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Data Analytics on Agrometeorological Parameters for Building A Utility System for Farmer Community

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Abstract ***The day-to-day evolution of the world is throwing many challenges, thereby demanding the humans to be on par with the modern tools and technologies that are on offer. These technologies are contributing to the overall growth across all the domains. One such domain that is highly affected by the modern tools and techniques is Agriculture. Gone are the days, when only a handful methodologies and tools were utilized to understand about agriculture. Although the farmers are sceptical to the modernization, the end result has been encouraging at many a times. With the use of analytics, one can get to know more about the type of soil, crops and fertilizers, amount of water to be utilized depending on the climatic conditions and thereby have an effective yield. In this work, the elementary task of portraying the effect of climatic conditions on the production of different varieties of crops is carried out. Also, the application of Multivariate Linear Regression and Artificial Neural Network (ANN) techniques provides a significance outcome in the prediction of yield with the focus on Ragi and Rice. The work provides an accuracy of 65% with the 3-fold cross validation technique and 68% accuracy with ANN model.***

Keywords: agrometeorology, utility system, ANN, Linear Regression, humidity, cross validation.

I. INTRODUCTION

The innovation and inventions happening across the globe has drastically impacted the lifestyle and thereby challenging humans to get familiar with the modern tools, techniques and technologies. Due to this, the data being generated is escalating rapidly thus making it extremely difficult to handle by traditional database systems. This has paved the way to the fields of Artificial Intelligence (AI), Cloud Computing, Internet of Things (IoT), Data Analytics and much more.

All these fields have been contributing significantly across different domains, one such area being Agriculture. Agriculture is much more than a feeding source, especially in a country like India wherein it is a major source of food production as well as largely contributes to the Gross Domestic Product (GDP) of the country.

Till today, some the farmers across the nation follow the traditional approaches of Agriculture even though there are modern tools that aid better results as they are sceptical to use them. There has been a fall in GDP of India in the past few years with respect to agriculture due to factors such as irregular weather conditions resulting in crop damage and less awareness towards the use of modern technologies. Also, fresh water is not being properly utilized for irrigation. Due to the erratic climatic conditions, improper irrigation and inexperience of use of modern technologies and pesticides has led to the damage of crops, increase in plant diseases and thereby threatening food security. In this work, an effort is made to incorporate all the above-mentioned conditions and provide useful insights that guide the farmers for futuristic purpose. The primitive task of prediction of type and yield of crops given the climatic and soil conditions are carried out with the main focus on the yields of Ragi and Rice crops. The use of different algorithms such as Multivariate Linear Regression and Artificial Neural Network (ANN) model presents information that could help the farmers to follow certain protocols to have a better yield. Also, the attention is given to provide farmers with the training of modern tools and technologies so that they are better equipped and aware of the ongoing trend.

II. LITERATURE SURVEY

V.Sellam and E.Poovammal[1] have utilized linear regression analysis to anticipate the yield of crops. Yield desire benefits ranchers in diminishing their misfortunes and to get best expenses for their harvests. The creators have researched the natural features like Area under Cultivation (AUC), Annual Rainfall (AR) and Food Price Index (FPI) that affects the growth of gather and to develop a co-relation of these parameters. In this investigation, Regression Analysis (RA) is to contemplate the ecological variables and the effect of these factors on reap yield. RA is a multivariate investigation method which separates the components, bunches them into logical and reaction factors and gains a choice.

