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Crop Recommendation System Using Machine Learning

Pravallika
Apex institute of technology
CSE
Chandigarh university
Punjab, India
21bcs5831@cuchd.in

Nikhil
Apex institute of technology
CSE
Chandigarh university
Punjab, India
21bcs6673@cuchd.in

Yogi
Apex institute of technology
CSE
Chandigarh university
Punjab, India
21bcs6778@cuchd.in

Manohar krishna
Apex institute of technology
CSE
Chandigarh university
Punjab, India
21bcs6299@cuchd.in

Mohit lalit
Apex institute of technology
CSE
Chandigarh university
punjab,India
mohit.e13845@cumail.in

***Abstract* — Crop recommendation is an important part of precision agriculture for crop productivity improvement. Machine learning techniques have been used many times in this domain to analyze agricultural data and provide recommendations based on various factors such as soil parameters, climate, and other environmental conditions. In this research paper, we recommend a crop recommendation system based on Machine Learning methods that evaluates climatic variables like temperature, humidity, and rainfall as well as soil characteristics like nitrogen, potassium, and pH levels. We have used a dataset consisting of soil parameters and climate data along with corresponding crop yield information we're going to train and test our models. We have explored and compared the performance of several ML algorithms in providing crop recommendations. Our suggested crop suggestion system, which is based on machine learning, may help farmers and agricultural specialists choose and manage crops intelligently, ultimately improving crop yields and productivity.**

Keywords* — *Crop Prediction, recommendation, supervised learning, multilabel classification, machine learning.

I. INTRODUCTION

Crop recommendation is a crucial aspect of precision agriculture that involves the identification of the best crop to grow can depend on various factors like the climate and soil properties. The goal of this process is to maximize crop yield and quality while minimizing environmental impact and resource utilization. Traditionally, crop recommendation was based on expert knowledge and experience, which often lacked consistency and relied heavily on intuition. With the advent of machine learning (ML) techniques, the process of crop recommendation has become more efficient and accurate. ML algorithms can analyze large datasets of agricultural information, including soil properties, weather data, and historical crop yields, to identify the optimal crop to grow in a given region. The results of several studies have been promising and suggest that the development of crop recommendations is progressing well.

The main aim of the study is to make a crop recommendation system using ML algorithms, specifically Decision Tree, Random Forest, Naive Bayes, and Support Vector Machines (SVM). We have used a dataset consisting of soil parameters, climate data, and crop yield information to train and test our models. The system considers factors such as temperature and humidity, in addition to a number of other soil variables, when making a recommendation for crop growth. The essay is organized in the following order. The section which follows will look at previous work on crop recommendation systems and machine learning research. We shall detail the methodology utilized in developing the Crop recommendation system as well as the research that led to it. Afterwards, we will put together a summary of the research we performed and give insight into what the different combinations of technology would look like. Finally, we will discuss the implications of our findings and conclude with potential future work. Crop recommendation systems based on ML techniques have the potential to revolutionize the way crops are grown and managed. These systems can provide farmers with accurate and personalized recommendations based on the specific conditions of their land, leading to improved crop yields, reduced resource utilization, and increased profitability. Such systems have been developed in a number of research employing a variety of ML techniques, such as Decision Trees, Random Forests, SVM.

In recent years, researchers have also explored the use of Neural networks and convolutional neural networks are examples of deep learning techniques in crop recommendation systems. These techniques have shown promising results, particularly in image-based crop recognition systems, but they require large amounts of training data and computational resources.

MOTIVATION

Many farmers make mistakes in selection their crop which leads to many further problems like they experience many problems in further due to the wrong crop selection.
Crop selection must be done in a proper manner by knowing the water levels of the ground and taking care that is that sufficient for the crop they have selected and checking the pH range of soil, climatic conditions are they suitable to the crop that is being selected, humidity, moisture etc...
Many factors affect the growth of crop so one has to be very careful while selecting the crop, so our motivation is to help farmers with the right choice to select their crop.

ORGANISATION OF PAPER

The Paper is composed as follows, the related work of this paper which includes the Literature survey and need for crop prediction is described in section 2 and the proposed method is depicted in section 3. Section 4 shows the experimental results and analysis. In section 4 we apply some algorithms for analysis. Finally in section 5 there are some conclusions and also the future scope for further modifications of the Machine Learning model.

