Scenario 3: CROP RECOMMENDATION SYSTEM

A state Agricultural Development Officer is studying the relationship between soil conditions and crop yields. They have access to a dataset of soil nutrient levels and a shapefile of agricultural land parcels. They want to identify areas with optimal soil conditions for specific crops and recommend suitable crop types for those areas. Develop a model to solve the problem using Python and also explain your solution with complete documentation. Upload the solution code and documentation in the GitHub Public Repository. Share the code, visualization, GitHub Link and other stuff in the Google Classroom.

About the data

The information utilized in this project is generated by enhancing and merging diverse publicly accessible datasets from India, encompassing factors such as weather and soil. The dataset is available for access here. Unlike intricate factors that impact crop yield, this data is relatively straightforward, featuring a limited yet valuable set of features.

Included in the dataset are soil attributes like Nitrogen, Phosphorous, Potassium, and pH values. Additionally, it incorporates essential environmental factors such as humidity, temperature, and rainfall specific to each crop. Context Precision agriculture is in trend nowadays. It helps the farmers to get informed decision about the farming strategy. Here, I present you a dataset which would allow the users to build a predictive model to recommend the most suitable crops to grow in a particular farm based on various parameters.

Context This dataset was build by augmenting datasets of rainfall, climate and fertilizer data available for India.

Data fields

N - ratio of Nitrogen content in soil

P - ratio of Phosphorous content in soil

K - ratio of Potassium content in soil

temperature - temperature in degree Celsius

humidity - relative humidity in %

ph - ph value of the soil

rainfall - rainfall in mm

Importing libraries

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib as plt
from sklearn.model_selection import train_test_split
```

Loading and Displaying Dataset

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
dataset=pd.read_csv("/content/drive/MyDrive/cropdataset/Crop_recommendation.csv")
```

```
dataset.head()
```

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

this is a classification problem where the output will be in a categorical form

```
dataset.shape
```

```
(2200, 8)
```

```
dataset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2200 entries, 0 to 2199
Data columns (total 8 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   N            2200 non-null   int64  
 1   P            2200 non-null   int64  
 2   K            2200 non-null   int64  
 3   temperature  2200 non-null   float64
 4   humidity     2200 non-null   float64
 5   ph           2200 non-null   float64
 6   rainfall     2200 non-null   float64
 7   label        2200 non-null   object 
dtypes: float64(4), int64(3), object(1)
memory usage: 137.6+ KB
```

```
dataset.isnull().sum()
```

```
N              0
P              0
K              0
temperature    0
humidity       0
ph             0
rainfall       0
label          0
dtype: int64
```

```
dataset.duplicated().sum()
```

```
0
```

```
dataset.describe()
```

	N	P	K	temperature	humidity	ph	rainfall
count	2200.000000	2200.000000	2200.000000	2200.000000	2200.000000	2200.000000	2200.000000
mean	50.551818	53.362727	48.149091	25.616244	71.481779	6.469480	103.463655
std	36.917334	32.985883	50.647931	5.063749	22.263812	0.773938	54.958389
min	0.000000	5.000000	5.000000	8.825675	14.258040	3.504752	20.211267
25%	21.000000	28.000000	20.000000	22.769375	60.261953	5.971693	64.551686
50%	37.000000	51.000000	32.000000	25.598693	80.473146	6.425045	94.867624
75%	84.250000	68.000000	49.000000	28.561654	89.948771	6.923643	124.267508
max	140.000000	145.000000	205.000000	43.675493	99.981876	9.935091	298.560117

