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SITE-SPECIFIC CROP MANAGEMENT

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Abstract— Machine learning (ML) is an emerging technology in which both researchers and academic communities have been able to obtain a distinct range of numerous applications such as image recognition, healthcare, fraud detection and so on. In addition to this, ML algorithms have been identified for prediction, classification, and other purposes. On the contrary, agriculture plays an important role in a country's economy. Further the crop yield is mainly affected by diverse factors like types of soil, temperature, moisture, and rainfall. Moreover, the crops are not evenly distributed in an agricultural field restricting the possibility of complete utilization of the field. In today's world even technologies like the Internet of Things, Artificial Intelligence and ML plays a significant role to overcome the issues in agricultural factors. Thereby ML is reliable and suitable and well developed , which are not utilized properly by farmers. The proposed research work is to predict the crop yield of a given area and map the yield distribution using ML algorithm through Random Forest (RF) mechanism. RF algorithm is one among the popular supervised learning algorithms used for classification and regression purposes. Hence crop yield prediction is carried out by analyzing data of various factors affecting agriculture like temperature, soil type, moisture etc. Subsequently the main motivation of this research is to build an interactive user-friendly interface for the farmers which provides the yield map distinguishing the yield rate in a given field along with suggestions for the better utilization of the low yielding areas.**Keywords:** ***Machine learning, behavior, Crop, IoT, algorithm***

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I. INTRODUCTION

Machine learning (ML) is an expanding technology that focuses on building models from past data to enhance performance in carrying out certain tasks. ML is becoming inevitable over a wide range of sectors like healthcare, image and speech recognition, marketing, spam detection, finance and so on. ML has comprehensive algorithms which serve for various purposes like prediction, classification and so on. Enormous amounts of data generated in our day-to-day lives can be used adequately in building ML models. One of the most important assets of ML is that it enables machines to learn and improve by itself.

The agricultural sector is a major patron to the economy of India. India is one of the largest producers of major food staples like rice and wheat and leading producers of fruits, vegetables, dry fruits, sugarcane, cotton and so on. The most important purpose of Agriculture is that it is the source of the world's food supply. Henceforth, Agriculture plays an undeniable part in the development of a country. The increase in population over the last few decades has put a great demand on increasing food production.

The yield of an agricultural crop is highly influenced by a number of factors like temperature, soil type, moisture, water level and so on. Furthermore, agricultural fields are not evenly distributed in terms of yield. Although ML is well advanced, it is not being used effectively in the agricultural field by farmers. This study focuses on bridging the gap between technology and agriculture.

This study aims to predict crop yield by analyzing data on soil type, water level, moisture, and temperature, and satellite imagery using machine learning algorithm Random Forest (RF). The RF algorithm is one of the prominent supervised learning algorithms used for both classification and regression tasks. Additionally, the proposed research work discusses the use of a yield mapping technique to determine the yield rate of areas in an agricultural field, as well as suggestions for better utilizing low-yielding areas through a user-friendly interface by farmers. Additionally, the proposed research work discusses the use of a yield mapping technique to determine the yield rate of areas in an agricultural field, as well as suggestions for better utilizing low-yielding areas through a user-friendly interface.

II. LITERATURE SURVEY

Numerous studies on the use of machine learning in agriculture have been conducted. Combining agriculture and technology can provide a variety of solutions for raising productivity to meet the rising food demand, improving food quality, and other issues.

Namgirisuresh, N.V.K.Ramesh, Syed Inthiyaz, P.Poorna Priya,Kurra Nagasowmika, Kota.V.N.Harish Kumar, Mashkoor Shaik and B. N. K.Reddy(2021)"Crop Yield Prediction using Random ForestAlgorithm" [1], This study helps to capture the yield of crops before cultivation in the field of agriculture.Here prediction of crop yield is based on climate input parameters and the reliability of prediction

should be above 75 percent.The developed website is user-friendly.

M.Kalimuthu, P.Vaishnavi, M.Kishore(2020), "Crop Prediction using Machine Learning " [2], This study uses Naive Bayes Gaussian classifiers with boosting algorithm .A mobile application for android has developed which gets the parameter like temperature and location to start the prediction process.

