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Farmer Assistant

In partial fulfilment of the requirements for the degree of

Bachelor of Science in Computer Science

Supervisor: Summaira Nosheen

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C e r t i f i c a t e

We accept the work contained in the report titled

"Farmer Assistant"

written by

ABU HURAIRA

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as a confirmation to the required standard for the partial fulfilment of the degree of Bachelor of Science in Computer Science.

Approved by:

Supervisor: Ms. Summaira Nosheen (Lecturer).

_____ (Signature)

June 14, 2022

DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations which have been duly acknowledged. We also declare that it has not been previously and concurrently submitted for any other degree or award at Bahria University or other institutions.

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Date : June 14, 2022

Specially dedicated to
my beloved parents and teachers
(ABU HURAIRA)
my beloved parents and teachers
(ASJAD BUTT)

ACKNOWLEDGEMENTS

Starting with the name of Allah (S.W.T), first we are very grateful to Allah (S.W.T) for giving us strength to complete this project. We would like to thank everyone who had contributed to the successful completion of this project. We would like to express our gratitude to our research supervisor, Miss Summaira Nosheen for her invaluable advice, guidance, and her enormous patience throughout the development of the research.

In addition, we would also like to express our gratitude to our loving parents and friends who helped and encouraged us.

ABU HURAIRA
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FARMER ASSISTANT

ABSTRACT

Agriculture plays a very key role in the growth of a country like Pakistan where quarter of its GDP is produced by agriculture every year. Top agricultural countries in the world with the passage of time evolve their agriculture with the technology. While in contrast to that, the problem is that Pakistan is still using the conventional agricultural techniques for their farming and not taking advantage from the latest technology. There is not any online platform that provides farmers of Pakistan that which crop is suitable according to their soil, when to use fertilizer, about weather forecast and awareness of technology for farming. Due to unavailability of any platform or guidance, farmers take random decision based on their knowledge without considering many factors like climate change and ultimately these decisions sometimes lead towards the loss and this loss in a way effects the agricultural rate of Pakistan.

The problem of finding the right crop for the right soil is solved if we provide a platform where we recommend farmers that which crop is suitable according to your soil by taking some input regarding that soil. By using that platform guidance and awareness to farmers also be provided. Machine learning is used for the recommendation of crop. Different classification algorithms K Nearest Neighbour, Decision Tree, Logistic Regression, Support Vector Machine and Random Forest are used for the recommendation system. The best accurate algorithm is further used for recommendation. Further system is deployed into a mobile application which is farmer friendly and has an interactive outlook.

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CHAPTER 1

1 INTRODUCTION

1.1 Background

There is not even a single online platform exist in Pakistan where farmers get recommended that which crop is suitable according to their soil. Due to lack of these platforms, farmers are still using the old conventional techniques and are unaware of that how technology helps them increase in their growth of their crop. Weather forecast also plays a very important role in the life of the crop of the farmer. So, weather prediction is also required. Due to unavailability of any such platform or due to unawareness, farmers take random decision based on their knowledge about crop production and this thing sometimes leads them towards a big loss. So, a platform is needed where guidance and awareness are provided to farmers to increase the growth of their crop.

1.2 Problem Statements

It is essential for farmers to know that their soil is suitable for which crop so that after knowing about the property of their soil they increase the growth of their crop. There is no such an easily accessible platform available to farmers though which they know about the best suitable crop according to their soil. Similar problems are for weather prediction and fertilizer prediction. There is also lack of awareness in farmers that how technology is used to increase the production rate of agriculture. To resolve all these queries related to farmers, a platform is needed that is easily accessible to farmers.

1.3 Aims and Objectives

The objectives behind developing the farmer assistant application are as followings:

i) Design a mobile application that primarily focuses on recommending farmers appropriate crops related to their soil.
ii) Give awareness to farmers that how they use technology to improve the growth of their crop to fill the communication gap between them.
iii) Recommend weather forecast.
iv) Recommend when it is the right time to use fertilizer.
v) Create a farmer friendly application.

1.4 Scope of Project

Farmer Assistant app primarily focuses on assisting farmers in many ways. Application assists farmers by recommending right crop for them and recommending when to use fertilizers and predicting about weather, so farmers are saved from any big loss. Awareness content is available on the application through which awareness is provided to farmers that what are the Do's and Don'ts that they must do regarding the current situation. Tips were given to farmers that how they improve their crop production. Successful farmers or experienced farmers shared their views or tips with other farmers on the application. Every farmer has his own profile on the application. Registered farmer users are notified about weather and fertilizer prediction based on their location. For crop recommendation selected classification algorithms K Nearest Neighbour, Decision Tree, Logistic Regression, Support Vector Machine and Random Forest are used. Further with Random Forest maximum accuracy of 99% is achieved. Application is available in both English and Urdu languages. In case of any query or problem, users contact the admin and admin will response to users.

CHAPTER 2

2 SOFTWARE REQUIREMENT SPECIFICATIONS (SRS)

2.1 User Types and Attributes

The two types of users that uses the system are:

Admin

Admin login to the system through which admin will have the full access to the system and admin view all the registered farmers, update any farmer user, delete any farmer user, reset the password of any registered farmer user and logout as well. Admin also post content related to farmers awareness on application.

Farmers

Farmers will register to the application though which after that they get their crop recommendation, weather prediction, fertilizer prediction and access awareness content available on the application. Registered farmers will have to just login to access all the above features.

2.2 Operating Environment

The hardware and software requirements of the system are as followings.

Table 1 System Features

Name	Description
Operating Systems	UNIX and Windows
Browsers	Google Chrome 77.0.3865.120, Firefox 94, Microsoft Edge 86.0.622.63 and Internet explorer11.
Languages	PHP8.0, Python3, C#10.0, Unity
Tools	Anaconda Navigator 2.1.0, Unity 3D LTS, Visual Studio Code 1.62, HEROKU, 000webhost
Database	MYSQL 8.0.27

2.3 Implementation and Interface Constraints

C# and unity are used for the front end interface of the application and for back-end development python is used. The database that is used for storing the data of the farmers is MySQL. Machine learning is used to build a model of dataset in the back end and then that model is deployed into the application.

2.4 Assumptions and Dependencies

- The performance of application is limited to motivate farmers that they really need this application, and they must use it.
- Marketing or availability of application is another challenge related to the performance of the application that the farmers must know that there exists a platform through which they get their crop recommendation and other facilities.
- To make the application in such a way that it is usable by every farmer (farmer friendly).
- Consistently achieving the accuracy in real time for all farmer users.
- To get trust of farmers on the application.

2.5 System Requirement Chart

Table 2 System Requirement Chart

Req.ID	Req. Type	Req. Priority	Req. Source	Req. Title	Req. Description
FR 1	Functional	High	Farmer User Admin	Access	System provides its access to the farmer user and admin.
FR 2	Functional	High	Farmer Users	User Registration	Farmers are able to register into the system and the system restricts more than one farmer user with the same username.
FR 3	Functional	High	Admin Farmer	Content	Admin post awareness content on the application. Farmers access the awareness content.
FR 4	Functional	High	Admin	Manage farmers account	The system allows the admin to view, delete and update farmer user details.
FR 5	Functional	High	Farmer Users	Crop Recommendation	System will provide the admin the access of

					viewing farmer details.
FR 6	Functional	High	Farmer Users	Prediction	The system will provide farmer users prediction regarding when to use fertilizer.
FR 7	Functional	High	Farmer Users	Weather Forecast	System will provide weather forecast to farmers.
FR 8	**Account Management**				
FR 8.1	Functional	Medium	Admin	Account Management	The system allows the admin to edit, update and view his account.
FR 8.2	Functional	Medium	Farmer	Account Management	The system allows the farmer user to edit, update and view his account.

FR 9	Functional	High	Farmer	Query	Farmers contact the admin in case of any queries through chat service.
FR 10	Functional	High	Farmer	Language	The system will allow farmer users to switch between languages (i.e., English and Urdu).

2.6 Other Non-functional Requirements

2.6.1 Performance Requirements

- The framework consistently and correctly performs all of its functions.
- The framework responds to the request in a fair amount of time.
- After the user submits information to the system, the system shows a confirmation message to the user in a reasonable amount of time.
- In a suitable period, the system loads the results of recommendation and prediction.

2.6.2 Requirements for Security:

- Only approved farmer users have access to the system.
- To access the services, the user must first log into the system.

2.6.3 Additional Requirements

2.6.3.1 Availability:

- The system is available 24 hours a day, seven days a week.

2.6.3.2 Maintainability:

- The system is simple to maintain and configure..

2.7 Literature Review

2.7.1 Related Work to Farmer Assistant:

2.7.1.1 Crop Recommender System Using Machine Learning Approach

Agriculture and the sectors associated to it are surely the large providers of livelihood in a country whose quarter of its Gross Domestic Product is produced by agriculture. Top agricultural countries in the world with the passage of time evolve their agriculture with the technology. There is not any online platform exists that tell farmers which crop is suitable according to their soil. Due to unavailability of any platform or guidance, farmers take random decision based on their knowledge without considering many factors like climate change and ultimately these decisions sometimes lead towards the loss. To recommend crops, weather forecast and fertilizer prediction different classification algorithms K Nearest Neighbour, Decision Tree, Logistic Regression, Support Vector Machine and Random Forest are used (PANDE, et al., 2021).

2.7.1.2 Crop Recommendation System for Precision Agriculture

The paper is about how data mining is helpful in deriving meaningful information from large sets of data. Precision agriculture is a technique that is used in the proposed system of this paper. This technique is based on different attributes of soil. A web-based system is proposed in the paper where after entering attributes of his soil farmer will get recommended about best suitable crop. Random Tree, Naïve Bayes, K-Nearest Neighbour and CHAID are the algorithms used for recommendation. The accuracy of the proposed system is 88 percent (S. Pudumalar, 2017).

2.7.1.3 Crop Recommendation System:

The paper is about recommending crops to farmers using Arduino microcontrollers and by machine learning techniques. The system works in such a way that environmental data is gathered from the sensors and then that collected data is further processed by machine learning algorithms to recommend the right suitable crop. Sunlight, ph., Soil Moisture, temperature and humidity sensors are used. Naïve Bayes, Support Vector Machine and K-Means Clustering are the algorithms that are used (Pradeepa Bandara, 2020).

2.7.1.4 Efficient Crop Yield Recommendation System:

The paper proposed a web-based crop recommendation system for farmers using Support Vector Machine algorithm. The system recommends the crop and predicts the yield by taking soil attributes as an input from users. System also predicts that how much quantity of a fertilizer is required by a crop. Crop prediction is city wise. Backing Vector Machine Approach is used for calculations. System also stores data in the database (Dr.G.Suresh, 2021).

2.7.1.5 Smart Farming using Machine Learning Techniques:

The paper proposed a web system which recommends farmers the right crop for their soil, weed estimation, pesticides recommendation and the cost that occurred on cultivation of the crops. For crop recommendation a dataset has been taken from Kaggle and different machine learning algorithms are applied to recommend crops. For weed identification they system takes the image of the plant as an input and then identifies the weed. Similar approach is used for pest identification (DivyaShamilib, 2022) .

2.7.2 Conclusion:

Author(s)	Method	Subject(s)	Results
(PANDE, et al., 2021)	Machine Learning Algorithms (K Nearest Neighbour, Decision Tree, Logistic Regression, Support Vector Machine and Random Forest)	Crop Recommendation, Fertilizer Recommendation	User friendly application, crop recommendation model, Random Forest algorithm with 95% accuracy, fertilizer recommendation system
(S. Pudumalar, 2017)	Precision Agriculture, Machine Learning Algorithms (Random Tree, Naïve Bayes, K-Nearest Neighbour and CHAID), Dataset Collection	Precision Agriculture, Data Mining, Crop Recommendation	Web Based System of crop recommendation with an accuracy of 88%.
(Pradeepa Bandara, 2020)	Arduino Microcontrollers, Machine Learning Techniques (Naïve Bayes, Support Vector Machine and K-Means Clustering), Dataset Collection	Crop Prediction, Arduino Sensors, Internet of Things (IOT)	IOT based system with an accuracy of more than 95% for different attributes.
(Dr.G.Suresh, 2021)	Support Vector Machine Artificial Intelligence	Crop Recommendation, Fertilizer Recommendation, Soil Nutrients	Web Based Recommender System of Crop Prediction and Crop Recommendation
(DivyaShamilib, 2022)	Machine Learning Algorithms Ada Boost Classifier, XGB Classifier	Crop Recommendation, Weed Identification, Pest Identification	Web Based system with crop recommendation, weed identification and pest identification

2.7.3 CLASSIFICATION ALGORITHMS

2.7.3.1 Decision Tree:

In data mining classification is a very important problem. There are many classification algorithms that are used for classification problems. A classification problem has training set which was based on the input dataset. The categorical attributes in a dataset are called as class labels.

Decision tree is a tree-based technique in which the data is separated from the root node until the Boolean outcome at the leaf node is achieved. It is used in machine learning, image processing and for identification of patterns. In decision tree, entropy is used to calculate the impurity or randomness in the data (Bahzad Taha Jijo, 2021).

2.7.3.2 K Nearest Neighbour:

K Nearest Neighbour is a simple and effective classification algorithm which classifies data based on its neighbours. To select its neighbours a value of k is used. Moreover, it also classifies its neighbours based on Euclidean distance. It measures the distance between the tested data and each of the training data to determine the final output from class label. In k nearest neighbour the value of k is an important decision to take because very large of k causes noises in data and due to very small value of k there are chances of including datapoints from other classes (Gweon, M, & SH., 2019).

2.7.3.3 Random Forest:

Random forest is a classification algorithm which is considered as an advanced version of decision trees. It is called as random forest because it is a combination of multiple decision trees. In random forest the algorithm first chooses the trees randomly and then the splitting is done based on the best features from the randomly chosen trees. While the problem in decision trees is that they sometime lead towards overfitting while random forest is robust to overfitting (Abdulazeez, 2021).

2.7.3.4 Support Vector Machine:

Support vector machine is a classification algorithm that is used for limited classification problems. Support vector machine did classification by dividing the class labels into two parts by drawing a line classed as hyperplane or decision boundary. So, by this next time whenever a data point comes it is easily put it into the right class label or a datapoint is easily identified that to which class does it belong. Drawback of support vector machine algorithm is that it didn't work well on large datasets because then it led towards overfitting (S. Ghosh, 2019).

CHAPTER 3

3 DESIGN AND METHODOLOGY

This chapter gives an overview of the design and methodology of the Farmer Assistant. Design and methodology give a complete view of how the farmer assistant application operates. This will aid developers and users in fully comprehending and inspecting the design.

This chapter contains the following objects.

