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Application Of Machine Learning in Modern Agriculture for Crop Yield Prediction and Fertilizer Suggestions Along with The Amount of Usage

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Abstract - *The use of the internet has brought vast numbers of users online through different platforms. Unlike the old days, the internet is not just limited to email surfing, there's so much on the internet or let's say everything is on the internet. The Internet has solutions for almost everything, from mental health to technical issues. In this agriculture, fields cannot be untouched. The 21st Century has been the age of technology where technology has been used everywhere. So, for optimum results in each field, we use various methods which can minimize the loss and give us maximum benefits. The application of Machine learning in Crop type prediction for modern world farming is very much essential. Also, suggesting the type of fertilizer and amount can increase the usability of the application.*

Crop yield prediction and fertilizer suggesting application use machine learning algorithms to predict the crops yield based on various aspects: like the amount of rainfall and other different real-world parameters.

Key Words: Machine Learning, Agriculture, Crop Type, Fertilizer, KNN, Logistic Regression, Random Forest, XGB Classifier.

1. INTRODUCTION

A Crop Yield Prediction and Fertilizer Recommender or simply agriculture assistance application is a model or system where farmers get suggestions or assistance in various aspects. The system assists farmers by providing crop yield prediction and fertilizer suggestions. These kinds of suggestions and predictions in real-time can help farmers to plan their crops which can overall impact their livelihood including annual expenses, and other aspects. Indian farmers are majorly dependent on waterfall each year to decide what kind of crop to sow. Each year suicide of farmers has become one of the serious issues. A major reason for such cases is found to be untimely rainfall, drought, heavy rainfall, and other similar weather conditions. Due to such reasons, farmers do not get to harvest the crops after a whole struggle. If this is the case all the farmers will be forced to leave their occupations and opt for alternatives.

Agriculture and associated sectors are vital to the Indian economy. More people are working in agriculture, either directly or indirectly. Because of the increase in population and the need for food, a significant amount of fertiliser is used in soil, which may result in contamination of soil and deterioration of soil quality, causing a variety of problems for future generations. It is critical to evaluate the amount of fertiliser needed for a specific crop in relation to soil fertility. The use of fertiliser has been measured using a variety of methods.

Following each rainfall event, there is a correlation among rainfall intensity and nutrient loss for different fertiliser treatments. While timely and moderate rainfall can help dissolve dry fertiliser and move nutrients into the soil rooting zone, excessive rain can increase runoff and leaching of nutrients like nitrate, sulphate, chloride, and boron.

1.1 EXISTING SYSTEM

The existing system suggests us the previous works done in a specific domain, where we can refer to and get ideas from. Many farming or agriculture assistance systems have been implemented or proposed focused in only a particular aspect or crop.

In a research paper, the scholars proposed a system to predict the amount of fertiliser needed for a specific crop banana, as well as regression methods for future plantations using Neural Networks. Nitrogen (N), phosphorus (P), and potassium (K) are the three most important soil nutrients for crop growth. The amount of NPK in the soil varies depending on where you live. The requirements for each crop differ as well. In this paper, a model is built to recommend the amount of fertiliser needed for the banana crop [1].

In a different paper proposed system's goal is to assist farmers in cultivating crops for higher yield. The crops chosen for this work are based on important crops from the chosen location. Rice, Jowar, Wheat, Soyabean, Sunflower, Cotton, Sugarcane, Tobacco, Onion, Dry Chili, and other crops have been chosen. Crop yield data is compiled from various sources over the last five years. Scholars proposed the system in 3 steps: a. Soil Classification b. Crop Yield Prediction and c. Fertilizer Recommendation [2].

A paper published at IEEE predicts the yield of nearly all types of crops grown in India. This script is novel because it uses simple parameters such as state, district, season, and area to predict crop yields in whatever year the user desires. The paper predicts yield using advanced regression techniques such as Kernel Ridge, Lasso, and ENet algorithms, as well as the concept of Stacking Regression to improve the algorithms [3].