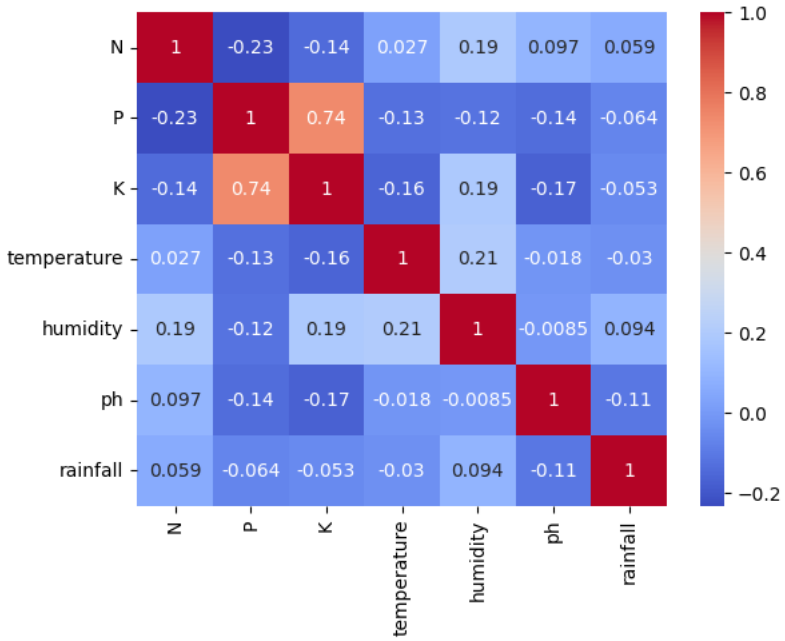
Exploring Dataset

```
corr=dataset.drop(['label'],axis=1).corr()
corr
```

	N	P	K	temperature	humidity	ph	rainfall
N	1.000000	-0.231460	-0.140512	0.026504	0.190688	0.096683	0.059020
P	-0.231460	1.000000	0.736232	-0.127541	-0.118734	-0.138019	-0.063839
K	-0.140512	0.736232	1.000000	-0.160387	0.190859	-0.169503	-0.053461
temperature	0.026504	-0.127541	-0.160387	1.000000	0.205320	-0.017795	-0.030084
humidity	0.190688	-0.118734	0.190859	0.205320	1.000000	-0.008483	0.094423
ph	0.096683	-0.138019	-0.169503	-0.017795	-0.008483	1.000000	-0.109069
rainfall	0.059020	-0.063839	-0.053461	-0.030084	0.094423	-0.109069	1.000000

```
sns.heatmap(corr,annot=True,cbar=True,cmap='coolwarm')
```

```
<Axes: >
```

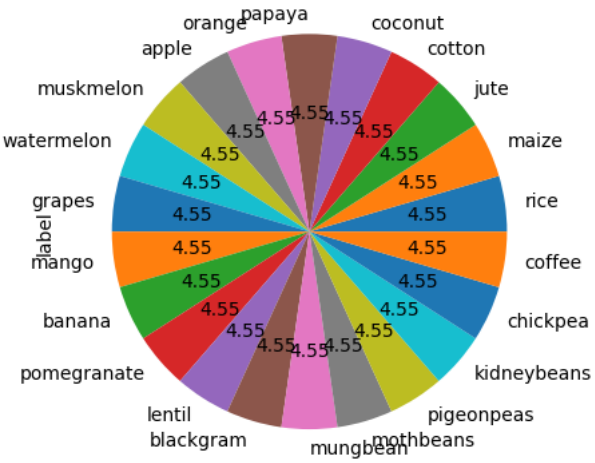



```
dataset['label'].value_counts()
```

```
rice           100
maize          100
jute           100
cotton         100
coconut        100
papaya         100
orange         100
apple          100
muskmelon      100
watermelon     100
grapes         100
mango          100
banana         100
pomegranate    100
lentil         100
blackgram      100
mungbean       100
mothbeans      100
pigeonpeas     100
kidneybeans    100
chickpea       100
coffee         100
Name: label, dtype: int64
```

