MACHINE LEARNING BASED NUTRIENT RECOMMENDATION SYSTEM FOR SOIL FERTILISATION

CS8811 - A PROJECT REPORT

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ABSTRACT

Fertilizer use is typically under the limited control of farmers. For the farmers to achieve higher yields and reduce fertilizer loss, competent guidance is required for the best use of these fertilizers. Additionally, there is a connection between rainfall volume and nutrient loss for various fertilizer applications after each rainfall event. Rainfall that is moderate and falls at the right moment can help nutrients penetrate the soil's rooting zone and dissolve dry fertilizer. However, too much rain can increase the possibility of runoff and the pace at which nutrients like nitrogen (N) which is quintessential, phosphorus (P), and potassium (K) which are crucial, manganese (Mn), and boron (B) that are present in the soil. This research presents nutrient recommendations using an updated iteration of the random forest algorithm which is based on time-series data to forecast the required quantity of nutrients for various crops by examining rainfall patterns and crop fertility. The method suggested in this study comes in handy for improving soil fertility by providing nutrients recommendations for optimum conditions for crop growth and reducing leaching and runoff potential.

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CHAPTER 1
INTRODUCTION

Agriculture plays a very important role in national economic growth. Agriculture contributes 17-18% to India's GDP and ranks second worldwide in farm outputs. Plants need fertilizers and fertilizers replace the nutrients which crops take from the top layer of the soil. The absence of fertilizers can cause a drastic reduction in the volume of crop output. But fertilization requires precise action. Rainfall patterns and the amount of nutrients needed for a certain crop must be considered when using fertilizers. Machine learning is the current technology that can solve this problem by using available data for crop fertility and rainfall. Farmers can greatly benefit from the support of robust information about crops. The proposed model also uses a machine learning algorithm (random forest algorithm with k-fold cross-validation technique) and takes two inputs from the user that are crop and location. After applying the algorithm, the model predicts the amount of nutrients required along with the best time to use fertilizers. The website is built using Flask Python (web framework) to provide access on all platforms and can be shared among users.

1.1 OBJECTIVE

Crop production is essential to the global food and biofuel economies, and ML is significantly enhancing farmers' contributions on both fronts. To enhance crop productivity and yield, herbicides, insecticides, and fungicides must all be applied at the right time. Even if crop spraying is possible later in the season as soil moisture decreases, crop yields will almost certainly be harmed. Every year, farmers make hundreds of intricate and connected decisions that affect their risk, sustainability, and financial results.

The goal of employing machine learning in our project is to provide relevant insight for nutrient requirement for crops by taking short-term weather forecasts (specifically for seven days) into account, as well as to prevent water pollution by slowing down the leaching process.

1.2 PLANT ROOT LOSS

Farmers face a number of challenges every year like heavy rainfall or unpredictable weather, including high interest rates, an overreliance on traditional crops, and a lack of water. Crops may be submerged in water as a result of flooding, which could cause catastrophic losses. As soon as a plant is submerged, its foliage starts to deteriorate because its leaves are unable to exchange gases with the air above (mainly oxygen & carbon dioxide). Producers face flooding or continuously flooded soil more frequently, which hinders roots' ability to absorb nutrients. If the soil is completely soaked for an extended period of time, root loss may result. Because they can't exchange gases, root cells in waterlogged soils risk dying.

Depending on how long the soil is entirely soaked, different amounts of root loss may occur. Plant mortality and complete crop failure would result in total root loss. Lower plant performance and crop output would result from partial root loss. Conditions that are too moist might have other detrimental effects on crop productivity. Unusually excessive rainfall can wash away nutrients from the soil, particularly nitrogen. Granular fertilizer that has been put to the soil as nitrogen is particularly susceptible to leaching. If this happens, farmers would either have to pay more money to reapply fertilizer or see a decrease in crop yield due to nitrogen shortage.

1.3 SOIL LEACHING

Leaching is the downward transport of pollutants via porous soils, such as water-soluble pesticides or fertilizers. The majority of pesticides, notably clay, adhere to soil particles, become stationary, and do not drain. However, the multiple degradation mechanisms and leaching to groundwater can be seen as competitors in the fate of mobile pesticides. Groundwater does not continuously dilute the pollutants that enter it, in contrast to surface water. It could take many years to remove contaminated plumes from groundwater. Chemical deterioration is slowed by the soil's depth, the freezing temperatures, the limited microbial activity, the lack of sunlight, and the low oxygen levels. As a result, once pesticides enter an

aquifer, there is little to no degradation, if any at all. This leads to water pollution.

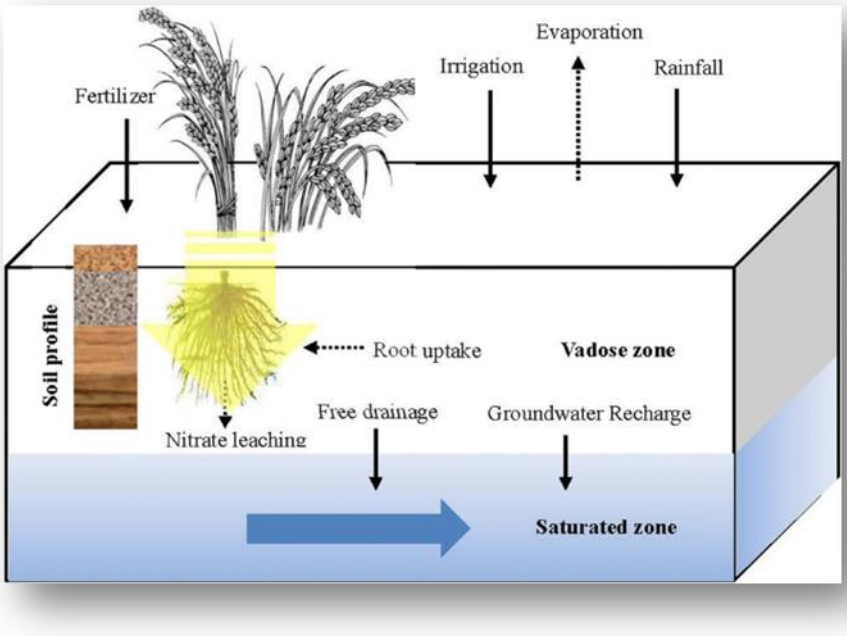


Fig.1.3 SOIL LEACHING

Soil Features that Influence Leaching:

- *Organic Matter:* The amount of organic matter in a soil is thought to be the single factor that has the greatest impact on how microorganisms break down pesticides. Pesticides are less likely to leach into groundwater because organic matter in the soil improves the surface area available for adsorption, boosts the soil's capacity to retain water and break down pesticides, and nourishes microorganisms. Crop leftovers can be added to the soil, manure can be added, and cover crops can be grown to increase the organic matter in the soil.
- *Soil Texture:* The amounts of sand, silt, and clay in the soil have an impact on how water moves through it. Large pores and high permeability characterize coarse-textured soils with more sand particles, which allow water to pass through quickly. Groundwater is more likely to become contaminated by pesticides delivered by water via soil with a coarse texture. Soils with a clay texture have less permeability. More water is retained and more chemicals are absorbed from the water by soil with high clay content. This lessens the likelihood of groundwater pollution, increases the likelihood of chemical

breakdown and binding to soil particles, and slows the downward migration of the pollutants.

- *Soil Structure:* Water can travel through the soil quickly because to loosely packed soil particles. Tightly compacted soil acts as a dam, holding water back and preventing its free flow. Openings and channels can be made for water flow in a number of different ways. For instance, animals and earthworms generate openings for water to flow through when they dig burrows. In soil and rock, freezing and thawing causes fissures or splits that dislodge compacted particles. When plant roots decay and die, they pierce the soil and make great water routes. Even through some clay soils, these apertures and channels might allow for a somewhat quick water flow.
- *Soil Water Content:* Rain or irrigation can recharge the groundwater and perhaps cause pesticides to seep into the aquifer, depending on how much water is already present in the soil. Once soil moisture content is getting close to or near saturation, soluble substances are much more likely to enter groundwater. When it rains and there is snowmelt in the spring, saturation is normal. Contrarily, when soils are dry, the additional water simply fills soil pores close to the soil surface, decreasing the likelihood that it will contact the groundwater supply.

CHAPTER 2

LITERATURE SURVEY

A comprehensive study of the available literature presents a catalog of previous studies to address this issue. The authors show in [1] that predicting fertilizer usage can assist farmers to attain a proper yield with little waste by preventing toxicity and deficiency in plants to some extent. Paper [2] makes use of fuzzy logic systems that enable the reduction of fertilizer usage which results in an increase in crop productivity. Additionally, [10] shows that the enhanced efficiency of fertilizers is not sufficient for complications that can be caused by compaction. These issues can be prevented by improving the fertilizer recommendation which requires the establishment of a quantifiable relation under N and P for fertilizer usage, in terms of agricultural yield, nitrogen need, and nitrate remnant level which is shown in [11] and paper [4] seconds this by providing a comprehensive measure to estimate the weightage of nutrient requirements and the role of the chemical properties of soil.

It is a difficult task to predict crop yield due to stochastic rainfall patterns and temperature variation. So, we can apply different data mining techniques as propounded in [3] for crop yield prediction. Laura J.T. Hess et al. in [5] state that nitrogen leaching is prone in areas that have no-till management and this may cause crop loss. In [7] the authors suggest a novel metric for ‘soil health and quality’ including refinement of soil’s health.

The objective of the paper [8] is to examine the characteristic changes in the creation and elements of soil populaces and capabilities because of the collaboration between long haul treatment and precipitation variances, to decide if preparation history affects the water-obstruction of soil microorganisms. Also, Paper [13] predicts agricultural yield as a function of rainfall. This is accomplished by giving a general summary of how production is affected by rainfall and how much a given crop can yield given the amount of rainfall received. Because it examines all regression procedures, the suggested method of evaluation is superior to other existing methods of evaluation.

Potnuru Sai Nishant et al. in paper [6] predict the yield of practically all types of crops in

India. This script makes innovative use of straightforward criteria such as state, district, and area, allowing the user to forecast crop yields in any year. Paper [12] suggests the use of Transfer Learning techniques to create a pre-trained model for detecting patterns in the dataset, which we then used to predict crop yields. In [14], supervised algorithms that boost crop yields, reduce human labor, time, and energy exerted on various agricultural tasks, and plant suggestions based on particular soil parameters are used to produce a complete way to predict crop sustainability. The study [16] demonstrated the capabilities of a machine learning model that can interpret and evaluate results, can be utilized to create the most useful information in long-term fertilizer studies, and that these methods can be employed in other long-term experiments. Paper [17] develops an interesting decision-based system on climatic, crop, and insecticide/pesticide data.

Senthil Kumar Swami Durai et al. in [18] propose an integrated solution to Pre-Cultivation activities. The goal of this study is to assist a small farm in becoming more efficient and achieving a high production at a low cost. It also aids in the estimation of total growth expenses. It will assist one in planning forward. Pre-cultivation activities lead to an integrated solution in agriculture. M.S. Suchithra and Maya L. Pai propose solutions to soil nutrient classification problems utilizing the rapid learning classification technique called an Extreme Learning Machine (ELM) with various activation functions in [19].

Crop diseases are one of the primary causes that impact the overall yield. Paper [15] conducts this study using an IoT system in the Kashmir Valley, it proposes an apple disease prediction model using data analysis and machine learning. The challenges of incorporating new technology into traditional agricultural practices are discussed in this paper.

CHAPTER 3
SYSTEM ANALYSIS

3.1 EXISTING SYSTEM

There are several methods and systems for nutrient recommendation for soil fertilization, including soil testing, crop-specific recommendations, precision agriculture technologies, decision support systems, and nutrient management planning. Soil testing is the most common method and can be done through on-site testing kits or by sending soil samples to a laboratory. Crop-specific recommendations and precision agriculture technologies provide customized recommendations based on the specific needs of each crop and field, while decision support systems use data to inform fertilizer application rates and timing.

3.1.1 DISADVANTAGES OF EXISTING SYSTEM

- Existing system doesn't account for rainfall patterns and eventually fails to prevent leaching.
- The system only works for few crops and few places and their accuracy is low.
- The smart farming system is not quite affordable even though it is reliable.

3.2 PROPOSED SYSTEM

The proposed system is used to reduce farmers' losses by providing useful insights about the amount and use of fertilizers, and to reduce water pollution by slowing down the process of leaching. It serves as a link between farmers and modern technology and enables them to increase yields while using less inputs. The system is designed as a website to provide platform-independent functionality, so that the user can access it from any device. The user interface has been kept simple with more emphasis on functionality and can be used by any naive user. It takes inputs such as crop, state and city using the drop-down menus provided on the website

and applies machine learning algorithms to estimate the correct amount of nitrogen, potassium and phosphorus content required. The location is fed to the Weather API which will return certain characteristics (e.g., temperature, humidity, rainfall) and if there is a possibility of heavy rainfall, a precautionary message is displayed to the user, otherwise the proposed algorithm is followed. This system provides good accuracy in its decision about the nutrients required for the crop.

