CONTENTS

EXPLORATORY ANALYSIS OF RAINFALL DATA IN INDIA FOR AGRICULTURE

1. INTRODUCTION

1.1. Project Overview

India is an agricultural country and secondary agri-based market will be steady with a good monsoon. The economic growth of each year depends on the amount of duration of monsoon rain, bad monsoon can lead to destruction of some crops, which may result in scarcity of some agricultural products which in turn can cause food inflation, insecurity and public unrest. In our analysis we are trying to understand the behavior of rainfall in India over the years, by months and different subdivisions.

Agriculture is the backbone of the Indian economy. For agriculture, the most important thing is water source, i.e., rainfall. The prediction of the amount of rainfall gives alertness to farmers by knowing early they can protect their crops from rain. So, it is important to predict the rainfall accurately as much as possible. Exploration and analysis of data on rainfall over various regions of India and especially the regions where agricultural works have been done persistently in a wide range. With the help of analysis and the resultant data, future rainfall prediction for those regions using various machine learning techniques such as Logistic Regression, Linear Regression, Cat boost Classifier etc.

1.2. Purpose

The main aim of objective is to find the

• Rainfall Prediction is the application of science and technology to predict the amount of rainfall over a region.

• It is important to exactly determine the rainfall for effective use of water resources, crop productivity and pre-planning of water structures.

2. LITERATURE SURVEY

2.1. Existing Problem

Climate is important aspect of human life. So, the Prediction should accurate as much as possible. In this paper we try to deal with the prediction of the rainfall which is also a major aspect of human life, and which provide the major resource of human life which is Fresh Water. Fresh water is always a crucial resource of human survival – not only for the drinking purposes but also for farming, washing and many other purposes. Making a good prediction of climate is always a major task because of the climate change.

Now climate change is the biggest issue all over the world. Peoples are working on to detect the patterns in climate change as it affects the economy in production to infrastructure. So as in rainfall also making prediction of rainfall is a challenging task with a good accuracy rate. Making prediction on rainfall cannot be done by the traditional way, so scientist is using machine learning and deep learning to find out the pattern for rainfall prediction.

A bad rainfall prediction can affect the agriculture mostly framers as their whole crop is dependent on the rainfall and agriculture. It is always an important part of every economy. So, making an accurate prediction on the rainfall. There are number of techniques are used of machine learning, but accuracy is always a matter of concern in prediction made in rainfall.

There are number of causes made by rainfall affecting the world ex. Drought, Flood, and intense summer heat etc. And it will also affect water resources around the world.

2.2. References

PROJECT TITLE	AUTHOR	OBJECTIVE/OUTCOME
Spatial analysis of Indian Summer monsoon Rainfall (Mar 26,2014)	Markand Oza C.M.Kishtawal	Understanding the variability in rainfall, analysis of IndianSummer monsoon rainfall using Spatial resolution.
Climate impacts on Indian Agriculture. (16 June,2004)	K.Krishna Kumar K.Rupa Kumar R.G.Ashrit N.R.Deshpande J.W.Hansen	Presents about the analysis of Crop-climate relationships for India, using historical predictions.
Exploratory data Analysis of Indian Rainfall Data	Anusha Gajinkar	This Study shows that, India has two monsoon rainfall season one is northwest monsoon and second one is southeast monsoon.

2.3. Problem Statement Definition

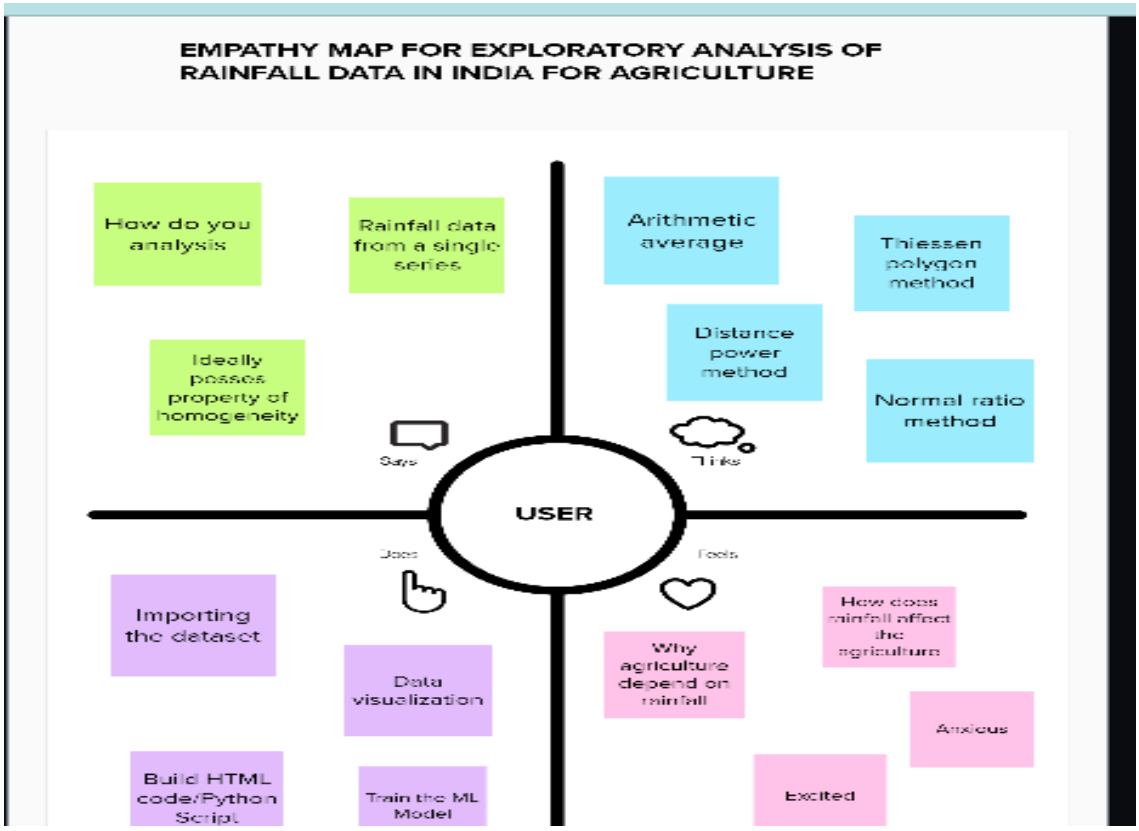
Rainfall has been a major concern these days. Weather conditions have been changing for time being. Rainfall forecasting is important otherwise, it may lead to many disasters. Irregular heavy rainfall may lead to the destruction of crops, heavy floods that can cause harm to human life. It is important to exactly determine the rainfall for effective use of water resources, crop productivity, and pre-planning of water structures.

This comparative study is conducted concentrating on the following aspects: modeling inputs, visualizing the data, modeling methods, and pre-processing techniques. The results provide a comparison of various evaluation metrics of these machine learning techniques and their reliability to predict rainfall by analyzing the weather data.

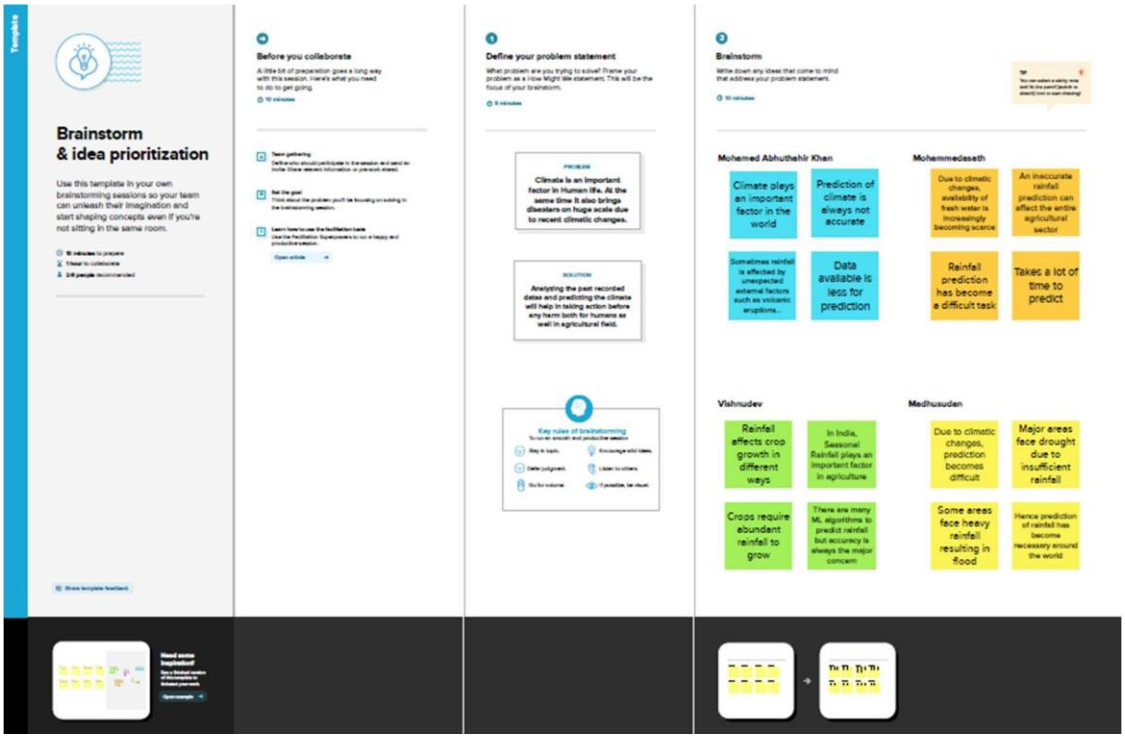
We will be using classification algorithms such as Decision tree, Random-Forest, KNN, and Xgboost. We will train and test the data with these algorithms. From this best model is selected and saved in pkl format. Once the model is saved, we integrate it with flask application and also deploy the model in IBM.

