A



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report on

**ADVANCED CROP PRICE PREDICTION USING MACHINE LEARNING**

*Submitted to Jawaharlal Nehru Technological University for the partial Fulfilment of the requirement for the Award of Degree in*

**BACHELOR OF TECHNOLOGY**

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**CERTIFICATE**

This is to certify that the Major Project Report entitled **“ADVANCED CROP PRICE PREDICTION USING MACHINE LEARNING”** is being submitted by **K. SRI CHANDANA (19271A05D3), Y. HARSHAVARDHAN REDDY (19271A05F0),V.SAHANA(19271A05E9), B.HEMANTH KUMAR (18275A0505)** in partial fulfilment of the requirements for the award of the Degree of **Bachelor of Technology** in **Computer Science & Engineering** to the **JYOTHISHMATHI INSTITUTE OF TECHNOLOGY & SCIENCE,** Karimnagar, during academic year 2022-2023, is a bonafide work carried out by them under my guidance and supervision.

The results presented in this project work have been verified and are found to be satisfactory. The results embodied in this work have not been submitted to any other University for the award of any other degree.

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**DECLARATION**

We hear by declare that the work which is being presented in this dissertation entitled, **“ADVANCED CROP PRICE PREDICTION USING MACHINE LEARNING”,** submitted towards the partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science & Engineering, JYOTHISHMATHI INSTITUTE OF TECHNOLOGY & SCIENCE,** Karimnagar is an authentic record of our own work carried out under the supervision of **Dr. V. Neelima, Associate Professor , Department of CSE , JYOTHISHMATHI INSTITUTE OF TECHNOLOGY & SCIENCE ,** Karimnagar.

To the best of our knowledge and belief, this project work bears no resemblance with any report submitted to JNTUH or any other University for the award of any degree.

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# ADVANCED CROP PRICE PREDICTION USING MACHINE LEARNING

# ABSTRACT

Agriculture is the primary dependence of the economy in our country. In recent times because of uncertain trends in climate and other oscillations in the price trends, the price of the crop has varied to a larger position. Farmers remain unconscious of these misgivings, which spoils the crops and causes massive loss. They are ignorant of the crop type which would benefit them most. Due to their limited knowledge of different crop conditions and their specific remedies, crops get damaged. So, Our project is designed to help the farmers. This system is hand easy to use. Project = AI + Crop + Fertilizer + Pesticide + Price, taking care of soil’s health. Our Project honors the Indian farmer’s love, hard work and character. Farmers help to feed a nation whose population is nearly 1.4 billion, still the productivity of ranches is floated by various natural factors that ruin the crops and farmer’s livelihood. wash small action enhancing husbandry, making smart opinions to consider the demographics of the field, the factors affecting the crop, as well as how to keep the estate healthy for a super miraculous yield. The algorithms reviewed in this project are SVM, Random forest, KNN, Naive bayes, Decision Tree Regression. This will be executed in the form of a website furnishing features of Crop Recommendation, Fertilizer Recommendation Pesticide Recommendation and Price prediction on point specific parameters.

INDEX TERMS: Agriculture, crop recommendation, Pesticide, Fertilizer, Price

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# LIST OF ABBREVIATIONS

### ABBREVIATION DESCRIPTION

### N Nitrogen

### P Phosphorus

### K Pottassium

CNN Convolutional Neural Network

SVM Support Vector Machine

KNN K Nearest Neighbor

DTL Deep Transfer Learning

ANN Artificial Neural Network

LR Logistic Regression

PH Potential of Hydrogen

# CHAPTER 1

# INTRODUCTION

# 1.1 INTRODUCTION

India is one of the biggest directors of agrarian products and still has veritably lower ranch productivity. Productivity needs to be increased so that growers can get further pay from the same piece of land with lower labour. Precision husbandry provides a way to do it. Precision husbandry, as the name implies, refers to the applying of precise and proper aggregate of comment like pee, diseases, soil etc. at the proper time to the craw for adding its productivity and adding its yields. Not all perfection husbandry systems offer stylish results. But in husbandry it is important that the recommendations made are accurate and precise because in case of crimes it may lead to heavy material and capital loss [1].

In India, perfection husbandry isn't important estimated. Now a day we set up that every day the terrain is changing continuously which is dangerous to the crops and leading growers towards debt and self-murder. In numerous cases like this and with growing population to maximize yield growers are using further fungicides and diseases which are leading to the soil gravidity as well as dwindling the holding capacity of soil and adding toxin of soil. tilling land is used by growing industrialization, so again adding rate of the soil pollution which affects the quality of shops. Colorful operations of perfection husbandry are vaticination of conditions, vaticination of rainfall soothsaying, bracket of soil, covering crop, yield vaticination, automatic irrigation system, etc [2].

we present a recommendation system named as RSF for farmers, which can recommend farmers most suitable crops to produce in different areas. The system first detects a user’s position and works with different agro- ecological and agro- climatic data in up a zila position to calculate similarity between upazilas using pearsonco- relation similarity algorithm. Then it selects top- n similar upazilas. ultimately, exercising the seasonal information and crop product rates of each crop of the similar upazilas, it recommends top- k crops to a user of a upazila. The system has been estimated with real data and we have set up a reasonable and satisfactory delicacy. The system can help farmers in producing applicable crops. As a result, they can increase their life and can contribute further to the society. We handed the system layout both in Bangla and English so that the farmers as well as the people who works with farmers can get help easily from this [3].

India is a country where husbandry and husbandry related diligence are the major source of living for the people. Agriculture is a major source of frugality of the country. It's also one of the country which suffer from major natural disasters like failure or flood tide which damages the crop. This leads to huge fiscal loss for the growers therefore leading to the self-murder. Predicting the crop yield well in advance previous to its crop can help the growers and Government associations to make applicable planning like storing, dealing, fixing minimal support price, importing/ exporting etc. Predicting a crop well in advance requires a methodical study of huge data coming from various variables like soil quality, pH, EC, N, P, K etc. As vaticination of crop deals with large set of database therefore making this vaticination system a perfect seeker for operation of data mining. Through data mining we prize the knowledge from the huge size of data. This paper presents the study about the various data mining ways used for prognosticating the crop yield. The success of any crop yield vaticination system heavily relies on how directly the features have been uprooted and how meetly classifiers have been employed. This paper summarizes the results attained by colorful algorithms which are being used by colorful authors for crop yield vaticination, with their delicacy and recommendation [4].

Agriculture is the most important sector that influences the frugality of India. It contributes to 18 of India's Gross Domestic Product (GDP) and gives employment to 50 of the population of India. People of India are rehearsing Agriculture for times but the results are no way satisfying due to colorful factors that affect the crop yield. To fulfill the requirements of around1.2 billion people, it's veritably important to have a good yield of crops. Due to factors like soil type, rush, seed quality, lack of specialized installations etc the crop yield is directly told. Hence, new technologies are necessary for satisfying the growing need and growers must work dashingly by concluding new technologies rather than going for trivial styles. This paper focuses on enforcing crop yield vaticination system by using Data Mining ways by doing analysis on husbandry dataset. Different classifiers are used videlicet J48, LWL, LAD Tree and IBK for vaticination and also the performance of each is compared using WEKA tool. For assessing performance delicacy is used as one of the factors. The classifiers are farther compared with the values of Root Mean Squared Error (RMSE), Mean Absolute Error (MAE) and Relative Absolute Error (RAE). lower the value of error, more accurate the algorithm will work. The result is grounded on comparison among the classifiers [5].

**1.2 MOTIVATION**

Agriculture is the primary dependence of the economy in our country. In recent times because of uncertain trends in climate and other oscillations in the price trends, the price of the crop has varied to a larger position. Farmers remain unconscious of these misgivings, which spoils the crops and causes massive loss. They are ignorant of the crop type which would benefit them most. Due to their limited knowledge of different crop conditions and their specific remedies, crops get damaged. So, Our project is designed to help the farmers. This system is hand easy to use. Project = AI + Crop + Fertilizer + Pesticide + Price, taking care of soil’s health. Our Project honors the Indian farmer’s love, hard work and character.

**1.3 ORGANIZATION OF DOCUMENT**

**CHAPTER 1: INTRODUCTION**

This chapter deals with the goals and inspiration for our project work and also gives summary of our work and research. It identifies the issue of the project that is meant to solve and the goals to be met. This will be a map for the reader which provides a brief description of structure. Here brief discussion is given about our system. Proposed system is introduced which is important for our work.

**CHAPTER 2: LITERATURE SURVEY AND PROBLEM IDENTIFICATION**

In this chapter in order to collect essential data and requirements for the project, a thorough literature review is depicted. It examines recent findings, investigations, and practical answers. The software requirement specification is also provided, including the hardware, software and domain specifications needed for the project.

**CHAPTER 3: LITERATURE SURVEY**

In this chapter all the literature survey needed for our project is gathered and provided the detail information about each and every research paper we used as reference in our project.

**CHAPTER 4: METHODOLOGY AND DESIGN ANALYSIS**

In this chapter, the project's methodology is explained. It provides an overview of the architecture of the suggested system as well as an introduction to the project's methodology. Random Forest, KNN, support vector machine (SVM), Naïve bayes algorithms the project presented. It includes the system design as well as UML diagrams like use case diagram, class 3 diagram, sequence diagram, activity diagram, and data flow diagram. An overview of the methodology and design analysis is provided at the end of the chapter.

**CHAPTER 5: IMPLEMENTATION**

An introduction to the project's implementation phase opens this chapter. The implementation's key components are thoroughly described in detail. The methods used for implementation are discussed, giving details about how the development process was carried out. The source code is provided together with the code implementation. Testing approaches, such as testing levels and specifics of test cases, suites, scripts, and scenarios are discussed. To assess the system's performance and functionality, test cases are offered.

**CHAPTER 6: RESULT ANALYSIS**

The analysis of the outcomes is the primary focus of this chapter. It provides a thorough analysis and explanation of the project's results, evaluating the system's effectiveness, accuracy, and efficiency.

**CHAPTER 7: CONCLUSION**

A summary of the project's findings and results finishes the document in its final chapter. On the accomplishment of the project's goals, it offers a final response. It highlights prospects for expanding the functionality and enhancing the system in the future by discussing prospective areas for future growth and expansion.

**1. 4 PROBLEM STATEMENT**

Our project aims to help Indian farmers and reduce their hardship. The problems faced by Indian farmers are defined as follows:

Productivity needs to be increased so that farmers can get more pay from the same piece of land without degrading soil.

Indian farmers aren’t able to choose the right crop based on their soil requirements depending upon factors like N, P, K, temperature, humidity, rainfall, PH.

Farmers are generally unaware about the organic fertilizers or standard fertilizers to use as per soil requirements.

Due to inadequate and imbalanced fertilization, soil degradation is occurring, which leads to nutrient mining and the development of second-generation problems in nutrient management.

According to a study by the Associated Chambers of Commerce and Industry of India, annual crop losses due to pests amount to Rs. 50,000 crore.

## 1.5 OBJECTIVE OF THE PROJECT

Corresponding to problems cited above, following are objectives that “Our project” is trying to solve:

The right crop based on their site specific parameters to reduce the wrong choice on a crop and increase in productivity).

To solve the problem by proposing a recommendation system through an ensemble model with majority voting technique crop for the site specific parameters with high accuracy and efficiency.

To recommend organic fertilizer on the basis of N, P, K values and crop.

To recognize the pest and recommend particular pesticide available in India as per ISO standards (ISO 9001, ISO 14001, ISO 17025).

To implement precision agriculture (A modern farming technique that uses research data of soil characteristics, soil types, crop yield data collection and suggests the farmers

To design a web application for achieving above objectives.

**1.6 EXISTING MODEL**

There is no platform where farmers can find all the functionalities like crop recommendation, fertilizer recommendation, pesticide recommendation and price prediction. There are individual platform with less functionalities. The accuracy of the results is very low. Attributes used for crop recommendation are less so that accuracy may differ. Pesticide recommendation is done by taking disease name as input from the user that means user has to know what disease is effected their crop.

Fertilizer recommendation is given just to say whether your soil is suitable or not, but doesn’t give any suggestions. Price prediction is not known to farmers, they just randomly guess the future price with previous year data. It may be inaccurate.

**1.7 PROPOSED MODEL**

In order to provide advantages to underprivileged farmers, our initiative strives to efficiently handle the problem of crop price forecasting. It makes use of machine learning techniques to produce better solutions from various data. With the help of trained data from approved datasets, this system employs decision tree regression techniques to forecast crop values. This program can enhance productivity. Recognising and foreseeing Under varied environmental settings, cropper induces acne. An efficient crop price forecasting system can offer clients options that can satisfy customers in a variety of situations. Ultimately, the outcomes are presented in the form of a web application so that struggling farmers can quickly access them.

In this project we used the SVM, KNN, Naive Bayes, Random Forest, Decision Tree regression algorithm.

Support vector machines (SVM) is set of supervised learning strategies used for classification, regression and outlier’s discovery. it's a classification technique. Here, we have a tendency to plot every information item as some extent in n-dimensional house (where n is variety of options you have) with the worth of every feature being the worth of a selected coordinate. it's a classification technique. during this algorithmic rule, we have a tendency to plot every information item as some extent in n-dimensional house (where n is variety of options you have) with the worth of every feature being the worth of a selected coordinate. A Support Vector Machine (SVM) is discriminative classifier correctly bounded by a separating hyperplane. In alternative words, given labeled coaching information (supervised learning), the algorithmic rule outputs associate degree best hyperplane that categorizes new examples. Support vector simple machine (SVM) may be a set of supervised learning strategies used for classification, regression and outlier’s uncovering.

It's a classification technique supported Bayes’ theorem with associate degree assumption of independence between predictors. In straightforward terms, a Naive Thomas Bayes categoryifier assumes that the presence of a specific feature in an exceedingly class is dissimilar to the presence of the other feature. as an example, a fruit could also be thought of to be associate degree apple if it's red, round, and concerning a pair of inches in diameter. Even if these features depend on each other or upon the existence of the other features, a naive Bayes classifier would consider all of these properties to independently contribute to the probability that this fruit is an apple. These Learners predict the class label for each of the training data set. The class label that is predicted by the majority of the models is voted through the majority voting technique and the class label of the training data set is decided. From the ensembled models the rules are generated.

Random forests square measure associate ensemble learning methodology for classification, regression and different tasks, that operate by building a mess of call trees at coaching time and outputting the category that's the mode of the categories or mean prediction of the individual trees. Random call forests correct for call tree custom of over fitting to their coaching set. Though random forests are naturally designed to figure solely with third-dimensional information, it's been shown that one may use them for random objects with the employment of solely pairwise similarities between objects. Random Forest could be a trademark term for associate ensemble of call trees. Random Forest is assortment of call trees (so called Forest). To classify a replacement object supported attributes, every tree offers a categorifications and that we say the tree votes for that class.

Decision Tree regression : This supervised learning technique uses trees to make decisions. Unlike other supervised learning algorithms, the decision tree method can be utilized to address regression and classification problems. A decision tree can be used to create a training model that can be used to forecast the class or value of the target variable by learning fundamental choice rules inferred from prior data (training data). In Decision Trees, we anticipate the class label for the record by starting at the top of the tree and working our way down. The cost of the initial attribute and the value of the attribute in the record are contrasted. We collaborated to find answers to the attribute selection issue. And advised employing criteria such as: Entropy, Gaining Information, Gini Index, Gain Ratio, Chi-Square. Each characteristic's worth will be determined using these criteria. The features are organized in a tree with the most significant feature at the top (in the case of information gain) and the values are sorted. We look at hierarchical qualities when using information gain as a criterion, and we look at continuous characteristics when using the Gini index. We utilized Decision Tree Regression because the dataset’s data is continuous. Prices for crops change throughout time since they are seasonal.

