Web based Crop Rotation Recommendation in Agrarian Society

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***Abstract*-- Agriculture is a formal occupation in India from ages and thus plays a vital role in Indian heritage. In India, the traditional method of recommendation is still used for agriculture where the farmers are not aware about the nutrients consideration, land and soil characteristics. The traditional agriculture does not have more interaction of social and environmental systems that leads to poor crop production. Recommendation can be provided to farmers using past agricultural performance with the help of classification algorithms, which facilitate decision support for crop rotation. The crop rotation is a practice of growing a series of dissimilar types of crops in the same area in sequential seasons which leads to organic farming. The proposed system uses the Nominal Ratio Classification (NRC) algorithm for suggesting crop rotation. This will help the farmers to choose whether the particular crop is suitable for that specific soil or land depending upon characteristics such as soil type, soil texture, land type, temporal data, current crop, soil macronutrients like N (Nitrogen), P(Phosphorous) and K(Potassium) values. The proposed system overcomes the limitations of traditional agricultural procedures that uplift the lives of farmers and also improves crop production.**

Keywords—Classification; Crop rotation; Organic farming; Nitrogen; Phosphorous; Potassium.

I. INTRODUCTION

Agriculture is considered as the basis of life for the human genus as it is the main source of food grains and other raw materials. It plays vital role in the growth of Indian economy. Growth in agricultural sector is necessary for the development of economic condition of the country.

Agriculture in today's life is based on traditional approach which decreases productivity rate. The farmers are unaware of the crop selection criteria that facilitate the crop production. Hence there is a need for the system to improve the crop yield which can be achieved using data mining techniques. Thereby the farmers will be able to choose the right crop at right place. Data mining involves the process of finding large quantity of previously unknown data and their use in significant business decision making. Unfortunately, many farmers still use the traditional methods of farming which results in near to the ground yielding of crops and fruits.

As a keystone of good agronomic practice, crop rotation has a clear role to play in recovering our country's economy. Not only it reduce farmers production costs, it has multiple environmental benefits, including the limited wastage of water, the improvement of soil quality, contributing to climate change mitigation and reducing input dependency.

Crop rotation has many agronomic, economic and environmental benefits compared to monoculture cropping. Appropriate crop rotation increases organic matter in the soil, improves soil structure, reduces soil degradation, and can result in higher yields and greater farm profitability in long-term. Increased levels of soil organic matter enhances water and nutrient retention, and decreases synthetic fertilizer requirements. Better soil structure in turn improves drainage, reduces risks of water-logging during floods, and boosts the supply of soil water during droughts. Moreover web based crop rotation effectively delivers on climate change mitigation.

Crop rotation is used to control weeds and diseases, and limit insect and other pest infestations and as a result significantly reduce pesticide use. Leguminous crops in the rotation fix atmospheric nitrogen and bind it in the soil, increasing fertility and reducing the need for synthetic fertilizers and the use of pesticides.

The paper is structured as follows. In Section 2 the related work is described. In Section 3 the proposed methodology is described. In Section 4 the experimentation and results is described. In Section 5 the conclusion follows.

II. RELATED WORK

Agriculture is the major resource of income for the largest population in India and is major provider to Indian economy. However technological involvement and its usability still have to be grown and civilized for agro sector in India [1]. Although few initiatives have also been taken by the Indian Government for providing online and mobile messaging services to farmers related to farming queries, agro vendor's information to farmers [2], it provides static data related to soil quality at each region. India is an agricultural country but is still using traditional ways of recommendations for farming purpose. Presently, recommendations for farmers are based on one to one interaction between farmers and the experts and different experts have different recommendations. Recommendation can be provided to farmers using past agricultural activities data [3].Connect all agricultural entities together including farmers, agro marketing agencies, agro product vendors and Ministry of agriculture and Agro Banks. This will facilitate distribution of products from farmers to buyers and from agro vendors to farmers. Through the bureau of agriculture, farmers will be able to get notifications about new schemes announced by the government for agriculture sector [4].