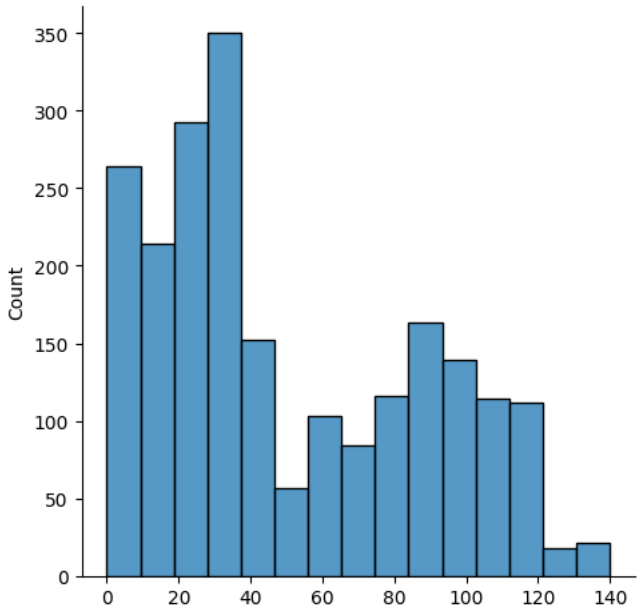
```
dataset['label'].value_counts().plot(kind='pie',autopct="%.2f")
```

```
<Axes: ylabel='label'>
```




```
sns.displot(dataset['N'])
```

```
<seaborn.axisgrid.FacetGrid at 0x7da9fc61ceb0>
```




```
import matplotlib.pyplot as plt

plt.figure(figsize=(16,12))
plt.subplot(3,2,1)
sns.distplot(dataset['N'])

plt.subplot(3,2,2)
sns.distplot(dataset['P'])

plt.subplot(3,2,3)
sns.distplot(dataset['K'])

plt.subplot(3,2,4)
sns.distplot(dataset['temperature'])

plt.subplot(3,2,5)
sns.distplot(dataset['ph'])

plt.subplot(3,2,6)
sns.distplot(dataset['humidity'])

plt.show()
```

```
<ipython-input-163-ee3f2516cc75>:5: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['N'])
<ipython-input-163-ee3f2516cc75>:8: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['P'])