**CHAPTER 2**

**LITERATURE SURVEY**

## LITERATURE SURVEY

Agriculture is a major source of livelihood in India and Indian farmers put in their heart and soul to feed people. Farmers generally deal with crops, fertilizers, pests and pesticides. Hence, Our project aims to serve Indian farmers via all three modules of Crop Recommendation, Fertilizer Recommendation and Pesticide Recommendation. Crop recommendation has been an area which is explored a lot, but all of the systems vary on the basis of parameters that are fed into the ML model. Most of the ML models use Random Forest, some use Decision Tree, while others use Ensemble methods via Majority Voting Mechanism. Fertilizer Recommendation doesn't work much in the area of AI. Main reason can be disintegrated data, but Our project collected all of the data from various sources and integrated it to have a well formed dataset. A dictionary based solution is implemented in Our project. Thirdly, Pesticide Recommendation is not at all touched area, researchers have just restricted it to Pest Detection only, but Our project extends the idea of identification of pest, along with a dictionary based solution for the corresponding pesticide, available in India. Our project uses ISO 9001, ISO 14001 and ISO 17025 standards for pesticide recommendation. Most of the pesticides are taken from biostadt site which is a really popular site for farmers but the problem is that search isn’t easy there and maximum pesticides recommended aren’t available in India. Following is discussed about various research papers pertaining to services offered by Our project.

**Rohit Kumar Rajak, Ankit Pawar, Mitalee Pendke , Pooja Shinde, Suresh Rathod, Avinash Devare, Crop Recommendation System to Maximize Crop Yield using Machine Learning Technique, International Research Journal of Engineering and Technology (IRJET), DEC-2017**

This talks about crop prediction using various learners like SVM used as a classifier, Naive Bayes, Multilayer perceptron (ANN) and lastly Random Forest. The parameters used for crop prediction are: pH, depth, water holding capacity, drainage, erosion.

The rule below demonstrates an example of the proposed recommendation system. IF ph is mild alkaline

AND depth is above 90

AND water holding capacity is LOW AND drainage is moderate

AND erosion is LOW THEN PADDY

**Deepti Dighe1, Harshada Joshi, Aishwarya Katkar, Sneha Patil, Prof. Shrikant Kokate, Survey of Crop Recommendation Systems,(IRJET), NOV 2018**

This isreviewed CHAID, KNN, K-means, Decision Tree, Neural Network, Naïve Bayes, C4.5, LAD, IBK and SVM algorithms and generated rules for recommendation system. Considering various factors like pH level of soil, month of cultivation, weather in the region, temperature, type of soil, etc. factors were considered to select maximum likely crops for plantation.

**Miftahul Jannat Mokarrama, Mohammad Shamsul Arefin , Department of CSE, CUET, Bangladesh ,RSF: A Recommendation System for Farmers, IEEE Region 10 Humanitarian Technology Conference (R10-HTC) ,21 - 23 Dec 2017,**

This discussed Location Detection, Data analysis and storage, Similar location detection and Recommendation generation module. Physiographic database, Thermal zone database, Crop growing period database, crop production rate database and seasonal crop database were used to get the final crop.

**Gandge, Yogesh, and Sandhya. “A study on various data mining techniques for crop yield prediction.” IEEE Xplore, 2017. IEEE Xplore.**

This talks about Attribute selection, Multiple Linear Regression, Decision Tree using ID3, SVM, Neural Networks, C4.5, K-means and KNN. The proposed system consists of firstly Selection of agricultural field then Selection of crop previously planted, it takes input from user, preprocesses it, then in backend there is attribute selection followed by classification algorithm on data and then crop is recommended.

**Mishra, Shruti, et al. Use of data mining in crop yield prediction. 2018. ResearchGate uses J48,** LAD Tree, LWL, IBK algorithm, firstly WEKA tool is used, LAD tree showed the lowest accuracy, though pruning the tree can minimize the errors, IBK gave good accuracy.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr.**  **No.** | **Name of Researcher, Year of Publication** | **Paper Title** | **Parameters Used/ Database Used** | **Methodology Adopted/ Modules Used** |
| 1 | Rajak et al. , 2017 | Crop Recommendation System to Maximize Crop Yield using Machine Learning Technique. | pH, depth, water holding capacity, drainage, erosion. | SVM used as a classifier, Naive Bayes, Multilayer perceptron (ANN) and Random Forest. |
| 2 | Dighe et al, 2018 | Crop Recommendation System for Precision Agriculture. | pH level of soil, month of cultivation, weather in the region, temperature, type of soil | CHAID, KNN, K-means,  Decision Tree, Neural Network, Naïve Bayes, C4.5, LAD, IBK and SVM |
| 3 | Mokarrama and Arefin, 2017 | RSF: A Recommendation System for Farmers. | Physiographic database, Thermal zone database, Crop growing period database, crop production rate database and seasonal crop database. | Location Detection, Data analysis and storage, Similar location detection and Recommendation generation. |
| 4 | Gandge and Sandhya, 2017 | A study on various data mining techniques for crop yield prediction. | Agricultural field, Crop previously planted. | Attribute selection,  Multiple Linear Regression, Decision Tree using ID3, SVM, Neural Networks, C4.5, K-means and KNN |
| 5 | Mishra et al. , 2018 | Use of data mining in crop yield prediction | Not mentioned | J48, LAD Tree, LWL, IBK  algorithm. |

Table 2.1.1: performs a compared study of all research papers for Crop Recommendation

**Wu, Xiaoping, et al. A Large-Scale Benchmark Dataset for Insect Pest Recognition. 2019.**

**IEEE Xplore**

This collects a large-scale dataset for insect pest identification called IP102, which contains over 75, 000 photographs of 102 insects. In comparison to previous datasets, the IP102 complies with a number of features of insect pest distribution in real-world settings . Meanwhile, they use the dataset to test certain cutting-edge recognition techniques. The findings show that existing handcrafted feature methods and deep feature methods are insufficient for pest identification.

**Kasinathan, Thenmozhi, et al. Insect classification and detection in field crops using modern machine learning techniques. 2020. Science Direct**

Using a machine learning and insect pest detection algorithm, various insect datasets were identified and detected, and the results were correlated. ANN, SVM, KNN, Naive Bayes, and the CNN model were used to test classification accuracy between different machine learning techniques. According to the findings, the CNN model has the best classification precision of 91.5 percent and 90 percent for 9 and 24 insect groups, respectively, from the Wang and Xie datasets.

**Ding, Weiguang, and Graham Taylor. Automatic moth detection from trap images for pest management. 2016. Science Direct**

This describes a tool for automatically tracking pests using photographs from traps. A sliding window-based detection pipeline is proposed, in which a convolutional neural network is applied to image patches at various locations to decrease the success of possessing a particular pest type. To generate the final detections, image patches are filtered using non-maximum suppression and thresholding based on their positions and related confidences.

**TÜRKOĞLU, Muammer, and Davut HANBAY. Plant disease and pest detection using deep learning-based features. 2018. Turkish Journal of Electrical Engineering & Computer Sciences**

For the identification of plant diseases and pests, the different effects are compared of deep feature extraction and transfer learning. Deep features for tunings layers of these deep models were extracted. The results of the obtained deep features were then determined using SVM, ELM, and KNN classifiers. Deep models were then fine-tuned using pictures of plant disease and pests. In comparison to conventional approaches, deep learning models achieved better outcomes, according to the evaluation results. The findings of deep feature extraction surpassed those of transfer learning.

**Selvaraj, Michael Gomez, et al. AI-powered banana diseases and pest detection. 2019.**

**Plant Methods**

Using a transfer learning approach, massive datasets of expert pre-screened banana disease and pest symptom/damage images were gathered and used to model three distinct convolutional neural network (CNN) architectures for detection. The DCNN proved to be a reliable and simple-to-implement technique for detecting digital banana disease and pests. Deep transfer learning (DTL) uses a pre-trained disease recognition algorithm to create a network that can make reliable predictions, and it was discovered that ResNet50 and InceptionV2 based models worked better than MobileNetV1 three distinct convolutional neural network (CNN) architectures for detection. The DCNN proved to be a reliable and simple-to-implement technique for detecting digital banana disease and pests. Deep transfer learning (DTL) uses a pre-trained disease recognition algorithm to create a network that can make reliable predictions, and it was discovered that ResNet50 and InceptionV2 based models worked better than MobileNetV1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr.**  **No.** | **Name of Researcher, Year of Publication** | **Paper Title** | **Parameters Used/ Database Used** | **Methodology Adopted/ Modules Used** |
| 6 | Wu et al., 2019 | A Large-Scale Benchmark Dataset for Insect Pest Recognition | Pest identification database IP102 | handcrafted feature methods and deep feature methods |
| 7 | Kasinathan et al., 2020 | Insect classification and detection in field crops using modern machine learning techniques | Different field crops | ANN, SVM, KNN,  Naive Bayes, and the CNN model |
| 8 | Ding and Taylor, 2016 | Automatic moth detection from trap images for pest management | commercial codling moth dataset | CNN |
| 9 | TÜRKOĞLU and HANBAY, 2018 | Plant disease and pest detection using deep learning-based features | Plant diseases and pest database | SVM, ELM, and  KNN classifiers |
| 10 | Selvaraj et al., 2019 | AI-powered banana diseases and pest detection | Datasets of expert pre-screened banana disease and pest | Distinct convolutional neural network, Deep transfer learning algorithm, ResNet50 model, InceptionV2 model and MobileNetV1 model |

Table 2.1.2: Comparative Study for Pest Detection

**CHAPTER 3**

**REQUIREMENTS AND DOMAIN INFORMATION**

**2.1 SOFTWARE SYSTEM REQUIREMENTS:**

**2.1.1 Hardware Requirements:**

* System : MINIMUM i3.
* Hard Disk : 40 GB.
* Ram : 4 GB.

**2.1.2 Software Requirements:**

* **Operating System:** Windows 8 or above
* **Languages**: Python 3.8, HTML, CSS

Following is the list of tools and technology used while making the “Our project”:

1. Numpy - working with arrays
2. Pandas - working with csv files
3. Flask - app routing, web application
4. Heroku - cloud deployment
5. Pickle - saving ML model
6. pymongo
   1. databases for Our project users
   2. databases for Our project feedback
7. neural networks (keras, tensorflow, CNN)
   1. for classification and training
8. ssl and passlib - for hashing of password for storage
9. PyCharm - python offline coding
10. OS - for manipulating files
11. matplotlib.pyplot
    1. plotting graphs for training and testing accuracy
    2. plotting graphs for training and testing loss
12. h5 - storing DL model
13. sklearn – classifier

**2.2 DOMAIN INFORMATION**

Python is a general-purpose interpreted, interactive, object-oriented, and highlevel programming language. It was created by Guido van Rossum during 1985- 1990. Like Perl,Python source code is also available under the GNU General Public License (GPL). This tutorial gives enough understanding on Python programming language.

**Python**

• Python is a high-level, interpreted, interactive and object-oriented scripting language. Python is designed to be highly readable. It uses English keywords frequently where as other languages use punctuation, and it has fewer syntactical constructions than other languages.

• Python is a MUST for students and working professionals to become a great Software Engineer specially when they are working in Web Development Domain.

I will list down some of the key advantages of learning Python:

• Python is Interpreted − Python is processed at runtime by the interpreter. 12 You do notneed to compile your program before executing it. This is similar to PERL and PH.

Python isInteractive − You can actually sit at a Python prompt and interact with the interpreter directly to write your programs.

• Python is Object-Oriented − Python supports Object-Oriented style or technique of programming that encapsulates code within objects. Python is a Beginner's Language − Python is a great language for the beginnerlevel programmers and supports the development of a wide range of applications from simple text processing to WWW browsers to games.

**Characteristics of Python:**

Following are important characteristics of python programming.

➢ It supports functional and structured programming methods as well as OOP.

➢ It can be used as a scripting language or can be compiled to byte-code for building large applications.

➢ It provides very high-level dynamic data types and supports dynamic type checking.It supports automatic garbage collection.

➢ It can be easily integrated with C, C++, COM, ActiveX, CORBA, and Java. Hello World using Python Just to give you a little excitement about Python, I'm going to give you a small conventional.

**Applications of Python:**

As mentioned before, Python is one of the most widely used language over the web. I'm going to list few of them here:

❖ Easy-to-learn − Python has few keywords, simple structure, and a clearly defined syntax. This allows the student to pick up the language quickly.

❖ Easy-to-read − Python code is more clearly defined and visible to the eyes.

❖ Easy-to-maintain − Python's source code is fairly easy to maintain.

❖ A broad standard library − Python's bulk of the library is very portable and cross- platform compatible on UNIX, Windows, and Macintosh.

❖ Interactive Mode − Python has support for an interactive mode which allows interactive testing and debugging of snippets of code.

❖ Portable − Python can run on a wide variety of hardware platforms and has the same interface on all platforms.

❖ Extendable − You can add low-level modules to the Python interpreter. These modulesenable programmers to add to or customize their tools to be more efficient.

❖ Databases − Python provides interfaces to all major commercial databases.

❖ GUI Programming − Python supports GUI applications that can be created and ported to many system calls, libraries and windows systems, such as Windows MFC, Macintosh,and the X Window system of Unix.

❖ Scalable − Python provides a better structure and support for large programs than shellscripting

**MACHINE LEARNING**

Machine learning is a field of artificial intelligence (AI) and computer science that focuses on utilizing data and algorithms to mimic human learning processes and progressively increase accuracy. Usually, classifications or predictions are generated using many machine learning algorithms. algorithm will produce an estimate about a pattern in the input data based on some unlabeled or labelled input data. The model's prediction will be assessed using an error function. If there are known examples, an error function can compare them to evaluate the model's correctness.

**CHAPTER 4**

# METHODOLOGY AND DESIGN ANALYSIS

## 4.1 Introduction

Our project has four different modules. Methodology for all the modules will be discussed one by one.

### Crop Recommendation

This module can be implemented in four steps as discussed below and shown in Figure 4.1.1 :

### Step 1: Data Acquisition

Dataset can be acquired from kaggle.

### Step 2: Values Input

Users are expected to input the site specific parameters like: N, P, K (all of them in %), temperature (in °C), relative humidity (in %), rainfall (in mm) and pH.

### Step 3: ML Model Training and creating .pkl file

Recommendation system is based on the ensemble model with majority voting technique. The constituent models are:

SVM,

Random Forest

Naive Bayes

KNN

After the model is trained, a .pkl file is created.

### Step 4: Crop Recommendation

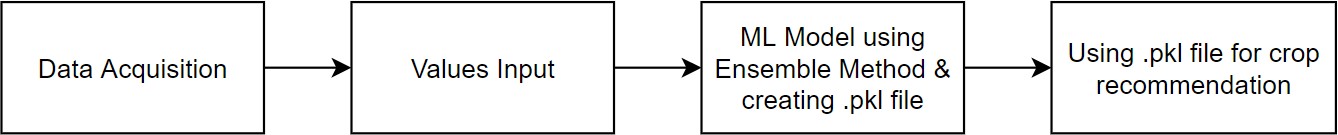


Figure 4.1.1: Methodology for Crop Recommendation

### 4.1.2 Fertilizer Recommendation

This module can be implemented in four steps as discussed below and shown in Figure 4.1.2:

### Step 1: Data Acquisition

Dataset will be created manually after collecting data from verified sources listed below:

The Fertilizer Association of India

Indian Institute of Water Management,

Kaggle

The columns of the dataset are: N, P, K (all of them in %) and crop.