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An example of ecological elements like AR, AUC, FPI are considered for a time of 10 years from 1990-2000.Linear Regression (LR) is utilized to set up connection between informative factors (AR, AUC, FPI) and the harvest yield as reaction variable. R2 esteem obviously demonstrates that yield is principally subject to AR. AUC and FPI are the other two variables affecting the harvest yield. This exploration can be reached out by considering different elements like Minimum Support Price (MSP), Cost Price Index (CPI), Wholesale Price Index (WPI) and so on and their association with harvest yield. Jharna Majumdar et.al[2] has expanded the work referenced in[1] by utilizing different linear regression in their investigation model. Numerous linear regression is a variety of " linear regression " investigation. This model is utilized to set up the relationship that exists between one ward variable and in any event two independent factors. Before applying the multiple linear regression to make sense of the collect yield, it's imperative to know the huge properties from the database. Every single one of the qualities used in the database won't be noteworthy or changing the estimations of these attributes won't impact anything on the reliant factors. Such attributes can be overlooked. P value test is performed on the database to find the basic properties and multiple linear regression is associated just on the imperative characteristics to evaluate the reap yield. Before applying the multiple linear regression, the "p value test" is performed on the dataset to choose the significant qualities. A free factor which has a "p value" of under 0.05, confirms that the “Null Hypothesis" can be dismissed and infers that it will have sway on the relapse investigation. So these free qualities can be added to the model. However, in the event that the p worth is more than the basic alpha level i.e., 0.05, the variable is said to be not basic to the model. S. Veenadhari et.al., [3] utilized Decision Tree calculations to display the efficiency of the Soybean crop. Information mining applications in agribusiness is a for the most part new procedure for envisioning/anticipating of agrarian yield/creature the executives. In their investigation an endeavor has been had to consider the effect of climatic parameters on soybean gainfulness using choice tree enlistment strategy. The revelations of choice tree were confined into different principles for better appreciation by the end customers. The examination disclosures bolster the researchers, approach creators and ranchers in foreseeing/deciding the gather yield early for market components. Choice tree enlistment strategy is associated with the present examination to make imaginative approaches to manage/envision the effect of climatic parameters on the pervasive gather (soybean) profitability of Bhopal territory. A Decision tree is a flowchart like tree structure, where each interior hub demonstrates a test on a trademark, each branch addresses an aftereffect of the test, and leaf hubs address classes or class dispersions. The top most hubs in a tree is the root hub. In order to group an obscure example, the quality estimations of the model are attempted against the Decision tree. A procedure is pursued from the root to a leaf hub that holds the class expectation for that model. Choice trees were then changed over to arrangement principles using IF-THEN-ELSE. Intelligent Dichotomizer 3 (ID3), one of the Decision tree calculations embraced in this examination

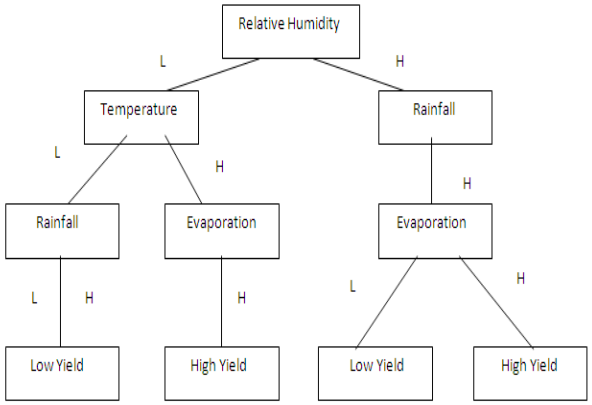

Fig 1: Decision tree for yield data [3].

M.C. Ramya et.al[4] thinks about various information mining methods to investigate mulberry crop efficiency. This work, various Decision tree classifier was utilized and was tested on the guideline of error rate, true positive rate, false positive rate and exactness. The investigation says, the J48 model is a standout amongst the most direct and the classifier gives best accuracy for test data for creating exact soil range. The highlights containing information example that can arrange them the best is said to have the most noteworthy information gain. The estimations of these parts which has no ambiguity for instance having a similar incentive as target variable, will end the branch by naming target worth acquired. They by then continue with various highlights chasing down most raised data gain. C4.5, a variant of decision tree algorithm can be suggested for accurate classification and is considered as a Statistical Classifier. Random forests is a ensemble learning calculation that can be used for gathering, that is foreseeing an obvious reaction parameters and regression on those parameters incorporates envisioning a ceaseless response variable. Random forest regression and classification models fit an ensemble of decision tree models to a lot of information. For each tree, the data are recursively part into progressively homogenous units, which are typically suggested as hubs, to improve the consistency of the reaction variable. Split focuses rely upon estimations of predictor factors. Thusly, factors used to part the data are seen as significant illustrative factors. Random forest regression fit separate choice trees to a predefined number of bootstrapped informational collections. The foreseen estimation of a categorical response is the method of the classes from all the individual fitted choice trees, and the foreseen value of a constant reaction is the mean fitted reaction from all the individual trees that came about in view of each bootstrapped test. P.Priya et.al[4] focus on Random Forest algorithms to predict crop yield.