<ipython-input-163-ee3f2516cc75>:11: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['K'])
<ipython-input-163-ee3f2516cc75>:14: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['temperature'])
<ipython-input-163-ee3f2516cc75>:17: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

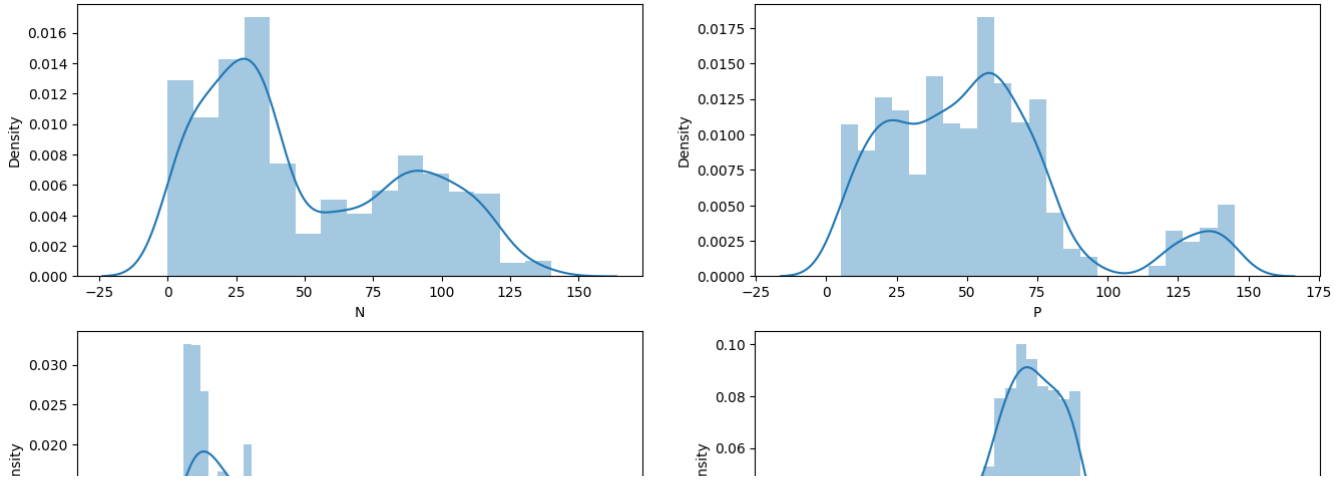
  sns.distplot(dataset['ph'])
<ipython-input-163-ee3f2516cc75>:20: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(dataset['humidity'])
```



```
import seaborn as sns
plt.figure(figsize=(16,10))
plt.subplot(3,2,1)
sns.boxplot(dataset['N'])

plt.subplot(3,2,2)
sns.boxplot(dataset['P'])

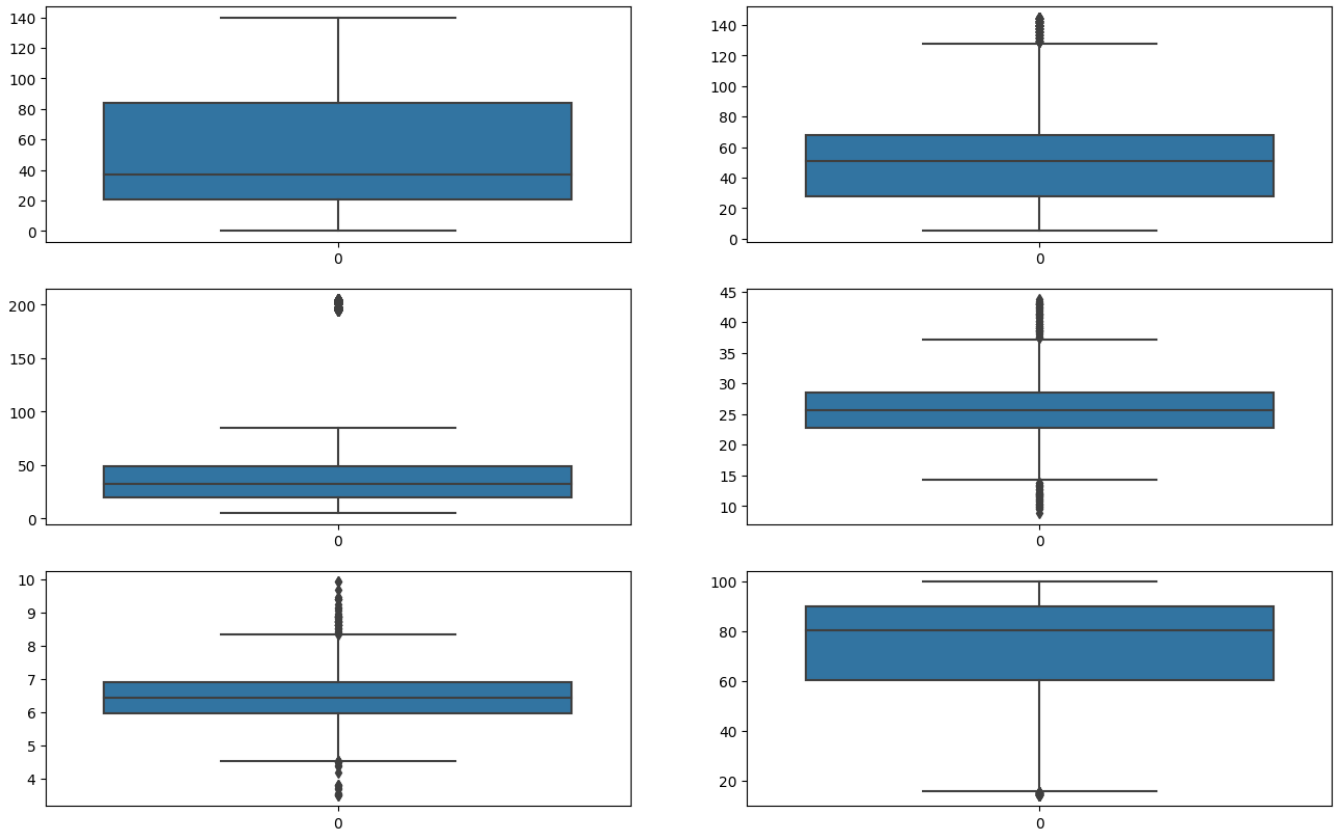
plt.subplot(3,2,3)
sns.boxplot(dataset['K'])

plt.subplot(3,2,4)
sns.boxplot(dataset['temperature'])

plt.subplot(3,2,5)
sns.boxplot(dataset['ph'])

plt.subplot(3,2,6)
sns.boxplot(dataset['humidity'])

plt.show()
```