3.2.1 ADVANTAGES OF PROPOSED SYSTEM

- ✓ The proposed system provides a helping hand to our farmers using a predictive model by random forest algorithm.
- ✓ Random forest regression with k-fold cross-validation technique represents the model with acceptable accuracy for prediction.
- ✓ It gives information about the quantity of nutrients required by the crops using a predictive model.
- ✓ It provides weather alerts and messages. Alerts are displayed in the output of this application in case of bad weather conditions.
- ✓ Seven-day weather forecasts is displayed to timely plan the fertilization.

CHAPTER 4
REQUIREMENT SPECIFICATIONS

4.1 HARDWARE SPECIFICATION

- Processor: Intel(R) Core (TM) i3-4005U CPU @ 1.70GHz
- RAM: 4.00 GB
- System type: 64-bit operating system, x64-based processor
- Network Interface Card
- Keyboard
- Mouse

4.2 SOFTWARE SPECIFICATION

- Operating System (any)
- Google Chrome (web browser)
- Visual Studio Code
- Jupyter Notebook
- Python 3.11

4.3 PYTHON

Python is a high-level, interpreted, general-purpose programming language. It supports a range of programming paradigms, such as functional, object-oriented, and structured programming (particularly procedural). Python is a scripting language that may be used for web applications, including through Apache's mod wsgi. The Web Server Gateway Interface has become a standardised API for these applications. Web frameworks like Pylons, Django, web2py, Pyramid, Flask, Zope, Tornado, TurboGears, and Bottle enable programmers to create and maintain sophisticated applications. Iron Python and Pyjs can be used to create the client-side of Ajax-based applications. One option for a relational database data mapper is SQLAlchemy. A framework for creating computer-to-computer communication is called Twisted.

Python is a fantastic choice for scientific computing thanks to tools like SciPy, Matplotlib, and Numpy as well as specialist libraries like Astropy and Biopython. SageMath

is a notebook-based, Python-programmable computer algebra system that includes numerical mathematics, calculus, combinatorics, number theory, and algebra among many other mathematical specialties. Some of the libraries frequently used in Python-based machine learning and AI applications are Pytorch, Scikit-learn, TensorFlow, and Keras.

Here is a collection of the main arguments in favor of Python:

- Additionally, the Python framework features packages and modules, which aid with code reuse.
- Open-source software exists for Python. It is available for free download and use in applications. The source code can also be read and changed.
- Code does not need to be compiled, making the Edit-Test-Debug cycle quick.
- Supports handling of exceptions. Errors can occur in any program. Python creates exceptions which can be handled, preventing program crashes.
- Automatically managing memory. Python's memory management system uses a private heap, a data structure that acts as a queue and houses all of the language's data structures and objects.

4.4 FLASK

A micro-web framework built on Python is called Flask. Because it doesn't need any particular tools or libraries, it is known as a microframework. It doesn't have a form validation layer, database abstraction layer, or any other elements that depend on already-built third-party libraries to carry out basic functions. But at the other hand, extensions can be utilized to increase application capabilities as if they had been created in Flask. The following standard framework-related tools all have extensions: upload handling, form validation, object-relational mappers and numerous open authentication protocols.

Python is used to create the Flask web application framework. It is created by Armin Ronacher, the founder of Pocco, a global community of Python fans. The Jinja2 template engine, Werkzeug and WSGI toolkit serve as the foundation for Flask. They're both Pocco projects.

WSGI

Python web application development now adheres to the Web Server Gateway Interface (WSGI) standard. A uniform gateway between both the web applications and web

server is described by the WSGI protocol.

Werkzeug

This is a WSGI toolkit that carries out utility operations like requests and response objects. As a result, a web framework may be built on top of it. Werkzeug serves as one of the foundations for the Flask framework.

4.5 HTML

- Hyper Text Markup Language is what HTML stands for.
- Website and applications are created using HTML.
- Hypertext: "Text within Text" is what hypertext is. A hypertext link can be found within a text. A link is considered a hypertext when it sends users to a new webpage when user click on it. Hypertext can be used to connect two or more web content.
- Markup language: A text document can be formatted and designed using this computer language. It can convert text into pictures, tables, and other formats.
- A web page is typically an HTML document that a web browser translates. Entering the URL will take you to the website. Both static and dynamic web pages are possible.
- Static Pages can be produced using HTML.
- HMTL main tags:
  - <!DOCTYPE>: It describes the type of document or informs the browser of the HTML version.
  - <html>: This element informs the browser that the document is an HTML one.
  - <head>: The metadata should be contained in the first element of the html element. The body tag must open before it can be closed.
  - <title>: It is employed to include the HTML page's title, which is displayed just at top of the web browser.
  - <body>: The HTML's primary material is included in here.
  - <h1>: That the very first level heading of the page is described in the text inside the <h1> tag.
- HTML's key attributes include:
  - It is an extremely basic language. HTML is comprehensible and adaptable.

- HTML makes it simple to create a presentation that is compelling.
- It offers a versatile method for designing text-based web pages.
- It gives programmers the ability to link to websites, which makes users more interested in exploring.
- It may be seen on any platform, including Windows, Linux, and Macintosh, making it platform independent.
- It makes it easier for programmers to enhance web sites with pictures, videos, and sound, making them more appealing and engaging.
- Both lowercase and uppercase tags are supported by HTML.

4.6 CSS

- Cascading style sheets, or CSS for short, is a language that governs how web pages are displayed, including their colors, fonts, and layout, making them more user-friendly.
- The primary use of CSS is to create style sheets for the internet. Even HTML is unrelated to it.
- Let's break down the CSS (acronym):
  - Falling into Style: Cascading
  - Imbuing our HTML tags: Style
  - Using style in a variety of publications' writing: Sheets
- Our HTML file can contain CSS in one of three ways:
  - Inline CSS
  - Internal CSS
  - External CSS
- Considering Priority:
  - Inline (then) Internal (then) External
- Inline CSS:
  - The only way to apply a style.
  - Independence
  - Adheres to each piece clearly.
  - The concept of separating issues has been forgotten.
- Internal CSS:

- We can use style tags to apply styles in HTML files.
- Redundancy is eliminated.
- But the concept of separating issues is still misunderstood.
- Particularly used on a single document.

- External CSS:
  - We can apply styles with the aid of the link tag in the head tag.
  - References are included.
  - Documents end with a .css (extension).
  - Redundancy is eliminated.
  - The concept of distinct concerns is maintained.
  - Particularly used for each document.
- CSS characteristics:
  - A selector element and a declaration block element make up a style rule.
  - The HTML component that we want to have its style applied to is indicated by the selector.
  - One or more assertions are contained in the declaration block, separated by semicolons.
  - Every declaration that is entered has a semicolon, a value, and a name for the CSS attribute. For instance, if color is the property, then red is the value. The property is font size, and the value is 15 pixels.
  - These blocks are enclosed in curly braces, and the CSS declaration is completed with a semicolon.
  - The ones that are used to find HTML elements dependent on the element id, class, name, attribute, and more are known as CSS selectors.

4.7 PARALLAX EFFECT

- The parallax effect is one of the little tricks that can make our landing page great and get our visitors' attention.
- CSS has matured considerably in the last few years. In short, there is a lot of flexibility in how things are done.
- The parallax effect is when two slices moving at a constant speed move at a constant

speed.

- We have seen a parallax effect app in front of a 2D game. In those apps, the background changes slowly compared to the front.
- We have noticed the parallax effect when the object is sitting in a car that is moving slower than other cars on the road.
- Simply put, the conditions that must be met for a parallax effect to occur are:
  - The parallax layer's perception changes, so it appears to move relatively fast or slowly without deviating from its original size.
  - Do not change the position or speed.
- To achieve both of these conditions, you need to increase the perceived distance between the user and the plane before moving along the negative Z axis.
- The longer the apparent distance, the smaller the aircraft may look. To counter this size reduction, you can reduce it to its original size.
- This mainly means using two CSS properties, Perspective and Transform. Use translateZ () and scale () transformation.

4.8 JAVASCRIPT

- Website programming languages include JavaScript.
- Recognized for creating websites that are also often used outside of browsers.
- JavaScript is a declarative as well as an imperative language. There is a standard library of objects in JavaScript, including arrays, dates, math, and other types.
- Client-side: Provides objects to manipulate the browser's Document Object Model (DOM).
- For instance, client-side extensions let your program include HTML components.
- React to user events including form submission, mouse clicks, page navigation, etc. as well as forms and user events.
- Convenient client-side libraries include AngularJS, ReactJS, and VueJS.
- Server-side: Provides objects related to the execution of JavaScript on the server.
- Imperative Languages-In this type of language, we are primarily interested in how to do it.

- Controls only the calculation flow. The object-oriented approach, which is a procedural programming approach, is equivalent to asynchronous wait when considering what to do next after an asynchronous call.
- Declarative programming: I'm worried about how to do that in this kind of language. Basically, it requires logical operations. The main goal here is to explain the desired result without directly defining the acquisition method like the arrow function.
- There are two ways to include JavaScript in HTML:
  - Internal JS: As necessary, tags can be inserted inside of other tags.
  - External JS: The JavaScript code can be written in a separate file with a.js extension and linked within the tag of the HTML file we wish to add to.

4.9 VS CODE

The Code - OSS repository is made available under a standard Microsoft product license, but with the Microsoft-specific modification of Visual Studio Code. The functionality that developers need to finish their edit-build-debug cycle is combined with a code editor's simplicity of use in Visual Studio Code. It offers comprehensive code editing, navigation, and comprehension support along with a deep extension architecture, light-weight debugging, and a light-weight interface with existing tools. Every month, Visual Studio Code receives updates with bug fixes and new features. On the Visual Studio Code website, we may download Visual Studio Code for Linux, Windows and macOS.

4.10 JUPYTER NOTEBOOK

A free online application called Jupyter Notebook allows users to create and share documents that include text, live code, equations, and visualizations. Jupyter Notebook is maintained by Project Jupyter. The IPython project, which formerly had its own IPython Notebook project, gave birth to Jupyter Notebooks. Julia, Python, and R are the three primary programming languages that Jupyter supports. Although Jupyter includes the IPython kernel, which enables you to create Python program, there are already over 100 other kernels available.

CHAPTER 5
SYSTEM DESIGN

The process of defining a system's architecture, modules, components, interfaces, and data in order to meet predetermined requirements is known as system design. We could think of systems design as the applications of systems approach to the creation of products.

5.1 Architectural Design

- A conceptual model known as system architecture describes the structure and behavior of the system. It consists of the system's elements and the connections between them that explain how the whole system is implemented. The Fig 5.1 below shows the system’s architecture and the various components added to them.

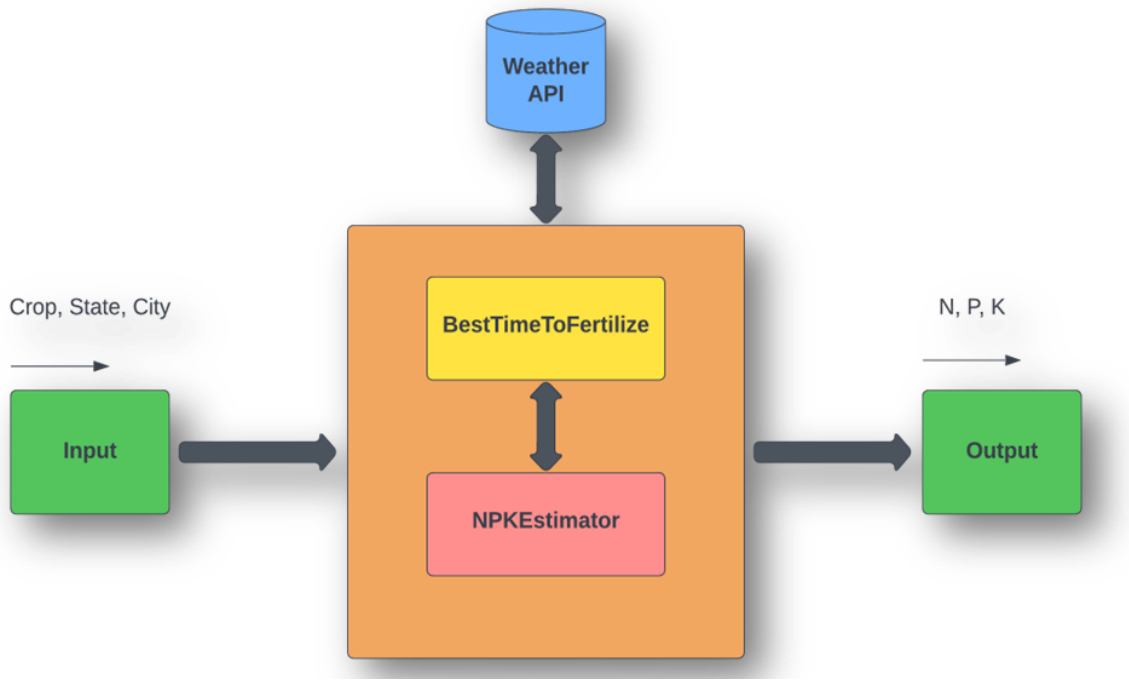


Fig 5.1: Block Diagram

- The description of each component from the block diagram above and their major functionalities with respect to the Eco-Fertilization as a complete unit is described in the table below.

