Marathwada Shikshan Prasarak Mandal's
Deogiri Institute of Engineering and Management Studies, Aurangabad

Project Report

on

FARMEASY

Submitted By

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Department of Computer Science and Engineering **(TNR-16)**
Deogiri Institute of Engineering and Management Studies, Aurangabad
(2021- 2022)

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In partial fulfillment of

Bachelor of Technology

(Computer Science & Engineering)

Guided By

Ms. Manisha Munde

Department of Computer Science & Engineering

Deogiri Institute of Engineering and Management Studies,

Aurangabad

(2021- 2022)

CERTIFICATE

This is to certify that, the Project entitled "**Farmeasy**" submitted by **Arti Mule, Nutan Bhoyar, Shubhangi Hiwale** is a bonafide work completed under my supervision and guidance in partial fulfillment for award of Bachelor of Technology (Computer Science and Engineering) Degree of Dr. Babasaheb Ambedkar Technological University, Lonere.

Place: Aurangabad
Date:15/1/2022

Ms Manisha Munde
Guide

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DECLARATION

This is to certify that, the partial project report entitled , **"Farmeasy"** Submitted by **Arti Mule, Nutan Bhoyar, Shubhangi Hiwale** is a bonafide work completed under my supervision and guidance in partial fulfillment for award of Bachelor degree in Computer Science and Engineering of Deogiri Institute of Engineering and Management Studies, Aurangabad under Dr. Babasaheb Ambedkar Technological University, Lonere.

Place: Aurangabad
Date: 15/1/2022

Ms Manisha Munde

External Examiner

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Abstract

Economy of India highly depends on agriculture. Still traditional ways of recommendations are used for agriculture. Currently, agriculture is done based on various approximations of fertilizers quantity and the type of crop to be grown or planted. Agriculture highly depends on the nature of soil and climate. Therefore, it becomes important to make advancement in this field. The paper proposes development of an ontology-based recommendation system for crop suitability and fertilizers recommendation. It bridges the gap between farmers and technology. The system predicts suitable crop for the field under consideration based on region in Maharashtra state of India and type of soil. It provides proper recommendation of fertilizers to the farmers. Fertilizer recommendation is done based on nitrogen, phosphorus, and potassium (NPK) contents of soil and using past years research data that is stored in ontology. Along with fertilizer recommendation system also provides suggestions about crop suitability in particular region. In this project, we present a website in which the following applications are implemented; Crop recommendation, Fertilizer recommendation and Plant disease prediction, respectively.

- In the crop recommendation application, the user can provide the soil data from their side and the application will predict which crop should the user grow.
- For the fertilizer recommendation application, the user can input the soil data and the type of crop they are growing, and the application will predict what the soil lacks or has excess of and will recommend improvements.
- For the last application, that is the crop disease prediction application, the user can input an image of a diseased plant leaf, and the application will predict what disease it is and will also give a little background about the disease and suggestions to cure it.

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INTRODUCTION

1.1 Introduction

India is an agriculture-based country where most of the people derive their living from this sector. Agriculture is having a great impact on the country's economy. The prediction of crop yield in advance can help the farmers and the Government bodies to plan for storage, selling, fixing minimum support price, importing /exporting etc. Till now only the past experience of the farmer was used which consist of randomly counting the number of seed buds that a plant is having and within each seed bud the number of seed it holds. Then based on experience the farmer used to predict the crop yield. Information technology can be used to avert the risk associated with the agriculture and it can also be used to predict the crop yield more accurately prior to harvest. Yield prediction needs different kinds of data gathered from different sources like meteorological data, Agri meteorological, soil (pH,N,P,K) data, remotely sensed data, agricultural statistics etc. To handle such a huge data the best option we have is Data Science. Data Science is a method by which one can extract the knowledge from the huge bulk of data. We predict crop yield and also suitable required fertilizers recommended to improvise the crop yield. We use all different agriculture parameters for prediction of crop yield and fertilizers recommendation. The system comes with a model to be precise and accurate in predicting crop yield and deliver the end user with proper recommendations about required fertilizer ratio based on atmospheric and soil parameters of the land which enhance to increase the crop yield and increase farmer revenue. We need to use some technology to find or understand the crop details and guide the farmers to grow crops accordingly and moreover fertilizer also one of the major factors to grow crops accordingly. If fertilizer is used more or less in the field the soil may lose it fertility and crop may not give the expected yield. So, fertilizer also becomes the major factor in it. mostly understanding the temperature conditions is much necessary for India because we can improve the Indian economy with the help of the crop prediction because it plays a major role in the Indian economy. Generally, machine learning algorithms will predict the most efficient output of the yield. 1. Previously yield is predicted on the bases of the farmers prior experience but now weather conditions may change drastically so they cannot guess the yield.

so, technology can help them to predict the yield of the crop weather to go for that crop or no. machine learning model will understand the pattern of the crop and yield based on the several conditions and predicts the yield of the area in which he is going to crop.

The choice of a crop for planting is one of the major challenges faced by farmers in the cultivation of crops. It is influenced by several factors. By recommending the most appropriate crops and suggesting the suitable fertilizer for the crop, the crop recommendation system can help farmers to select the appropriate crop for the crop yield. Thus there is a need for suggesting suitable crops and fertilizers using the data mining algorithm. Data mining is a technique that uses complex algorithms and a series of predefined rules to function intelligently. It uses the past data to interpret patterns and then performs the intended task according to defined rules and algorithms based on an analysis it makes predictions. Data mining is a significant field of informatics that can be applied very efficiently to the agriculture sector. Together with big data technologies and high performance computing, new possibilities have arisen to unravel the quantification and comprehensive of the information intensive process in agricultural operating environments. Data mining is everywhere over the entire growing and harvesting process. The crop recommendation system incorporates the agricultural datasets. The soil's Nitrogen (N), Phosphorus (P) and Potassium (K) levels are used as input to recommend crops. The proposed system constructs a collaborative system of crop yield prediction, forecasting and fertilizer recommendation. In this project a system is build that incorporates the agricultural dataset and the Random Forest algorithm is applied to suggest the most appropriate crops. The existing system focuses only on crop yield prediction and forecasting or crop recommendation or on crop rotation. the prediction was ineffective due to certain vital characteristics of the soil not considered. Existing works suggest fertilizer only based on the crop. The nutrients already present in the soil were not taken into account to make suggestions. Hence the proposed system considers the soil type, land type, soil texture and NPK values for suggesting the fertilizer. 2. For crop disease we use pytorch and ResNets perform significantly well for image classification when some of the parameters are tweaked and techniques like scheduling learning rate, gradient clipping and weight decay are applied. The model is able to predict every image in test set perfectly without any errors.

1.2 Necessity

Soil quality is determined by NPK's value the soil. 'N' is nitrogen content in soil, 'P' is the content of phosphorus and "K" is the content of potassium the soil. Based on NPK contents, soil value can be predicted. Nitrogen in the soil is responsible for the color the leaves of crop. If a low amount of nitrogen is found in the soil then the plants will have a slight yellowish leaves and quantity moderate or high will have green leaves. The content of phosphorus in the soil is responsible for Plant reproductive system. Its value will predict growth of fruits and flowers of plants. Potassium Soil content is responsible for its overall growth. Its value will predict the strength of plant roots will also determine the overall growth of the plant. The data set for which we took the data the training group tried to apply the algorithms to it take the past data as a test group, and then view the output. This output is compared with the actual output. Crop with maximum points can be recommended for Farmer. The market trend for crops is saved in database. While recommending more than one crop, the first factor that is selected will be the year factor that you will to be followed by the market factor and the ratio factor. To on recommend the crop to the user, we use Random Forest Algorithm.

The component of crop rotation is adequate use of nitrogen, phosphorus and potassium through the use of green manure and fertilizers. Crop rotation also reduces the accumulation of pathogens and pests which occur frequently when one type is down produced. Soil structure and fertility can also be improved alternating between different leguminous plants. Rotation is a component of poly culture. In the agricultural area, crop rotation is very necessary over the years.

1.3 Objectives

- To develop relationships between soil test values and crop response to fertilizers, in order to provide a calibration for fertilizer recommendation based on soil testing.
- To obtain a basis for making fertilizer recommendations for targeted yields.
- To evaluate various soil test methods for their suitability under field conditions.
- To evaluate the joint use of chemical fertilizers and organic manures for enhanced nutrient use efficiency.
- To derive a basis for making fertilizer recommendations for a whole cropping sequence based on initial soil test values.
- Development of crops that have high water-use efficiency (drought-tolerance), are high yielding, early maturing, and high consumer acceptability.
- Development of environmentally compatible strategies for the efficient management of pests and diseases.
- Developing of cropping systems for food and value-added products, which are compatible with environment safeguard.
- Advancement of biotechnological innovations in improved crop development.
- Identification, development and application of advances in science and technology leading to improved production of safe and nutritious food.
- Playing a strong and key advocacy role in technology transfer to agriculture and the food industry.
- Training of competent and highly motivated graduates of careers in agriculture, food and environmental science, and capable of making significant contributions to the national effort in crop production, and to foster in these graduates life-long habits of leadership, innovation and extension service delivery.
- Development of low-cost, high intensity modified Hydroponics systems for small and urban farm production.
- Continuous review of curricular and developing demand-driver research and extension linkages

- Assisting governments and other Stakeholders in developing agriculture policies that will facilitate and enhance increased agricultural productivity.
- Organisation demand-driven short courses in various aspects of crop production and protection.
- Dissemination of research findings through seminars, workshops and publications.

1. LITERATURE SURVEY

India is known as an agricultural country, where the recommendations are given by traditional methods. At present, recommendations for farmers are based on communication between farmers and Krishi Adhikari who testing a farm. Recommendation can be provided to farmers using past agricultural activities' data. The application provides recommendations to Krishi Adhikari they inform to farmer for identification of appropriate fertilizer and crop. This system can be used by website. The application can be used for increasing the crop yield. Also, the recommended the fertilizers you should use in your farm and provide crop disease solution.

Crop Recommendation and Fertilizer recommendation

Agricultural crop suggestion frameworks are accessible in the market which consider different parameters like climate at the time the yield is to be planted, soil type, geology of the locale, temperature and precipitation in the area, showcase costs of the harvest, trim length, and so on. Research has been completed in this field and the accompanying papers have been alluded with the end goal of research and study.

The framework in paper [1] recommended by creators S.Pudumalar and related co-creators utilizes a gathering system called Majority Voting Technique which consolidates the intensity of numerous models to accomplish more prominent forecast precision. The strategies utilized are Random Trees, KNN, CHAID and Naïve Bayes for gathering so that regardless of whether one strategy predicts erroneously, alternate models are probably going to make right forecasts and since the greater part casting a ballot system is utilized, the last expectation is right one. On the off chance that rules are the fundamental segments which are utilized in the expectation procedure.

The exactness got is 88% utilizing the gathering model. Paper [2] is an audit paper for concentrate different calculations and their exactness in the rural field proposed by Yogesh Gandge and Sandhya. It was seen that Multiple Linear Regression gave a precision of 90-95% for rice yield. Choice tree utilizing ID3 calculation was considered for soybean edit and the proposals were created.

The third calculation was SVM which was utilized on every one of the harvests and the precision was great with computationally less prerequisites.

Neural system was utilized on corn information to accomplish 95% of precision. Different calculations were additionally utilized which are KNN, C4.5, K-implies, J48, LAD Tree and Naïve Bayes. The end was that still enhancement is required for the calculations to accomplish better precision.

Being used of Data Mining in Crop Yield Prediction [3], paper [3], the dataset utilized was gathered from Kaggle.com The creator has broke down the information utilizing WEKA apparatus for calculations which are LWL, J48, LAD Tree and IBK. The exactness was estimated utilizing explicitness, affectability, precision, RMSE and mean outright blunder. For every classifier, perplexity network was utilized to get the effectively distinguished occurrences. The perception was that better precision can be acquired if pruning is utilized.