### Step 2: Values Input

Users are expected to input the site specific parameters like: N, P, K (all of them in %), and crop (select from list - only 22 crops supported).

### Step 3: Difference between desired and actual

Difference is calculated between desired value of N, P, K as per crop and the farm’s actual value, based on it there are 3 outcomes possible for all three nutrients:

1. High
2. Low
3. Upto the mark

### Step 4: Fertilizer Recommendation

Based on the outcomes from the above step, a dictionary based solution (organic fertilizers) will be displayed.

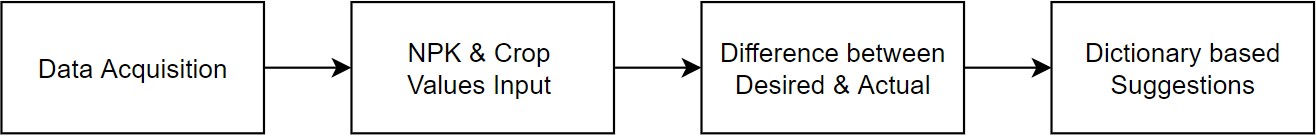


Figure 4.1.2: Methodology for Fertilizer Recommendation

### 4.1.3 Pesticide Recommendation

This module can be implemented in four steps as discussed below and shown in Figure 4.1.3:

### Step 1: Data Acquisition

Dataset will be created by scraping images from Google via automatic script using Selenium and Chrome Driver. Along with that, pest labels will be provided as well.

### Step 2: Data Cleaning and Data Augmentation

The data collected from Google needs to be cleaned manually to get rid of non-useful content e.g: In case of scraping images of pest named “beetle” there are also few images of “car called beetle”. Later on, the dataset needs to be augmented so as to increase variability.

### Step 3: DL Model Creation

This involves model configuration, training configuration and model evaluation. Later on, .h5 file will be created to store the model.

### Step 4: Pest Identification and corresponding Pesticide Recommendation

.h5 model will be loaded to identify the pest, later on based on the result, corresponding pesticide will be recommended based on dictionary based solution.

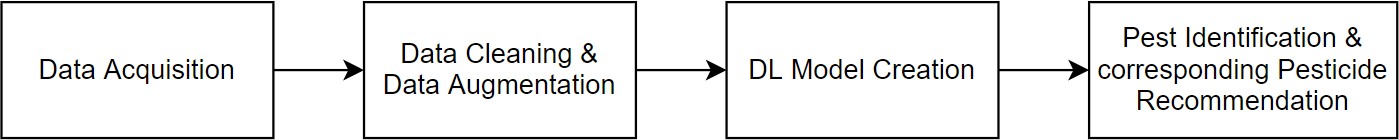


Figure 4.1.3: Methodology for Pesticide Recommendation

### 4.1.4 Price Recommendation

This module can be implemented in four steps as discussed below and shown in Figure 4.1.4:

### Step 1: Data Acquisition

Dataset will be created by scraping images from Google via automatic script using Selenium and Chrome Driver. Along with that, pest labels will be provided as well.

### Step 2: Data Cleaning and Data Augmentation

The data collected from Google needs to be cleaned manually to get rid of non-useful content e.g: In case of scraping price named “wheat” there are also few images of “price prediction”. Later on, the dataset needs to be augmented so as to increase variability.

### Step 3: DL Model Creation

This involves model configuration, training configuration and model evaluation. Later on, .h5 file will be created to store the model.

### Step 4: Price Recommendation

.h5 model will be loaded to identify the pest, later on based on the result, corresponding pesticide will be recommended based on dictionary based solution.

Price Recommendation

### DL Model

### creation

Data Cleaning and Data Augmentation

### Data Acquisition

Figure 4.1.4: Methodology for Price Recommendation

## 4.2 Architecture of the proposed system

Our project has three different modules as shown in Figure 4.2.1. All the work breakdown structures are made based on project objectives and deliverables.

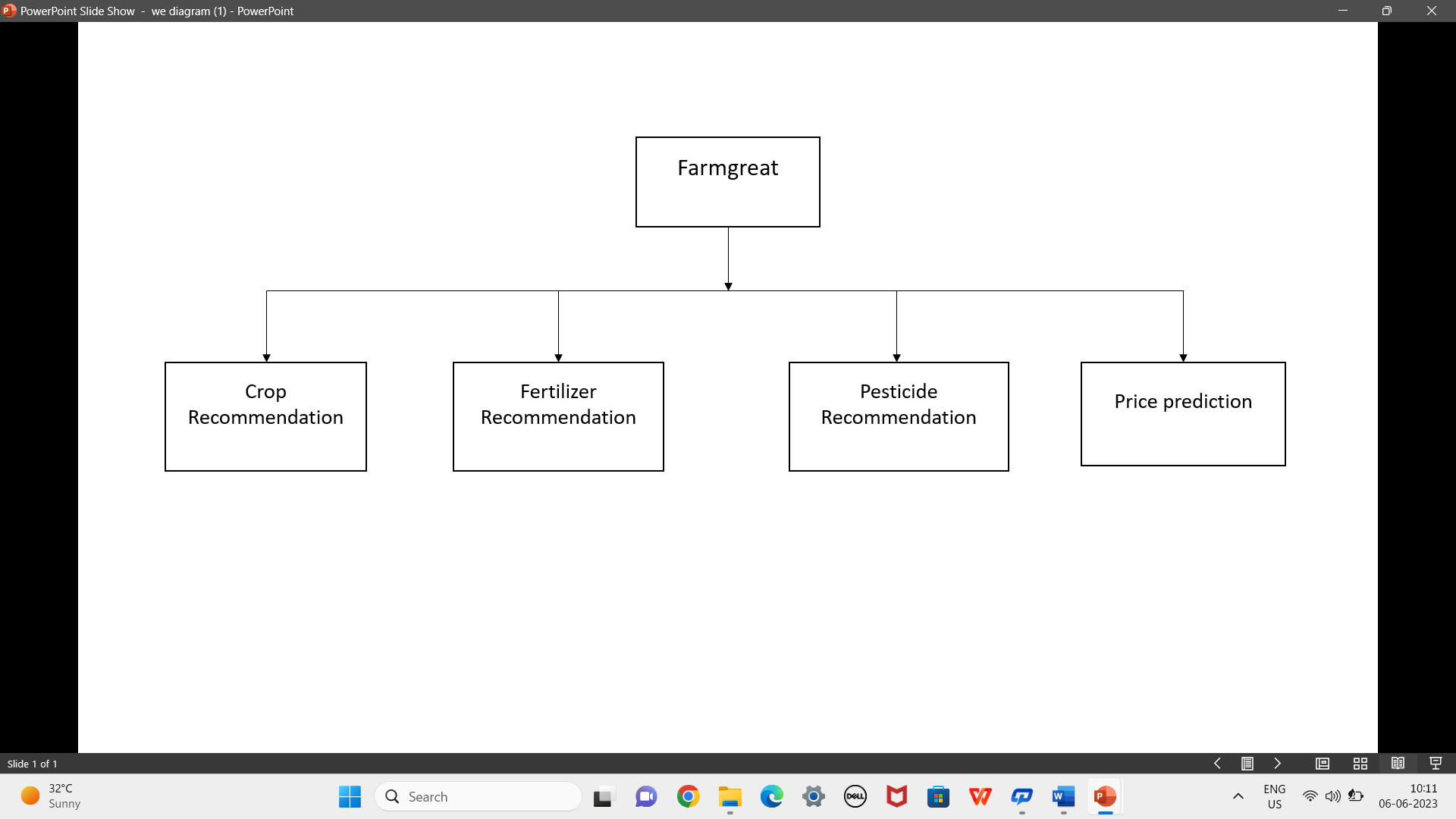


Figure 4.2.1: Overall architecture

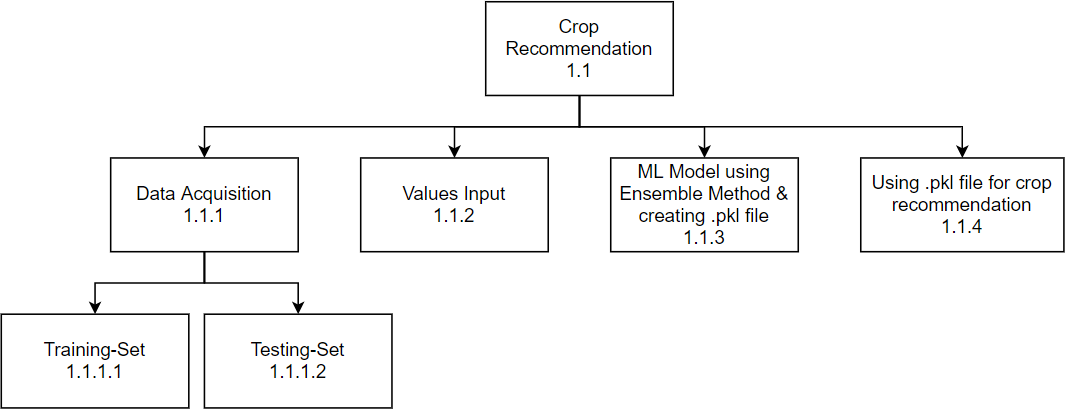


Figure 4.2.2: Crop Recommendation

The second submodule is Fertilizer Recommendation, it’s submodules are shown in Figure 4.2.3 while for the third and last submodule which is Pesticide Recommendation, its submodules are shown in Figure .

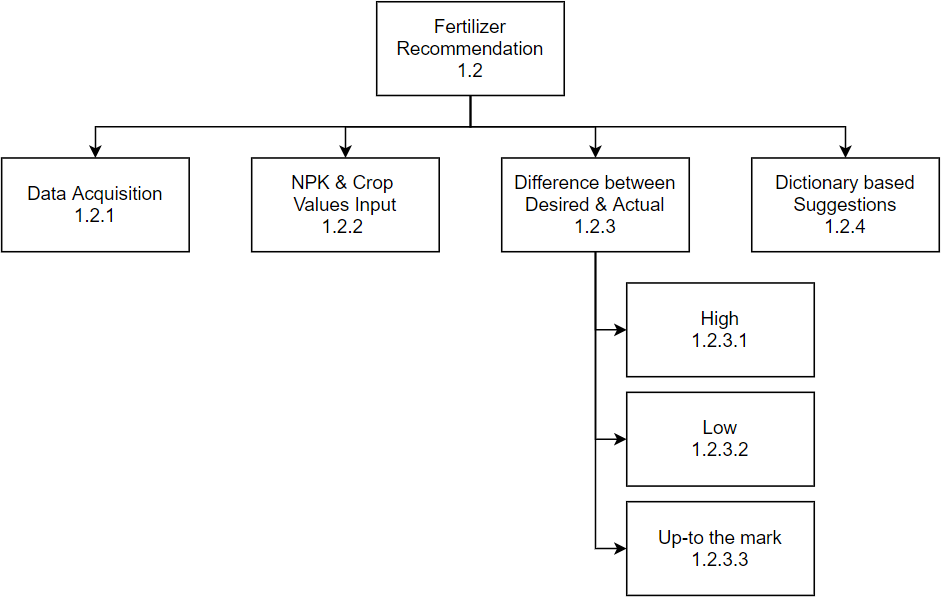


Figure 4.2.3: Fertilizer Recommendation

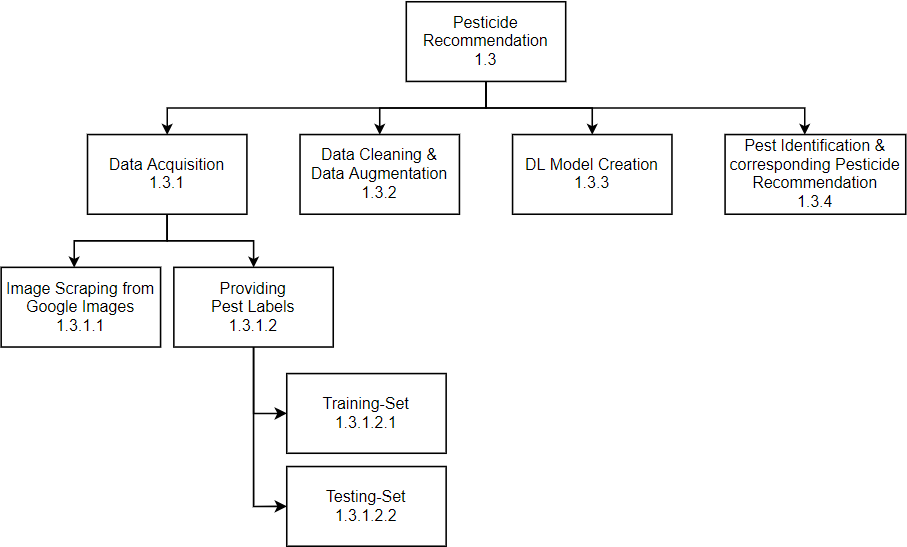


Figure 4.2.4: Pesticide Recommendation WBS

**4.3 Algorithms**

In order to provide advantages to underprivileged farmers, our initiative strives to efficiently handle the problem of crop price forecasting. It makes use of machine learning techniques to produce better solutions from various data. With the help of trained data from approved datasets, this system employs decision tree regression techniques to forecast crop values. This program can enhance productivity. Recognising and foreseeing Under varied environmental settings, cropper induces acne. An efficient crop price forecasting system can offer clients options that can satisfy customers in a variety of situations. Ultimately, the outcomes are presented in the form of a our project so that struggling farmers can quickly access them.

In this project we used the SVM, KNN, Naive Bayes, Random Forest, Decision Tree regression algorithm.

**4.3.1 Support vector machines (SVM)**

Support vector machines (SVM) is set of supervised learning strategies used for classification, regression and outlier’s discovery. it's a classification technique. Here, we have a tendency to plot every information item as some extent in n-dimensional house (where n is variety of options you have) with the worth of every feature being the worth of a selected coordinate. it's a classification technique. during this algorithmic rule, we have a tendency to plot every information item as some extent in n-dimensional house (where n is variety of options you have) with the worth of every feature being the worth of a selected coordinate.

**Hyperplane:** There can be multiple lines/decision boundaries to segregate the classes in n-dimensional space, but we need to find out the best decision boundary that helps to classify the data points. This best boundary is known as the hyperplane of SVM.

**4.3.2 Naive Bayes**

Naive Bayes’ is not single algorithm, but a clan of algorithmic rules. All naive Bayes socio-economic classifiers adopts that the value of a particular feature is independent of the value of any other feature, given the class variable. Naive Thomas Bayes classifier could be a straightforward probabilistic classifier that works supported applying theorem (from Bayesian statistics) with robust naive independence assumptions. it's a classification technique supported Bayes’ theorem with associate degree assumption of independence between predictors. In straightforward terms, a Naive Thomas Bayes categorifies assumes that the presence of a specific feature in an exceedingly class is dissimilar to the presence of the other feature. as an example, a fruit could also be thought of to be associate degree apple if it's red, round, and concerning a pair of inches in diameter. Even if these features depend on each other or upon the existence of the other features, a naive Bayes classifier would consider all of these properties to independently contribute to the probability that this fruit is an apple. These Learners predict the class label for each of the training data set.

1. Convert the given dataset into frequency tables.
2. Generate Likelihood table by finding the probabilities of given features.
3. Now, use Bayes theorem to calculate the posterior probability.