Sl No.	Block Name	Functions
1	Input	User provides data such as crop, state and city using drop-down menu.
2	Weather API	Weather details like temerature, humidity, rainfall etc. is fetched from the weather API.
3	BestTimeToFertilize	This module provides the functionality to determine the best time to fertilize using fetched weather data and provides warning for heavy rain.
4	NPKEstimator	This module estimates the required ratio of NPK contents in the soil.
5	Output	Nitrogen, Phosphorus and Potassium content displayed on the website.

Table 5.1: Block Diagram functionalities

5.2 Data Flow Diagram

- A data flow diagram is a visual representation of how data "flows" throughout a data system, simulating certain features of its operation. It is frequently used as an initial stage to develop, without going into great depth, an overview of the system that may then be expanded upon. They may also be utilized to display data processing.
- The type of data that will be input into and generated by the system, how well the data will move through the system, and how the data will be kept are all displayed in a data flow diagram. Unlike a flowchart, which additionally displays information about timing and whether processes will run in succession or parallel, it does not provide this information.
- As shown in Fig 5.2, the system requires input from the user (such as location and crop). The location is fed to the Weather API which will return certain characteristics (e.g. temperature, humidity, rainfall) and if there is a possibility of heavy rainfall, a precautionary message is displayed to the user, otherwise, the proposed algorithm is followed.

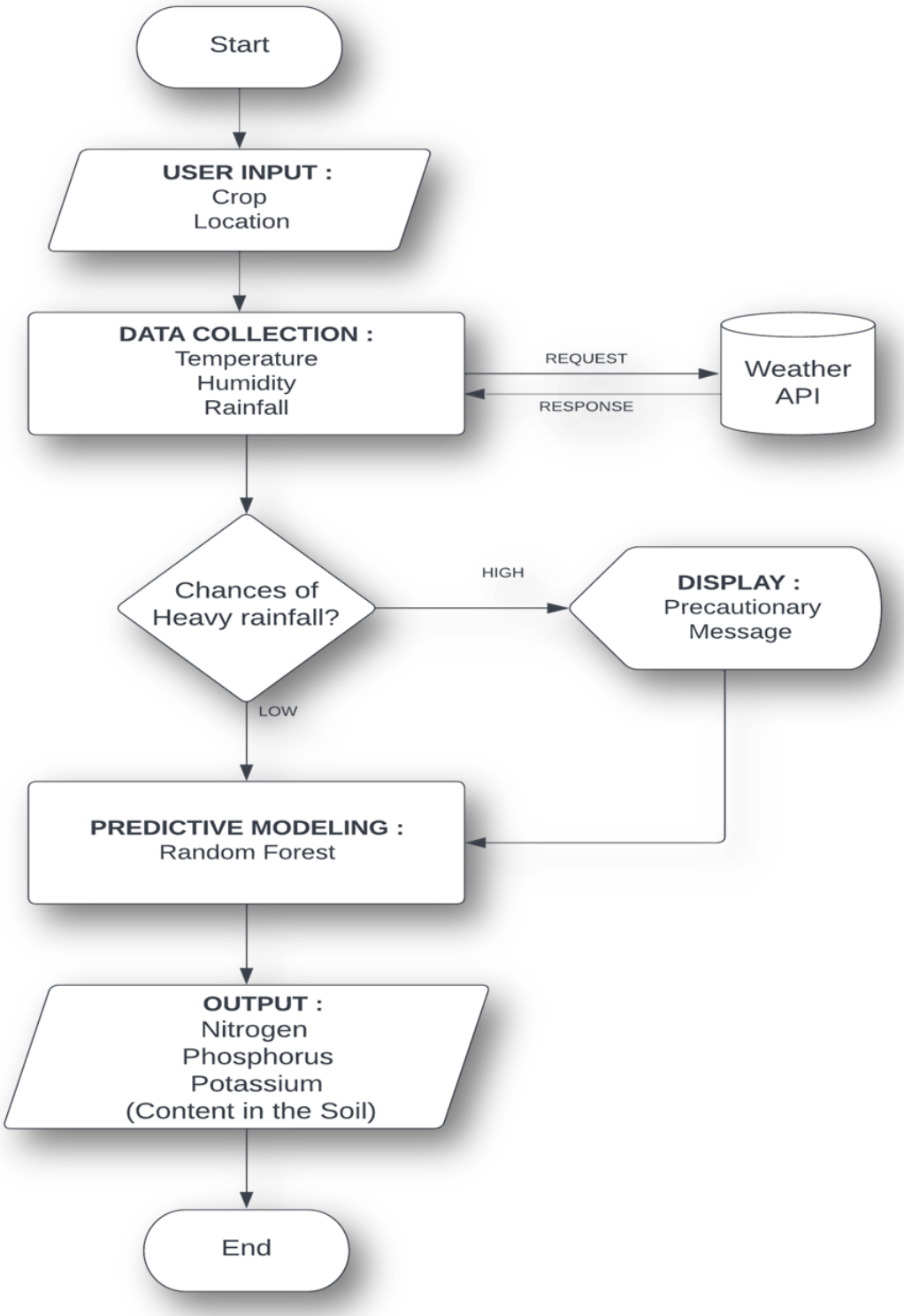


Fig 5.2: Data flow Diagram

5.3 Class Diagram

- Static diagrams include class diagrams. It represents the application's static view. Class diagrams are used to create executable code for software applications as well as for visualizing, explaining, and documenting various elements of systems.
- A collection of classes, interfaces, affiliations, collaborations, and constraints are displayed in a class diagram. A structural diagram is another name for it.

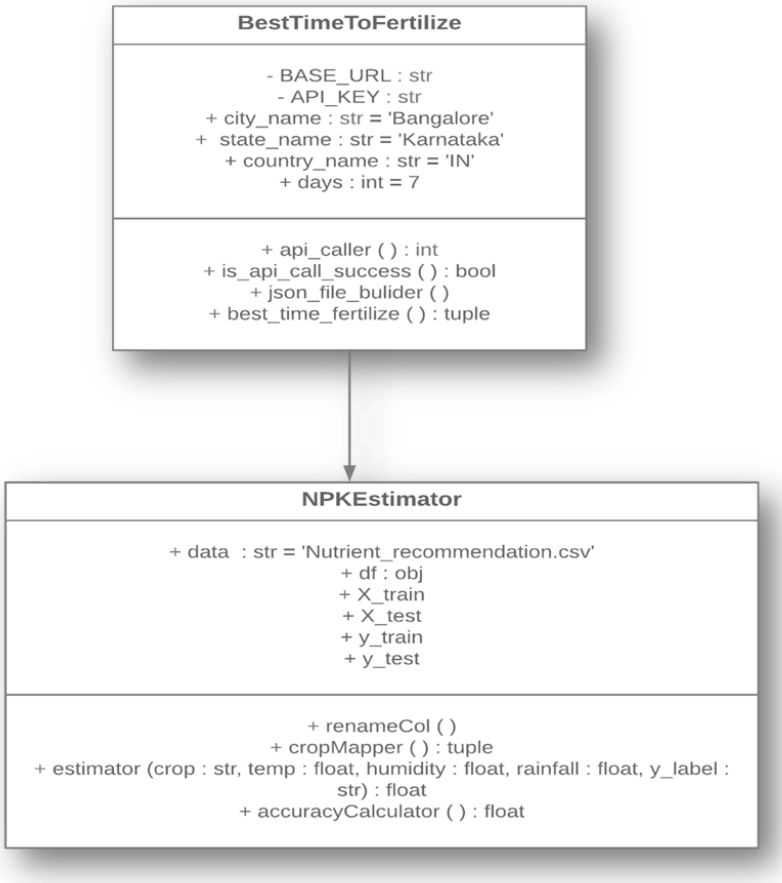


Fig 5.3: Class Diagram

5.4 Sequence Diagram

- Object interactions are arranged in temporal sequence in a sequence diagram. It shows the classes and objects engaged in the scenario as well as the flow of messages that must be exchanged for the objects to work as intended. Inside the logical view of the system being developed, sequence diagrams are often connected to use case realizations. Event diagrams and event scenarios are other names for sequence diagrams.
- A sequence diagram is made up of vertical parallel lines (called "lifelines") that represent several processes or things that exist at the same time and horizontal arrows that represent the messages sent between them in the chronological order in which they take place. This enables the graphical specification of straightforward runtime scenarios.

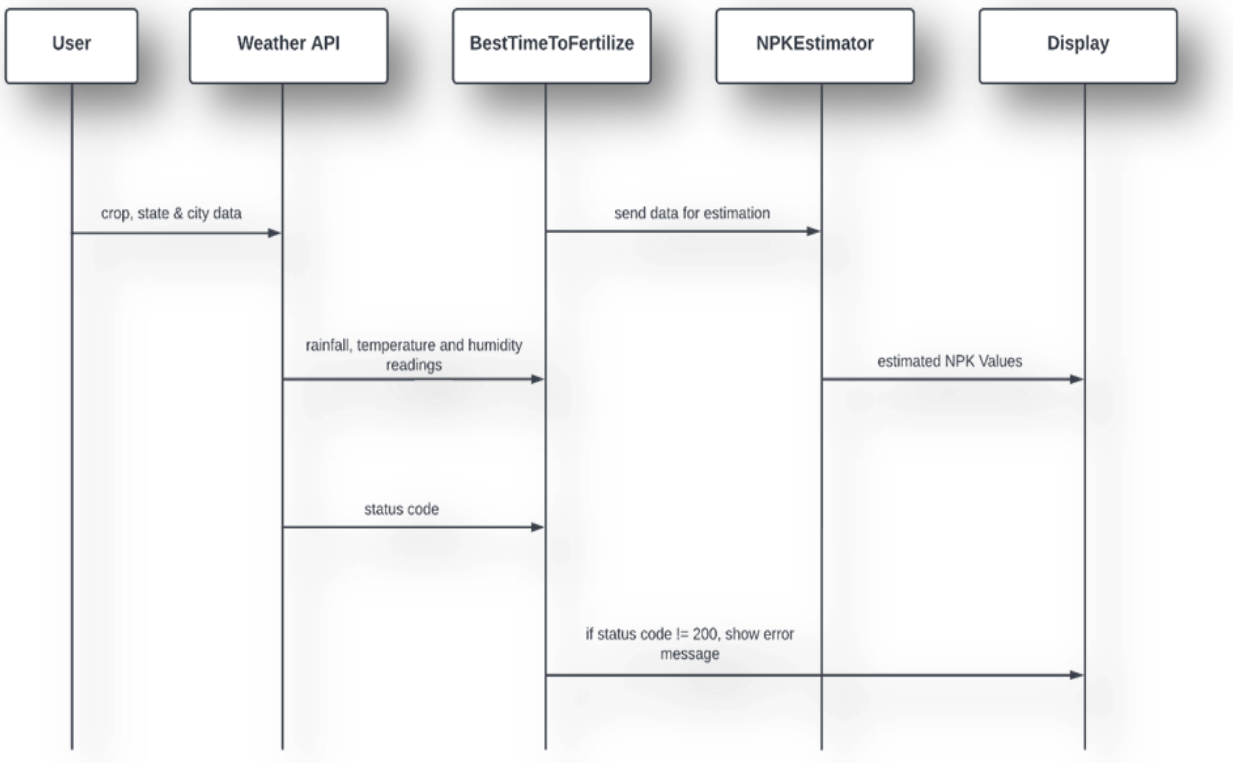


Fig 5.4: Sequence Diagram

CHAPTER 6
MODULES

6.1 LIST OF MODULES

- Dataset collection and preparation
- Build Machine Learning Model
- Build a Web Page

6.2 MODULE EXPLANATION

6.2.1 DATASET COLLECTION AND PREPROCESSING

Actual dataset contains eight features. All of the features are not useful for the proposed model. Therefore, a dimension reduction technique called feature selection is applied and seven features, then selected for evaluation.