The main techniques for data mining include Association rules, Classification, Clustering and Regression [5]. The different data mining techniques used for solving different agricultural problem has been discussed [6] [7]. Data Mining techniques are mainly divided in two groups, classification and clustering techniques [8] [9]. Classification techniques [10] are designed for classifying unknown sample using information provided by a set of classified samples. This set is usually referred to as a training set as it is used to train the classification technique how to perform its classification. Generally, Neural Networks [11] and Support Vector Machines [12], these two classification techniques learn from training set how to classify unknown samples. Another classification technique, K- Nearest Neighbor, does not have any learning phase, because it uses the training set every time a classification must be performed. A training set is known, and it is used to classify samples of unknown classification. The basic assumption in the K-Nearest Neighbor algorithm is that similar samples should have similar classification. The parameter K shows the number of similar known samples used for assigning a classification to an unknown sample [13]. The K-Nearest Neighbor uses the information in the training set, but it does not extract any rule for classifying the other. In the event training set not available, there is no previous knowledge about
the data to classify [14]. In this case, clustering techniques can be used to split a set of unknown samples into clusters. One of the most used clustering techniques is the K-Means algorithm [15]. Given a set of data with unknown classification, the intent is to find a partition of the set in which comparable data are grouped in the same cluster.

There are several applications of Data Mining techniques in the field of agriculture. Some of the data mining techniques are related to weather conditions and forecasts. For example, the K-Means algorithm is used to perform forecast of the pollution in the atmosphere, the K Nearest Neighbor (KNN) is applied for simulating daily precipitations and other weather variables, and different possible changes of the weather scenarios are analysed using SVMs. Data Mining techniques are applied to study sound recognition problems. For instance, Fagerlund S uses SVMs to classify the sound of birds and other different sounds [16].

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. Meyer GE et al. uses a K-Means approach to classify soils and plants and Camps Valls et al. uses SVMs to classify crops. Apples are checked using different approaches before sending them to the market. Leemans V et al. uses a K-Means approach to analyze colour images of fruits as they run on conveyor belts. Shahin MA et al. uses X-ray images of apples to monitor the presence of water cores, and a neural network is trained for discriminating between good and bad apples. A Mucherino et al. [17] apply a supervised biclustering technique to a dataset of wine fermentations with the aim of selecting and discovering the features that are responsible for the problematic fermentations and also exploit the selected features for predicting the quality of new fermentations. Taste sensors are used to obtain data from the fermentation process to be classified using ANNs. Similarly, sensors are used to odour milk that is classified using SVMs.

In India agricultural is carried out from ages and thus we have a rich collection of agricultural past data which can used for recommendation. Data mining techniques and algorithms can be used for recommending particular crop and pattern of crops for crop rotation. In agricultural field, crop rotation is very essential. This will yield crops for entire year and the fertility of soil is maintained [18]. Crop rotation returns different nutrients to the soil and restores its fertility [19]. An aspect of crop rotation is the sufficient use of nitrogen, phosphorous and potassium through the use of green manure and fertilizers. Crop rotation also decreases the build-up of pathogens and pests that often occur when one type species is continuously produced. It can also improve soil structure and fertility by alternating between different leguminous plants.

The soil quality can be determined by the soil NPK values. The 'N' is the nitrogen content of the soil, 'P' is the phosphorous content and 'K' is the potassium content of the soil. Based on the NPK contents, the value of soil can be predicted [20]. The nitrogen content in the soil gives the colour of the leaves. The phosphorous in the soil is responsible for the plants reproductive system. Its value will predict the growth and development of fruits and flowers of the plants. The potassium content of the soil is responsible for its overall growth. Its value will predict how stronger the plant roots will be and will also determine the overall growth process of the plant. Depending upon these values crop rotation can be recommended.

From the above literature it is evident that the existing methodologies had solely focused on the factors like frequently used crops, soil salinity and nutrients. The traditional approaches had predicted crop rotation based on the family of crops and farmers suggestions. The proposed methodology has the architecture that predicts the rotation of crops on a hierarchy basis in order to make the results more accurate.

III.PROPOSED METHODOLOGY

The proposed architecture aims at developing an efficient predictive system that let the farmers to take decision regarding crop rotation based on analysis of data using data mining techniques. The methodology is organised as follows: Overall architecture of crop rotation recommendation system, Agri data processing, Classification. The Nominal Ratio Classification algorithm and Random Forest algorithm are implemented for suggesting the crops.

A .Crop Rotation Recommendation Architecture

Figure1. shows the overall architecture for crop rotation recommendation. The raw data containing agricultural dataset was pre-processed to user understandable data. The system was trained according to the agricultural application. The Nominal Ratio Classification algorithm was applied on the trained data to obtain the best crop rotation recommendation with greater precision. In the classification phase five layers are involved which leads to higher accuracy. The five layers are the sequence of steps for effective farming. From the decision support system the crops can be suggested to the farmers for the rotation.