1. Farmer Assistant Use Case Diagrams.
2. Farmer Assistant Use Case Descriptions.
3. Farmer Assistant Sequence Diagrams.
4. Farmer Assistant Domain Model.
5. Farmer Assistant Entity Relationship Diagram
6. Farmer Assistant Operation Contracts

3.1 Farmer Assistant Use-Case Diagrams

3.1.1 Farmer Assistant System Use-Case

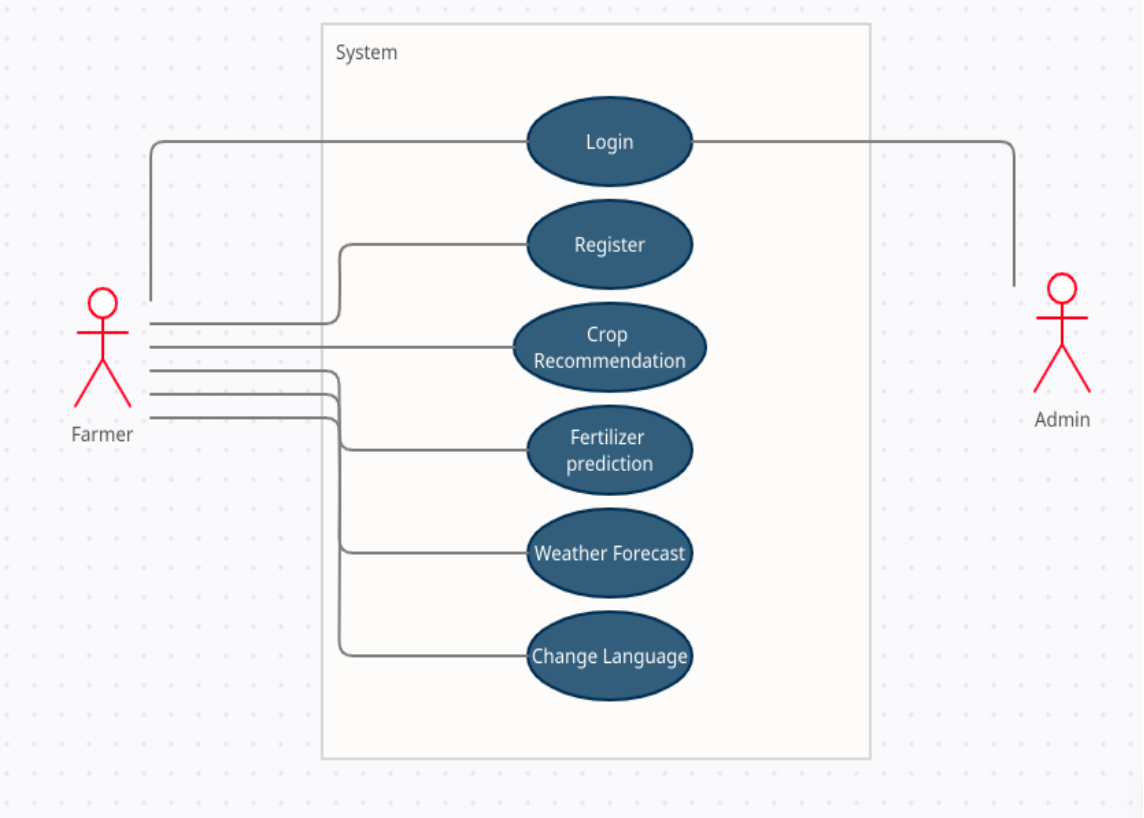

Figure 1 Farmer Assistant System Use-Case

3.1.2 Farmer Assistant Login Use-Case

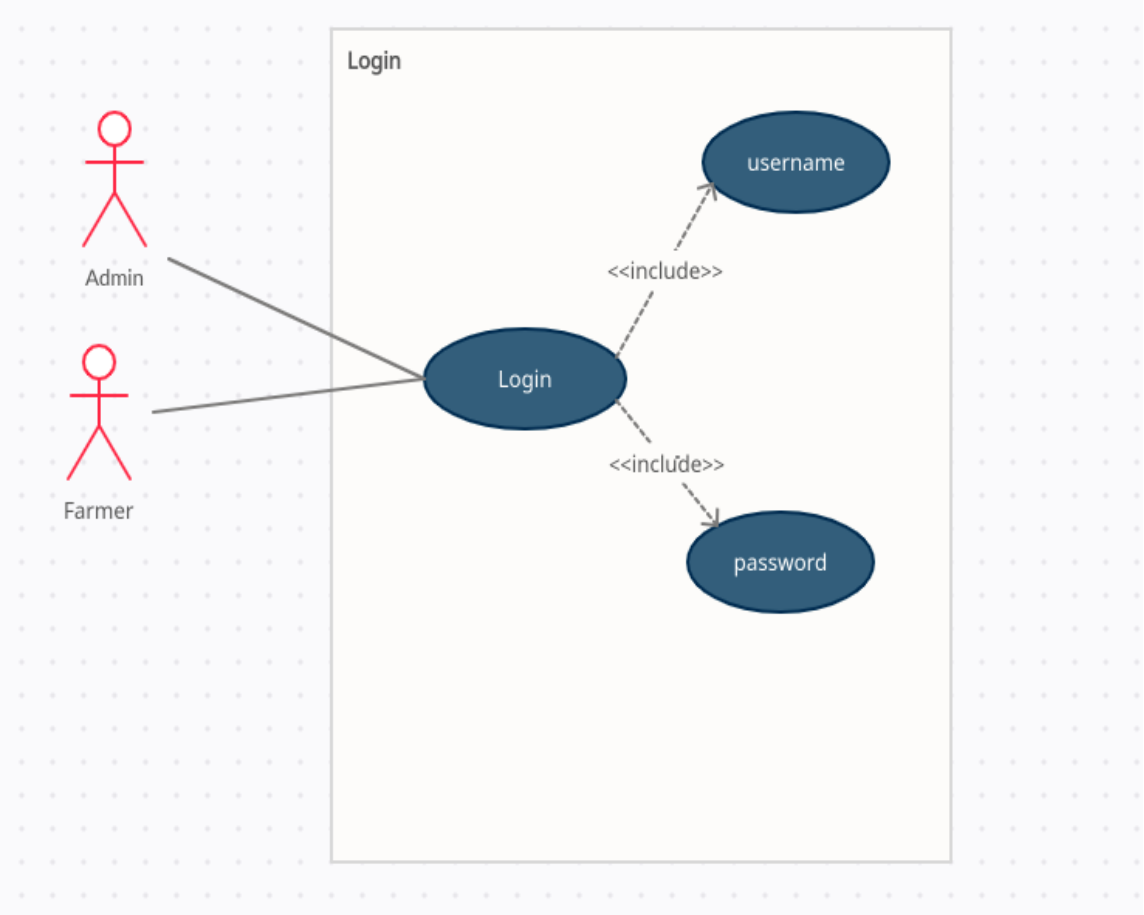

Figure 2 Farmer Assistant Login Use-Case

3.1.3 Farmer Assistant Registration Use-Case

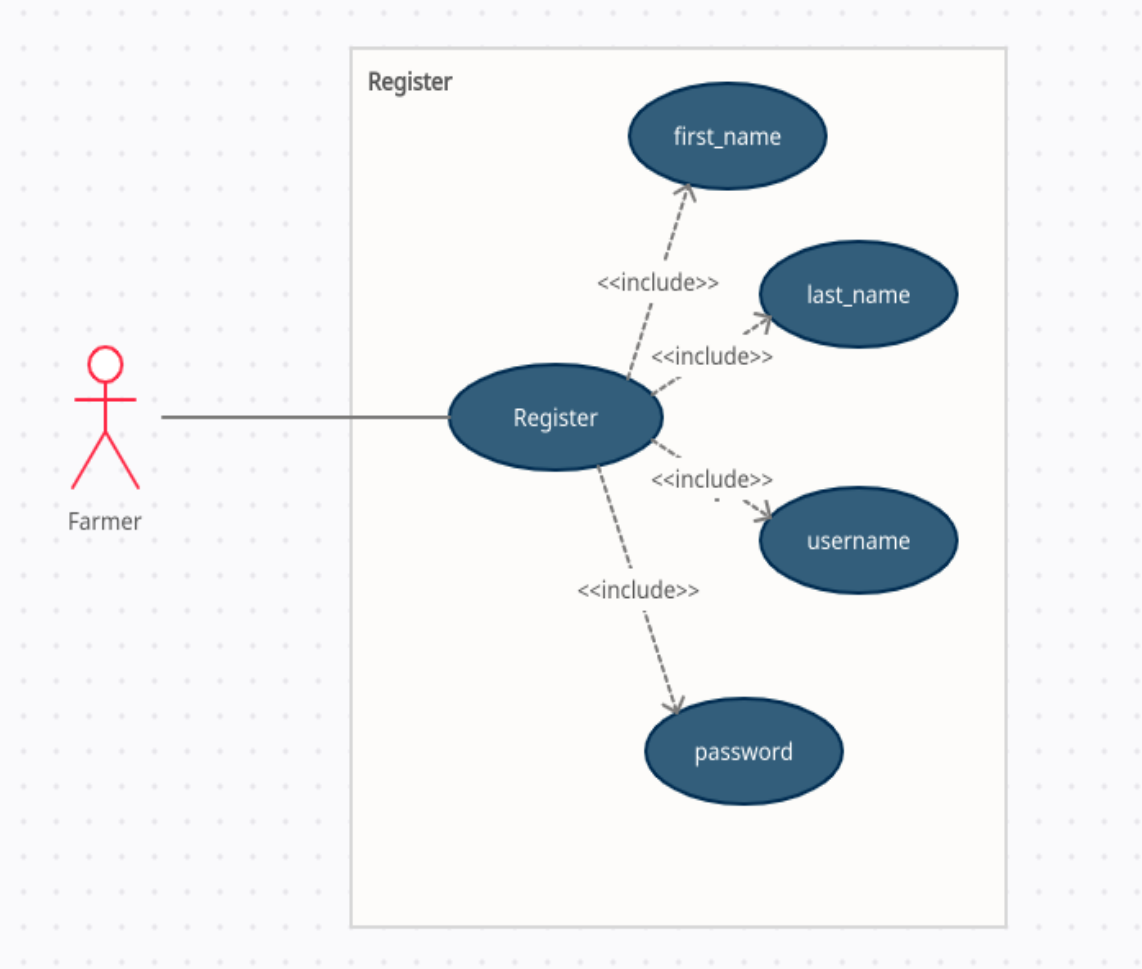

Figure 3 Farmer Assistant Registration Use-Case

3.1.4 Crop recommendation Use-Case

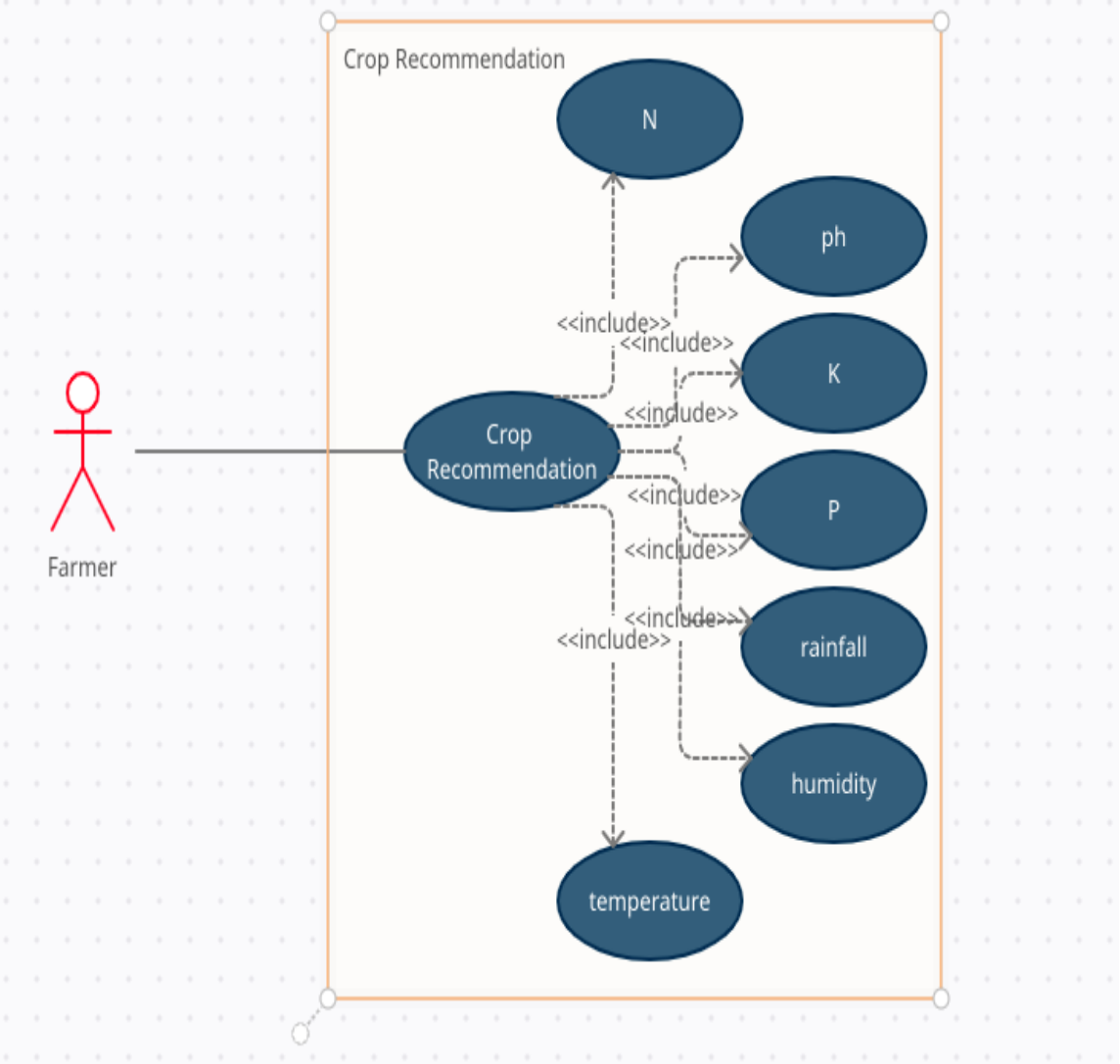

Figure 4 Crop recommendation Use-Case

3.1.5 Fertilizer Prediction Use-Case

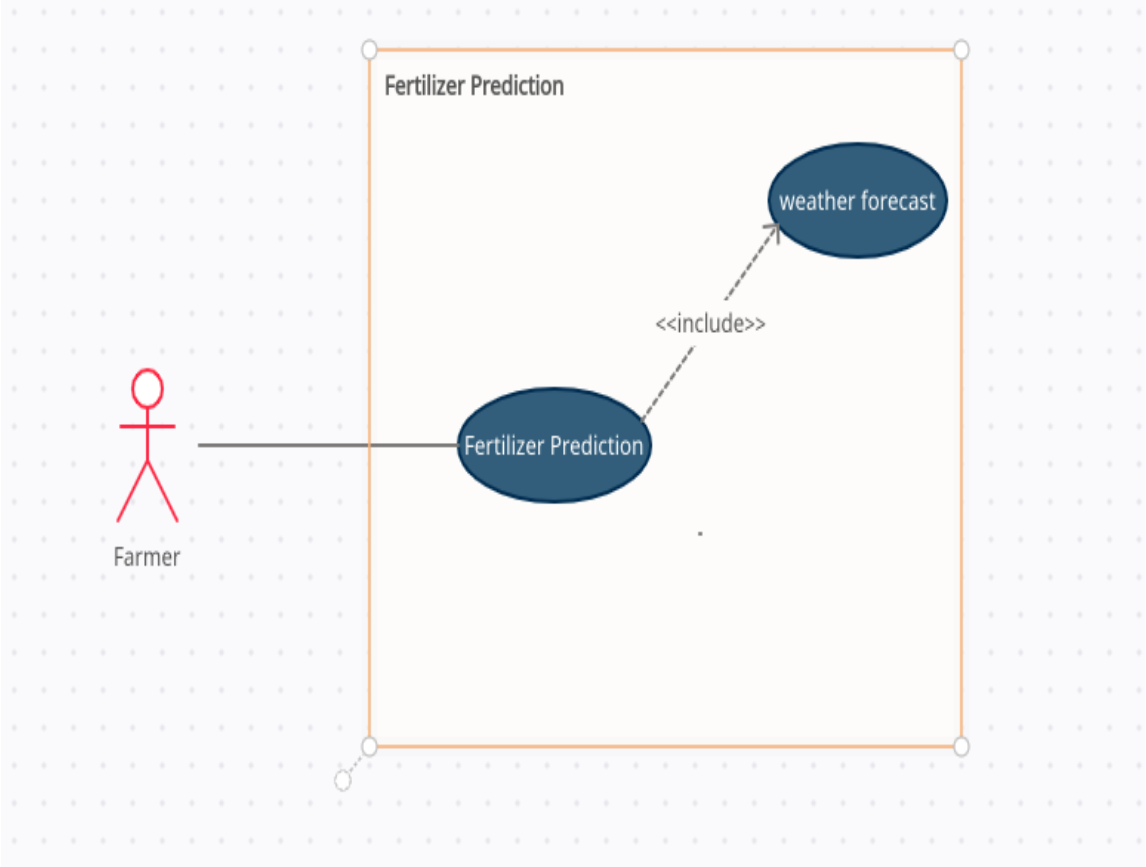

Figure 5 Fertilizer Prediction Use-Case

3.1.6 Weather forecast Use-Case

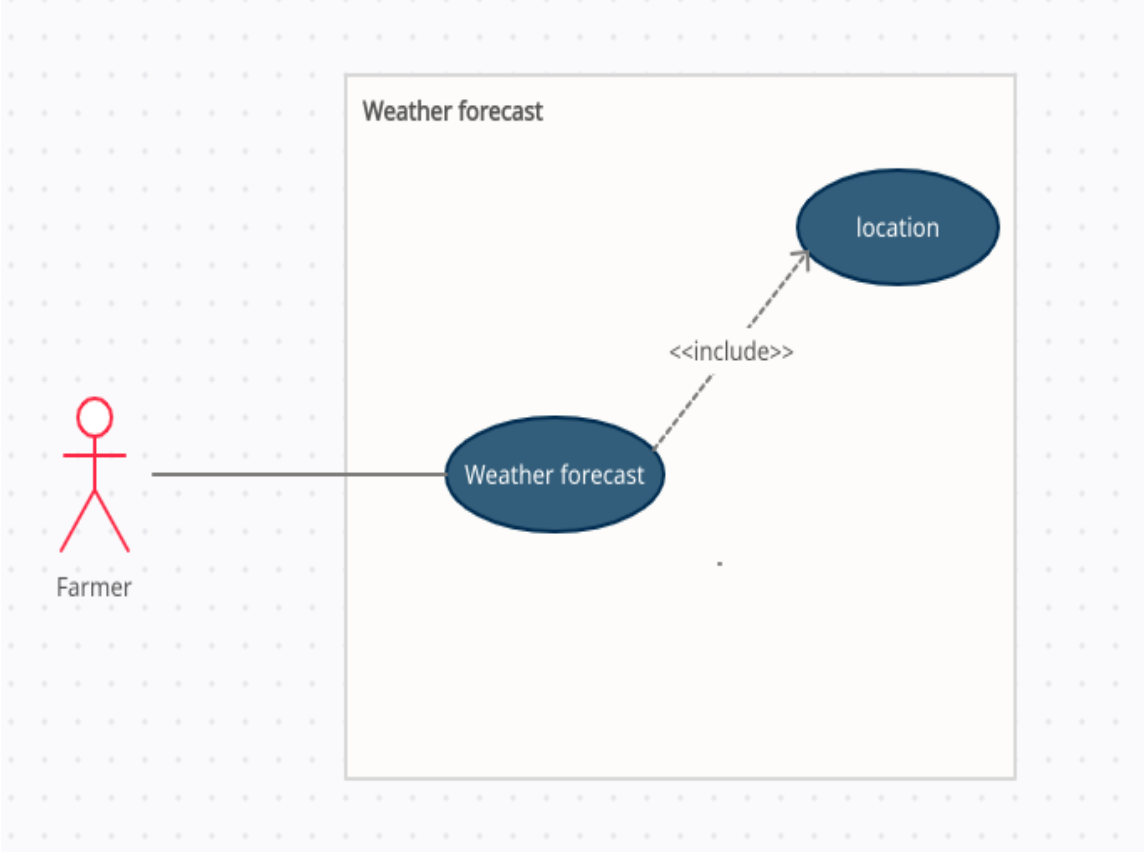

Figure 6 Weather forecast Use-Case

3.2 Farmer Assistant Use Case Descriptions

3.2.1 Farmer Assistant Main UC-Description

Table 3 Farmer Assistant Main UC-Description

UC Name: Farmer Assistant	**Id:** FA-1	**Priority:** High
Actor: Farmer, Admin		
Description: The table describes the main uses of the Farmer Assistant system.		
Triger: The use case is about the general operation of the Farmer Assistant system.		
Type: External		
Pre-Condition: The farmer logs onto the application and creates an account.		
Normal Course	**Information for steps**	
1. Farmer opens the application and registers himself.. **1.1** Application send request to the server and server stores data in the database. **1.2** After registration, application gives a registration successful message to the user.	Username and Password	
2. Farmer user requests for login	Verify login and redirect to the profile	
2.1 System approved the request for login	N, P, K, rainfall, humidity, temperature	
3. Farmer do crop recommendation.	Location	
3.1 System recommends which crop to grow.	Weather Forecast	
4. Farmer checks weather forecast.		
5. System does fertilizer prediction.		
5.1. System recommends whether to use fertilizers or not depending on the weather forecast.	Urdu, English Database update	

6. Farmer user is able to switch languages. **7.** Admin add, remove, update, and delete farmer's data from the database and notify the users. **8.** Farmer and Admin user is able to logout.	

Post condition: The farmer saves the results to view them later and logout at the end to keep their account secure.
Exception: System might recommend wrong crop due to the inconsistent or wrong input data attributes of soil.

3.2.2 Farmer Assistant Login UC-Description

Table 4 Farmer Assistant Login UC-Description

UC ID:	FA-2
UC Name:	Manage Sign in
Actors:	Farmer, Admin
Description:	This use case will trigger when the user wants to login to the system
Preconditions:	The farmer visits the application and register himself/herself.
Post conditions:	If the farmer is a registered user, then it is directed to the main page.
Typical Flow:	
Farmer Action	**System Response**
1. The farmer opens the login page by clicking the sign in button.	The system acknowledges the request and redirects the user to the sign in page.
2. Farmer user provides sign in information.	In response, system verifies and if credentials are correct, the user is directed to his account.

Exceptions:	User entered wrong credentials
Includes:	Username, Password
Priority:	High

3.2.3 Farmer Assistant Registration UC-Description

Table 5 Farmer Assistant Registration UC-Description

UC-ID:	FA-3
UC-Name:	Signup
Actor:	Farmer
Description:	The use case is about the signup of the farmer user.
Preconditions:	1. Farmer is connected to the internet. 2. Farmer clicks the signup button to register. 3. Farmer provides the registration details to register.
Post conditions:	Farmer user is directed to the login page after registration.
Normal Flow:	
User Action	**System Response**
1. Farmer user clicks the signup button.	System accepts the request and shows registration page.
2. Users enter registration credentials	System shows the message of successfully registered after the registration.