- **INPUT FEATURES:**

  Below are the input features of our system:

  - **Crop:** rice, cotton, mango, orange, lentil, etc.
  - **Temperature:** temperature measured in Celsius
  - **Humidity:** measured relatively in percentages
  - **Rainfall:** rainfall in mm

- **OUTPUT FEATURES:**

  Below are the output features of our system:

  - **Label_N:** ratio of soil Nitrogen content
  - **Label_P:** ratio of soil Phosphorus content
  - **Label_K:** ratio of soil Potassium content

Dataset used in our proposed system:

	A	B	C	D	E	F	G	H
1	N	P	K	temperature	humidity	ph	rainfall	label
2	90	42	43	20.8797437	82.0027442	6.50298529	202.935536	rice
3	85	58	41	21.7704617	80.3196441	7.03809636	226.655537	rice
4	60	55	44	23.0044592	82.3207629	7.84020714	263.964248	rice
5	74	35	40	26.4910964	80.1583626	6.98040091	242.864034	rice
6	78	42	42	20.1301748	81.6048729	7.62847289	262.717341	rice
7	69	37	42	23.0580487	83.3701177	7.0734535	251.055	rice
8	69	55	38	22.708838	82.6394139	5.70080568	271.32486	rice
9	94	53	40	20.2777436	82.8940862	5.71862718	241.974195	rice
10	89	54	38	24.5158807	83.5352163	6.68534642	230.446236	rice
11	68	58	38	23.2239739	83.0332269	6.33625353	221.209196	rice
12	91	53	40	26.5272351	81.4175385	5.38616779	264.61487	rice
13	90	46	42	23.9789822	81.450616	7.50283396	250.083234	rice
14	78	58	44	26.800796	80.8868482	5.10868179	284.436457	rice
15	93	56	36	24.0149762	82.0568718	6.98435366	185.277339	rice
16	94	50	37	25.6658521	80.6638505	6.94801983	209.586971	rice
17	60	48	39	24.2820942	80.3002559	7.04229907	231.086335	rice
18	85	38	41	21.5871178	82.7883708	6.24905066	276.655246	rice
19	91	35	39	23.7939196	80.4181796	6.97085975	206.261186	rice
20	77	38	36	21.8652524	80.1923008	5.95393328	224.555017	rice
21	88	35	40	23.5794363	83.5876032	5.85393208	291.298662	rice
22	89	45	36	21.3250416	80.474764	6.44247538	185.497473	rice
23	76	40	43	25.1574553	83.1171348	5.07017567	231.384316	rice
24	67	59	41	21.9476674	80.973842	6.01263259	213.356092	rice
25	83	41	43	21.0525355	82.6783952	6.25402845	233.107582	rice
26	98	47	37	23.4838134	81.3326507	7.37548285	224.058116	rice
27	66	53	41	25.0756354	80.5238915	7.77891515	257.003887	rice
28	97	59	43	26.3592716	84.0440359	6.28650018	271.358614	rice
29	97	50	41	24.5292268	80.5449858	7.07096	260.263403	rice
30	60	49	44	20.7757615	84.497744	6.24484149	240.081065	rice

Fig 6.2.1 Actual Dataset

	A	B	C	D	E	F	G
1	Crop	Temperature	Humidity	Rainfall	Label_N	Label_P	Label_K
2	rice	20.87974371	82.00274423	202.9355362	90	42	43
3	rice	21.77046169	80.31964408	226.6555374	85	58	41
4	rice	23.00445915	82.3207629	263.9642476	60	55	44
5	rice	26.49109635	80.15836264	242.8640342	74	35	40
6	rice	20.13017482	81.60487287	262.7173405	78	42	42
7	rice	23.05804872	83.37011772	251.0549998	69	37	42
8	rice	22.70883798	82.63941394	271.3248604	69	55	38
9	rice	20.27774362	82.89408619	241.9741949	94	53	40
10	rice	24.51588066	83.5352163	230.4462359	89	54	38
11	rice	23.22397386	83.03322691	221.2091958	68	58	38
12	rice	26.52723513	81.41753846	264.6148697	91	53	40
13	rice	23.97898217	81.45061596	250.0832336	90	46	42
14	rice	26.80079604	80.88684822	284.4364567	78	58	44
15	rice	24.01497622	82.05687182	185.2773389	93	56	36
16	rice	25.66585205	80.66385045	209.5869708	94	50	37
17	rice	24.28209415	80.30025587	231.0863347	60	48	39
18	rice	21.58711777	82.7883708	276.6552459	85	38	41
19	rice	23.79391957	80.41817957	206.2611855	91	35	39
20	rice	21.8652524	80.1923008	224.5550169	77	38	36
21	rice	23.57943626	83.58760316	291.2986618	88	35	40
22	rice	21.32504158	80.47476396	185.4974732	89	45	36
23	rice	25.15745531	83.11713476	231.3843163	76	40	43
24	rice	21.94766735	80.97384195	213.3560921	67	59	41
25	rice	21.0525355	82.67839517	233.1075816	83	41	43
26	rice	23.48381344	81.33265073	224.0581164	98	47	37
27	rice	25.0756354	80.52389148	257.0038865	66	53	41
28	rice	26.35927159	84.04403589	271.3586137	97	59	43
29	rice	24.52922681	80.54498576	260.2634026	97	50	41
30	rice	20.77576147	84.49774397	240.0810647	60	49	44

Fig 6.2.2 Customised Dataset

6.2.2 BUILD MACHINE LEARNING MODEL

6.2.2.1 Random Forest Regression

A group of several decision trees called a random forest (RF) are trained using different subsets of data and have changeable hyper-parameters. In our project, we are going to take crop and location as input, and based on it, we will predict the value of N, P, and K. First, we will divide our dataset into training and test datasets, where the training dataset is 80% of the original data and the rest 20% is test data. Then we will create three different random forests of size 50 (decision tree) for each N, P, and K and produces the average of the classes as the overall tree projection, shown in Table.

BEGIN:
Step 1: The dataset of size n = 2200 is divided into training and test dataset (where the raining set is 80% and the test set is 20% that is training set=1,760 and the test set=240).
Step 2: Apply random forest regression to each N, P and K (Nitrogen, Phosphorus & Potassium) value with n estimators=50 (n estimators is the number of decision trees).
Step 3: Train the N Label, P Label and K Label with the training dataset and dependent variable (Where the dependent variable is N for N Label, P for P Label and K for K Label).
Step 4: Each N Label, P Label and K Label generates a 50-decision tree as an output based on the training dataset.
END

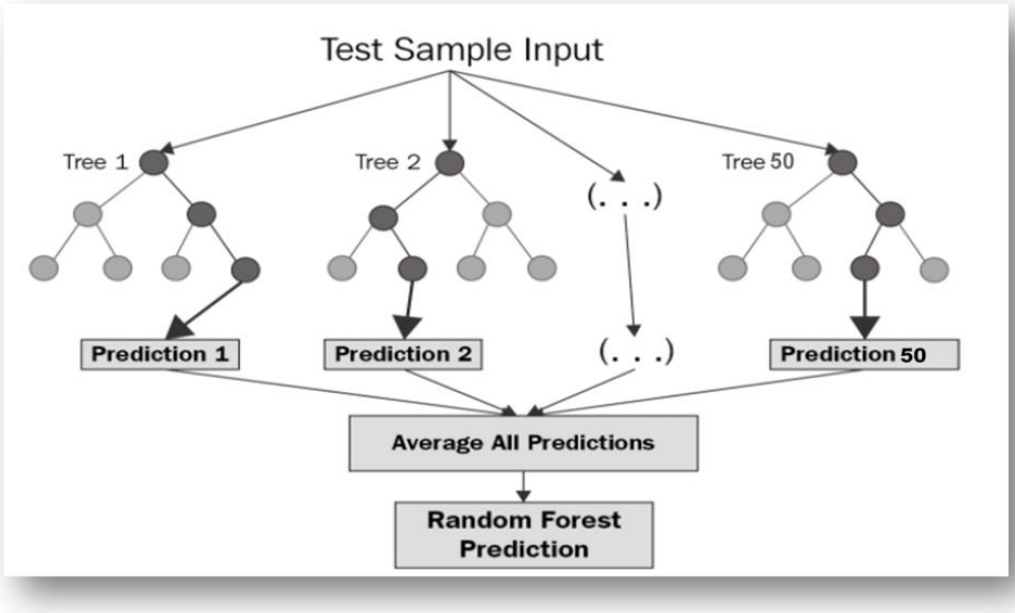


Fig: Random Forest Regression Algorithm

Why we selected 50 decision trees (n_estimator = 50) for each label?

- We have tested for different n_estimator values, but the upmost accuracy achieved for *N_Label* is 0.87 for two decimal digit precision. As shown in below figure.

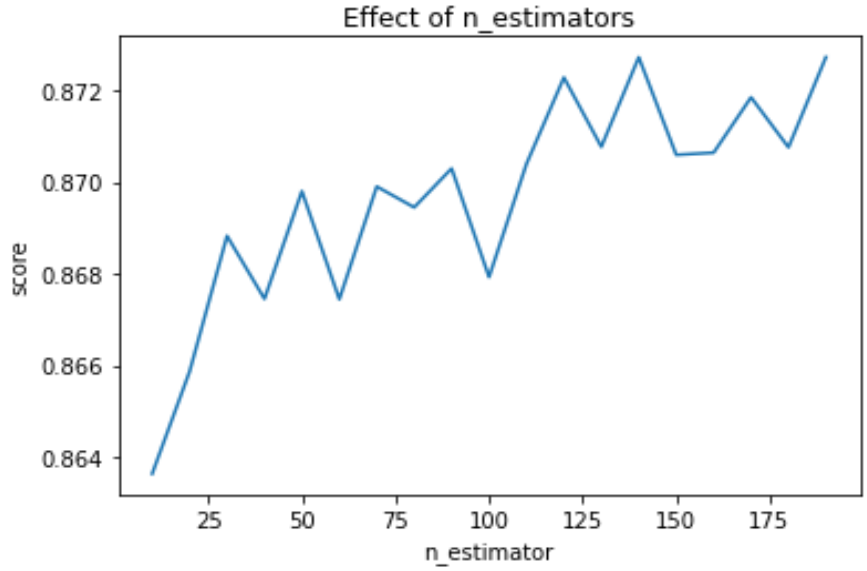


Fig 6.2.2.1: Effect of n_estimator

Why is a Random Forest chosen instead of a Decision Tree for this project?

- Decision trees are trees that show all possible consequences of a selection using a branched technique, which is a key distinction between them and the random forest algorithm. In contrast, a set of decision trees that follow the output are produced by the random forest method.
- In general, adding more trees will increase performance and predictability while decreasing calculation speed. The end solution for regression issues is the mean of all the trees. The samples in the tree target cell is the initial level of means in a random forest method regression model, followed by all trees. In contrast to linear regression, it estimates values beyond the observed range using prior observations.
- The accuracy in the decision tree depends on the number of right predictions made divided by the total number of predictions, since it uses huge value attributes at each node, and it produces less accurate results when we apply an algorithm to handle the regression problem in a random forest. Decision trees are greedy and may be deterministic, meaning they produce different answers if we add or remove any additional rows. So, compared to decision trees, random forest forecasts outcomes with higher accuracy.
- The main problem with machine learning is overfitting. Overfitting may be viewed as a generic bottleneck in machine learning and occurs when we apply algorithms. When machine learning models are unable to perform well on unknown datasets, this is a sign of overfitting. This is especially true if the problem is detected mostly on testing or validation datasets and is significantly larger than the error on the training dataset. Overfitting occurs when models gain knowledge non - constant data in the training data, which has a negative effect on the performance on the new data model. Due to the employment of several decision trees in the random forest, the danger of overfitting is lower than that of the decision tree.
- The accuracy increases when we employ a decision tree classifier on a data set since it

contains more splits, which makes it easier to overfit the dataset and validate it.

- So, that's why we decided to select random forest as our machine learning model rather than decision tree to predict the required nutrients (Nitrogen, Phosphorus, Potassium) for the given crop. Random Forest performs well in terms of computation if we adjust the n_estimator value carefully. In our case we have used n_estimator = 50 after taking readings of our model's accuracy with different n_estimator values, same is shown in Figure.

6.2.2.2 Cross Validation

In order to evaluate machine learning algorithm on a small set of data, cross-validation is a re - sampling technique. The algorithm's sole parameter, k, indicates how many groups should be formed from a given data sample. As a result, the technique is frequently referred to as k-fold cross-validation. When a precise value for k is given, it can be substituted for k in the model's regard, such as k=4 for cross-validation that is performed four times.

In applied machine learning, cross-validation is mostly used to gauge how well a machine learning model performs on untrained data. That is, to use a small sample to assess how the model will generally perform when used to generate predictions on data that was not utilized during the model's training.

It is a well-liked technique since it is easy to comprehend and typically yields a less biased or overly optimistic assessment of the model ability than other techniques, including a straightforward train/test split.

Following is the general process:

1. Randomly shuffle the dataset.
2. Create k groups from the dataset.
3. For every distinct group:
    a. The group should be used as a holdout or test data set.
    b. As a training dataset contains, use the remaining groupings.
    c. Adapt a model to the training set, then evaluate it against the test set.

d. Keep the evaluation result but discard the model.

4. Using a sample of quality assessment ratings, summaries the model's.

It's significant that every observation in the sample data is given a unique group and remains there throughout the process. This indicates that each sample has the chance to be used k times to train the model and k times in the hold out set.

It is crucial that all data preparation done before fitting the model takes place on the loop's CV-assigned training dataset rather than the larger data set. This also holds true for any hyperparameter adjustment. Data leakage and an exaggerated assessment of the model's skill may occur from failing to carry out these procedures within the loop.

The mean of the model skill scores is frequently used to sum up the outcomes of a k-fold cross-validation run. A measure of the skill scores' volatility, like the standard error or standard deviation, should also be included.