Rainfall regimes, P application rates, soil P content, and field management practices such as field bund and open ditch construction can all influence phosphorus losses in rice-wheat cropping systems. Heavy rainfalls shortly after P applications, in particular, cause significant P loss, and P loss increases with increasing P application rates and soil P content. During the rice-growing season, P concentrations in field ponding water regulate P concentrations in surface runoff. The construction of open ditches can increase phosphorus loss during the winter wheat growing season. As a result, we propose that rice-wheat cropping systems be managed to avoid heavy rain events while also balancing crop P removal (20–30 kg P ha–1 in this study). Furthermore, appropriate water management practices are recommended, such as increasing the capacity of field ponding water or using controlled irrigation in conjunction with natural drying of the field rather than open ditches during the wheat growing season [4].

2. PROPOSED SYSTEM

The previously proposed methods for predicting fertiliser type are based on crop type and crop production. The amount of fertiliser is only classified using image data. We propose in this paper a method for predicting the amount and type of fertiliser based on tabular data. To predict the amount and type of fertiliser, multiple machine learning algorithms are used.

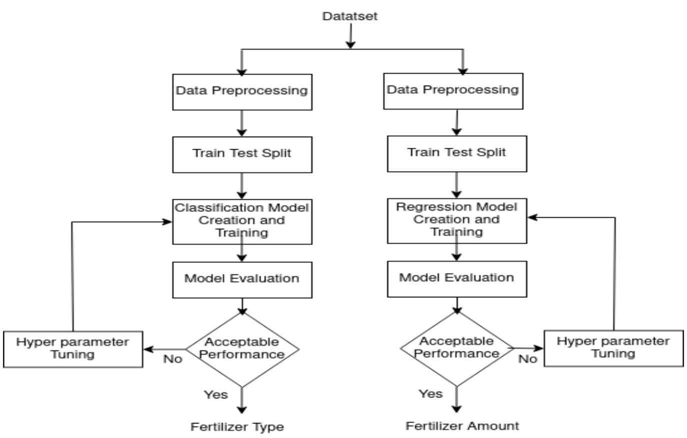


Fig- 1 : Proposed System

3. PROPOSED METHODOLOGY

3.1 System Design & Architecture

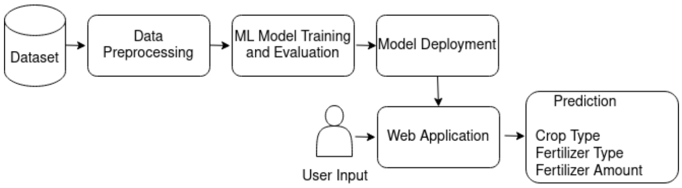


Fig – 2 : System Design

Dataset: A dataset containing information about fertilizer is gained from Kaggle.

Pre-processing: Various preprocessing methods used in the tabular dataset are done. Different techniques are employed for preparing datasets for classification and regression.

Model Creation and training: Different machine models based on operation are created. Each model is trained with the corresponding dataset.

Model Tuning: Models are compared based on metric values. The best one is further tuned and used for the final prediction.

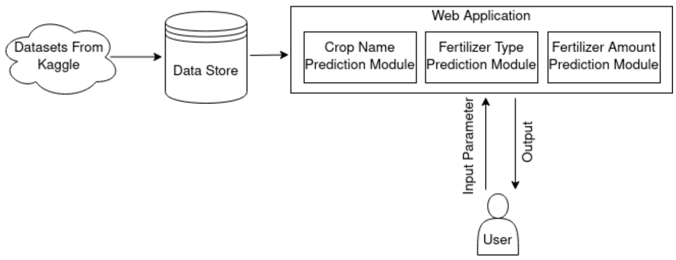


Fig - 3 : Architecture

3. IMPLEMENTATION

3.1 DATASET DETAILS

Crop Name Prediction Module

	Temparature	Humidity	Moisture	Soil Type	Crop Type
0	26	52	38	4	3
1	29	52	45	2	8
2	34	65	62	0	1
3	32	62	34	3	9
4	28	54	46	1	6

Fig – 4 : Dataset for Crop Prediction

Table for Temperature, Humidity, Moisture, and Soil Type is used as features. Crop Type is the target Label.