**4.3.3 Random Forest**

Random forests square measure associate ensemble learning methodology for classification, regression and different tasks, that operate by building a mess of call trees at coaching time and outputting the category that's the mode of the categories or mean prediction of the individual trees. Random call forests correct for call tree custom of over fitting to their coaching set.

The Working process can be explained in the below steps and diagram:

**Step-1:** Select random K data points from the training set.

**Step-2:** Build the decision trees associated with the selected data points (Subsets).

**Step-3:** Choose the number N for decision trees that you want to build.

**Step-4:** Repeat Step 1 & 2.

**Step-5:** For new data points, find the predictions of each decision tree, and assign the new data points to the category that wins the majority votes.

**4.3.4 Decision Tree regression**

This supervised learning technique uses trees to make decisions. Unlike other supervised learning algorithms, the decision tree method can be utilised to address regression and classification problems. A decision tree can be used to create a training model that can be used to forecast the class or value of the target variable by learning fundamental choice rules inferred from prior data (training data). In Decision Trees, we anticipate the class label for the record by starting at the top of the tree and working our way down. The cost of the initial attribute and the value of the attribute in the record are contrasted. We move to the subsequent node by following the branch that is associated with that value based on the comparison. measures for choosing properties It may be challenging to decide which attributes to utilise as internal nodes at the root. We collaborated to find answers to the attribute selection issue. And advised employing criteria such as: Entropy, Gaining Information, Gini Index, Gain Ratio, Chi-Square. Each characteristic's worth will be determined using these criteria. The features are organised in a tree with the most significant feature at the top (in the case of information gain) and the values are sorted. We look at hierarchical qualities when using information gain as a criterion, and we look at continuous characteristics when using the Gini index. We utilised Decision Tree Regression because the datasets' data is continuous. Prices for crops change throughout time since they are seasonal. Rainfall and WPI are used in the dataset as the parameters for crop price prediction.

**KNN**

The k-nearest neighbors algorithm, also known as KNN or k-NN, is a non-parametric, supervised learning classifier, which uses proximity to make classifications or predictions about the grouping of an individual data point. While it can be used for either regression or classification problems, it is typically used as a classification algorithm, working off the assumption that similar points can be found near one another**.**

The K-NN working can be explained on the basis of the below algorithm:

* **Step-1:** Select the number K of the neighbors
* **Step-2:** Calculate the Euclidean distance of **K number of neighbors**
* **Step-3:** Take the K nearest neighbors as per the calculated Euclidean distance.
* **Step-4:** Among these k neighbors, count the number of the data points in each category.
* **Step-5:** Assign the new data points to that category for which the number of the neighbor is maximum.
* **Step-6:** Our model is ready.

## 4.4 System Design

Figure 4.4.1 shows the layered architecture of the product, constituting client, server, business layer, persistence layer, database.

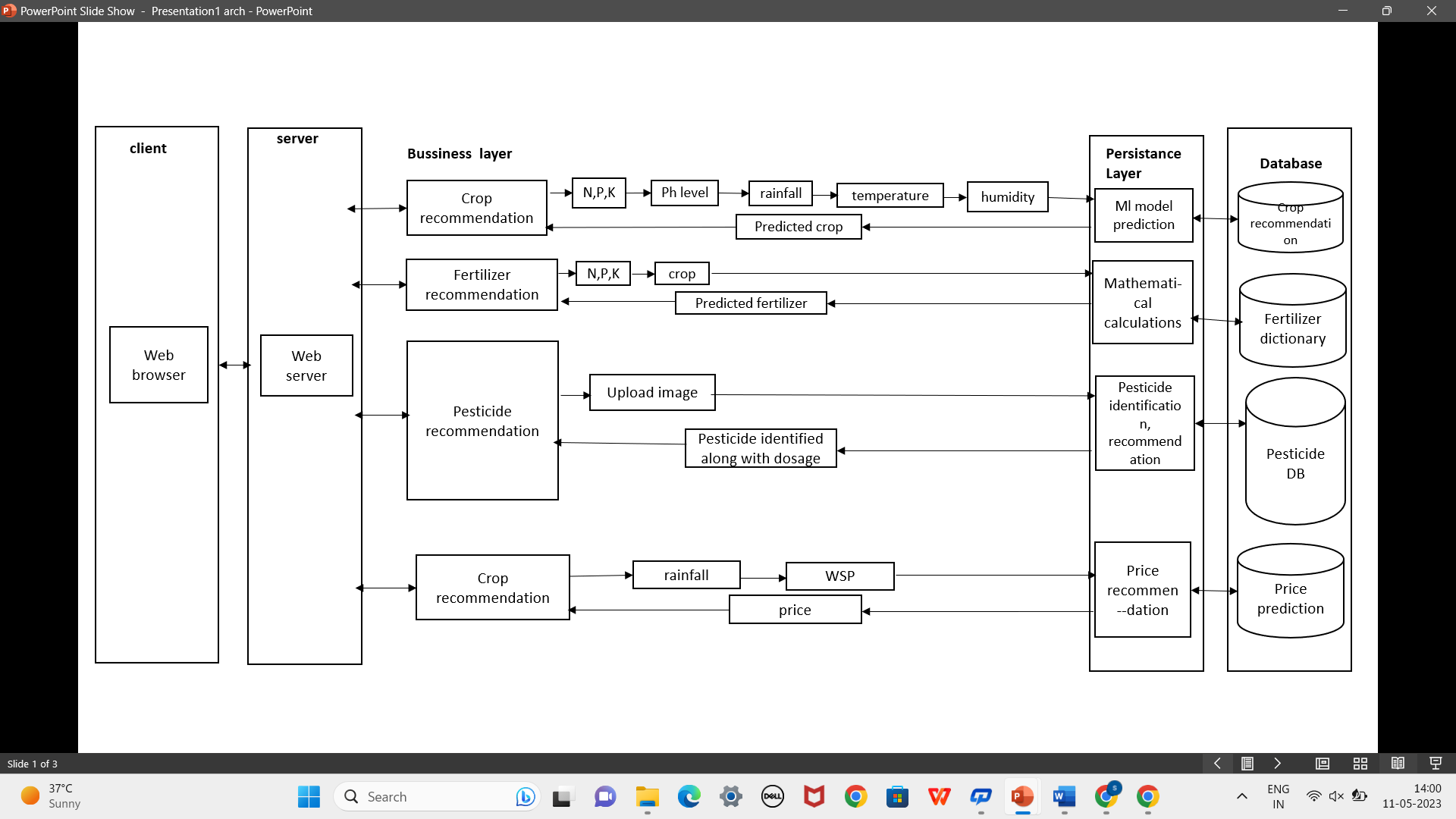


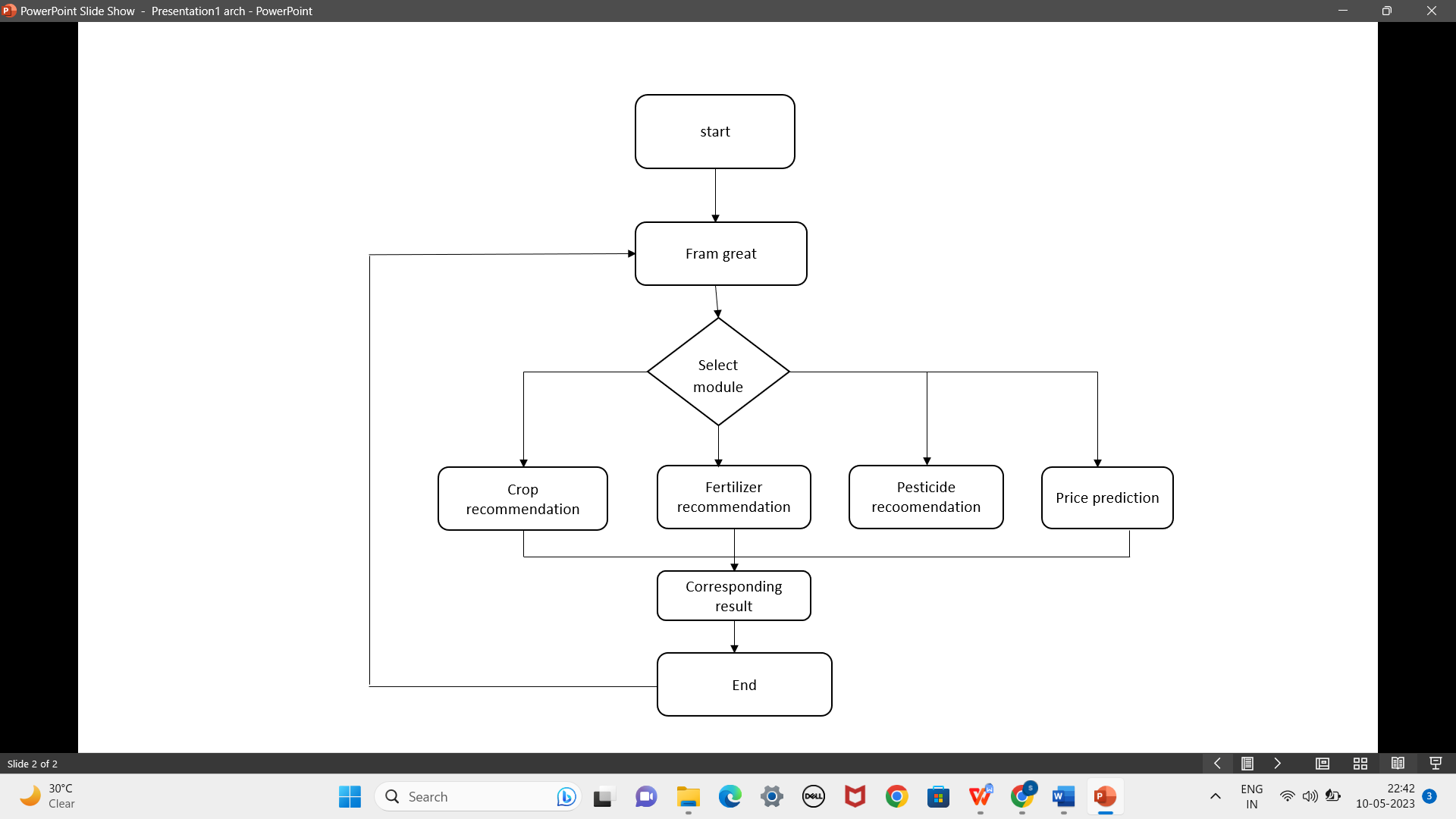
Figure 4.4.1: System Design of the project

## 4.5 UML Diagrams

Analysis diagrams capture the system behavior and tell how the system will behave in different scenarios. In this report, use case diagram, use case template, activity diagram, workflow diagram and various other diagrams are made so as to design the system before the coding starts.

### 4.5.1 Workflow Diagram

Workflow for Our project is displayed below which provides an insight on all the three modules and the control flow which takes place as per the selected module.

 Figure 4.5.1(a): Workflow Diagram

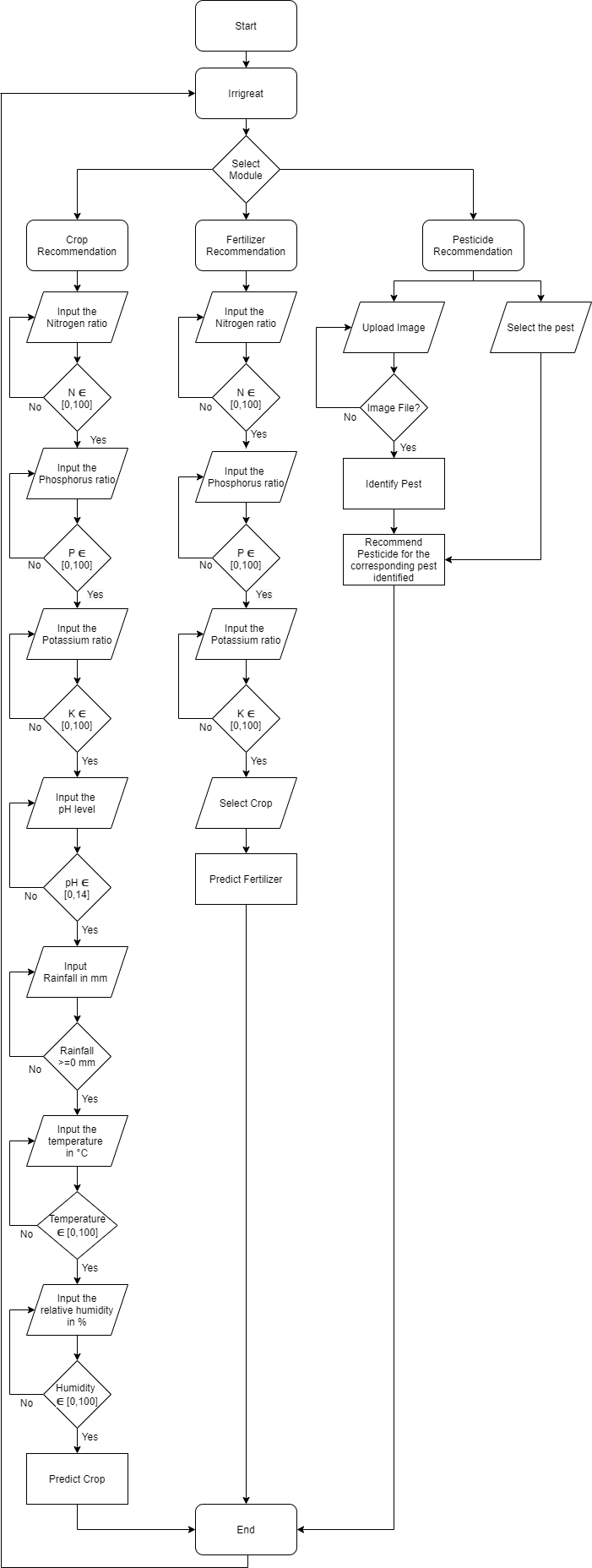


Figure 4.5.1(b): Overall Workflow Diagram

### Activity Diagram

To portray the workflow of “Our project” from start till the end, activity diagram of overall system is shown in Figure 4.5.2 . To see the overall diagram.