Paper [4] displayed by Rakesh Kumar, M.P. Singh, Prabhat Kumar and J.P. Singh proposed utilization of seven machine learning methods for example ANN, SVM, KNN, Decision Tree, Random Forest, GBDT and Regularized Gradient Forest for crop choice. The framework is intended to recover every one of the yields sowed and time of developing at a specific time. Yield rate of each harvest is acquired and the crops giving higher yields are chosen. The framework additionally proposes an arrangement of crops to be planted to get the higher yields.

Prof. Rakesh Shirsathand other co-creator in paper [5] proposed a framework which causes the clients to settle on choices with respect to the crop to be planted. The framework utilized is a membership based framework which would have customized data of each rancher enlisted. The framework incorporates a module which keeps up the data of the past harvests planted gathered from different sources and demonstrates a coordinating crop that can be planted. The entire procedure is finished with the assistance of fake impartial systems. Toward the end a criticism framework is given with the goal that the designer can make changes required if the rancher discovers some trouble while utilizing the framework

Enormous Data Analysis Technology Application in Agricultural Intelligence Decision System paper creators Jichun Zhao and Jian-xin Guo in paper [6] considers information database as large information and derivations from the information is drawn. It considers different modules like clients, information build, area master, manmachine interface, deduction motor and learning base.

The learning procurement framework gets information for the choice framework and sets up a powerful learning base to take care of the issue. The paper utilizes different Hadoop modules with the end goal of highlight extraction. It utilizes the unstructured information and procedures it utilizing NoSQL, Hive, Mahout and utilizations HDFS to store the information. The information was simply introduced for wheat edit and different crops were not considered.

RSF as referenced in paper [7] is a proposal framework for famers which considers an area location module, information investigation and capacity module, trim developing database, physiographic database. The comparative area discovery module distinguishes the areas which are like the client's areas and checks the comparable harvests that are planted in those areas. Likewise, utilizing comparability framework, the proposals for the client is produced. Area recognition module utilizes the Google API administrations to get the present area of the client to distinguish the comparative areas. Be that as it may, the framework does not inspire client criticism to enhance the procedure.

CROP DISEASE PREDICTION

There are different studies have been carried out in the past in developing and designing the crop based predicting system. The each work completed and reported in the past have their own advantages and disadvantages in developing the system based on particular problem of crop production enhancement.

In the paper [1] published by Naveen Kumar P R et al., proposed the prediction for crop using neural network. The system is developed based on the concept of linear predictive model to predict yield and best crop suitable to grow. The model has trained to produce the best answer using the train and test datasets. The system processed the information and generated a forecasted lucrative crop, as well as a list of required fertilizers and an overall yield per hectare. The system only predicated the yield of the selected crop with an accuracy of 85%. Kevin Tom Thomas et al. [2] proposed the yield expectation utilizing conventional neural systems administration dependent on the dirt supplement esteems and pH given as information. The model is trained using the KNN algorithm for the crop prediction. The system recommends crop using soil properties only with accuracy of 88%. In the paper [3], Rohit Kumar Rajak et al., proposed the crop suggestive system. The system is modeled using SVM and ANN to recommend the crop for site using soil parameters. The system is valid for only Maharashtra state, India.

The only soil properties are used as input. Shashikala et al, in the paper [4] designed a rain prediction using Polynomial Regression for the Field of Agriculture Prediction for Karnatakka. The best match of rain and crop category is out final output. The system recommends crop using only rain prediction as input. The proposed system is valid for only Karnatakka state, India. N.L Chourasiya et al., [5] proposed the crop prediction system using ANN machine learning tool to predict seed sowing for farmers which ends up in high crop production. The system takes seed and soil data as input then predict the crop for planting. Devdatta A. Bondre et al., [6] proposed the prediction of crop using the Random Forest and SVM for crop yield prediction and fertilizer recommendation. In [7] by P. Surya, the system based on crop yield using Data Mining Predictive Analytical Techniques. The analysis was conducted using data from the state of Tamilnadu. The predictor model predict the yield of crops and compare the yield of different crops that which crop is most useful for the Tamilnadu state. The proposed system only compares the yield prediction of different crops using previous year data for a Tamilnadu state. In [8] by Mannem Ganesh Reddy proposed the system of classification KNN algorithm for prediction of crop. The system takes season, temperature, rainfall and soil characteristics as input to predict the yield of crops. The proposed system only predict yield per hectare and valid for only Telagana state, India. The existing systems using Machine Learning different algorithms are valuable with good accuracy used for their own regions. Mainly the existing systems use the soil parameters as input for the crop prediction. The main focuses of these systems were based on yield prediction, not for the crop suggestion. In the proposed system the input parameters are climatic conditions and soil properties to suggest the favorable crop to get maximum yield for enhancing the crop production for local farmer of rural of area of Sindh, Pakistan. Furthermore, the proposed system for the classification of knowledge of crops to the farmers. In addition to that the accuracy of existing systems is low as compared to our work. In comparison to that proposed system offer better accuracy. The one of the limitation of the proposed work is that dataset in the system is particularly used for Nawabshah, Sindh, Pakistan region only. However, the similar system can be implemented for any region across the world using proposed methodology. In the next, methodology of the proposed system is discussed.

Data mining approach for prediction of crop yield and analysis of soil behavior. Prediction of Yield is popular among farmers these days, which contributes to the proper selection of crops for sowing. This makes the problem of predicting the yielding of crops an interesting challenge. Earlier yield prediction was performed by considering the farmer's experience on a particular field and crop. This work presents a system, which uses data mining techniques in order to predict the category of the analyzed soil datasets. The category, thus predicted will indicate the yielding of crops. The problem of predicting the crop yield is formalized as a classification rule, where Naive Bayes and Random Forest, SVM, XGBoost, Decision Tree algorithm are used.

[1]S. Pudumalar, E. Ramanujam, R. H. Rajashree, C. Kavya, T. Kiruthika and J. Nisha, "Crop recommendation system for precision agriculture"

The crops that were considered in the model for prediction include coriander, pulses, cotton, paddy, sorghum, groundnut, sugarcane, banana and vegetables. Different attributes of the soil were considered in order to predict the crop, which included pH, depth, erosion, permeability, texture, drainage, dater holding and soil color. The technique used was ensembling, which combined the power of using two or more different models for better prediction. The ensembling technique used was called the Majority Voting Technique.

[2] R. Kumar, M. P. Singh, P. Kumar and J. P. Singh, "Crop Selection Method to maximize crop yield rate using machine learning technique"

The crops were inspected and graded depending on an examination to estimate crop yielding. This categorisation is found from different data mining algorithms. This paper provides a perception into various grouping rules, such as K-Nearest Neighbour and Naive Bayes. By making use of this document, we evaluated the classification rules and established which all will match the set of data we will be using in our project.

[3] T.R. Lekhaa, "Efficient Crop Yield and Pesticide Prediction for Improving Agricultural Economy using Data Mining Techniques"

The paper hypothesizes analysis of Explorative Data and considers the design of different types of predictive models.

A data set is taken as a sample data set, and different regression techniques are tried to recognise and examine each property. Specific regression methods discussed here are Multiple Linear, Linear, Non-Linear, Polynomial, Ridge regression and Logistic. Using this article, we obtain a comparative study of the different algorithms in data analytics. This helped in determining which algorithm is most appropriate to the proposed system.

[4] Viviliya, B. and Vaidhehi, V., "The Design of Hybrid Crop Recommendation System using Machine Learning Algorithms"

The attributes in the dataset included the soil type, groundwater level, rainfall, water availability, temperature of one dataset and the other dataset included the potassium, phosphorus, and nitrogen values, fertilizers, soil pH and organic carbon value. The dataset was preprocessed using basic preprocessing tasks. Naive Bayes and J48 classifiers were used for the crop recommendation. The final recommendation was done using association rules based on the results obtained from the classifiers. The model was trained using 10-cross validation. The testing was done based on different metrics like the Accuracy, ROC Area, Recall, Precision, F-Measure etc.

The main ideology of the research revolves around the concept of identifying the most suitable crop to be grown with the help of a machine learning model. Thus, the results can prove to be exceedingly beneficial for the agriculture farmers. We have used a dataset from Kaggle containing 2200 values of 22 unique crops. We have applied machine learning algorithms on the dataset. The dataset is used to train the model according to the actual values and then test the model for its accuracy

So, we have also included graphical user interface to make it seamless and attractive to operate for even the first-time users who have no prior experience of using any such app or facility. The Web App has been added using the Machine Learning Algorithm and library of python. Our research aims to take into consideration the ground reality reflecting the actual requirements instead of assuming any of the factors. Since we are mainly catering to uneducated farmers, we have made it more and more visual and easier to operate. This process is laying the foundation for further evaluation through addition of secondary factors having an impact on deciding the crop to be grown on a particular field in a particular place.

2. SYSTEM DEVELOPMENT

3.1 Requirement Specification

- In this project, we have proposed a model that addresses the existing issues. The novelty of the proposed system is to guide the farmers to maximize the crop yield as well as suggest the most profitable crop for the specific region.
- The proposed model provides crop selection based on economic and environmental conditions, and benefit to maximize the crop yield that will subsequently help to meet the increasing demand for the country's food supplies. The proposed model predicts the crop yield by studying factors such as rainfall, temperature, area, season, soil type etc. The system also helps to determine the best time to use fertilizers.
- The user provides an area under cultivation and soil type as inputs. According to the requirement, the model predicts the crop yield for a specific crop. The model also recommends the most profitable crop and suggests the right time to use the fertilizers.
- The main objective is to obtain a better variety of crops that can be grown over the season. The proposed system would help to minimize the difficulties faced by farmers in choosing a crop and maximize the yield.

Machine Learning

We have used machine learning to make our model capable of suggesting the optimum crop which can be sown by a farmer according to various input factors. Machine learning is a method of analyzing data to automate the building of an analytical model. It is in fact a branch of AI as it is based on the concept of systems learning from data and identifying some patterns to make decisions without much human intercession.

Kaggle

Kaggle is a subsidiary of Google which gives users a platform to get and publish data sets. Apart from this, it also allows the users to build models in an environment that is generally web-based and data-science oriented. Basically, it is a community for machine learning and data science enthusiasts to get data to work and a platform to display their work. It also hosts competitions where people can compete and hone their ML skills and also get some useful research ideas. We have taken our dataset from Kaggle which we have used to train our model

CROP REQUIREMENT

The proposed system provides connectivity to farmers via a mobile application. GPS helps to identify the user location. The user provides the area & soil type as input. Machine learning algorithms allow choosing the most profitable crop list or predicting the crop yield for a user-selected crop.

To predict the crop yield, selected Machine Learning algorithms such as

- Random Forest Algorithm
- Gaussian Naive Bayes Algorithm
- Decision Tree Algorithm
- Support Vector Machine Algorithm
- Logistic Regression Algorithm are used.

