Crop Advisor: A Software Tool for Forecasting Paddy Yield

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Abstract--- *The highly erratic rainfall and associated climatic parameters in India, have greater influence on the performance of cropping systems and are adversely affecting the crop yields. Forecasting of crop yields from the climatic input parameters would not only help the farmers in deciding the sale price of their produce, but it also helps the policy makers to decide the minimum support price and the buffer stock expected. Such predictions will also help the associated industries for planning the logistics of their business. Several methods of predicting and modeling crop yields have been developed in the past with varying rates of success. Statistical models often don't take into account characteristics of the weather, they are mostly are empirical in nature. In the present study a software tool named 'Crop Advisor' has been developed as a user friendly web page. This website is designed as an interactive software tool for predicting the influence of climatic parameters on the crop yields. C 4.5 algorithm is used to find out the most influencing climatic parameter on the crop yields of selected crops in selected districts of Madhya Pradesh. This software provides an indication of relative influence of different climate parameters on the crop yield, other agro-input parameters responsible for crop yield are not considered in this tool, since, application of these input parameters varies with individual fields in space and time.*

I. INTRODUCTION

CROP production is a complex phenomenon that is influenced by agro-climatic input parameters. Agriculture input parameters varies from field to field and farmer to farmer. Collecting such information on a larger area is a daunting task. However, the climatic information collected in India at every 1 sq.m area in different parts of the district is tabulated by Indian Meteorological Department. The huge such data sets can be used for predicting their influence on major crops of that particular district or place. There are different forecasting methodologies developed and evaluated by the researchers all over the world in the field of agriculture or associated sciences. Some of the such studies are: Studies conducted by agricultural researchers in Pakistan have shown that attempts of crop yield maximization through pro-pesticide state policies have led to a dangerously high pesticide usage. These studies have reported negative correlation between pesticide usage and crop yield[1]. In their study they have shown that how data mining integrated agricultural data including pest scouting, pesticide usage and meteorological recordings are useful for optimization of pesticide usage.

Thematic information related to agriculture which has spatial attributes was reported in one of the study [6]. Their study aimed at discerning trends in agriculture production with references to the availability of inputs. K-means method was used to perform forecasts of the pollution in the atmosphere [4], the k nearest neighbor was applied for simulating daily precipitations and other weather variables [11], and different possible changes of the weather scenarios are analyzed using SVMs [13]. Data mining techniques are often used to study soil characteristics. As an example, the k-means approach is used for classifying soils in combination with GPS-based technologies [14]. Apples were checked using different approaches before sending them to the market. [9], uses a k-means approach to analyze color images of fruits as they run on conveyor belts[12]. Uses X-ray images of apples to monitor the presence of watercores, and a neural network is trained for discriminating between good and bad apples. Spatial data mining introduced especially decision tree algorithm applying to agriculture land grading [15]. He combined spatial data mining/decision tree techniques with expert system techniques and applied them to establish an intelligent agriculture land grading information system. The author adopted decision tree c4.5 algorithm and implement with Mo2.0 and VC++6.0 to build agriculture land grading expert system. The study showed the particular advantages of this methodology in addressing problems in land grading such as missing land information, difficulties in quantitative analysis of factors. A decision tree classifier for agriculture data was proposed [5]. Although some data set includes missing values, the experiment showed the performance of the proposed method. This new classifier uses new data expression and can deal with both complete data and incomplete data. In the experiment, 10-fold cross validation method is used to test abalone data set, horse-colic data set and soybean data set. Their results showed the proposed decision tree is capable of classifying all kinds of agriculture data. Data mining techniques for evolution of association rules for droughts and floods in India was applied using climate inputs [2]. In their study, a data-mining algorithm using the concepts of minimal occurrences with constraints and time lags was used to discover association rules between extreme rainfall events and climatic indices. Rainfall events were forecasted the using data mining techniques [7]. The occurrence of prolonged dry period or heavy rain at the critical stages of the crop growth and development may lead to significant reduction in crop yield. Sugarcane yield estimated at municipality level in São Paulo State, Brazil, using 10-day periods of SPOT Vegetation NDVI images and ECMWF meteorological data [3]. Data Mining Approach based on Spatio-Temporal data to forecast irrigation water demand [8]. In their study data set were prepared containing information on suitable attributes obtained from

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three different sources namely meteorological data, remote sensing images and water delivery statements. In order to make the prepared data sets useful for demand forecasting and pattern extraction data sets were processed using a novel approach based on a combination of irrigation and data mining knowledge. Decision tree techniques were applied to forecast future water requirement.