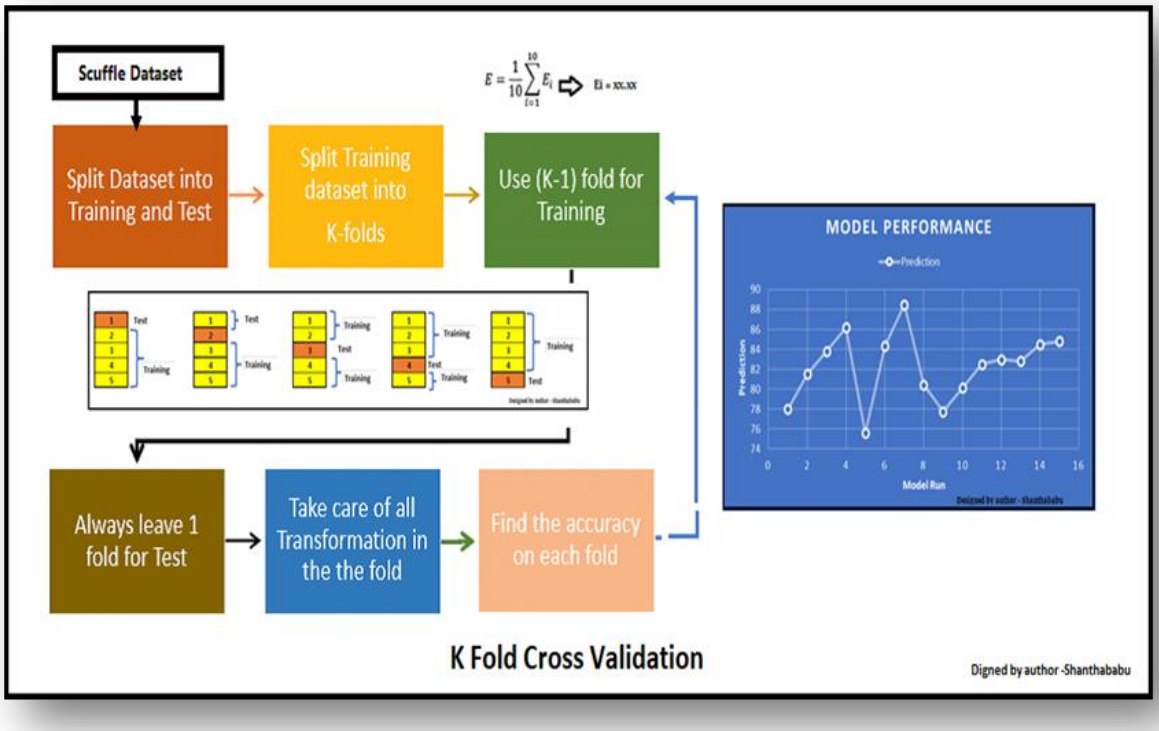


Fig 6.2.2 k-fold Cross-Validation

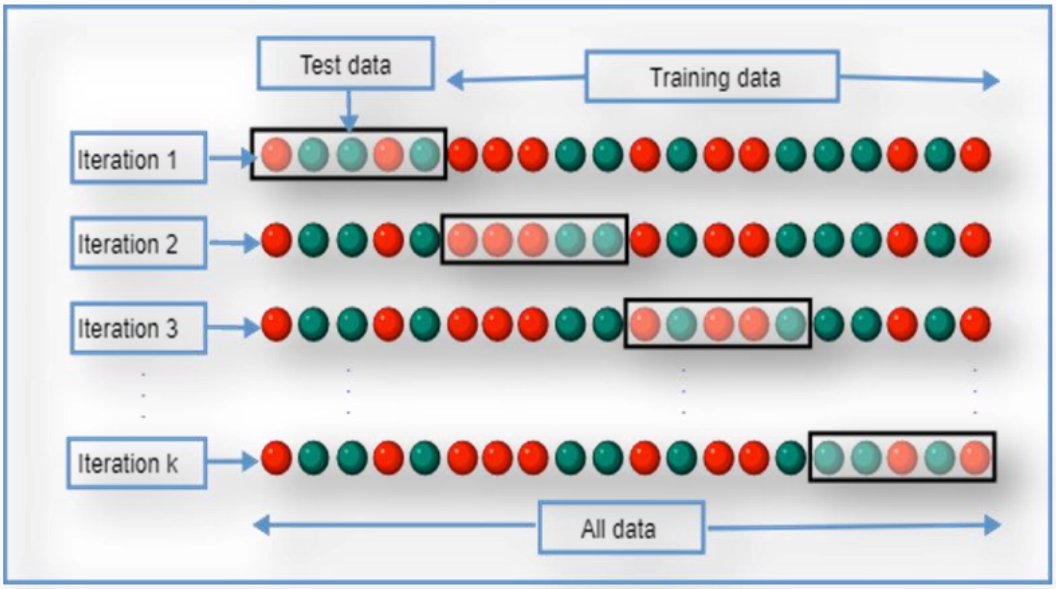


Fig: Cross-Validation procedure

6.2.3 BUILD A WEB PAGE

In this application, we have developed a web application using Flask that allows users to input information about a city, state, and crop, and then uses an algorithm to display a 7-day weather report fetched from a weather API. Thus, the application predicts and displays the nutrient requirements for the soil based on the input data. By combining different sources of data and applying algorithms, we are able to provide useful information to users in a simple and accessible way. This application is a useful tool for farmers and gardeners who are looking to plan their crops and optimize their soil nutrients.

CHAPTER 7

CODING AND TESTING

7.1 CODING

Once the design aspect of the system is finalizing the system enters into the coding and testing phase. The coding phase brings the actual system into action by converting the design of the system into the code in a given programming language. Therefore, a good coding style has to be taken whenever changes are required it easily screwed into the system.

7.2 CODING STANDARDS

Coding standards are guidelines to programming that focuses on the physicalstructure and appearance of the program. They make the code easier to read, understand and maintain. This phase of the system actually implements the blueprint developed during the design phase. The coding specification should bein such a way that any programmer must be able to understand the code and can bring about changes whenever felt necessary. Some of the standard needed to achieve the above-mentioned objectives are as follows:

- Program should be simple, clear and easy to understand.
- Naming conventions
- Value conventions
- Script and comment procedure
- Message box format
- Exception and error handling

7.2.1 NAMING CONVENTIONS

Naming conventions of classes, data member, member functions, procedures etc., should be self-descriptive. One should even get the meaningand scope of the variable by its name. The conventions are adopted for easy understanding of the intended message by the user. So, it

is customary to follow the conventions. These conventions are as follows:

- **CLASS NAMES**

Class names are problem domain equivalence and begin with capital letterand have mixed cases.

- **MEMBER FUNCTION AND DATA MEMBER NAME**

Member function and data member name begins with a lowercase letter with each subsequent letters of the new words in uppercase and the rest of lettersin lowercase.

7.2.2 VALUE CONVENTIONS

Value conventions ensure values for variable at any point of time. This involves the following:

- Proper default values for the variables.
- Proper validation of values in the field.
- Proper documentation of flag values.

7.2.3 SCRIPT WRITING AND COMMENTING STANDARD

Script writing is an art in which indentation is utmost important. Conditional and looping statements are to be properly aligned to facilitate easy understanding. Comments are included to minimize the number of surprises that could occur when going through the code.

7.2.4 MESSAGE BOX FORMAT

When something has to be prompted to the user, he must be able to understand it properly. To achieve this, a specific format has been adopted in displaying messages to the user. They are as follows:

- X – User has performed illegal operation.
- ! – Information to the user.

7.3 TEST PROCEDURE

7.3.1 SYSTEM TESTING

Testing is performed to identify errors. It is used for quality assurance. Testing is an integral part of the entire development and maintenance process. The goal of the testing during phase is to verify that the specificationhas been accurately and completely incorporated into the design, as well as to ensure the correctness of the design itself. For example, the design must not have any logic faults in the design is detected before coding commences, otherwise the cost of fixing the faults will be considerably higher as reflected. Detection of design faults can be achieved by means of inspection as well as walkthrough.

Testing is one of the important steps in the software development phase. Testing checks for the errors, as a whole of the project testing involves the following test cases:

- Static analysis is used to investigate the structural properties of the Sourcecode.
- Dynamic testing is used to investigate the behavior of the source code by executing the program on the test data.

7.4 TEST DATA AND OUTPUT

7.4.1 UNIT TESTING

Unit testing is conducted to verify the functional performance of each modular component of the software. Unit testing focuses on the smallest unit of the software design (i.e.), the module. The white-box testing techniques were heavily employed for unit testing.

7.4.2 FUNCTIONAL TEST

Functional test cases involved exercising the code with nominal input values for which the expected results are known, as well as boundary values and special values, such as logically related inputs, files of identical elements, and empty files.

Three types of tests in Functional test:

- Performance Test
- Stress Test
- Structure Test

7.4.3 PERFORMANCE TEST

It determines the amount of execution time spent in various parts of the unit, program throughput, and response time and device utilization by the program unit.

7.4.4 STRESS TEST

Stress Test is those, test designed to intentionally break the unit. A Great deal can be learned about the strength and limitations of a program by examining the manner in which a programmer in which a program unit breaks.

7.4.5 STRUCTURED TEST

Structure Tests are concerned with exercising the internal logic of a program and traversing particular execution paths. The way in which White- Box test strategy was employed to ensure that the test cases could Guaranteethat all independent paths within a module have been exercised at least once.

1. Exercise all logical decisions on their true or false sides.
2. Execute all loops at their boundaries and within their operationalbounds.
3. Exercise internal data structures to assure their validity.
4. Checking attributes for their correctness.
5. Handling end of file condition, I/O errors, buffer problems and textual errors in output information
6.

7.4.6 INTEGRATION TESTING

Integration testing is a systematic technique for construction theprogram structure while at

the same time conducting tests to uncover errors associated with interfacing. i.e., integration testing is the complete testing of the set of modules which makes up the product. The objective is to take untested modules and build a program structure tester should identify critical modules. Critical modules should be tested as early as possible. One approach is to wait until all the units have passed testing, and then combine them and then tested. This approach is evolved from unstructured testing of small programs. Another strategy is to construct the product in increments of tested units. A small set of modules are integrated together and tested, to which another module is added and tested in combination. And so on. The advantages of this approach are that, interface dispenses can be easily found and corrected.

The major error that was faced during the project is linking error. When all the modules are combined the link is not set properly with all support files. Then we checked out for interconnection and the links. Errors are localized to the new module and its intercommunications. The product development can be staged, and modules integrated in as they complete unit testing. Testing is completed when the last module is integrated and tested.

7.5 TESTING TECHNIQUES / TESTING STRATEGIES

7.5.1 TESTING

Testing is a process of executing a program with the intent of finding an error. A good test case is one that has a high probability of finding an as-yet – undiscovered error. A successful test is one that uncovers an as-yet- undiscovered error. System testing is the stage of implementation, which is aimed at ensuring that the system works accurately and efficiently as expected before live operation commences. It verifies that the whole set of programs hang together. System testing requires a test consists of several key activities and steps for run program, string, system and is important in adopting a successful new system. This is the last chance to detect and correct errors before the systemis installed for user acceptance testing.

The software testing process commences once the program is created, and the documentation and related data structures are designed. Software testing is essential for correcting errors. Otherwise, the program or the project is not said to be complete. Software

testing is the critical element of software quality assurance and represents the ultimate the review of specification design and coding. Testing is the process of executing the program with the intent of finding the error. A good test case design is one that as a probability of finding an undiscovered error. A successful test is one that uncovers an undiscovered error. Any engineering product can be tested in one of the two ways:

7.5.1.1 WHITE BOX TESTING

This testing is also called as Glass box testing. In this testing, by knowing the specific functions that a product has been designed to perform test can be conducted that demonstrate each function is fully operational at the same time searching for errors in each function. It is a test case design method that uses the control structure of the procedural design to derive test cases. Basis path testing is a white box testing.

Basis path testing:

- Flow graph notation
- Cyclometric complexity
- Deriving test cases
- Graph matrices Control

7.5.1.2 BLACK BOX TESTING

In this testing by knowing the internal operation of a product, test can be conducted to ensure that "all gears mesh", that is the internal operation performs according to specification and all internal components have been adequately exercised. It fundamentally focuses on the functional requirements of the software.

The steps involved in black box test case design are:

- Graph based testing methods.
- Equivalence partitioning.
- Boundary value analysis.

7.5.2 SOFTWARE TESTING STRATEGIES

A software testing strategy provides a road map for the software developer. Testing is a set

activity that can be planned in advance and conductedsystematically. For this reason, a template for software testing a set of steps into which we can place specific test case design methods should be strategy should have the following characteristics:

- Testing begins at the module level and works –outward‖ toward the integration of the entire computer-based system.
- Different testing techniques are appropriate at different points intime.
- The developer of the software and an independent test groupconducts testing.
- Testing and Debugging are different activities but debugging mustbe accommodated in any testing strategy.

7.5.2.1 INTEGRATION TESTING

Integration testing is a systematic technique for constructing the program structure while at the same time conducting tests to uncover errors associated with. Individual modules, which are highly prone to interface errors, should not be assumed to work instantly when we put them together. Theproblem of course, is –putting them together‖- interfacing. There may be the chances of data lost across on another's sub functions, when combined may not produce the desired major function; individually acceptable impression may be magnified to unacceptable levels; global data structures can present problems.