II. RELATED WORK

A. Literature Survey:

This paper[1]discusses the development of a crop recommender system for Indian farmers. The system employs neural networks to determine the optimum type of crop based on many soil factors, including temperature, humidity, and soil moisture content. The system is trained using a dataset containing pre-taken values, and once trained, it can predict the type of crop on its own. The study concludes that such recommender systems can be beneficial for farmers in India to increase crop yield and make more informed decisions about crop cultivation. This technique can assist farmers in selecting the ideal crop to produce in a particular soil by taking these factors into account, which can directly affect crop output and minimize financial losses. per [2] proposes the development of an Android-based mobile application for Indian farmers that provides recommendations for appropriate fertilizers and crops. Currently, recommendations for farmers are based on communication between farmers and experts, which can lead to varying recommendations. However, the application can provide farmers with more consistent and informed recommendations using past agricultural activities data. The application can also suggest frequently purchased fertilizers in pairs to the user and provide an option to purchase the recommended fertilizers from the site. By using the application, farmers can increase their crop yield and make more informed decisions about fertilizers and crops. This paper[3] discusses the application of data mining in agriculture, specifically in addressing the common problem faced by Indian farmers of choosing the wrong the crop is decided by their soil needs., leading to decreased productivity. The solution proposed is precision agriculture, a modern farming method that suggests the best crop based on site-specific features using research data on crop productivity and soil characteristics.
The research of ensemble model used is based on the Random tree, CHA ID, K-Nearest Cluster, and Naive Bayes technique. in order to further increase the accuracy of crop recommendations. The proper crop can be suggested using this recommendation system with great There are two things for the particular site: accuracy and efficiency. factors, enabling farmers to make better selections and increase output. In spite of the fact that half of the population depends on agriculture for a living, crop planning is not practiced in India's agricultural sector, which only contributes 14% to the GDP of the nation. The suggested approach uses a sliding window non-linear regression technique to analyze historical data and forecast crop output and pricing based on several variables like rainfall, temperature, market prices, land area, and previous crop yield. The system intends to advise farmers on the finest crops to grow in order for them to cope with the current social crisis they are now facing, notably in the state of Tamil Nadu. This essay [5] focuses on how India's economy and jobs are significantly influenced by agriculture.

However, selecting the ideal crop for a given soil can be difficult for farmers, which reduces output. Precision agriculture addresses this problem by using a soil database, crop recommendations, and soil testing lab data to recommend the best crop based on site-specific parameters. In this paper, an ensemble model using SVM and ANN as learners is proposed to recommend a crop with high accuracy and efficiency. The system takes data from the soil testing lab and uses majority voting technique to make a recommendation. This paper[6] focuses on agriculture is crucial to India's economy and livelihood. However, most farmers rely on intuition to choose which crop to grow, ignoring weather and soil conditions. Big data is critical to machine learning. Consultant is an intelligent system that assists farmers in deciding which crop to grow based on sowing season, location, soil, and environmental factors.
This paper [7] tells us about that agriculture has always been a crucial aspect of India's economy, providing employment to a significant portion of the population. However, many farmers struggle with choosing Right crop for growing., leading to reduced productivity. To address this problem, a crop recommendation system using an ensemble technique of machine learning has been developed. The system uses independent base learners such as Random Forest, Naive bayes and linear simulation can be utilized to classify the soil data. based on physical and chemical characteristics, as well as climatic conditions like rainfall and temperature.
Crop farming is a step towards improving the productivity of the agricultural sector in the country. This paper [8] highlights the economic losses caused by pests in crops and the need for effective solutions without damaging the environment. The study highlights how governments have established regulations and norms to limit the use of products and techniques for pest control, but that it is challenging to maintain current pest-related information systems because these norms are frequently updated.

