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An Intelligent and Service Based Smart Agriculture Recommendation System

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Abstract: In Ancient India, people were depended on farming for their livelihood. Even today, Agriculture and allied sectors contributes one of the major portion in the Pi-chart of India's GDP. But day by day, Agriculture sector declining and many are reluctant towards farming due to many reasons Such as Short of water levels in the underground, Lack of seasonal cropping, Multi cropping, Soil management etc. Artificial intelligence and machine learning is research area that can make use of to develop algorithms which will give assistance to the human in making right decisions by taking numerous in to account such a climatical conditions, Soil factors, idea on seasonal crops, right crops for multi cropping for better yield etc,. This paper presents several machine learning algorithms as a part of Agriculture Recommendation System in selecting right crop for right soil and climatical conditions to improve yield of the crop, to make farmer more flexible and comfort to farming with proper soil management.

Keywords: *Agriculture Recommendation System, Artificial Intelligence, Machine Learning, precision Farming, Multi Cropping.*

1. Introduction:

In the past, basic economic source of India is Agriculture and farming. Even Today, primary sector in the GDP of India is Agriculture and allied sector. According to the IndianMinistry of Agriculture & Farmers Welfare, the gross value-added(GVA) share of Agri & allied share in the year 2022-2023 is 18.3%. Figure 1. Shows GVA share of Agri & allied Sectors in India's total economy (%). GAV share in the year 2021-22 is 19% and in the year 2020-2021 is 20.3%. It is clear that GVA share is declining year by year. Not only in India, even in the global economy the Agri & allied sector share was declined to 42% approximately. In the year 1980, it was 7 % where as in 2021 it was 4% as per the survey of World bank. In the other view, according to the Global Report on Food Crises (GRFC) for 2023, Currently over 258 million public in 58 nations and terrains who are extremely hungry. This shows intensive food insecure. By observing all these statistics, precision and productive farming in essential to upsurge the GAV share and also to feed the people globally to bring out from the food insecurity[17][19].

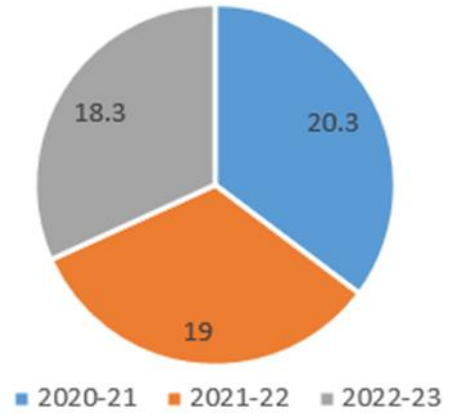

Fig 1: GVA share of Agri & allied Sectors inIndia's total economy (%)

Many reasons for declining the agriculture sector year by year, few are randomness and rapid changes in the climatical conditions, Lack of knowledge on seasonal crops, Multi cropping and soil management for the upcoming generations[19]. Utilization of chemical and pesticides more than essential, this is one of the major problem leads to low productiveness from crop to crop.Lack of credits, insufficient government subsidies, and corruption alienate the farming community and increase debt, which in turn causes suicides and leaves families with mounting debt[12][23].Using statistical

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skills, artificial intelligence and Machine learning, productivity of agriculture can improve at relatively reduced prices. In line with the statement, we proposed anagriculture recommendation system (ARS) empowered by machine learning algorithm which leads precision agriculture [2],[3].

Agriculture recommendation system entails the use of technology to suggest fertilisers, agricultural methods, and crops to farmers among others. The agriculture recommendation system employs various machine learning algorithms to suggest crops in accordance with predetermined rules and data[20]. The kind and quantity of data input determines how accurate the advice is. This statistical nature of the Algorithm can result in a sizable boost in yield. A high degree of accuracy is desired since failure to do so will have far-reaching negative effects, such as seed and time waste, severe reductions in production, etc. Recommendations can be based on a wide range of predictors, including temperature, soil characteristics, humidity, etc[4][21].

In the paper [5], Author proposed a crop recommendation system to identify the type of disease affecting the crop by using image processing algorithms and suggesting the pesticides accordingly. The major draw back with the system is not a smart system [24]. Source of data might be limited which leads a partial recommendation and limited to a specific type of crop.

The survey work of the author[6] bring out the categories of smart agriculture recommendation system based on soil characteristics, various pests, weather conditions and crop type[25]. Author also focused on transition era from the tradition agriculture[30-32].

Author[7] focused on structural planning requirements for successful development of software model in the precision farming. The collective object of the author is provide direct service to the small scale farmers, but the specified system is state or location specific and it used the generic communication service like sms [26].