7.5.2.2 PROGRAM TESTING

The logical and syntax errors have been pointed out by program testing. A syntax error is an error in a program statement that in violates one or more rules of the language in which it is written. An improperly defined field dimension or omitted keywords are common syntax error. These errors areshown through error messages generated by the computer. A logic error on the other hand deals with the incorrect data fields, out-off-range items and invalid combinations. Since the compiler s will not deduct logical error, the programmer must examine the output. Condition testing exercises the logical conditionscontained in a module. The possible types of elements in a condition include a Boolean operator, Boolean variable, a pair of Boolean parentheses A relational operator or on arithmetic expression. Condition testing method focuses on testing each condition in the program the purpose of condition test is to deduct not only

errors in the condition of a program but also other a errors in the program.

7.5.2.3 SECURITY TESTING

Security testing attempts to verify the protection mechanisms built in to a system well, in fact, protect it from improper penetration. The system security must be tested for invulnerability from frontal attack must also be tested for invulnerability from rear attack. During security, the tester places the role of individual who desires to penetrate system.

7.5.2.4 VALIDATION TESTING

At the culmination of integration testing, software is completely assembled as a package. Interfacing errors have been uncovered and corrected and a final series of software test-validation testing begins. Validation testing can be defined in many ways, but a simple definition is that validation succeeds when the software functions in manner that is reasonably expected by the customer. Software validation is achieved through a series of black box tests that demonstrate conformity with requirement. After validation test has been conducted, one of two conditions exists.

- The function or performance characteristics confirm to specifications and areaccepted.
- A validation from specification is uncovered and a deficiency created.

Deviation or errors discovered at this step in this project is corrected prior to completion of the project with the help of the user by negotiating to establish a method for resolving deficiencies. Thus, the proposed system underconsideration has been tested by using validation testing and found to be working satisfactorily. Though there were deficiencies in the system they were not catastrophic

7.5.2.5 USER ACCEPTANCE TESTING

User acceptance of the system is a key factor for the success of any system. The system under consideration is tested for user acceptance by constantly keeping in touch with prospective system and user at the time of developing and making changes whenever required. This is done in regard to the following points.

- Input screen design.
- Output screen design.

CHAPTER 8

CONCLUSION

The proposed system demonstrates an impressive level of performance, achieving a remarkable 92% accuracy. This accuracy rate is commendable for any predictive model, highlighting its effectiveness. The system's primary purpose is to furnish essential insights concerning the utilization and optimal quantities of nutrients necessary for crops to attain satisfactory growth and maximize production, considering prevailing weather conditions. Additionally, it serves as a platform for relaying valuable weather alerts and messages to users. In instances where adverse weather conditions are detected, the application promptly displays alerts within its output, ensuring that users remain informed and prepared. Although the current accuracy level is already commendable, there is room for further enhancement through technological advancements. By leveraging the continual progress in technology, the system's accuracy can be refined and improved, leading to even more precise predictions and ultimately benefiting users in their agricultural endeavors.

CHAPTER 9

FUTURE ENHANCEMENT

The proposed system provides a helping hand to our farmers. It gives information about the use and quantity of nutrients required by the crops. There is scope for improvement in the system by providing user interface in the native language, so that the user can operate the system easily if he or she is unfamiliar with the English language. In addition, speech recognition systems can be added to handle illiterate users.

CHAPTER 10
APPENDIX-1

Backend Code:

app.py

```
from flask import Flask, render_template, request, url_for
from BestTimeToFertilizeModule import BestTimeToFertilize
from NPKEstimatorModule import NPKEstimator

app = Flask(__name__)

@app.route('/processing/', methods=['GET', 'POST'])
def processing():
    # print('Processing.....')
    if request.method == "GET":
        print("The URL /processing is accessed directly.")
        return url_for('index.html')

    if request.method == "POST":
        form_data = request.form
        call_success = []
        npk_list_dict = []
        popup_data = []
        seven_days = []

        crop = form_data['crop']
        state = form_data['state']
        city = form_data['city']

        with open("InputData.csv", "w") as fh:
            input_data = "%s,%s,%s" % (crop.strip(), state.strip(), city.strip())
            fh.write(input_data)
```

```
        bttf = BestTimeToFertilize(city_name = city, state_name = state)
        bttf.api_caller()

        if bttf.is_api_call_success():
            category, heading, desc = bttf.best_time_fertilize()
            call_success.append(1)
            popup_data.append([category, heading, desc])
            seven_days = bttf.weather_data[:]
            # print(seven_days)

            # today's weather data
            di = bttf.weather_data[0]
            temp = di['Temperature']
            humidity = di['Relative Humidity']
            rainfall = di["Rainfall"]

            est = NPKEstimator()
            est.renameCol()

            npk = {'Label_N':0, 'Label_P':0, 'Label_K':0}
            for y_label in ['Label_N', 'Label_P', 'Label_K']:
                npk[y_label] = est.estimator(crop, temp, humidity, rainfall, y_label)
            # print(npk)

            npk_list_dict.append(npk)

            output_data = category +"\n"+ heading +"\n"+ desc +"\n"+ str(npk['Label_N'])  +"\n"+ str(npk['Label_P'])  +"\n"+
str(npk['Label_K'])
            with open("output.txt", "w") as fh:
                fh.write(output_data)
        else:
            print("Error Occured")
        #print(call_success, npk_list_dict, form_data, popup_data)
```

```
    return render_template('update.html', CALL_SUCCESS = call_success, NPK = npk_list_dict, FORM_DATA = form_data, POPUP_DATA = popup_data, SEVEN_DAYS = seven_days)


@app.route('/', methods=['POST', 'GET'])
def index():
    return render_template('index.html')


if __name__ == "__main__":
    app.run(host="0.0.0.0", port=5000)
```

BestTimeToFertilizeModule.py

```
import requests as rq
import json as js
from time import sleep


class BestTimeToFertilize:
    __BASE_URL = "https://api.weatherbit.io/v2.0/forecast/daily?"
    __API_KEY = "480589e42e7c4352abe4fe25bd398ab0"


    def __init__(self, city_name = 'Bangalore', state_name = 'Karnataka', days = 7):
        self.city_name = '+'.join(city_name.lower().strip().split())
        self.state_name = '+'.join(state_name.lower().strip().split())
        self.country_name = 'IN'
        self.days = days
        self.response = None
        self.response_code = None
        self.weather_data = list()

    def api_caller(self):
        try:
            complete_url = "{0}city={1}&state={2}&country={3}&key={4}&days={5}".format(self.__BASE_URL, self.city_name, self.state_name, self.country_name, self.__API_KEY, self.days)
            # print(complete_url)
            # while self.response == None:
            self.response = rq.get(complete_url)
            sleep(5)
            self.response_code = self.response.status_code
            return self.response_code
```

```
    except Exception as msg:
        print("api_caller():", msg)
        return -1


def is_api_call_success(self):
    if self.response_code == 200:
        return True
    elif self.response_code == 204:
        print('Content Not available, error code: 204')
    return False


def json_file_bulider(self):
    try:
        json_obj = self.response.json()
        with open('weather_data.json', 'w') as file:
            js.dump(json_obj, file, indent = 1, sort_keys = True)
        print("weather_data.json file build successfully")
    except Exception as msg:
        print("json_bulider():", msg)


def best_time_fertilize(self):
    json_obj = self.response.json()

    # print("City:", json_obj['city_name'], "\n")

    prolonged_precip = 0
    prolonged_prob = 0
    heavy_rain_2d = False
    heavy_rain_chance_2d = 0
    precip_2d = 0
    precip_chance_2d = 0

    for i in range(self.days):
        date = json_obj['data'][i]['datetime']
        temp = json_obj['data'][i]['temp']
        rh = json_obj['data'][i]['rh']
        precip = json_obj['data'][i]['precip']
        prob = json_obj['data'][i]['pop']
        w_code = json_obj['data'][i]['weather']['code']
        w_desc = json_obj['data'][i]['weather']['description']
        i_code = json_obj['data'][i]['weather']['icon']
```

```
            prolonged_precip += precip
            prolonged_prob += prob

            count_2d = 0
            if i < 2:
               precip_2d += precip
               precip_chance_2d += prob
               if w_code in [202, 233, 502, 521, 522]:
                  heavy_rain_2d = True
                  heavy_rain_chance_2d += prob
                  count_2d += 1
                  heavy_rain_chance_2d //= count_2d

            di = {
                 "Date":date,
                 "Temperature":temp,
                 "Relative Humidity":rh,
                 "Rainfall":precip,
                 "Probability of Precipitation":prob,
                 "Weather Description": w_desc
                }
            self.weather_data.append(di)

        prolonged_prob //= self.days
        precip_chance_2d //= 2

        if heavy_rain_2d:
            print("*"*21, "Warning !!!", "*"*21)
            print("Heavy Rain Chances within 2 days:", heavy_rain_chance_2d)
            print("Heavy Rainfall puts your fertilizer at risk.")
            print("*"*21, "Warning !!!", "*"*21)
            return ('Warning', 'Heavy Rain Alert', 'Heavy Rain Chances within two days from now is %d%%' %
(heavy_rain_chance_2d))

        elif prolonged_precip > 12.7 and prolonged_prob >= 50:
            print("*"*21, "Warning !!!", "*"*21)
            print("Prolonged Rainfall of greater than 12.7 mm puts your fertilizer at risk.")
            print("*"*21, "Warning !!!", "*"*21)
            return ('Warning', 'Prolonged Rainfall Alert', 'Prolonged Rainfall of greater than 12.7 mm puts your
fertilizer at risk. From now %.2f mm rainfall will receive for upcoming seven days, chances %d%%' %
(prolonged_precip, prolonged_prob))
        else:
            print("-"*80)
            print("The amount of rain for 2 days, counting today:", precip_2d)
```

```
        print("Chances of rain for 2 days, counting today:", precip_chance_2d)
        print()
        return ('Message', 'Precipitation Amount', 'The amount of rain for 2 days, counting today is %.2f mm and chances is %d%%' % (precip_2d, precip_chance_2d))
```

NPKEstimatorModule.py

```
import warnings
import numpy as np
import pandas as pd
from sklearn import metrics
import category_encoders as ce
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor

warnings.filterwarnings('ignore')


class NPKEstimator:
    def __init__(self, data = 'Nutrient_recommendation.csv', ):
        self.df = pd.read_csv(data, header=None)
        self.X_train = None
        self.X_test = None
        self.y_train = None
        self.y_test = None


    def renameCol(self):
        self.df.columns = ['Crop', 'Temperature', 'Humidity', 'Rainfall', 'Label_N', 'Label_P', 'Label_K']
        self.df.drop(self.df.index[:1], inplace=True)


    def cropMapper(self):
        # create mapping of crop(string) to int type
        mapping = dict()

        with open("mapped_crops.csv", "w") as fh:
            fh.write("Crops,Key\n")
            for i, crop in enumerate(np.unique(self.df[['Crop']]), 1):
                mapping[crop] =  i
                fh.write("%s,%d\n" % (crop, i))
            mapping['NA'] = np.nan
            fh.write("NA,nan")
```

```
    # print(mapping)

    ordinal_cols_mapping = [{"col": "Crop", "mapping": mapping}, ]
    encoder = ce.OrdinalEncoder(cols = 'Crop', mapping = ordinal_cols_mapping, return_df = True)
    return mapping, encoder


def estimator(self, crop, temp, humidity, rainfall, y_label):
    X = self.df.drop(['Label_N', 'Label_P', 'Label_K'], axis=1)
    y = self.df[y_label]

    self.X_train, self.X_test, self.y_train, self.y_test = train_test_split(X, y, test_size = 0.20, random_state = 42)

    mapping, encoder = self.cropMapper()
    self.X_train = encoder.fit_transform(self.X_train)
    self.X_test = encoder.transform(self.X_test)

    regressor = RandomForestRegressor(n_estimators = 50, random_state = 0)
    regressor.fit(self.X_train, self.y_train)

    # y_pred = regressor.predict(self.X_test)
    query = [mapping[crop.strip().lower()], temp, humidity, rainfall]
    y_pred = regressor.predict([query])
    return y_pred[0]


def accuracyCalculator(self):
    model = RandomForestRegressor(n_jobs=-1)
    estimators = np.arange(10, 200, 10)
    scores = []
    for n in estimators:
        model.set_params(n_estimators=n)
        model.fit(self.X_train, self.y_train)
        scores.append(model.score(self.X_test, self.y_test))

    scores_arr = [round(sc, 3) for sc in scores]
    unique, counts = np.unique(scores_arr, return_counts = True)

    max_count = max(counts)
    accuracy = -1
    for uni, count in zip(unique, counts):
        # print(uni, count)
        if count == max_count:
            accuracy = uni
```

```
    # print("Model accuracy: %.2f" % (accuracy))
    return accuracy
```