Reference NO	Soil	Humidity	Temperature	Rainfall	PH
[1]	✓	✓	✓	✓	✗
[2]	✗	✓	✗	✓	✓
[3]	✓	✗	✓	✓	✓
[4]	✗	✓	✓	✓	✗
[5]	✓	✗	✓	✗	✓
[6]	✓	✓	✓	✗	✓
[7]	✓	✗	✓	✓	✗
[8]	✓	✓	✓	✗	✓
[9]	✓	✗	✓	✓	✓
[10]	✓	✓	✓	✓	✗
[11]	✓	✓	✓	✗	✓
[12]	✓	✓	✓	✓	✗
[13]	✓	✓	✓	✓	✓
[14]	✓	✓	✓	✗	✓
[15]	✓	✗	✓	✓	✗
[16]	✓	✓	✓	✓	✗
[17]	✓	✗	✓	✗	✓
[18]	✓	✓	✓	✓	✗
[19]	✓	✗	✓	✓	✗
[20]	✓	✓	✓	✓	✗
[21]	✓	✓	✓	✓	✗
[22]	✓	✓	✓	✗	✓
[23]	✓	✗	✓	✓	✗
[24]	✓	✓	✗	✓	✓
[25]	✓	✗	✓	✓	✗

Table 1: Analysis of Potential parameters w.r.t crop.

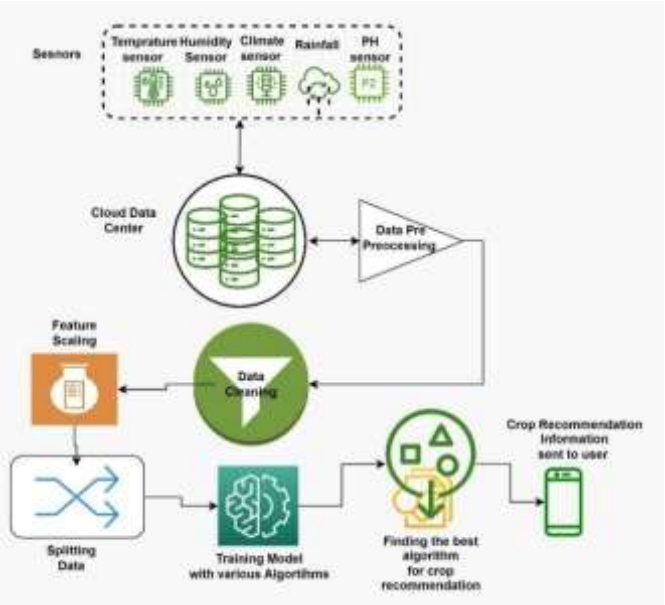

Fig 1: Working diagram of proposed model

In working diagram of proposed model, we have taken parameters like temperature sensor, humidity sensor, climate sensor, rainfall sensor, pH sensor and then the data is sent to cloud data center after that the data is preprocessed for further processes like data cleaning and feature scaling and then the data is split into training data and testing data to train the model using various algorithms so that the model can find the best algorithm for crop recommendation and is sent to user. Then the user can yield the crop according to the information. voting techniques used to combine the results of the various regions is majority voting., resulting in a highly accurate recommendation for the suitable crop type for the soil. The recommended crop types, according to the soil dataset, are; Kharif and frais., with an average classification accuracy of. making informed decisions 99.91%.

To address this challenge, the paper proposes a recommendation system that uses an to make a model of the interactions between crops and pests. This system aims to facilitate the identification of pests and the selection of suitable treatments by reducing the manual labor required to update and maintain pest-related information systems The

paper [9] discusses the major role of agriculture in the Indian economy and the common problem faced by Farmers look at soil necessity to choose the right crop which results in productivity setbacks. In order to recommend suitable crops based on soil factors with high precise accuracy and efficiency the research suggests an ensemble model with majority voting approaches using random tree, CHA ID, K Nearest neighbor, and Naive Bayes. The proposed precision agricultural technology is anticipated to decrease the growing of unsuitable crops, boost productivity, and enhance farming decision-making.

The paper [10] examines the necessity of automating agricultural processes in Sri Lanka due to a lack of available land and the significance of selecting the most suitable crops depending on local conditions. It suggests a recommendation system that employs integrated models, including environmental factor collection using Arduino microcontrollers, Machine learning techniques, natural language processing and supervised machine learning are used to recommend a crop for a chosen land with site specific parameters. The system aims to address the problem of identifying what crop to grow, given uncertain environmental factors, and help farmers make informed decisions about crop selection. This research paper[11] proposes the fuzzy logic-based crop recommendation system is helpful for rural farmers in selecting the most suitable crop for sustained production. The paper [12] discusses the integration of technology and machine learning with crop-yielding prediction methodology to optimize the production level in the agricultural industry. The study suggests using an ensemble algorithm that combines three types of models to make an effective prediction that can help maintain the expected amount of crop production. The paper highlights the importance of information technology in the agricultural industry and its potential to improve farming practices. The study [13] emphasizes the significance of India's agricultural industry and the necessity of raising crop yields in order to reduce farmer suicides. The suggested approach may be able to assist farmers in making wise decisions and increase agricultural productivity. In order to increase crop production in India, this paper [14] discusses. Overall, this system aims to improve the quality of crop production in India by providing farmers with a user-friendly tool to monitor and optimize crop growth. This research work [15] Farmers will be help in selecting the best crop for their land based on sowing season, soil, and geographical location. Traditional and non-scientific methods of crop selection have resulted in serious issues such as farmer suicides and quitting agriculture. Precision agriculture with modern technology is being implemented in developing countries to improve site-specific crop management.

