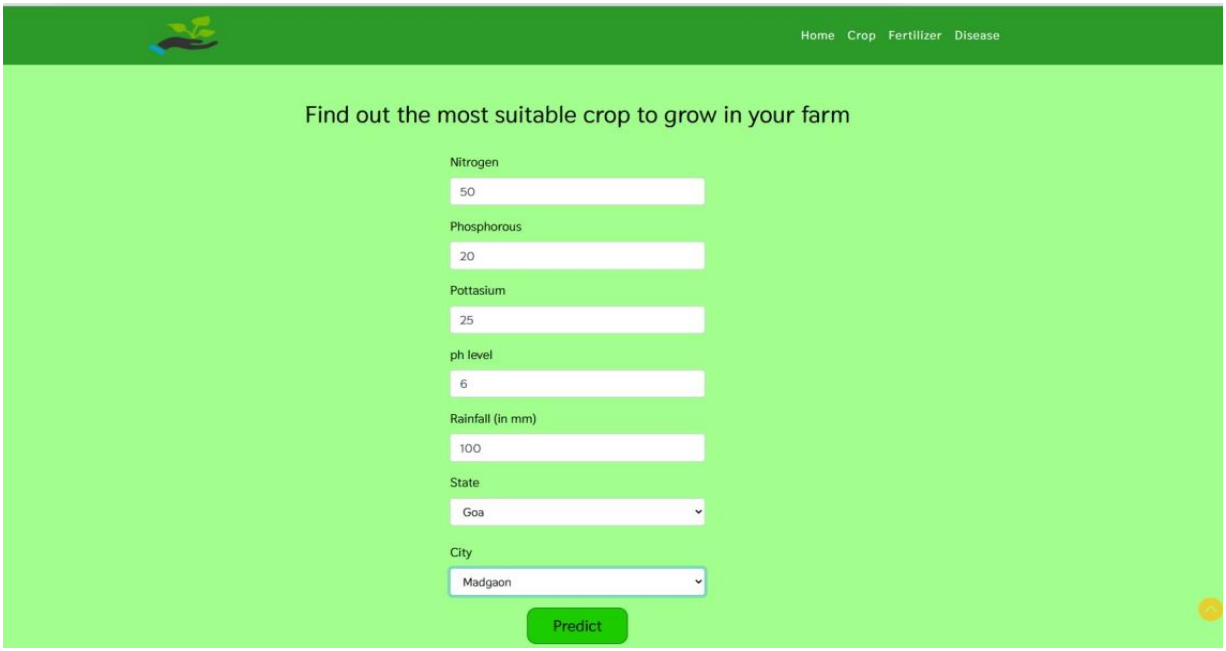
Result

Crop Recommendation (Input and Output)

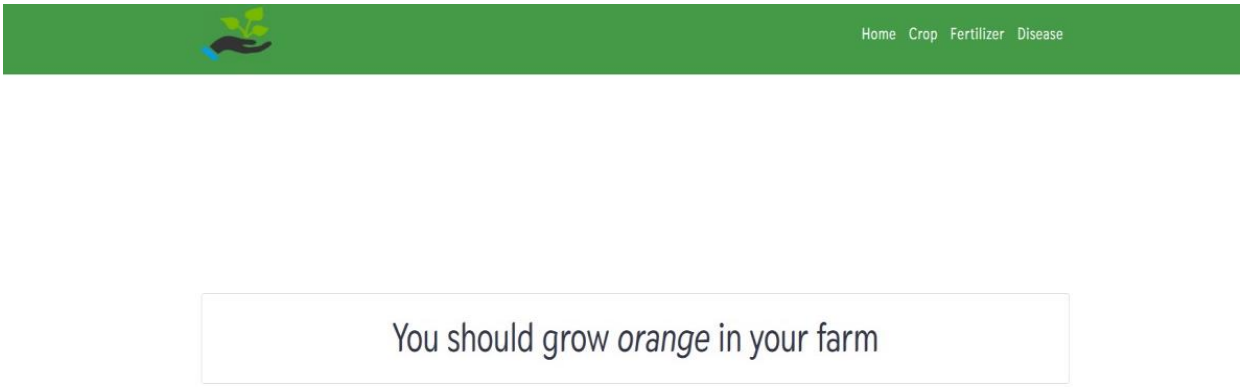


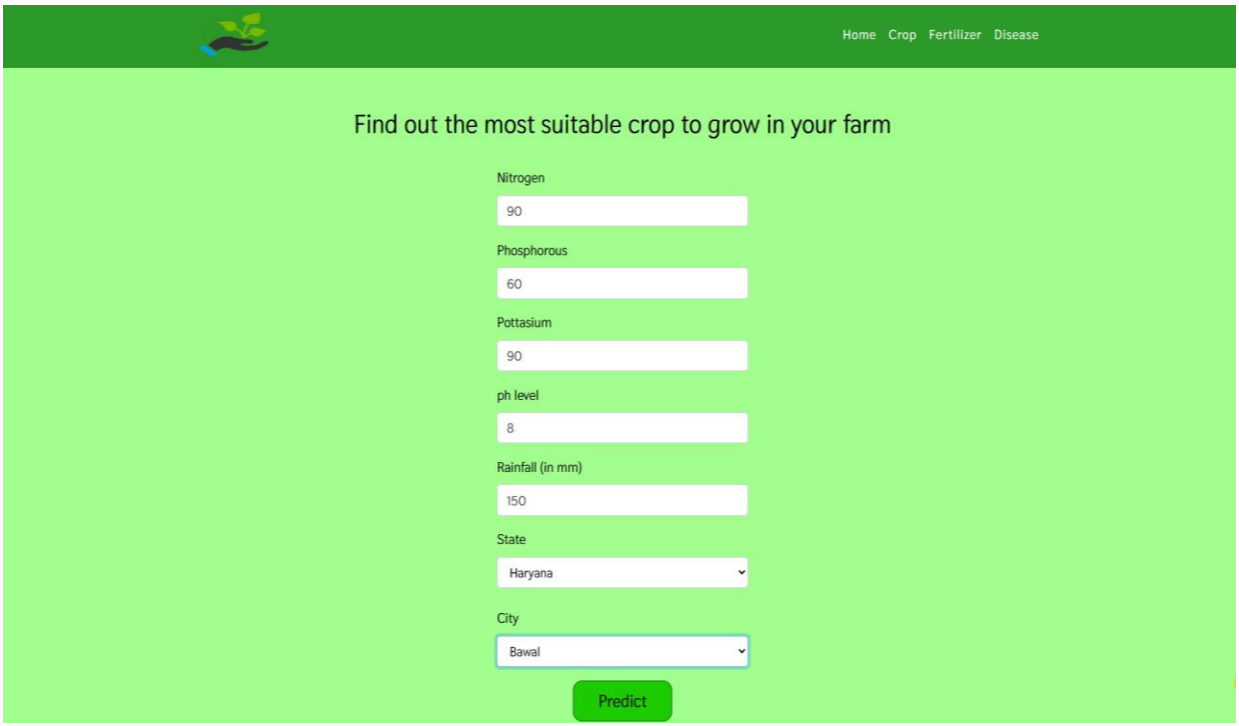
Output:



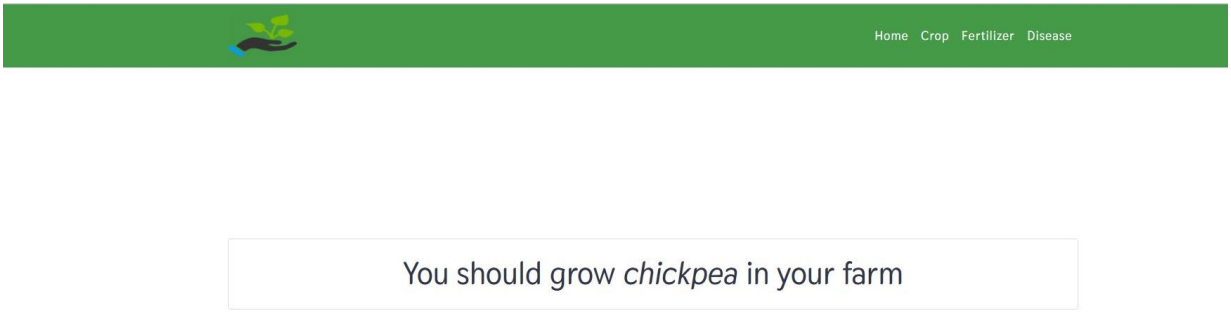

Home Crop Fertilizer Disease
Find out the most suitable crop to grow in your farm
Nitrogen
50
Phosphorous
20
Pottasium
25
ph level
6
Rainfall (in mm)
100
State
Goa
City
Madgaon
Predict

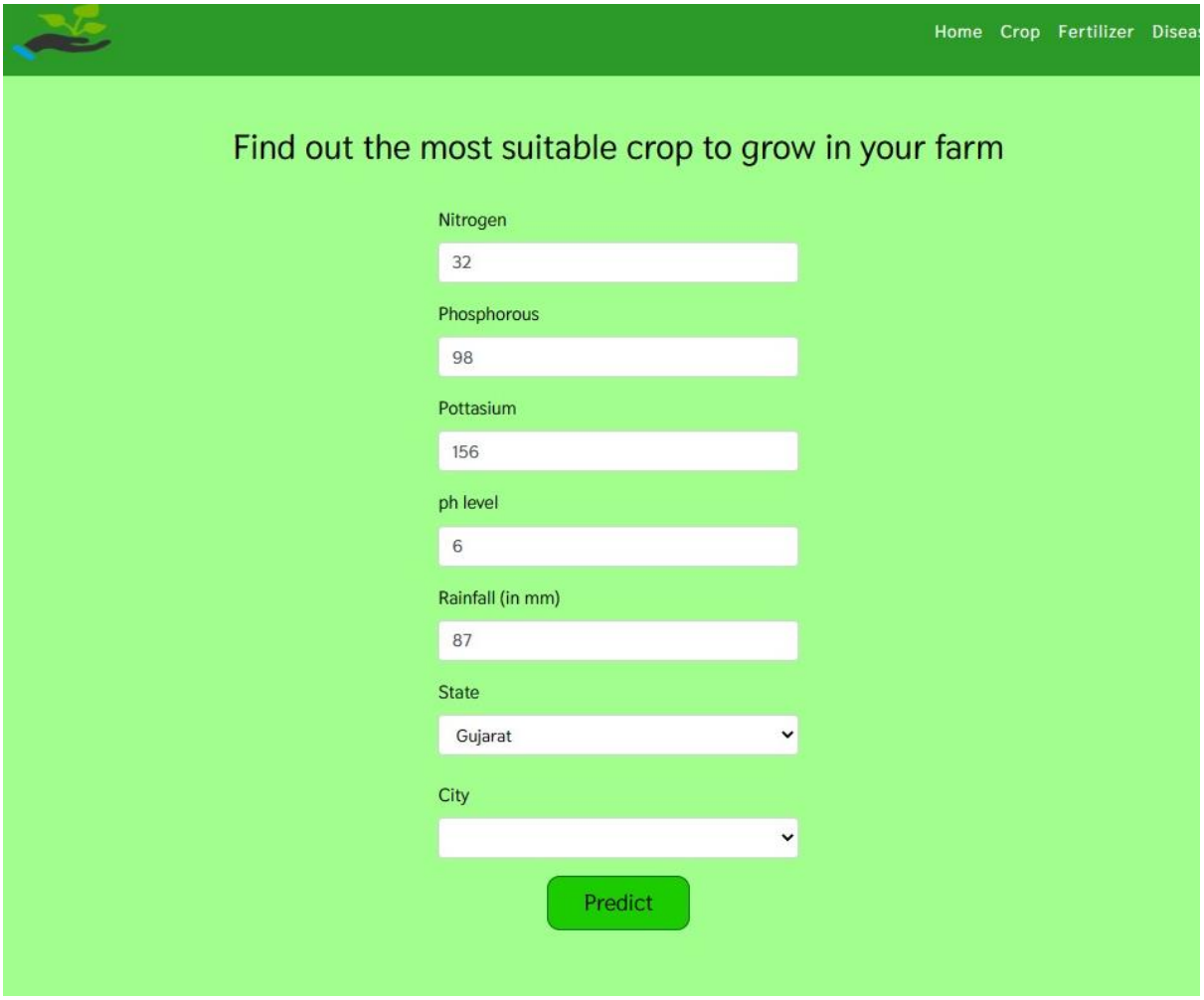
Ouput:


Home Crop Fertilizer Disease
You should grow orange in your farm

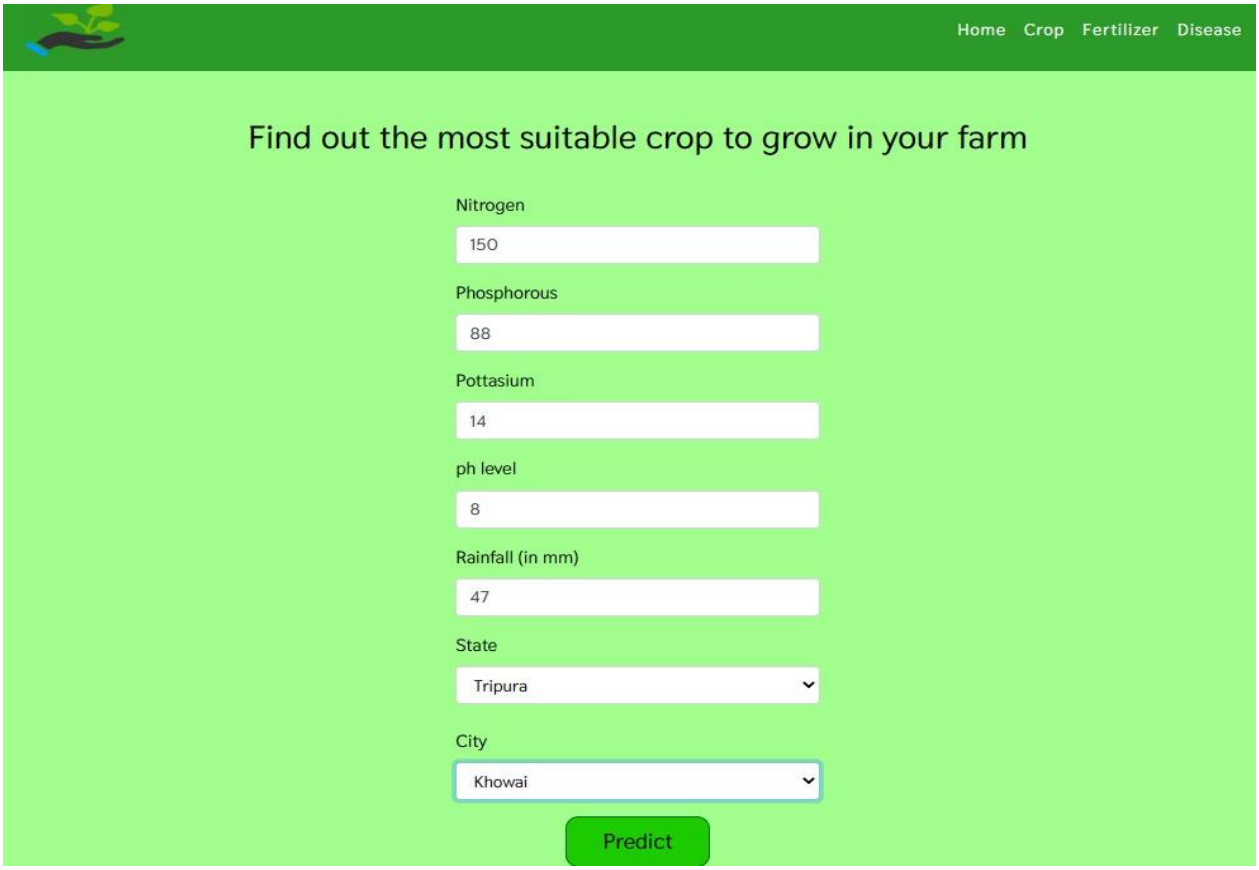

Home Crop Fertilizer Disease
Find out the most suitable crop to grow in your farm
Nitrogen
90
Phosphorous
60
Pottasium
90
ph level
8
Rainfall (in mm)
150
State
Haryana
City
Bawal
Predict

Output:


Home Crop Fertilizer Disease
You should grow *chickpea* in your farm

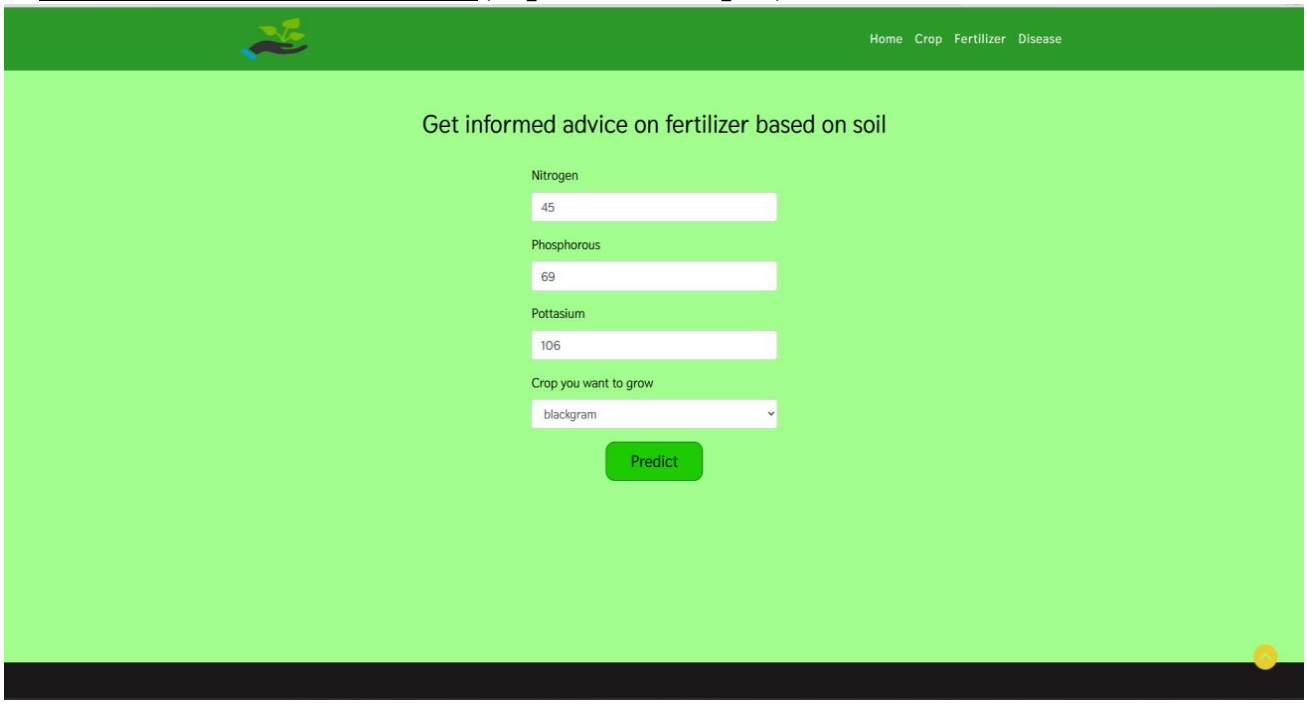


You should grow *chickpea* in your farm



You should grow *maize* in your farm

Fertilizer Recommendation(Input and Output)



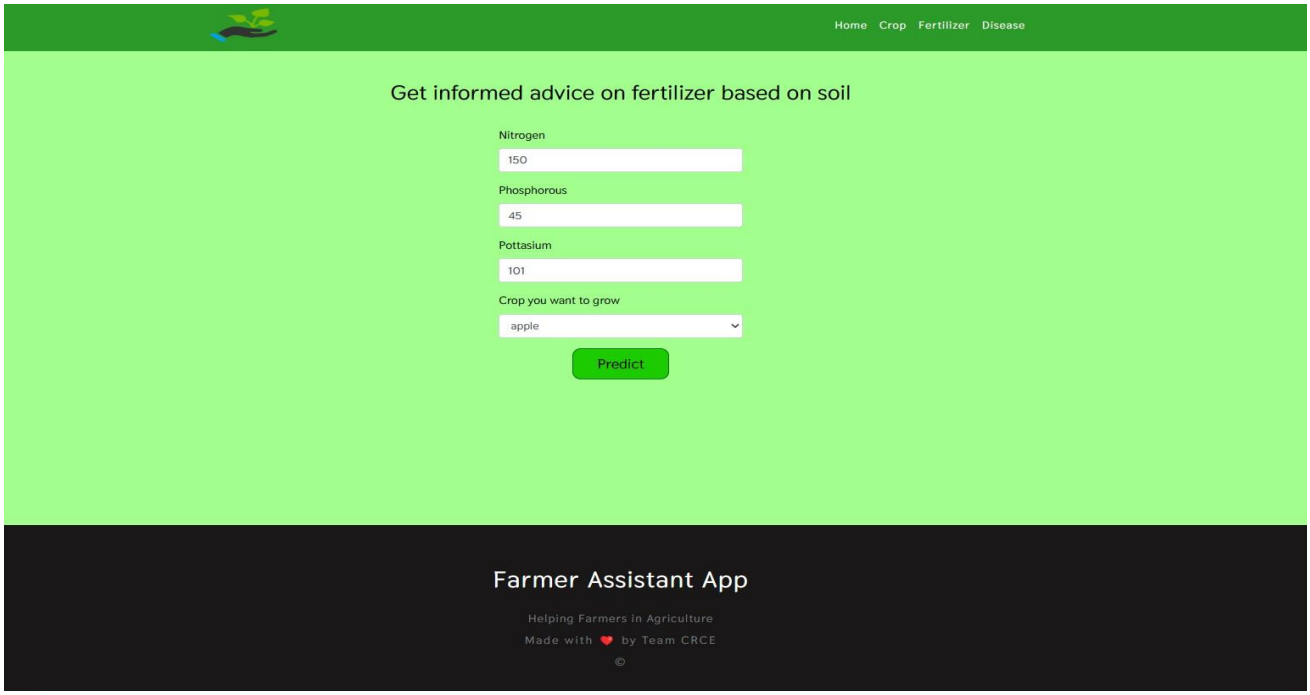
Output:

The N value of soil is high and might give rise to weeds.
Please consider the following suggestions:

1. *Manure* – adding manure is one of the simplest ways to amend your soil with nitrogen. Be careful as there are various types of manures with varying degrees of nitrogen.
2. *Coffee grinds* – use your morning addiction to feed your gardening habit! Coffee grinds are considered a green compost material which is rich in nitrogen. Once the grounds break down, your soil will be fed with delicious, delicious nitrogen. An added benefit to including coffee grounds to your soil is while it will compost, it will also help provide increased drainage to your soil. AZ
3. *Plant nitrogen fixing plants* – planting vegetables that are in Fabaceae family like peas, beans and soybeans have the ability to increase nitrogen in your soil
4. Plant 'green manure' crops like cabbage, corn and brocolli
5. *Use mulch (wet grass) while growing crops* - Mulch can also include sawdust and scrap soft woods

Fertilizers

If a soil test shows that the nitrogen levels are high, but the soil is deficient in other nutrients, a balanced fertilizer such as a 10-10-10 or a 14-14-14 may be used. These types of fertilizers provide a balance of nitrogen, phosphorus, and potassium, and can help to promote healthy plant growth. Additionally, you may consider fertilizers that are specific to your crop, for example Nitrogen-Phosphorus-Potassium (NPK) fertilizers for vegetables, fruits and grains. It is always good to consult with local extension services or agronomists for best practices.