Frontend Code:

base.html

```
<!DOCTYPE html>
<html lang="en">
<head>
   <meta charset="UTF-8">
   <meta http-equiv="X-UA-Compatible" content="IE=edge">
   <meta name="viewport" content="width=device-width, initial-scale=1.0">
   <script type="text/javascript" src="{{ url_for('static',filename='script/cities.js') }}"></script>
   <script type="text/javascript" src="{{ url_for('static',filename='script/crops.js') }}"></script>
   <link rel="stylesheet" href="{{ url_for('static', filename='css/style.css')}}">
   <script src="https://unpkg.com/sweetalert/dist/sweetalert.min.js"></script>
   <title>Eco-Fertilization</title>
   {% block head %} {% endblock %}
</head>

<body>
   {% block body %} {% endblock %}
</body>
<script type="text/javascript" src="{{ url_for('static',filename='script/app.js') }}"></script>
<script type="text/javascript" src="{{ url_for('static',filename='script/button.js') }}"></script>
</html>
```

index.html

```
{% extends 'base.html' %}
```

```
{% block head %}
{% endblock %}
{% block body %}
<header>
   <nav>
      <div class="container">
         <h3 class="logo" style="color: #008000; font-weight: 1000;">Eco<span
               style="color: #ffffff;">Fertilization</span></h3>
      </div>
   </nav>
   <h1 class="big-title translate" data-speed="0.5"></h1>
   <img src="static/parallax/top1.png" class="top translate" data-speed="0.3" alt="">
   <img src="static/parallax/bottom2.png" class="Bottom translate" data-speed="-0.25" alt="">
</header>

<section id="scroll2">
   <div class="shadow">
      <a href="#scroll2">
         <div class="scroll-down"></div>
      </a>
   </div>
   <div class="container">
      <div class="content opacity">
         <h3 class="title">
            Fill out the Details
         </h3>
         <form action="{{ url_for('processing') }}" method="post">
            <div class="option2">
               <select class="state1" name="crop" onchange="print_crop('crop',this.selectedIndex);" id="sts"
                  required></select>
               <script>
                  print_crop("sts");
               </script>
```

```
            </div>
            <br>
            <div class="option1">
               <select class="state1" onchange="print_city('state',this.selectedIndex);" name="state" id="s"
                  required></select>
               <br><br>
               <select class="state1" name="city" id="state" required></select>
               <script>
                  print_state("s");
               </script>
            </div>
            <div class="animaton">
               <button type="submit" id="color">
                  <span></span>
                  <span></span>
                  <span></span>
                  <span></span>
                  Submit
               </button>
            </div>
         </form>
      </div>
      <div class="imgcontainer">
         <img src="static/parallax/ferti.jpg" style="opacity: 0.8;">
      </div>
   </div>
</section>
{% endblock %}
```

update.html

```
{% extends 'base.html' %}
```

```
{% block head %}
{% endblock %}
{% block body %}
<header>
   <nav>
      <div class="container">
         <h3 class="logo" style="color: #008000; font-weight: 1000;">Eco<span
               style="color: #ffffff;">Fertilization</span></h3>
      </div>
   </nav>
   <h1 class="big-title translate" data-speed="0.5"></h1>
   <img src="/static/parallax/top1.png" class="top translate" data-speed="0.3" alt="">
   <img src="/static/parallax/bottom2.png" class="Bottom translate" data-speed="-0.25" alt="">
</header>

<section id="scroll2">
   <div class="shadow">
      <a href="#scroll2">
         <div class="scroll-down"></div>
      </a>
   </div>
   <div class="container">
      <div class="content opacity">
         <h3 class="title">
            Entered Details
         </h3>
         <div class="option2">
            <p class="state1">{{FORM_DATA['crop']}}</p>
         </div>
         <br>
         <div class="option1">
            <p class="state1">{{FORM_DATA['state']}}</p>
            <br>
```

```
    <p class="state1">{{FORM_DATA['city']}}</p>
</div>
{% if CALL_SUCCESS|length == 1 %}
<div class="answer">
    <h3 style="text-align: center; margin-bottom: auto; margin-top: auto;">Required Nutrient Ratio</h3>
        <br>
    <dl>
        <dt><h4>N :    </h4></dt>
        <dd>{{ NPK[0]['Label_N'] }}</dd>
        <br>
        <dt><h4>P :   </h4></dt>
        <dd>{{ NPK[0]['Label_P'] }}</dd>
        <br>
        <dt><h4>K :     </h4></dt>
        <dd>{{ NPK[0]['Label_K'] }}</dd>
        <br>
    </dl>
    <hr>
    <h4>{{ POPUP_DATA[0][0]}}</h5>
    <h5>{{ POPUP_DATA[0][1]}}</h5>
    <h6>{{ POPUP_DATA[0][2]}}</h6>
</div>
{% endif %}
{% if CALL_SUCCESS|length == 0 %}
<div class="answer">
<h4>Data not available, try different city.</h4>
</div>
{% endif %}
<a href="/" style="text-align: center;">
    <form action="/">
        <button type="submit">&lt; Back</button>
    </form>
</a>
```

```
        </div>
        {% if CALL_SUCCESS|length == 1 %}
        <div class="days3">
            <h3 style="text-align:left;  letter-spacing: 5px;">     7 DAYS REPORT<hr></h3>
            <br>
            {% for di in SEVEN_DAYS %}
            <div class="days2">
            {% for key,value in di.items() %}
                {{key}} : {{value}}
                <br>
                {% endfor %}
            </div>
            {% endfor %}
        </div>
        {% endif %}
    </div>
<script>
    window.scrollBy(0, 1110)
</script>
 </section>
{% endblock %}
```

update.html

```
@import url('https://fonts.googleapis.com/css2?family=Poppins:wght@300;400;600&display=swap');
*{
    padding: 0;
    margin: 0;
    box-sizing: border-box;
}
html{
  scroll-behavior: smooth;
}
```

```
body{
    font-family: 'Poppins',sans-serif;
}
.container {
    max-width: 90rem;
    margin: 3% auto;
}
header {
    width: 100%;
    height: 100vh;
    position: relative;
    overflow: hidden;
}
header::after {
    content: '';
    position: absolute;
    width: 100%;
    height: 100%;
    left: 0;
    top: 0;
    background-color: rgba(0, 0, 0, 0.05);
    z-index: 25;
}
.Bottom{
    position: absolute;
    width: 100%;
    bottom: -14.5%;
    z-index: 22;
}
.top {
    top: 0;;
    position: absolute;
    width: 100%;
```

```
    z-index: 17;
}
nav{
    position: absolute;
    top: 0;
    left: 0;
    width: 100%;
    padding: 1rem 0;
    z-index: 30;
    color: aliceblue;
    background-color: linear-gradient(to bottom, rgba(0, 0, 0, 0.05), transparent);
}
.logo {
color: #fff;
font-size: 3rem;
text-transform: uppercase;
font-weight: 600;
letter-spacing: 2px;
}
.big-title {
    color: #fff;
    position: absolute;
    z-index: 18;
    line-height: 4rem;
    top: calc(50% - 2rem);
    width: 100%;
    text-align: center;
    font-size: 3rem;
    font-weight: 600;
    text-shadow: 1px 1px 5px #151515;
}
section{
    width: 100%;
```

```
    background-color: rgb(254, 254, 254);
  position: relative;
}
section .container{
  padding: 3rem;
  display: grid;
  grid-template-columns: repeat(2,1fr);
  align-items: center;
  justify-content: center;
  min-height: 70vh;
}
section img{
  width: 100%;
}

section .container > *{
    margin: 2rem;
}
.content{
    transform: translateY(-50px);
}
.title {
    font-weight: 600;
    font-size: 1rem;
    margin-bottom: 1rem;
    padding-bottom: .5rem;
    position: relative;
    color: #151515;
}
.shadow{
    position: absolute;
    bottom: 100%;
    height: 300px;
```

```
    width: 100%;
    left: 0;
    z-index: 95;
    background: linear-gradient(to top,#151515,transparent);
}
.opacity{
    opacity: 0;
}
section .container{
    padding: 3rem;
    display: grid;
    align-items: center;
    justify-content: center;
    min-height: 100vh;
}
section img{
    width: 100%;
    border-radius: 10px;
    box-shadow: 2px 2px 5px;
}
section .container > *{
    margin: 2rem;
}
.content{
    color: #fff;
    transform: translateY(-50px);
}
.imgContainer{
    transform: translateY(50px);
}
/* ----------changes start---------- */
.days3{
  display: grid;
```

```
  grid-template-columns: 50% 50%;
  border-radius: 10px;
  transform: translateY(-20px);
}
.days2{
  color: #151515;
  background-color: transparent;
  border-radius: 20px;
  border: #151515;
  box-shadow: 0.5px 0.5px 2px;
  margin-top: 20px;
  margin-left:20px ;
  padding: 20px;
  transition: 0.5s
}
h3 hr{
  margin-right: 55px;
    padding: 0.8px;
    background-color: black;
    margin-left: 16%;
}
.days2:hover{
  transform: scale(1.0);
  box-shadow: 0px 0px 5px;
  cursor: pointer;
}
dl{
  margin-left: 13%;
}
dt {
  display:block;
  float: left;
  text-align: center;
```

```
  color:#151515;
}
dt h4{
  margin-left: 100px;
}
dd {
  display: flex;
  margin-left: -50px;
}
.answer {
    margin: 50px 80px 10px;
    padding: 35px;
    background-color: #ffffff;
    color: #151515;
    border-radius: 10px;
    box-shadow: 0px 0px 4px;
    text-align: center;
}

/* ------------ changes end---------------------- */
.scroll-down{
  height: 50px;
  width: 30px;
  border:2px solid #ffffff;
  left: 50%;
  bottom: 50%;
  position: absolute;
  right: 50%;
  border-radius: 50px;
  cursor: pointer;
}
.scroll-down::before,
.scroll-down::after{
```

```
  content: '';
  position: absolute;
  top: 20%;
  left: 50%;
  border:2px solid yellow;
  height: 10px;
  width: 10px;
  transform: translate(-50%,-100%) rotate(45deg);
  border-top: transparent;
  border-left: transparent;
  animation: scroll-down 1s ease-in-out infinite;
}
.scroll-down::after{
  top : 30%;
  animation-delay: 0.3s;
}
@keyframes scroll-down{
  0%{
    opacity: 0;
  }
  30%{
    opacity: 1;
  }
  60%{
    opacity: 1;
  }
  100%{
    opacity: 0;
    top: 90%;
  }
}
.state1 {
    width: 100%;
```

```
    padding: 12px;
    border-radius: 5px;
    letter-spacing: 1px;
    background: #283747;
    color: #fff;
    box-shadow: 0px 3px 5px rgba(0, 0, 0, 0.3);
    cursor: pointer;
}

button {
    background-color: #6e0025;;
    position: relative;
    border: none;
    display: inline-block;
    padding: 10px 20px;
    color: #ffffff;
    font-size: 16px;
    text-decoration: none;
    text-transform: uppercase;
    overflow: hidden;
    transition: .5s;
    border-radius: 5px;
    margin-top: 40px;
    transition: 5s;
    letter-spacing: 4px
  }
  button:hover{
      cursor: pointer;
  }
  button span {
    position: absolute;
    display: block;
  }
```

```
#hideshow {
background-color: #fefefe;
margin-top: 3rem;
padding: 3rem;
border-radius: 5px;
box-shadow: 0px 3px 5px rgba(0, 0, 0, 0.3);
color: #151515;
}

#hideshow button{
  align-items: center;
  background-color: #151515;
  box-shadow: 0px 3px 5px rgba(0, 0, 0, 0.3);
  padding: 10px 30px;
}
#hideshow button:hover{
  background-color: green;
}
.npk{
 display: none;
}
.container2{
  max-width: 1170px;
  margin: auto;
}
.row{
  display: flex;
  flex-wrap: wrap;
}
ul{
  list-style: none;
}
footer{
```

```
  background-color: #151515;
  padding: 70px 0;
}
.footer-col{
  width: 25%;
  padding: 0 15px;
}

.footer-col h4{
  font-size: 18px;
  color: #ffffff;
  margin-bottom: 35px;
  position: relative;
}
.footer-col h4::before{
  content: '';
  position: absolute;
  left: 0;
  bottom: -10px;
  height: 2px;
  background-color: #FFC400;
  box-sizing: border-box;
  width: 50px;
}
.footer-col ul li:not(:last-child){
  margin-bottom: 10px;
}
.footer-col ul li a {
  font-size: 16px;
  text-transform: capitalize;
  color: #ffffff;
  text-decoration: none;
  color: #bbbbbb;
```

```
  display: block;
}
.footer-col ul li a:hover{
  color: #ffffff;
}
/* ---------------------- Responsive---------------------- */
@media(max-width:767px){
  .footer-col{
    width: 50%;
  margin-bottom: 30px;
  }
}
@media(max-width:474px){
  .footer-col{
    width: 100%;
  margin-bottom: 30px;
  }
}
@media  screen and (max-width: 1366px) {
  .big-title {
    color: #fff;
    position: absolute;
    z-index: 18;
    line-height: 4rem;
    top: calc(50% - 4rem);
    width: 100%;
    text-align: center;
    font-size: 3rem;
    font-weight: 600;
    text-shadow: 1px 1px 5px #151515;
}
.Bottom{
  position: absolute;
```

```
  width: 100%;
  bottom: -18.5%;
  z-index: 22;
}

.logo {
  color: #fff;
  font-size: 2.5rem;
  text-transform: uppercase;
  font-weight: 600;
  margin-left: 7%;
  letter-spacing: 2px;
  }
  .days2{
    transform: scale(0.8);
  }
  .scroll-down{
    transform: translateY(70px);
]
}
@media  screen and (max-width: 1024px) and (orientation:landscape) {
  .big-title {
    color: #fff;
    position: absolute;
    z-index: 21;
    line-height: 4rem;
    transform: translateY(-700px);
    width: 100%;
    text-align: center;
    font-size: 1.5rem;
    font-weight: 600;
    text-shadow: 1px 1px 5px #151515;
}
```

```
.Bottom{
  position: absolute;
  width: 100%;
  bottom:21.5%;
  z-index: 22;
}
.scroll-down{
  transform: translateY(-105px);
}
.logo {
  color: #fff;
  font-size: 2rem;
  text-transform: uppercase;
  font-weight: 600;
  margin-left: 7%;
  margin-top: 2%; ;
  letter-spacing: 2px;
  }
  header {
    width: 100%;
    height: 113vh;
    position: relative;
    overflow: hidden;
}
header::after {
  top: -26%;
}
.shadow {
  bottom: 120%;
}
}
@media  screen and (max-width: 854px) {
  section .container{
```

```
    grid-template-columns: 1fr;
  }
}
```

