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A Novel approach for Crop Suitability and Fertilizer Recommendation Using Machine Learning

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ABSTRACT: For the farming and agricultural sectors, online marketing can easily cause more sales, brand awareness and increased market share. And, unlike within the past, this growth is allowing the farmers and business owners to dictate how they need to work, which is one among the most important reasons why websites really are helpful. But with the reverse labour migration leading to scarcity of labour which affected harvesting, farmers need a way to increase productivity. In order to keep the output constant, farmers need to grow the right crops and use the right fertilizers. Many farmers are unaware and grow crops which are unsuitable on a particular land which lead to a huge loss of time and equipment. Therefore, to solve this problem, farmers can take help from online applications to know the most suitable crop to grow on their land. In this Paper, it recommends the optimal crop to grow and fertilizers to use for the crops. Farmers can get crop recommendation and fertilizer recommendation. In the crop recommendation module, the user can provide the soil data from their side and the application will predict which crop should the user grow. For the fertilizer suggestion module, the user can input the soil data and the type of crop they are growing, and the application will predict what the soil lacks or has an excess of and will recommend improvements.

KEYWORDS: Recommender System, Machine learning, Decision tree, Naive Bayes, Random Forest

I. INTRODUCTION

Agriculture is the primary source of livelihood for about 58% of India's population. India has second highest land of more than 1.6 million square-kilometres under cultivation. India possesses a power potential to be a superpower in the field of agriculture. Agriculture remains a central pillar of the Indian economy. The sector serves the food consumption needs of the whole country, while also placing among the top exporters of agricultural produce in the world. The sector has been facing its share of challenges in recent years, but few have been as severe as the domestic and international travel restrictions during Covid-19 pandemic. Many farmers are unaware and grow crops which are unsuitable on a particular land which lead to a huge loss of time and equipment. There is no universal system to assist optimum crop to cultivated by farmers. Since India has been following agriculture from ages, we have a rich collection of agriculture data which can used for new technologies like precision agriculture. Precision agriculture is modern farming technique that uses data of soil characteristics, soil types, crop yield data, whether conditions and suggests farmers with the optimal crop to grow in their farmland for maximum yield and profit. This technique can reduce crop failures and will help farmers to take informed decision about their farming strategy. The main motive of this paper is to recommend optimum crops to be cultivated by farmers based on several parameters and help them make an informed decision before cultivation. Farmers can also know what type of fertilizer to use on the crop based on their soil ph value

II. METHODOLOGY

The crop yield recommendation is a significant problem in the agriculture sector . Every farmer tries to know crop yield and whether it meets their expectations, thereby evaluating the previous experience of the farmer on the specific crop predict the yield. Agriculture yields rely primarily on weather conditions, pests, and preparation of harvesting operations. Accurate information on crop history is critical for making decisions on agriculture risk management. Despite many solutions that have been recently proposed, there are still open challenges in creating a user-friendly application with respect to crop and fertilizer recommendation. In the proposed system, The data is made by augmenting and combining various publicly available datasets of India like weather, soil, etc. This data is relatively simple with very few but useful features unlike the complicated features affecting the yield of the crop and fertilizer. The main objective is



to obtain a better variety of crops that can be grown. The proposed system would help to minimize the difficulties faced by farmers in choosing a crop and maximize the yield in effect to reduce the suicide rates. The proposed model predicts the crop yield for the datasets of the given region. Integrating agriculture and ML will contribute to more enhancements in the agriculture sector by increasing the yields and optimizing the resources involved. The data from previous years are the key elements in forecasting current performance. Historical data is collected from kaggle.com.

