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A REVIEW ON THE WORK OF CROP YIELD PREDICTION

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Abstract – Agriculture is the support of any economy and in India this plays a vital role in rural areas and over all development of the country. We have been talking about this since ages and yet even in today's scenario there are lot of areas where scope of improvement is there, and technology helps in filling the gap. Technology plays a vital role to upliftment of it but there are challenges which haunt till we find the best solution to the problems faced. The reason for delay in technological development is due to lack of measuring benefits and even if measurable the time taken to reap those benefits is time taking in this Industry. Nevertheless, there have been few techno giants and other startups which are working for a better India and contribution from these technocrats helps in developing cultivation and applying different tools and technique to have a precision farming and targeting the root cause of the problem and finding a solution with cost effectiveness. This paper gives a gist of technological solutions provided which gives boots to the agriculture and algorithms used for crop yield prediction.

Index Terms— *Agriculture, crop yield, machine learning, ensemble techniques.*

I. INTRODUCTION

India is primarily supported by the agricultural industry, which produces a wide variety of fruits, vegetables, and other crops. It is the second-largest food supplier in the world as well as the second-largest producer of fish, groundnuts, vegetables, rice, and other grains. The latest release of the 2021 Global Hunger Index (GHI) reflects the dire state of hunger in India. In addition, the Food and Agriculture Organization (FAO) has a significant impact on India's development in the areas of agriculture, fisheries, cattle, and natural resource management. Increased farm incomes and sustainable agricultural output are FAO's top priorities.

In addition to increasing output and lowering costs, agriculture benefits from the adoption of new technologies because it increases plant longevity. The amount of land required for agriculture is decreasing, and if we don't focus on increasing productivity per acre, it will be challenging for the next generation because the supply won't be enough to meet demand as the population rises. The crop depends on various external factors like climatic conditions, water quality, soil quality, rainfall temperature, fertilizers, landscapes and seasons etc.

In the past, farmers relied on historical data as well as their limited experience and informal advice, which was frequently ineffective and could result in improper output even when the data was successfully converted into action due to other factors like abrupt changes in weather conditions, such as ad hoc rains, and market pricing policies. To improve agricultural yield and quality, several academics are now utilizing data mining, machine learning, and deep learning techniques. Machine learning algorithms are used to forecast crop yields because they produce the best results. Machine learning uses a wide variety of algorithms to forecast agricultural productivity.

II. FACTORS THAT AFFECT CROP PRODUCTION

1. Water: Water has a direct impact on the growth and general development of a crop because it is the primary source of nutrition for plants. This implies that the yield and quality of the crop will be affected by any shortfall or surplus. [11]

2. Wind: The direction and speed of the wind will affect the development of the crop. The amount of carbon dioxide available relies on the wind speed, and a greater amount of it leads to a greater photosynthesis process. [1]

3. Sunlight: Energy from the sun's rays enables plants to transform carbon dioxide and water into carbohydrates and air. These aid in the development and reproduction processes of plants. [10]

4. Temperature: The development of plants and crop yield will be affected by frequent temperature changes. Less productivity will result from more extreme temperatures because they impede pollination, cause crop dehydration, and slow down photosynthesis. [4]. Cardinal temperatures are the lowest, ideal, and maximum temperatures at which all crops' growth processes are impacted. [2]