Among them, the Random Forest showed the best results with 95% accuracy. Additionally, the system also suggests the best time to use the fertilizers to boost up the yield.

```
df = pd.read_csv('../Data-processed/crop_recommendation.csv')
```

```
df.head(2220)
```

	N	P	K	temperature	humidity	ph	rainfall	label
0	68	47	36	20.879744	82.002744	6.502985	202.935536	rice
1	98	55	35	21.770462	80.319644	7.038096	226.655537	rice
2	71	58	35	23.004459	82.320763	7.840207	263.964248	rice
3	82	58	44	26.491096	80.158363	6.980401	242.864034	rice
4	95	39	41	20.130175	81.604873	7.628473	262.717340	rice
...	...	...	...	...	...	...	...	...
2195	100	39	26	26.774637	66.413269	6.780064	177.774507	coffee
2196	104	36	34	27.417112	56.636362	6.086922	127.924610	coffee
2197	118	40	27	24.131797	67.225123	6.362608	173.322839	coffee
2198	111	34	27	26.272418	52.127394	6.758793	127.175293	coffee
2199	120	36	26	23.603016	60.396475	6.779833	140.937041	coffee

2200 rows × 8 columns

Fig 3.1 Crop Recommendation Dataset

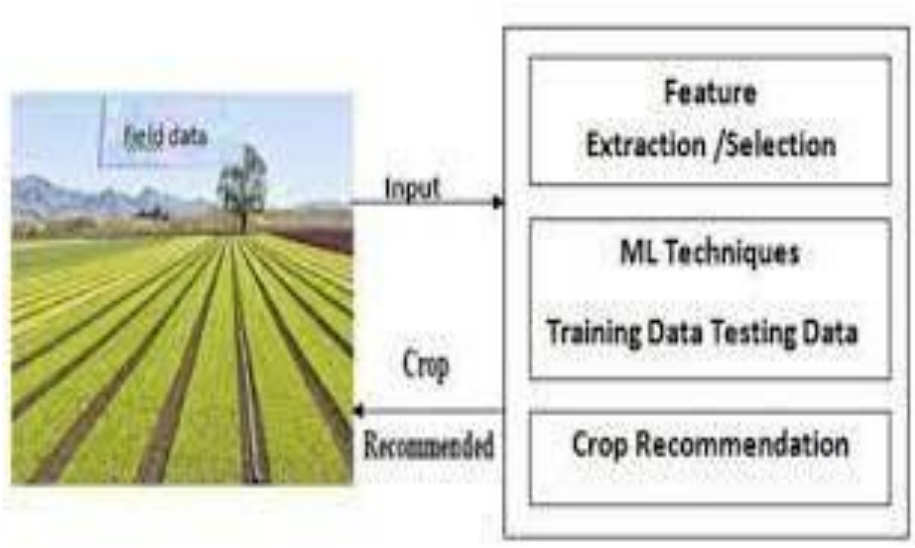


Fig 3.2 processing dig

FERTILIZER REQUIREMENTS

An estimation of the fertilizer requirements of the country is crucial not only for the development of agriculture but also to permit correct investment decisions in the fertilizer manufacturing industry. Incorrect forecasts might result either in shortages for the farmer or in excess capacity and low profits for the producers.

The general fertilizer recommendations are based on multi-locational trials conducted with different doses of N, P and K fertilizers and their economic evaluation obtained at an optimum dose for a particular crop.

These recommendations are suitable for medium soil fertility condition irrespective of wide variation that occurs in soil fertility status Hence, under high or low soil fertility conditions, the applied nutrients prove often a wasteful expenditure and insufficient, respectively Two main factors are taken as a basis for estimating the fertilizer requirements for the country. The first factor is the "indicative cropping pattern" i.e. the optimum rotation, and the area allocated to each crop. The second is the economic optimum rate of fertilizer for each crop under different agroclimatic conditions**.**

In addition to these two main factors, the following factors are taken into consideration:

1. Expansion of the newly reclaimed area
2. Crop rotations and their impact on crop responses to fertilizers
3. Soil and plant tissue analysis
4. The fertilizing value of the various sources of fertilizers
5. Residual effect of the fertilizers and the organic manures
6. Crop intensification, whether by increasing the number of plants per unit area or by intercropping
7. Nutritional balances for the various crops
8. Improvements in the irrigation and drainage systems
9. New technology implemented by the fertilizer industry to produce new types of fertilizers with higher efficiency

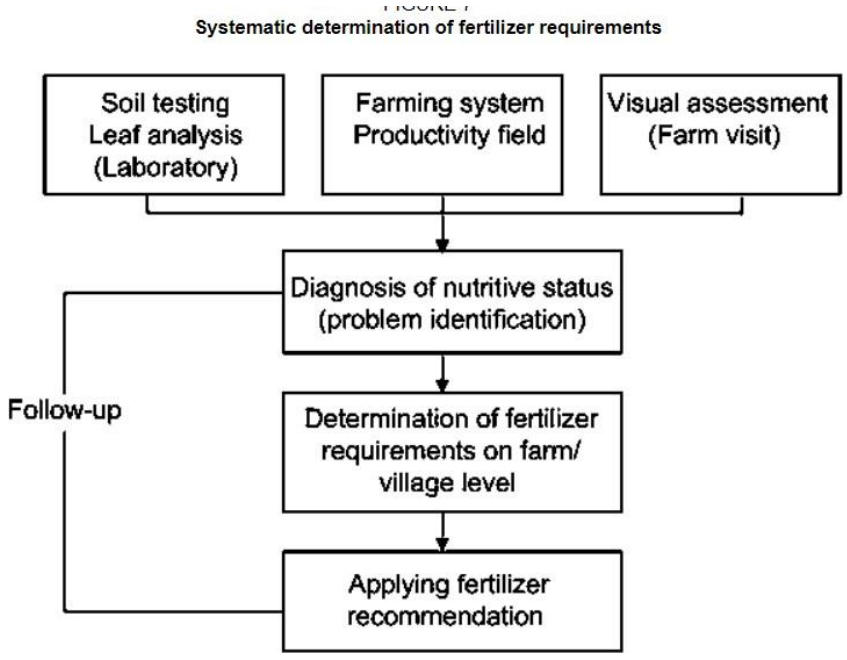


Fig 3.3 flow dig

The main types of fertilizers used are:

Nitrogen

- urea (46.5 percent N)
- ammonium nitrate (33.5 percent N)
- ammonium sulphate (20.6 percent N)
- calcium nitrate (15.5 percent N)

Phosphate

- single superphosphate (15 percent P_2O_5)
- concentrated superphosphate (37 percent P_2O_5)

Potassium

- potassium sulphate (48 to 50 percent K_2O)
- potassium chloride (50 to 60 percent K_2O)

Crops	Fertilizer dose (kg ha^{-1})		
	N	P_2O_5	K_2O
Rice	120	60	60
Wheat	120	60	60
Maize	120	60	50
Pearl millets	80	60	40
Chickpea	20	50	20
Pegion pea	20	50	20
Lentil	20	40	40

Table 3.1 Dataset

```
fertilizer_data_path = '../Data-raw/FertilizerData.csv'
merge_fert = pd.read_csv(fertilizer_data_path)
```

```
merge_fert.head()
```

	Unnamed: 0	Crop	N	P	K	pH
0	0	rice	80	40	40	5.5
1	3	maize	80	40	20	5.5
2	5	chickpea	40	60	80	5.5
3	12	kidneybeans	20	60	20	5.5
4	13	pigeonpeas	20	60	20	5.5

Table 3.2 Fertilizer Recommendation Dataset

CROP DISEASE PREDICTION:

Plant Disease Classification Using RESNET-9 We would require torchsummary library to print the model's summary in keras style (nicely formatted and pretty to look) as Pytorch natively doesn't support that `torchvision.datasets` is a class which helps in loading all common and famous datasets. It also helps in loading custom datasets. we have used subclass `torchvision.datasets.ImageFolder`

Next, after loading the data, we need to transform the pixel values of each image (0-255) to 0-1 as neural networks works quite good with normalized data. The entire array of pixel values is converted to torch tensor and then divided by 255. If you are not familiar why normalizing inputs help neural network, read this post.

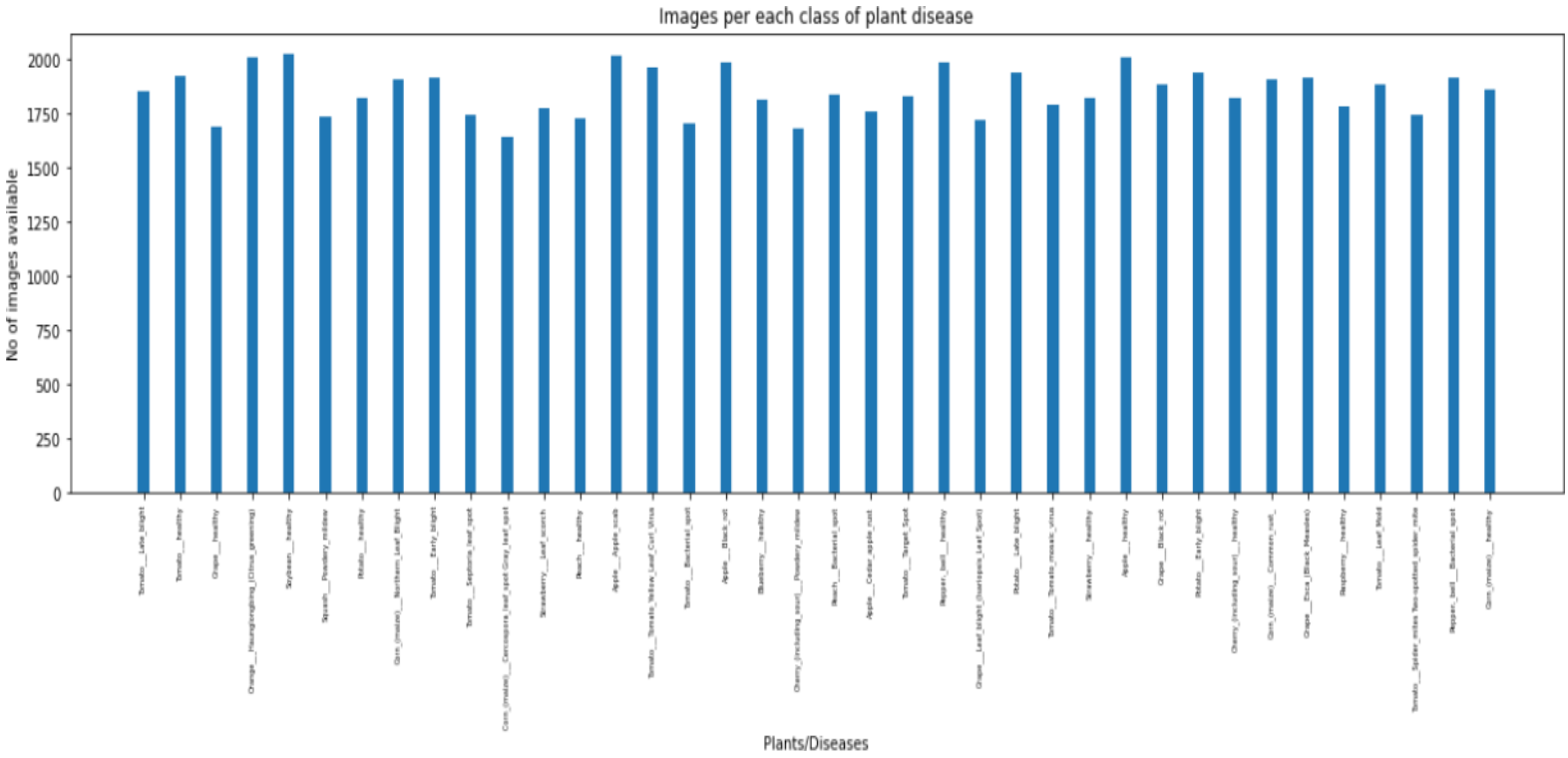


Table 3.3

- DataLoader is a subclass which comes from torch.utils.data. It helps in loading large and memory consuming datasets. It takes in batch_size which denotes the number of samples contained in each generated batch.
- Setting shuffle=True shuffles the dataset. It is heplful so that batches between epochs do not look alike. Doing so will eventually make our model more robust.
- num_workers, denotes the number of processes that generate batches in parallel. If you have more cores in your CPU, you can set it to number of cores in your CPU.