Exceptions:	There are possibilities that multiple accounts are registered with the same username.
Includes:	First name, last name, username, and password

3.2.4 Crop recommendation UC-Description

Table 6 Crop recommendation UC-Description

UC ID:	FA-4
UC Name:	Crop Recommendation

Actor:	Farmer
Description:	When the system recommends the crop to the user according to his soil then this use case will be triggered.
Preconditions:	The farmer enters the values of humidity, temperature, rainfall, K, P, N, and ph. of the land.
Post conditions:	The farmer enters the correct values before getting recommendation.

Normal Flow:	
User Action	**System Response**
1. User clicks on Crop recommendation.	System opens the Crop recommendation page.
2. User enter values and clicks on calculate button.	System passes the values to the machine learning algorithm and returns the result to the user.
3. Users click on save result.	System saves it in database.
Exceptions:	System may recommend wrong crop if the input data is wrong.
Includes:	Humidity, temperature
Priority:	High
Special Requirements:	The user interface is simple and easy to use.

3.2.5 Fertilizer Prediction UC-Description

Table 7 Fertilizer Prediction UC-Description

UC ID:	FA-5
UC Name:	Fertilizer Prediction
Actor:	Farmer

Description:	The use case is about when the farmer user wants to know whether to use fertilizer in the upcoming week or not.
Preconditions:	The weather forecast is accurate for the fertilizer prediction.
Post conditions:	The farmer is redirected to the home page.

Normal Flow:	
User Action	**System Response**
1. User clicks on fertilizer prediction.	System opens the fertilizer prediction page.
2. Users enter weather and click on predict button.	System passes the value to the algorithm and returns the result to the user and redirects to the home page
Exceptions:	System may recommend wrong prediction if the weather forecast is not accurate.
Includes:	Weather forecast
Priority:	High
Special Requirements:	The user-interface is farmer friendly.

3.2.6 Weather forecast UC-Description

Table 8 Weather forecast UC-Description

UC ID:	FA-6
UC Name:	Weather Forecast
Actor:	Farmer
Description:	The use case is about when the farmer user wants to check the weather forecast.
Preconditions:	The location is accurate for the weather forecast.
Post conditions:	Weather forecast is pass to the fertilizer prediction.
Normal Flow:	
User Action	**System Response**
1. User clicks on weather forecast.	System opens the weather forecast page.
2. Users enter location and click on check button.	System passes the value to the API and returns the result to the user and redirects to the fertilizer prediction page.
Exceptions:	System may recommend wrong weather forecast if the location is not accurate.
Includes:	Location
Priority:	High
Special Requirements:	The user-interface is farmer friendly.

3.3 Sequence Diagrams

3.3.1 Sequence diagram of system

Figure 7 Sequence diagram of system

3.3.2 Farmer Assistant Login Sequence Diagram

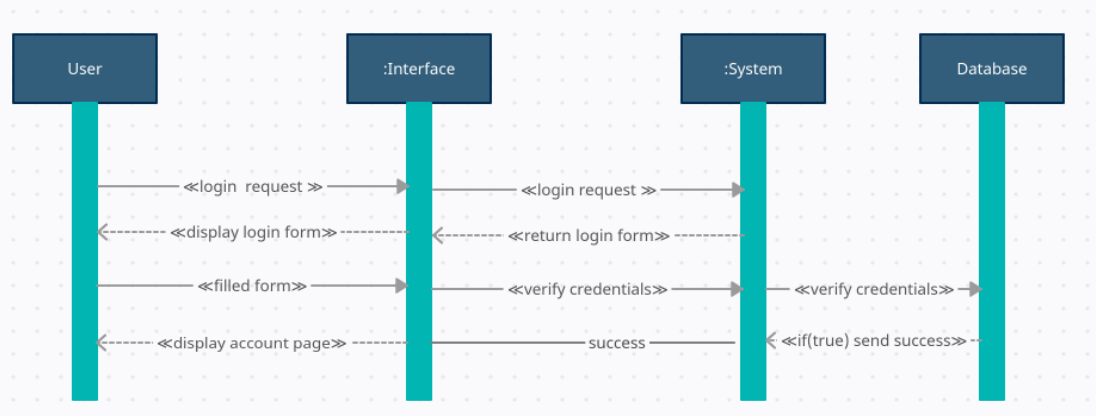

Figure 8 Farmer Assistant Login Sequence Diagram

The farmer accesses the application and sign in by clicking the sign in button. The interface sends a login request to the system. If it is successful, then login form is displayed to the farmer user. The farmer user then enters his login credentials, and the system will verify the user against the user login credentials from the database. The system will verify from the database that whether the user information is matched or not. If information is matched from the database, then the system directs the user to main home page, otherwise the system will redirect the user to sign in page.

3.3.3 Farmer Assistant Registration Sequence diagram

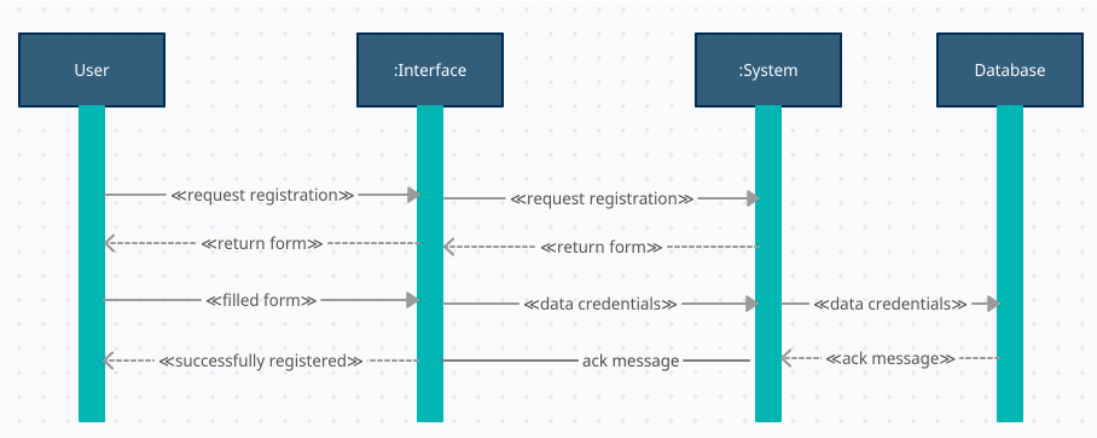

Figure 9 Farmer Assistant Registration Sequence diagram

The user will go to the application and click the signup button, after which the system will show the user the signup form. The farmer user enters his details and fill the form and then system save the credentials of the user in the database after the confirmation of its username.