5. Rainfall: A major factor in crop development has always been rainfall, and most of the time there is an inverse link between rainfall and grain yield. The best time to produce straw is from April to June when compared to other months. The main influence on grain production is precipitation. [9]
6. Photosynthesis: The primary mechanism influencing crop production is photosynthesis. It is a fundamental requirement for crop development, yield, biomass, or grain production. [3]
7. Season: It is crucial in determining the crops to be grown and the harvesting season, but it is even more significant for the staple food, which has only one harvest per year and a set window for selling. The influence of the seasons on agriculture and related activities allows for more accurate planning and trend-spotting. [5]
8. Crop type: The decision of what crop, when, and where to grow it all depends on the information that has been collected over the years by various organizations for the benefit of farmers and for the protection of their crops by insurance companies. Additionally, it aids in predicting the availability of sustenance in the months ahead. [6]
9. Fertilizers: Fertilizers are crucial to output because they replace nutrients that have been lost due to the repeated growth of crops in the same location. Additionally, plants rapidly take these in. [7]
10. Area: It is the space needed for a specific crop and the yield that can be obtained over time. It also aids in determining the expense of such production. [8]
11. Soil: The crop that can be cultivated with the best yield depends on the chemical composition and fertility of the soil. Regular cultivation reduces fertility, but leaving land fallow, rotating crops, or using fertilizers and manures to restore nutrients in the soil for the following crop can all help to reduce such infertility. [12]
12. Climate: When predicted, climatic circumstances can greatly aid in growing the best crop and obtaining the highest yield. [13]
13. Topography: Topographic information aids in understanding the extent of soil erosion, cultivation techniques, available means of transportation, and the availability of labor in that region for agriculture. [14]

III. LITERATURE SURVEY

Machine learning methods are broadly used nowadays to increase crop quality and output. Such algorithms are numerous, and there are many variables that affect crop output.

S.P. Raja et.al., proposed Crop Prediction by considering various characteristics of the environment using different machine learning algorithms. They used Felin real-time dataset and included rainfall, humidity and temperature as parameters to that dataset for potato crops. To balance the dataset during data pre-processing, various sampling approaches like SMOTE, MWMOTE, and ROSE were applied. For feature selection, MRFE, RFE, And Boruta algorithms are used with various classifiers. They employed Naive Bayes, Decision Trees, SVM, KNN, Bagging, and Random Forest as classification approaches. Random Forest has provided the best accuracy out of all of these, at 87.43%. As evaluation metrics, they employed F1 score, Accuracy, AUC, MAE, Log loss, Kappa, Precision, Recall, Specificity, AUC, and MAE. Modern forecasting methods can result in quantifiable financial advantages. [15]

Gunnar Lischeid et al., proposed crop yield model using the methods of Random Forest and Support Vector Machine for winter wheat, winter rapeseed, winter barley, and silage corn. The dataset includes soil and meteorological information and was gathered from a German website during a 40-year span. The performance of RF models is somewhat better than that of the SVM model, although there are no obvious differences between the four crops when employing RF models rather than SVM models. Compared to the SVM models, the findings of this investigation were less conclusive. [16]

K. Priyadarshini et.al., proposed an enhanced approach for crop yield prediction. In this study, a new technique is suggested for producing support vectors that are appropriate for SVM classification. The dataset is downloaded from the website of the Indian Government and includes soil, yearly subterranean water, yearly rainfall, and temperature as its properties. The proposed model's accuracy is 91%. By using precision, recall, and F-measure, this model is assessed. A technique for recommending fertilizers will raise the crop's quality. [17]

Monika Gupta et.al., proposed Several crop yield prediction methods by considering machine learning algorithms. By taking into account Phosphorous, Nitrogen, and Potassium as well as environmental variables like temperature, humidity, soil pH, and rainfall for different crops, researchers used Naive Bayes, Decision Tree, SVM and Logistic Regression, and compared the results to find that Naive Bayes method had 99% accuracy. To assess the model, accuracy, precision, recall, and F1-score are employed. To increase effectiveness, the datasets can be updated periodically, and the prediction process can be automated. [18]

M.Keerthana et.al., ensemble model to predict the crop yield. In this,AdaBoost Regressor with Decision Tree achieved 95% accuracy utilising a combination of regressors and other machine learning algorithms. The final

data frame included country, crop_name, year, yield value, average rainfall, pesticide in tonnes, and average temperature as characteristics for various crops, while R-Squared, MSE, and MAE were utilized as assessment metrics. This technique can be modified by using a larger ensemble of algorithms and more complicated algorithms with better prediction capabilities. [19]