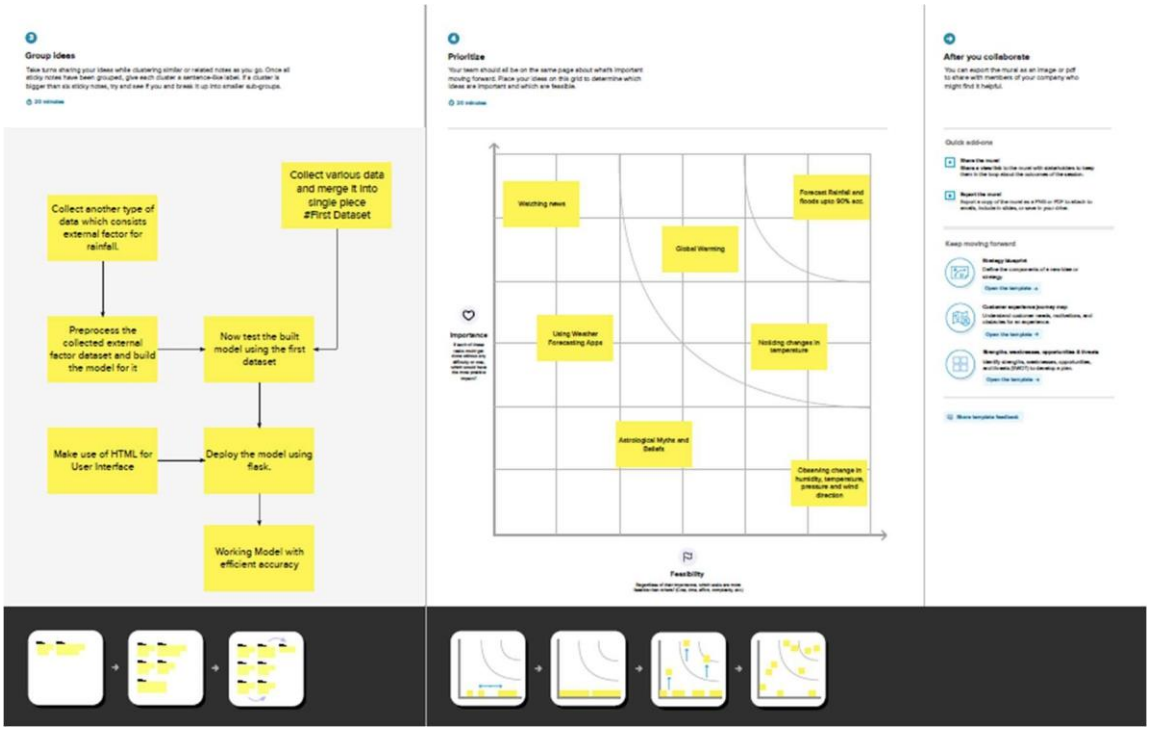
3. IDEATION AND PROPOSED SOLUTION

3.1. Empathy Map Canvas



3.2. Ideation and Brainstorming

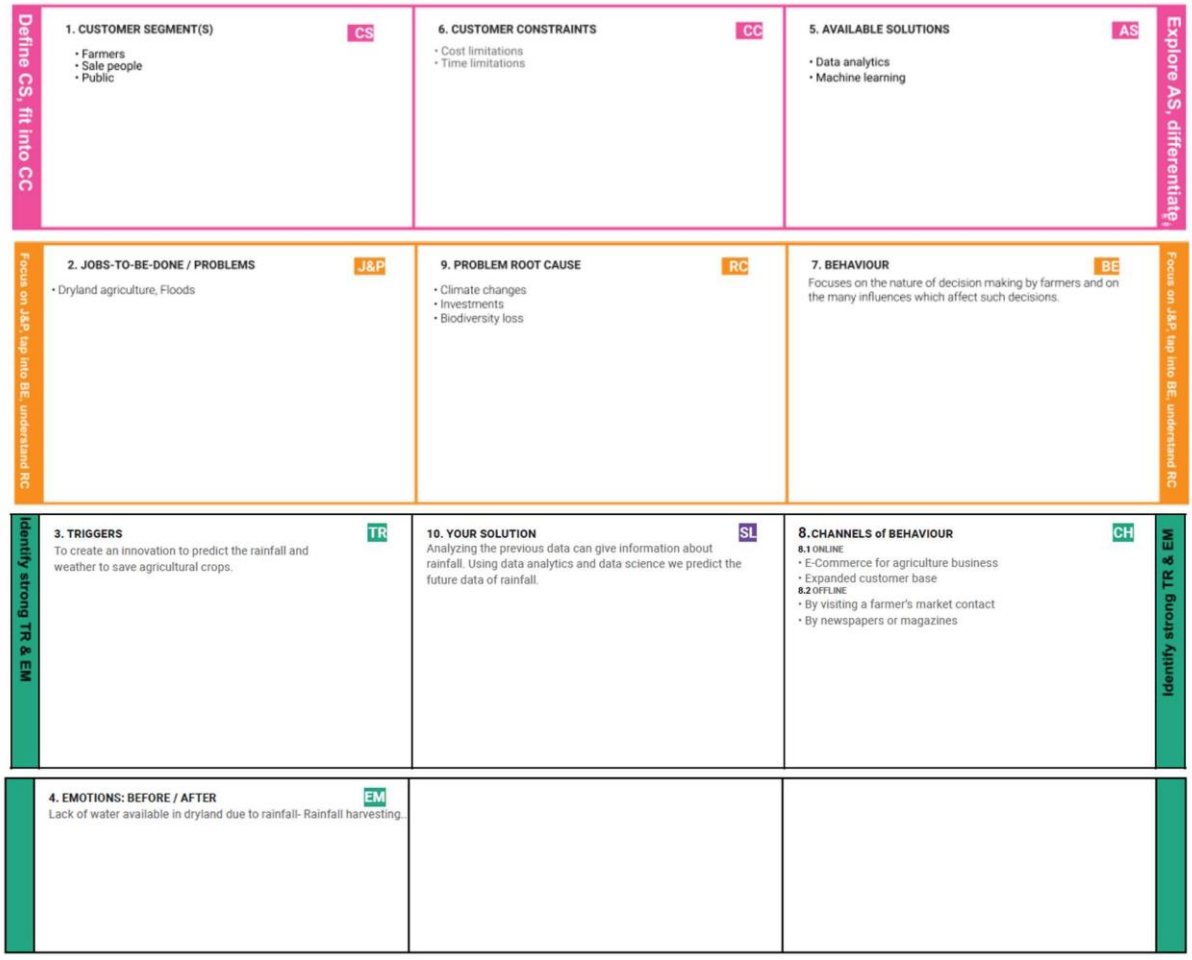




3.3. Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement	It is a known fact that uncertainty of rainfall in India leads to a lot of disaster every year like flood, drought, agriculture destination etc. Also, some of the parts of India have abundance of rainfall and some parts go completely dry. This type of differences in rainfall creates lot of problems in Indian economy. Predicting Rainfall is a major task in both summer and Rainy season.
2.	Proposed Solution	Analyzing the previous 10 years data can give us a rough idea about Rainfall pattern. Using Data Science, we can predict the Rainfall up to some good extent.
3.	Uniqueness	We won't be using AI, IoT or other fields and will only make use of ML concepts hence it is cost and time efficient.
4.	Social Impact	Farmers - Can save crops and plan which crops can be planted next. Citizens – Can save their life from natural disasters beforehand itself.
5.	Business Model	This could cost low as a person should develop knowledge in Data Science and probably a gadget to develop this. However, deploying as an App attached with other facilities might be expensive.
6.	Scalability	Farmers, Citizens

3.4. Proposed Solution Fit



4. REQUIREMENT ANALYSIS

4.1. Functional Requirements

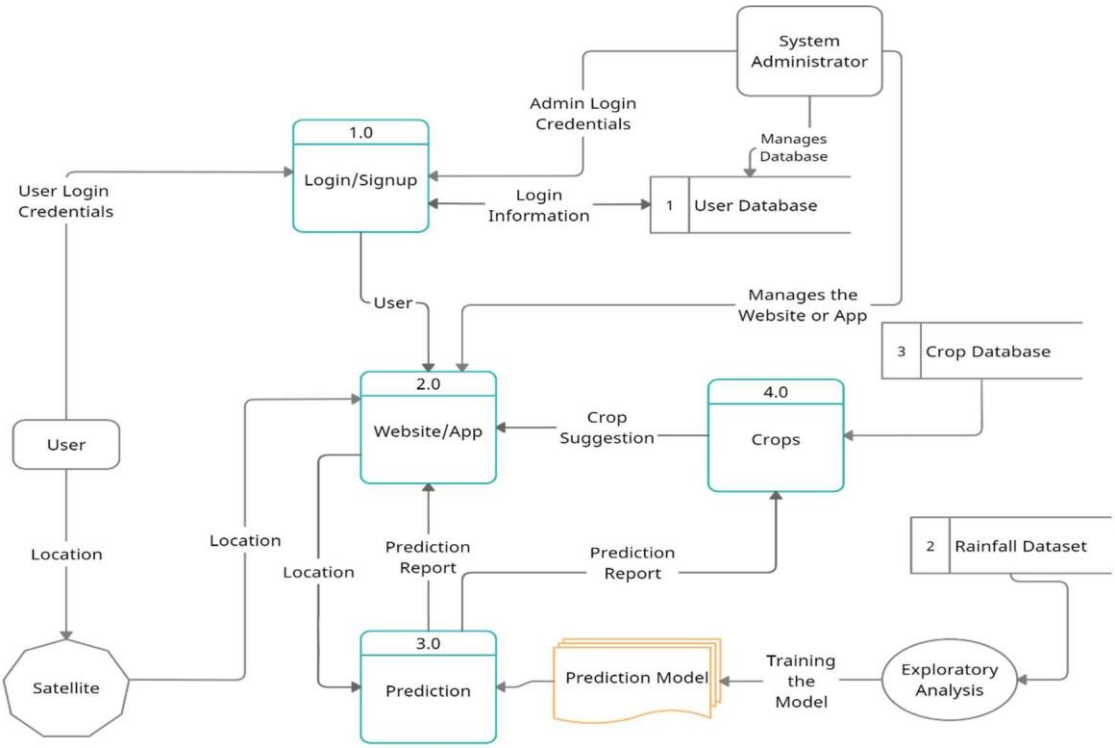
FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail Registration through LinkedIn
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Prediction details	User should enter the current location to get the predicted result.
FR-4	Forecasting Accuracy	Retrieve the forecasted weather conditions and measure the accuracy.
FR-5	Forecast	Forecasted flood probability from the rainfall amount is displayed on the webpage.
FR-6	Snapshots	The web page will display the condition as a report and pictures.

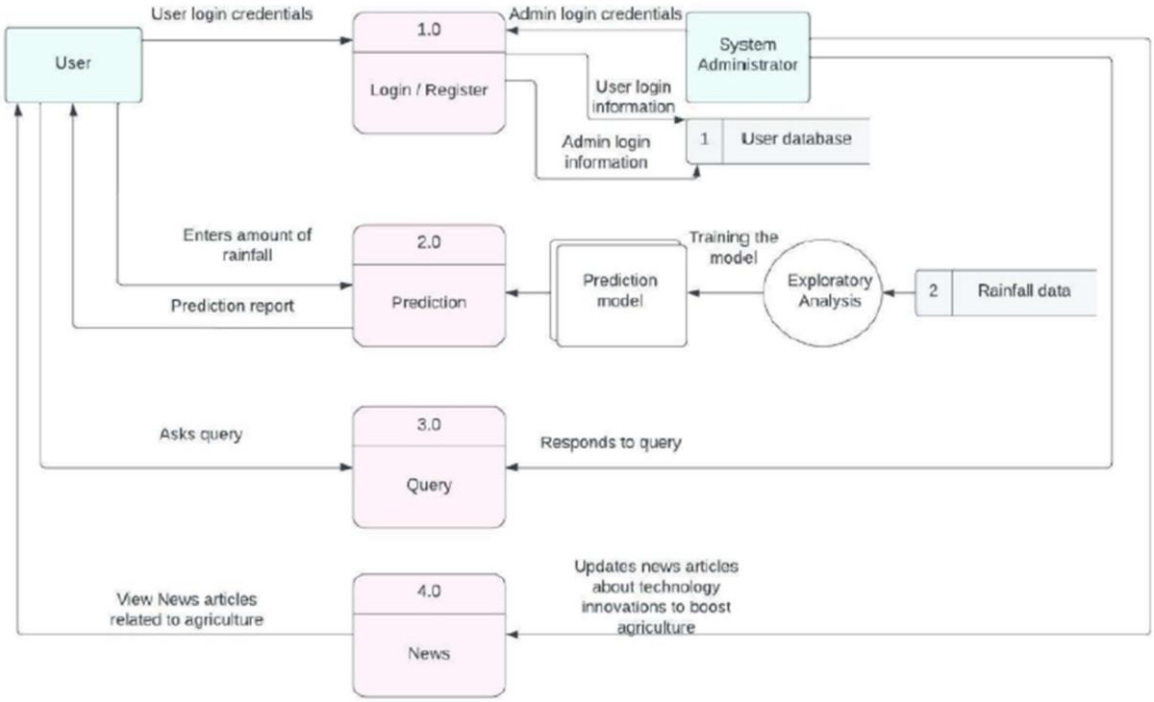
4.2. Non-Functional Requirements

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The usability of the website is to make all users will be satisfied with our requirements of the product. The user should reach the summarized text or result with one button press if possible
NFR-2	Security	The security of the project is to develop the website that prevents SQL injection attack, XSS attack and DOS attack
NFR-3	Reliability	The reliability of the system is to make sure the website does not go offline. The users can be reach and use program at any time, so maintenance should not be big issue.
NFR-4	Performance	The performance of the website isto provide data to all users without unnecessary delay and provide 24*7 availability.
NFR-5	Availability	The availability of the website is that the website will be active on The Internet and people will be able to browse to it.
NFR-6	Scalability	The scalability of the system is we have limited our project to Indian cities We have plans to scale it to continent's level in coming updates.