3.3.4 Crop Recommendation Sequence Diagram

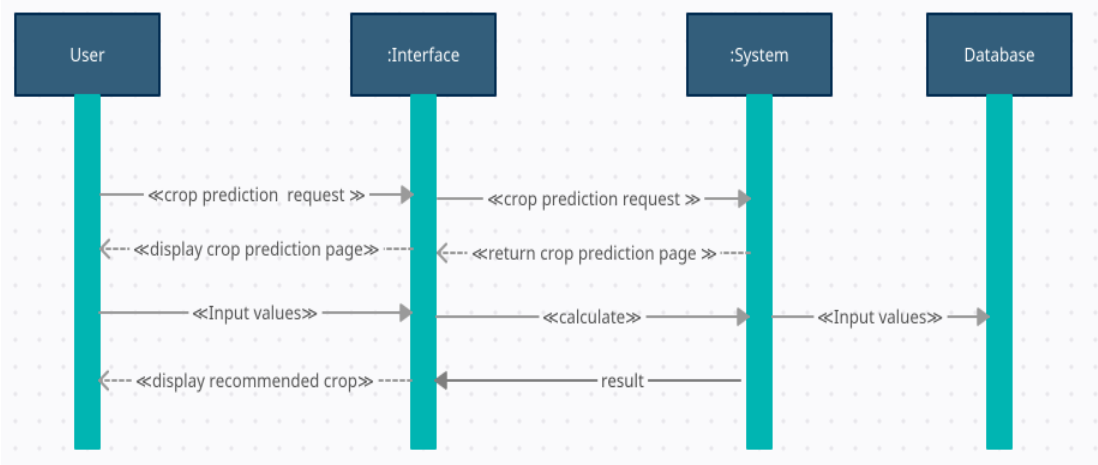

Figure 10 Crop Recommendation Sequence Diagram

This diagram explains the process of crop recommendation. When the famer wants to get crop recommendation, then he/she will click on the crop recommendation button. By clicking on the crop recommendation button, the system will display crop recommendation form to the farmer. Farmer enters the properties of its soil and by entering so system will recommend the best suitable crop to farmer according to its soil.

3.3.5 Fertilizer Prediction Sequence Diagram

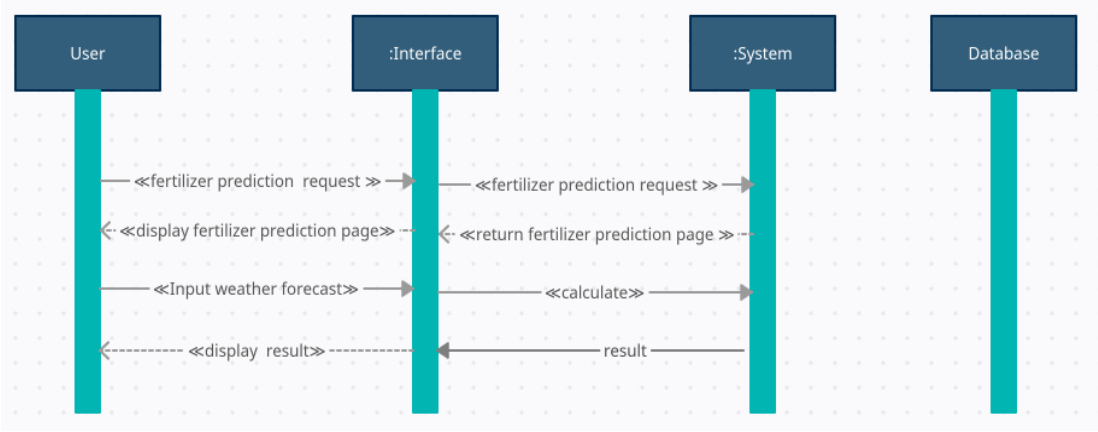

Figure 11 Fertilizer Prediction Sequence Diagram

3.3.6 Weather Forecast Sequence Diagram

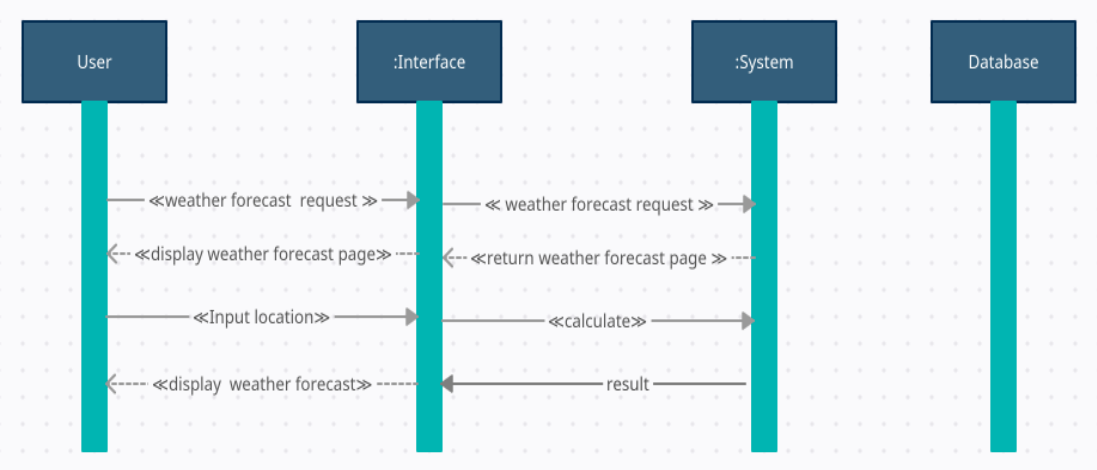

Figure 12 Weather Forecast Sequence Diagram

3.4 Farmer Assistant Domain Model

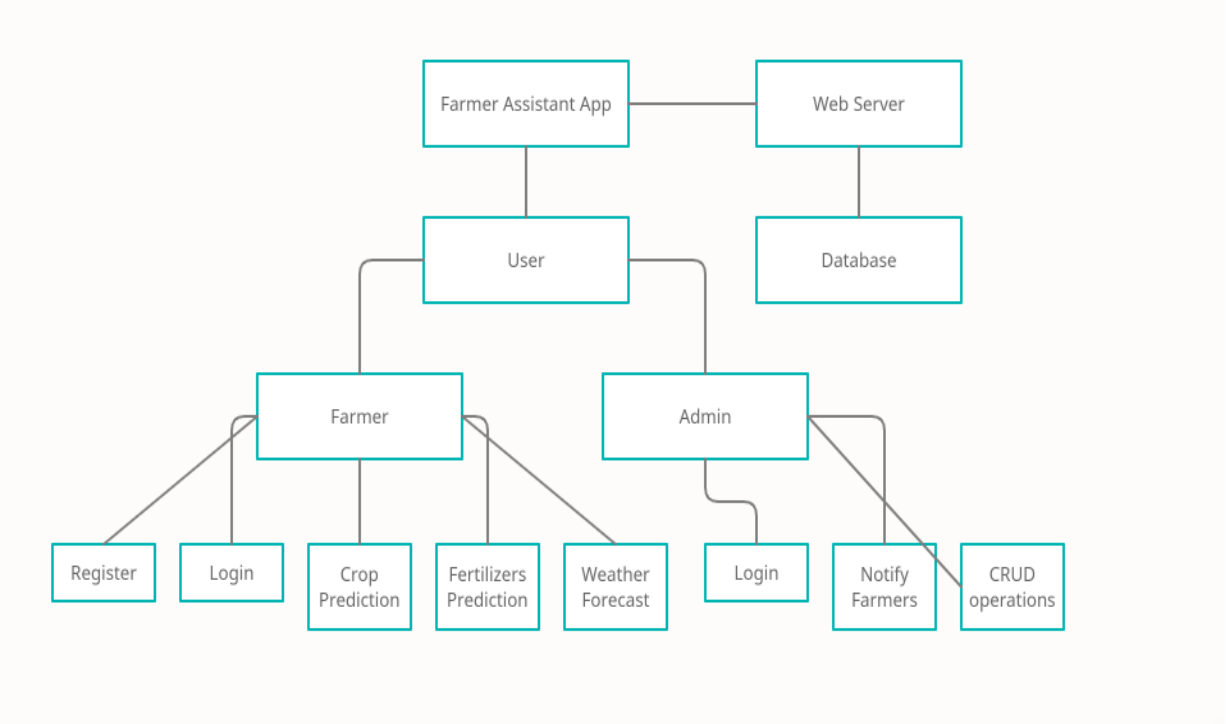

Figure 13 Farmer Assistant Domain Model

3.5 Farmer Assistant Entity Relationship Diagram

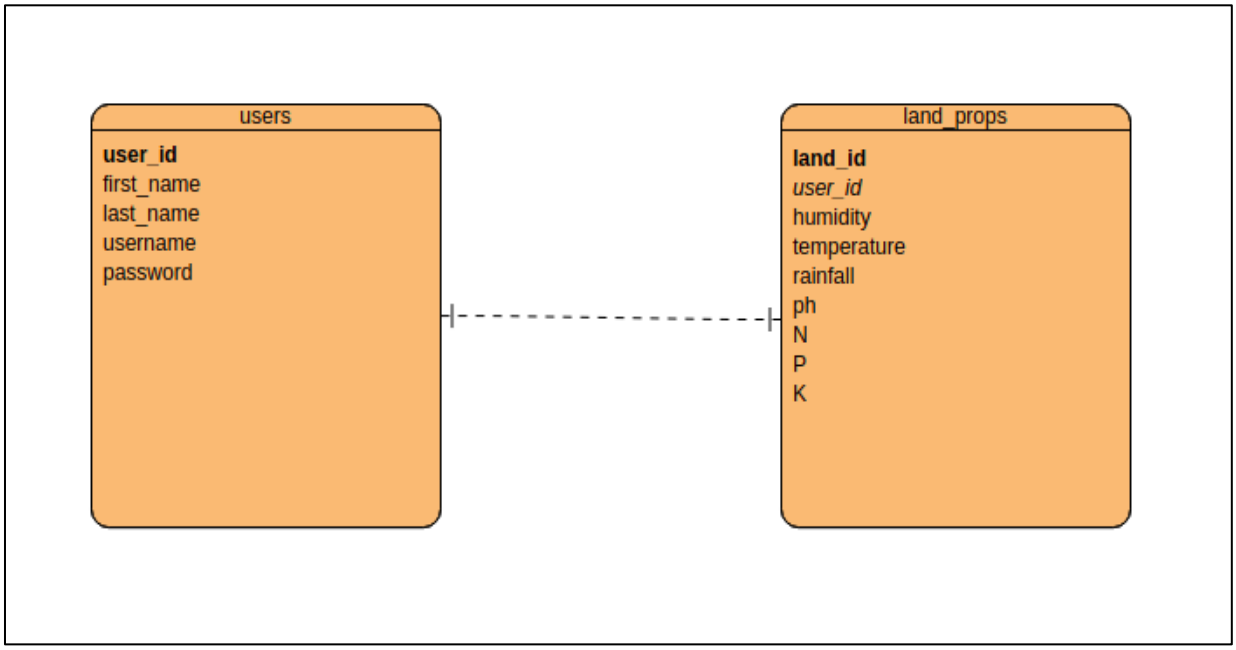

Figure 14 Farmer Assistant Entity Relationship Diagram

3.6 Farmer Assistant Operation Contracts

3.6.1 Sign Up

Table 9 Sign Up

Name	Sign Up
Responsibilities	Make Account of the farmer user
Cross Reference	None
Exception	If the server is down user would not be able to register himself
Post Conditions	Success message and redirect to login page

3.6.2 Sign In

Table 10 Sign In

Name	Sign In
Responsibilities	Farmer sign to the application
Cross Reference	None
Exception	Farmer user may not be registered or invalid credentials
Pre-Conditions	User is registered
Post Conditions	After login redirect them to account

3.6.3 Crop recommendation

Table 11 Crop recommendation

Name	Crop recommendation
Responsibilities	Recommend the user crop depending on the land attributes
Cross Reference	none
Exception	It recommends wrong crop if the dataset is not consistent
Pre-Conditions	User inputs the accurate values
Post Conditions	User saves the input values for the later use

3.6.4 Fertilizer Prediction

Table 12 Fertilizer Prediction

Name	Fertilizer Prediction
Responsibilities	To predict whether user uses fertilizer or not in the upcoming days
Cross Reference	None
Exception	It gives you wrong recommendation if the weather forecast is not correct
Pre-Conditions	Accurate weather forecast
Post Conditions	The farmer is redirected to the home page

3.6.5 Weather Forecast

Table 13 Weather Forecast

Name	Weather forecast
Responsibilities	Tell the weather forecast in the upcoming days
Cross Reference	None
Exception	System may recommend wrong weather forecast if the location is not accurate
Pre-Conditions	The location is accurate for the weather forecast
Post Conditions	Weather forecast is pass to the fertilizer prediction

CHAPTER 4

4 DATA AND EXPERIMMENTS

4.1 Languages Used for Farmer Assistant Implementation:

4.1.1 Python:

Python is used for the machine learning part of the project. At the back end, the crop recommender model is being created in python and moreover, data pre-processing, data visualization and model evaluation all functionalities are performed in python.

4.1.2 C#:

C# is used to develop the mobile application using unity. Using C#, the data is being fetched from machine learning models from Heroku. It is an object-oriented programming language also used for gaming, windows applications etc

4.1.3 SQL:

SQL stands for Structured Query Language, which is a database query language for storing, modifying, and retrieving data. It is used to store data in the project's database.

4.1.4 PHP:

PHP: Hyper Text Pre-processor is an acronym for PHP: Hyper Text Pre-processor. PHP is a scripting language that is free and open source. PHP is being used for the project's back end.

4.2 Tools used for Implementation:

4.2.1 VS Code:

Stands for Visual Studio Code. It is a code editor which is used for debugging applications. All the C#, PHP code is being written on it.

4.2.2 Anaconda Navigator:

For machine learning part of the project anaconda navigator is used. All the python code is being written on the jupyter notebook of anaconda navigator. Machine learning model of crop recommendation system is being created on the anaconda navigator.

4.2.3 Heroku:

Heroku is a server used for deployment of projects. Machine learning model is being deployed on the Heroku server using GitHub.