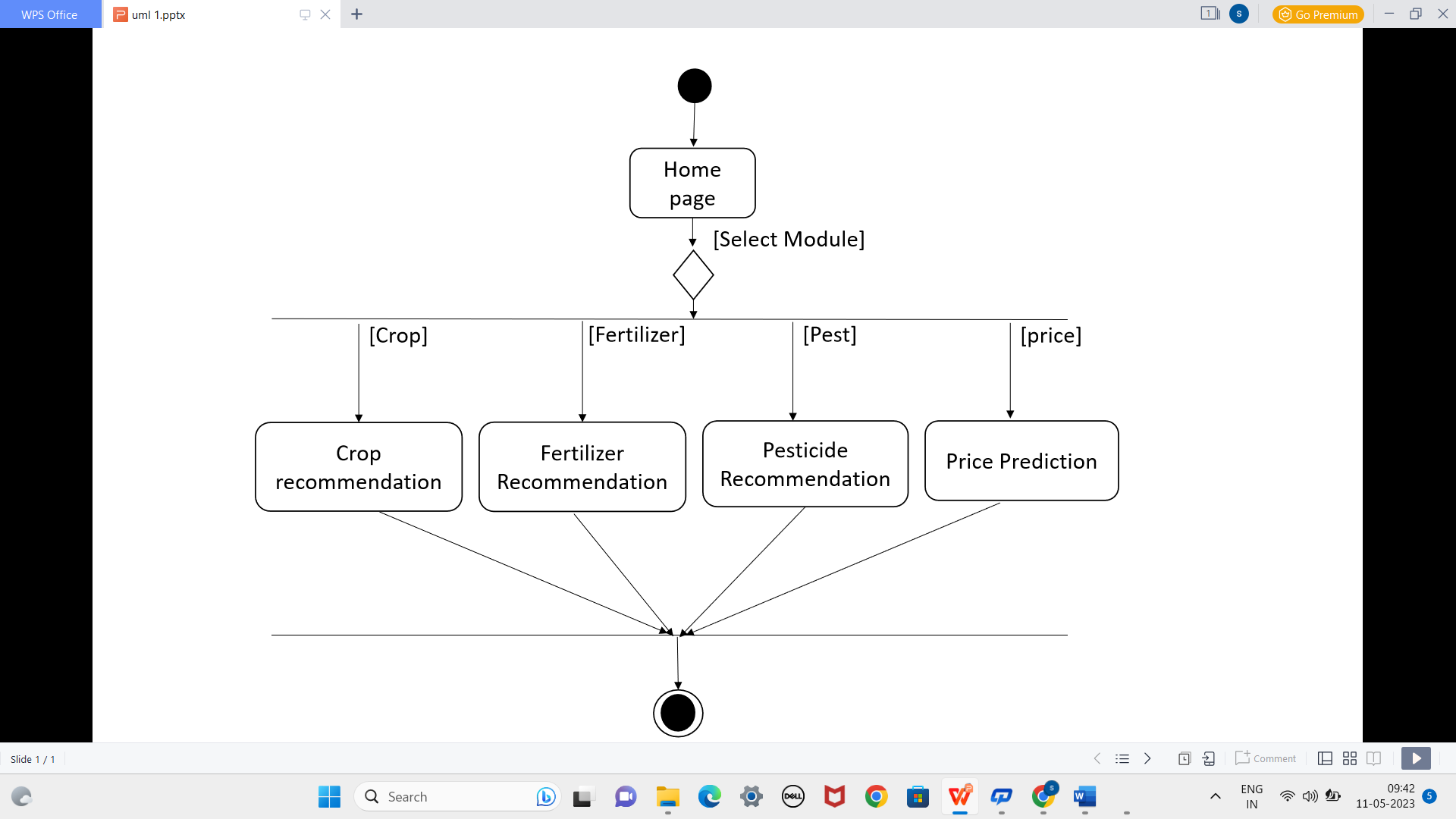


Figure 4.5.2: Activity Diagram

Following displays the activity diagram for Crop Recommendation.

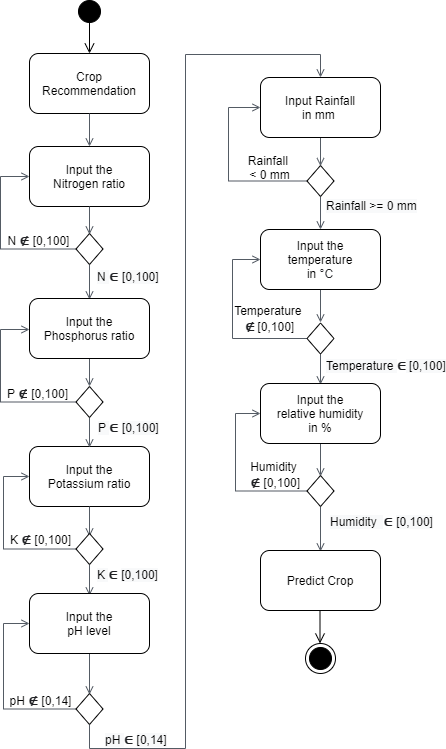


Figure 4.5.2 (a): Crop Recommendation Activity Diagram

Following displays the activity diagram for Fertilizer Recommendation.

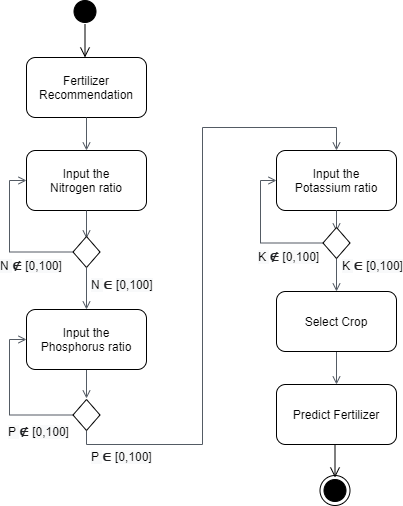


Figure 4.5.2 (b): Fertilizer Recommendation Activity Diagram

Following displays the activity diagram for Pesticide Recommendation.

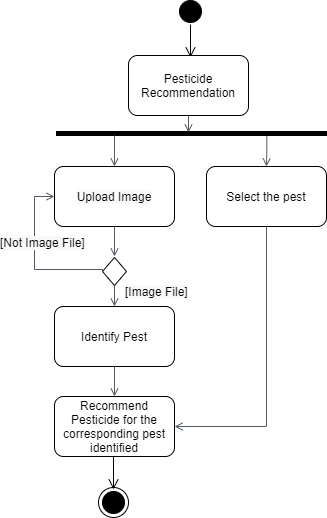


Figure 4.5.2 (c): Pesticide Recommendation Activity Diagram

### 4.5.3 Use Case Diagram

Since the system is quite simple and the aim was to make it as user friendly as possible, keeping in view the farmer, so the actor here is only one which is the user, the farmer. Further the use cases, communication link, system boundary and use case relationships are shown in Figure 4.5.3 as given below.

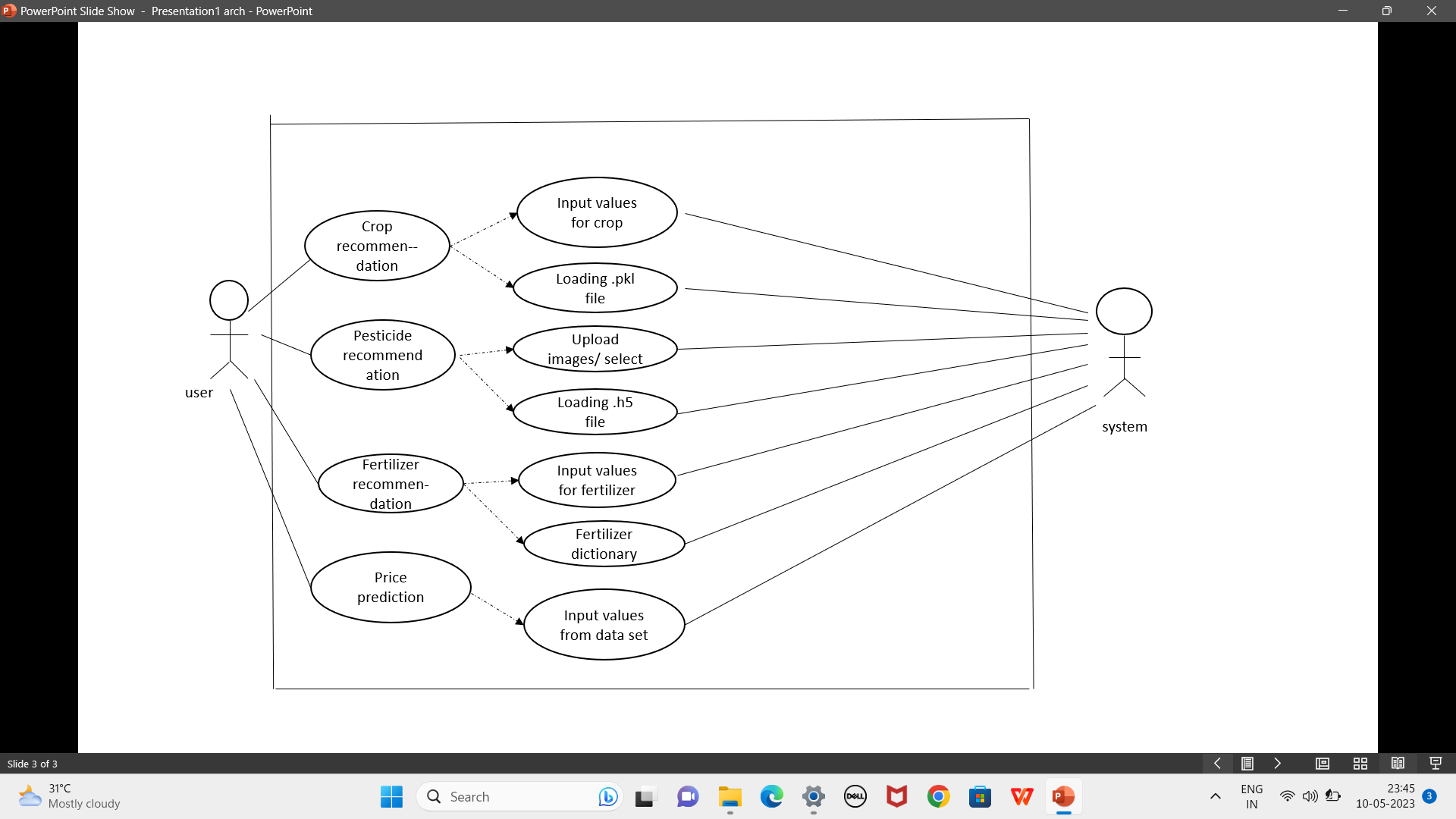
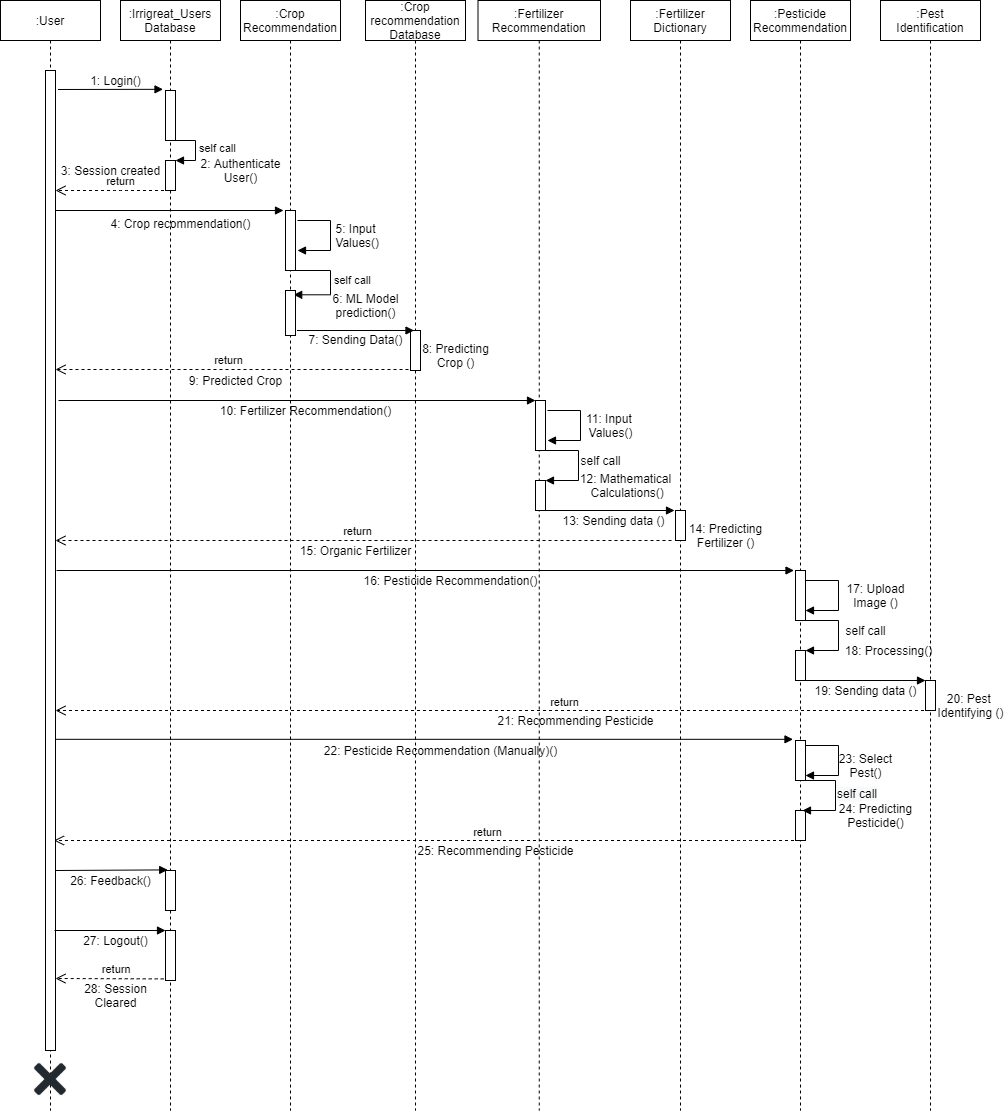


Figure 4.5.3: Use Case Diagram

**4.5.4** **Sequence Diagram**

Figure 4.5.4 depicts interaction between the objects in a sequential order. There are 8 objects named User, Our project\_Users Database, Crop recommendation, Crop recommendation Database, Fertilizer recommendation, Fertilizer Dictionary, Pesticide Recommendation and Pest Identification. The diagram below shows the order in which the interaction between the objects takes place.

Figure 4.5.4: Sequence Diagram

### 4.5.5 Class Diagram

Following Class Diagram (Figure 4.5.5) shows various classes, attributes and functions.