Converting Categorical varibales to a integer format

```
crop_dict = {
    'rice': 1,
    'maize': 2,
    'jute': 3,
    'cotton': 4,
    'coconut': 5,
    'papaya': 6,
    'orange': 7,
    'apple': 8,
    'muskmelon': 9,
    'watermelon': 10,
    'grapes': 11,
    'mango': 12,
    'banana': 13,
    'pomegranate': 14,
    'lentil': 15,
    'blackgram': 16,
    'mungbean': 17,
    'mothbeans': 18,
    'pigeonpeas': 19,
    'kidneybeans': 20,
    'chickpea': 21,
    'coffee': 22
}
dataset['crop_num']=dataset['label'].map(crop_dict)
```

```
dataset.head()
```

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

Removing Label column from the dataset

```
dataset=dataset.drop('label',axis=1)
```

Training , Testing and Splitting Dataset

```
features=dataset.drop('crop_num',axis=1)
target=dataset['crop_num']
```

```
features.head()
```

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

```
target.head()
```

```
0    1
1    1
2    1
3    1
4    1
Name: crop_num, dtype: int64
```

```
# Splitting into train and test data

from sklearn.model_selection import train_test_split
Xtrain, Xtest, Ytrain, Ytest = train_test_split(features,target,test_size = 0.2,random_state =2)
```

```
Xtrain.shape
```

```
(1760, 7)
```

```
Xtest.shape
```

```
(440, 7)
```

```
Xtrain
```

	N	P	K	temperature	humidity	ph	rainfall
1936	113	38	25	22.000851	79.472710	7.388266	90.422242
610	28	35	22	29.530376	86.733460	7.156563	59.872321
372	11	61	21	18.623288	23.024103	5.532101	135.337803
1559	29	139	205	23.641424	93.744615	6.155939	116.691218
1500	24	128	196	22.750888	90.694892	5.521467	110.431786
...	...	...	...	...	...	...	...
1071	105	88	54	25.787498	84.511942	6.020445	114.200546
433	27	71	23	23.453790	46.487148	7.109598	150.871220
674	23	39	22	29.256493	81.979522	6.864839	42.024833
1099	117	81	53	29.507046	78.205856	5.507642	98.125658
1608	39	24	14	30.554726	90.903438	7.189260	106.071198

1760 rows × 7 columns

```
# Initializing empty lists to append all model's name and corresponding name
acc = []
model = []
```

Model Building

Decision Tree

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report
from sklearn import metrics
from sklearn import tree
DecisionTree = DecisionTreeClassifier(criterion="entropy",random_state=2,max_depth=5)

DecisionTree.fit(Xtrain,Ytrain)

predicted_values = DecisionTree.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Decision Tree')
print("DecisionTrees's Accuracy is: ", x*100)

print(classification_report(Ytest,predicted_values))
```

```
DecisionTrees's Accuracy is:  90.0
              precision    recall  f1-score   support

           1       1.00      0.62      0.77        16
           2       1.00      1.00      1.00        21
           3       0.74      0.93      0.83        28
           4       1.00      1.00      1.00        20
           5       0.91      1.00      0.95        21
           6       1.00      0.84      0.91        19
           7       1.00      1.00      1.00        29
           8       1.00      1.00      1.00        13
           9       1.00      1.00      1.00        23
          10       1.00      1.00      1.00        15
          11       1.00      1.00      1.00        18
          12       1.00      1.00      1.00        26
          13       1.00      1.00      1.00        17
          14       1.00      1.00      1.00        17
          15       0.68      1.00      0.81        23
          16       0.59      1.00      0.74        16
          17       1.00      1.00      1.00        24
          18       0.00      0.00      0.00        19
```

```
                19       0.62      1.00      0.77        18
                20       0.00      0.00      0.00        14
                21       1.00      1.00      1.00        21
                22       1.00      1.00      1.00        22

            accuracy                           0.90       440
           macro avg       0.84      0.88      0.85       440
        weighted avg       0.86      0.90      0.87       440

      /usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are
        _warn_prf(average, modifier, msg_start, len(result))
      /usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are
        _warn_prf(average, modifier, msg_start, len(result))
      /usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are
        _warn_prf(average, modifier, msg_start, len(result))
```

```
from sklearn.model_selection import cross_val_score


# Cross validation score (Decision Tree)
score = cross_val_score(DecisionTree, X, target,cv=5)


score
```

```
array([0.93636364, 0.90909091, 0.91818182, 0.85909091, 0.93636364])
```

Saving trained Decision Tree model

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
DT_pkl_filename = 'DecisionTree.pkl'
# Open the file to save as pkl file
DT_Model_pkl = open(DT_pkl_filename, 'wb')
pickle.dump(DecisionTree, DT_Model_pkl)
# Close the pickle instances
DT_Model_pkl.close()
```