4.3 Dataset:

The dataset that is used for recommending crops to farmers consists of the following attributes.

N:

- Stands for Nitrogen.
- Ratio of nitrogen content in soil.
- Nitrogen is used in plants for the growth of leaves and good green color.
- It is involved in the process of photosynthesis and promotes better growth.
- Forms essential part of proteins.
- Value ranges from 0-140 in the dataset.

P:

- Stands for Phosphorus.
- Ratio of phosphorus content in soil.
- Phosphorus is used by plants to help form new roots, make seeds fruits and flowers.
- Increases stem strength.
- Increased resistance to plant diseases.
- Value ranges from 5-145 in the dataset.

K:

- Stands for Potassium.
- Ratio of potassium content in soil.
- Potassium is used in plants for the transfer of essential nutrients, water and other substances.
- Value ranges from 5-205 in the dataset.

Temperature:

- Temperature in degree Celsius.
- Temperature of the environment near the soil.
- Plants metabolism is influenced by temperature.
- Value ranges from 8.8-43.6(Celsius) in the dataset.

Humidity:

- Relative humidity in percentage.
- Humidity makes photosynthesis possible.
- Humidity saturates leaves with water vapor.
- Value ranges from 99.9-14.25 in the dataset.

PH:

- ph. value of the soil.
- ph. value tells the acidity or alkalinity of a solution.
- ph. value 7 is neutral, values more than 7 are alkaline and values less than 7 are acidic.
- Value ranges from 3.5-9.9 in the dataset.

rainfall:

- Rainfall in millimeters.
- Plants grow with the help of rain showers.
- Rainfall determines how fast a crop will grow.
- Value ranges from 20.2-298.5 in the dataset.

Sample Soil Test Lab Reports:

- See in Appendix-A.

4.4 Experimentation:

4.4.1 Importing Libraries:

Importing Libraries

```
import pandas as pd # for reading the dataset
import numpy as np # for statistical operations
import matplotlib.pyplot as plt # for data visualization
import seaborn as sns
from sklearn.metrics import classification_report,confusion_matrix
from sklearn import metrics
%matplotlib inline
```

Figure 15 Importing Libraries

4.4.2 Reading the Dataset:

Reading the Dataset

```
crop_dataset = pd.read_csv("E:\FYP PROPOSAL\Crop_recommendation.csv")
```

```
crop_dataset.head()
```

	N	P	K	temperature	humidity	ph	rainfall	label
0	90	42	43	20.879744	82.002744	6.502985	202.935536	rice
1	85	58	41	21.770462	80.319644	7.038096	226.655537	rice
2	60	55	44	23.004459	82.320763	7.840207	263.964248	rice
3	74	35	40	26.491096	80.158363	6.980401	242.864034	rice
4	78	42	42	20.130175	81.604873	7.628473	262.717340	rice

Figure 16 Reading Dataset

4.4.3 Data Cleaning:

Data Cleaning

```
#Remove Null values
```

```
crop_dataset.isnull().values.any()
```

```
False
```

Figure 17 Data Cleaning

4.4.3.1 Checking for Duplicate Values:

Checking For Duplicate Values

```
duplicate_values = crop_dataset.duplicated()
print ("Duplicated Values In Dataset: ",sum(duplicate_values))
```

```
Duplicated Values In Dataset:  0
```

Figure 18 Check Duplicate Values

4.4.3.2 Checking for Missing Values:

```
print ('Missing Values in Cloumns::')
print ('N:',len(crop_dataset.loc[crop_dataset.N == 0, 'N']))
print ('P:',len(crop_dataset.loc[crop_dataset.P == 0, 'P']))
print ('K:',len(crop_dataset.loc[crop_dataset.K == 0, 'K']))
print ('temperature:',len(crop_dataset.loc[crop_dataset.temperature == 0, 'temperature']))
print ('humidity:',len(crop_dataset.loc[crop_dataset.humidity == 0, 'humidity']))
print ('ph:',len(crop_dataset.loc[crop_dataset.ph == 0, 'ph']))
print ('rainfall:',len(crop_dataset.loc[crop_dataset.rainfall == 0, 'rainfall']))
print ('label:',len(crop_dataset.loc[crop_dataset.label == 0, 'label']))
```

```
Missing Values in Cloumns::
N: 27
P: 0
K: 0
temperature: 0
humidity: 0
ph: 0
rainfall: 0
label: 0
```

Figure 19 Check Missing Values

4.4.3.3 Fill Missing Values with Mean Values:

Fill Missing Values with mean values

```
crop_dataset.loc[crop_dataset.N == 0, 'N'] = crop_dataset.N.mean()
```

Figure 20 Fill Missing Values

4.4.1 Data Visualization:

4.4.1.1 Finding Co-Relation:

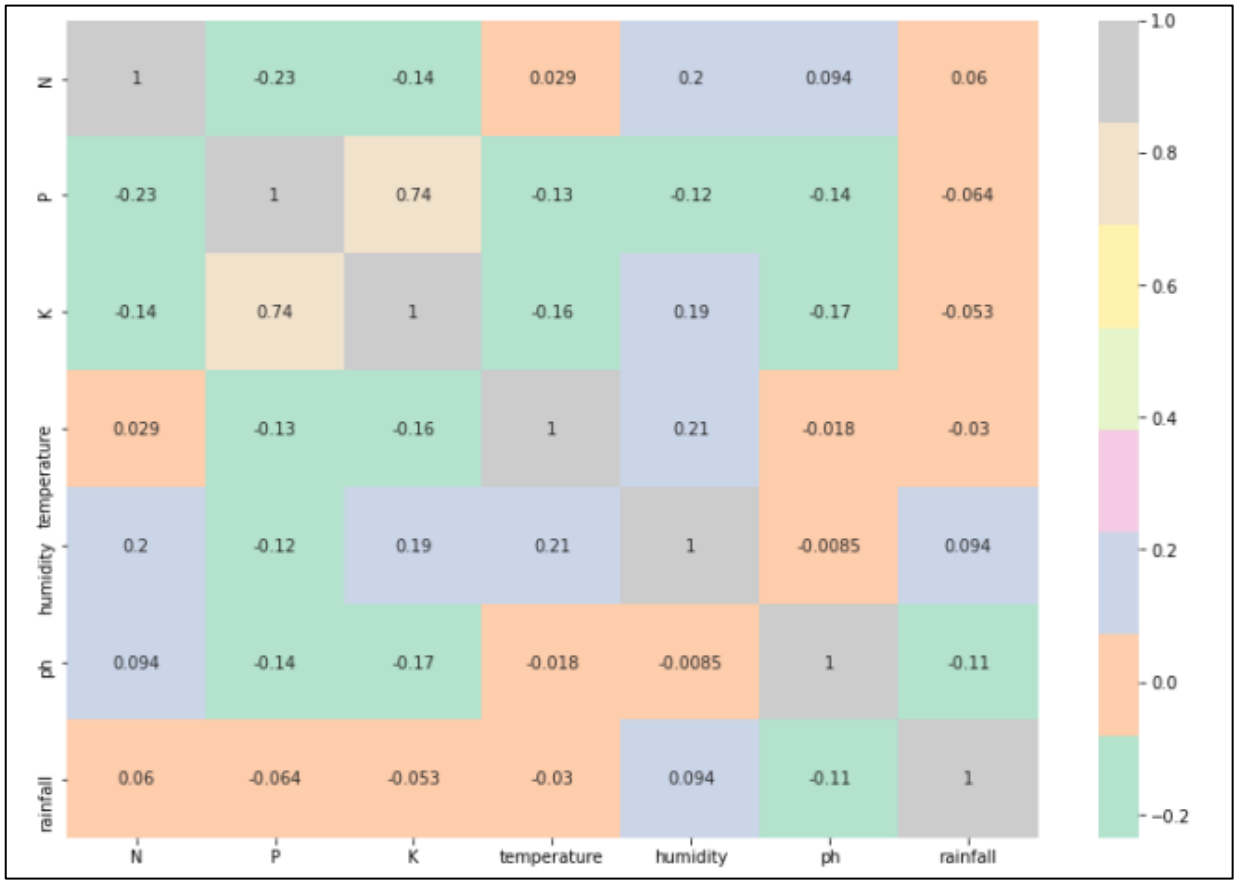

Figure 21 Co-relation Matrix

4.4.1.1 Histogram For Each Feature:

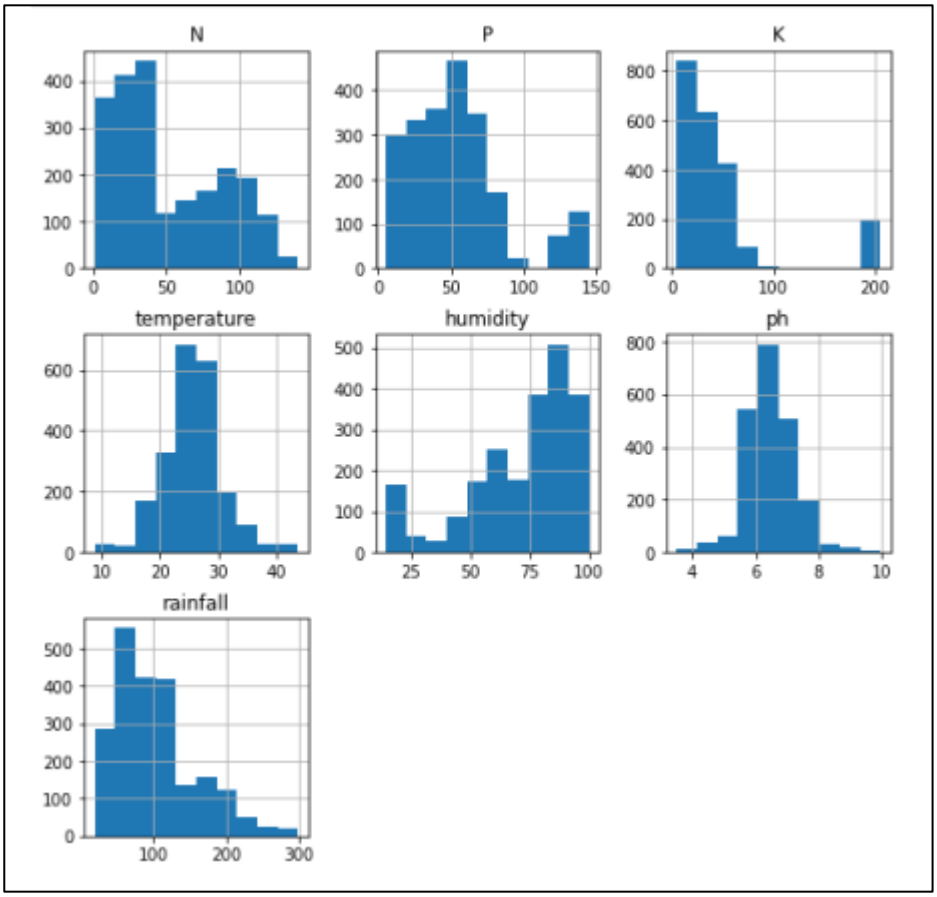

Figure 22 Histogram for Each Feature

4.4.1.2 Scatter Plot:

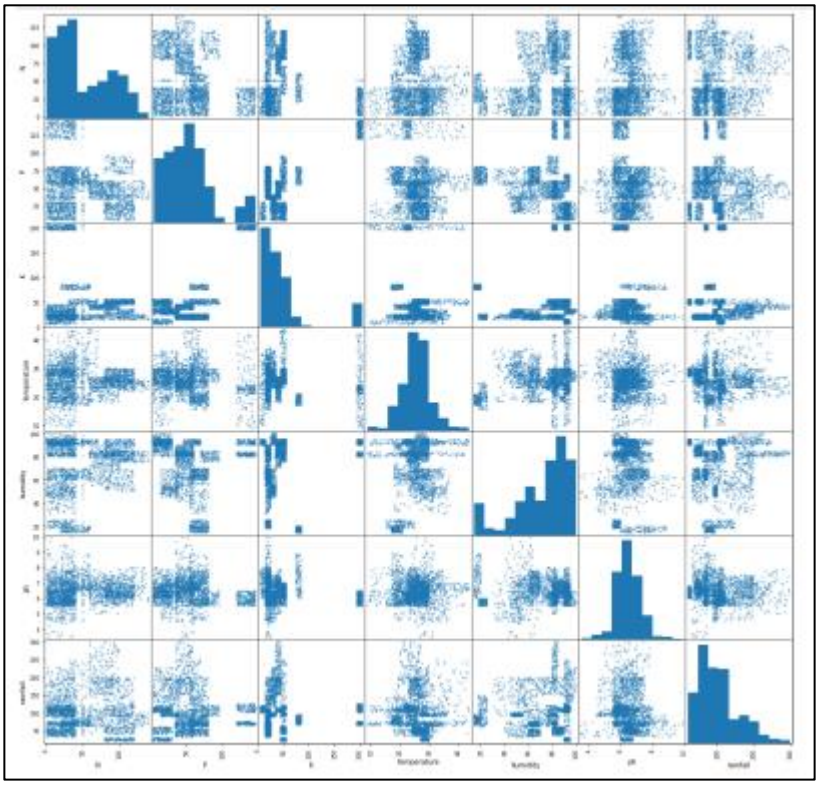

Figure 23 Scatter Plot

4.4.1.3 Pair Plot:

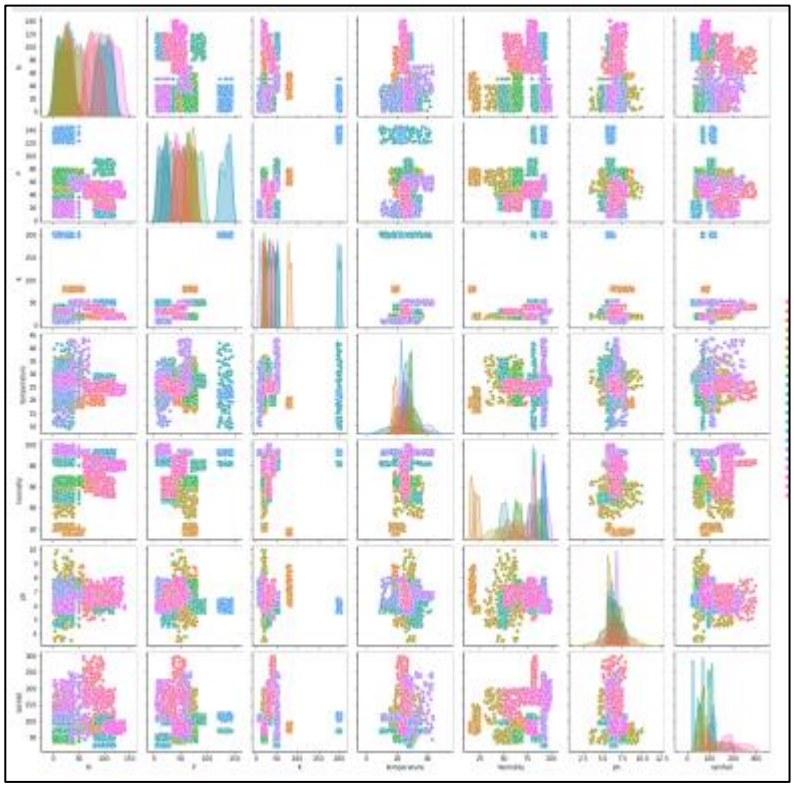

Figure 24 Pair Plot

4.4.2 Split the Data Frame into X and Y Labels:

```
target = 'label'
X = crop_dataset.drop(target,axis=1)
Y = crop_dataset[target]
```

```
X.head() #ALL INPUT FEATURES ARE HERE
```