It is advisable to use GPU instead of CPU when dealing with images dataset because CPUs are generalized for general purpose and GPUs are optimized for training deep learning models as they can process multiple computations simultaneously. They have a large number of cores, which allows for better computation of multiple parallel processes. Additionally, computations in deep learning need to handle huge amounts of data — this makes a GPU's memory bandwidth most suitable. To seamlessly use a GPU, if one is available, we define a couple of helper functions (get_default_device & to_device) and a helper class DeviceDataLoader to move our model & data to the GPU as required

System Requirements

Hardware Requirements:

- System : Pentium i3 Processor.
- Hard Disk : 500 GB.
- Monitor : 15'' LED
- Input Devices : Keyboard, Mouse
- Ram : 4 GB

Software Requirement:

- Operating system : Windows 10.
- Coding Language : Python 3.8,HTML,CSS
- Web Framework : Flask, Pytorch

3.1.1 DFD

A data flow diagram (DFD) is a graphical representation of the "flow" of data through an information system. DFDs can also be used for the visualization of data processing (structured design). On a DFD, data items flow from an external data source or
an internal data store to an internal data store or an external data sink, via an internal process. A DFD provides no information about the timing of processes, or about whether processes will operate in sequence or in parallel. It is therefore quite different
from a flowchart, which shows the flow of control through an algorithm, allowing a reader to determine what operations will be performed, in what order, and under what circumstances, but not what kinds of data will be input to and output from the system, nor where the data will come from and go to, nor where the data will be stored

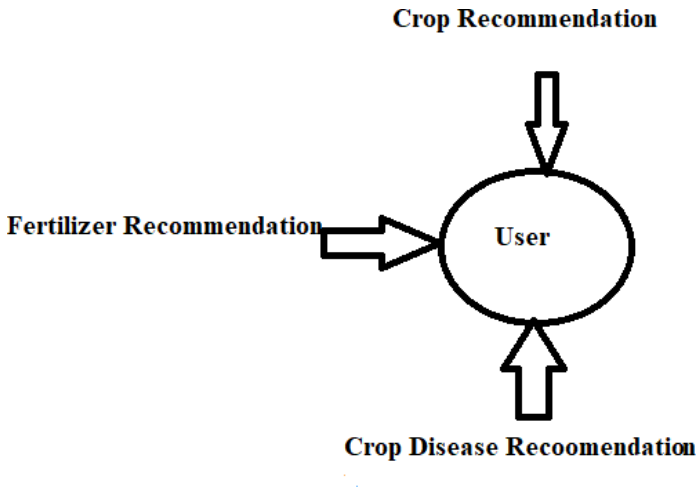


Fig3.1.1.1 (Level 0)

1-level DFD

In 1-level DFD, a context diagram is decomposed into multiple bubbles/processes. In this level, we highlight the main objectives of the system and breakdown the high-level process of 0-level DFD into subprocesses

It is common practice to draw a context-level data flow diagram first, which shows the interaction between the system and
external agents which act as data sources and data sinks. On the context diagram (also known as the 'Level 0 DFD') the system's interactions with the outside world are modelled purely in terms of data flows across the system boundary. The
context diagram shows the entire system as a single process, and gives no clues as to its internal organization. This context-level DFD is next "exploded", to produce a Level 1 DFD that shows some of the detail of the system being modelled. The
Level 1 DFD shows how the system is divided into sub-systems (processes), each of which deals with one or more of the data flows to or from an external agent, and which together provide all of the functionality of the system as a whole. It also
internal data stores that must be present in order for the system to do its job, and shows the flow of data between the various parts of the system.

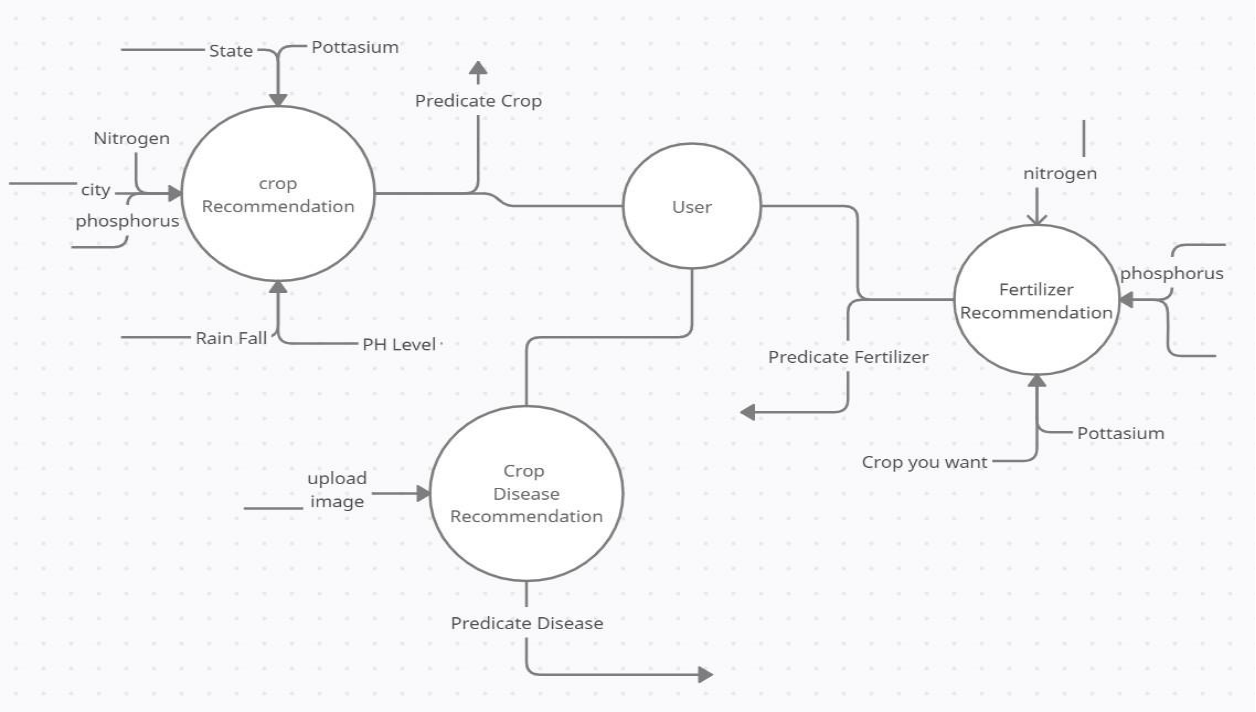


Fig3.1.1.2 (Level 1)

3.1.2 UML Diagrams of all modules

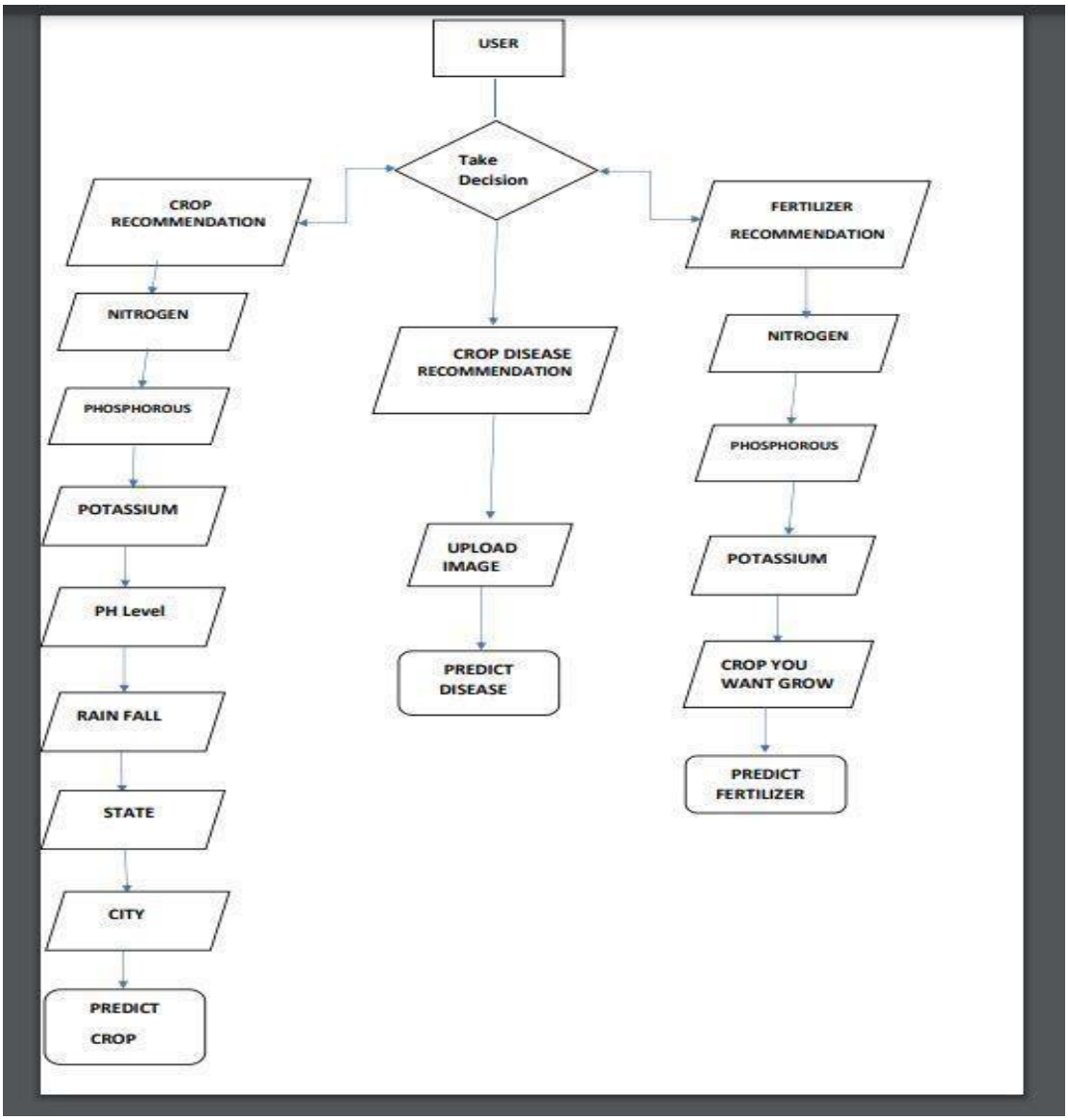
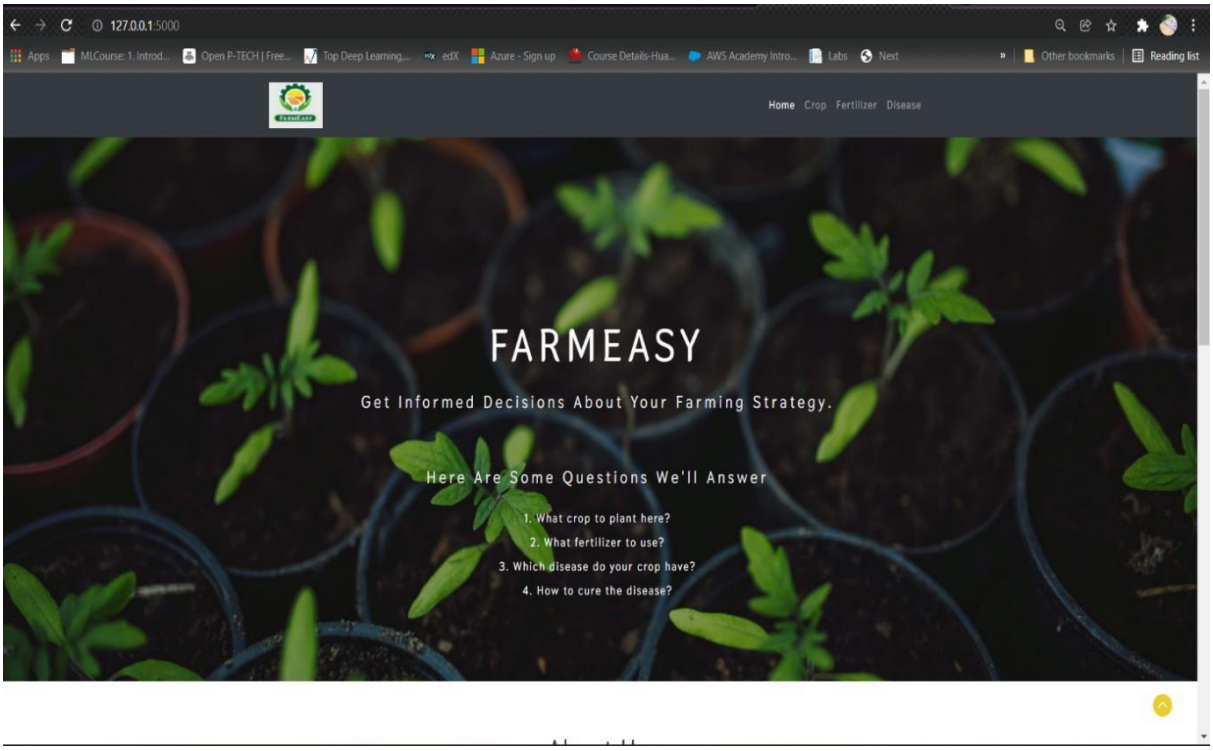