Fertilizer Type Prediction Module

	Temparature	Humidity	Moisture	Soil Type	Crop Type	Nitrogen	Potassium	Phosphorous	Fertilizer Name
0	26	52	38	Sandy	Maize	37	0	0	Urea
1	29	52	45	Loamy	Sugarcane	12	0	36	DAP
2	34	65	62	Black	Cotton	7	9	30	14-35-14
3	32	62	34	Red	Tobacco	22	0	20	28-28
4	28	54	46	Clayey	Paddy	35	0	0	Urea

Fig - 5 : Dataset for Fertilizer Type Prediction

All the inputs from the previous module are taken. Besides that, the crop type given as output by the previous module is taken, and the Nitrogen, Potassium, and Phosphorus value is taken.

Fertilizer Amount Prediction Module

	Temparature	Humidity	Moisture	Soil Type	Crop Type	Fertilizer Name	Total Fertilizer
0	26	52	38	Sandy	Maize	Urea	37
1	29	52	45	Loamy	Sugarcane	DAP	48
2	34	65	62	Black	Cotton	14-35-14	46
3	32	62	34	Red	Tobacco	28-28	42
4	28	54	46	Clayey	Paddy	Urea	35

Fig - 6 : Fertilizer Amount Prediction Module

A complex feature (Total Fertilizer) is gained from the Nitrogen, Potassium, and Phosphorus value. Since this feature can be gained from the NPK value, these features might be biased, so they are removed. The Crop Type and Fertilizer Name are gained from previous modules.

3.2 ALGORITHM USED

The macro average gives each prediction a similar weight while calculating loss but there might be cases when your data might be imbalanced and you want to give importance to some predictions more (based on their proportion), there you use a 'weighted' average. So, the weighted average value for metrics is used.

Algorithm	Accuracy	Precision	Recall	F1 Score
Logistic Regression	30%	20%	30%	23%
Random Forest	70%	80%	70%	73%
XGB Classifier	70%	75%	70%	71%
Neighbors Classifier	70%	80%	70%	73%

Fig – 7 : Comparison in Initial Result of different implementation

Besides Random Forest, all other algorithms are performing good and they have similar metric values In order to increase model performance hyperparameter tuning and Isolation forest is done but there is no improvement in model performance. So, a concept of stacking multiple models is used and there is some improvement in the model performance.

Stacked Algorithm	Accuracy	Precision	Recall	F1 Score
KNeighbors and XGB	70%	75%	70%	70%
KNeighbors and Random Forest	70%	80%	70%	73%
XGB and Random Forest	80%	90%	80%	83%

Fig – 8 : Comparison of the result of the implementation

From the above table, it can be clearly seen that the stacked XGB and Random Forest perform the best.

The table below provides the information about the second part where the fertilize type prediction is done.

From the Table, it can be clearly seen that all models perform similarly in the four basic metrics used. So, cross-validation is used to check the model performance in a different split of data. Among all the classifiers, XGB Classifier performs the best.

Model	Accuracy	Precision	Recall	F1-Score	Cross-Validation
KNeighbors Classifier	95%	100%	95%	97%	80%
XGB Classifier	**95%**	**100%**	**95%**	**97%**	**90%**
Stack Model: XGB Classifier and Random Forest Classifier	90%	96%	90%	91%	90%

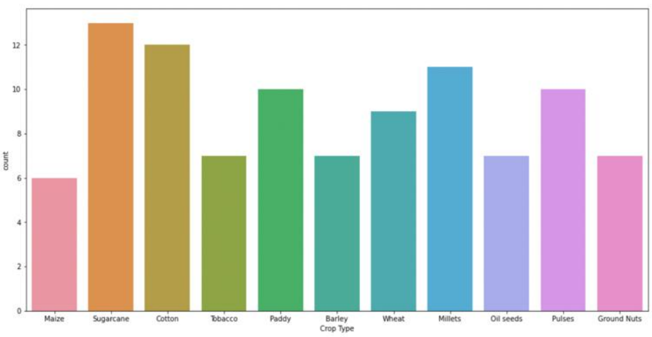
Fig – 9 : Comparison of different parameters in the different algorithms.