	N	P	K	temperature	humidity	ph	rainfall
0	90.0	42	43	20.879744	82.002744	6.502985	202.935536
1	85.0	58	41	21.770462	80.319644	7.038096	226.655537
2	60.0	55	44	23.004459	82.320763	7.840207	263.964248
3	74.0	35	40	26.491096	80.158363	6.980401	242.864034
4	78.0	42	42	20.130175	81.604873	7.628473	262.717340

```
Y.head() #Only target feature is here
```

```
0    rice
1    rice
2    rice
3    rice
4    rice
Name: label, dtype: object
```

Figure 25 Splitting

4.4.3 Train Test Split:

Train Test Split

```
from sklearn.model_selection import train_test_split
X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.2,random_state=2)
```

```
X_train.shape,Y_train.shape
```

```
((1760, 7), (1760,))
```

```
X_test.shape,Y_test.shape
```

```
((440, 7), (440,))
```

Figure 26 Train Test Split

4.4.4 Applying different Classification Algorithms:

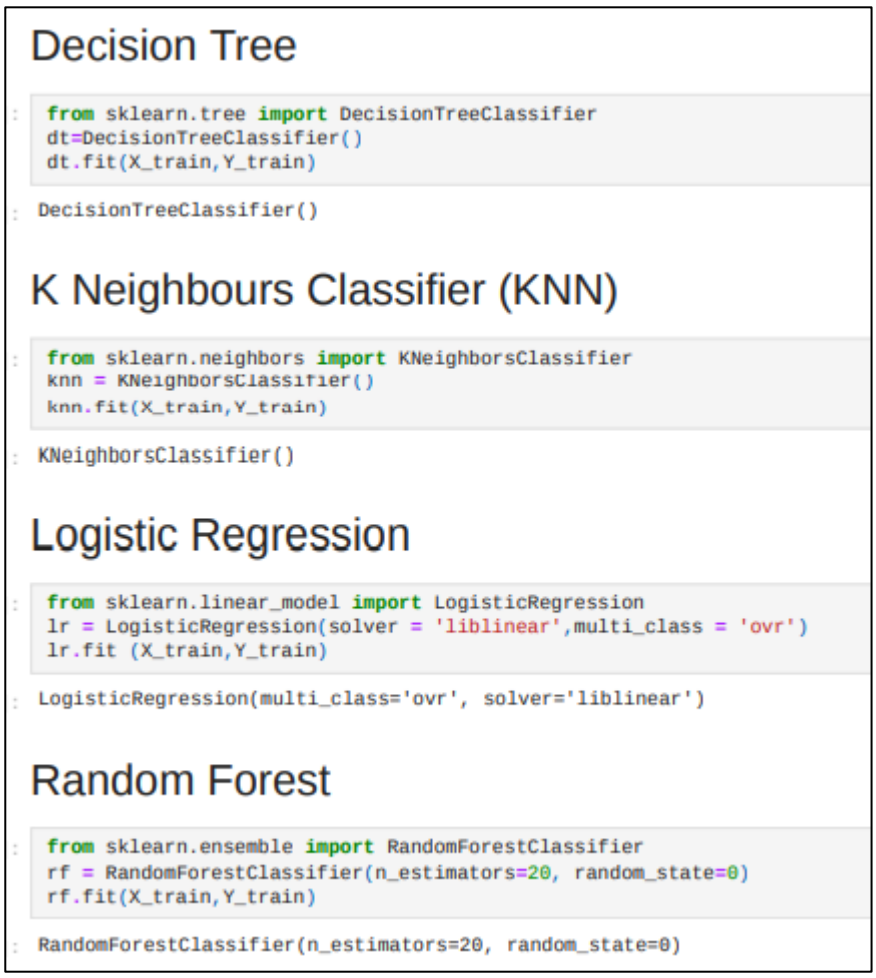

Figure 27 Applying Algorithms

4.4.5 Prediction:

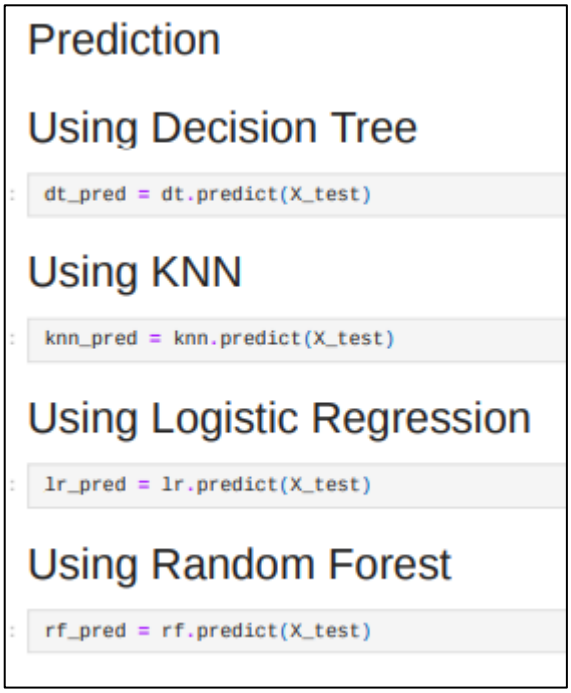

Figure 28 Prediction

4.4.6 Model Evaluation:

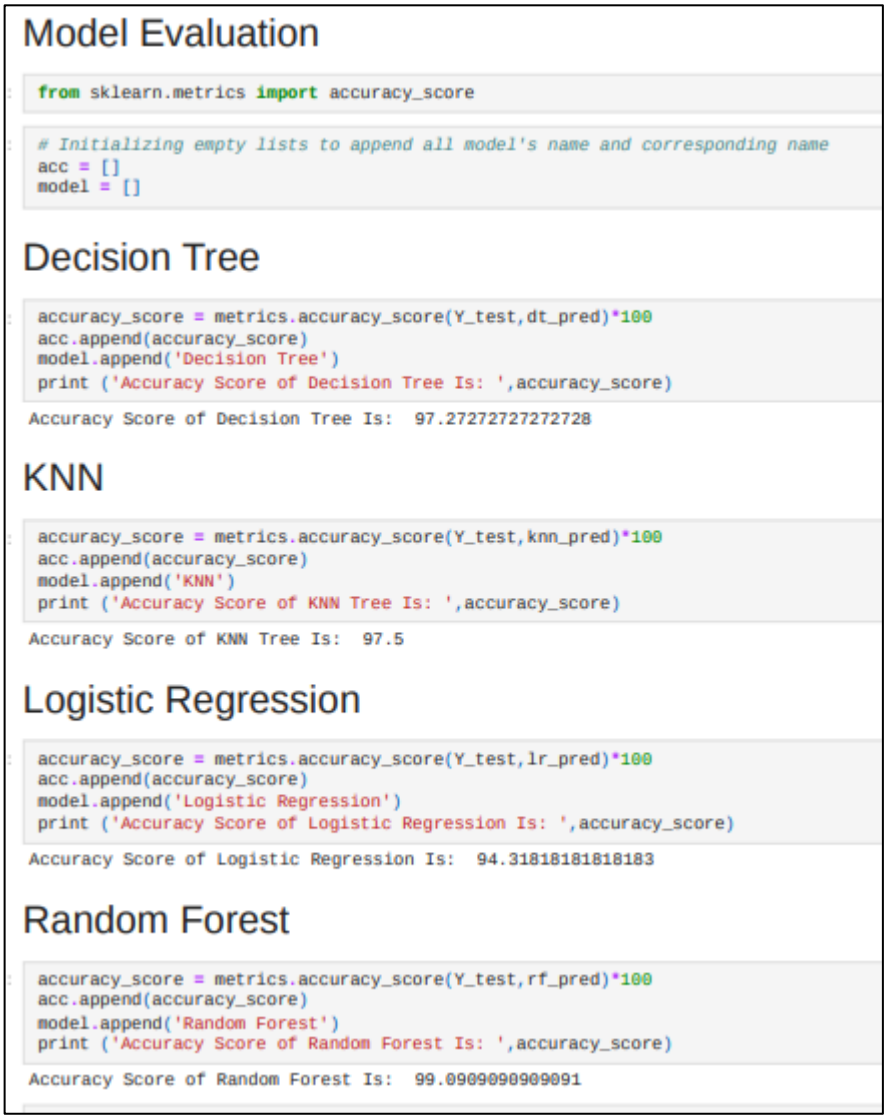

Figure 29 Model Evaluation

4.4.7 Accuracy Comparison:

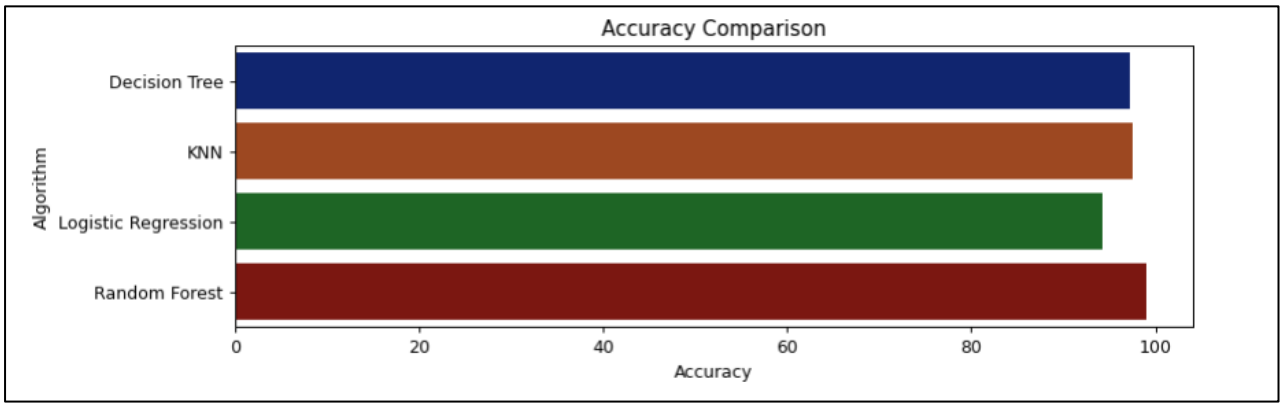

Figure 30 Accuracy Comparison

4.4.8 Confusion Matrix:

	Predicted apple	Predicted banana	Predicted blackgram	Predicted chickpea	Predicted coconut	Predicted coffee	Predicted cotton	Predicted grapes	Predicted jute	Predicted kidneybeans	...	Predicted mango	Predicted mothbeans	Predicted mungbean	Predicted muskmelon	Predicted orange	Predicted papaya
Actual apple	13	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual banana	0	17	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual blackgram	0	0	16	0	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual chickpea	0	0	0	21	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual coconut	0	0	0	0	21	0	0	0	0	0	...	0	0	0	0	0	0
Actual coffee	0	0	0	0	0	22	0	0	0	0	...	0	0	0	0	0	0
Actual cotton	0	0	0	0	0	0	20	0	0	0	...	0	0	0	0	0	0
Actual grapes	0	0	0	0	0	0	0	18	0	0	...	0	0	0	0	0	0
Actual jute	0	0	0	0	0	0	0	0	28	0	...	0	0	0	0	0	0
Actual kidneybeans	0	0	0	0	0	0	0	0	0	14	...	0	0	0	0	0	0
Actual lentil	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual maize	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual mango	0	0	0	0	0	0	0	0	0	0	...	26	0	0	0	0	0
Actual mothbeans	0	0	1	0	0	0	0	0	0	0	...	0	18	0	0	0	0
Actual mungbean	0	0	0	0	0	0	0	0	0	0	...	0	0	24	0	0	0
Actual muskmelon	0	0	0	0	0	0	0	0	0	0	...	0	0	0	23	0	0
Actual orange	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	29	0
Actual papaya	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	19
Actual pigeonpeas	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual pomegranate	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0
Actual rice	0	0	0	0	0	0	0	0	3	0	...	0	0	0	0	0	0
Actual watermelon	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0