5. PROJECT DESIGN

5.1. Data Flow Diagrams





5.2. Solution and Technical Architecture

S.No	Component	Description	Technology
1.	Website	User interacts with the prediction model through website to predict the rainfall Data	HTML, CSS, JavaScript
2.	Cloud Database	The model is provided with data from IBM cloud database	IBM Cloud DB, ibm_db(python package)
3.	API	Used to extend the service to other applications	Flask Application
4.	JWT & Sessions	It is used for Handling JSON web tokens (signing, verifying, decoding)	PyJWT, Flask-Sessions
5.	Machine Learning Model	This model is developed to predict the rainfall using ML algorithms.	Sklearn, Algorithms - DT & MLR
6.	Data processing	Data is pre-processed and then used for prediction.	Pandas, Numpy, Matplotlib
7.	File Storage	File storage requirements	IBM Block Storage or Other Storage Service or Local Filesystem

5.3. User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
	Registration	USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	Medium	Sprint-2
	Login	USN-3	As a user, I can log into the application by entering email & password	I can access the system	High	Sprint-1
	Dashboard	USN-4	As a user, I can view the details about the system and can navigate through the pages.	I can navigate through pages	High	Sprint-3
	Prediction	USN-5	As a user, I can enter the rainfall amount and get the prediction results	I can get the prediction result	High	Sprint-4
	News	USN-6	As a user, I can view latest news articles related to agriculture	I can view the articles	Medium	Sprint-3
Customer (Web user)	Contact	USN-7	As a user, I can ask queries regarding the system	I can clarify my doubts	High	Sprint-3
	Chat bot	USN-8	As a user, I can interact with chatbot to ask queries	I can get my queries clear instantly	Low	Sprint-4
Administrator	Login	USN-9	As a user, I can register for the application by entering my email, password, and confirming my password.	I can view and update the system	High	Sprint-1
	Prediction	USN-10	As a user, I can see the prediction result from the model trained by the system administrator	I can train the prediction model	High	Sprint-3

6. PROJECT PLANNING AND SCHEDULING

6.1. Sprint Planning and Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	5	High	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-1	Confirmation	USN-2	As a user, I will receive confirmation email once I have registered for the application	2	High	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-2	Registration	USN-3	As a user, I can register for the application through Facebook	3	Low	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-2	Registration	USN-4	As a user, I can register for the application through Gmail	4	Low	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-1	Login	USN-5	As a user, I can log into the application by entering email & password	3	High	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-3	Dashboard	USN-6	As a user, I can view the details about the system and can navigate through the pages	5	High	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-4	Prediction	USN-7	As a user, I can enter the location and get the prediction results for that particular location	5	High	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-3	News	USN-8	As a user, I can view latest news articles related to agriculture	3	Medium	Kiruthika, Deepika, Priyanka. Thilagavathi.
Sprint-4	Chatbot	USN-9	As a user, I can interact with chatbot to ask queries	3	Low	Kiruthika, Deepika, Priyanka. Thilagavathi.

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-4	Feedback	USN-10	As a user, I can give my feedbacks about the prediction rates, user interface and if any issue to be solved	5	High	Kiruthika, Deepika, Priyanka. Thilagavathi.

6.2. Sprint Delivery Schedule

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	10	6 Days	24 Oct 2022	29 Oct 2022	10	30 Oct 2022
Sprint-2	7	6 Days	31 Oct 2022	05 Nov 2022	7	8 Nov 2022
Sprint-3	8	6 Days	07 Nov 2022	12 Nov 2022	5	14 Nov 2022
Sprint-4	13	6 Days	14 Nov 2022	1 9 Nov 2022	10	18 Nov 2022

7. CODING AND SOLUTIONING

7.1. Feature-1: Model Building

For this feature we have made use of Jupyter notebook which uses Python programming language.

To use Jupyter Notebook install Anaconda, which is a desktop graphical user interface (GUI) included in Anaconda® Distribution that allows you to launch applications and manage conda packages, environments, and channels without using command line interface (CLI) commands. Navigator can search for packages on Anaconda.org or in a local Anaconda Repository. It is available for Windows, macOS, and Linux. It provides all basic necessary python libraries which are needed for Data Analysis and Visualizations.

Below images are source code for this feature:

Data Pre-Processing

1. Importing Neccessary Libraries

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn import preprocessing
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import RobustScaler
import scipy.stats as stats
from collections import Counter
from imblearn.over_sampling import SMOTE

from sklearn import metrics
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import GaussianNB
from sklearn.neighbors import KNeighborsClassifier
from catboost import CatBoostClassifier
from xgboost import XGBClassifier

from sklearn.metrics import accuracy_score,confusion_matrix,classification_report

import warnings
warnings.filterwarnings("ignore", category=FutureWarning)
warnings.filterwarnings("ignore", category=UserWarning)

import joblib
```

In the above image, we import all necessary libraries needed for data exploration, preprocessing, model building and saving it. The below image specifies the values present in the dataset.

2. Exploratory Data Analysis

In [2]:
```
df = pd.read_csv("weatherAUS.csv")
pd.set_option("display.max_columns", None)
df
```

Out[2]:

	Date	Location	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustDir	WindGustSpeed	WindDir9am	WindDir3pm	WindSpeed9am	WindSp
0	01-12-2008	Albury	13.4	22.9	0.6	NaN	NaN	W	44.0	W	WNW	20.0	
1	02-12-2008	Albury	7.4	25.1	0.0	NaN	NaN	WNW	44.0	NNW	WSW	4.0	
2	03-12-2008	Albury	12.9	25.7	0.0	NaN	NaN	WSW	46.0	W	WSW	19.0	
3	04-12-2008	Albury	9.2	28.0	0.0	NaN	NaN	NE	24.0	SE	E	11.0	
4	05-12-2008	Albury	17.5	32.3	1.0	NaN	NaN	W	41.0	ENE	NW	7.0	
...	...	...	...	...	...	...	...	...	...	...	...	...	
145455	21-06-2017	Uluru	2.8	23.4	0.0	NaN	NaN	E	31.0	SE	ENE	13.0	
145456	22-06-2017	Uluru	3.6	25.3	0.0	NaN	NaN	NNW	22.0	SE	N	13.0	
145457	23-06-2017	Uluru	5.4	26.9	0.0	NaN	NaN	N	37.0	SE	WNW	9.0	
145458	24-06-2017	Uluru	7.8	27.0	0.0	NaN	NaN	SE	28.0	SSE	N	13.0	
145459	25-06-2017	Uluru	14.9	NaN	0.0	NaN	NaN	NaN	NaN	ESE	ESE	17.0	

145460 rows × 23 columns

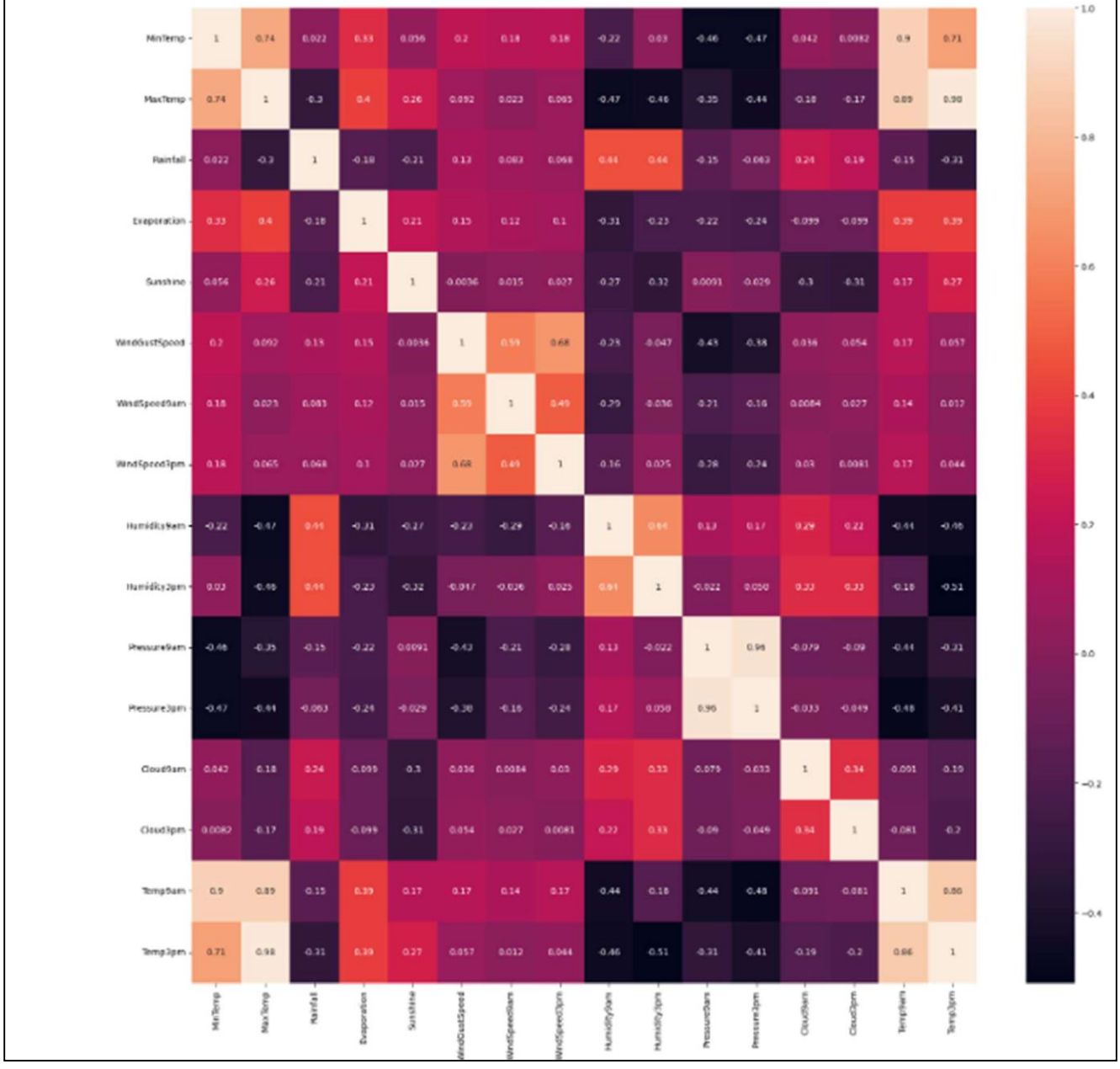
The below image specifies types of features and its count along with number of missing values in the dataset.