D.Jayanarayana Reddy,Dr M. Rudra Kumar(2021), " Crop Yield Prediction using Machine Learning Algorithm" [3], This study provides a detailed analysis in terms of accuracy using Machine Learning techniquesThe work discussed about the variety of features that are dependent on data availability.The features were chosen based on geological position and crop features.

Mayank Champaneri, Darpan Chachpara, Chaitanya Chandwadkar, Mansing Rathod (2020) International Journal of Science and Research (IJSR), "Crop Yield Prediction Using Machine Learning" [4], This study demonstrated that data mining techniques can be used to predict crop yields based on climatic input parameters. In all crops and districts selected in the study, the accuracy of prediction was above 75 percent, indicating higher prediction accuracy. The developed webpage is user-friendly.

Thomas Van Klompenburg, Ayalew Kassahun, Cagatay Catal (2020) Science Direct- Elsevier, "Crop Yield Prediction Using Machine Learning : A Systematic Literature Review " [5], The algorithms and features used in crop yield prediction studies have been extracted and synthesized.

A Convolutional Neural Network (CNN) is the deep learning algorithm most widely used in these studies, according to this analysis.Chan Fu Wei, Leonardo Felipe Maldaner, PedMarceloro Medeiros Netto Ottoni ,Jose, Paulo Molin (2020) MDPI-AI, " Carrot Yield Mapping :A precision Agriculture Approach Based on Machine Learning. " [6]

The aim of this study is to create a carrot yield map using a Random Forest(RF) regression algorithm on a database containing satellite spectral data.The aim of this study is to engender a carrot yield map utilizing a Arbitrary Forest(RF) regression algorithm on a database containing satellite spectral data.

Anakha Venugopal,Aparna S,Jinsu Mani,Rima Mathew,Vinu Williams (2020) International Journal of Science and Research (IJSR)."Crop yield prediction using Machine Learning Algorithms" [7] The system forecasts agricultural yield based on the collection of historical data. Here, the most accurate classifier models utilized are Random Forest and logistic regression.

Mamunur Rashid , Bifta Sama Bari ,Yusri Yusup Mohamad Anuar Kamaruddin , And Nuzhat Khan(2021), "A Comprehensive Review of Crop Yield Prediction Using Machine Learning Approaches With Special Emphasis on Palm Oil Yield Prediction" [8] This study provides a review on the use of machine learning algorithms to predict crop yield on palm oil yield prediction.

The paper analyzed crops like Soybean yield,Corn yield,Maize yield, Paddy yield,Palm oil yield prediction. Ze He , Shihua Li1 , Pengfei Zhai , Yuchuan Deng (2020), "Mapping Rice Planting Area using Muli-Temporal Quad-Pol RADARSAT-2 datasets and Random Forest Algorithm" [9] The study focused on mapping rice planting areas using RADARSAT-2 datasets using random forest algorithm and backscatter coefficients, polarimetric variables and decomposition parameters.

Potnuru Sai Nishant , Pinapa Sai Venkat , Bollu Lakshmi Avinash , B. Jabber (2020)," Crop Yield Prediction based on Indian Agriculture using Machine Learning" [10], The research study used stacked regression to improve the models previously used for crop yield prediction by taking into account the state, district and types of crops suitable for the region and built a web application which was intended to be user-friendly.

III. MATERIALS AND METHODS

A. Data Collection

Data related to crop production in Indian agricultural lands were collected during the data collection phase for predicting crop yields [10]. Furthermore, a crop recommendation dataset was also collected to suggest crops suitable for the agricultural land based on its temperature, humidity, and soil composition [11].The dataset utilized for agricultural yield prediction had 246,092 observations with attributes such as season, crop, area, yield, and so on. The crop recommendation dataset included 2,201 observations with attributes such as temperature, humidity, rainfall, and nitrogen, potassium, and phosphorus proportions in the soil.

```
In [33]: crop_data.info()

<class 'pandas.core.frame.DataFrame'>
Index: 242361 entries, 0 to 246090
Data columns (total 8 columns):
 #   Column         Non-Null Count   Dtype
---  ------         --------------   -----
 0   State_Name     242361 non-null  object
 1   District_Name  242361 non-null  object
 2   Crop_Year      242361 non-null  int64
 3   Season         242361 non-null  object
 4   Crop           242361 non-null  object
 5   Area           242361 non-null  float64
 6   Production     242361 non-null  float64
 7   Yield          242361 non-null  float64
dtypes: float64(3), int64(1), object(4)
memory usage: 16.6+ MB
```