Paper [8] discussed about various machine learning algorithms used in the recommendation system such as support vector machine, REPTree and random forest etc. Among various observations, author identified a particular matric called minimum error deviation based which paper were concluded with best from studied algorithms. Data Mining approaches used for crop selection is proposed in the research work[9]. Tool such as clusttering , K-nearest neigbhor, ANN and linear regression are analysed for the implementation of crop selection system [27].

In the view of author[10] traditional farming is not adequate to achieve the demands. Major areas need to be kept in mind during cultivation are water resources, crop monitoring, crop disease, lack of storage space, and warehouse storage space. So, author proposeda system that employed ML and DLabove mentioned factors [28].

After all these observation, current research work presents the AR System employed with intelligent machine learning algorithm to analyse the situations in the field and atmosphere and suggest suitable crops for the location, to the land and crop for integrated cropping. The rest of the paper is organized in well understandable structure [29].

1. **Agriculture Recommendation System:**By perusing and observing research articles on various on smart and precision farming approaches[1],[3],[4] including data collection, forecast various factor and pathway directions, a collective frame work or base structure of Agriculture recommendation system is presented in the figure 2.

Data Pooling:

Initially ARS collects the data from various sources such a historical data of the land and type of crops growing from past decades of year, about the under-ground water levels and its variations for past few decades[33]. System also gather information arial survey of the cultivation land, local crops soil characteristics and rainfall over past decades, different types of crops, their deceases and corresponding pesticides etc.

Feature Extraction:

Data is processed for feature extraction. There are many features to be consider for the purpose of suggesting type of seasonal crops or type of crop combinations of multi-cropping or based on area availability for small farmers etc. in order to consider crop combination for multi cropping, one of the major factor is crop family and the underground water levels has to be consider.[34][35]

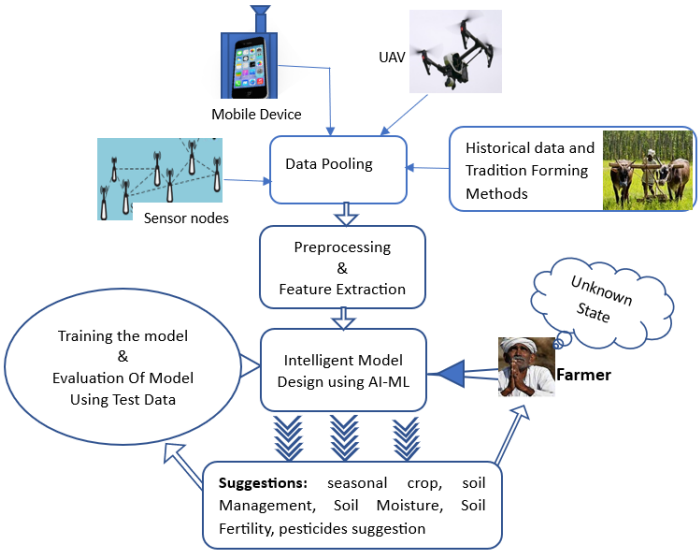


Fig 2: Smart Agriculture recommendation system

2. **ML algorithms:**An intelligent AI&ML based algorithm is employed in the system. The algorithm was trained and test based on the collected and some synthesized data sets, then it will be deployed into the ARS system. Two machine learning algorithms random forest [2],[12], KNN[13] and naïve bayes[2],[12] algorithms are examine for finding crop combination in the multi cropping system[36].

Training&Testing:Training and testing the machine learning algorithms. In the entire data set, 70 percent of the data is used for training and 30 percent of data is used for testing purpose.

Performance evaluation matrices:Machine learning algorithms are evaluated their performance based on parameters accuracy, error rate, precision, recall and F-measure. All these parameters are working based confusion matric that includes predicted output and the actual output.

Recommendation: Where ever an innocent or a farmer under unknown state gives a query, ARS system suggest an appropriate solution which may leads to increase in the productivity of the crop. Here, farmers are advised to choose crops that will produce large income. Crop recommendations are produced by the random forest, KNN and naive Bayes algorithm based on priority.

2. Results and Discussions:

The performance of the proposed system is summarized based on the performance of the machine learning algorithms. Evaluation of the proposed system has been done based on the crop suggestion for multi cropping. Initial Sugar cane, Groundnut, papaya, banana, brinjal, potato, chilli, cucumber and ginger radish, onions are considered. The actual crop combination for multilayer croppingas mentioned in the Table1.Some features that are considered in the proposed systems are Height of the plant, soil fertility, moisture, Location, water level, field area, weeding etc.