```
In [3]: numerical_feature = [feature for feature in df.columns if df[feature].dtypes != 'O']
        discrete_feature=[feature for feature in numerical_feature if len(df[feature].unique())<25]
        continuous_feature = [feature for feature in numerical_feature if feature not in discrete_feature]
        categorical_feature = [feature for feature in df.columns if feature not in numerical_feature]
        print("Numerical Features Count {}".format(len(numerical_feature)))
        print("Discrete feature Count {}".format(len(discrete_feature)))
        print("Continuous feature Count {}".format(len(continuous_feature)))
        print("Categorical feature Count {}".format(len(categorical_feature)))

        Numerical Features Count 16
        Discrete feature Count 2
        Continuous feature Count 14
        Categorical feature Count 7

In [4]: # Handle Missing Values
        df.isnull().sum()*100/len(df)

Out[4]: Date             0.000000
        Location         0.000000
        MinTemp          1.020899
        MaxTemp          0.866905
        Rainfall         2.241853
        Evaporation     43.166506
        Sunshine        48.009762
        WindGustDir      7.098859
        WindGustSpeed    7.055548
        WindDir9am       7.263853
        WindDir3pm       2.906641
        WindSpeed9am     1.214767
        WindSpeed3pm     2.105046
        Humidity9am      1.824557
        Humidity3pm      3.098446
        Pressure9am     10.356799
        Pressure3pm     10.331363
        Cloud9am        38.421559
        Cloud3pm        40.807095
        Temp9am          1.214767
        Temp3pm          2.481094
        RainToday        2.241853
        RainTomorrow     2.245978
        dtype: float64
```

```
In [5]: print(numerical_feature)

        ['MinTemp', 'MaxTemp', 'Rainfall', 'Evaporation', 'Sunshine', 'WindGustSpeed', 'WindSpeed9am', 'WindSpeed3pm', 'Humidity9am',
        'Humidity3pm', 'Pressure9am', 'Pressure3pm', 'Cloud9am', 'Cloud3pm', 'Temp9am', 'Temp3pm']

In [6]: def randomsampleimputation(df, variable):
            df[variable]=df[variable]
            random_sample=df[variable].dropna().sample(df[variable].isnull().sum(),random_state=0)
            random_sample.index=df[df[variable].isnull()].index
            df.loc[df[variable].isnull(),variable]=random_sample

In [7]: randomsampleimputation(df, "Cloud9am")
        randomsampleimputation(df, "Cloud3pm")
        randomsampleimputation(df, "Evaporation")
        randomsampleimputation(df, "Sunshine")
```

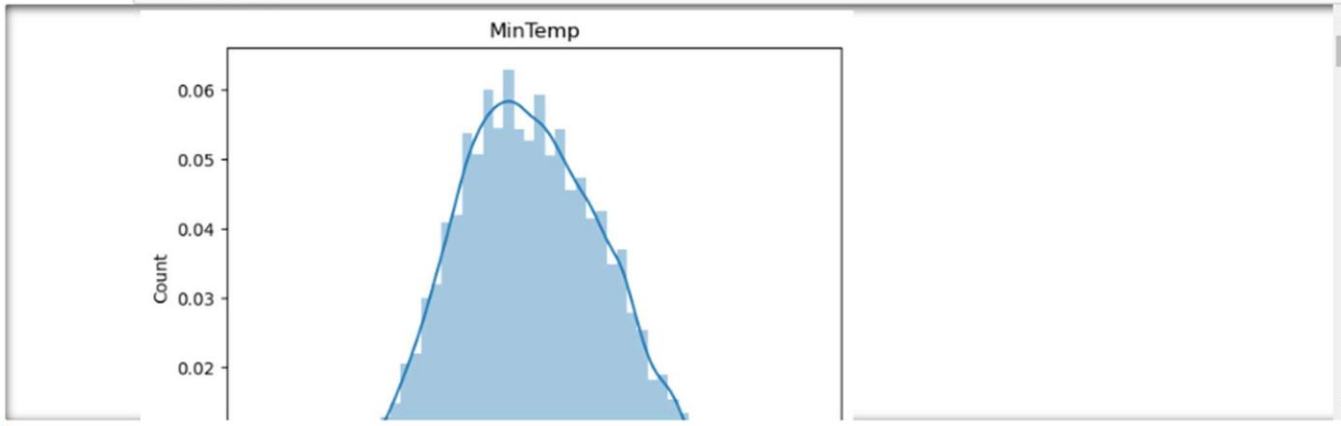
The lines 6 is used to drop rows which have high count missing values.

```
In [9]: corrmat = df.corr(method = "spearman")
        plt.figure(figsize=(20,20))
        #plot heat map
        g=sns.heatmap(corrmat,annot=True)
```

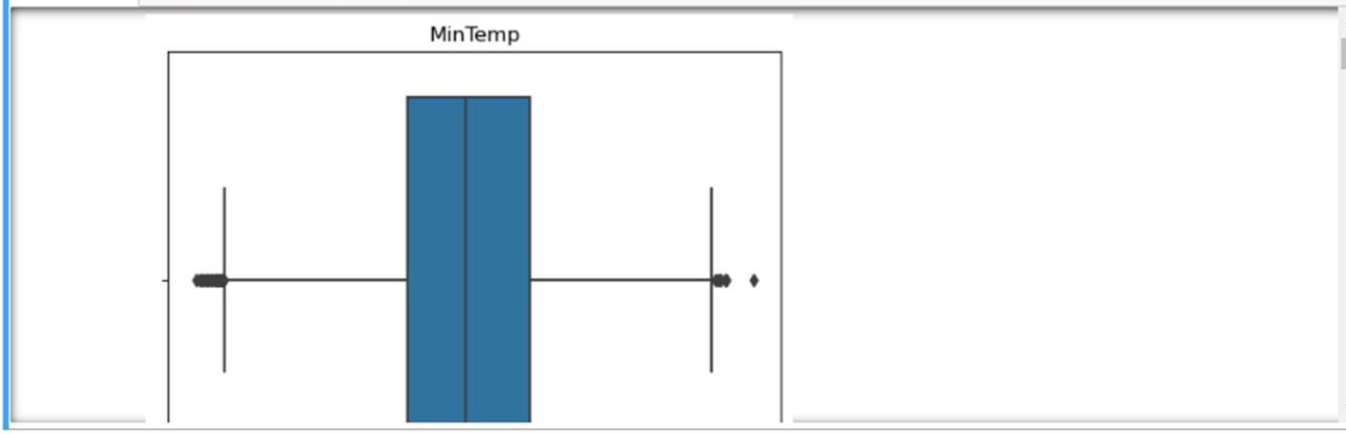


The above code displays the correlation between the columns present in the dataset.

```
In [10]: for feature in continuous_feature:
             data=df.copy()
             sns.distplot(df[feature])
             plt.xlabel(feature)
             plt.ylabel("Count")
             plt.title(feature)
             plt.figure(figsize=(15,15))
             plt.show()
```




```
In [11]: for feature in continuous_feature:
             data=df.copy()
             sns.boxplot(data[feature])
             plt.title(feature)
             plt.figure(figsize=(15,15))
```



The above code shows the distance plot and box plot of continuous features.

```
In [12]: for feature in continuous_feature:
             if(df[feature].isnull().sum()*100/len(df))>0:
                 df[feature] = df[feature].fillna(df[feature].median())

In [13]: df.isnull().sum()*100/len(df)

Out[13]: Date             0.000000
         Location         0.000000
         MinTemp          0.000000
         MaxTemp          0.000000
         Rainfall         0.000000
         Evaporation      0.000000
         Sunshine         0.000000
         WindGustDir      7.098859
         WindGustSpeed    0.000000
         WindDir9am       7.263853
         WindDir3pm       2.906641
         WindSpeed9am     0.000000
         WindSpeed3pm     0.000000
         Humidity9am      0.000000
         Humidity3pm      0.000000
         Pressure9am      0.000000
         Pressure3pm      0.000000
         Cloud9am         0.000000
         Cloud3pm         0.000000
         Temp9am          0.000000
         Temp3pm          0.000000
         RainToday        2.241853
         RainTomorrow     2.245978
         dtype: float64
```

The above code removes null values from continuous features.

```
In [14]: discrete_feature

Out[14]: ['Cloud9am', 'Cloud3pm']

In [15]: def mode_nan(df,variable):
             mode=df[variable].value_counts().index[0]
             df[variable].fillna(mode,inplace=True)
         mode_nan(df,"Cloud9am")
         mode_nan(df,"Cloud3pm")
```

The above code removes null values by replacing it with Mode value.

```
In [16]: df["RainToday"] = pd.get_dummies(df["RainToday"], drop_first = True)
         df["RainTomorrow"] = pd.get_dummies(df["RainTomorrow"], drop_first = True)
         df
```

Out[16]:

	Date	Location	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustDir	WindGustSpeed	WindDir9am	WindDir3pm	WindSpeed9am	WindS
0	01-12-2008	Albury	13.4	22.9	0.6	2.4	8.3	W	44.0	W	WNW	20.0	
1	02-12-2008	Albury	7.4	25.1	0.0	3.6	10.0	WNW	44.0	NNW	WSW	4.0	
2	03-12-2008	Albury	12.9	25.7	0.0	2.6	4.4	WSW	46.0	W	WSW	19.0	
3	04-12-2008	Albury	9.2	28.0	0.0	18.4	8.9	NE	24.0	SE	E	11.0	
4	05-12-2008	Albury	17.5	32.3	1.0	5.4	3.0	W	41.0	ENE	NW	7.0	
...	...	...	...	...	...	...	...	...	...	...	...	...	
145455	21-06-2017	Uluru	2.8	23.4	0.0	1.4	7.8	E	31.0	SE	ENE	13.0	
145456	22-06-2017	Uluru	3.6	25.3	0.0	7.6	13.5	NNW	22.0	SE	N	13.0	
145457	23-06-2017	Uluru	5.4	26.9	0.0	6.8	11.0	N	37.0	SE	WNW	9.0	
145458	24-06-2017	Uluru	7.8	27.0	0.0	2.6	13.2	SE	28.0	SSE	N	13.0	
145459	25-06-2017	Uluru	14.9	22.6	0.0	1.4	0.7	NaN	39.0	ESE	ESE	17.0	

145460 rows × 23 columns

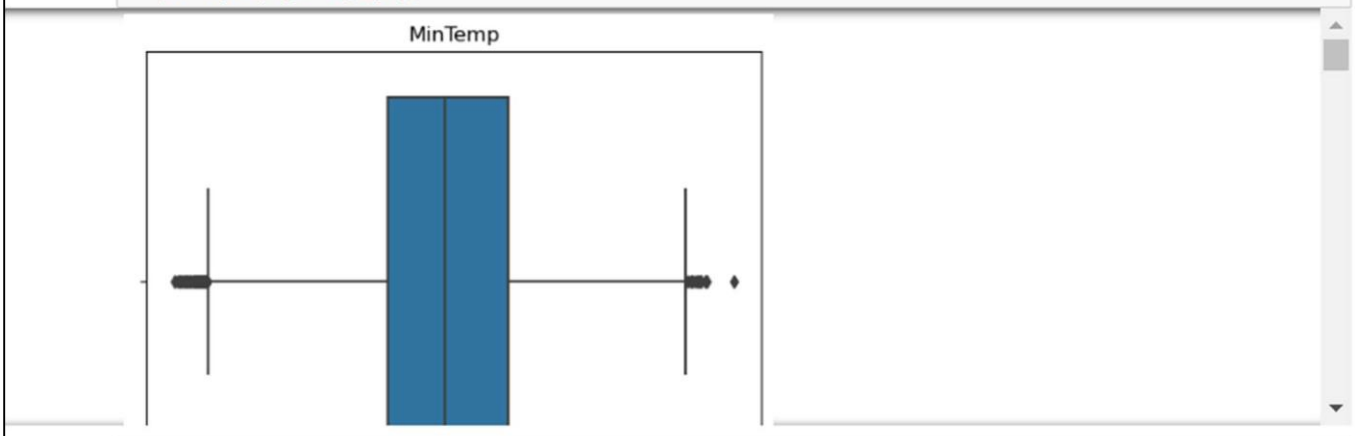
The above code makes use of Label Encoding technique, which is used to convert labels into machine readable numeric values.