II. METHODOLOGY

The present study was aimed to develop a web site for finding out the influence of climatic parameters on crop production in selected districts of Madhya Pradesh. The selection of districts has been made based on the area under that particular crop. Based on this criteria first top five districts in which the selected crop area is maximum were selected. The crops selected in the study is based on the predominate crops in the selected district. The selected crop includes: Soybean, Maize, Paddy and Wheat. The yield of these crops was tabulated for continuous 20 years by collecting the information from secondary sources. Similarly for the corresponding years climatic parameters such as Rainfall, Maximum temperature, Minimum temperature, Potential Evapotranspiration, Cloud cover, Wet day frequency were also collected from the secondary sources. For analysis in developing the software .net(c#) is used as a front end tool, and SQL server 2008 is used as back end tool to maintain the database. C4.5 algorithm was used in the analysis. C4.5 is an algorithm which is a successor to ID3 (Iterative Dichotomies 3) is used in study [10]. It is also based on Hunt's algorithm. C4.5 handles both categorical and continuous attributes to build a decision tree and in this study the collected input parameters are continuous values. In order to handle continuous attributes, C4.5 splits the attribute values into two partitions based on the selected threshold such that all the values above the threshold as one child and the remaining as another child. It also handles missing attribute values. In pseudo code the algorithm is:

1. Check for base cases
2. For each attribute 'a' (Find the normalized information gain from splitting on a)
3. Let 'a' best be the attribute with the highest normalized information gain
4. Create a decision node that splits on 'a' best
5. Recur on the sub lists obtained by splitting on a best, and add those nodes as children of node.

Entropy and Gain Calculations

Let S be a set consisting of s data samples. Suppose the class label attribute has m distinct values defining m distinct classes, C_i (for $i=1, \dots, m$). Let s_i be the number of samples of S in class C_i . The expected information needed to classify a given sample is given by:

$$I(s_1, s_2, \dots, s_m) = -\sum_{i=1}^m p_i \log_2(p_i)$$

Where p_i is the probability that an arbitrary sample belongs to class C_i and is estimated by s_i/s . Note that log function to the base 2 is used since the information is encoded in bits.

Let attribute A have v distinct values $\{a_1, a_2, \dots, a_v\}$. Attribute A can be used to partition S into v subsets, $\{S_1, S_2, \dots, S_v\}$, where S_j contains those samples in S that have values a_j of A. If A were selected as the test attribute (i.e., the best attribute for splitting), then these subsets would correspond to the branches grown from the node containing the set S. Let s_{ij} be the number of samples of class C_i in a subset S_j . The entropy, or expected information based on the partitioning into subsets by A, is given by the subset (i.e., having value a_j of A) divided by the total number of samples in S. The smaller the entropy value, the greater the purity of the subset partitions. Note that for a given subset S_j

$$I(s_{1j}, s_{2j}, \dots, s_{mj}) = -\sum_{i=1}^m p_{ij} \log_2(p_{ij})$$

Where p_{ij} is the probability that a sample in S_j belongs to class C_i . Encoding the information that would be gained by branching on A is

$$\text{Gain}(A) = I(s_1, s_2, \dots, s_m) - E(A)$$

In other words, Gain (A) is the expected reduction in entropy caused by knowing the value of attribute A. Decision tree is constructed based on the maximum gain value till there are no remaining attributes on which the tuples may be further partitioned.

III. RESULTS AND DISCUSSION

The collected information of climate and crop yield data were tabulated and average values of each of these parameters for continuous 20 years were worked out. To represent the calculations used in the study a sample table for paddy crop in Balaghat district of Madhya Pradesh is presented in the following table 1.

Prediction of Crop Yield

Home Decision Tree Show Details View District View Crops Crop Details Add New Climate View Climate User Details Logout

Climate Information

Crop Name: Paddy District Name: Balaghat

Add New Back View

S.No	Rain Fall	Max Temp	Min Temp	PET	WetDay	Cloud Cover	Yield	Edit	Delete
1	1449.940	33.170	20.472	6.530	4.820	36.560	1304.000		
2	2093.380	32.960	20.476	6.530	4.520	39.560	1180.000		
3	1459.510	33.000	20.320	6.500	4.320	36.780	1240.000		
4	1079.580	33.480	20.790	6.610	4.470	36.790	1140.000		
5	1169.670	32.770	20.120	6.480	4.830	40.340	1287.000		
6	1226.200	32.930	20.450	6.480	5.120	40.500	1257.000		
7	1320.140	32.900	20.320	6.440	5.280	41.890	1105.000		
8	1029.570	32.940	20.290	6.560	4.430	36.770	1100.000		
9	1293.240	33.210	20.630	6.490	4.940	40.660	1510.000		
10	1161.310	33.670	20.990	6.570	4.720	36.770	1148.000		
11	1347.000	32.830	20.200	6.500	4.740	40.690	1017.000		
12	1499.000	33.250	20.470	6.540	5.010	39.130	1155.000		
13	1213.000	33.100	20.380	6.540	4.060	36.150	1106.000		
14	1175.000	33.250	20.600	6.540	4.690	36.200	1116.000		
15	1062.000	33.130	20.410	6.520	4.470	40.130	1112.000		
16	1535.000	32.570	20.160	6.420	4.350	41.190	1057.000		
17	1244.000	33.310	20.580	6.540	5.430	36.560	1159.000		
18	1104.000	33.960	20.840	6.550	4.510	39.560	1028.000		
19	1241.000	33.500	20.080	6.520	4.900	40.450	1046.000		
20	1120.000	32.850	20.140	6.500	5.100	40.690	992.000		

Using such tabulated values a software was developed in .net as a front end tool and sql server as back end support. The software is further developed into user friendly web site. The

home page contains, the methodology adopted in the study and registration of the new users. The screen shot of the home page of the website is presented below.