This paper centres around anticipating the yield of the harvest based on existing information by utilizing Random Forest algorithm. Real data of Tamil Nadu was utilized for building the models. The prediction will equip farmers to foresee the yield of the harvest before cultivation. Random Forest is a most prevalent and powerful supervised machine learning algorithm prepared for performing both classification and regression undertakings that work by building up an enormous number of decision trees at the time of training and yielding the class that is the method of the classes (characterization) or mean estimate (regression) of the individual trees. The more trees in a forest the more robust the forecast. Random decision forests make up for the choice trees propensity for over fitting to their training set. Surabhi Chouhan, Bhopal Divakar Singh, Bhopal Anju Singh[8], use a different method for mining that is used for imparting and obtaining significant data so that the information can be ordered in an effective and rapid manner. These mining algorithms can be connected in different fields including arrangement of agricultural crops production. Here in this paper an overview of all the current procedures, their preferences and issues are being talked about. Thus by examining their different preferences and issues another and proficient procedure for the order of agricultural crop production is proposed in future work, for example, grouping using Fuzzy Conclusion Tree by optimizing the feature withdrawal using PSO-SVM (Particle Swarm Optimization with Support Vector Machine).

DECISION TREES-

A decision tree speaks to a structure with two sorts of segments:

1. Leaf hubs that allot class marks to perceptions;

2. Interior hubs that indicate tests on individual characteristics with one branch and subtree for every result of the test.

The tree groups perceptions in a top-down way, beginning from the root and working one's way down as indicated by the results of the tests at the interior hubs, until a leaf hub has been come to and a class name has been doled out. The tree is then built by methods for recursive apportioning until the present leaf hubs contain just examples of a solitary class or until no test offers any improvement. Be that as it may, since most genuine informational collections contains noise, and since by and large the traits have restricted prescient power, this tree developing system frequently results in a complex tree with numerous inward hubs that overfits the information SML Venkata Narasimhamurthy and AVS Pavan Kumar[9], have been very specific in their work of analyzing the crop yield, especially for rice grown in India. Rice is the key and prevailing crop of India after wheat. India is at second position on the planet after China, and is regularly referred to as a principle patron of the rice production and records for 20% of the world's yearly production. The amount of hectares in India under rice development is as high as 40 million hectares in 20 states. India is additionally the biggest exporter of rice in the world exceeding 100 million tonnes. The sustainability and productivity of rice in developing territories is subject to appropriate climatic conditions. Growing better strategies to anticipate crop profitability in various climatic conditions can help an agriculturist and other financially involved partners in better decision making in not only the agronomy but also the crop choice. For their crop, they have used the powerful and popular supervised machine learning algorithm called Random Forests.

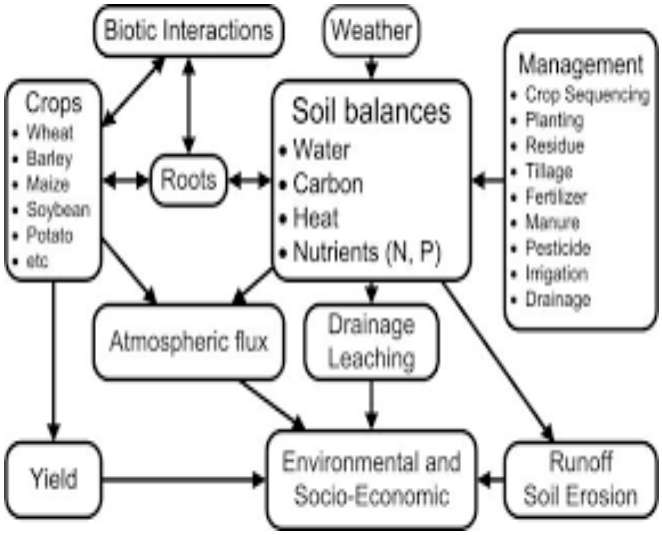

Fig 2: Attributes required for the crop yield

The above figure shows us the basic attributes needed for crop yield and these attributes play an important role in the algorithms used.