A. Dataset

The dataset of this paper is taken from Kaggle. The data is made by augmenting and combining various publicly available datasets of India like weather, soil, etc. This data is relatively simple with very few but useful features unlike the complicated features affecting the yield of the crop. The data have Nitrogen, Phosphorous, Potassium, and pH values of the soil. Also, it also contains the humidity, temperature, and rainfall required for a particular crop. The crops considered in our model include rice, maize, chickpea, kidney beans, pigeon peas, moth beans, mung beans, black gram, lentil, pomegranate, banana, mango, grapes, watermelon, musk melon, orange, papaya, coconut, cotton, jute, coffee. The dataset has a hundred records of Nitrogen, Phosphorous, Potassium, and pH values of the soil corresponding to each crop mentioned above.

The above-stated parameters of soil play a major role in crop's ability to grow. Nitrogen is used by plants for lots of leaf growth and good green colour. Phosphorous is used by plants to help form new roots, make seeds, flowers, and fruits. It's also used by plants to fight diseases. Potassium helps plants make strong stems and keep growing fast. It's also used by plants to fight diseases. The soil pH can influence plant growth by its effect on the activity of beneficial microorganisms Bacteria that decompose soil organic matter are hindered in strong acid soils. Temperature influences most plant processes, including photosynthesis, transpiration, respiration, germination, and flowering. Hence for the following reasons, the above-stated parameters are considered for choosing a crop.

```
In [15]: merge_crop
```

Unnamed: 0	temperature	humidity	ph	rainfall	label	N	P	K	
0	0	20.879744	82.002744	6.502985	202.935536	rice	90	42	43
1	1	21.770462	80.319644	7.038096	226.655537	rice	85	58	41
2	2	23.004459	82.320763	7.840207	263.964248	rice	60	55	44
3	3	26.491096	80.158363	6.980401	242.864034	rice	74	35	40
4	4	20.130175	81.604873	7.628473	262.717340	rice	78	42	42
...
2195	895	26.774637	66.413269	6.780064	177.774507	coffee	107	34	32
2196	896	27.417112	56.636362	6.086922	127.924610	coffee	99	15	27
2197	897	24.131797	67.225123	6.362608	173.322839	coffee	118	33	30
2198	898	26.272418	52.127394	6.758793	127.175293	coffee	117	32	34
2199	899	23.603016	60.396475	6.779833	140.937041	coffee	104	18	30

2200 rows × 9 columns

Fig. 1 – crop dataset

Precision agriculture is in trend nowadays. It helps the farmers to get informed decision about the farming strategy. Here, In Fig.1 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. This dataset was built by augmenting datasets of rainfall, climate and fertilizer data available for India. Fig.2 gives the data of various fertilizers information. This data was by researching various websites and sources. For the fertilizer suggestion we need to enter the nutrient contents of the soil



and the crop you want to grow. The algorithm will tell which nutrient the soil has excess of or lacks. Accordingly, it will give suggestions for buying fertilizers.

	Crop	N	P	K	pH	soil_moisture
0	rice	80	40	40	5.5	30
3	maize	80	40	20	5.5	50
5	chickpea	40	60	80	5.5	60
12	kidneybeans	20	60	20	5.5	45
13	pigeonpeas	20	60	20	5.5	45
14	mothbeans	20	40	20	5.5	30
15	mungbean	20	40	20	5.5	80
18	blackgram	40	60	20	5	60
24	lentil	20	60	20	5.5	90
60	pomegranate	20	10	40	5.5	30
61	banana	100	75	50	6.5	40
62	mango	20	20	30	5	15
63	grapes	20	125	200	4	60
66	watermelon	100	10	50	5.5	70
67	muskmelon	100	10	50	5.5	30
69	apple	20	125	200	6.5	50
74	orange	20	10	10	4	60
75	papaya	50	50	50	6	20
88	coconut	20	10	30	5	45
93	cotton	120	40	20	5.5	70

Fig.2 –Fertilizer dataset

The dataset are trained using the following algorithms:

- Decision Tree
- Gaussian Naïve Bayes
- Support Vector Machine (SVM)
- Logistic Regression
- Random Forest
- XGBoost .