Prediction of Crop Yield
Influencing Parameters

Home Methodology Contact Us Register Login Here

Prediction of crop yield

Crop Advisor This website is designed as an interactive software tool for predicting the influence of climatic parameters on the crop yields. C 4.5 algorithm was used to find out the most influencing climatic parameter on the crop yields of selected crops in selected districts of Madhya Pradesh. The users however, can change the data sets (input parameters) suiting to their study area. For using this tool, the users are advised to register their details on this website, with a confirmation from administrator, users are free to use the tool. This software provides an indication of relative influence of different climate parameters on the crop yield, other factors responsible for crop yield are not considered in this tool.

ID3 and C4.5 are algorithms introduced by Quinlan for Inducing Classification Models, also called Decision Trees, from data if we are given a set of records. Each record has the same structure, consisting of a number of attribute/value pairs. One of these attributes represents the category of the record. The problem is to determine a decision tree that on the basis of answers to questions about the non-category attributes predicts correctly the value of the category attribute. Usually the category attribute takes only the values {true, false}, or {success, failure}, {high, low} or something equivalent. In any case, one of its values will mean failure.

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The first time users of the website need the administrators approval for login into the site for further use. Once the user

gives the login and password details the next screen appears as:

From the tabulated data, decision tree is constructed using c4.5 algorithm based on gain values of each attribute. After calculating the gain, the attribute with the highest gain value is selected as root node and is further splits the table into tree,

this process continues recursively till all the tuples belong to the same class. The screen shot of the decision tree constructed is presented below:

Prediction of Crop Yield

Home | Decision Tree | Show Details | View District | View Crops | Crop Details | Add New Climate | View Climate | User Details | Logout

Crops Name : District Name :

PET	CloudCover	MaxTemp	MinTemp	Y	PET	CloudCover	MaxTemp	MinTemp	Y	PET	CloudCover	MaxTemp	WetDay	Y	PET	CloudCover	MaxTemp	WetDay	Y
1	0	1	1	0	0	1	0	0	1	0	1	0	0	1	1	0	1	1	1
1	0	0	0	0	0	1	0	0	1	0	1	0	1	1	1	0	0	0	1
1	0	1	1	0	0	1	0	0	0	0	1	0	1	0	0	1	1	1	1
1	0	0	0	0	1	0	1	1	1	1	0	1	1	0	0	1	1	1	1
1	0	1	1	0	1	1	1	1	0	0	1	0	0	0	0	1	0	0	0
1	1	1	0	0															
1	0	1	1	0															

If Rainfall <1293.023 and WetDay < 4.736 then Yield < 1156.600
 If Rainfall <1293.023 and WetDay > 4.736 then Yield > 1156.600
 If Rainfall >1293.023 and MinTemp < 20.465 then Yield < 1156.600
 If Rainfall >1293.023 and MinTemp > 20.465 then Yield > 1156.600

यदि वर्षा <1293.023 एवं नमीका दिन आर्द्रता < 4.736 तब उपज < 1156.600
 यदि वर्षा <1293.023 एवं नमीका दिन आर्द्रता > 4.736 तब उपज > 1156.600
 यदि वर्षा >1293.023 एवं न्यूनतम तापमान < 20.465 तब उपज < 1156.600
 यदि वर्षा >1293.023 एवं न्यूनतम तापमान > 20.465 तब उपज > 1156.600

In the above screen shot it was revealed that paddy crop yield is influenced mostly by the climatic parameter Rainfall, followed by wetday and minimum temperature. The decision rules thus formed for forecasting yield as follows.

1. if Rainfall <1293.023 and WetDay < 4.736 then Yield < 1156.600
2. if Rainfall <1293.023 and WetDay > 4.736 then Yield > 1156.600
3. if Rainfall >1293.023 and MinTemp < 20.465 then

Yield < 1156.600

if Rainfall >1293.023 and MinTemp > 20.465 then Yield > 1156.600

In the above rules the rainfall is in mm, wet day frequency is in number of days and yield is in kg/ha.

Thus using the CROPADVISOR website, the user can predict the crop yields of their choice by giving input of climatic parameters and crop yield values of previous known years to arrive at a expected value.

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