III. IMPLEMENTATION AND RESULTS

In this the different data sets were analysed to predict the crop yield. The analysis were as shown below. Figure 3 has more cook's distance lines hence model is well fit. Predicting the value of production given the area, crop, crop_year.

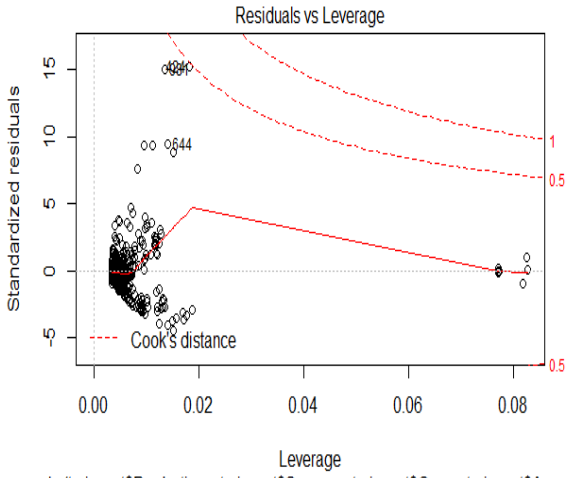

Fig 3: Cook's distance

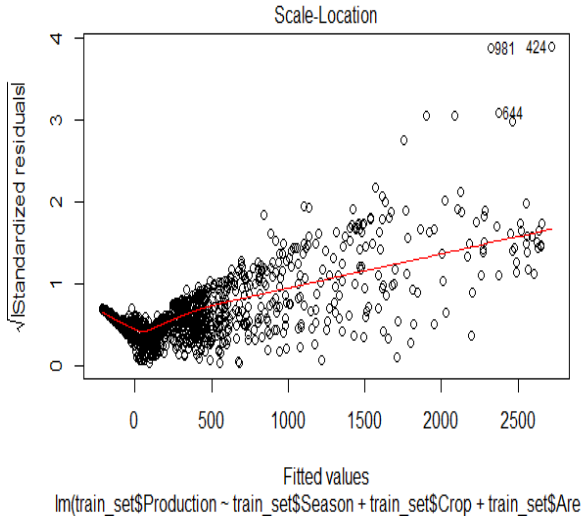

Fig 4: Best fit line and inference of correlation between the attributes and the production.

The inference that can be drawn from the graph in Figure 4 is that when the values of the attributes are smaller the correlation between the attributes and the production is more. This goes on decreasing when the values decrease. The red line denotes the best fit line.

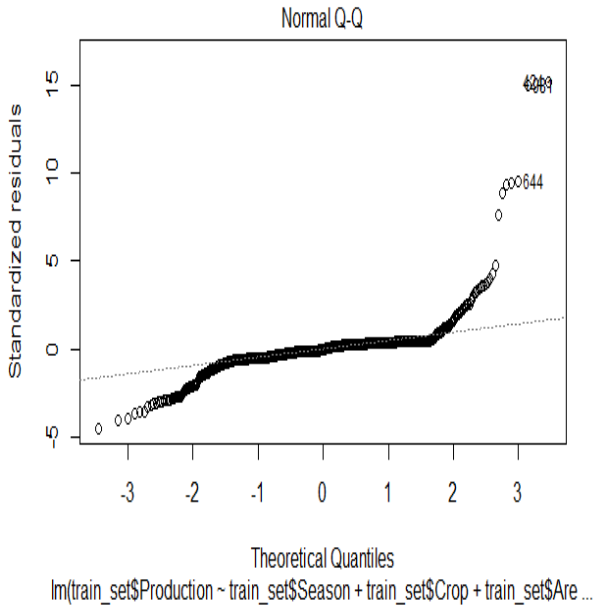

Fig 5: Q-Q plot to identify the outliers

The graph in Figure 5 shows the Q-Q plot lying very near to the best fit line of regression. Whereas we can also see the outlier values.