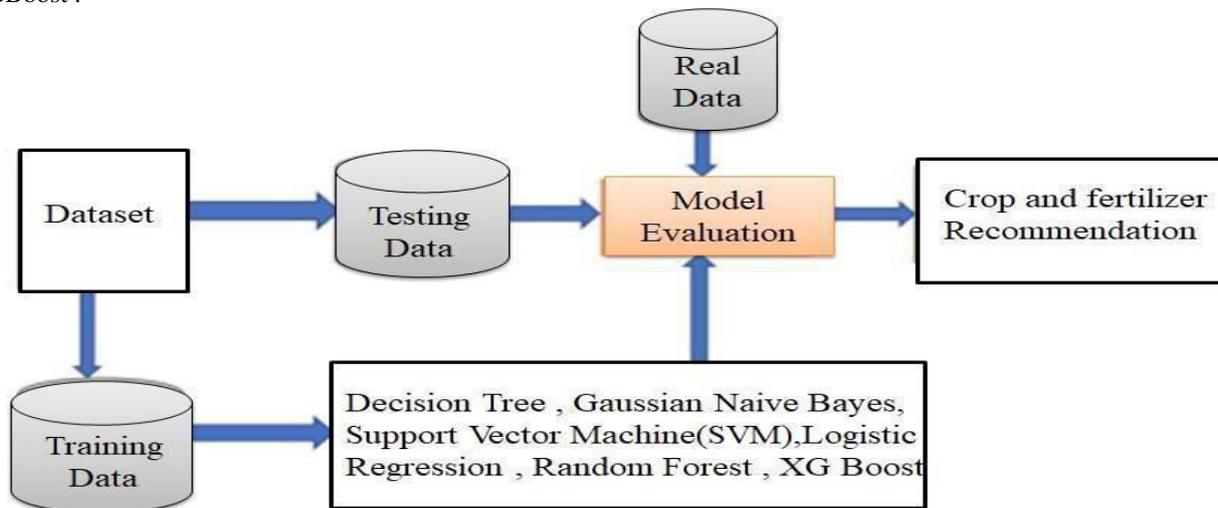


Fig. 3 – System Architecture

```

features = df[['N', 'P', 'K', 'temperature', 'humidity', 'ph', 'rainfall']]
target = df['label']
#features = df[['temperature', 'humidity', 'ph', 'rainfall']]
labels = df['label']

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

# 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)

from sklearn.tree import DecisionTreeClassifier

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("Decision Trees's Accuracy is: ", x*100)

print(classification_report(Ytest, predicted_values))

Decision Trees's Accuracy is: 90.0

from sklearn.model_selection import cross_val_score

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

score

array([0.93636364, 0.90909091, 0.91818182, 0.87045455, 0.93636364])

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()

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)

```

Fig. 4 – Demo of python implementation code

III. EXPERIMENTAL RESULTS

The dataset gets trained using the algorithms mentioned above. Every trained model is then saved into files, respectively. Accuracy of the models is then compared.



```
In [42]:
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 --> 0.9795454545454545
Logistic Regression --> 0.9522727272727273
RF --> 0.990909090909091
XGBoost --> 0.9931818181818182
```

Fig. 4 – crop recommendation accuracy

The above Fig. 4 gives the accuracies of each model. The prediction accuracies of the models are Decision Tree 90%, Naive Bayes 99.090%, SVM 10.6%, Logistic Regression