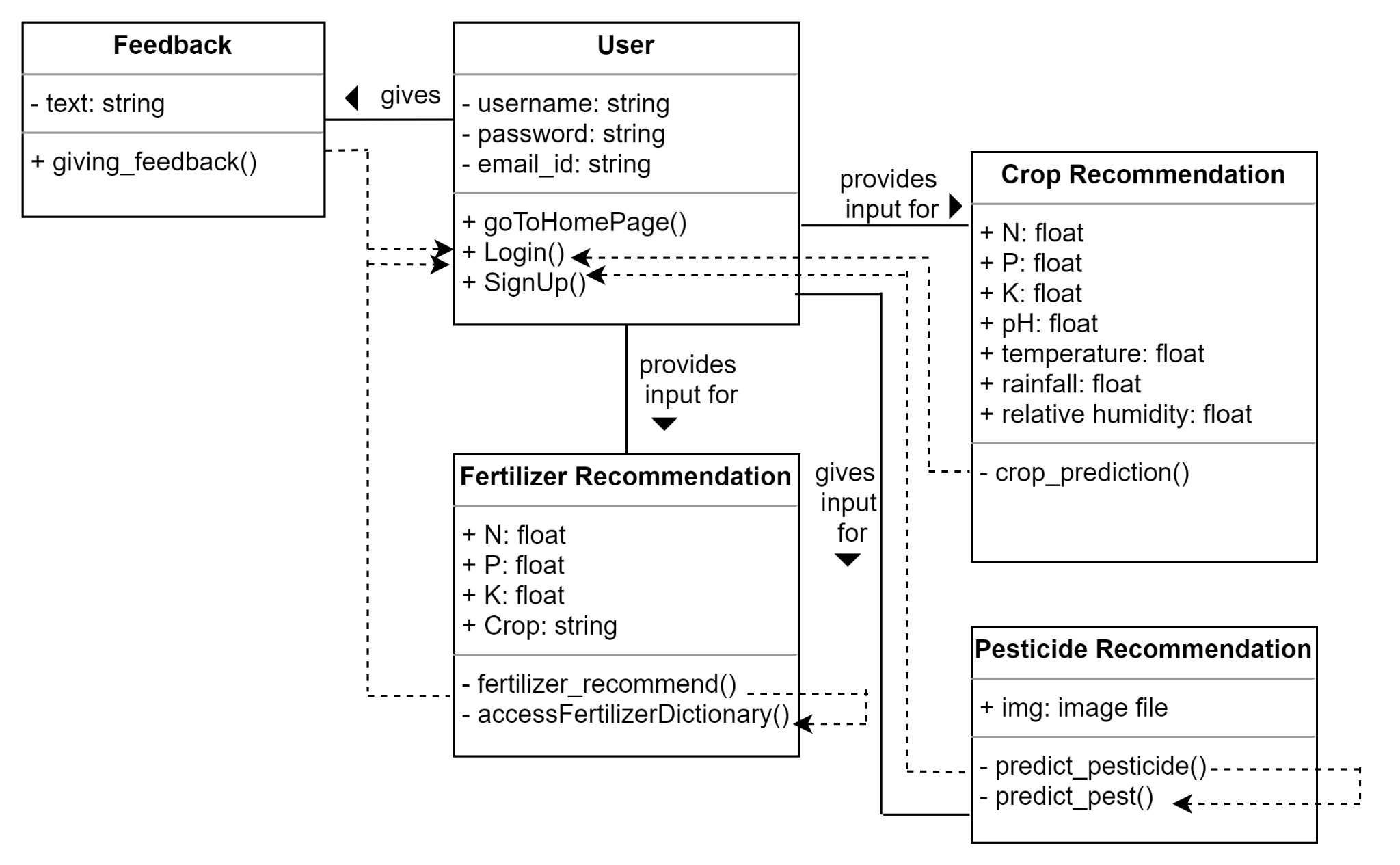


Figure 4.5.5: Class Diagram

**4.6 Summary**

In order to provide advantages to underprivileged farmers, our initiative strives to efficiently handle the problem of crop price forecasting. It makes use of machine learning techniques to produce better solutions from various data. With the help of trained data from approved datasets, this system employs decision tree regression techniques to forecast crop values. This program can enhance productivity. Recognising and foreseeing Under varied environmental settings, cropper induces acne. An efficient crop price forecasting system can offer clients options that can satisfy customers in a variety of situations. Ultimately, the outcomes are presented in the form of a our project so that struggling farmers can quickly access them.

**CHAPTER 5**

# IMPLEMENTATION

# 5.1 Introduction

This section deals with discussion of implementation and experimentation with regards to the project. It also mentions all the test plans including the features to be tested, the test cases and discusses the inference drawn from the results. This doesn’t end here, this section will also discuss algorithms used, system screenshots and in the end validate project objectives.

Our project has majorly 4 modules namely: Crop Recommendation. Fertilizer Recommendation, Pesticide Recommendation, Price Prediction. Following will discuss the experimental setup for all the four modules.

* + 1. For all the services, the user needs to have an account created on the website, post that user can login any no. of times to avail any of the three services. During signup, the user needs to have an email address. Along with that, the user will give any username and password (minimum 8 characters and maximum 20 characters). For one email address, the user can have only one account and the username must be unique, hence not be taken. During signup, the user just needs to enter username and password.
    2. Post successful authentication, the user can avail any of the 3 services.
    3. For the first module, which is crop recommendation, the user needs to fill in the values for N, P, K (all in ratio), temperature (in °C), relative humidity (in %), rainfall (in mm) and pH. After that, the user will be recommended the most suitable crop as per the land.
    4. For the second module which is Fertilizer Recommendation, the user needs to have values for N, P, K and select the crop, based on that natural fertilizers will be recommended as per deficiency or surplus of nutrients.
    5. For the third module, the user can choose to select the pest manually if the user knows about the pest and directly pesticide would be recommended, otherwise the user can choose to upload the picture that clearly shows the pest, thereby pest will be identified in the backend and corresponding pesticide would be recommended.
    6. Post all the activities, the user can give optional feedback. Later on, he/she can again go to “Home” and look for services or logout.

## 5.2 Explanation of key elements

**Agriculture**

Agriculture is the art and science of cultivating the soil, growing crops and raising livestock. It includes the preparation of plant and animal products for people to use and their distribution to markets.  
 Agriculture provides most of the world’s food and fabrics. Cotton, wool, and leather are all agricultural products. Agriculture also provides wood for construction and paper products.  
These products, as well as the agricultural methods used, may vary from one part of the world to another.

**Crop Recommendation**

Crop recommendation is the process of providing farmers with guidance on the most suitable crops to grow based on factors such as soil type, climate conditions, market demand, and available resources. It involves analyzing data, utilizing agronomic knowledge, and leveraging technology to suggest optimal crop choices that maximize yield, profitability, and sustainability. Crop recommendation aims to assist farmers in making informed decisions and optimizing their agricultural practices for successful crop production**.**

**Pesticide Recommendation**

Pesticides recommendation involves providing guidance on the appropriate and judicious use of pesticides to control pests, diseases, and weeds in agriculture. It considers factors such as the type of pest, crop, and specific conditions, while also emphasizing safety, efficacy, and environmental sustainability. Pesticide recommendations take into account integrated pest management (IPM) principles, which prioritize non-chemical methods and the minimal use of pesticides. The goal is to optimize pest control while minimizing risks to human health, beneficial organisms, and the environment.

**Fertilizer Recommendation**

Fertilizer recommendation involves advising farmers on the appropriate types and amounts of fertilizers to apply to crops to improve plant growth, yield, and nutrient uptake. It considers factors such as soil nutrient levels, crop nutrient requirements, and the specific needs of the plants being grown. Fertilizer recommendations aim to optimize nutrient management, prevent deficiencies or excesses, and promote sustainable agricultural practices. By providing tailored guidance, farmers can enhance soil fertility, maximize crop productivity, and minimize environmental impacts associated with fertilizer use.

**Price Prediction**

Price prediction is the process of forecasting the future value or price of a particular asset, product, or financial instrument. It involves analyzing historical data, market trends, and relevant factors to make informed estimations about future price movements. Price prediction methods vary depending on the asset being analyzed and can include techniques such as statistical analysis, technical analysis, machine learning, or a combination of approaches. While price prediction models can provide valuable insights, it's important to note that future prices are influenced by numerous factors and are inherently uncertain, making accurate predictions challenging.

**5.3 Code Implementation**

**5.3.1 Source Code**

from flask import Flask, render\_template, request, Markup

import pandas as pd

from utils.fertilizer import fertilizer\_dict

import os

import numpy as np

from keras.preprocessing import image

from keras.models import load\_model

import pickle

from flask\_cors import CORS, cross\_origin

from datetime import datetime

import crops

import random

classifier = load\_model('Trained\_model.h5')

classifier.\_make\_predict\_function()

crop\_recommendation\_model\_path = 'Crop\_Recommendation.pkl'

crop\_recommendation\_model = pickle.load(open(crop\_recommendation\_model\_path, 'rb'))

app = Flask(\_\_name\_\_)

#Crop prediction code start

app.config['CORS\_HEADERS'] = 'Content-Type'

cors = CORS(app, resources={r"/ticker": {"origins": "http://localhost:port"}})

commodity\_dict = {

    "arhar": "static/Arhar.csv",

    "bajra": "static/Bajra.csv",

    "barley": "static/Barley.csv",

    "copra": "static/Copra.csv",

    "cotton": "static/Cotton.csv",

    "sesamum": "static/Sesamum.csv",

    "gram": "static/Gram.csv",

    "groundnut": "static/Groundnut.csv",

    "jowar": "static/Jowar.csv",

    "maize": "static/Maize.csv",

    "masoor": "static/Masoor.csv",

    "moong": "static/Moong.csv",

    "niger": "static/Niger.csv",

    "paddy": "static/Paddy.csv",

    "ragi": "static/Ragi.csv",

    "rape": "static/Rape.csv",

    "jute": "static/Jute.csv",

    "safflower": "static/Safflower.csv",

    "soyabean": "static/Soyabean.csv",

    "sugarcane": "static/Sugarcane.csv",

    "sunflower": "static/Sunflower.csv",

    "urad": "static/Urad.csv",

    "wheat": "static/Wheat.csv"

}

annual\_rainfall = [29, 21, 37.5, 30.7, 52.6, 150, 299, 251.7, 179.2, 70.5, 39.8, 10.9]

base = {

    "Paddy": 1245.5,

    "Arhar": 3200,

    "Bajra": 1175,

    "Barley": 980,

    "Copra": 5100,

    "Cotton": 3600,

    "Sesamum": 4200,

    "Gram": 2800,

    "Groundnut": 3700,

    "Jowar": 1520,

    "Maize": 1175,

    "Masoor": 2800,

    "Moong": 3500,

    "Niger": 3500,

    "Ragi": 1500,

    "Rape": 2500,

    "Jute": 1675,

    "Safflower": 2500,

    "Soyabean": 2200,

    "Sugarcane": 2250,

    "Sunflower": 3700,

    "Urad": 4300,

    "Wheat": 1350

}

commodity\_list = []

class Commodity:

    def \_\_init\_\_(self, csv\_name):

        self.name = csv\_name

        dataset = pd.read\_csv(csv\_name)

        self.X = dataset.iloc[:, :-1].values

        self.Y = dataset.iloc[:, 3].values

        #from sklearn.model\_selection import train\_test\_split

        #X\_train, X\_test, Y\_train, Y\_test = train\_test\_split(X, Y, test\_size=0.1, random\_state=0)

        # Fitting decision tree regression to dataset

        from sklearn.tree import DecisionTreeRegressor

        depth = random.randrange(7,18)

        self.regressor = DecisionTreeRegressor(max\_depth=depth)

        self.regressor.fit(self.X, self.Y)

        #y\_pred\_tree = self.regressor.predict(X\_test)

        # fsa=np.array([float(1),2019,45]).reshape(1,3)

        # fask=regressor\_tree.predict(fsa)

    def getPredictedValue(self, value):

        if value[1]>=2019:

            fsa = np.array(value).reshape(1, 3)

            #print(" ",self.regressor.predict(fsa)[0])

            return self.regressor.predict(fsa)[0]

        else:

            c=self.X[:,0:2]

            x=[]

            for i in c:

                x.append(i.tolist())

            fsa = [value[0], value[1]]

            ind = 0

            for i in range(0,len(x)):

                if x[i]==fsa:

                    ind=i

                    break

            #print(index, " ",ind)

            #print(x[ind])

            #print(self.Y[i])

            return self.Y[i]

    def getCropName(self):

        a = self.name.split('.')

        return a[0]

#crop prediction code end

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

def fertilizer\_recommend():

    crop\_name = str(request.form['cropname'])

    N\_filled = int(request.form['nitrogen'])

    P\_filled = int(request.form['phosphorous'])

    K\_filled = int(request.form['potassium'])

    df = pd.read\_csv('Data/Crop\_NPK.csv')

    N\_desired = df[df['Crop'] == crop\_name]['N'].iloc[0]

    P\_desired = df[df['Crop'] == crop\_name]['P'].iloc[0]

    K\_desired = df[df['Crop'] == crop\_name]['K'].iloc[0]

    n = N\_desired- N\_filled

    p = P\_desired - P\_filled

    k = K\_desired - K\_filled

    if n < 0:

        key1 = "NHigh"

    elif n > 0:

        key1 = "Nlow"

    else:

        key1 = "NNo"

    if p < 0:

        key2 = "PHigh"

    elif p > 0:

        key2 = "Plow"

    else:

        key2 = "PNo"

    if k < 0:

        key3 = "KHigh"

    elif k > 0:

        key3 = "Klow"

    else:

        key3 = "KNo"

    abs\_n = abs(n)

    abs\_p = abs(p)

    abs\_k = abs(k)

    response1 = Markup(str(fertilizer\_dict[key1]))

    response2 = Markup(str(fertilizer\_dict[key2]))

    response3 = Markup(str(fertilizer\_dict[key3]))

    return render\_template('Fertilizer-Result.html', recommendation1=response1,

                           recommendation2=response2, recommendation3=response3,

                           diff\_n = abs\_n, diff\_p = abs\_p, diff\_k = abs\_k)

def pred\_pest(pest):

    try:

        test\_image = image.load\_img(pest, target\_size=(64, 64))

        test\_image = image.img\_to\_array(test\_image)

        test\_image = np.expand\_dims(test\_image, axis=0)

        result = classifier.predict\_classes(test\_image)

        return result

    except:

        return 'x'

@app.route("/")

@app.route("/index.html")

def index():

    return render\_template("index.html")

@app.route("/CropRecommendation.html")

def crop():

    return render\_template("CropRecommendation.html")

@app.route("/FertilizerRecommendation.html")

def fertilizer():

    return render\_template("FertilizerRecommendation.html")

@app.route("/PesticideRecommendation.html")

def pesticide():

## 5.4 Testing

## 5.4.1 Testing Levels

## System testing

## System testing, also referred to as system-level testing or system integration testing, is the process in which a quality assurance (QA) team evaluates how the various components of an application interact together in the full, integrated system or application.

## Unit testing

## Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application. Test strategy and approach: Field testing will be performed manually and functional tests will be written in detail. Test objectives

## • All field entries must work properly.

## • Pages must be activated from the identified link.

## • The entry screen, messages and responses must not be delayed. Features to be tested

## • Verify that the entries are of the correct format

## • No duplicate entries should be allowed • All links should take the user to the correct page.

## White Box Testing

## White Box Testing is a testing in which in which the software tester has knowledge of the inner workings, structure and language of the software, or at least its purpose. It is purpose. It is used to test areas that cannot be reached from a black box level.

## Black Box Testing

## Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works.

## User Acceptance Testing

## User Acceptance of a system is the key factor for the success of any system. The system under consideration is tested for user acceptance by constantly keeping in touch with the prospective system users at the time of developing and making changes wherever required. The system developed provides a friendly user interface that can easily be understood even by a person who is new to the system. esters, who are typically the end-users or their representatives, execute test cases based on real-world scenarios and report any issues encountered. Once all test cases are completed and acceptance criteria are met, stakeholders provide approval for the software's release.