Sushila Shidnal et.al., proposed a two-tiered model by for predicting the crop yield, using a Neural network and Rule-based matrix. In this work, they found a nutrient deficiency of paddy crop by using a set of images. They used two worn-out machine learning techniques to arrive at a fair prediction of 76-77%. In comparison to existing models, the proposed model provides less accuracy. [20]

Author/Year	Paper title/ Journal	Algorithm/Data Set	Crop/Features	Results	Research Gap
S. P. Raja et. al 2022	[15] IEEE Access	Feature selection- RFE, Boruta &MRFE Classification-KNN, DT, NB, SVM, RF, Bagging Felin dataset(Real time)	Potato rainfall, humidity and temperature	RF Accuracy-87.43%	The use of modern forecasting methodologies can result in quantifiable financial gains.
K. Priyadarshini et.al 2022	[17] IEEE Conference	Linear support vector machine Indian Govt. Website Data.gov.in	Various crops Soil, water, annual rainfall, temperature	Accuracy-91%	A technique for recommending fertilizers will improve the crop's quality.
M. Keerthana et. al 2021	[19] IEEE conference	Combination of Adaboost Regressor with DT,RF, Bagging with KNN classifiers, DT with Gradient Boosting, DT with RF Regressor. From various Databases	Various crops country, crop_name, Year, Yield_value, Avg_rainfall, Pesticide_tonns, Avg_temp	Accuracy-95.7%	can combine a larger number of algorithms. There are sophisticated and intricate algorithms available.
Janmejay Pant et. Al 2021	[21] Elsevier	Gradient Boosting Regressor, Random forest regressor, SVM, Decision tree regressor FAO Data Repository (1990-2016)	Maize, Potatoes, Paddy,Wheat area, item, year ,Hg/ha_yield,average_rain_fall_mm_per_year,pesticides_tonnes,avg_temp	Accuracy- 96%	Can get more accuracy if some relevant features are added
P. Sai Nishant et. al 2020	[28] IEEE conference	Kernel Ridge, Lasso, Enet algorithms are stacked Indian govt. Repository	Various crops state, district, season , year,area and production	RMSE: Enet-4% Lasso-2% Kernel Ridge-1% Stacking<1%	Can check for other metrics and can use other ensemble techniques

M. Kalimuthu et. al 2020	[27] IEEE conference	Naive Bayes Govt. Websites (10 years data)	Different crops Temp, humidity, moisture content, seed data	Accuracy- 97%	Can include fertilizer, crop health etc for achieving better accuracy
Shivani S. Kale et. al 2019	[30] IEEE conference	Neural network regression modeling Indian government website (1997-2014)	Various crops summer, kharif, rabi, autumn and whole year	Accuracy-97.5%	Limited to only one region and to few parameters
Aruvansh nigam et.al 2019	[29] IEEE conference	Naive Bayes KNN Previous years Data	Rice, Wheat Crop, district, season, yield	Accuracy: NB-91% KNN-75%	Missing, invalid, inconsistent data from different data sources create a large obstacle for successful datamining
Suvidha Jambekar et. al 2018	[32] IEEE conference	MLR, RF regressor, Multivariate Adaptive regression Splines Indian Government website (1950-2013)	Rice, wheat, maize Rainfall, temperature, area, production, yield	MSE, RMSE, and R-squared are calculated for rice, wheat, and maize crops, Multivariate adaptive regression Splines outperformed than other two algorithms	Missing, invalid, inconsistent data from different data sources create a large obstacle for successful datamining

Table 1. Summary of Crop Yield Prediction

Janmejay Pant et.al., proposed a model using statistical techniques to predict the crop yield, utilizing different machine learning techniques, such as SVM, Random Forest, Gradient Boosting Regressor, and Decision Tree Regressor, which obtained 96% accuracy. The evaluation matrix for the previously described four models was developed using the R-Squared regression score function. For maize, potatoes, rice, and wheat, data are gathered from the FAOSTAT website by factoring in the following variables: area, item, year, Hg/ha_yield, average_rain_fall_mm_per_year, pesticides_tonnes, and average temperature. By including more useful features, accuracy can be improved. [21]