22 rows × 22 columns

Figure 31 Confusion Matrix

4.4.9 Visualizing Confusion Matrix Using Heatmap:

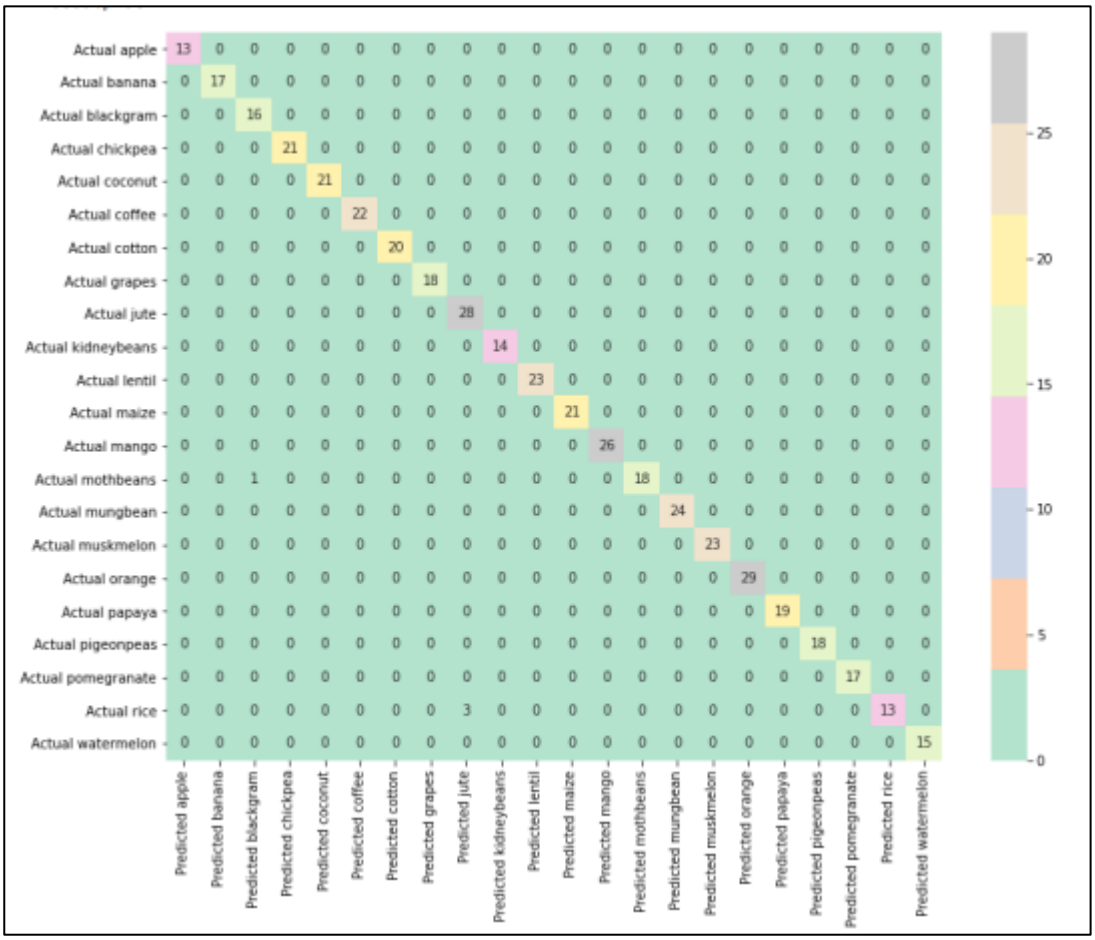

Figure 32 Confusion Matrix Heatmap

4.4.10 Classification Report:

Classification Report

```
print(classification_report(Y_test,rf_pred))
```

	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

Figure 33 Classification Report

4.4.11 Making a Prediction:

Making a Prediction

```
data = np.array([[104,18, 30, 23.603016, 60.3, 6.7, 140.91]])
prediction = rf.predict(data)
print(prediction)
```

```
['coffee']
```

```
data = np.array([[90, 42, 43, 20.87974371, 82.00274423, 6.502985292, 202.9355362]])
prediction = rf.predict(data)
print(prediction)
```

```
['rice']
```

Figure 34 Making a Prediction

CHAPTER 5

5 Results and Discussions

5.1 Application Prototypes:

5.1.1 Splash Screen:

This is our splash screen. When user open our application, it takes 3 to 4 seconds to load during that time splash screen is shown to user.

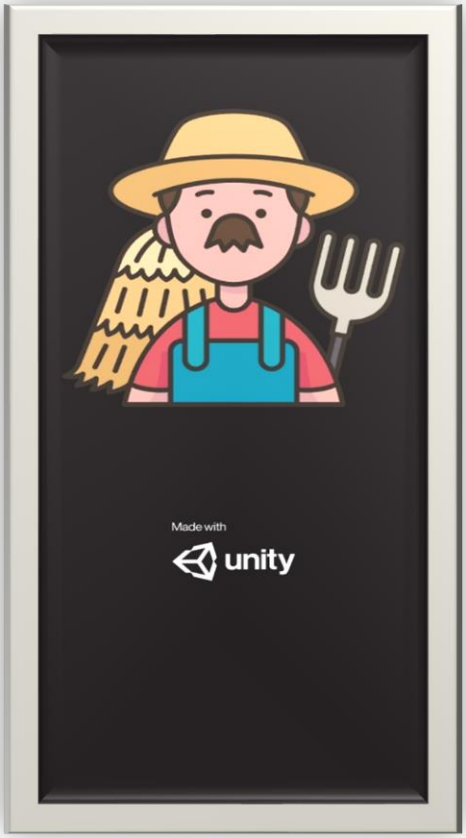

Figure 35 Splash Screen

5.1.2 Login:

This is the login screen. If the user has an account so, the user login to his account by entering his correct username and password. If the user does not have any account, then by clicking on sign up button he will navigate to signup screen.

Figure 36 Login Screen

5.1.3 Signup:

This is the signup screen. If the user does not have any account, then by entering his first name, last name and username the user signs up to his account.

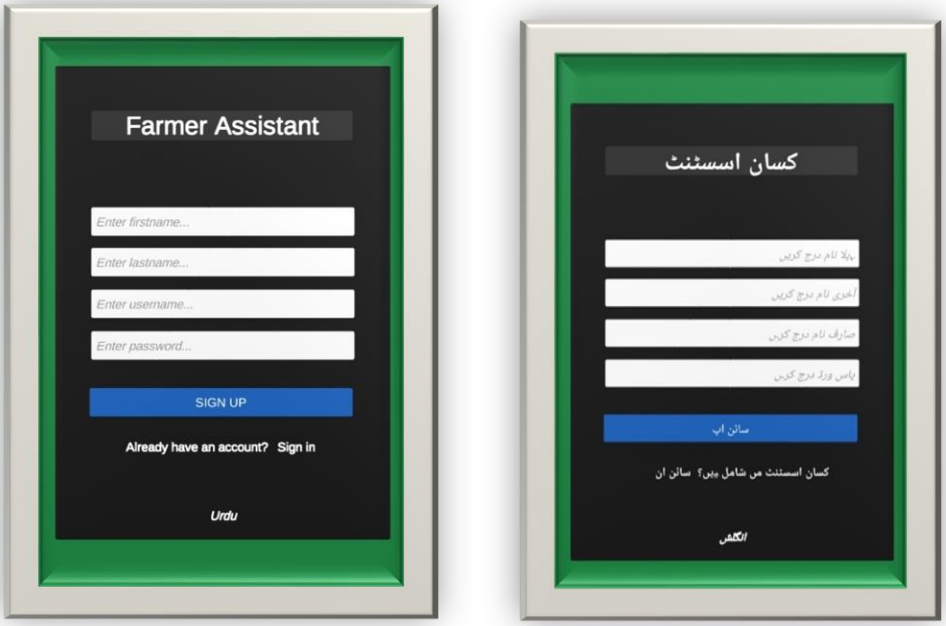

Figure 37 Signup Screen

5.1.4 Home Page:

This the home screen. There are four multiple choices in the home screen. Farmer choose any option based on his need.

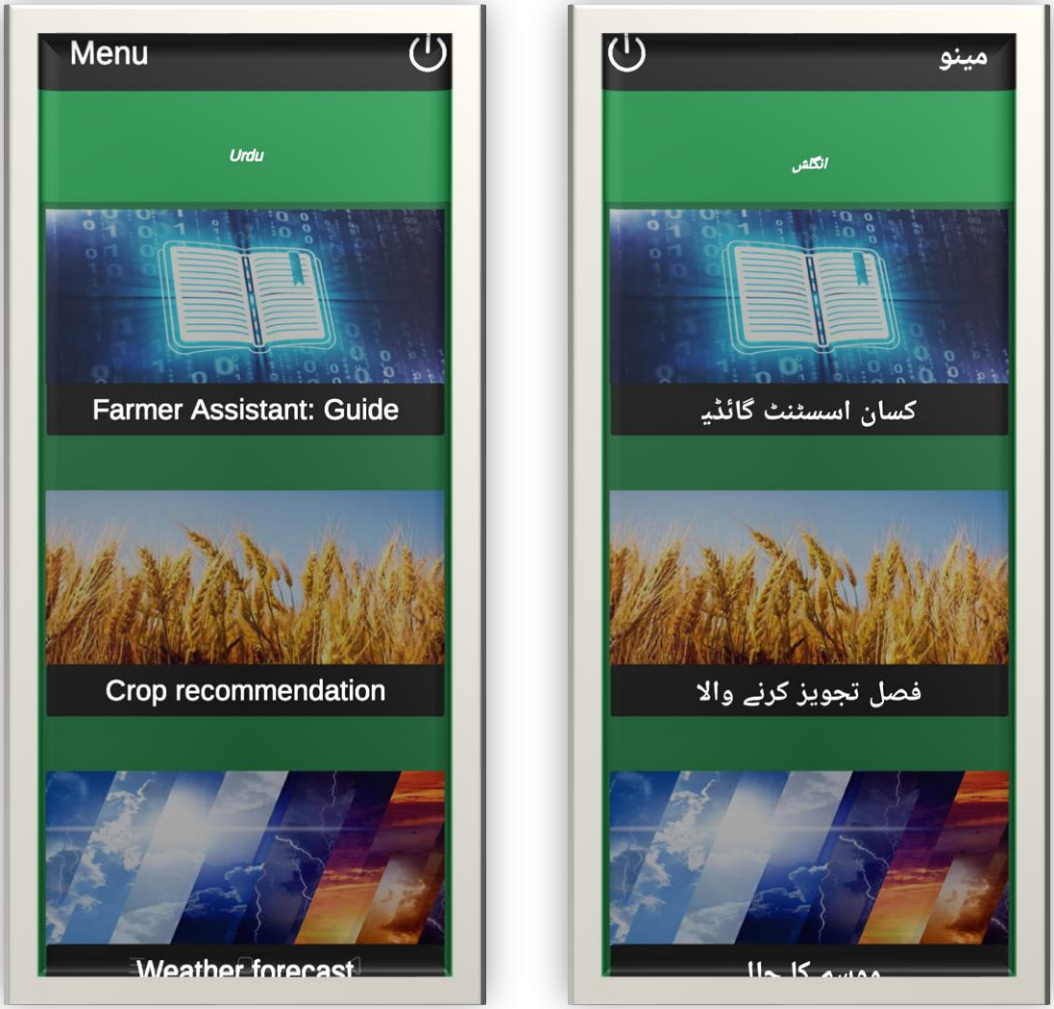

Figure 38 Home Screen

5.1.5 Crop Recommendation:

This is the crop recommendation screen. Farmer enter the properties of his soil and get the best suitable crop recommended.

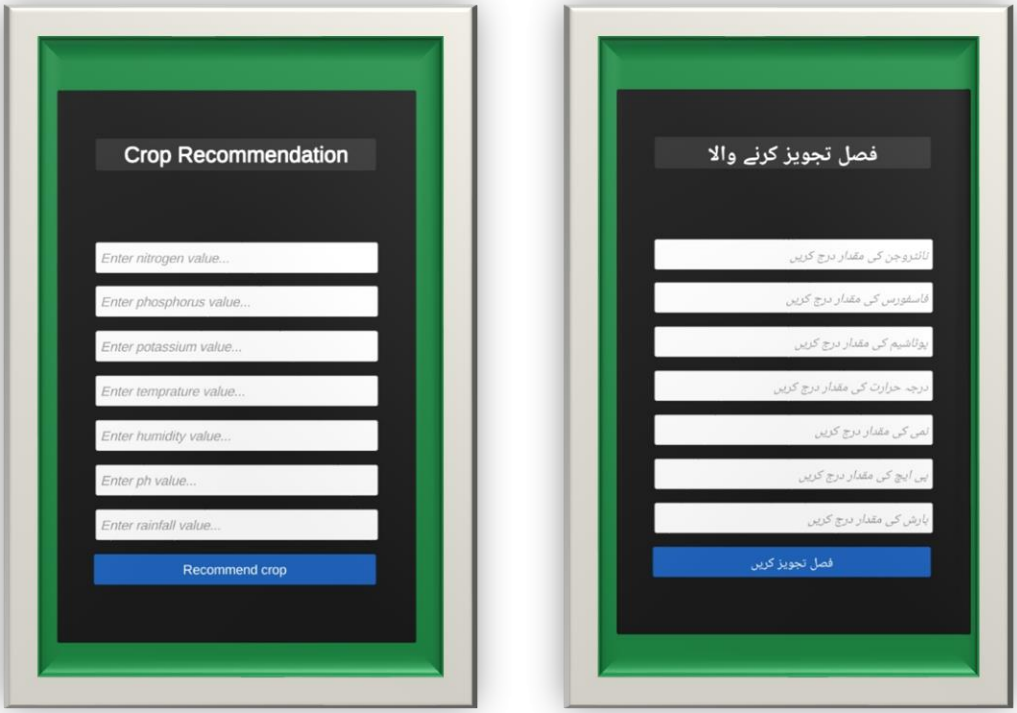

Figure 39 Crop Recommendation Screen

5.1.6 Generate Report:

This is the generate report button. User generates the report by clicking on it.

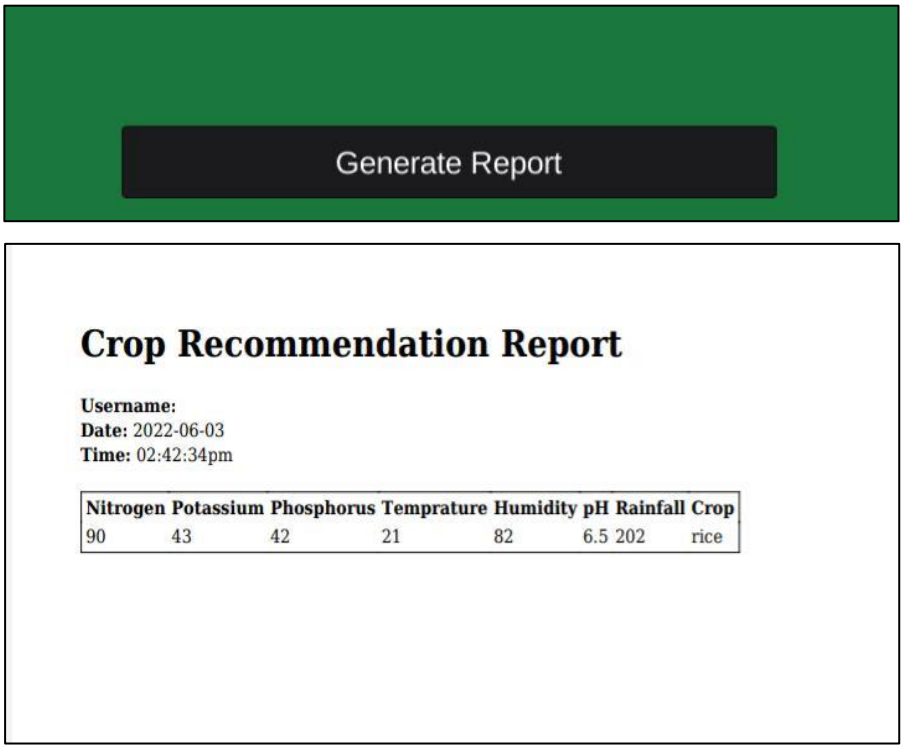

Figure 40 Generate Report

5.1.7 Fertilizer Recommendation:

This is the fertilizer recommendation screen. Fertilizer is recommended to farmer based on the rainfall.