## 5.5 Test Cases

A project is successful in real terms if it passes all the tests and if not all the tests then at least it must be able to handle the cases: base cases, corner cases with good accuracy. Some errors can be neglected depending upon application. Our project also underwent a rigorous series of tests and how it performed is given below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr.**  **No.** | **Test Case** | **Expected Output** | **Actual Output** | **Pass** |
| 1 | N value < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 2 | N value > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 3 | P value < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 4 | P value > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 5 | K value < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 6 | K value > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 7 | pH > 14 | Value must be less than or equal to 14 | Value must be less than or equal to 14 | Yes |
| 8 | pH < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 9 | Rainfall < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 10 | Temperature < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 11 | Temperature > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 12 | Relative Humidity < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 13 | Relative Humidity > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 14 | Any field empty | Please fill out this field | Please fill out this field | Yes |
| 15 | N = 90, P = 42, K = 43, pH  = 6.5, rainfall = 202.9, temperature = 20.88, relative humidity = 82 | rice | rice | Yes |
| 16 | N = 3, P = 18, K = 31, pH =  6.39, rainfall = 91.09, temperature = 31.65, relative humidity = 48.2 | mango | mango | Yes |

Table 5.5.1: Test Cases for Crop Recommendation

Fourth module to be tested is Fertilizer Recommendation. The test cases are given below in Table 5.5.2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr.**  **No.** | **Test Case** | **Expected Output** | **Actual Output** | **Pass** |
| 1 | N value < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 2 | N value > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 3 | P value < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 4 | P value > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 5 | K value < 0 | Value must be greater than or equal to 0 | Value must be greater than or equal to 0 | Yes |
| 6 | K value > 100 | Value must be less than or equal to 100 | Value must be less than or equal to 100 | Yes |
| 7 | Any field empty | Please fill out this field | Please fill out this field | Yes |
| 8 | No crop selected | Selected Crop: apple | Selected Crop: apple | Yes |
| 9 | N = 45, P = 45, K = 78, crop  = maize | Nlow, Plow, KHigh and measures | Nlow, Plow, KHigh and measures | Yes |

Table 5.5.2: Test Cases for Fertilizer Recommendation

Fifth module to be tested is Pesticide Recommendation. The test cases are given below in Table 5.5.3.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr.**  **No.** | **Test Case** | **Expected Output** | **Actual Output** | **Pass** |
| 1 | Manual Selection of pest: grasshopper | Recommended products: Malathion (Dose 750 g/L), Perfek (Dose 2.5-3.5 Tbsp / 16 L) | Recommended products: Malathion (Dose 750 g/L), Perfek (Dose 2.5-3.5 Tbsp / 16 L) | Yes |
| 2 | File uploaded is not image file | File format is not appropriate. Kindly upload an image file. | File format is not appropriate. Kindly upload an image file. | Yes |
| 3 | No file uploaded and pressed “Recommend” button. | No file uploaded! Kindly upload an image file. | No file uploaded! Kindly upload an image file. | Yes |
| 4 | Uploaded Image is of aphids | Identified pest: aphids | Identified pest: aphids | Yes |
| 5 | Uploaded Image is of armyworm | Identified pest: armyworm | Identified pest: aphids | No |
| 6 | Uploaded Image is of beetle | Identified pest: beetle | Identified pest: beetle | Yes |
| 7 | Uploaded Image is of sawfly | Identified pest: sawfly | Identified pest: sawfly | Yes |
| 8 | Uploaded image is blur image of sawfly | Identified pest: sawfly | Identified pest: stem borer | No |

Table 5.5.3: Test Cases for Pesticide Recommendation

## CHAPTER 6

## RESULT ANALYSIS

## Result

Below figure is the landing page of our project. It is the main page where user start interacting with our project. User can avail all the functionalities of our project from here.



## Figure 6.1 Landing Page

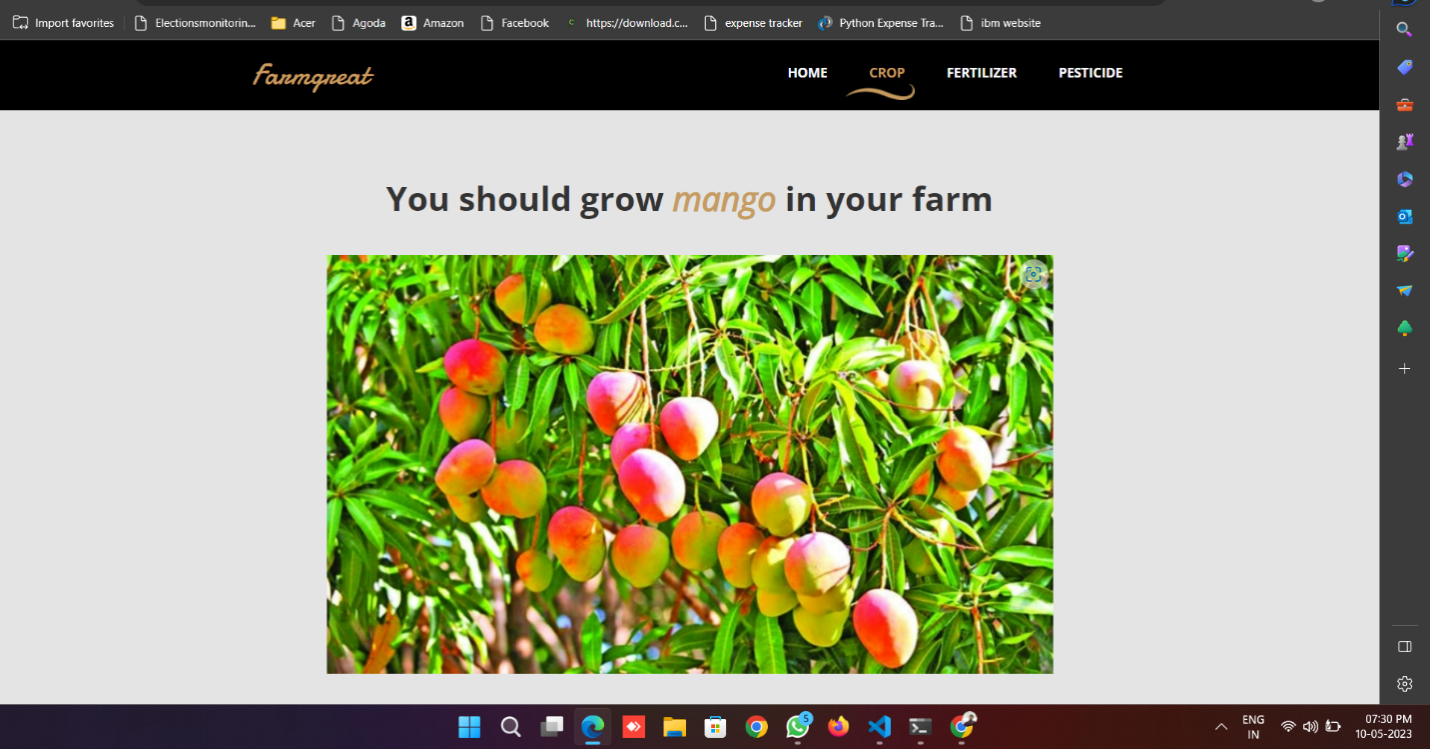


Figure 6.2 : Crop Recommendation Module (Input the values)

Now, after the user pressed the “Recommend” button then the result will be shown on the screen (Figure 6.3), here in this case, it recommends “rice”. Hence this is most suitable to the soil as per current weather conditions and soil conditions.

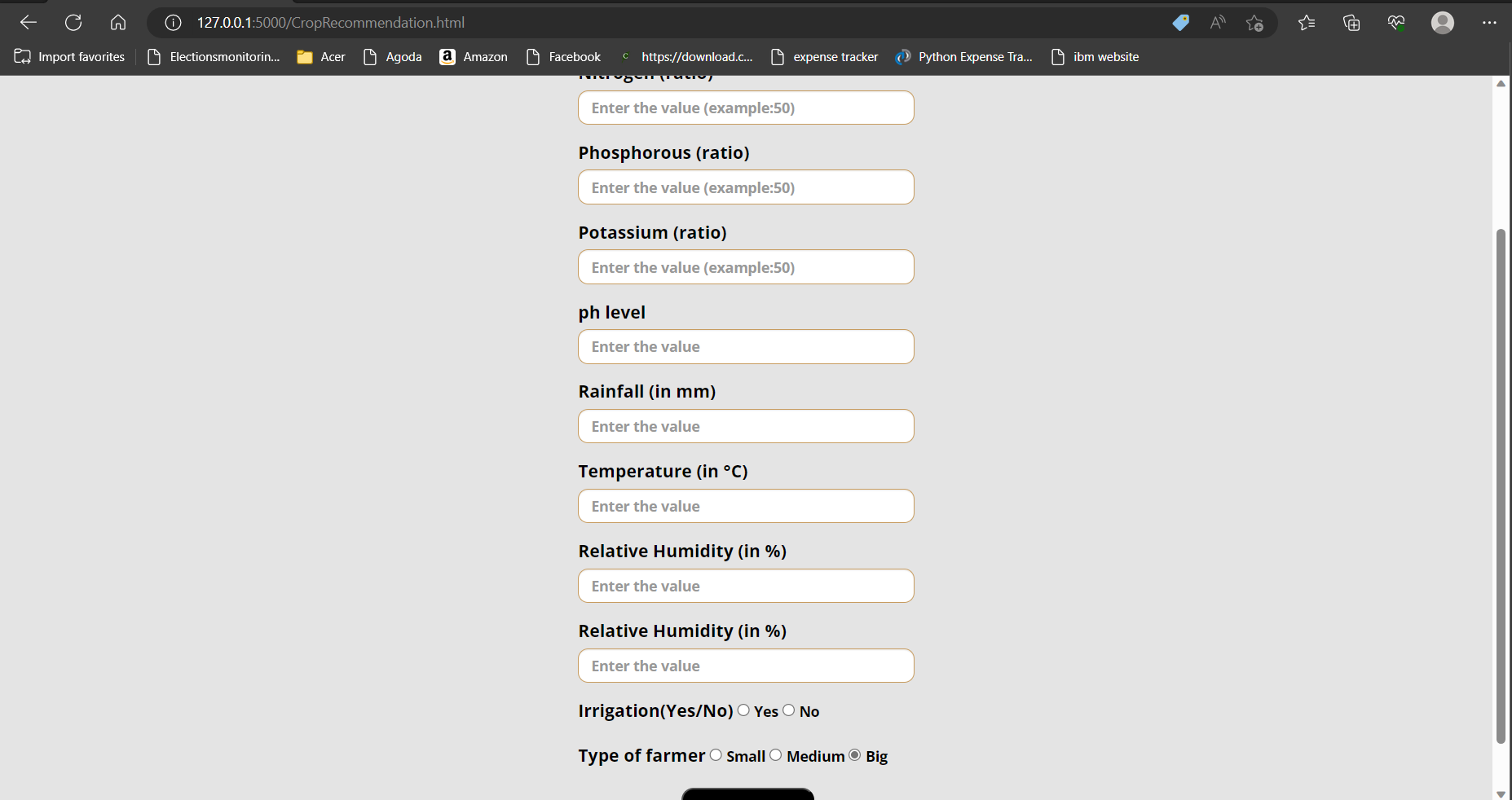


Figure 6.3: Crop Recommendation Module (Result)

Similarly the user can avail the “Fertilizer Recommendation” Service by filling the values for N, P, K and crop (Figure 6.4). Post that the user will know about the status of the soil and will tell the difference between the desired value of nutrients and the user's farm’s nutrients and then “Our project” will give informed advice on organic fertilizers to use as per the current condition of soil. See Figure 4.2.4 for reference.

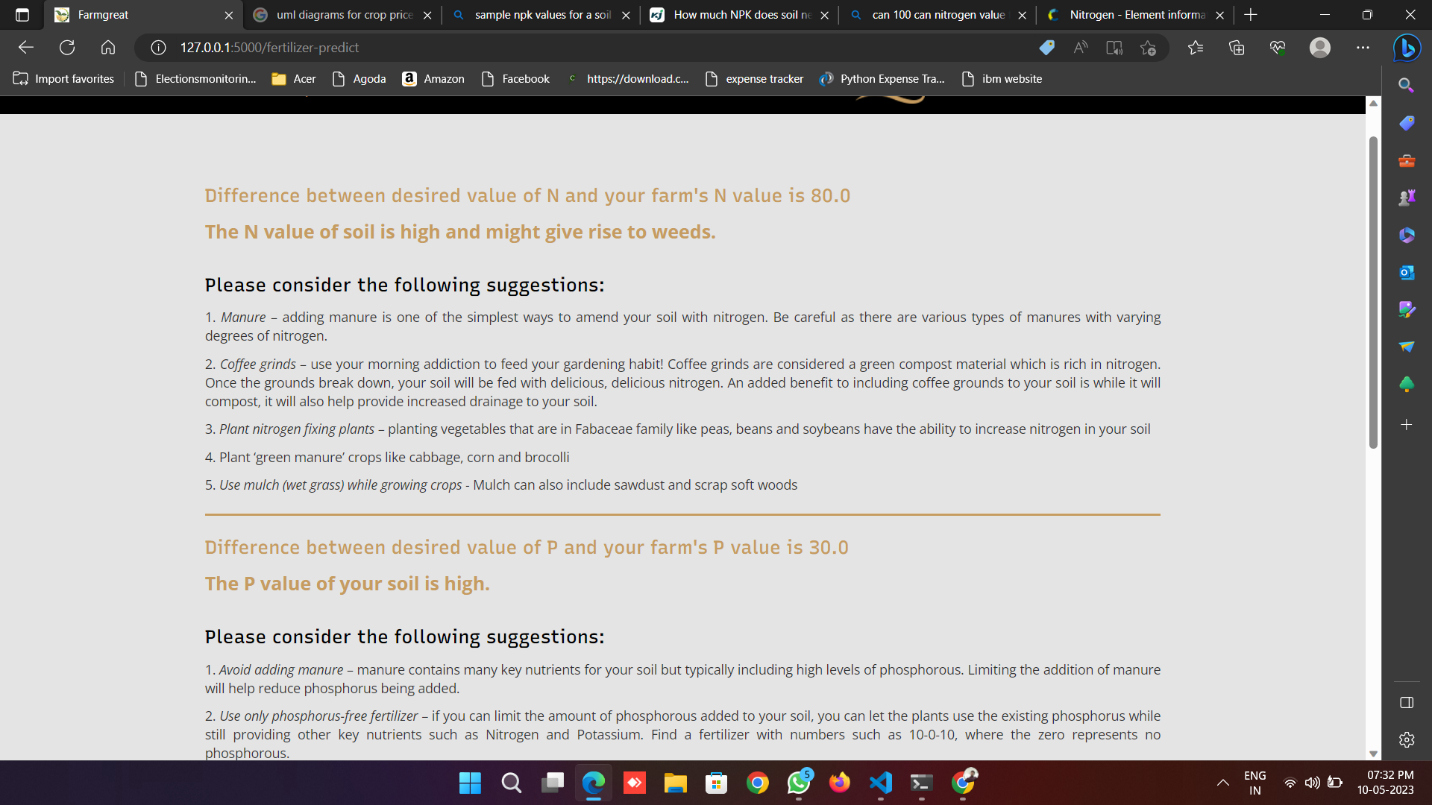


Figure 6.4: Fertilizer Recommendation Module (Input the values)