B. *Need for Crop Prediction:*

a) Precision agriculture:

Crop prediction systems can assist Farmers are making informed decisions on the type of crop to grow., climate data, and other environmental factors. This can help to optimize resource utilization, reduce waste, and maximize crop yields.

b) Climate change adaptation:

The impact is expected to come from climate change. agricultural production in many regions. Crop prediction systems can help farmers to adapt to changing environmental conditions by identifying crops that are better suited to changing weather patterns and soil conditions.

c) Risk assessment:

Crop prediction systems can help to assess the risk associated with growing certain crops in a particular region. For example, the system could identify \ Crops that are more vulnerable. to pests or diseases, or crops that are more likely to fail due to adverse weather conditions.

d) Agricultural research:

Crop prediction systems can also be used in agricultural To study the impacts of different topics. environmental factors On the yields of crops.. This can help to improve our understanding of crop biology, ecology and to develop new strategies for crop management and production.

e) Agricultural policy:

Crop prediction systems can provide valuable insights to policymakers and other stakeholders in the agricultural sector. For example, the system could be used to identify regions where certain crops are more profitable or where there is a greater need for investment in agricultural infrastructure.

III. PROPOSED METHOD

In this study, the dataset used in our study was obtained from the internet and consisted of soil parameters, weather data, and crop yield information for various crops grown in the region and performed initial data exploration to Gain a better understanding of the data would be beneficial.

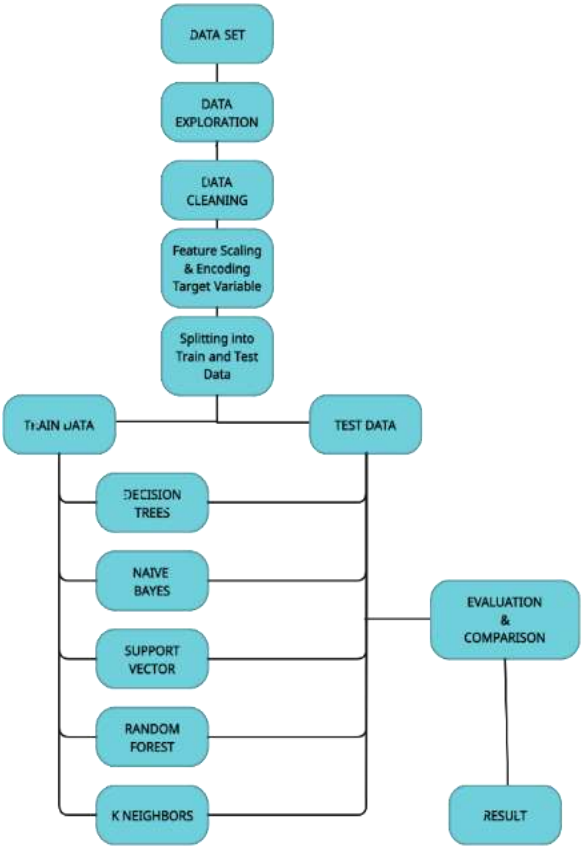

Fig 2: Working Flowchart

Following we have cleaned the data., which involved identifying and handling missing or incorrect values, handling categorical variables, and addressing outliers. We then scaled the independent features to prepare them for use in our machine-learning models and encoded the target variables if necessary.