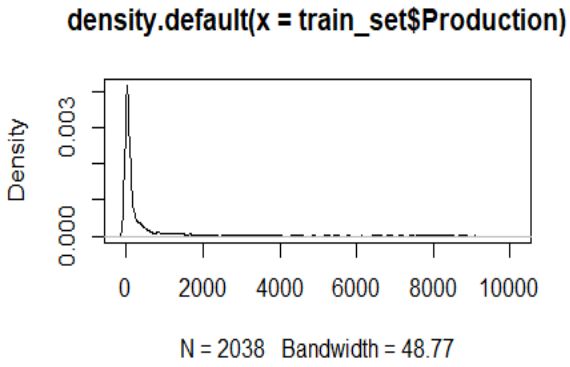

Fig 6: Density curve of the train data set for Production attribute.

The graph in Figure 6 shows the density curve of the training set attribute Production. Given N values = 2038 and bandwidth of 48.77

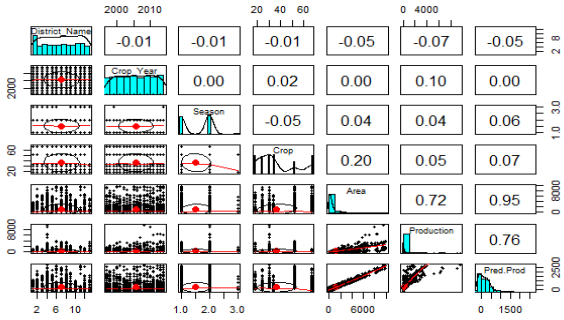

Fig 7: A plot to represent the correlation between the attributes.

The Figure 7 shows the correlation between the attributes for which the graphs are drawn to the other attributes. For example, the correlation between the district name and production is -0.05 because the production does not depend upon the district whereas the production highly depends on area as it has high correlation. This all information can be gained from the diagram.

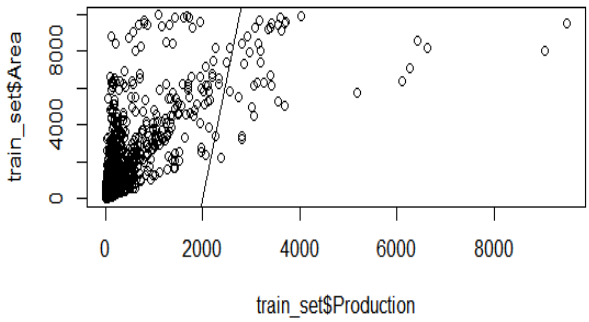

Fig 8: best fit line and correlation curve for best model

After performing the transformation to the train set. The best line shifts due to increased accuracy as shown in Figure 8.

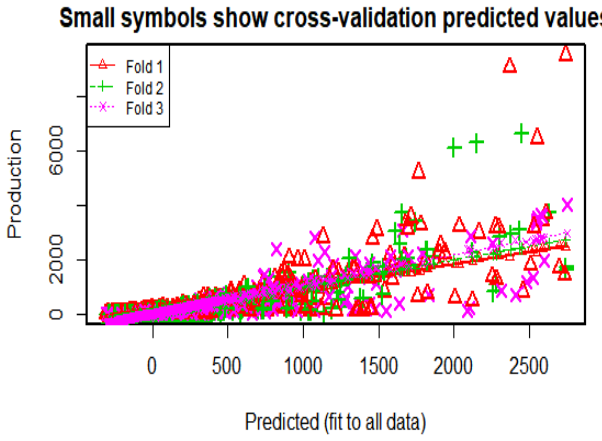

Fig 9: cross validation for training dataset

Figure 9 represents the cross validation done on the dataset by dividing the dataset into 3 folds. It shows the accuracy of about 65%. From the developed model using regression we can infer the dependence of the production on the attributes like area, crop,crop_year and predict the production for the future values which is nearly 65% correct. Based on the obtained bar chart as shown in Figure 10, we can conclude that Uttar Pradesh has the largest area of land Suitable for agriculture, followed by Madhya Pradesh, Rajasthan and Maharashtra.