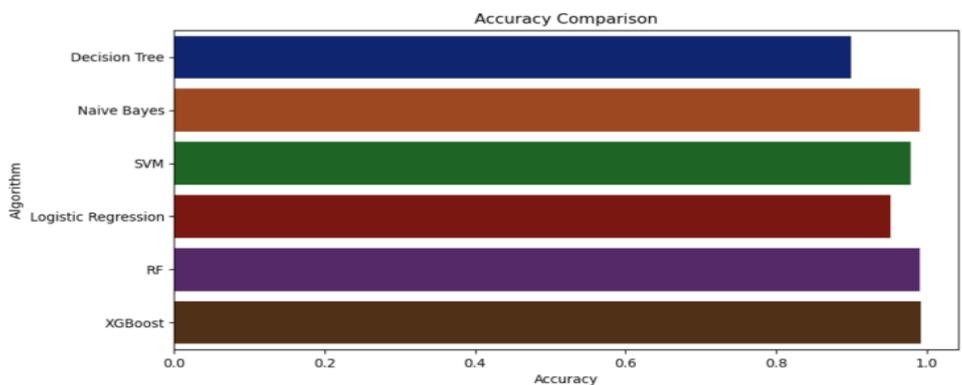


Fig. 5 –fertilizer recommendation accuracy

95.227%, Random forest 99.7%, XGBoost 99.318%. Since prediction accuracy of Random Forest is high, the random forest model is used to predict which crop to be cultivated.

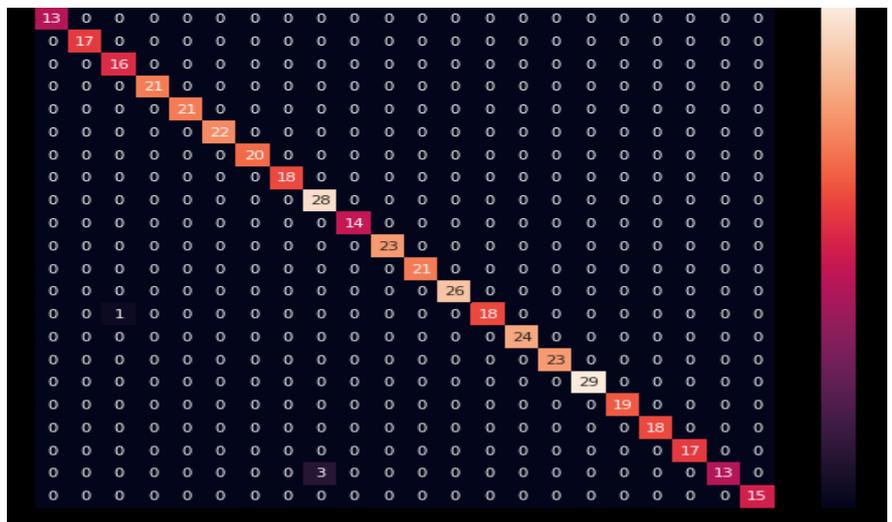


Fig. 6 – Confusion matrix

The above Figure tells that in the field of machine learning and specifically the problem of statistical classification, a confusion matrix, also known as an error matrix, is a specific table layout that allows visualization of the performance of an algorithm, typically a supervised learning one. The below Fig 7. shows the crop recommendation when we execute the code.

Making a prediction

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

['coffee']
```

Fig. 7 – Crop Recommendation

If we want to recommend what fertilizer to be used for a specific crop then the output is as shown in the Fig. 8

```
ferti = pickle.load(open('fertilizer.pkl', 'rb'))
ferti.classes_[6]

'Urea'
```

Fig. 8 – Fertilizer Recommendation

IV. CONCLUSION

After the final validation, it was concluded that the paper is successful in carrying out all the functionalities mentioned throughout this report. This will therefore provide a platform for farmers to get informed strategies and is developed in such a way that they can get the crop and fertilizer recommendation with respect to the real-time weather data.

V. FUTURE SCOPE

A better user interface can be made. More features can be added. Multi-language support can also be added as not all the farmers know English. Only states and cities of India have been taken in the present version of the module and therefore the cities of other countries can be added in the upcoming versions. In the future, a website and a mobile app can also be made, and be uploaded onto the Google Play Store where everyone can download and install this app for their use. These limitations are implemented in further versions, along with any further areas of growth. New features and modules can be added into the system in the future.

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