```
In [17]: for feature in categorical_feature:
             print(feature, (df.groupby([feature])["RainTomorrow"].mean().sort_values(ascending = False)).index)

Date Index(['19-12-2007', '30-01-2008', '24-12-2007', '13-04-2008', '19-06-2008',
       '02-11-2007', '03-11-2007', '20-12-2007', '03-12-2007', '21-12-2007',
       ...
       '29-04-2008', '25-04-2008', '14-01-2008', '14-02-2008', '19-08-2008',
       '29-03-2008', '29-02-2008', '08-03-2008', '19-07-2008', '01-01-2008'],
      dtype='object', name='Date', length=3436)
Location Index(['Portland', 'Walpole', 'Cairns', 'Dartmoor', 'NorfolkIsland',
       'MountGambier', 'Albany', 'Witchcliffe', 'CoffsHarbour', 'MountGinini',
       'NorahHead', 'Darwin', 'Sydney', 'SydneyAirport', 'Ballarat',
       'GoldCoast', 'Watsonia', 'Newcastle', 'Hobart', 'Wollongong',
       'Williamtown', 'Launceston', 'Brisbane', 'MelbourneAirport', 'Adelaide',
       'Sale', 'Albury', 'Perth', 'Melbourne', 'Nuriootpa', 'Penrith',
       'BadgerysCreek', 'PerthAirport', 'Tuggeranong', 'Richmond', 'Bendigo',
       'Canberra', 'WaggaWagga', 'Townsville', 'Katherine', 'PearceRAAF',
       'SalmonGums', 'Nhil', 'Moree', 'Cobar', 'Mildura', 'AliceSprings',
       'Uluru', 'Woomera'],
      dtype='object', name='Location')
WindGustDir Index(['NNW', 'NW', 'WNW', 'N', 'W', 'WSW', 'NNE', 'S', 'SSW', 'SW', 'SSE',
       'NE', 'SE', 'ESE', 'ENE', 'E'],
      dtype='object', name='WindGustDir')
WindDir9am Index(['NNW', 'N', 'NW', 'NNE', 'WNW', 'W', 'WSW', 'SW', 'SSW', 'NE', 'S',
       'SSE', 'ENE', 'SE', 'ESE', 'E'],
      dtype='object', name='WindDir9am')
WindDir3pm Index(['NW', 'NNW', 'N', 'WNW', 'W', 'NNE', 'WSW', 'SSW', 'S', 'SW', 'SE',
       'NE', 'SSE', 'ENE', 'E', 'ESE'],
      dtype='object', name='WindDir3pm')
RainToday UInt64Index([1, 0], dtype='uint64', name='RainToday')
RainTomorrow UInt64Index([1, 0], dtype='uint64', name='RainTomorrow')
```

```
In [18]: windgustdir = {'NNW':0, 'NW':1, 'WNW':2, 'N':3, 'W':4, 'WSW':5, 'NNE':6, 'S':7, 'SSW':8, 'SW':9, 'SSE':10,
                'NE':11, 'SE':12, 'ESE':13, 'ENE':14, 'E':15}
         winddir9am = {'NNW':0, 'N':1, 'NW':2, 'NNE':3, 'WNW':4, 'W':5, 'WSW':6, 'SW':7, 'SSW':8, 'NE':9, 'S':10,
                'SSE':11, 'ENE':12, 'SE':13, 'ESE':14, 'E':15}
         winddir3pm = {'NW':0, 'NNW':1, 'N':2, 'WNW':3, 'W':4, 'NNE':5, 'WSW':6, 'SSW':7, 'S':8, 'SW':9, 'SE':10,
                'NE':11, 'SSE':12, 'ENE':13, 'E':14, 'ESE':15}
         df["WindGustDir"] = df["WindGustDir"].map(windgustdir)
         df["WindDir9am"] = df["WindDir9am"].map(winddir9am)
         df["WindDir3pm"] = df["WindDir3pm"].map(winddir3pm)

In [19]: df["WindGustDir"] = df["WindGustDir"].fillna(df["WindGustDir"].value_counts().index[0])
         df["WindDir9am"] = df["WindDir9am"].fillna(df["WindDir9am"].value_counts().index[0])
         df["WindDir3pm"] = df["WindDir3pm"].fillna(df["WindDir3pm"].value_counts().index[0])
```

The above image is used to remove the remaining null values.

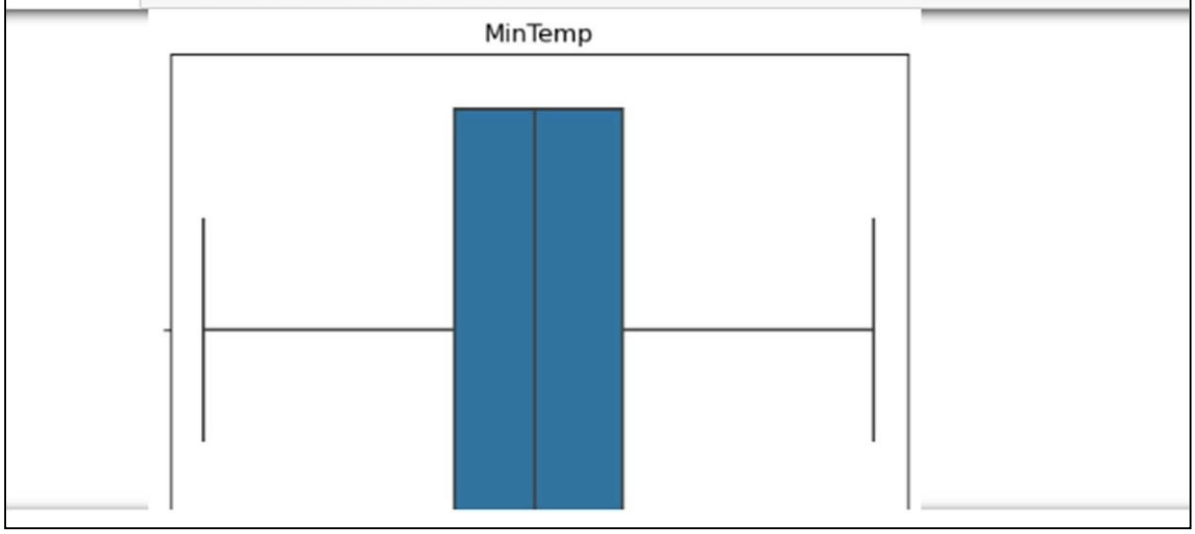
```
In [33]: for feature in continuous_feature:
             data=df.copy()
             sns.boxplot(data[feature])
             plt.title(feature)
             plt.figure(figsize=(15,15))
```




```
In [34]: for feature in continuous_feature:
             print(feature)

MinTemp
MaxTemp
Rainfall
Evaporation
Sunshine
WindGustSpeed
WindSpeed9am
WindSpeed3pm
Humidity9am
Humidity3pm
Pressure9am
Pressure3pm
Temp9am
Temp3pm
```

The above image is used to find values which lies outside the Inter-Quartile Range of each continuous feature. After finding the lower and higher bound, we remove the outliers from each continuous feature.

```
In [59]: for feature in continuous_feature:
             data=df.copy()
             sns.boxplot(data[feature])
             plt.title(feature)
             plt.figure(figsize=(15,15))
```



The above image shows the boxplot of each continuous feature after removing the outliers.

3. Splitting Dataset into Independent and Dependent Variables

```
In [64]: X = df.drop(["RainTomorrow", "Date", "Date_month", "Date_day"], axis=1)
         Y = df["RainTomorrow"]
```

4. Feature Scaling

```
In [65]: scaler = RobustScaler()
         X_scaled = scaler.fit_transform(X)
```

We split the dataset into independent and dependent variables. Here we must predict 'RainTomorrow', hence it will be the dependent variable and Date columns are unnecessary columns hence we drop it. And all other columns are independent variables. Using RobustScaler, we perform feature scaling to normalize the independent variables such that the standard distribution results to zero and standard deviation to one. This also removes remaining outliers in the independent variables.

5. Splitting The Data Into Train And Test

```
In [66]: X_train, X_test, y_train, y_test = train_test_split(X_scaled,Y, test_size =0.2, stratify = Y, random_state = 0)

In [67]: X_train.shape
         X_test.shape

Out[67]: (29092, 21)

In [68]: y_train.shape
         y_test.shape

Out[68]: (29092,)
```

Now using 'train_test_split', we split the variables into train and test variables for each variable.

6. Balancing the Data

```
In [69]: sm=SMOTE(random_state=0)
         X_train_res, y_train_res = sm.fit_resample(X_train, y_train)
         print("The number of classes before fit {}".format(Counter(y_train)))
         print("The number of classes after fit {}".format(Counter(y_train_res)))

         The number of classes before fit Counter({0: 90866, 1: 25502})
         The number of classes after fit Counter({0: 90866, 1: 90866})
```

SMOTE (Synthetic Minority Oversampling Technique) is used to increase the number of test cases in a balanced way to avoid overfit cases.

Model Building

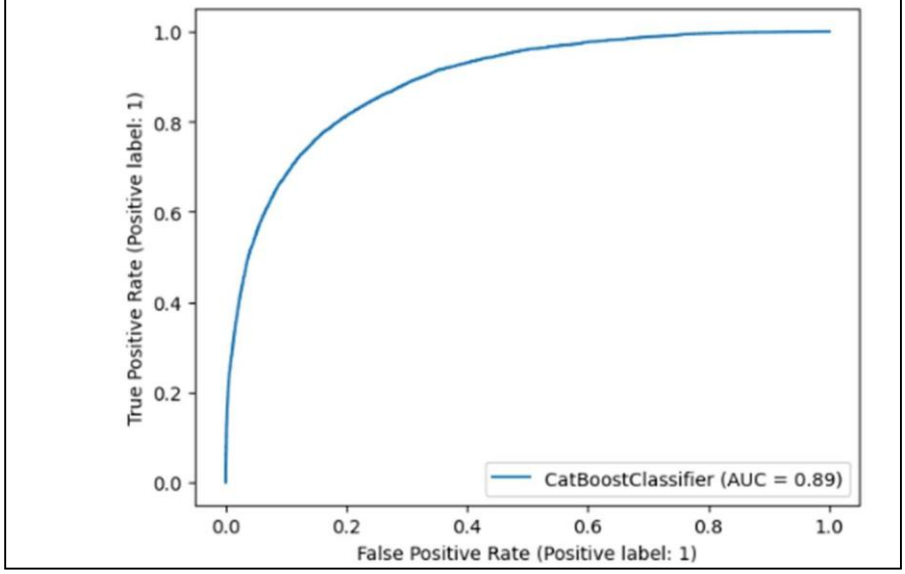
```
In [70]: cat = CatBoostClassifier(iterations=2000, eval_metric = "AUC")
         cat.fit(X_train_res, y_train_res)

         Learning rate set to 0.050311
         0:      total: 470ms    remaining: 15m 38s
         1:      total: 513ms    remaining: 8m 32s
         2:      total: 555ms    remaining: 6m 9s
         3:      total: 597ms    remaining: 4m 57s
         4:      total: 634ms    remaining: 4m 12s
         5:      total: 670ms    remaining: 3m 42s
         6:      total: 707ms    remaining: 3m 21s
         7:      total: 750ms    remaining: 3m 6s
         8:      total: 790ms    remaining: 2m 54s
         9:      total: 829ms    remaining: 2m 44s
         10:     total: 869ms    remaining: 2m 37s
         11:     total: 910ms    remaining: 2m 30s
         12:     total: 951ms    remaining: 2m 25s
         13:     total: 990ms    remaining: 2m 20s
         14:     total: 1.03s    remaining: 2m 16s
         15:     total: 1.07s    remaining: 2m 12s
         16:     total: 1.11s    remaining: 2m 9s
         17:     total: 1.15s    remaining: 2m 6s
```

The algorithm chosen here to build the model is CatBoostClassifier. CatBoost is based on gradient boosted decision trees. During training, a set of decision trees is built consecutively. Each successive tree is built with reduced loss compared to the previous trees. The number of trees is controlled by the starting parameters.

```
In [71]: y_pred = cat.predict(X_test)
         print(confusion_matrix(y_test,y_pred))
         print(accuracy_score(y_test,y_pred))
         print(classification_report(y_test,y_pred))

         [[21506  1211]
          [ 2792  3583]]
         0.8624020349236904
                       precision    recall  f1-score   support

                    0       0.89      0.95      0.91     22717
                    1       0.75      0.56      0.64      6375

             accuracy                           0.86     29092
            macro avg       0.82      0.75      0.78     29092
         weighted avg       0.85      0.86      0.85     29092
```

The above image shows the Confusion Matrix, Accuracy Score and Classification report.