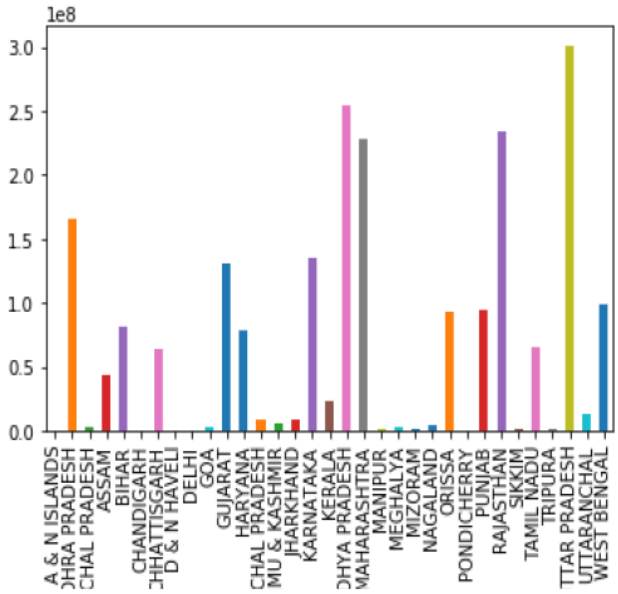

Figure 10: State wise representation of largest area of land suitable for Agriculture.

	state	area
30	UTTAR PRADESH	14.036440
17	MADHYA PRADESH	11.873377
26	RAJASTHAN	10.906314
18	MAHARASHTRA	10.628637
1	ANDHRA PRADESH	7.700220

Fig 11: Total Agricultural area of each state

Although Andhra Pradesh only contributed for 7.7% of the total cultivation area, it resulted in the maximum yield, i.e, 56.44% of the total yield from all the states over the past 20 years.

Number of crops in each season over 20 year as seen in Figure 12:

	state	yield
1	ANDHRA PRADESH	56.443686
28	TAMIL NADU	15.895008
16	KERALA	6.556727
30	UTTAR PRADESH	3.716868
9	GOA	2.975426

Fig 12: Statewide Description o Yield per year.

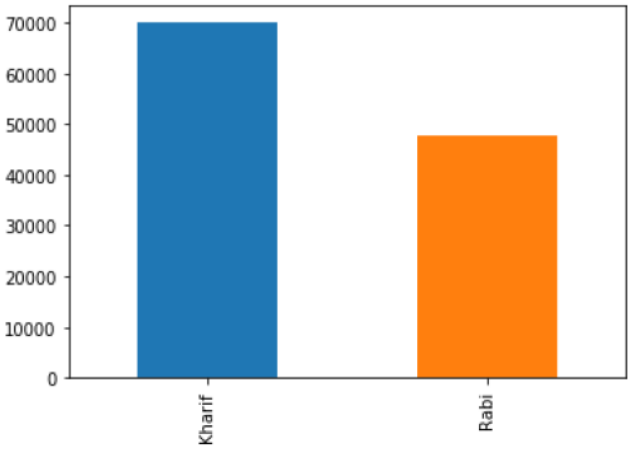

Fig 13: Season wise Production.

When we compare the production in Kharif season against that in Rabi season as in Figure 13, we find that the production in Kharif season is higher. When we compare the production in summer, winter and autumn as in Figure 14, we find that the production in summer season is higher. Kharif season in the first plot corresponds to the summer and autumn seasons.

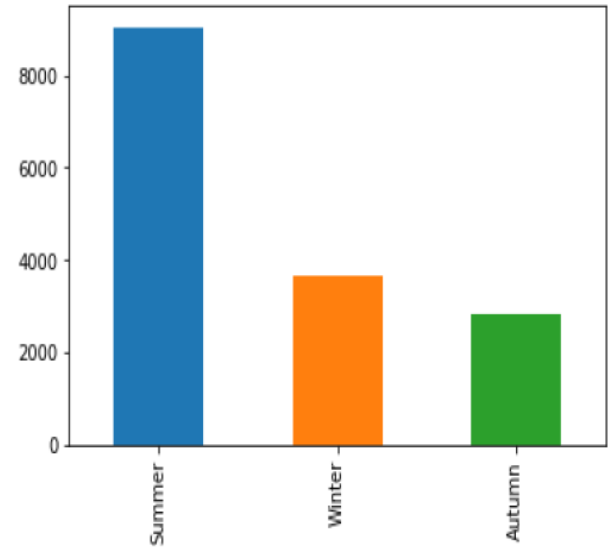

Fig 14: Season wise Production.