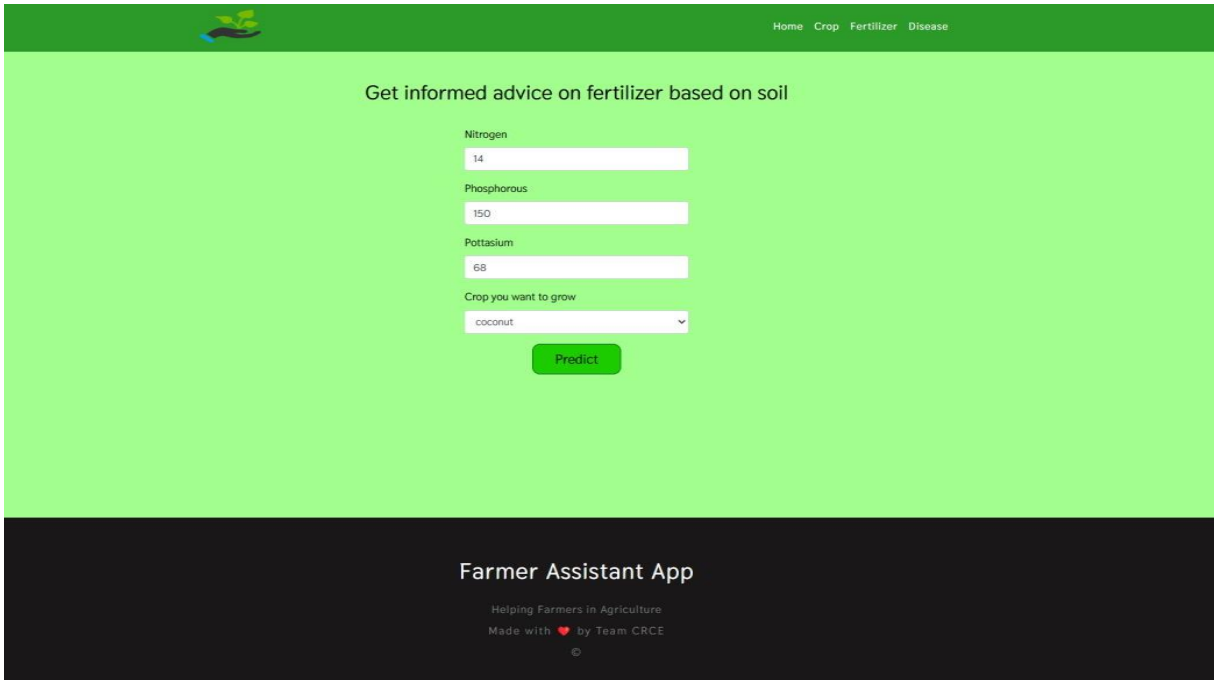


The K value of your soil is high.
Please consider the following suggestions:

1. *Loosen the soil* deeply with a shovel, and water thoroughly to dissolve water-soluble potassium. Allow the soil to fully dry, and repeat digging and watering the soil two or three more times.
2. *Sift through the soil*, and remove as many rocks as possible, using a soil sifter. Minerals occurring in rocks such as mica and feldspar slowly release potassium into the soil slowly through weathering.
3. Stop applying potassium-rich commercial fertilizer. Apply only commercial fertilizer that has a '0' in the final number field. Commercial fertilizers use a three number system for measuring levels of nitrogen, phosphorous and potassium. The last number stands for potassium. Another option is to stop using commercial fertilizers all together and to begin using only organic matter to enrich the soil.
4. Mix crushed eggshells, crushed seashells, wood ash or soft rock phosphate to the soil to add calcium. Mix in up to 10 percent of organic compost to help amend and balance the soil.
5. Use NPK fertilizers with low K levels and organic fertilizers since they have low NPK values.
6. Grow a cover crop of legumes that will fix nitrogen in the soil. This practice will meet the soil's needs for nitrogen without increasing phosphorus or potassium.

Fertilizers

If you want to lower the potassium level in your soil, you can use a fertilizer that is lower in potassium and higher in other essential nutrients. For example, a fertilizer with a ratio of 10-10-10 (10% nitrogen, 10% phosphorus, 10% potassium) would be a good choice. You can also use fertilizers specifically formulated for your plants, such as a fertilizer for vegetables, flowers, or lawns. It's also important to use fertilizer in the correct amounts, as over-fertilizing can be harmful to plants. Always follow the instructions on the fertilizer package, and be sure to water the soil after fertilizing to help the nutrients reach the roots of your plants.



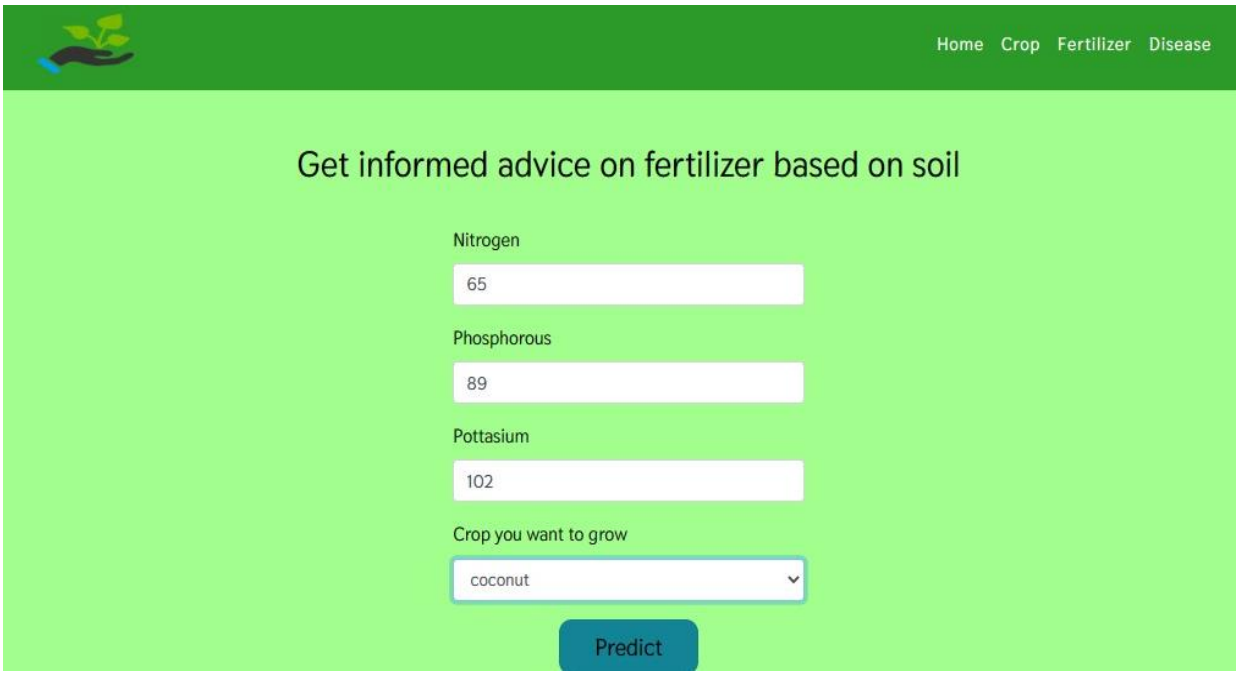
Output:

The P value of your soil is high.
Please consider the following suggestions:

1. *Avoid adding manure* – manure contains many key nutrients for your soil but typically including high levels of phosphorous. Limiting the addition of manure will help reduce phosphorus being added.
2. *Use only phosphorus-free fertilizer* – if you can limit the amount of phosphorous added to your soil, you can let the plants use the existing phosphorus while still providing other key nutrients such as Nitrogen and Potassium. Find a fertilizer with numbers such as 10-0-10, where the zero represents no phosphorous.
3. *Water your soil* – soaking your soil liberally will aid in driving phosphorous out of the soil. This is recommended as a last ditch effort.
4. Plant nitrogen fixing vegetables to increase nitrogen without increasing phosphorous (like beans and peas).
5. Use crop rotations to decrease high phosphorous levels

Fertilizers

For high phosphorous levels in the soil, a fertilizer with a low P (phosphorus) and high N (nitrogen) and K (potassium) ratio, such as a 10-10-20 or 16-4-8 fertilizer, would be a good choice. It is important to note that overuse of fertilizers can lead to soil imbalances and excess nutrients in the water supply, so it's always best to follow the manufacturer's instructions and consult with a local expert or extension service for specific recommendations for your area.



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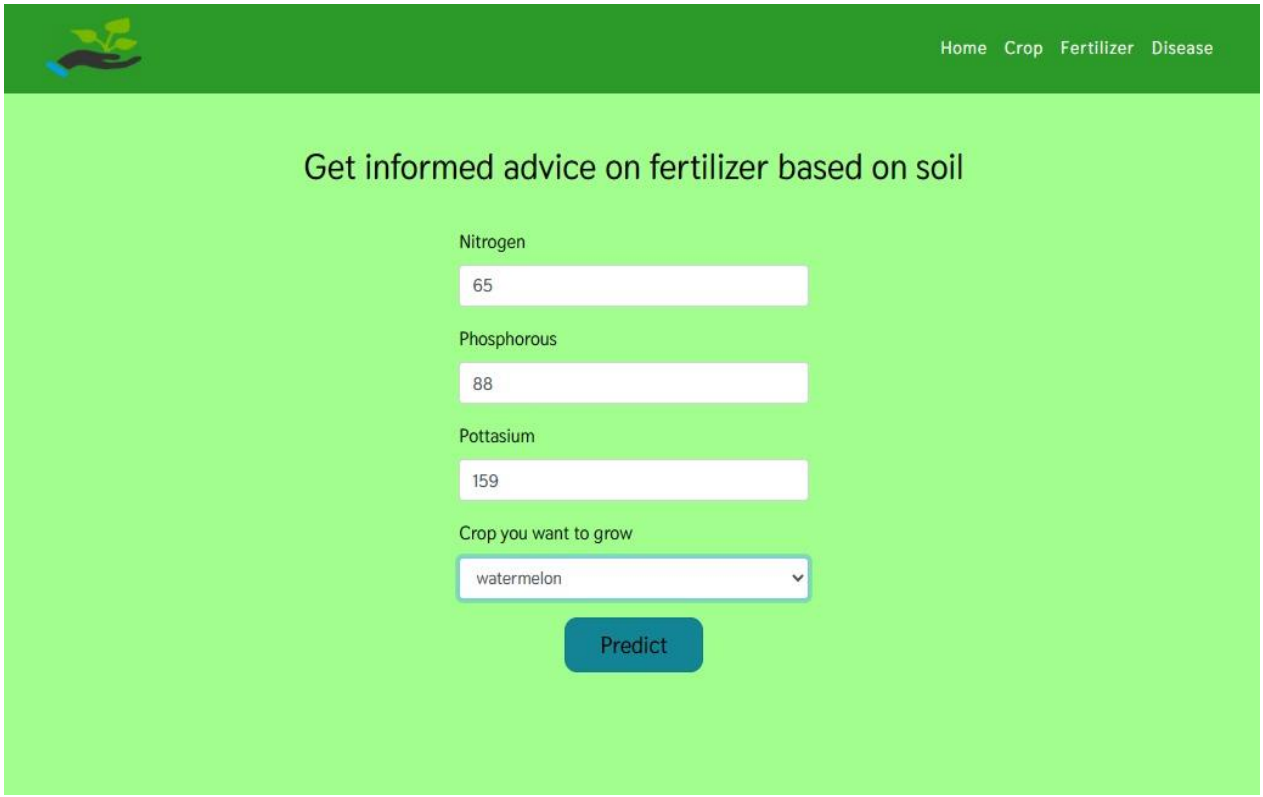

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Disease Prediction:

Home Crop Fertilizer Disease

Find out which disease has been caught by your plant

Please Upload The Image

Choose File 0a31549c-8adb..._B.Rot 0687.JPG

Predict

Crop: Grape
Disease: Black Rot

Cause of disease:

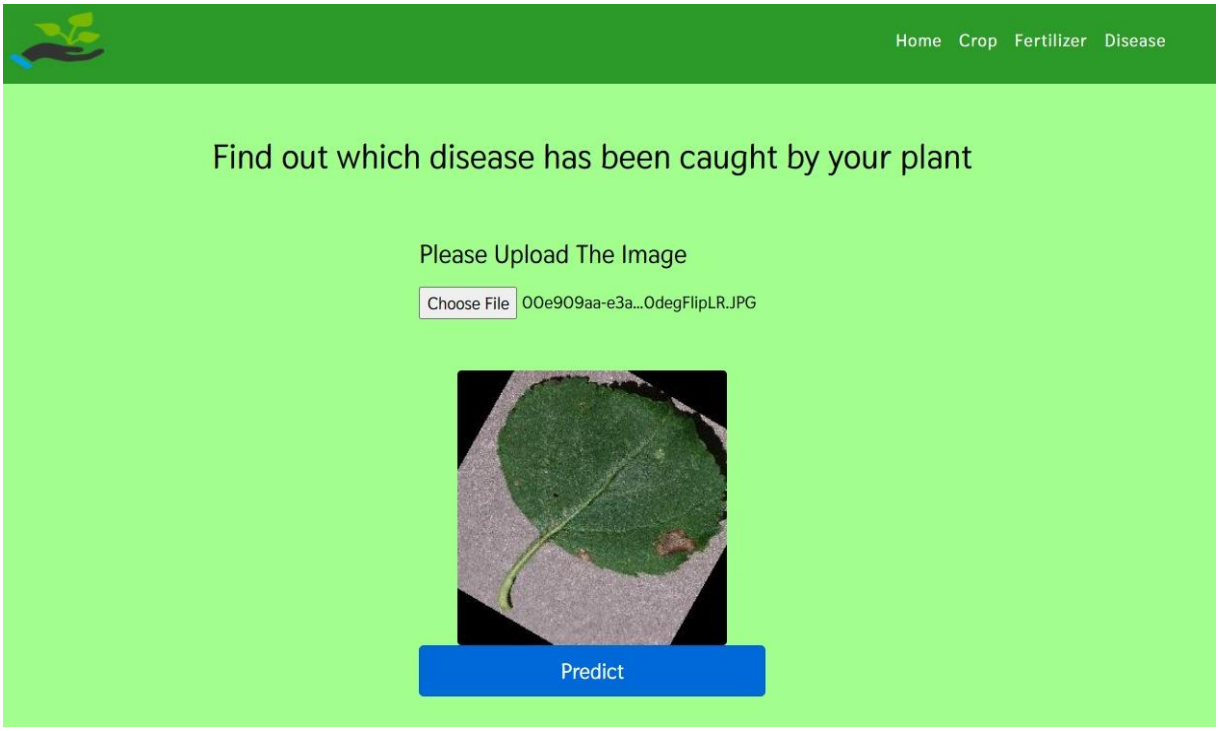
1. The black rot fungus overwinters in canes, tendrils, and leaves on the grape vine and on the ground. Mummified berries on the ground or those that are still clinging to the vines become the major infection source the following spring.
2. During rain, microscopic spores (ascospores) are shot out of numerous, black fruiting bodies (perithecia) and are carried by air currents to young, expanding leaves. In the presence of moisture, these spores germinate in 36 to 48 hours and eventually penetrate the leaves and fruit stems.
3. The infection becomes visible after 8 to 25 days. When the weather is wet, spores can be released the entire spring and summer providing continuous infection.

How to prevent/cure the disease

1. Space vines properly and choose a planting site where the vines will be exposed to full sun and good air circulation. Keep the vines off the ground and insure they are properly tied, limiting the amount of time the vines remain wet thus reducing infection.
2. Keep the fruit planting and surrounding areas free of weeds and tall grass. This practice will promote lower relative humidity and rapid drying of vines and thereby limit fungal infection.
3. Use protective fungicide sprays. Pesticides registered to protect the developing new growth include copper, captan, ferbam, mancozeb, maneb, triadimefon, and ziram. Important spraying times are as new shoots are 2 to 4 inches long, and again when they are 10 to 15 inches long, just before bloom, just after bloom, and when the fruit has set.

Pesticides

Several pesticides are available for controlling black rot on grapes. These include:
Copper-based fungicides: These fungicides, such as copper hydroxide and copper oxychloride, are effective in controlling black rot and are often used as a protective spray. They work by preventing fungal spores from germinating and infecting the vine.
Sterol biosynthesis inhibitors: These fungicides, such as propiconazole and tebuconazole, work by inhibiting the growth and reproduction of the fungus. They are usually applied as a protective spray and can be effective in controlling black rot.
Qol fungicides: These fungicides, such as pyraclostrobin, are also effective in controlling black rot and are usually applied as a protective spray.
DMI fungicides: These fungicides, such as myclobutanil and penconazole, are also effective in controlling black rot and are usually applied as a protective spray.



Crop: Apple

Disease: Black Rot

Cause of disease:

Black rot is caused by the fungus Diplodia seriata (syn Botryosphaeria obtusa).The fungus can infect dead tissue as well as living trunks, branches, leaves and fruits. In wet weather, spores are released from these infections and spread by wind or splashing water. The fungus infects leaves and fruit through natural openings or minor wounds.

How to prevent/cure the disease

1. Prune out dead or diseased branches.
2. Prune out dead or diseased branches.
3. Remove infected plant material from the area.
4. Remove infected plant material from the area.
5. Be sure to remove the stumps of any apple trees you cut down. Dead stumps can be a source of spores.
6. Common fungicides used to control apple black rot include captan, thiophanate-methyl, and pyraclostrobin
7. Pesticides that can be used to control apple black rot include captan, thiophanate-methyl, and pyraclostrobin.

Find out which disease has been caught by your plant

Please Upload The Image

Choose File 0c83302d-423...RS_LB 4904.JPG

Predict

Crop: Potato

Disease: Late Blight

Late blight is a potentially devastating disease of potato, infecting leaves, stems and fruits of plants. The disease spreads quickly in fields and can result in total crop failure if untreated. Late blight of potato was responsible for the Irish potato famine of the late 1840s.

Cause of disease:

1. Late blight is caused by the oomycete Phytophthora infestans. Oomycetes are fungus-like organisms also called water molds, but they are not true fungi.
2. There are many different strains of P. infestans. These are called clonal lineages and designated by a number code (i.e. US-23). Many clonal lineages affect both tomato and potato, but some lineages are specific to one host or the other.
3. The host range is typically limited to potato and tomato, but hairy nightshade (Solanum physalifolium) is a closely related weed that can readily become infected and may contribute to disease spread. Under ideal conditions, such as a greenhouse, petunia also may become infected.