```
In [72]: metrics.plot_roc_curve(cat, X_test, y_test)
         metrics.roc_auc_score(y_test, y_pred, average=None)

Out[72]: 0.7543655602136087
```



The above image shows the roc curve and roc accuracy score for the built model.

Hyperparameter Tuning

```
In [74]: from sklearn.model_selection import RandomizedSearchCV
         from scipy.stats import randint
         param_dist = { "learning_rate": np.linspace(0,0.2,5),"max_depth": randint(3, 10)}
         rscv = RandomizedSearchCV( CatBoostClassifier(), param_dist, scoring='accuracy', cv = 5)
         rscv.fit(X_train_res, y_train_res)
         print(rscv.best_params_)
         print(rscv.best_score_)
```

```
983:    learn: 0.1411624        total: 54.3s    remaining: 883ms
984:    learn: 0.1410823        total: 54.3s    remaining: 828ms
985:    learn: 0.1410310        total: 54.4s    remaining: 772ms
986:    learn: 0.1409701        total: 54.5s    remaining: 717ms
987:    learn: 0.1409060        total: 54.5s    remaining: 662ms
988:    learn: 0.1408196        total: 54.6s    remaining: 607ms
989:    learn: 0.1407667        total: 54.6s    remaining: 552ms
990:    learn: 0.1406785        total: 54.7s    remaining: 497ms
991:    learn: 0.1406161        total: 54.8s    remaining: 442ms
992:    learn: 0.1405794        total: 54.8s    remaining: 386ms
993:    learn: 0.1405091        total: 54.9s    remaining: 331ms
994:    learn: 0.1404368        total: 54.9s    remaining: 276ms
995:    learn: 0.1403839        total: 55s      remaining: 221ms
996:    learn: 0.1402899        total: 55.1s    remaining: 166ms
997:    learn: 0.1402249        total: 55.1s    remaining: 110ms
998:    learn: 0.1401474        total: 55.2s    remaining: 55.2ms
999:    learn: 0.1400710        total: 55.2s    remaining: 0us
{'learning_rate': 0.1, 'max_depth': 8}
0.8892227301457538
```

Cross Validation

```
In [73]: from sklearn.model_selection import cross_val_score
         accuracies = cross_val_score(estimator = CatBoostClassifier(), X = X_train_res, y = y_train_res, cv = 3)
         print("Accuracy:{:.2f} %".format(accuracies.mean()*100))
         print("Standard Deviation:{:.2f} %".format(accuracies.std()*100))
```

```
983:    learn: 0.2312273        total: 25.2s    remaining: 409ms
984:    learn: 0.2311698        total: 25.2s    remaining: 384ms
985:    learn: 0.2311267        total: 25.2s    remaining: 358ms
986:    learn: 0.2310880        total: 25.2s    remaining: 333ms
987:    learn: 0.2310416        total: 25.3s    remaining: 307ms
988:    learn: 0.2310012        total: 25.3s    remaining: 281ms
989:    learn: 0.2309517        total: 25.3s    remaining: 256ms
990:    learn: 0.2309123        total: 25.3s    remaining: 230ms
991:    learn: 0.2308675        total: 25.4s    remaining: 205ms
992:    learn: 0.2308233        total: 25.4s    remaining: 179ms
993:    learn: 0.2307680        total: 25.4s    remaining: 153ms
994:    learn: 0.2307091        total: 25.4s    remaining: 128ms
995:    learn: 0.2306458        total: 25.5s    remaining: 102ms
996:    learn: 0.2306044        total: 25.5s    remaining: 76.7ms
997:    learn: 0.2305532        total: 25.5s    remaining: 51.2ms
998:    learn: 0.2304996        total: 25.6s    remaining: 25.6ms
999:    learn: 0.2304346        total: 25.6s    remaining: 0us
Accuracy:83.11 %
Standard Deviation:17.73 %
```

The above image shows the Hyperparameter and Cross Validation score of the model.

Saving the built Models

```
In [76]: joblib.dump(rscv, "cat2.pkl")
Out[76]: ['cat2.pkl']
```

Finally save the model using joblib library.

7.2. Feature-2:

User Interface

Index.html:

```
<!DOCTYPE html>
<html>
    <head>
        <meta charset="UTF-8">
        <title>Rainfall prediction Webpage</title>

        <link rel="stylesheet" href="{{ url_for('static',
filename='css/index.css') }}">

    <style>
         .head1{

        color: rgb(10, 73, 112);
        font-family: 'Century Gothic';
        font-size: 60px;
        width: 40%;
        margin-left: 30%;
        text-align: center;
        margin-top: 2vh;
        padding: 5px;
    }


    </style>
    </head>

<body>
    <div class="login">
        <div>
```

```
<div class="head1">
            RAINFALL PREDICTION
        </div>


            <form action="{{ url_for('predict')}}"method="post">
        <br>
        <br>
        <div class="body1">
        <label for="Location">Location:</label>
         <select id="Location" name="Location">
            <option value=2>Albury</option>
            <option value=4>Badgeryscreek</option>
            <option value=10>Cobar</option>
            <option value=11>CoffsHarbour</option>
            <option value=21>Moree</option>
            <option value=24>Newcastle</option>
            <option value=26>NorahHead</option>
            <option value=27>Norfolksland</option>
            <option value=30>Penrith</option>
            <option value=34>Richmond</option>
            <option value=37>Sydney</option>
            <option value=38>SydneyAirport</option>
            <option value=42>Waggawagga</option>
            <option value=45>Williamtown</option>
            <option value=47>Wollongong</option>
            <option value=9>Canberra</option>
            <option value=40>MountGinini</option>
            <option value=5>Ballarat</option>
            <option value=6>Bandigo</option>
            <option value=35>Sale</option>
            <option value=19>MelborneAirport</option>
            <option value=18>Melborne</option>
            <option value=20>Mildura</option>
```

```
            <option value=25>Nhill</option>
             <option value=33>Portland</option>
             <option value=44>Watsonia</option>
          </select>

          <label for="MinTemp">MinTemp:</label>
          <input type = "number" step="any" id="MinTemp"
name="MinTemp" value="MinTemp">

          <label for="MaxTemp">MaxTemp:</label>
          <input type = "number" step="any" id="MaxTemp"
name="MaxTemp" value="MaxTemp">

          <label for="Rainfall">Rainfall:</label>
          <input type = "number" step="any" id="Rainfall"
name="Rainfall" value="Rainfall">

          <label for="WindGustSpeed">WindGustSpeed:</label>
          <input type = "number" step="any" id="WindGustSpeed"
name="WindGustSpeed" value="WindGustSpeed">
<br>
<br>
          <label for="WindSpeed9am">WindSpeed9am:</label>
          <input type = "number" step="any" id="WindSpeed9am"
name="WindSpeed9am" val="WindSpeed9am">

          <label for="WindSpeed3pm">WindSpeed3pm:</label>
          <input type = "number" step="any" id="WindSpeed3pm"
name="WindSpeed3pm" val="WindSpeed3pm">

          <label for="Humidity9am">Humidity9am:</label>
          <input type = "number" step="any" id="Humidity9am"
name="Humidity9am" val="Humidity9am">

          <label for="Humidity3pm">Humidity3pm:</label>
          <input type = "number" step="any" id="Humidity3pm"
name="Humidity3pm" val="Humidity3pm">
```

```
<br>
<br>
        <label for="Pressure9am">Pressure9am:</label>
        <input type = "number" step="any" id="Pressure9am"
name="Pressure9am" val="Pressure9am">

        <label for="Pressure3pm">Pressure3pm:</label>
        <input type = "number" step="any" id="Pressure3pm"
name="Pressure3pm" val="Pressure3pm">

        <label for="Temp9am">Temp9am:</label>
        <input type = "number" step="any" id="Temp9am"
name="Temp9am" val="Temp9am">

        <label for="Temp3pm">Temp3pm:</label>
        <input type = "number" step="any" id="Temp3pm"
name="Temp3pm" val="Temp3pm">

<br>
<br>

<label for="RainToday">RainToday</label>
<select id="RainToday" name="RainToday">
    <option value="1">Yes</option>
    <option value="2">No</option>
</select>

<label for="WindGustDir">WindGustDir</label>
    <select id="WindGustDir" name="WindGustDir">
        <option value=14>W</option>
        <option value=15>WNW</option>
        <option value=0>WSW</option>
        <option value=7>NE</option>
        <option value=13>NNW</option>
        <option value=10>N</option>
        <option value=2>NNE</option>
```

```
            <option value=1>SW</option>
            <option value=6>ENE</option>
            <option value=11>SSE</option>
            <option value=12>S</option>
            <option value=9>NW</option>
            <option value=3>SE</option>
            <option value=8>ESE</option>
            <option value=5>E</option>
            <option value=5>NA</option>
            <option value=4>SSW</option>
        </select>   

        <label for="WindDir9am">WindDir9am</label>
        <select id="WindDir9am" name="WindDir9am">
            <option value=14>W</option>
            <option value=15>NNW</option>
            <option value=0>SE</option>
            <option value=7>ENE</option>
            <option value=13>SW</option>
            <option value=10>SSE</option>
            <option value=2>S</option>
            <option value=1>NE</option>
            <option value=6>NA</option>
            <option value=11>SSW</option>
            <option value=12>N</option>
            <option value=9>WSW</option>
            <option value=3>ESE</option>
            <option value=8>E</option>
            <option value=5>NW</option>
            <option value=4>WNW</option>
            <option value=4>NNE</option>
        </select>   

    <label for="WindDir3pm">WindDir3pm</label>
        <select id="WindDir3pm" name="WindDir3pm">
```

```
        <option value=14>WNW</option>
         <option value=15>WSW</option>
         <option value=0>E</option>
         <option value=7>NW</option>
         <option value=13>W</option>
         <option value=10>SSE</option>
         <option value=2>ESE</option>
         <option value=1>ENE</option>
         <option value=6>NNW</option>
         <option value=11>SSW</option>
         <option value=12>SW</option>
         <option value=9>SE</option>
         <option value=3>N</option>
         <option value=8>S</option>
         <option value=5>NNE</option>
         <option value=5>NA</option>
         <option value=4>NE</option>
    </select>   

    </div>
<br>

<br><br>

<center><button class="button-3"
role="button">PREDICT</button></center>
</form>
<br>

    {{output}}

    <br>
    <br>
    <img src="{{url_3}}" alt="Submit Form"
height="180" width="233" onerror="this.style.display='none'"/>
```

```
<img src="{{url_1}}" alt="Submit Form"
height="180" width="233" onerror="this.style.display='none'"/>
    <img src="{{url_4}}" alt="Submit Form"
height="180" width="233" onerror="this.style.display='none'"/>
    <br>
    <br>

 <img src="{{url_2}}" alt="Submit Form"
height="150" width="711" onerror="this.style.display='none'"/>
    </div>

    </body>
    <footer><p>IBM - Nalaiya Thiran</p></footer>
</html>
```

INDEX.CSS

```
body{
    background-image: url('background.jpg');
    background-size:cover;
    background-repeat: no-repeat;
    }
    footer {
        display: flex;
        justify-content: center;
        padding: 5px;
        margin-top: -40px;
        background-color:rgb(10, 73, 112);
        color: #fff;
    }

    .body1{
        background-color:rgb(255, 255, 255,0.8);
        background-origin: padding-box;
        color: #3d3d3d;
```

```
        font-size: 20px;
        width: 90%;
        height: 280px;
        margin-left:6%;
        margin-top: 6vh;
        text-align: center;
        padding: 5px;
        background-blend-mode: lighten;

    }



/* CSS */
.button-3 {
  appearance: none;
  background-color: rgb(10, 73, 112);
  border: 1px solid rgba(27, 31, 35, .15);
  border-radius: 6px;
  box-shadow: rgba(27, 31, 35, .1) 0 1px 0;
  box-sizing: border-box;
  color: #fff;
  cursor: pointer;
  display: inline-block;
  font-family: -apple-system,system-ui,"Segoe
UI",Helvetica,Arial,sans-serif,"Apple Color Emoji","Segoe UI Emoji";
  font-size: 14px;
  font-weight: 600;
  line-height: 20px;
  padding: 6px 16px;
  position: relative;
  text-align: center;
  text-decoration: none;
  user-select: none;
  -webkit-user-select: none;
```

```
 touch-action: manipulation;
  vertical-align: middle;
  white-space: nowrap;
}

.button-3:focus:not(:focus-visible):not(.focus-visible) {
  box-shadow: none;
  outline: none;
}

.button-3:hover {
  background-color: rgb(119, 214, 224);
}

.button-3:focus {
  box-shadow: rgba(46, 164, 79, .4) 0 0 0 3px;
  outline: none;
}

.button-3:disabled {
  background-color: #94d3a2;
  border-color: rgba(27, 31, 35, .1);
  color: rgba(255, 255, 255, .8);
  cursor: default;
}

.button-3:active {
  background-color: rgb(10, 73, 112);
  box-shadow: rgba(20, 70, 32, .2) 0 1px 0 inset;
}
```

HOME.HTML