Pranay Malik et.al., Proposed Comparative evaluation of soil characteristics to forecast crop yield and fertility, Naive-Bayes, K-Nearest Neighbour, and Decision Tree Classifier were used, and the Decision Tree Classifier achieved 95% accuracy, which is high compared to other algorithms. The model is assessed using the Gini index. 1320 examples of each of the three crops—potato, tomato, and chilli—and the four parameters of pH, moisture, temperature, and sunlight—were used to gather the data for the suggested model. In this paper, datasets with fewer parameters were taken into consideration. [22]

Guna Sekhar sajja et.al. proposed a study on machine learning for crop yield prediction, using SVM, Random Forest, and ID3 algorithms, SVM achieved 96% accuracy. The dataset consists of 750 instances with attributes for cotton, groundnut, jowar, rice, and wheat including year, crop, season, region name, average temperature, soil, average rainfall, pH value, principal fertilizers, nitrogen, phosphorus, and potassium. To evaluate the model, accuracy and error rate are employed. can boost the accuracy by using ensembling techniques. [23]

Akshay Kumar Gajula et.al., predicted crop production using the K-Nearest Neighbour algorithm to detect the soil quality and to predict the suitable crop for cultivation. The dataset is taken from the FAOSTAT website by considering features such as Nitrogen(N), Phosphorous(P), potassium(K), pH, and temperature for tomato crops. Geospatial analysis can be added to the model for better data and accuracy. [24]

Dhivya Elavarasan and P. M. Durairaj Vincent proposed For Sustainable Agrarian Applications, Predicted Crop Yield which utilizes a Deep Recurrent Q-Network model, which effectively and accurately (93%) predicts crop yield. Temperature, precipitation, evapotranspiration, humidity, ground frost frequency, and wind speed are measured as qualities for the paddy crop over a 35-year period. The model is evaluated using the metrics MAE, MSE, RMSE, and R2. It is restricted to a single crop. [25]

Dr. Y. Jeevan Nagendra Kumar et.al. suggested an approach using supervised model for predicting the crop yield which uses Random Forest and achieves more accuracy compared to other models. The dataset has 3101 instances with attributes including temperature, rainfall, humidity, and pH. Future applications for data-independent systems should function accurately regardless of the format. [26]

M. Kalimuthu recommended a model for crop prediction, using a Naive Bayes Gaussian classifier and a boosting technique, diverse crops had 97% accuracy. Here, the seed information for the crops is gathered by taking into account factors like location and temperature, and the information is offered for up to 10 years in succession. only one crop and a small number of attributes are chosen. [27]

Potnuru Sai Nishant et.al., proposed a model for agriculture in India using different ML techniques, using the stacking method in ensemble learning. Lasso, Ridge and ENET regressors are used in stacking by taking Lasso as a meta-model and achieving better predictions for different districts for different crops. Data is collected from a government website with simple parameters such as state, district, season and area. A web application can be built that the farmers can use it as app. [28]

Aruvansh et.al., suggested a model for the crop yield using ML algorithms, comparing several machine learning techniques, the Random Forest algorithm achieved 67% accuracy when tested for different crops. Temperature, rainfall, area, and season are the main elements contained in the data set, which was gathered from the website of the Indian government. They employed the measures MAE, Minkowski, and sqrt to assess performance. only had a few settings, and accuracy wasn't very good. [29]

Shivani S. Kale and Preeti S. Patil proposed an approach for the crop yield prediction, achieved 97% accuracy for a multilayer perceptron neural network. The dataset, which has 2 lakh 40 000 records, was obtained from the website of the Indian government. It uses crop cycle data from the summer, kharif, rabi, autumn, and entire year. The model is assessed using MAE, MSE, and RMSE. It only applies to a few crops and one state. [30]

Ramesh Medar et. al., proposed a method for crop yield uses the Naive Bayes and KNN algorithms, with

Naive Bayes achieving 91% accuracy. The dataset is applied to the rice and wheat crop by taking into account the crop, place, and season as attributes. It is taken from past years and transformed to a supported format. can enhance performance by comparing the accuracy of several crops. can increase effectiveness by using ensemble approaches. [31]