Guassian Naive Bayes

```
from sklearn.naive_bayes import GaussianNB

NaiveBayes = GaussianNB()

NaiveBayes.fit(Xtrain,Ytrain)

predicted_values = NaiveBayes.predict(Xtest)
x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Naive Bayes')
print("Naive Bayes's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
      Naive Bayes's Accuracy is:  0.990909090909091
                    precision    recall  f1-score   support

                 1       1.00      0.75      0.86        16
                 2       1.00      1.00      1.00        21
                 3       0.88      1.00      0.93        28
                 4       1.00      1.00      1.00        20
                 5       1.00      1.00      1.00        21
                 6       1.00      1.00      1.00        19
                 7       1.00      1.00      1.00        29
                 8       1.00      1.00      1.00        13
                 9       1.00      1.00      1.00        23
                10       1.00      1.00      1.00        15
                11       1.00      1.00      1.00        18
                12       1.00      1.00      1.00        26
                13       1.00      1.00      1.00        17
                14       1.00      1.00      1.00        17
                15       1.00      1.00      1.00        23
                16       1.00      1.00      1.00        16
                17       1.00      1.00      1.00        24
                18       1.00      1.00      1.00        19
                19       1.00      1.00      1.00        18
                20       1.00      1.00      1.00        14
                21       1.00      1.00      1.00        21
                22       1.00      1.00      1.00        22
```

```
          accuracy                           0.99       440
         macro avg       0.99      0.99      0.99       440
      weighted avg       0.99      0.99      0.99       440
```

```
# Cross validation score (NaiveBayes)
score = cross_val_score(NaiveBayes,features,target,cv=5)
score
```

```
array([0.99772727, 0.99545455, 0.99545455, 0.99545455, 0.99090909])
```

Saving trained Guassian Naive Bayes model

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
NB_pkl_filename = 'NBClassifier.pkl'
# Open the file to save as pkl file
NB_Model_pkl = open(NB_pkl_filename, 'wb')
pickle.dump(NaiveBayes, NB_Model_pkl)
# Close the pickle instances
NB_Model_pkl.close()
```

Support Vector Machine (SVM)

```
from sklearn.svm import SVC

SVM = SVC(gamma='auto')

SVM.fit(Xtrain,Ytrain)

predicted_values = SVM.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('SVM')
print("SVM's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
SVM's Accuracy is:  0.10681818181818181
              precision    recall  f1-score   support

           1       0.50      0.06      0.11        16
           2       0.00      0.00      0.00        21
           3       1.00      0.07      0.13        28
           4       1.00      0.05      0.10        20
           5       1.00      0.05      0.09        21
           6       1.00      0.05      0.10        19
           7       1.00      0.03      0.07        29
           8       1.00      0.23      0.38        13
           9       1.00      0.30      0.47        23
          10       1.00      0.13      0.24        15
          11       1.00      0.06      0.11        18
          12       0.00      0.00      0.00        26
          13       1.00      0.24      0.38        17
          14       1.00      0.12      0.21        17
          15       0.00      0.00      0.00        23
          16       1.00      0.19      0.32        16
          17       1.00      0.12      0.22        24
          18       0.00      0.00      0.00        19
          19       0.00      0.00      0.00        18
          20       0.03      1.00      0.07        14
          21       1.00      0.05      0.09        21
          22       0.00      0.00      0.00        22

    accuracy                           0.11       440
   macro avg       0.66      0.13      0.14       440
weighted avg       0.66      0.11      0.13       440

/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are
  _warn_prf(average, modifier, msg_start, len(result))
```

```
# Cross validation score (SVM)
score = cross_val_score(SVM,features,target,cv=5)
score
```

```
array([0.27727273, 0.28863636, 0.29090909, 0.275     , 0.26818182])
```

Logistic Regression

```
from sklearn.linear_model import LogisticRegression

LogReg = LogisticRegression(random_state=2)

LogReg.fit(Xtrain,Ytrain)

predicted_values = LogReg.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('Logistic Regression')
print("Logistic Regression's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
Logistic Regression's Accuracy is:  0.9522727272727273
              precision    recall  f1-score   support