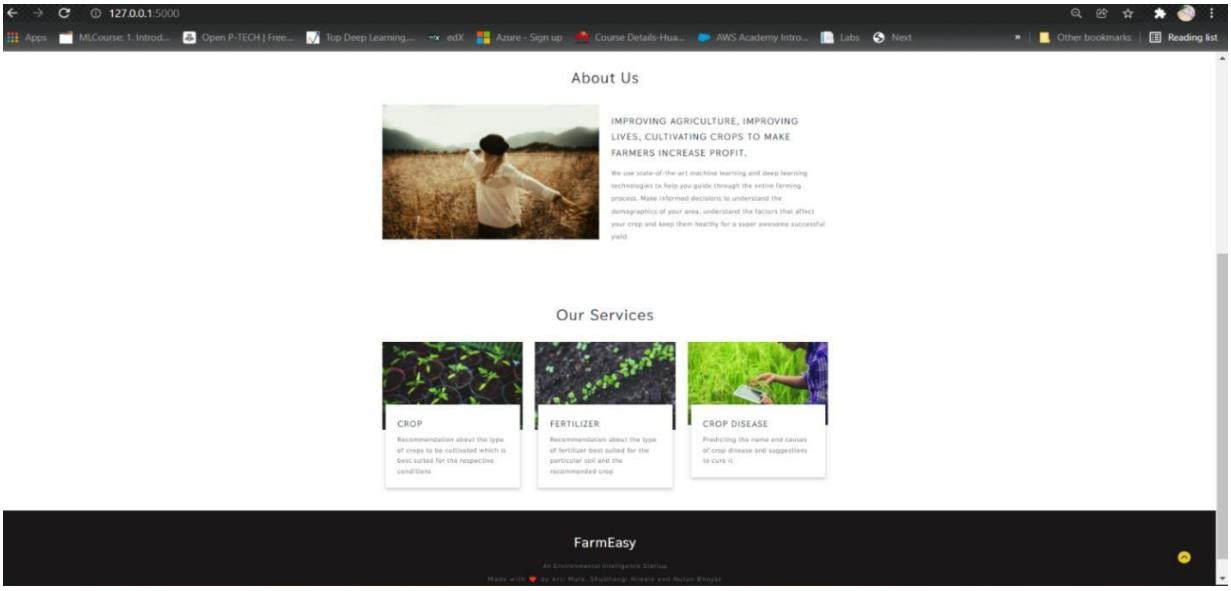
Fig.3.1.2

3.2 User Interface Design



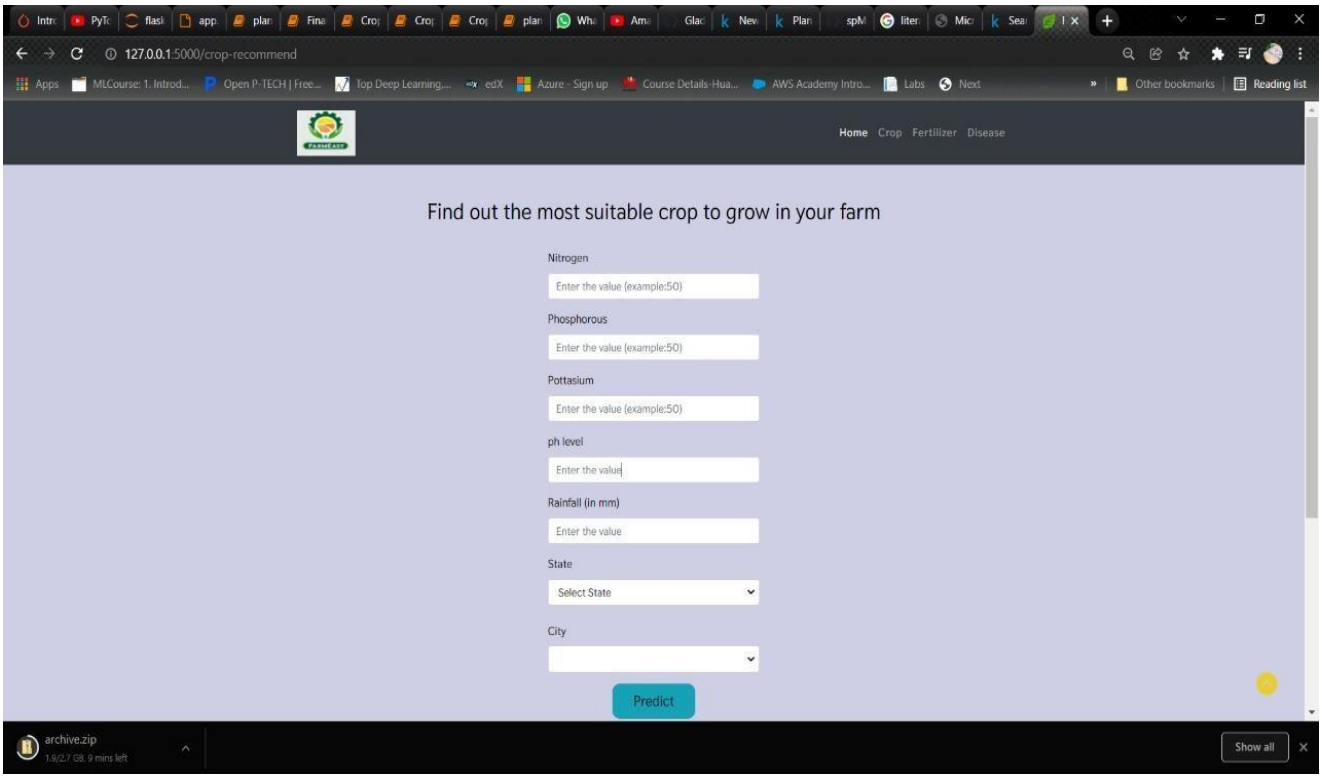
Screenshot.3.2.1

In this web page you can see abouts us and our services such as crop recommendation, fertilizer recommendation and plant disease.



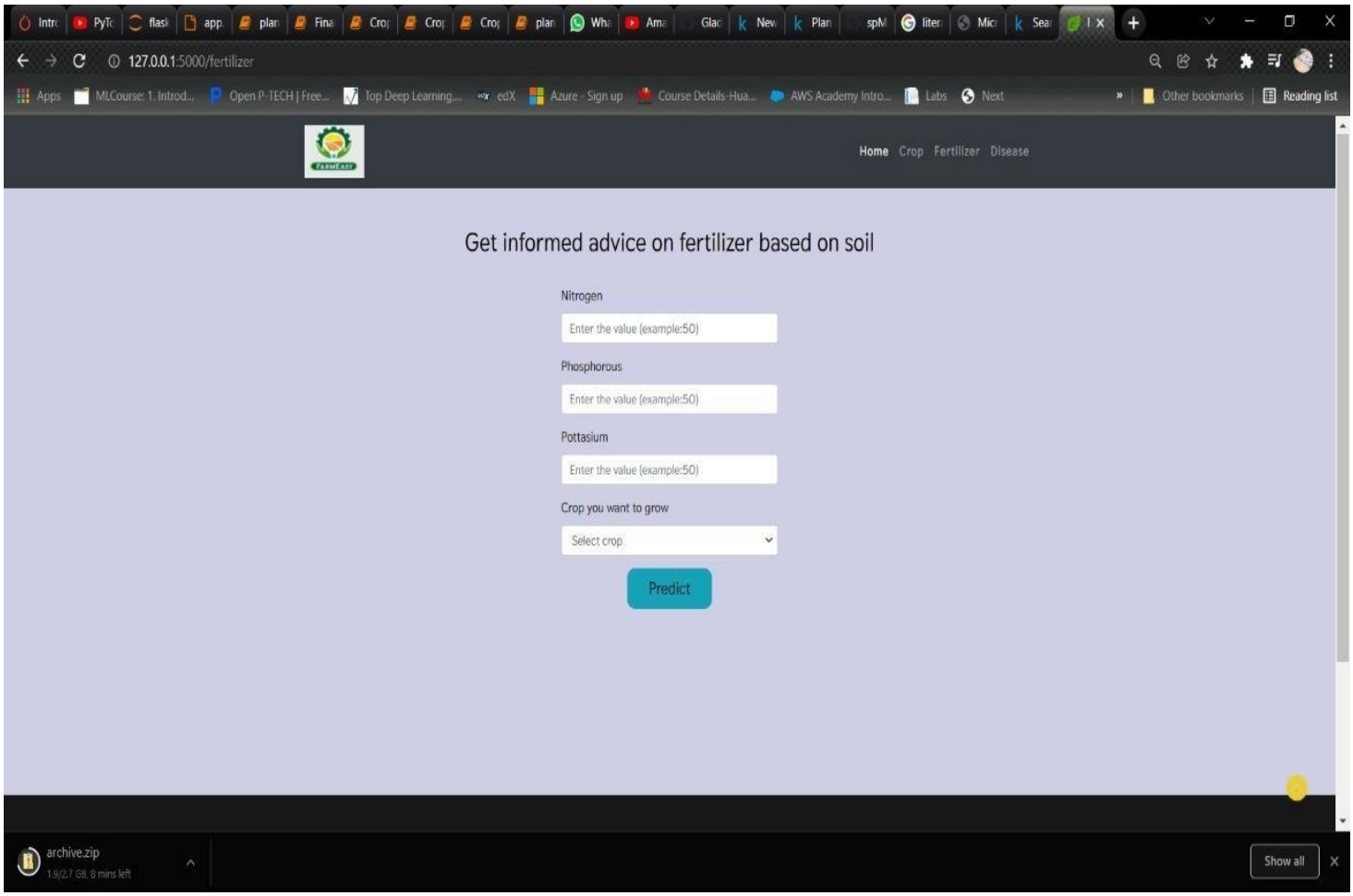
Screenshot 3.2.2

- Crop Recommendation system :>enter the corresponding nutrient values of your soil, state and city. Note that, the N-P-K (Nitrogen-Phosphorous-Pottasium) values to be entered should be the ratio between them. When you enter the city name, make sure to enter mostly common city names. Remote cities/towns may not be available in the Weather API from where humidity, temperature data is fetched.