Suvidha Jambekar et.al., proposed a method for the crop production and used datamining techniques for that by considering the features rainfall, mean temperature, area under irrigation, area, production, and yield for the crops of rice, wheat, and maize. It also employs multiple linear regression, random forest regression, and multivariate adaptive regression splines (Earth). The 64-year dataset was taken from the Indian government's website. The measures used for performance evaluation include Mean Square Error (MSE), Root Mean Squared Error (RMSE), and R2. The accuracy is undefined, and it is only applicable to one state. [32]

IV MACHINE LEARNING IN CROP YIELD

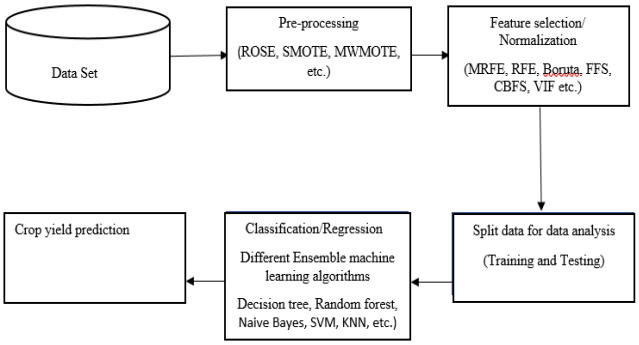

Fig 1: Proposed architecture of prediction system

Preprocessing Phase:

Datasets are collected from the different websites. In this stage all missing values are eliminated using some algorithms. Datasets are combined, and sampling techniques are employed to balance the dataset and improve prediction accuracy. ROSE, SMOTE, MWMOTE, among other sampling methods, are a few of them.

Feature selection phase:

After the data frame is complete, suitable features are chosen using various feature selection techniques. Three different feature selection algorithms exist: embedded, wrapped, and filters. Principal component analysis (PCA), linear discriminant analysis (LDA), KNN, auto-encoders, and recursive feature elimination (RFE) are a few of the feature selection algorithms.

Classification/ Regression phase:

Using a combination of machine learning techniques on the output dataset will result in higher accuracy. Individual algorithms are used to this dataset, and the accuracy is checked. The ensemble algorithms are compared to these results. Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and R2 metrics are used to assess the model.

CONCLUSION

In this, the agricultural yield is predicted using ensemble learning techniques and these algorithms will work efficiently by considering different datasets from various websites. Datasets are pre-processed using various sampling algorithms and have to choose appropriate algorithm for feature selection for the final data frame. This data frame fed to the classification module, results are compared with individual algorithms and with ensemble techniques.

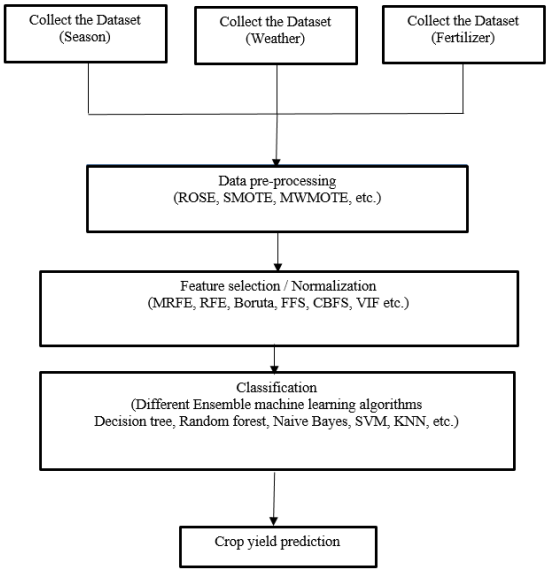

Fig 4: Flowchart of the Proposed Model

FUTURE SCOPE

Farmers will be able to anticipate crop yield using the proposed ensemble machine learning approaches. By creating an easy-to-use smartphone application for farmers, this work can be enhanced for subsequent research. can be subsequently expanded to various Indian areas for different crops.

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