Table 1: Multilayer crop combination for productive yield

Sno.	Crop Combination
1.	Onion+Potato+Sugarcane
2.	spinach+ radish+ onion
3.	maize+ green gram+ groundnut
4.	Chilli+Cucumber+Papaya
5.	Ginger+Spinach+Banana

Accuracy, error rate and F Measure metrics [14]are used to evaluate the proposed system under two different areas Andhra Pradesh and Karnataka.Mathematical formulae of the metrices are given below. Accuracy is defined as a fraction of the number of true estimates to all number of estimates. Error rate can be measured as a fraction of the number of wrong estimates to all number of estimates. F measure Calculate the accuracy of the test data using precision and recall.

$$\text{Accuracy} = \frac{\text{True estimates}}{\text{Total no. of estimates}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

$$\text{Error rate} = \frac{\text{Wrong estimates}}{\text{Total no.of estimates}} \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

$$\text{F Measure} = \frac{2*\text{Recall}*\text{Precision}}{\text{Recall}+\text{Precision}} \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

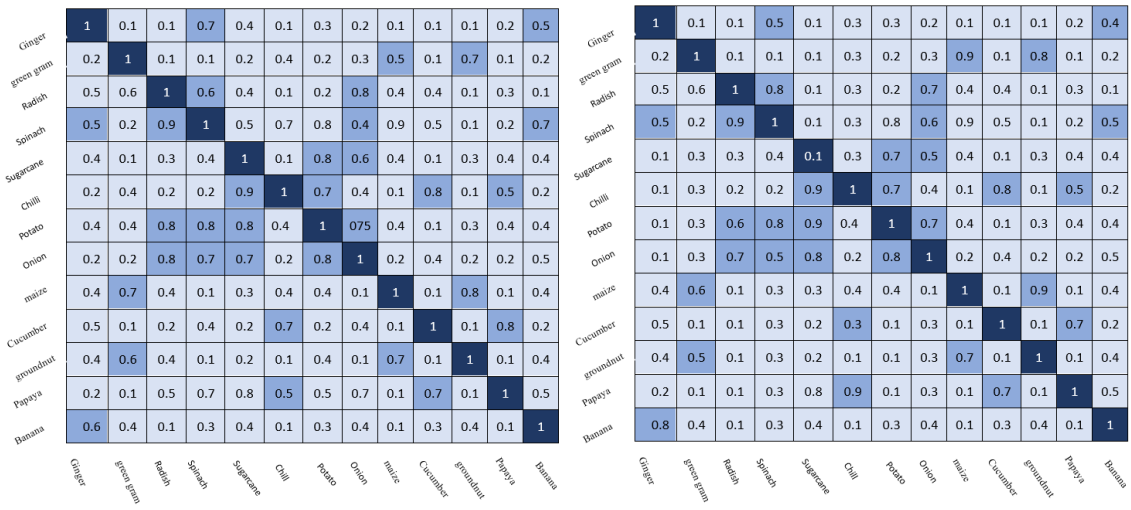
Table 2 and 3 show the performance evaluation of random forest, KNN and Naiva bayes algorithms in terms of accuracy and error rate. From the table it is clear that performance of the algorithms varies with location to location as feature will vary. It is observed that random forest performs 2.659% better than KNN and 8.223% better than naïve bayes in case of Andhra Pradesh where as in case of Karnataka, random forest performs 5.699% better than KNN and 8.917% better than naïve bayesFigure3a & Figure 3b three shows confusion matrices of random forest in two different location.

Table 2: Performance of the ML algorithms at Andhra Pradesh

Model	**Accuracy**	**Error rate**
Random Forest	73.846%	0.485
KNN	71.187%	0.542
Naïve Bayes	65.623%	0.618

Table3: Performance of the ML algorithms at Karnataka

Model	**Accuracy**	**Error rate**
Random Forest	76.552%	0.364
KNN	70.853%	0.501
Naïve Bayes	67.635%	0.577



(a) (b)

Fig 3: confusion matrix of random forest for a) Andhra Pradesh b) Karnataka

3. Conclusion:

In this research article an agriculture recommendation system is proposed in support with machine learning algorithms like random forest, KNN and Naïve bayes algorithms. By analysing various parameters, it was concluded that a productive crop recommendation system is still required. A large-scale system may benefit from adding big data analysis as well as data mining since the majority of ensemble approaches guarantee good accuracy.What we need is a way to effectively gather data and analyse it using a network of sensors. When making crop recommendations, we also need to take into account other elements including the farmer's

financial situation, the availability of fertiliser, and topography. We also need a strong system that can precisely predict the weather because rainfall and temperature have a significant impact on yield. Future work needs to pay particular attention to soil characteristics and nutrients because they are the main determinants of crop recommendation. a mobile and web

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