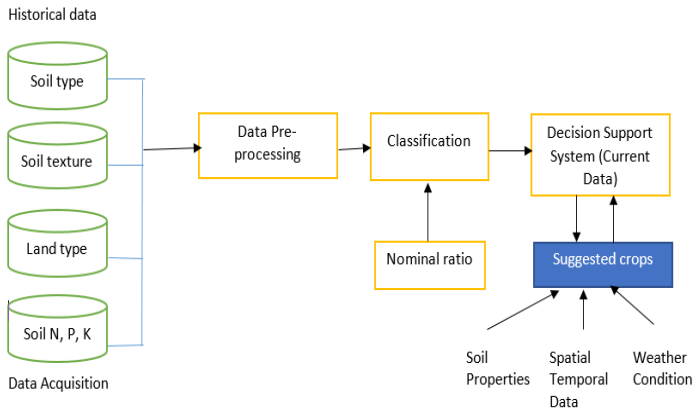

Fig.1. Overall architecture for crop rotation recommendation

B. Agri data pre-processing

The text dataset with various fields related to soil, land and plant from the various villages situated in and around the Dindigul district are collected. These heterogeneous data was pre-processed into user understandable format. The training sample data is in .xls format.

C. *Classification*

The proposed system is designed using Nominal Ratio Classification (NRC) algorithm for multi-level classification of data. The process involves the classification in hierarchies. The order holds accessing the variability, selecting the important soil features such as soil type, land type and soil texture, then measuring the soil macronutrients such as nitrogen (N), phosphorous (P), potassium (K), finally considering the month and current crop name for rotation recommendation.

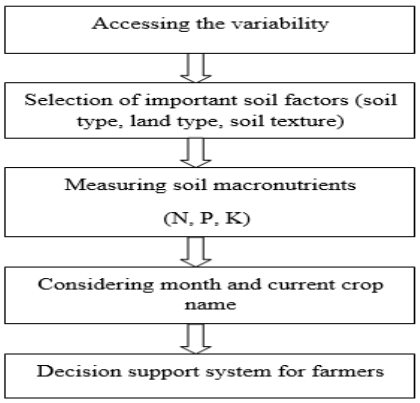

Fig.2. Sequence of Steps for Effective Farming

The Figure 2. gives the detailed description that take place in the classification process. The NRC algorithm uses the factors like soil type, land type, soil texture, month, current crop, soil N, soil P, soil k as its inputs. The classification begins with soil type such as red sandy, black soil, alluvial soil, laterite soil, mountain soil and desert soil. Land type classification includes wet land, dry land and grass land. Soil texture comes under various categories such as sandy (S), clay loam (CL), sandy clay loam (SCL). Month classification includes all the months of the year. Soil macronutrients such as N, P and K range were considered for further classification. The combination of these factors recommends the best crop for rotation.

Two results are generated, one result is based on the soil properties, month and soil macronutrients such as Nitrogen, Phosphorous and Potassium (NPK) range given by the farmer and another result depends on the soil properties and the decreasing and increasing value of the soil NPK range. From the two results it is inferred that the second result suggest the farmers more number of crops, as the range increases.

The Random Forest Algorithm is the random formation of many number of trees were the results are dependent upon maximum probability. Since this is formation of many nodes/tree it gives many possibilities of data. The Random Forest Algorithm is also implemented for the crop rotation recommendation application, in which the results are less accurate while comparing to the Nominal Ratio Classification Algorithm. The reason is Random Forest

works linearly and does not consider in and around values, these lead to poor accuracy.

IV. EXPERIMENTATION AND RESULTS

The performance metrics such as speed of code execution and data occurrence are calculated for both Nominal Ratio Classification and Random Forest algorithms. The speed of code execution can be calculated using the following formula.

$$\frac{Seconds}{Program} = \frac{instructions}{program} \times \frac{clocks}{instruction} \times \frac{seconds}{clock}$$

The data occurrence can be calculated using the data count function available. From the result it is evident that the NRC algorithm takes less time for code execution while comparing to Random Forest algorithm. Similarly the number of data i.e. crops for rotation suggestion are more using NRC rather than Random Forest.