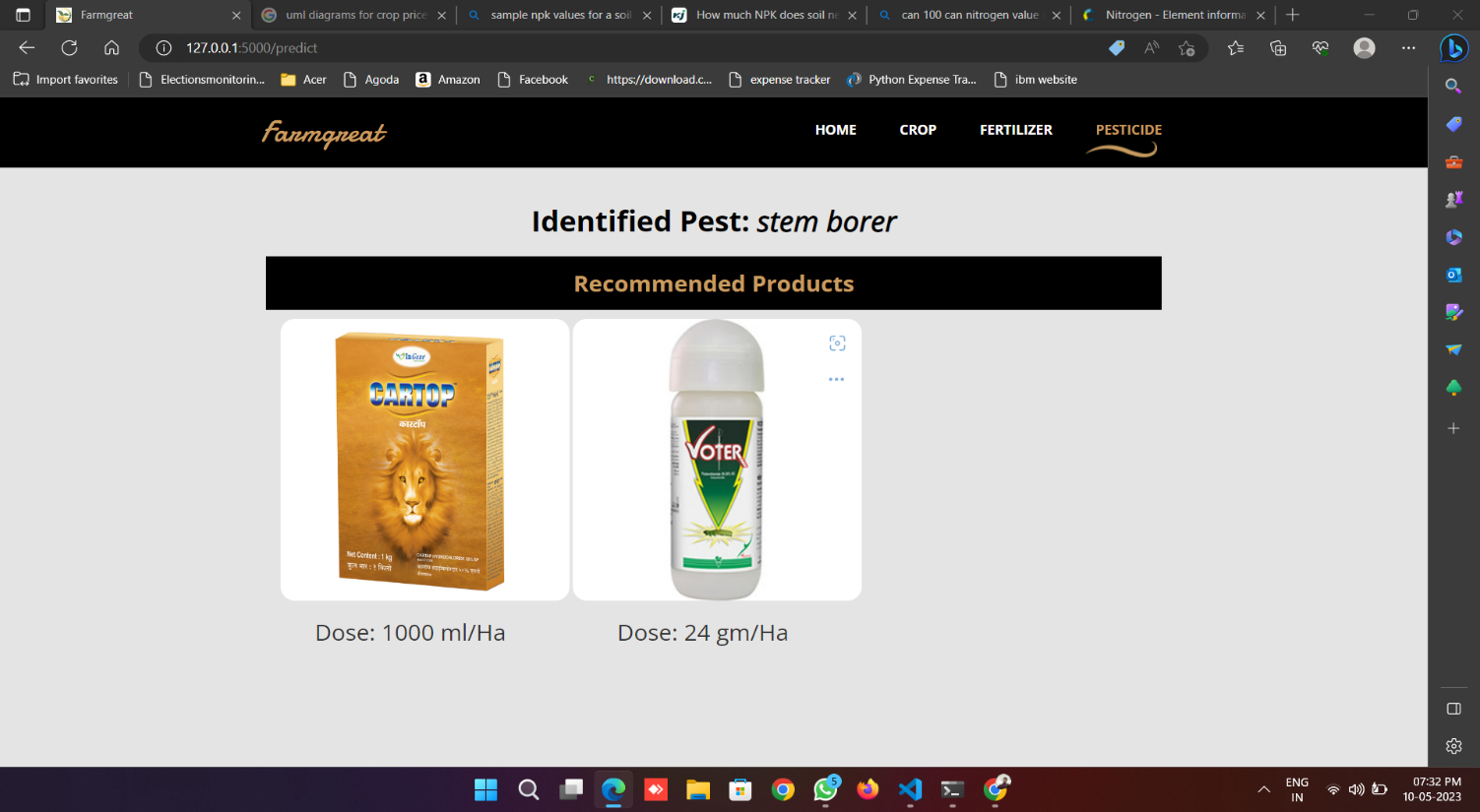


Figure 6.5: Pesticide Recommendation Module (Results after Manual Selection)

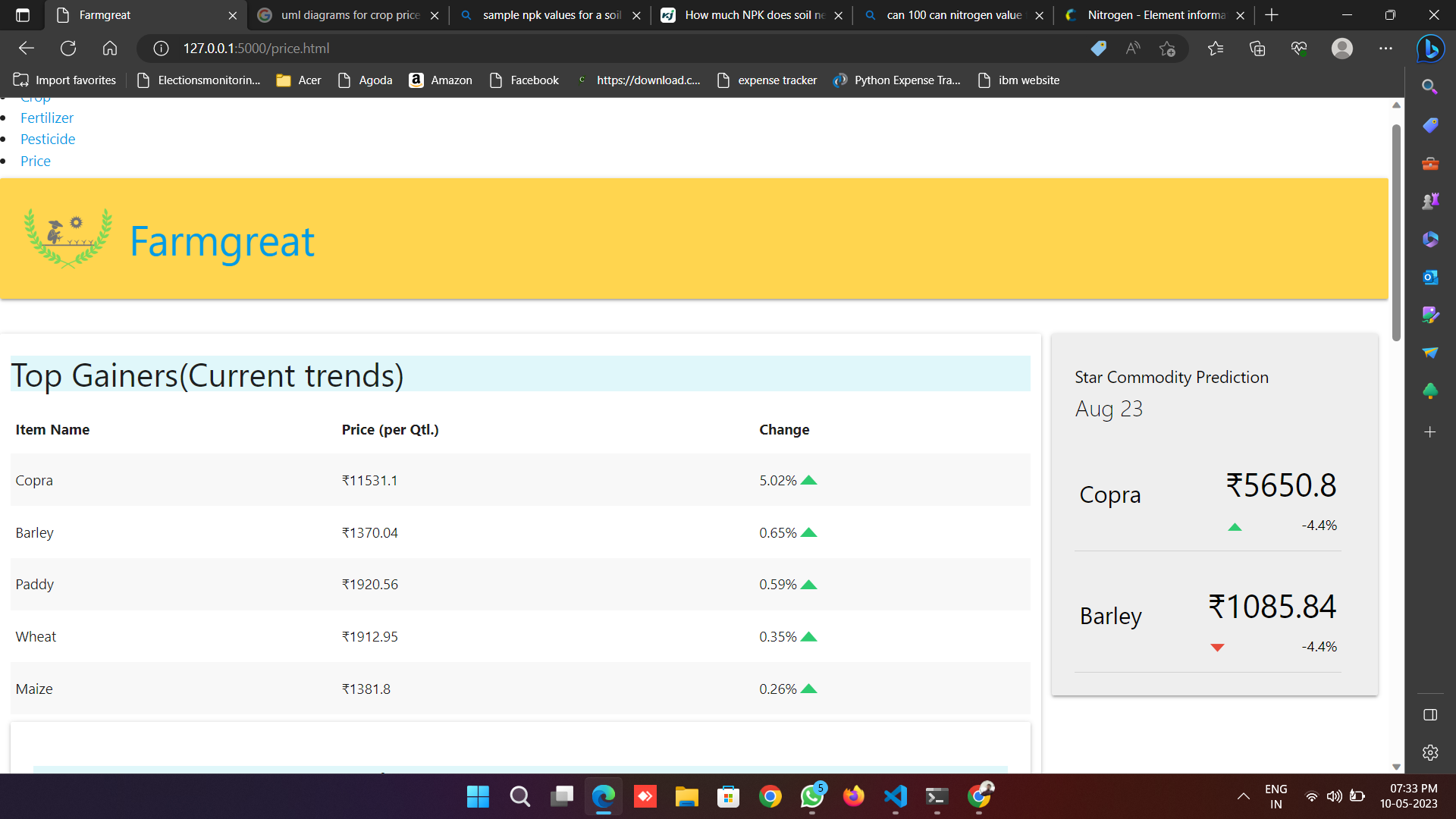


Figure 6.6 Price Prediction

## Analysis

The proposed model for our project can be judged in various aspects. Firstly, for the crop recommendation, since ML model is used to predict the crop which would be best suited as per site specific parameters, so here accuracy score helps to tell about how effective the solution is. Ensemble model using majority voting technique was used. The learners are: Naive Bayes, KNN, SVM and Random Forest. Accuracy Score came out to be 96.44%. The desired accuracy was >= 90%, but ML model is able to achieve 96.44%, hence it’s appreciable. Since, Fertilizer Recommendation is simply a dictionary based solution, so it is based on research performed by the team members. Last module is Pesticide Recommendation. If the user chooses to upload an image, then pesticide would be recommended post identification of the pest and pests are identified through the DL model which is CNN. Here, the performance metric is training and validation accuracy, training and validation loss which are shown below.

|  |  |  |
| --- | --- | --- |
|  | **ACCURACY** | **LOSS** |
| **TRAINING** | 0.9699 | 0.0311 |
| **VALIDATION** | 0.9520 | 0.0480 |

Figure 6.7 Bar Graph(Accuracy Analysis)

For pest identification, DL model is able to perform quite well but for some cases, DL model identifies “armyworm” as aphids due to close resemblance. Also, the system is not able to perform well with blur images, hence the user must upload the pictures that clearly show the pest.

**CHAPTER 7**

**CONCLUSION**

In this section conclusion and future scope with regards to this project is discussed.

## Conclusion

India’s farmers are hard at work. They help to feed a nation whose population is nearly 1.4 billion. However their productivity is threatened by some natural factors that can ruin their crops and their livelihoods.

So, this solution (Our project) will benefit farmers to maximize productivity in agriculture, reduce soil degradation in cultivated fields, and have informed advice on organic fertilizers/ other fertilizers and also know about the right crop by considering various attributes. This would provide a comprehensive prediction and hence benefit both farmers and the environment. Not only this, but pest control would also be a major issue to be solved via this project.

Our project suggests the crops based on soil characteristics, thereby preventing soil degradation which saves the environment. Natural fertilizers also benefit the environment. Pesticides that are recommended are as per ISO standards. Social benefits include that it will be helping that section of India to feed the nation of 1.4 billion, which means Indian farmers. Economic benefits are abundant because availing services of Our project just requires the user to have an account on the website which is absolutely free.

The whole journey of building “Our project” has been a valuable experience, starting with the

discovery of possible opportunities to think of the idea to the phase where the same idea was actually deployed. The team gained insight into the field of software development and now in the future, members shall feel more confident in the process of project development. Furthermore, it was learnt how to analyze the existing frameworks and perform literature surveys and utilize that analysis to identify the problem statement, research gaps and come up with the solution ideas. It was a learning of how to incorporate and take care of the user requirements. It was the time when the importance of documentation was realized and what are techniques involved in being organized about it. One of the takeaways was how to manage the resources in an efficient manner and most importantly to use common sense and build a viable and efficient model, but the best takeaway was development of analytical skills while working in the team and discussing each point of the assigned task in detail. The whole project helped us in exploring the skills as a computer engineer and improved confidence levels, ability to work under pressure and helped in learning project management techniques. It aided the members to be familiarized with the working and delivering of projects and how to build an entire product from just an idea.

## 7.2 Future Scope

Our project is not limited to current usage, it can be extended to many features as discussed below”:

* + 1. Our project currently supports 22 crops that are apple, banana, blackgram, chickpea, coconut, coffee, cotton, grapes, jute, kidney beans, lentil, maize, mango, mothbeans, mungbean, muskmelon, orange, papaya, pigeon peas, pomegranate, rice, watermelon. Later on, the admin can add other crops. Moreover in the future, fertilizers can also be added accordingly. The training was done on 10 pests: aphids, armyworm, beetle, bollworm, earthworm, grasshopper, mites, mosquito, sawfly and stem borer and with this pesticides are suggested. In future, training can be done on more pests and more pesticides can also be added according to the pests.
    2. In Crop Recommendation, values are manually entered by user of temperature, humidity, rainfall. Admin can also use some weather API to fetch the real time parameters by the city and state.
    3. In Pesticide Recommendation, the uploaded image should be clear for correct results, otherwise with a blur image, the system sometimes gives wrong results so, further filters can be used to obtain better results. Also the system can use better DL models.
    4. In future pesticide code can be integrated with drone code so that it can take live pictures of pests and by email or by mobile the farmers would be notified about the pest along with the pesticides.

**REFERENCES**

1. Rajak, Rohit Kumar, et al. “Crop Recommendation System to Maximize Crop Yield using Machine Learning Technique.” International Research Journal of Engineering and Technology (IRJET), vol. 04, no. 12, 2017, pp. 951-952. IRJET, <https://www.irjet.net/archives/V4/i12/IRJET-V4I12179.pdf>.
2. Dighe, Deepti, et al. “Crop Recommendation System for Precision Agriculture.” *IRJET*, vol.

05, no. 11, 2018, pp. 476-480. *IRJET*, <https://www.irjet.net/archives/V5/i11/IRJET-V5I1190.pdf>.

1. Mokarrama, Miftahul Jannat, and Mohammad Shamsul Arefin. “RSF: A Recommendation System for Farmers.” Region 10 Humanitarian Technology Conference, vol. 2, no. 17, 2017, [https://www.researchgate.net/publication/323203384\_RSF\_A\_recommendation\_system\_for\_far](https://www.researchgate.net/publication/323203384_RSF_A_recommendation_system_for_farmers) [mers](https://www.researchgate.net/publication/323203384_RSF_A_recommendation_system_for_farmers).
2. Gandge, Yogesh, and Sandhya. “A study on various data mining techniques for crop yield prediction.” IEEE Xplore, 2017. IEEE Xplore,<https://ieeexplore.ieee.org/document/8284541>.
3. Mishra, Shruti, et al. Use of data mining in crop yield prediction. 2018. ResearchGate, [https://www.researchgate.net/publication/326073480\_Use\_of\_data\_mining\_in\_crop\_yield\_predi](https://www.researchgate.net/publication/326073480_Use_of_data_mining_in_crop_yield_prediction) [ction](https://www.researchgate.net/publication/326073480_Use_of_data_mining_in_crop_yield_prediction).
4. Wu, Xiaoping, et al. A Large-Scale Benchmark Dataset for Insect Pest Recognition. 2019.

IEEE Xplore,

[https://openaccess.thecvf.com/content\_CVPR\_2019/papers/Wu\_IP102\_A\_Large-Scale\_Benchm](https://openaccess.thecvf.com/content_CVPR_2019/papers/Wu_IP102_A_Large-Scale_Benchmark_Dataset_for_Insect_Pest_Recognition_CVPR_2019_paper.pdf) [ark\_Dataset\_for\_Insect\_Pest\_Recognition\_CVPR\_2019\_paper.pdf](https://openaccess.thecvf.com/content_CVPR_2019/papers/Wu_IP102_A_Large-Scale_Benchmark_Dataset_for_Insect_Pest_Recognition_CVPR_2019_paper.pdf).

1. Kasinathan, Thenmozhi, et al. Insect classification and detection in field crops using modern machine learning techniques. 2020. Science Direct, <https://www.sciencedirect.com/science/article/pii/S2214317320302067>.
2. Ding, Weiguang, and Graham Taylor. Automatic moth detection from trap images for pest management. 2016. Science Direct, [https://www.sciencedirect.com/science/article/pii/S0168169916300266?casa\_token=EM\_2nL2k](https://www.sciencedirect.com/science/article/pii/S0168169916300266?casa_token=EM_2nL2kQswAAAAA%3APOy8LOCK6U1FOou5RxJujTtBAhO5ofZxktJ4jmUBcDryDZHXjbgvrNS5dJi6xwsu9vZVnAULFoh_) [QswAAAAA:POy8LOCK6U1FOou5RxJujTtBAhO5ofZxktJ4jmUBcDryDZHXjbgvrNS5dJi6x](https://www.sciencedirect.com/science/article/pii/S0168169916300266?casa_token=EM_2nL2kQswAAAAA%3APOy8LOCK6U1FOou5RxJujTtBAhO5ofZxktJ4jmUBcDryDZHXjbgvrNS5dJi6xwsu9vZVnAULFoh_) [wsu9vZVnAULFoh\_](https://www.sciencedirect.com/science/article/pii/S0168169916300266?casa_token=EM_2nL2kQswAAAAA%3APOy8LOCK6U1FOou5RxJujTtBAhO5ofZxktJ4jmUBcDryDZHXjbgvrNS5dJi6xwsu9vZVnAULFoh_).
3. TÜRKOĞLU, Muammer, and Davut HANBAY. Plant disease and pest detection using deep learning-based features. 2018. Turkish Journal of Electrical Engineering & Computer Sciences, <https://journals.tubitak.gov.tr/elektrik/issues/elk-19-27-3/elk-27-3-6-1809-181.pdf>.
4. Selvaraj, Michael Gomez, et al. AI-powered banana diseases and pest detection. 2019.

Plant Methods, <https://plantmethods.biomedcentral.com/articles/10.1186/s13007-019-0475-z?utm_source=dlvr.it> [&utm\_medium=twitter](https://plantmethods.biomedcentral.com/articles/10.1186/s13007-019-0475-z?utm_source=dlvr.it&utm_medium=twitter).