```
<!DOCTYPE html>
<html>
    <head>
```

```
  <meta charset="utf-8">
        <title>Rainfall Prediction Webpage</title>

        <link rel="stylesheet" href="{{ url_for('static',
filename='css/home.css') }}">

                    <link rel="preconnect"
href="https://fonts.googleapis.com">
                    <link rel="preconnect"
href="https://fonts.gstatic.com" crossorigin>
                    <link
href="https://fonts.googleapis.com/css2?family=Raleway&family=Roboto
:wght@100;500&display=swap" rel="stylesheet">
                    <style type="text/css"></style>
    </head>

<body>
<header>
    <div class="header1">

<img src="{{url_for('static', filename='css/logo.png')}}" alt="logo"
/>
      </div>
        <div class="navbar">
                      <ul>


<div class="nav">
<a href="">HOME</a></div>
<div class="nav">
<a href="{{ url_for('predict') }}">PREDICTOR</a>
</div>
<!-- <div class="nav">
<a href="{{ url_for('about') }}">ABOUT</a></div> -->
<!-- <div class="nav">
<a href="{{ url_for('help') }}">HELP</a></div> -->
```

```
  <!-- <div class="nav">
  <a href="{{ url_for('contact') }}">CONTACT</a></div> -->

</ul>

  </div>
  </header>
   <div>
   <div class="head1">
    Forecast Rainfall
   </div>
   <div class="body1">
  We serve as an early warning system to exactly determine the
  rainfall for effective use of water resources,  crop productivity,
  and pre-planning of water structures.
  </div>
  </div>
      </body>
      <footer><p>IBM - Nalaiya Thiran</p></footer>
      </html>
```

HOME.CSS

```
  body{
      background-image: url('drops.jpg');
      background-size:cover;
      }
      #title{
      margin-right: 11vw;
      width: 5vw;
      }

      .nav{
          margin:0 auto;
          float: left;
          list-style-type:none;
```

```
    width: 11vw ;
    height: 2vw;
    background-color: rgb(10, 73, 112,0.7);
    color: white;
    padding: 0.5%;

}

header{
    display: block ;
    width: 100%;
    height: 7vh;

}
a{
    text-decoration: none;
}
a:link{
    color: inherit;
}
a:link:hover{
    color: inherit;
}
a:visited{
    color: inherit;
}
a:visited:hover{

    color: inherit;
}
.nav:hover,.nav:active{
    background-color: #d3d3d3;

    color: black;
}
```

```
.head1{

        color: rgb(10, 73, 112);
        font-family: 'Century Gothic';
        font-size: 60px;

        width: 40%;
        margin-left: 30%;
        text-align: center;
        margin-top: 2vh;
        padding: 5px;
    }
    .body1{
        background-color:rgb(255, 255, 255,0.8);
        background-origin: padding-box;
        color: #3d3d3d;
        font-size: x-large;
        width: 75%;
        margin-left:12.5%;
        margin-top: 10vh;
        text-align: center;
        padding: 35px;
        background-blend-mode: lighten;

    }
    .navbar{
        margin-left: 20%;
    }



    *{
        font-family: 'Raleway', sans-serif;
    /*font-family: 'Roboto', sans-serif;*/
    }
```

```
footer {
        display: flex;
        justify-content: center;
        padding: 5px;
        margin-top: 43vh;
        background-color:rgb(10, 73, 112);
        color: #fff;

}

    .header1 img {
        float: left;
        width: 100px;
        height: 100px;
        background: #555;
        margin-left: 5%;
      }
```

CHANCE.HTML

```
<!DOCTYPE html>
<html>
<head>
      <title>Rainfall Prediction</title>
<style>
  body {
  background: linear-gradient(45deg, rgb(169, 250, 247), rgb(216,
77, 255)) fixed;
}
div.gallery {
  border: 1px solid rgb(0, 0, 0);
}

div.gallery:hover {
```

```
border: 1px solid #777;
}

div.gallery img {
  width: 366px;
  height: 280px;
}

div.desc {
  padding: 15px;
  text-align: center;
}

* {
  box-sizing: border-box;
}

.responsive {
  margin-top: 15vh;
  padding: 0 6px;
  float: left;
  width: 24.99999%;
}

@media only screen and (max-width: 700px) {
  .responsive {
    width: 49.99999%;
    margin: 6px 0;
  }
}

@media only screen and (max-width: 500px) {
  .responsive {
    width: 100%;
  }
```

```
}

.clearfix:after {
  content: "";
  display: table;

clear: both;
}


 .icon img {
        float: left;
        width: 100px;
        height: 100px;
        background: #555;
        margin-left: 5%;
      }
</style>
</head>
<body>
    <div class="icon">
        <img src="{{url_for('static',

filename='css/raincloud.png')}}" alt="logo" />
      </div>
<center><h1>Chances of rain today</h1>

<br>
<h2>You can follow any of the following process for effective
agriculture!</h2></center>

<div class="responsive">
  <div class="gallery">
    <a target="_blank"
href="https://affordabletreeservice.com.au/shared/content/uploads/La
nd-clearing-hero-1-1024x550.jpg">
```

```
      <img
src="https://affordabletreeservice.com.au/shared/content/uploads/Land-clearing-hero-1-1024x550.jpg" alt="Cinque Terre" width="600"
height="400">
    </a>
    <div class="desc">Land Clearing</div>

</div>

</div>

 <div class="responsive">
  <div class="gallery">
    <a target="_blank"
href="https://www.britannica.com/explore/savingearth/wp-content/uploads/sites/4/2019/04/0000156670-1024x681.jpg ">
      <img src="https://www.britannica.com/explore/savingearth/wp-content/uploads/sites/4/2019/04/0000156670-1024x681.jpg"
alt="Forest" width="600" height="400">
    </a>
    <div class="desc">Ensure proper drainage</div>
  </div>
</div>

<div class="responsive">

 <div class="gallery">
    <a target="_blank" href="https://4.imimg.com/data4/VQ/KS/MY-3597886/img_0112-500x500.jpg">
      <img src="https://4.imimg.com/data4/VQ/KS/MY-3597886/img_0112-500x500.jpg" alt="Northern Lights" width="600" height="400">
    </a>
    <div class="desc">Set up a rain cover</div>
  </div>
</div>

<div class="responsive">
```

```
  <div class="gallery">
    <a target="_blank"
href="https://soilsmatter.files.wordpress.com/2015/02/sensor-based-
nitrogen-application-to-corn-maize-in-the-midwest-photo-
raun.jpg?w=1200">
      <img
src="https://soilsmatter.files.wordpress.com/2015/02/sensor-based-
nitrogen-application-to-corn-maize-in-the-midwest-photo-
raun.jpg?w=1200" alt="Mountains" width="600" height="400">
    </a>
    <div class="desc">Pre-plant Fertilizer</div>

</div>
</div>
</body>
</html>
```

NOCHANCE.HTML

```
<!DOCTYPE html>
<html>
<head>
      <title>Rainfall Prediction</title>
<style>
  body {
  background: linear-gradient(45deg, rgb(250, 250, 169), rgb(255,
202, 77)) fixed;

}
div.gallery {
  border: 1px solid rgb(0, 0, 0);
}

div.gallery:hover {
  border: 1px solid #777;
```

```
}

div.gallery img {
  width: 366px;
  height: 280px;
}

div.desc {

 padding: 15px;
  text-align: center;
}

* {
  box-sizing: border-box;
}

.responsive {
  margin-top: 15vh;
  padding: 0 6px;
  float: left;
  width: 24.99999%;
}

@media only screen and (max-width: 700px) {
  .responsive {
    width: 49.99999%;
    margin: 6px 0;
  }
}

@media only screen and (max-width: 500px) {
  .responsive {
    width: 100%;
  }
```

```
}

.clearfix:after {
  content: "";
  display: table;
  clear: both;
}
.icon img {
        float: left;

       width: 100px;
       height: 100px;
        margin-left: 5%;
      }
</style>
</head>
<body>

  <div class="icon">
    <img src="{{url_for('static', filename='css/sun.png')}}"
alt="logo" />
  </div>

<center><h1>No chances of rain today</h1>
<br>
<h2>You can follow any of the following process for effective
agriculture!</h2></center>

<div class="responsive">
  <div class="gallery">
    <a target="_blank" href="https://westafricanagri.com/wp-
content/uploads/2020/06/Irrirgating.jpg">
      <img src="https://westafricanagri.com/wp-
content/uploads/2020/06/Irrirgating.jpg" alt="Cinque Terre"
width="600" height="400">
    </a>
```

```
<div class="desc">Calculate the water needed for Irrigation</div>
  </div>
</div>



<div class="responsive">
  <div class="gallery">

<a target="_blank"
href="https://media.istockphoto.com/id/1126541751/photo/hands-
planting-the-seeds-into-the-
dirt.jpg?s=612x612&w=0&k=20&c=aVUr7F_H4ZSJX89Nmiw59F8WvneKeg-
YsBoOiDQw0SA= ">
      <img
src="https://media.istockphoto.com/id/1126541751/photo/hands-
planting-the-seeds-into-the-
dirt.jpg?s=612x612&w=0&k=20&c=aVUr7F_H4ZSJX89Nmiw59F8WvneKeg-
YsBoOiDQw0SA="  alt="Forest" width="600" height="400">
    </a>
    <div class="desc">Sowing</div>
  </div>
</div>

<div class="responsive">
  <div class="gallery">
    <a target="_blank"
href="https://media.istockphoto.com/id/1151784210/photo/ripe-rice-
field-and-sky-background-at-
sunset.jpg?s=612x612&w=0&k=20&c=DZz4wxIbPXnMhmoTsEV06uYKup9MEZTtRFe2
XkDb0mY=">
      <img

src="https://media.istockphoto.com/id/1151784210/photo/ripe-rice-
field-and-sky-background-at-
sunset.jpg?s=612x612&w=0&k=20&c=DZz4wxIbPXnMhmoTsEV06uYKup9MEZTtRFe2
XkDb0mY=" alt="Northern Lights" width="600" height="400">
    </a>
```

```
<div class="desc">Sundrying / Threshing of crops</div>
  </div>
</div>

<div class="responsive">
  <div class="gallery">
    <a target="_blank"
href="https://static.vecteezy.com/system/resources/previews/010/508/
297/large_2x/old-farmers-spray-fertilizer-or-chemical-pesticides-in-
the-rice-fields-chemical-fertilizers-free-photo.jpg">

<img
src="https://static.vecteezy.com/system/resources/previews/010/508/2
97/large_2x/old-farmers-spray-fertilizer-or-chemical-pesticides-in-
the-rice-fields-chemical-fertilizers-free-photo.jpg" alt="Mountains"
width="600" height="400">

 </a>
    <div class="desc">Apply Agricultural chemicals</div>
  </div>
</div>
</body>
</html>
```

APP.PY

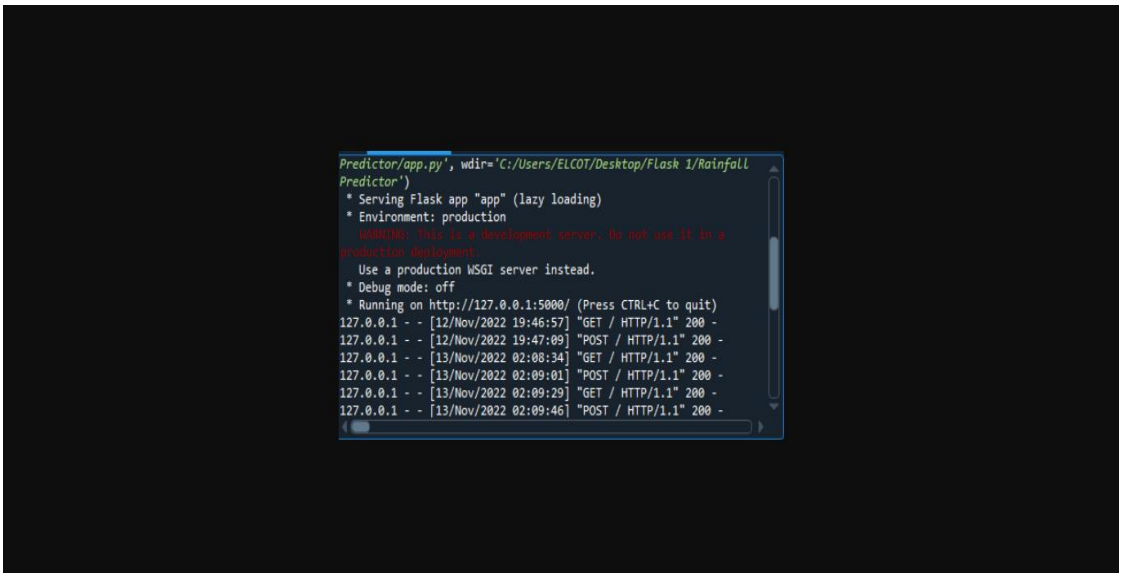
```
#from crypt import methods
from pyexpat import features, model
import numpy as np
import pickle
#import joblib