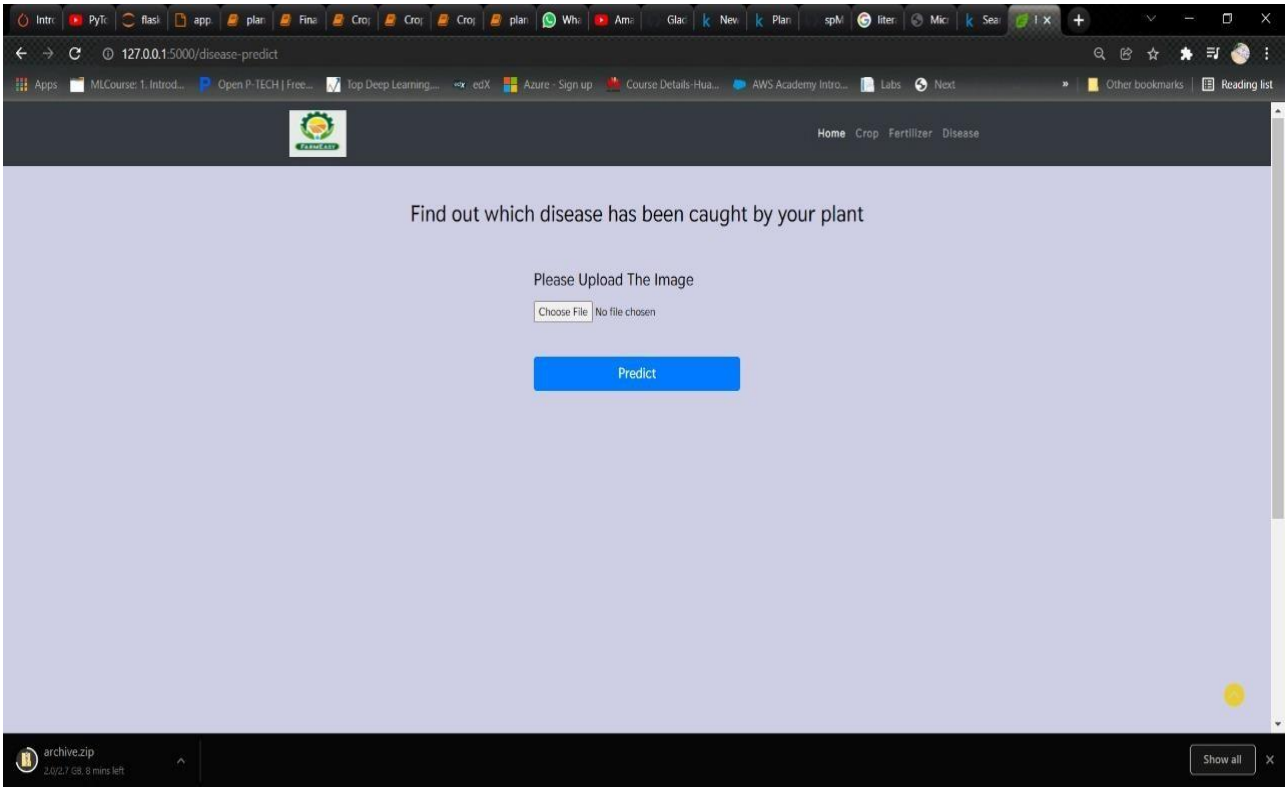
Screenshot 3.2.3

- Fertilizer suggestion system :> Enter the nutrient contents of your soil and the crop you want to grow. The algorithm will tell which nutrient the soil has excess of or lacks. Accordingly, it will give suggestions for buying fertilizers.



Screenshot 3.2.4

- Disease Detection System:> Upload an image of leaf of your plant. The algorithm will tell the crop type and whether it is diseased or healthy. If it is diseased, it will tell you the cause of the disease and suggest you how to prevent/cure the disease accordingly



Screenshot 3.2.5

3.3 ER Diagrams

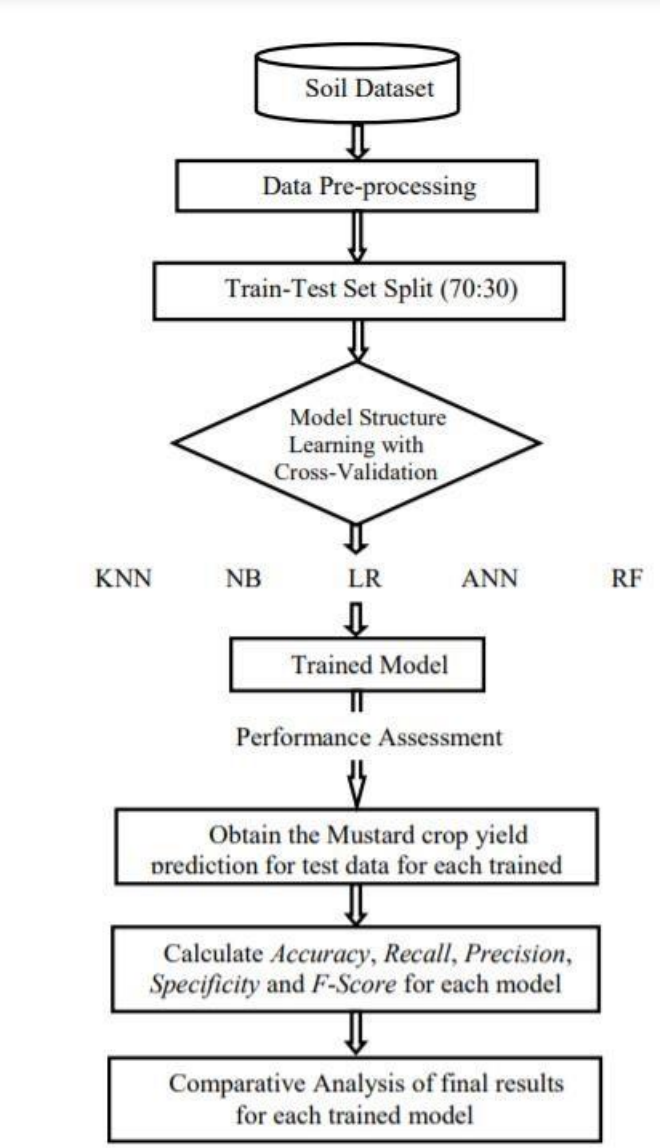


Fig3.3.1

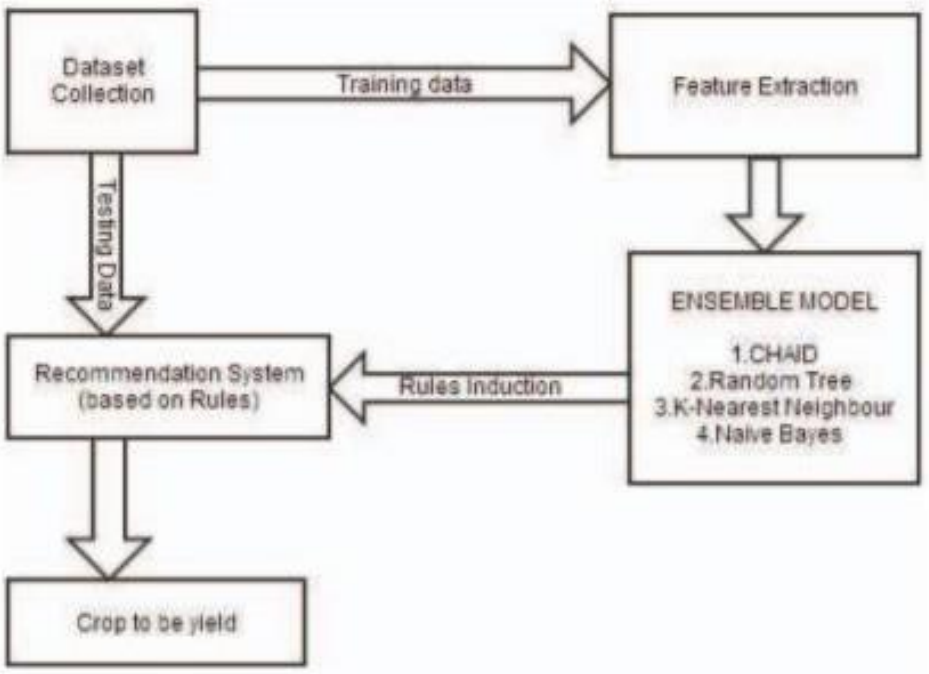

Dataset Collection
Training data
Feature Extraction
Testing Data
ENSEMBLE MODEL
1.CHAID
2.Random Tree
3.K-Nearest Neighbour
4.Naive Bayes
Recommendation System (based on Rules)
Rules Induction
Crop to be yield

Fig 3.3.2

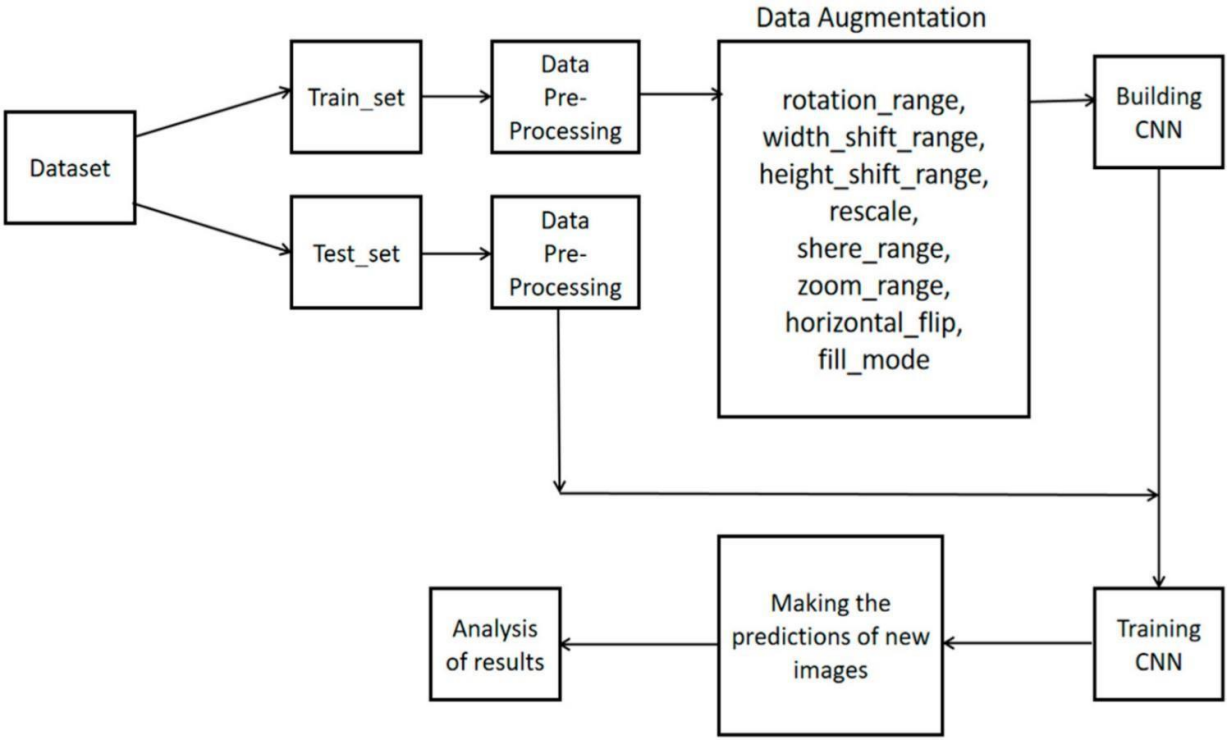

Data Augmentation
Dataset
Train_set
Test_set
Data Pre-Processing
Data Pre-Processing
rotation_range,
width_shift_range,
height_shift_range,
rescale,
shere_range,
zoom_range,
horizontal_flip,
fill_mode
Building CNN
Training CNN
Making the predictions of new images
Analysis of results

Fig 3.3.3

3. PERFORMANCE EVALUATION

Crop and Fertilizer recommendation requirements are affected by soil type and nutrient content, previous cropping, the expected length of the growing season and variety grown.

4.1 Grading of Soil

This module consists of Machine learning model that is built to help farmer understand the quality of his soil by considering various Soil nutrients (both macro as well as micro nutrients) and based on these parameters the following model is made.

• Content of various soil nutrient (N, P, K, pH) are the feature variables, while the grade of soil nutrient criterion is the target variable.

• Quantized rank of the soil macro as well as micro nutrients is the main objective of the model.

• Preprocessing of the dataset is done.

• Cost function is minimized by the algorithm, gradient descent is applied and appropriate learning rate is chosen.

• Root Mean Squared error between the predicted value and true value is calculated.

4.2 Data Collection

The data relating to the soil nutrition are collected from soil testing historical data which provides general crop data. The major crops like wheat, rice, bajra, maize and jowar and minor crops like pulses, gram, jute, cotton, groundnut, barley, ragi, mustard, sugarcane, sesame, and sunflower are considered in the model.

The important features of the dataset are of soil type Sandy, Silt, Clay and Loamy Soil, pH value of the Soil is a measure of the acidity and alkalinity in soils, NPK content of the soil which is nitrogen, phosphorus and potassium are the three nutrients used by plants, Permeability of the soil is the property to transmit water and air, the water content in the soil, average rainfall, temperature and previously harvested crop. All these parameters are really important to determine the best crop for current weather, market demand and availability of market infrastructure, expected profit and risk.