Fig. 1 Attributes of crop production dataset

```
In [53]: crop_data.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2200 entries, 0 to 2199
Data columns (total 7 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
dtypes: float64(4), int64(3)
memory usage: 120.4 KB
```

Fig. 2 Attributes of the crop recommendation dataset

B. Data Preprocessing

This phase includes the elimination of missing values. The collected datasets were coherent with no null values which could have been replaced with the median of the column to maintain consistency.

```
In [7]: crop_data.isnull().values.any()

Out[7]: False
```

Fig. 3 Data preprocessing

C. Exploratory Data Analysis

The exploratory data analysis is carried out to explore and encapsulate the characteristics with data visualization techniques.The crop yield against different seasons was scrutinized with the help of line plots and the crop production in each year was inspected with barplots.

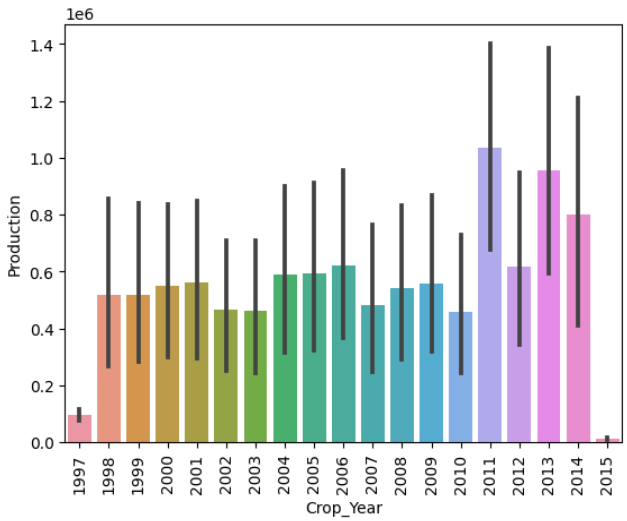

Fig. 4 Year vs crop production from crop production dataset

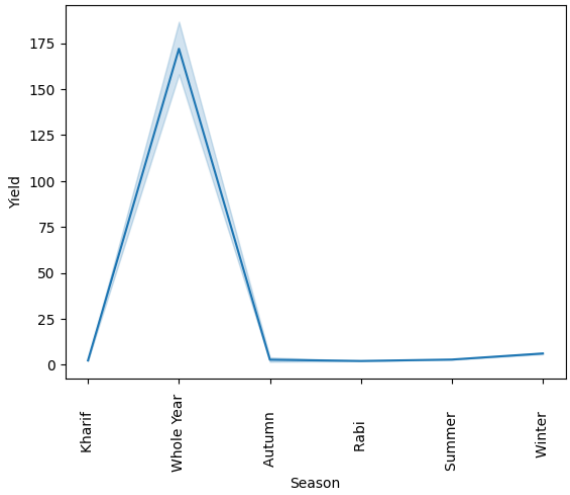

Fig. 5 Season vs Yield dataset from crop production dataset

D. Model

The datasets were divided by training (75%) and test (25%). Random Forest is a supervised learning technique that is used for regression and classification applications. The RF method was used to train the training dataset, while the test dataset was utilized to forecast crop yield and crop suggestion.

Experiments were carried out to collect soil moisture and temperature with the help of IOT.

Components used:

(i) Arduino UNO R3.

(ii) Soil moisture sensor.

(iii) Temperature sensor.