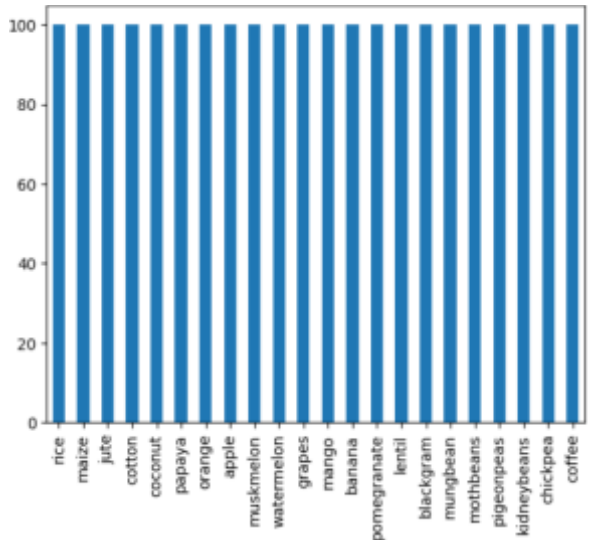

Fig 3: Target Variable

We divided the produced data into training and testing sets after finishing the preprocessing processes. Then, utilizing testing data, we trained the data using several machine learning algorithms and assessed their effectiveness. In the end, we chose the model that performed the best based on the evaluation measures, and we applied this model to forecast new data. The study's aim was to. choose the most suitable machine learning method for the given dataset and challenge.

C. The Machine Learning algorithms are:

i). Decision Tree Classifier:

The Decision Tree Classifier is a method that decides how to divide data into various categories using a tree-like model. Recursively dividing the data into subsets according to its features, it then builds a tree with each internal node standing for a feature and each leaf node for a classification label. Applications where the objective is to classify data into several categories based on a set of input features frequently utilize the decision tree classifier.

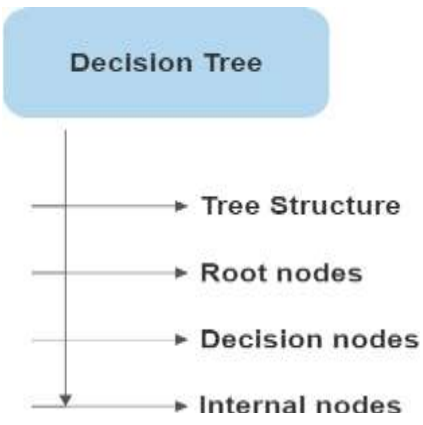

Fig 4: Decision tree features

ii). Naive Bayes Classifier:

The The chance of a data point being part of the data is estimated using a machine learning method. to a specific class using Bayes' theorem. In order to determine the likelihood of each class based on the occurrence of each feature in the data, it works by assuming that the features of the data are independent of one another.

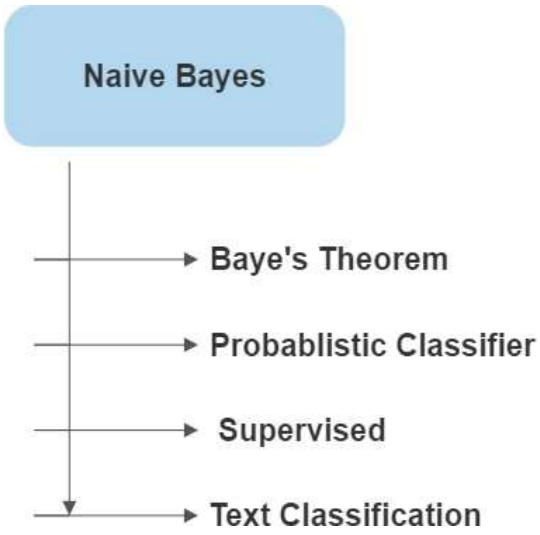

Fig 5: Features of Naïve Bayes

iii). Support Vector Classifier:

A machine learning algorithm called the Support Vector Classifier (SVC) identifies the most effective hyperplane for classifying data. It operates by maximising the distance between each class's closest points and the hyperplane. Applications where the objective is to divide data into two or more groups based on a set of input features frequently employ the SVC.