Finally, in the third module fertilizer amount is calculated using regression models. The table provides information about model performance.

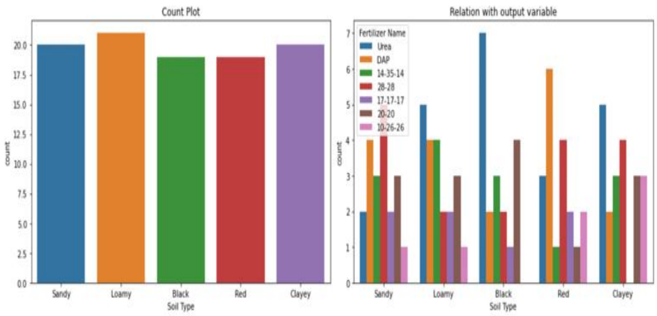
Model	Mean Absolute Error	R2 Score
Linear Regression	5.2445	0.3290
Ridge Regression	5.4904	0.2817
Lasso Regression	6.3279	0.1041
XGB Regressor	**3.6586**	**0.7592**

Fig - 10 : Comparison of Model Performance.

4. OUTCOMES



Graph – 1: Plot for Fertilizer amount



Graph – 2: Soil type with Fertilizer comparison

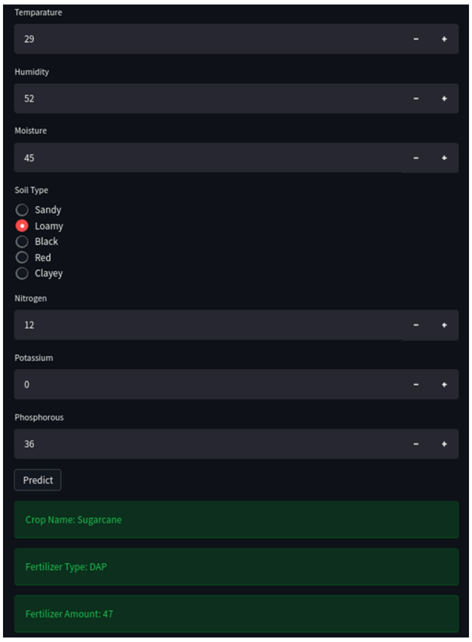


Fig – 11: Screenshot1 of the result in web-app

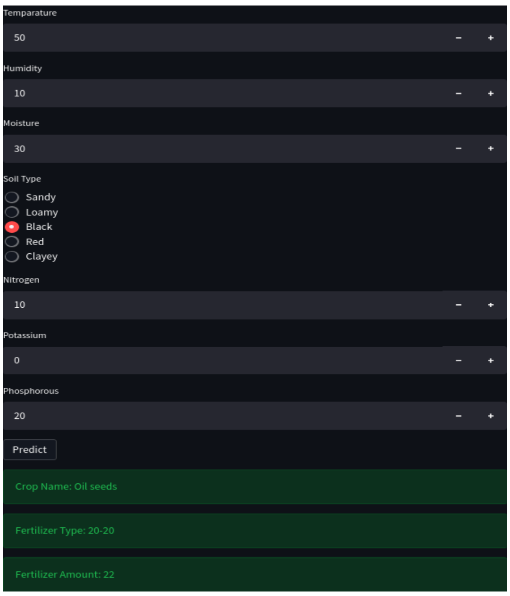


Fig - 12 : Screenshot2 of the result in web-app

5. CONCLUSION

When we use stacked regression, the results are far superior to when those models were used individually. This system is expected to solve modern life agriculture related problems. To make it best usable for Indian farmers we have kept the parameters according to Indian weather conditions. Also, system developed is more user-friendly since it has web app as well. Use of mobile phone is very much, so in future implementing the solution as mobile app would be better for common use.

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