(iv) Jumper wires

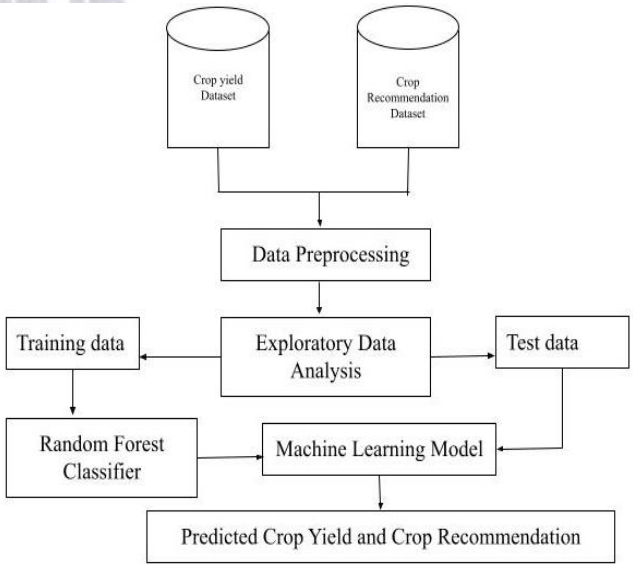

Figure 6. Site-Specific Crop Management

E. Yield Mapping

Yield mapping is a technique used to differentiate low yielding and high yielding areas. The proposed study uses 2019 Mali CropType Training data made available by Radiant MLhub [13]. The crop types included are Rice, Maize, Millet and Sorghum. The dataset was loaded, preprocessed and was semantically segmented with fully convolutional architectures.

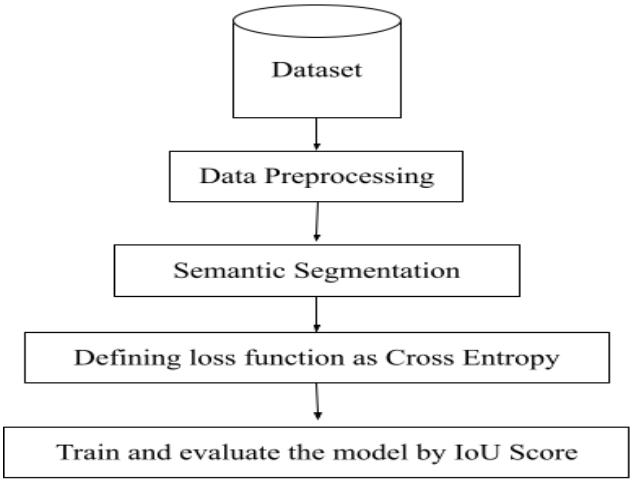

Fig . 7 Yield Mapping

The IoU(Intersection Over Union) score is used to evaluate the model which is the ratio between the overlap of predicted and ground truth annotations.

The research study aims at developing a user-friendly interface for the farmers which will help them in selection of suitable crops and knowing the expected crop yield in advance.

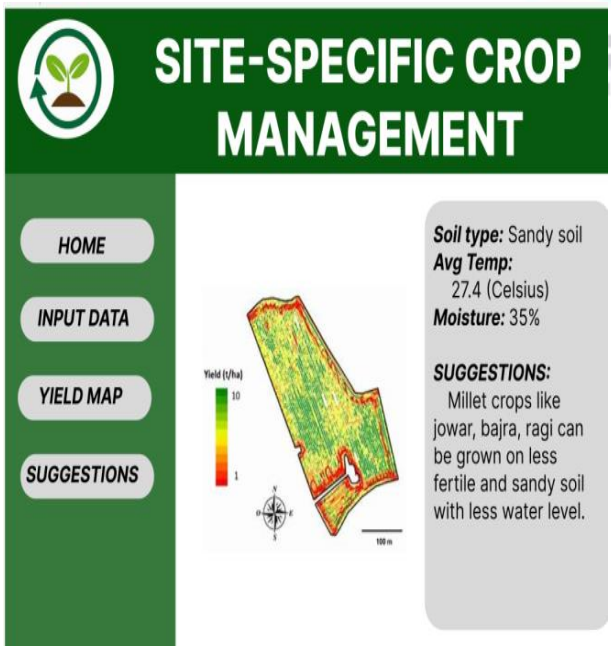

Fig. 8 Paradigm of the user-friendly interface

IV. RESULTS

The correlation matrix from the crop production dataset is as follows:

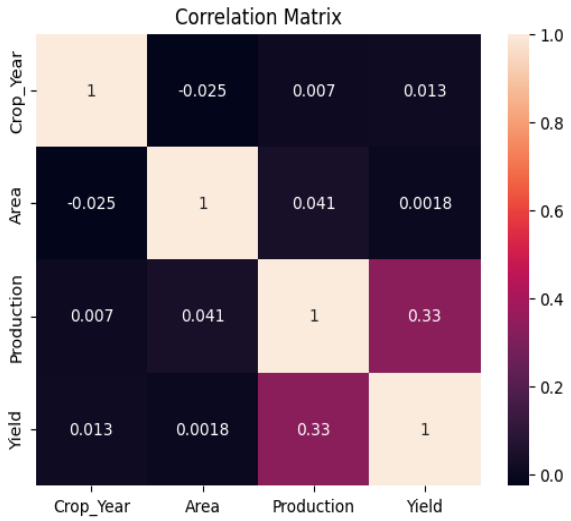

Fig . 9 Correlation matrix of crop yield prediction dataset

The Random Forest Algorithm provides an accuracy of 95.43%. The R2(R-Squared) score which refers to the coefficient of determination of the model is estimated to be 94.73%.

```
In [29]: model.score(x_test,y_test)

Out[29]: 0.9543893048576644

In [57]: # Calculating R2 score

         from sklearn.metrics import r2_score
         r1 = r2_score(y_test,rf_predict)
         print("R2 score : ",r1)

         R2 score :  0.9473978231931719

In [58]: # Calculating Adj. R2 score:

         Adjr2_1 = 1 - (1-r)*(len(y_test)-1)/(len(y_test)-x_test.shape[1]-1)
         print("Adj. R-Squared : {}".format(Adjr2_1))

         Adj. R-Squared : 0.9579747198113833
```

Fig. 10 Accuracy estimation of the model

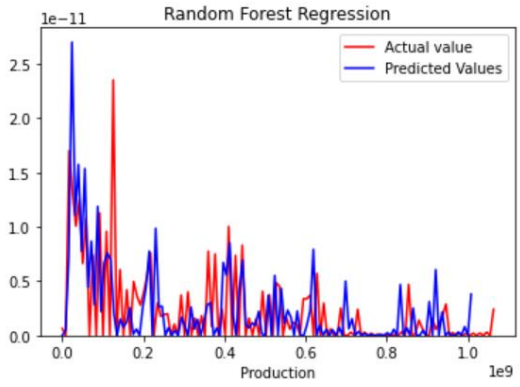

Fig.. 11 Actual value vs Predicted Values using RF Algorithm in the model

The correlation matrix of the crop recommendation dataset is as follows:

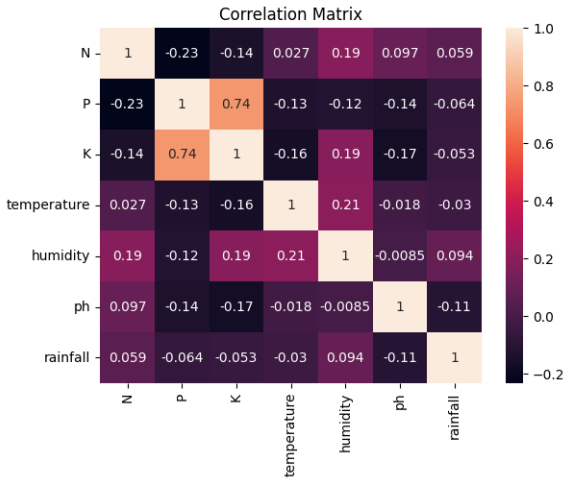

Fig. 12 Correlation matrix of crop recommendation dataset

The accuracy of the random forest classifier in recommending suitable crops is estimated to be 96.67% with a standard deviation of 0.69%.

```
In [44]: print("Accuracy : {:.2f}%".format (score.mean()*100))
         print("Standard Deviation : {:.2f}%".format(score.std()*100))

         Accuracy : 96.67%
         Standard Deviation : 0.69%
```

Fig. 13 Accuracy and standard deviation estimation

V. CONCLUSION AND FUTURE SCOPE

This project focuses on the prediction of crop and calculation of its yield with the help of Machine Learning. This approach is intended to be user-friendly with the use of GUI. This project can help farmers make the right decision in the selection of crops thereby leading to better production.

Thus, this project clearly depicts how we can prepare yield maps as it is most important and valuable sources of the spatial data for precision agriculture.When seen from an Indian agricultural point of view a lot of work is still yet to be done and this is just a preliminary step in that direction. This type of technology will be helpful in precision agriculture, as yield maps are the most important and valuable source of spatial data for precision agriculture.

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