4.3 Data Transformation:

The data also had several inconsistencies since it was obtained from several different sources such as:

1. Missing Values The missing values had to be removed from the dataset since they would lead to data inconsistencies and eventually to the wrong prediction.
2. Spelling Aberrations The spellings were not consistent throughout the files and had to be normalized to a single value to improve the model accuracy.
3. Redundant Data The redundant data had to be discarded since they would not add any additional significance to the process. The data was eventually coalesced into one dataset to ease the process of model building and computation.

Once, the data was collected the data types were checked and changes were made such as changing from String -> Integer where required. Also, since a machine learning model works only with numbers, the string values need to be converted into numerical values. For this, we made use of Label Encoder Technique. "Label Encoder is a tool provided by Scikit Learn which helps one to encode the categorical features/variables into their numeric features. The encoder targets variables between 0 to n_classes-1 where n is the number of distinct labels.

- **Scikit-Learn**

  Scikit-learn is an ML library for python. It has various algorithms for classification and regression like logistic regression, random forest classifiers and support vector machines. We can operate it along with other python libraries like NumPy and pandas. Scikit-learn is one of the best libraries especially for supervised learning which involves training the model by loading a sample dataset which it can observe and structure its learning accordingly. It also gives us the provision to use train_test_split for making training and testing datasets.

- **Train_test_split Library**

  We import train_test_split from scikit-learn to split our dataset into two different sets according to our needs- one for training the model and the other for testing the working and accuracy of the trained model so that we can choose the best possible algorithm. We apply different supervised learning algorithms on the training data and obtain results on testing data for all the applied algorithms. Then the best performing algorithm is selected for the model.

	N	P	K	temperature	humidity	ph	rainfall
count	2200.000000	2200.000000	2200.000000	2200.000000	2200.000000	2200.000000	2200.000000
mean	50.691818	53.359545	48.158182	25.616244	71.481779	6.469480	103.463655
std	37.125251	32.742540	50.652123	5.063749	22.263812	0.773938	54.958389
min	0.000000	5.000000	5.000000	8.825675	14.258040	3.504752	20.211267
25%	21.000000	28.000000	21.000000	22.769375	60.261953	5.971693	64.551686
50%	37.000000	51.000000	31.000000	25.598693	80.473146	6.425045	94.867624
75%	85.000000	69.000000	49.000000	28.561654	89.948771	6.923643	124.267508
max	139.000000	145.000000	205.000000	43.675493	99.981876	9.935091	298.560117

Table 4.1

4.4 Model Building

The model used here is: Ensemble Learning Model. “Ensemble Learning approach uses multiple learning algorithms in statistics and machine learning to achieve greater predictive efficiency than either of the constituent learning algorithms alone might obtain.” As seen in the code snippet the model was built using algorithms listed below:

• Random Forest Algorithm

• Gaussian Naive Bayes Algorithm

• Decision Tree Algorithm

• Support Vector Machine Algorithm

• Logistic Regression Algorithm

• XGBoost Algorithm

4.4.1 Random Forest Algorithm:

Random forest algorithm is one of the most famous and a widely used supervised learning technique. It contains a number of decision trees for different subsets of the data instead of working on the whole data as a single subset. This improves the accuracy of prediction of the model by several folds as it takes the average of predictions of all the trees and decides the final output on the basis of majority votes of the predictions. This makes it suitable even for the large and varied datasets as it can deliver results with high accuracy in very less amount of time.

Random Forest Accuracy is: 0.990909090909091

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13
banana	1.00	1.00	1.00	17
blackgram	0.94	1.00	0.97	16
chickpea	1.00	1.00	1.00	21
coconut	1.00	1.00	1.00	21
coffee	1.00	1.00	1.00	22
cotton	1.00	1.00	1.00	20
grapes	1.00	1.00	1.00	18
jute	0.90	1.00	0.95	28
kidneybeans	1.00	1.00	1.00	14
lentil	1.00	1.00	1.00	23
maize	1.00	1.00	1.00	21
mango	1.00	1.00	1.00	26
mothbeans	1.00	0.95	0.97	19
mungbean	1.00	1.00	1.00	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	1.00	1.00	19
pigeonpeas	1.00	1.00	1.00	18
pomegranate	1.00	1.00	1.00	17
rice	1.00	0.81	0.90	16
watermelon	1.00	1.00	1.00	15
accuracy			0.99	440
macro avg	0.99	0.99	0.99	440
weighted avg	0.99	0.99	0.99	440

Table 4.4.1

4.4.2 Gaussian Naive Bayes Algorithm

Naive Bayes are a group of supervised machine learning classification algorithms based on the Bayes theorem. It is a simple classification technique, but has high functionality. They find use when the dimensionality of the inputs is high. Complex classification problems can also be implemented by using Naive Bayes Classifier.

Naive Bayes's Accuracy is: 0.990909090909091

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13
banana	1.00	1.00	1.00	17
blackgram	1.00	1.00	1.00	16
chickpea	1.00	1.00	1.00	21
coconut	1.00	1.00	1.00	21
coffee	1.00	1.00	1.00	22
cotton	1.00	1.00	1.00	20
grapes	1.00	1.00	1.00	18
jute	0.88	1.00	0.93	28
kidneybeans	1.00	1.00	1.00	14
lentil	1.00	1.00	1.00	23
maize	1.00	1.00	1.00	21
mango	1.00	1.00	1.00	26
mothbeans	1.00	1.00	1.00	19
mungbean	1.00	1.00	1.00	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	1.00	1.00	19
pigeonpeas	1.00	1.00	1.00	18
pomegranate	1.00	1.00	1.00	17
rice	1.00	0.75	0.86	16
watermelon	1.00	1.00	1.00	15
accuracy			0.99	440
macro avg	0.99	0.99	0.99	440
weighted avg	0.99	0.99	0.99	440

Table 4.4.2

4.4.3 Decision Tree Algorithm

It is a tool that has applications spanning several different areas. Decision trees can be used for classification as well as regression problems. The name itself suggests that it uses a flowchart like a tree structure to show the predictions that result from a series of feature-based splits. It starts with a root node and ends with a decision made by leaves.

Decision Trees Accuracy is: 90.0

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13
banana	1.00	1.00	1.00	17
blackgram	0.59	1.00	0.74	16
chickpea	1.00	1.00	1.00	21
coconut	0.91	1.00	0.95	21
coffee	1.00	1.00	1.00	22
cotton	1.00	1.00	1.00	20
grapes	1.00	1.00	1.00	18
jute	0.74	0.93	0.83	28
kidneybeans	0.00	0.00	0.00	14
lentil	0.68	1.00	0.81	23
maize	1.00	1.00	1.00	21
mango	1.00	1.00	1.00	26
mothbeans	0.00	0.00	0.00	19
mungbean	1.00	1.00	1.00	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	0.84	0.91	19
pigeonpeas	0.62	1.00	0.77	18
pomegranate	1.00	1.00	1.00	17
rice	1.00	0.62	0.77	16
watermelon	1.00	1.00	1.00	15
accuracy			0.90	440
macro avg	0.84	0.88	0.85	440
weighted avg	0.86	0.90	0.87	440

Table 4.4.3

4.4.4 Support Vector Machine Algorithm

Support Vector Machines or SVM consists of a group of algorithms that analyze data for regression and classification. It represents different classes in a single plane iteratively to minimize the error and is also memory efficient. This makes it one of the best algorithms to use if the error persists in basic linear regression. But in case of noisy datasets and large datasets, its performance dips because of chances of overlapping of classes.

SVM's Accuracy is: 0.9795454545454545

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13
banana	1.00	1.00	1.00	17
blackgram	1.00	1.00	1.00	16
chickpea	1.00	1.00	1.00	21
coconut	1.00	1.00	1.00	21
coffee	1.00	0.95	0.98	22
cotton	0.95	1.00	0.98	20
grapes	1.00	1.00	1.00	18
jute	0.83	0.89	0.86	28
kidneybeans	1.00	1.00	1.00	14
lentil	1.00	1.00	1.00	23
maize	1.00	0.95	0.98	21
mango	1.00	1.00	1.00	26
mothbeans	1.00	1.00	1.00	19
mungbean	1.00	1.00	1.00	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	1.00	1.00	19
pigeonpeas	1.00	1.00	1.00	18
pomegranate	1.00	1.00	1.00	17
rice	0.80	0.75	0.77	16
watermelon	1.00	1.00	1.00	15
accuracy			0.98	440
macro avg	0.98	0.98	0.98	440
weighted avg	0.98	0.98	0.98	440

Table 4.4.4

4.4.5 Logistic Regression Algorithm

Logistic regression is a basic linear model that uses a logistic function for model creation. It categorizes the data into discrete classes by figuring out the relationship trends from the given dataset. It is easy to implement and very efficient to train and can classify unknown data records considerably quickly. But it by default assumes a linear relation between dependent and independent variables which can turn out to be a limitation in the performance of the model in some cases.

Logistic Regression's Accuracy is: 0.9522727272727273

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13
banana	1.00	1.00	1.00	17
blackgram	0.86	0.75	0.80	16
chickpea	1.00	1.00	1.00	21
coconut	1.00	1.00	1.00	21
coffee	1.00	1.00	1.00	22
cotton	0.86	0.90	0.88	20
grapes	1.00	1.00	1.00	18
jute	0.84	0.93	0.88	28
kidneybeans	1.00	1.00	1.00	14
lentil	0.88	1.00	0.94	23
maize	0.90	0.86	0.88	21
mango	0.96	1.00	0.98	26
mothbeans	0.84	0.84	0.84	19
mungbean	1.00	0.96	0.98	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	0.95	0.97	19
pigeonpeas	1.00	1.00	1.00	18
pomegranate	1.00	1.00	1.00	17
rice	0.85	0.69	0.76	16
watermelon	1.00	1.00	1.00	15
accuracy			0.95	440
macro avg	0.95	0.95	0.95	440
weighted avg	0.95	0.95	0.95	440

Table 4.4.5

4.4.6 XGBoost Algorithm

XGBoost is an ensemble learning method. Sometimes, it may not be sufficient to rely upon the results of just one machine learning model. Ensemble learning offers a systematic solution to combine the predictive power of multiple learners. The resultant is a single model which gives the aggregated output from several models.

XGBoost's Accuracy is: 0.9886363636363636

	precision	recall	f1-score	support
apple	1.00	1.00	1.00	13
banana	1.00	1.00	1.00	17
blackgram	1.00	1.00	1.00	16
chickpea	1.00	1.00	1.00	21
coconut	1.00	1.00	1.00	21
coffee	1.00	0.95	0.98	22
cotton	1.00	1.00	1.00	20
grapes	1.00	1.00	1.00	18
jute	0.96	0.86	0.91	28
kidneybeans	1.00	1.00	1.00	14
lentil	1.00	1.00	1.00	23
maize	0.95	1.00	0.98	21
mango	1.00	1.00	1.00	26
mothbeans	1.00	1.00	1.00	19
mungbean	1.00	1.00	1.00	24
muskmelon	1.00	1.00	1.00	23
orange	1.00	1.00	1.00	29
papaya	1.00	1.00	1.00	19
pigeonpeas	1.00	1.00	1.00	18
pomegranate	1.00	1.00	1.00	17
rice	0.84	1.00	0.91	16
watermelon	1.00	1.00	1.00	15
accuracy			0.99	440
macro avg	0.99	0.99	0.99	440
weighted avg	0.99	0.99	0.99	440

Table 4.4.6

We observed that most accurate accuracy is from Random Forest Algorithm so we implement predication using **Random Forest** Approach.