How to prevent/cure the disease

1. Seed infection is unlikely on commercially prepared tomato seed or on saved seed that has been thoroughly dried.
2. Inspect tomato transplants for late blight symptoms prior to purchase and/or planting, as tomato transplants shipped from southern regions may be infected
3. If infection is found in only a few plants within a field, infected plants should be removed, disced-under, killed with herbicide or flame-killed to avoid spreading through the entire field.

Pesticides

There are several fungicides that can be used to control potato late blight caused by Phytophthora infestans. Some examples include:

1-Mefenoxam: A systemic fungicide that is taken up by the plant and provides protection against the pathogen from within.

2-Chlorothalonil: A broad-spectrum fungicide that can be used to control a wide range of fungal diseases, including late blight.

3-Mancozeb: A protectant fungicide that forms a protective barrier on the surface of the plant, preventing the pathogen from infecting the plant.

4-Fosetyl-Al: A systemic fungicide that is taken up by the plant and provides protection against the pathogen from within.

5-Cymoxanil+Mancozeb: A combination of two fungicides that provides both systemic and protectant activity.

Find out which disease has been caught by your plant

Please Upload The Image

Choose File 0be84fb6-08e....Scorch 1001.JPG

Predict

Crop: Potato

Disease: Late Blight

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Find out which disease has been caught by your plant

Please Upload The Image

Choose File 000ec6ea-906...0degFlipLR.JPG

Predict

Crop: Tomato

Disease: Mosaic Virus

Cause of disease:

1. Tomato mosaic virus and tobacco mosaic virus can exist for two years in dry soil or leaf debris, but will only persist one month if soil is moist. The viruses can also survive in infected root debris in the soil for up to two years.
2. Seed can be infected and pass the virus to the plant but the disease is usually introduced and spread primarily through human activity. The virus can easily spread between plants on workers' hands, tools, and clothes with normal activities such as plant tying, removing of suckers, and harvest
3. The virus can even survive the tobacco curing process, and can spread from cigarettes and other tobacco products to plant material handled by workers after a cigarette

How to prevent/cure the disease

1. Purchase transplants only from reputable sources. Ask about the sanitation procedures they use to prevent disease.
2. Inspect transplants prior to purchase. Choose only transplants showing no clear symptoms.
3. Avoid planting in fields where tomato root debris is present, as the virus can survive long-term in roots.
4. Wash hands with soap and water before and during the handling of plants to reduce potential spread between plants.

Pesticides

1. Use of pesticides: There are no specific pesticides that target the ToMV virus. However, using pesticides to control the insect vectors that spread the virus, such as aphids and thrips, can help to reduce the spread of the disease.
2. Cultural control methods: Some cultural control methods that can help to prevent the spread of ToMV include crop rotation, removal of infected plant debris, and maintaining good hygiene in the greenhouse or field.
3. Resistant varieties: Planting tomato varieties that have been bred to be resistant to ToMV can also help to prevent the spread of the disease.

Accuracy

The four models we employed for our crop recommendation system, as shown in table no. 2.1, which have the highest accuracy.

Table No. 6.1 Crop Recommendation

Algorithm	**Accuracy (%)**
Logistic Regression	95
Decision Tree	90
Random Forest	99
SVM	97

In order to predict plant diseases, we now only used one model i.e the ResNet model which able to predict diseases with an accuracy of 98.03 percent.

Table no. 6.2 Disease Prediction

Algorithm	**Accuracy (%)**
ResNets	98.03

Accuracy for each class for disease prediction

Table 6.3 Accuracy of each diseases

	Disease Name	**Accuracy**
1	Apple scab	96%
2	Apple Black rot	98%
3	Cedar apple rust	97%
4	Blueberry healthy	99%
5	Cherry (including sour) healthy	95%
6	Cherry (including sour)Powdery mildew	95%
7	Corn (maize) Common rust_	96%
8	Grape Black rot	97%
9	Grape Leaf blight (Isariopsis Leaf Spot)	98%
10	Peach healthy	95%
11	Pepper, Bell Bacterial spot	96%
12	Potato Early_ light	97%
13	Potato Late blight	95%
14	Squash Powdery mildew	97%
15	Tomato Early blight	96%
16	Tomato healthy	97%
17	Tomato Late blight	95%
18	Tomato Leaf Mold	96%
19	Tomato Septoria leaf spot	97%
20	Tomato Tomato mosaic virus	96%
21	Tomato Tomato Yellow Leaf Curl Virus	96%

Chapter 7

Conclusion And Future Enhancements

7.1 Conclusion

The entire system aids in crop selection by offering information that most farmers would not be aware of, lowering the likelihood of crop failure and raising output. Additionally, it stops them from suffering losses. Millions of farmers around the nation may access the system, which can be expanded to the online. The crop recommendation system will be further developed to connect with a yield predictor, another subsystem that would also give the farmer an estimate of production if he plants the recommended crop. The outcomes are beneficial because they allow farmers to operate more effectively.

7.2 Future Enhancements

1. Integration of machine vision and deep learning: Machine vision and deep learning technologies can be used to analyze images and video data from drones, satellites, and other sources to provide highly detailed information on crop health, growth, and stress factors. By analyzing this data, the system can provide highly accurate and detailed recommendations for crop management, including fertilizer recommendations, disease prediction, and irrigation schedules.

2. Use of 5G technology: 5G technology can enable faster and more reliable data transfer between sensors, IoT devices, and other components of the crop management system. This can help to ensure real-time data collection and analysis, enabling more precise and timely recommendations.

3. Development of autonomous farming systems: Autonomous farming systems, such as robots and drones, can perform tasks such as soil sampling, planting, and crop monitoring without human intervention. These systems can collect and analyze data in real-time, allowing for rapid decision-making and response to changing conditions.

4. Integration of quantum computing: Quantum computing can provide significant advancements in the speed and accuracy of data analysis, allowing for more complex models and simulations. This can enable more accurate predictions and recommendations for crop management, including fertilizer recommendations, disease prediction, and irrigation schedules.