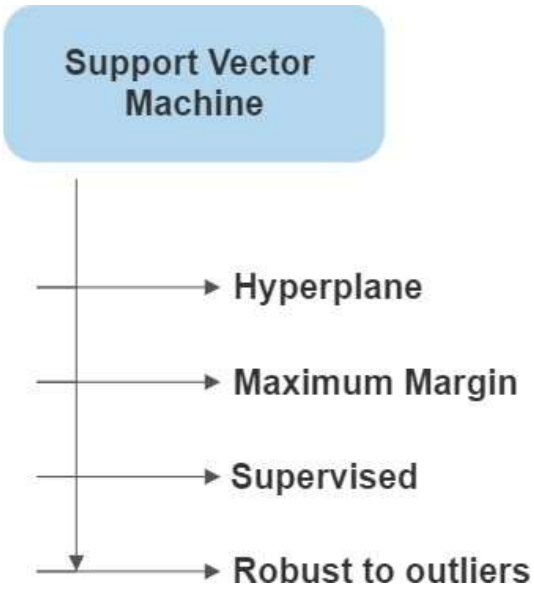

Fig 6: SVM Features

iv). Random Forest Classifier:

Several decision trees are created using the Random Forest Classifier, a machine learning technique, and their predictions are combined to get a final classification. It works by randomly selecting subsets of the data and features for each tree, and then aggregating the results of each tree to produce the final prediction. The Random Forest Classifier is often used in applications where the goal is to classify data into multiple categories based on a set of input features.

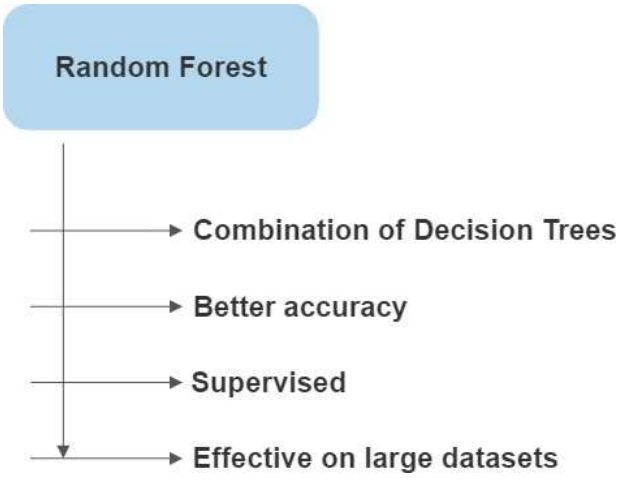

Fig 7: Features of Random Forest

v). K-Neighbors Classifier:

A machine learning technique known as the K-Neighbors Classifier makes predictions about the classification of a data point based on the classification of its k-nearest neighbors. It works by calculating the distance between each data point and its neighbors and then selecting the k closest neighbors To determine the classification data point. The K-Neighbors Classifier is used in applications where the goal is to classify data into two or more categories based on a set of input features.

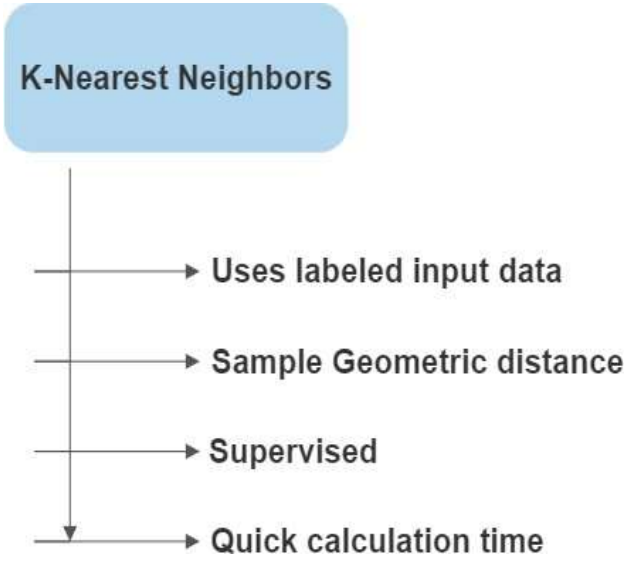

Fig 8: Features of KNN

IV. RESULT AND ANALYSIS

The world of machine learning is rife with algorithms designed to extract insights from complex datasets. To assess the performance of these algorithms, accuracy is often used as a key metric. In this study, we analyzed the accuracy of five classification algorithms on a given dataset, and the results are intriguing.