           1       0.85      0.69      0.76        16
           2       0.90      0.86      0.88        21
           3       0.84      0.93      0.88        28
           4       0.86      0.90      0.88        20
           5       1.00      1.00      1.00        21
           6       1.00      0.95      0.97        19
           7       1.00      1.00      1.00        29
           8       1.00      1.00      1.00        13
           9       1.00      1.00      1.00        23
          10       1.00      1.00      1.00        15
          11       1.00      1.00      1.00        18
          12       0.96      1.00      0.98        26
          13       1.00      1.00      1.00        17
          14       1.00      1.00      1.00        17
          15       0.88      1.00      0.94        23
          16       0.86      0.75      0.80        16
          17       1.00      0.96      0.98        24
          18       0.84      0.84      0.84        19
          19       1.00      1.00      1.00        18
          20       1.00      1.00      1.00        14
          21       1.00      1.00      1.00        21
          22       1.00      1.00      1.00        22

    accuracy                           0.95       440
   macro avg       0.95      0.95      0.95       440
weighted avg       0.95      0.95      0.95       440

/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed to converge (status
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

```
# Cross validation score (Logistic Regression)
score = cross_val_score(LogReg,features,target,cv=5)
score
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed to converge (status
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

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```
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    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
array([0.95      , 0.96590909, 0.94772727, 0.96818182, 0.94318182])
```

Saving trained Logistic Regression model

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
LR_pkl_filename = 'LogisticRegression.pkl'
# Open the file to save as pkl file
LR_Model_pkl = open(DT_pkl_filename, 'wb')
pickle.dump(LogReg, LR_Model_pkl)
# Close the pickle instances
LR_Model_pkl.close()
```

Random Forest

```
from sklearn.ensemble import RandomForestClassifier

RF = RandomForestClassifier(n_estimators=20, random_state=0)
RF.fit(Xtrain,Ytrain)

predicted_values = RF.predict(Xtest)

x = metrics.accuracy_score(Ytest, predicted_values)
acc.append(x)
model.append('RF')
print("RF's Accuracy is: ", x)

print(classification_report(Ytest,predicted_values))
```

```
RF's Accuracy is:  0.990909090909091
              precision    recall  f1-score   support

           1       1.00      0.81      0.90        16
           2       1.00      1.00      1.00        21
           3       0.90      1.00      0.95        28
           4       1.00      1.00      1.00        20
           5       1.00      1.00      1.00        21
           6       1.00      1.00      1.00        19
           7       1.00      1.00      1.00        29
           8       1.00      1.00      1.00        13
           9       1.00      1.00      1.00        23
          10       1.00      1.00      1.00        15
          11       1.00      1.00      1.00        18
          12       1.00      1.00      1.00        26
          13       1.00      1.00      1.00        17
          14       1.00      1.00      1.00        17
          15       1.00      1.00      1.00        23
          16       0.94      1.00      0.97        16
          17       1.00      1.00      1.00        24
          18       1.00      0.95      0.97        19
          19       1.00      1.00      1.00        18
          20       1.00      1.00      1.00        14
          21       1.00      1.00      1.00        21
          22       1.00      1.00      1.00        22

    accuracy                           0.99       440
```

```
           macro avg       0.99      0.99      0.99       440
        weighted avg       0.99      0.99      0.99       440
```

```
# Cross validation score (Random Forest)
score = cross_val_score(RF,features,target,cv=5)
score
```

```
array([0.99545455, 0.99545455, 0.99545455, 0.99318182, 0.98863636])
```

Saving trained Random Forest model

```
import pickle
# Dump the trained Naive Bayes classifier with Pickle
RF_pkl_filename = 'RandomForest.pkl'
# Open the file to save as pkl file
RF_Model_pkl = open(RF_pkl_filename, 'wb')
pickle.dump(RF, RF_Model_pkl)
# Close the pickle instances
RF_Model_pkl.close()
```

Accuracy Comparison

```
accuracy_models = dict(zip(model, acc))
for k, v in accuracy_models.items():
    print (k, '=', v)
```

```
Decision Tree = 0.9
Naive Bayes = 0.990909090909091
SVM = 0.10681818181818181
Logistic Regression = 0.9522727272727273
RF = 0.990909090909091
```

From the Above Accuracies, We have adopt Random Forest as it has Maximum Accuracy

```
classifier=RandomForestClassifier()
classifier.fit(Xtrain,Ytrain)
ypred=classifier.predict(Xtest)
```

```
accuracy_score(Ytest,ypred)*100
```

```
99.31818181818181
```

Sample Predictions

```
def recommendation(N,P,k,temperature,humidity,ph,rainfal):
    features = np.array([[N,P,k,temperature,humidity,ph,rainfal]])
    prediction = DecisionTree.predict(features).reshape(1,-1)

    return prediction[0]
```