Deployment of the model

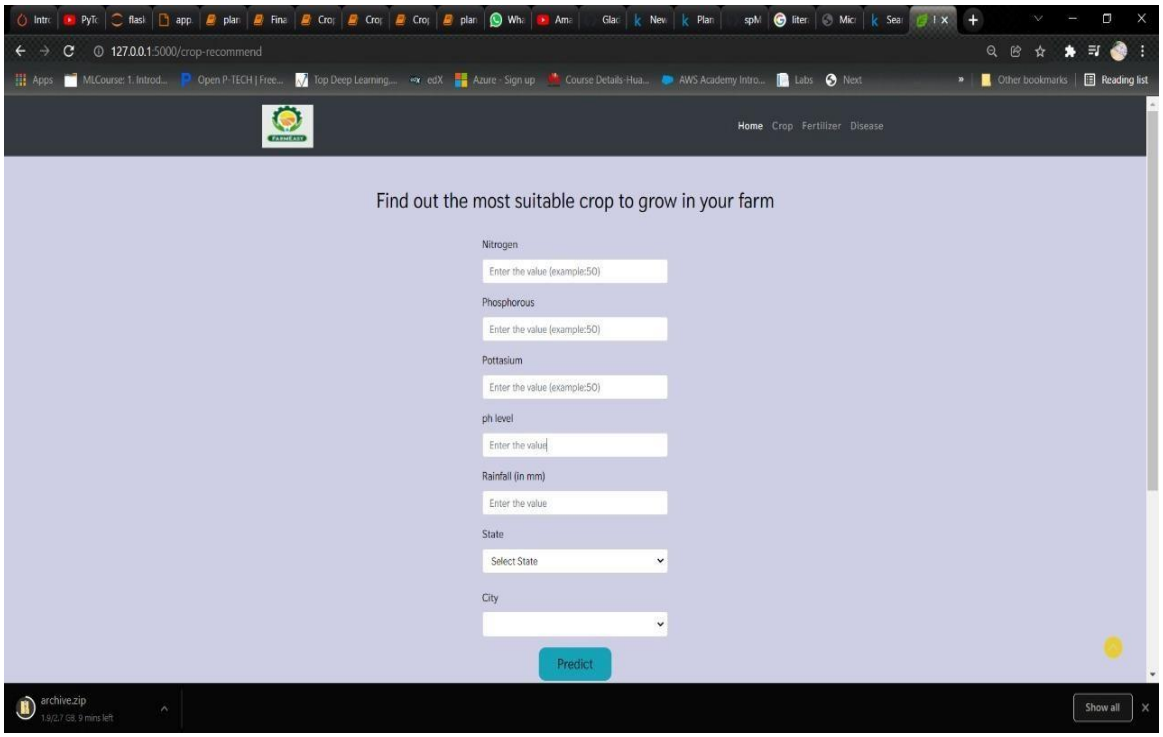
In order to deploy the trained model for the farmers to use off, we would need an application with a simple user interface which the farmers can utilise. Thus, here I made a simple web interface using HTML, CSS & Bootstrap.The next step was to have a create model by using machine learning and deep learning technologies. Lastly, I wanted to predict the results for the obtained values from the user for which I made use of Flask framework to integrate the front end. Also, we generated the pickle file for our model to generate the predictions for the input data. Okay, so you would be wondering what is a pickle file?“The pickle module implements binary protocols for serialising and de-serialising a Python object structure. “Pickling” is the process whereby a Python object hierarchy is converted into a byte stream, and “unpickling” is the inverse operation, whereby a byte stream (from a binary file or bytes-like object) is converted back into an object hierarchy.” In simple words, the pickled file converts the trained model into a byte stream and is sent to the website where it is unpickled again where it is used to train the incoming data from the farmers.

➢ Data fields

• N - ratio of Nitrogen content in soil
• P - ratio of Phosphorous content in soil
• K - ratio of Potassium content in soil
• temperature - temperature in degree Celsius
• humidity - relative humidity in %
• ph - value of the soil
• rainfall - rainfall in mm

- **Crop Recommendation:**

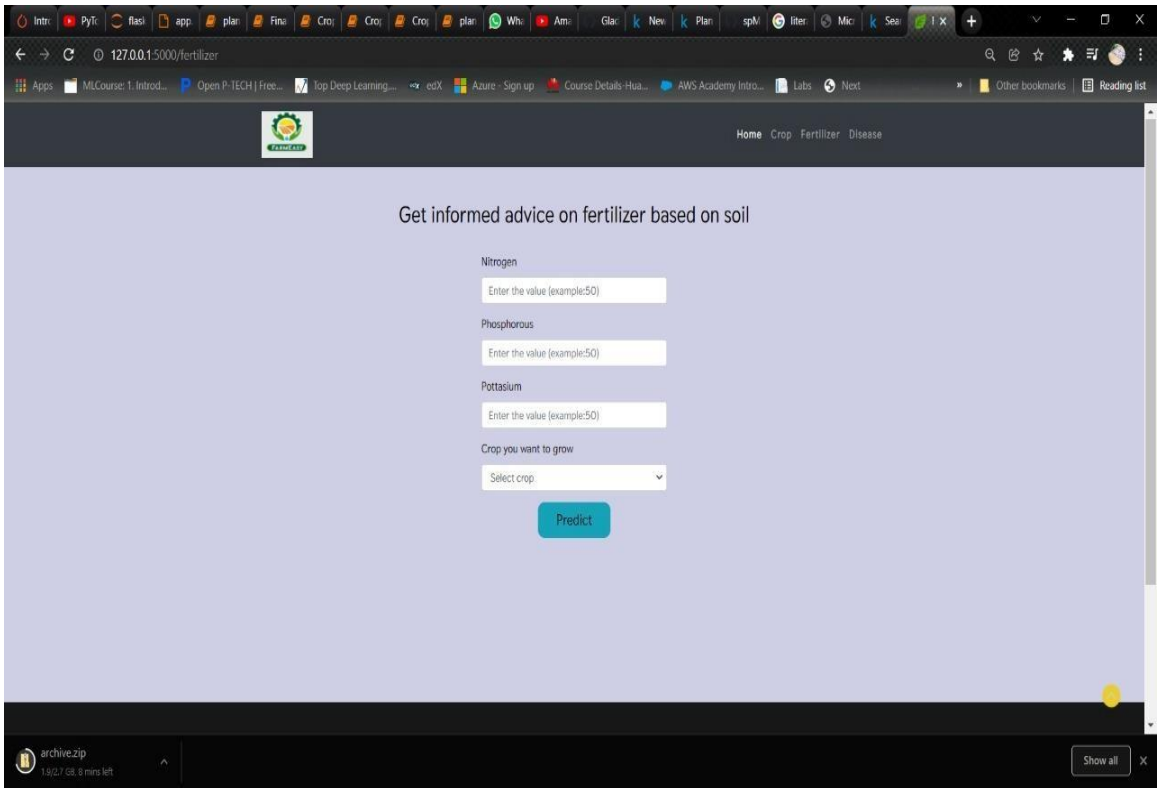
The Module is built keeping in mind the minimal soil nutrients requirements and Soil type that are necessary for growing a particular crop and helping farmers to maximize their yield and good utilization of the agricultural field. Enter the corresponding nutrient values of your soil, state and city. Note that, the N-P-K (NitrogenPhosphorous-Pottasium) values to be entered should be the ratio between them.



Crop Recommendation Web Design

- **Fertilizer Recommendation:**

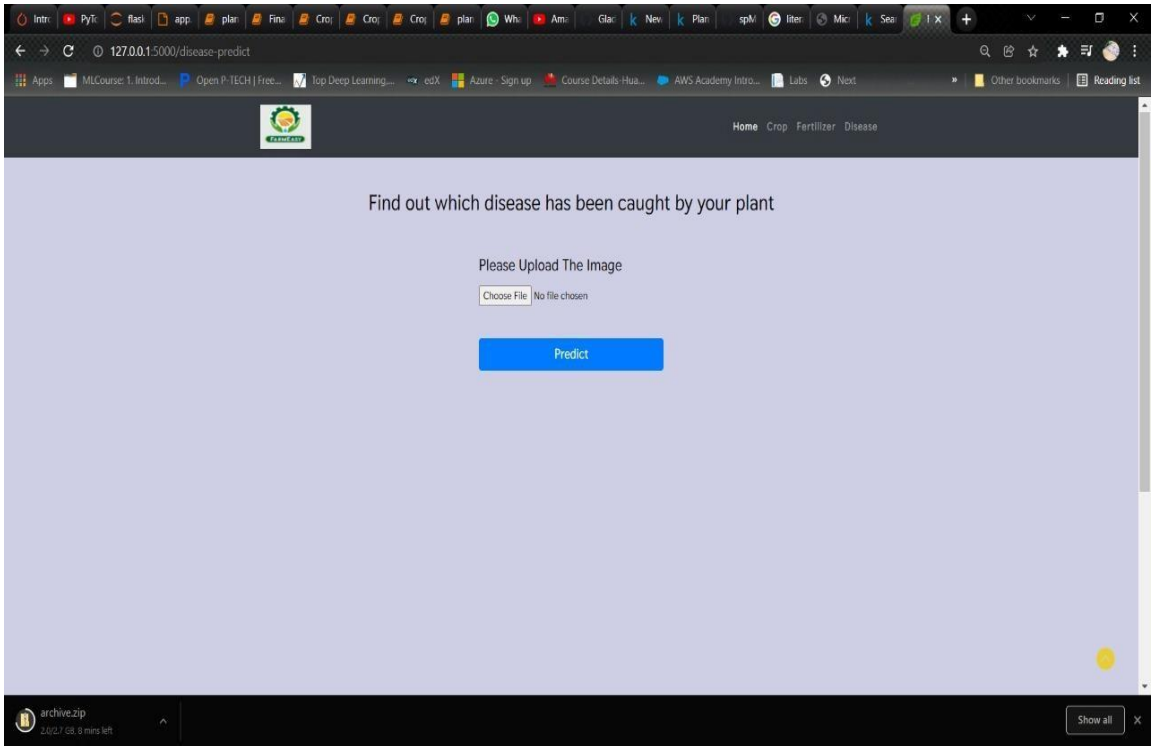
The Module is the user can input the soil data and Enter the nutrient contents of your soil and the crop you want to grow. The algorithm will tell which nutrient the soil has excess of or lacks. Accordingly, it will give suggestions for buying fertilizers, that are necessary for growing a particular crop and helping farmers to maximize their yield and good utilization of the agricultural field.



Fertilizer Recommendation Web Design

- **Disease Detection System:**

  Upload an image of leaf of your plant. The algorithm will tell the crop type and whether it is diseased or healthy. If it is diseased, it will tell you the cause of the disease and suggest you how to prevent/cure the disease accordingly. Note that, for now it only supports following crops.



Crop Disease Detection Web Design

4. CONCLUSION & FUTURE WORK:

The core strategy of this project is to predict the crop based on the soil nutrient content and the location where the crop is growing. This system will help he farmers to choose the right crop for their land and to give the suitable amount of fertilizer to produce the maximum yield. The Random Forest algorithm helps to predict the crop the precisely based on the pre-processed crop data. This system will also help the new comers to choose the crop which will grow in their area and produce them a good profit. A decent amount of profit will attract more people towards the agriculture. The system uses supervised Machine learning algorithms like Logestic Regression, Support Vector Machine, Random Forest Classifier and gives best result based on error analysis. The results of these algorithms will be compared and the best among them i.e., Random Forest Classifier which gives the best and accurate output is chosen. Therefore, We observed that most accurate accuracy is from Random Forest Algorithm so we implement predication using **Random Forest** Approach this system will help reduce the struggle faced by the farmers. Analysis of the important soil properties and based on that we are dealing with the Grading of the Soil and Prediction of Crops suitable to the land. This will act as simple solution to equip the farmers with necessary information required to obtain great yield and therefore maximizing their surplus and therefore will reduce his difficulties.

As a future work, the method can be extended to include diverse varieties of crops to be cultivated and to analyze its performance.

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ACKNOWLEDGEMENT

We would like to place on record my / our deep sense of gratitude to Prof. S. B. Kalyankar, HOD-Dept. of Computer Science and Engineering, Deogiri Institute of Engineering and management Studies Aurangabad, for his generous guidance, help and useful suggestions.

I/We express my / our sincere gratitude to Prof. Manisha Munde, Dept. of Computer Science and Engineering, Deogiri Institute of Engineering and management Studies Aurangabad, for his stimulating guidance, continuous encouragement and supervision throughout the course of present work.

I / We am / are extremely thankful to Dr. Ulhas Shiurkar, Director, Deogiri Institute of Engineering, and management Studies Aurangabad, for providing me infrastructural facilities to work in, without which this work would not have been possible.

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