Thus Nominal Ratio Classification is used for crop rotation recommendation system. The application allows two types of login. One for the purpose of admin and another for the farmer. The admin has privileges to access the agricultural data. The farmer can initially register and login using the generated password where the crop rotation can be recommended depending upon the inputs from farmer.

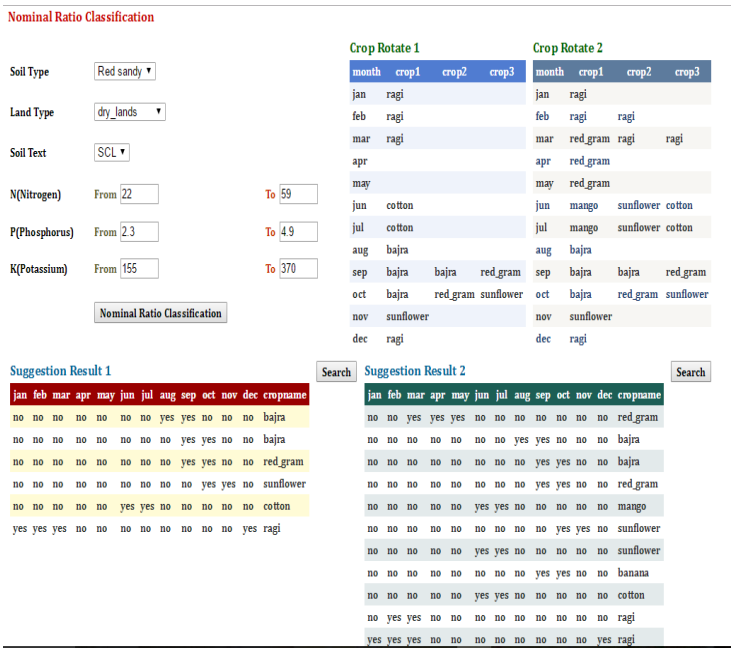

Fig.1. Nominal Ratio Classification Algorithm Result

Fig.2. Random Forest Algorithm Result

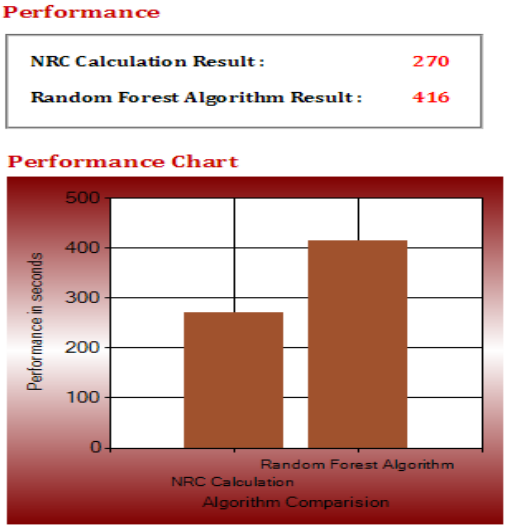

Fig.3. Speed of Execution

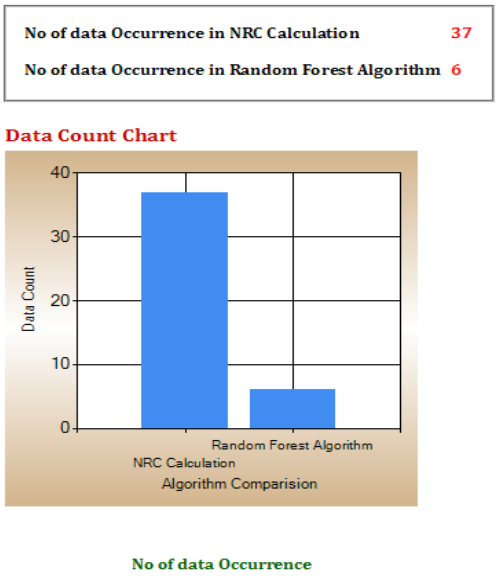

Fig.4. Data Occurrence

V. CONCLUSION AND FUTURE WORK

Thus the paper proposes an efficient recommendation for crop rotation to the farmers. The result is predicted using the Nominal Ratio Classification algorithm and Random Forest algorithm. Since the results are more accurate using NRC, it is used for suggesting the rotation of crops. The future work includes the classification of various level of parameters such as consideration of micronutrients, pH etc. for crop rotation recommendation which will result in the effectiveness of the system. The proposed work can also be developed as a mobile application where the smart phones are in higher use that uplifts the farmer lives by knowing the requirements earlier.

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