S.NO	Algorithm	Accuracy
1	Decision tree	0.988636
2	Navie Bayes	0.995455
3	SVM	0.968182
4	Random forest	0.993182
5	KNN	0.956818

Table 2: Result and analysis

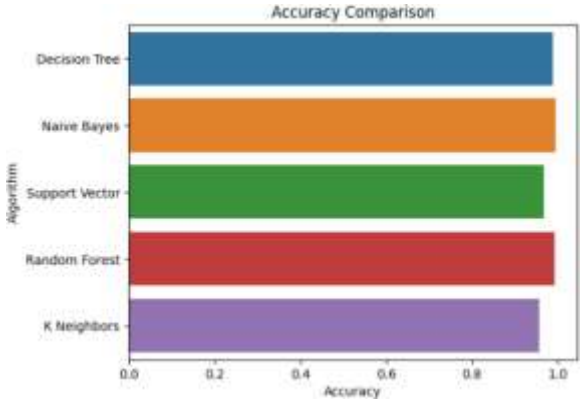

Fig 9: Graphical Representation

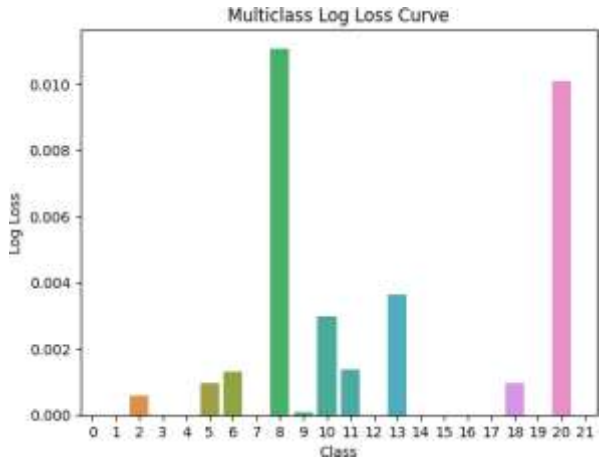

Fig 10: MLL Chart of Naive Bayes

At the top of the leaderboard is the Naive Bayes algorithm with an accuracy of 0.995455. This indicates that the model correctly classified almost 99% of the data, a remarkable feat indeed. The Naive Bayes algorithm's success lies in its ability to model complex dependencies between features while maintaining simplicity and efficiency.

A close second is the Random Forest algorithm with an accuracy of 0.993182. This ensemble method combines multiple decision trees to achieve higher accuracy than individual trees. In this case, the Random Forest algorithm managed to outperform the Decision Tree algorithm, which achieved an accuracy of 0.988636, highlighting the importance of combining multiple models for better accuracy.

The Support Vector algorithm, on the other hand, achieved an accuracy of 0.968182, which was lower than both the Naive Bayes and Random Forest algorithms. This could be due to the algorithm's sensitivity to the kernel function used to map the data into a higher-dimensional space.

The K Neighbors algorithm had the lowest accuracy of 0.956818, indicating that it was the least effective at classifying the data compared to the other algorithms.

V. CONCLUSION

We suggest a machine learning based crop recommendation system based on performance on a dataset comprising soil characteristics, meteorological data, and crop yield data. Our results showed that the Naïve Bayes algorithm outperformed the other models, achieving an accuracy score of 0.9954 on the test set. With an accuracy score of 0.9931, Random Forest also did well, while Decision Trees, SVM, and other algorithms scored reasonably well. Our suggested crop recommendation method can aid farmers and agricultural professionals in selecting and managing crops in a way that will ultimately improve crop yields and productivity.

Our results demonstrate that machine learning algorithms can analyze large datasets of agricultural information to identify the optimal crop to grow in a region.

To enhance the effectiveness of crop recommendation systems, however, there are a number of topics that could be researched in the future. To give more thorough information on environmental conditions, it may be possible to combine multiple data sources, such as remote sensing and satellite photography. Future work will explore the neural network and other deep learning techniques. improve the accuracy and robustness of crop recommendation systems.

As a result, it is advised to continue using the Naive Bayes and Random Forest algorithms with the provided dataset because they both showed the highest accuracy levels. When choosing the best algorithm for a certain task, it's crucial to keep in mind that additional aspects including the algorithm's complexity, interpretability, and computational needs should also be taken into account.

Overall, the findings of our study show the potential of machine learning algorithms in creating useful and effective crop recommendation systems that can help farmers choose and manage crops based on data.

FUTURE SCOPE

As in this paper we have discussed about the best training algorithm which predicts the crop recommendation .As in the future by using this algorithm we can find the best crop which suits the soil according to the conditions of different parameters and also they can be a Web application for crop recommendation so that it predicts the best crop according to the different conditions

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