#import matplotlib
```

```
#import matplotlib.pyplot as plt
#import time
import pandas
#import os
from flask import Flask, request, jsonify, render_template,
redirect, url_for




# Declare a Flask app
app = Flask(__name__,template_folder='template')

model = pickle.load(open("rainfall.pkl",'rb'))
scale = pickle.load(open("scale.pkl",'rb'))

@app.route('/')
def home():
    return render_template("home.html")

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

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


@app.route('/help/')
def help():
    return render_template("help.html")

@app.route('/contact/')
def contact():
```

```
return render_template("contact.html")

@app.route('/about/')
def about():
    return render_template("about.html")

@app.route('/predict',methods=["POST","GET"])
def predict():
    res = " "

 # If a form is submitted
    if request.method == "POST":
        input_feature=[x for x in request.form.values() ]

features_values=[np.array(input_feature)]
        names =
[['Location','MinTemp','MaxTemp','Rainfall','WindGustSpeed',
        'WindSpeed9am','WindSpeed3pm','Humidity9am','Humadity3pm',

'Pressure9pm','Pressure3am','Temp9pm','Temp3pm','RainyTodaty',
        'WindGustDir','WindDir9pm','WindDir3pm']]
        data = pandas.DataFrame(features_values,columns=names)
        data = scale.fit_transform(data)
        data = pandas.DataFrame(data,columns=names)

        #Get prediction
        prediction = model.predict(data)

    else:
        prediction = ""

    if prediction == 1:
       return redirect(url_for('chance'))

    elif prediction == 0:
        return redirect(url_for('nochance'))
```

```
    return render_template("index.html", output = res)


#Running the app

if __name__== "___main___":
    app.run(debug = True,host='0.0.0.0',port=80)
```

RUN THE APP



8.TESTING

7.3. Test Cases

Test case ID	Feature Type	Component	Test Scenario	Steps To Execute	Test Data	Expected Result	Actual Result	Status	Executed By
LoginPage_TC_001	UI	Home Page	Verify user is login by entering email,password,and confirming password.	1.Enter URL and click go 2.Enter the email id, password and confirm password. 3.click the login button.	https://rainfalldata.w3spaces.com	Login/ registering for the application	Working as expected	Pass	Mathusudhan
LoginPage_TC_002	UI	Home Page	Verify the can access the dashboard with the LinkedIn login.	1. Enter the URL and click enter 2.enter the valid mail id in the Email text box. 3.enter the valid password in the password text box. 4.click on tthe join now button in linked in.	https://rainfalldata.w3spaces.com/	Application should show below UI elements: a.email text box b.password text box c.join now button d.shows the dashboard page	Working as expected	pass	Vishnudev
LoginPage_TC_003	Functional	Home page	Verify user is able to log into application with Valid credentials and get the confirmation mail.	1.Enter URL and click go 2.Click on My Account dropdown button 3.Enter Valid username/email in Email text box 4.Enter valid password in password text box 5.Click on login and get mail.	Username: ibmmsec@gamil.com password: Testing123	Application should send the confirmation mail	Working as expected	Pass	Mohammedasath

Test case ID	Feature Type	Component	Test Scenario	Steps To Execute	Test Data	Expected Result	Actual Result	Status	Executed By
LoginPage_TC_004	Functional	Login page	Verify user is able to log into application with Valid credentials	1.Enter URL(https://shopenzer.com/) and click go 2.Click on My Account dropdown button 3.Enter Valid username/email in Email text box 4.Enter valid password in password text box 5.Click on login button	Username: ibmmsec@gmail.com password: Testing123	User should navigate to tne home page.	Working as expected	Pass	Mohamed Abhuthahir Khan
LoginPage_TC_005	Functional	Login page	Verify user is able to log into application with InValid credentials	1.Enter URL(https://shopenzer.com/) and click go 2.Click on My Account dropdown button 3.Enter Valid username/email in Email text box 4.Enter Invalid password in password text box 5.Click on login button	Username: chalam@gmail.com password: Testing12367868678687 6876	Application should show 'Incorrect email or password ' validation message.	Working as expected	pass	Mathusudhan
LoginPage_TC_006	Functional	Login page	Verify user is able to log into application with InValid credentials	1.Enter URL(https://shopenzer.com/) and click go 2.Click on My Account dropdown button 3.Enter InValid username/email in Email text box 4.Enter Invalid password in password text box 5.Click on login button	Username: ibmmseec@gamil.com password: Testing654	Application should show 'Incorrect email or password ' validation message.	Working as expected	pass	Vishnudev

7.4. User Acceptance Testing

8.2.1. Defect Analysis

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	4	2	3	20
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	11	2	4	20	37
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	5	2	1	8
Totals	24	14	13	26	77

8.2.2. Testcase Analysis

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	51	0	0	51
Security	2	0	0	2
Outsource Shipping	3	0	0	3
Exception Reporting	9	0	0	9
Final Report Output	4	0	0	4
Version Control	2	0	0	2

8. RESULTS

8.1. Performance Metrics

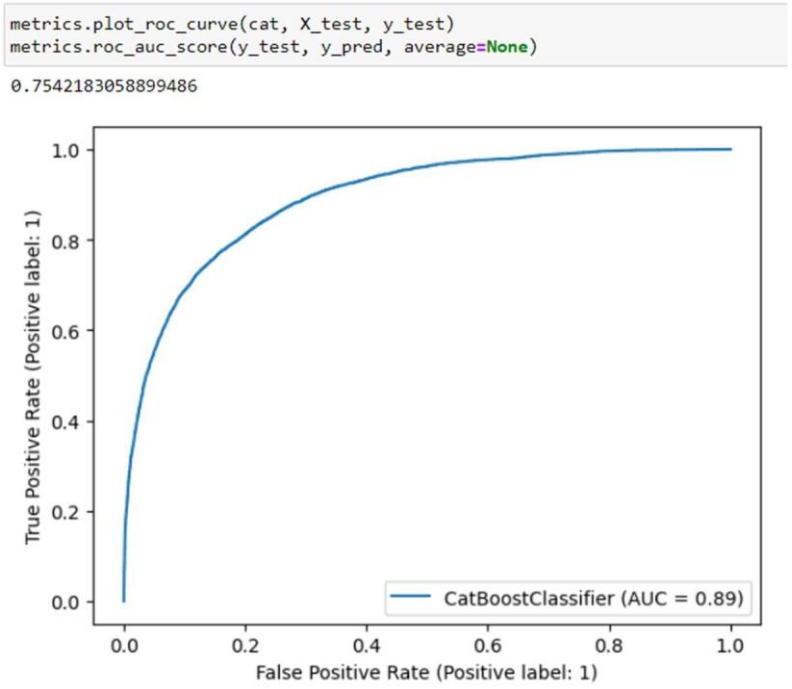
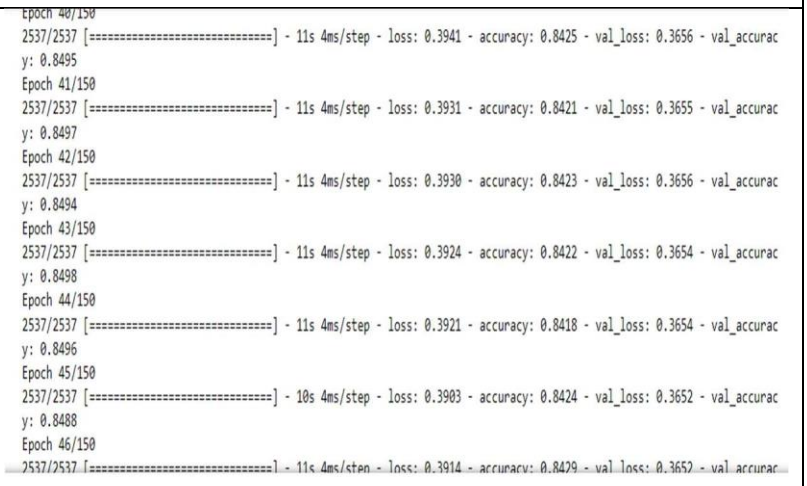
9.1.1. Machine Learning

S.No.	Parameter	Values	Screenshot

1.	Metrics	**Classification Model:**
		Confusion Matrix -
		Accuracy Score-
		Classification Report -
			`y_pred = cat.predict(X_test)`
			`print(confusion_matrix(y_test,y_pred))`
			`print(accuracy_score(y_test,y_pred))`
			`print(classification_report(y_test,y_pred))`
			`[[21510 1207]`
			`[ 2795 3580]]`
			`0.8624364086346762`
			`precision recall f1-score support`
			`0 0.89 0.95 0.91 22717`
			`1 0.75 0.56 0.64 6375`
			`accuracy 0.86 29092`
			`macro avg 0.82 0.75 0.78 29092`
			`weighted avg 0.85 0.86 0.85 29092`

2.	Tune the Model	Hyperparameter Tuning –
		Validation Method -
			`{'learning_rate': 0.1, 'max_depth': 8}`
			`0.8892227301457538`
			`Accuracy:83.11 %`
			`Standard Deviation:17.73 %`

9.1.2. Artificial Intelligence

S.No.	Parameter	Values	Screenshot
1.	Model Summary	-	
2.	Accuracy	Training Accuracy - Validation Accuracy -	

9. ADVANTAGES AND DISADVANTAGES

9.1. Advantages

- Farmers can know when to plant or harvest their crops
- People can choose where and when to take their holidays to take advantages of good weather
- Surfers known when large waves are expected
- Regions can be e vacuated if hurricanes or floods are expected
- Aircraft and shipping rely heavily on accurate weather forecasting

9.2. Disadvantages

- Weather is extremely difficult to forecast correctly
- It is expensive to monitor so many variables from so many sources
- The computers needed to perform the millions of calculations necessary are expensive
- The weather forecasters get blamed if the weather is different from the forecast

10. CONCLUSION

The weather prediction has become one of the most essential entities now a days. To improve the risk management systems and to know the weather in coming days in an automatic and in scientific way, many models have been emerging to assist in weather Prediction. In this paper, we have seen building a Weather Prediction Web Application from scratch by making use of 6 different ML algorithms namely CatBoost Classifier, Random Forset Classifier, Logistic Regression, GaussianNB, KNN and XGB Classifier. Inthe result section, the results from the all the six models and its results such as Accuracy, Error rate, mean absolute error, Root mean squared error, Relative squared error, Root relative squared error and time taken to build the model are tabulated. The results show that the CatBoost Classifier and XGB Classifier has output the results of high accuracy than all the other classifiers that were used. When coming to the time taken to build the model, The CatBoost Classifier outperforms all the other classifiers in solving the Problem under scrutiny.

11. FUTURE SCOPE

In upcoming future updates, the WEATHER FORECASTING application will have additional features such as:

- Live Location tracking
- News on Live Disasters
- Weather Forecast for next one week
- Will deploy as android app
- Help in predicting which crop will be best suited according to weather conditions

12. APPENDIX

12.1. Source Code

13.1.1. Ipynb file Link: RAINFALL PREDICTION

13.1.2. UI Link: FILE

12.2. Links

13.2.1. GITHUB

13.2.2. DEMO VIDEO