	crop	yield
9	Coconut	76.845106
42	Sugarcane	9.604266
33	Potato	2.120862
29	Onion	1.858775
3	Banana	1.838115

Fig 15: Different yields w.r.t to different crops.

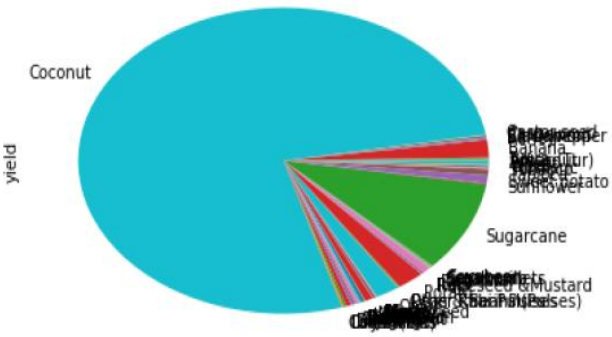

Fig 16: Different crop yields

The pie chart in Figure 16 indicate that yield of two crops: coconut and sugarcane from 1998-2008 in India that have been relatively much higher than that of the other crops.

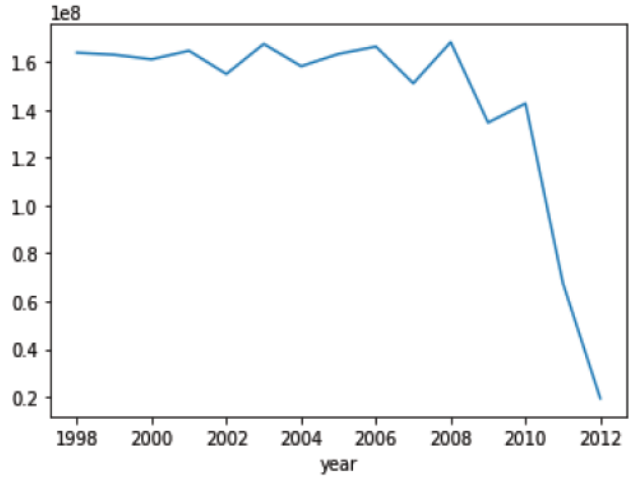

Fig 17: Prediction of crop yield for 2012

Based on the year vs area graph, we can conclude that over the time, the area of land used for agriculture has reduced. This decrease is more significant from the year 2010. This is due to more area being used forurbanization. The prediction was correct for the yield of crops in 2012. Decrease in soil richness: For a farming nation like India, soil is a valuable asset, and corruption of soil is a significant issue, which prompts exhaustion of soil fertility. Soil erosion is the principle type of corruption which happens as a result of deforestation and informal agrarian practices like shifting cultivation. Expanding saltiness, alkalinity and aridity in light of bungle and rehashed use are different purposes behind loss of soil fertility.

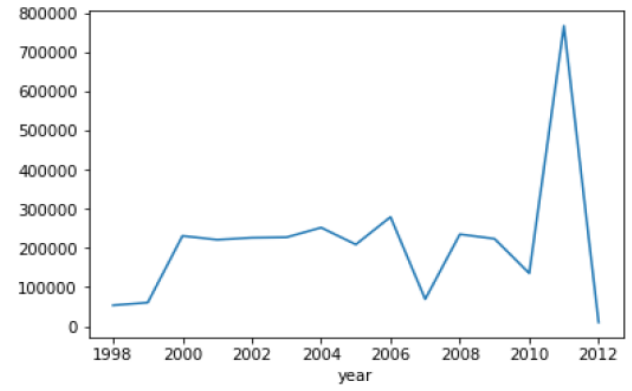

Fig 18: Prediction of crop yield for 2012

Since production and yield columns had high positive correlation, the graphs of year vs production and year vs yield are similar. Even though the area used for agriculture has reduced significantly from 2010, the production, and therefore the yield have increased significantly. This is due to improved techniques of cultivation. In 2007, the food grain situation was quite alarming as per reports by India Today network.