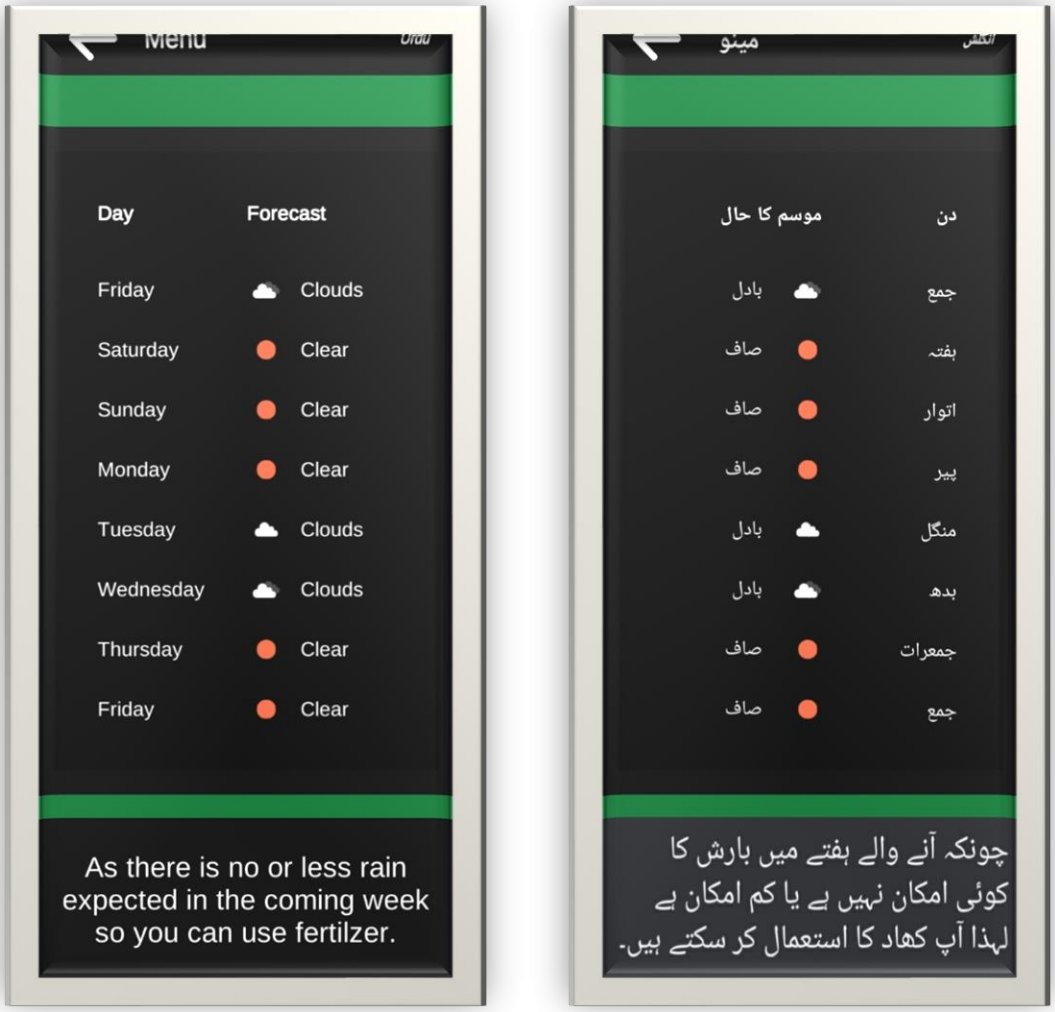

Figure 41 Fertilizer Recommendation Screen

5.1.8 Weather Forecast:

This is the weather forecast screen. All the weather details are mentioned here.

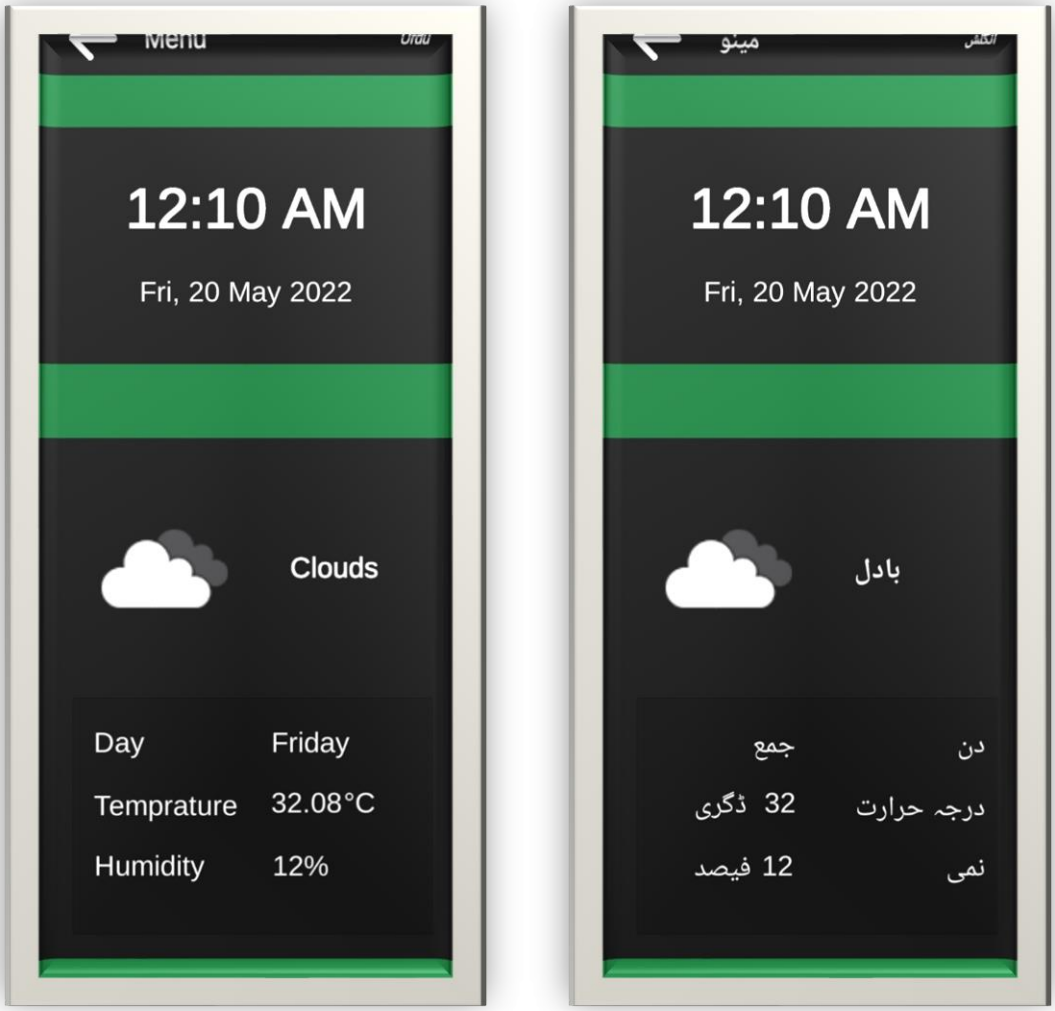

Figure 42 Weather Forecast Screen

CHAPTER 6

6 Conclusion and Recommendations

6.1 Conclusion:

To conclude that, farmer assistant application is a solution to multiple problems of farmers and its scope is further extended based on the needs of farmers. Without awareness, we do not bring change in the life of farmers by using technology. Therefore, by focusing on other technical issues, a major focus is also required on, in motivating farmers in different ways, so that they use the technology.

6.2 Recommendation:

In future the scope of the application is further extended by updating the datasets from time to time to produce accurate predictions. Other functionalities like provide correct type of fertilizer that is used for the given crop and location is also added. Moreover, farmers relate to the other farmers by using this application and they also share their experiences with each other.

References:

Journal Papers:

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[2] Charbuty, Bahzad, and Adnan Abdulazeez. "Classification based on decision tree algorithm for machine learning." *Journal of Applied Science and Technology Trends* 2.01 (2021): 20-28.

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[6] S. Pudumalar, E. Ramanujam, R. H. Rajashree, C. Kavya, T. Kiruthika and J. Nisha, "Crop recommendation system for precision agriculture," 2016 Eighth International Conference on Advanced Computing (ICoAC), 2017, pp. 32-36, doi: 10.1109/ICoAC.2017.7951740.

[7] Bandara, P., Weerasooriya, T., Ruchirawya, T., Nanayakkara, W., Dimantha, M. and Pabasara, M., 2020. Crop recommendation system. *International Journal of Computer Applications*, *975*, p.8887.

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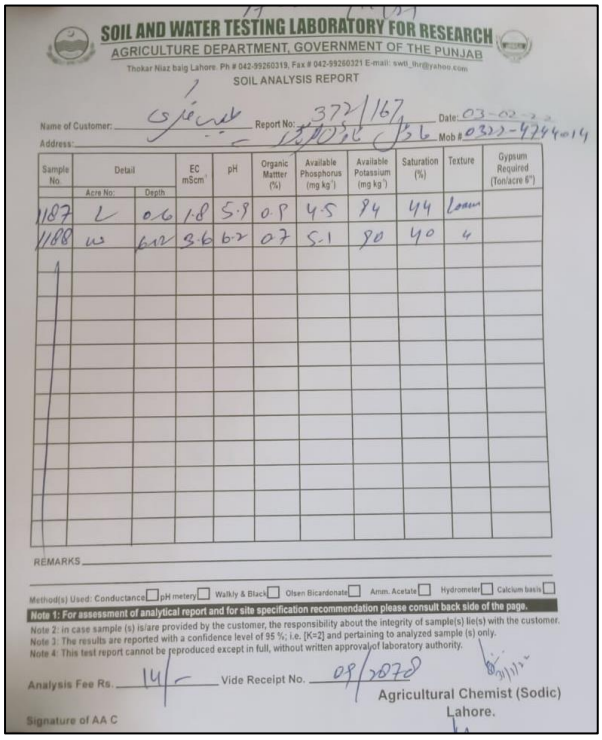
[2] Mohit Sharma, David Chappell "The Machine Learning Process" Online, Available at: What Steps ca one take while doing Data Preprocessing?

Appendices:

Appendix A: Sample Soil Test Lab Reports



SOIL AND WATER TESTING LABORATORY FOR RESEARCH
AGRICULTURE DEPARTMENT, GOVERNMENT OF THE PUNJAB
Thokar Niaz baig Lahore. Ph # 042-99260319, Fax # 042-99260321 E-mail: swtl_thr@yahoo.com
SOIL ANALYSIS REPORT

Name of Customer: Report No: 372/167 Date: 03-02-22
Address: Mob # 0322-4744014

Sample No.	Detail		EC mScm⁻¹	pH	Organic Matter (%)	Available Phosphorus (mg kg⁻¹)	Available Potassium (mg kg⁻¹)	Saturation (%)	Texture	Gypsum Required (Ton/acre 6")
	Acre No:	Depth								
1187	L	0-6	1.8	5.9	0.8	45	84	44	Loam	
1188	W	6-12	3.6	6.2	0.7	5.1	90	40	L	

REMARKS

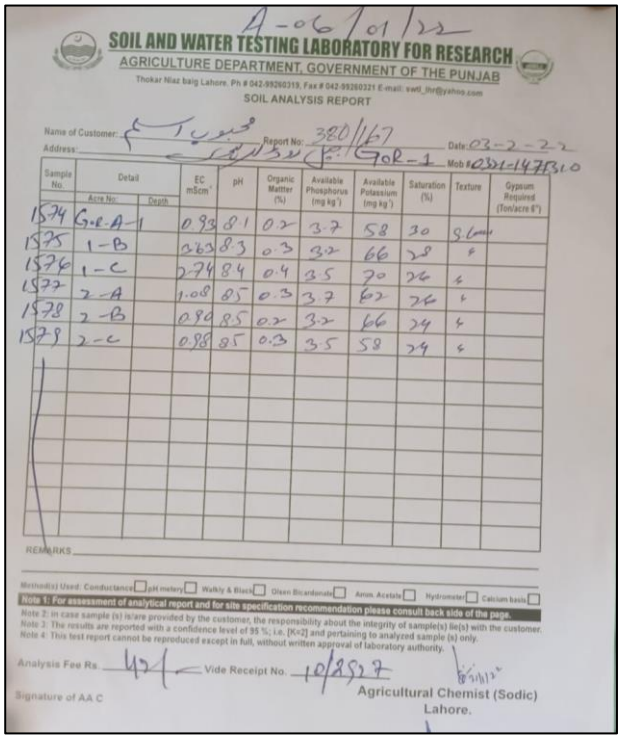
Method(s) Used: Conductance ☐ pH metery ☐ Walkly & Black ☐ Olsen Bicardonate ☐ Amm. Acetate ☐ Hydrometer ☐ Calcium basis ☐

Note 1: For assessment of analytical report and for site specification recommendation please consult back side of the page.
Note 2: in case sample (s) is/are provided by the customer, the responsibility about the integrity of sample(s) lie(s) with the customer.
Note 3: The results are reported with a confidence level of 95 %; i.e. [K=2] and pertaining to analyzed sample (s) only.
Note 4: This test report cannot be reproduced except in full, without written approval of laboratory authority.

Analysis Fee Rs. 14/- Vide Receipt No. 09/0070

Agricultural Chemist (Sodic)
Lahore.

Signature of AA C



SOIL AND WATER TESTING LABORATORY FOR RESEARCH
AGRICULTURE DEPARTMENT, GOVERNMENT OF THE PUNJAB
Thokar Niaz baig Lahore. Ph # 042-99260319, Fax # 042-99260321 E-mail: swtl_thr@yahoo.com
SOIL ANALYSIS REPORT

Name of Customer: Report No: 380/167 Date: 03-2-22
Address: Mob # 0321-4778310

Sample No.	Detail		EC mScm⁻¹	pH	Organic Matter (%)	Available Phosphorus (mg kg⁻¹)	Available Potassium (mg kg⁻¹)	Saturation (%)	Texture	Gypsum Required (Ton/acre 6")
	Acre No:	Depth								
1574	G-R-A-1		0.93	8.1	0.2	3.7	58	30	S.L	
1575	1-B		2.63	8.3	0.3	3.2	66	28	"	
1576	1-C		2.74	8.4	0.4	3.5	70	26	L	
1577	2-A		1.08	8.5	0.3	3.7	62	24	L	
1578	2-B		0.89	8.5	0.2	3.2	66	24	L	
1579	2-C		0.88	8.5	0.3	3.5	58	24	L	

REMARKS

Method(s) Used: Conductance ☐ pH metery ☐ Walkly & Black ☐ Olsen Bicardonate ☐ Amm. Acetate ☐ Hydrometer ☐ Calcium basis ☐

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Analysis Fee Rs. 42/- Vide Receipt No. 10/8527

Agricultural Chemist (Sodic)
Lahore.

Signature of AA C