app.js

```
const translate=document.querySelectorAll(".translate");
const big_title=document.querySelector(".big-title");
const header=document.querySelector("header");
const shadow=document.querySelector(".shadow");
const section=document.querySelector("section");
const content=document.querySelector(".content  ");
const opacity=document.querySelectorAll(".opacity  ");
let header_height=header.offsetHeight;
let section_height=section.offsetHeight;
window.addEventListener('scroll', () => {
    let scroll=window.pageYOffset;
    let sectionY=section.getBoundingClientRect();

    translate.forEach(element =>{
        let speed = element.dataset.speed;
        element.style.transform=`translateY(${scroll * speed}px)`;
    })
opacity.forEach(element =>{
    element.style.opacity = scroll / (sectionY.top + section_height);
})
    big_title.style.opacity= - scroll/ (header_height / 2) + 1;
    shadow.style.header=`${scroll * 0.5 + 300}px`;
    content.style.transform=`translateY(${scroll /(section_height + sectionY.top)* 50 - 50}px)`;

})
```

button.js

```
let btn = document.querySelector('#color');
```

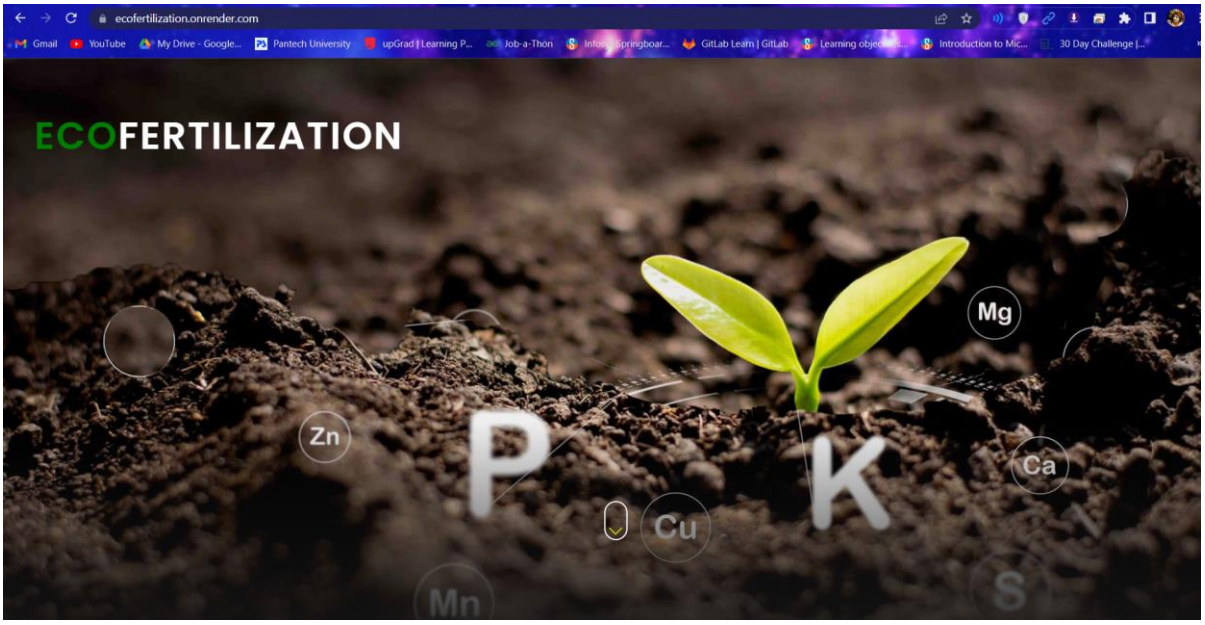
```
btn.addEventListener('click',()=> {
   btn.style.backgroundColor = '#006400';
   btn.textContent = 'Applying Algorithm..';
});
```

crop.js

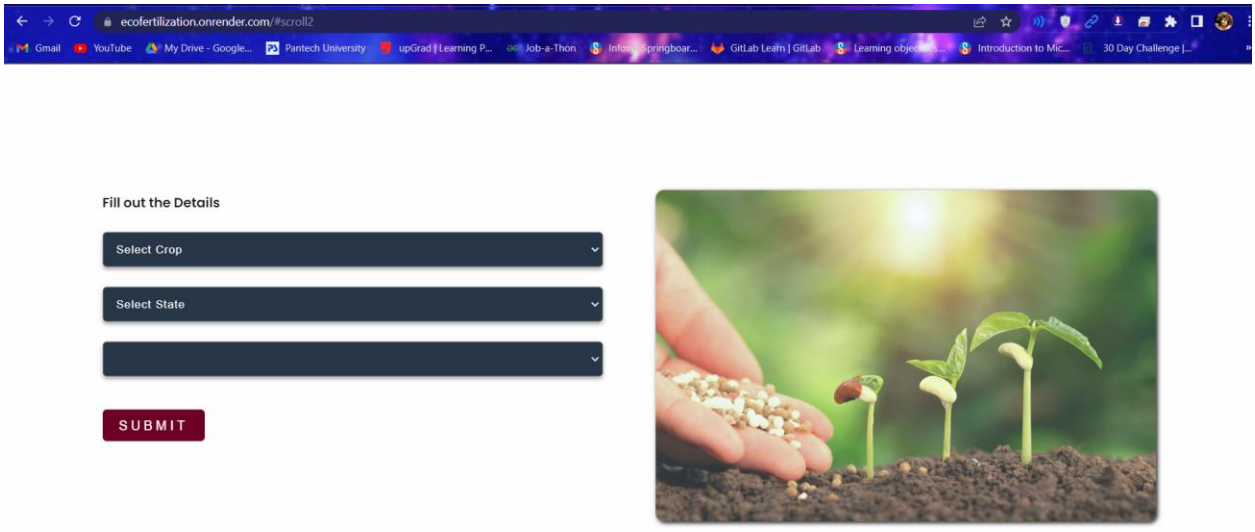
```
var crop_arr = new
Array("rice","maize","chickpea","kidneybeans","pigeonpeas","mothbeans","mungbean","blackgram","lentil","pomegranate","
banana","mango","grapes","watermelon","muskmelon","apple","orange","papaya","coconut","cotton","jute","coffee");

function print_crop(crop_id){
  // given the id of the <select> tag as function argument, it inserts <option> tags
  var option_str = document.getElementById(crop_id);
  option_str.length=0;
  option_str.options[0] = new Option('Select Crop','');
  option_str.selectedIndex = 0;
  for (var i=0; i<crop_arr.length; i++) {
            option_str.options[option_str.length] = new Option(crop_arr[i],crop_arr[i]);
  }}
```

CHAPTER 11
APPENDIX-2

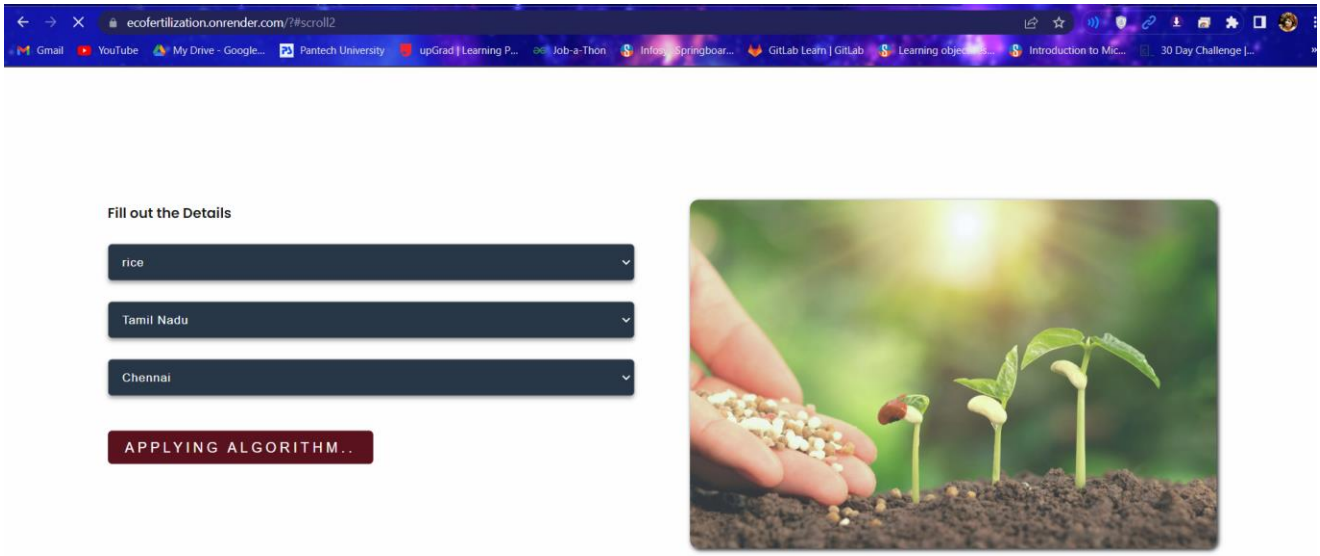
Home Page



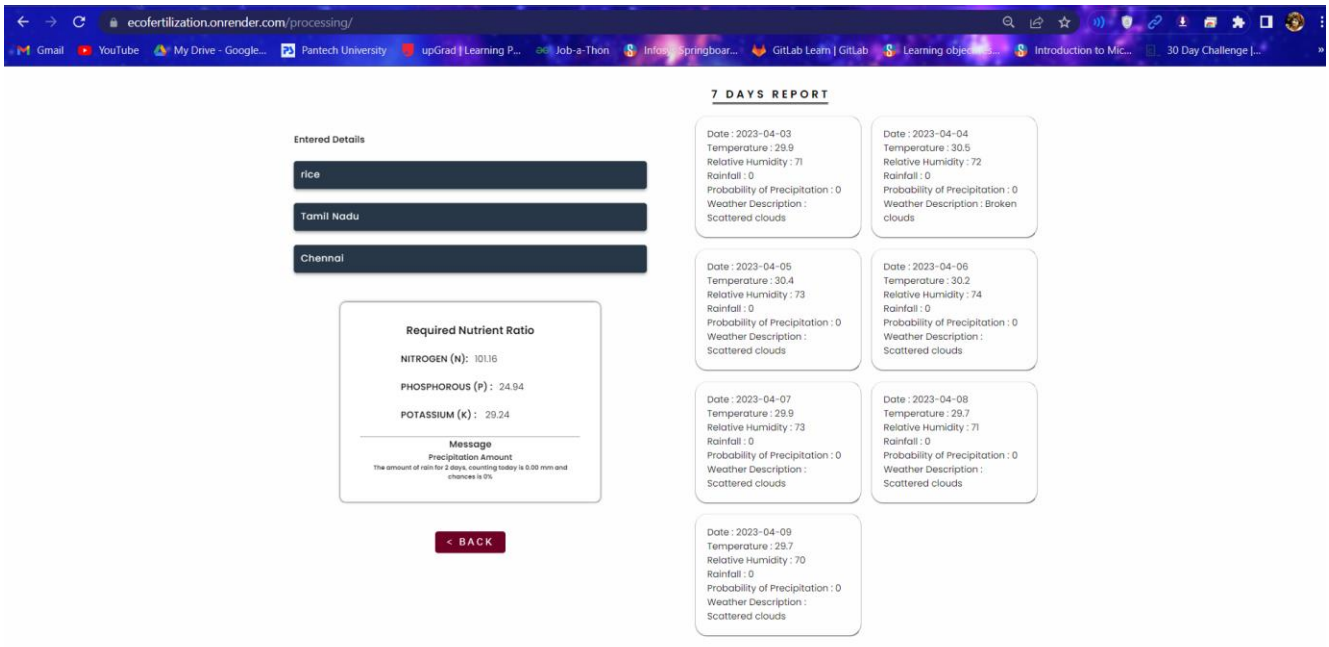
Input Page



Processing Page



Output Page



CHAPTER 12
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