The normal yearly rate of development of agriculture was conceivably the least since Independence. Investment in farming dropped essentially. Expansion to irrigation system was extremely low contrasted with earlier decades. Ground water tables have dropped quickly and deficiency of water for cultivating had achieved emergency levels. There had been no technical achievement that could help the yields of significant sustenance grains. In 2011, with an ordinary rainstorm season, Indian horticulture achieved a record-breaking record generation of 85.9 million tons of wheat, a 6.4% expansion from a year sooner. Rice yield in India hit another record at 95.3 million tons, a 7% expansion from the year sooner. In order to choose the right algorithm for the purpose, we test the accuracy using three algorithms: Multiple linear regression, decision tree regression and random forest regression. By applying multiple linear regression by considering the production as the target variable, we find that the accuracy on the test data set is only 3.44%. The score on the training set is only 4.58%. By applying decision tree regression by considering the production as the target variable, we find that the accuracy on the test data set is 54.87%. The score on the training set is 61.61%. Thus we can conclude that decision tree regression results in a significantly higher accuracy on this dataset as compared to multiple linear regression. By applying decision forest regression by considering the production as the target variable, we find that the accuracy on the test data set is 98.91%. The score on the training set is 95.98%. Thus we can conclude that random forest regression tree results in a significantly higher accuracy on this dataset as compared to decision tree regression method. This is due to the fact that random forest regression method generates a large number of decision trees and takes the average of the values generated by each of them. And also when the train and test scores are not close from one another i.e, the mean test score is significantly lower than the mean train score, it denotes over fitting. But in this case, the training and test scores are close to one another. This indicates that the model is not over fitted. Also we consider few soil parameters for the Ragi crop yield. The correlation between QNitro and YRagi is .5523, QP2O5 is .55332, QK2O is .366124, potential hydrogen is .0687, and annual rainfall is .1145.So we can conclude that the yield of Ragi depends more on Qnitro, QP2O5, QK20 and very less on potential hydrogen and annual rainfall. This in Figure 19.

```
#corelation of data
dataframe1.corr()
```

	QNITRO	QP2O5	QK2O	PH	YRAGI	RN_ANNUAL
QNITRO	1.000000	0.915340	0.601957	0.194278	0.552323	0.105053
QP2O5	0.915340	1.000000	0.636871	0.228412	0.533238	0.038223
QK2O	0.601957	0.636871	1.000000	0.064838	0.366124	0.062270
PH	0.194278	0.228412	0.064838	1.000000	0.068781	-0.129683
YRAGI	0.552323	0.533238	0.366124	0.068781	1.000000	0.114572
RN_ANNUAL	0.105053	0.038223	0.062270	-0.129683	0.114572	1.000000

Fig 19: The correlation matrix

```
Epoch 10/10
1149/1149 [==============================] - 0s 338us/step - loss:
0.6256 - acc: 0.6832

Enter nitrogen content 1234

Enter phosphoros content 5678

Enter Potassium 5623

Enter pH 8.5

Enter Rainfall 1903
High yield
```

Fig 20: Snapshot of the result of ANN

The above Figure 20 shows the output of our ANN model. We are applying the ANN model for the various soil parameters and verifying it whether it is high yield or low yield. We are getting 68% accuracy.

IV. CONCLUSION

Different analytical models are implemented to predict the crop yield. We have established best combination of input weather variables of different states to identify the types of crops. In general, the investigation recommends the adjustments in climate parameters, which are impacting the Crop yields. This is additionally the general recognition about the atmosphere changes in the study area. It is appropriate for huge harvest yield forecast in agrarian arranging. This makes the farmers to take the correct choice for right harvest to such an extent that the farming division will be created by inventive thoughts.

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