AI-DRIVEN FRAMEWORK FOR CROP SELECTION INTEGRATING YIELD AND SEASONAL FACTORS FOR ENHANCED PRODUCTIVITY

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Abstract-Global food security depends to some extent on agricultural systems, but changing environmental conditions and unstable production conditions are presenting challenges for farmers. Traditional systems that once had great importance are becoming ineffective due to uncertain weather conditions and changing agricultural conditions. With the development of data-driven solutions, the integration of machine learning and data mining has emerged as a powerful vision that can help farmers. These technologies analyze historical and environmental data to recommend the best decisions based on weather, soil conditions, water availability and market trends. Crop research systems not only help farmers choose high-yielding crops, but also promote sustainable farming systems. Using such measures, farmers can improve production, manage resources more efficiently and reduce the risks associated with climate change. The goal is to help rural communities eliminate inequalities, promote smarter decisions and contribute to better food production..

Keywords: Recommender System, Crop selection, AI-Driven Agriculturaldecision , Climate-smart framing Naive Bayes,

I. Introduction to Agriculture

Agriculture is the lifeline of India's economy,contributing significantly to employment, food security, and rural development.India's diverse agro-climatic zones enable the growth of various crops, including food grains, fruits, vegetables, spices, and cash crops like cotton, tea, and coffee. Agriculture not only feeds the second-largest populationin the world but also plays a crucial role in export earnings and poverty alleviation.

The structure of Indian agriculture is defined byseasonal patterns—*Rabi* (winter), *Kharif*(monsoon), and *Zaid*(summer) cropping seasons. Major staples like rice and wheat dominate the crop production, while pulses, oilseeds, and horticultural crops contribute to nutritional and economic diversification. Indian farmers rely heavily on the monsoon, as a significant part of agriculture is rainfed, though irrigation systems have expanded in several regions.

Despite its importance, Indian agriculture faces challenges such as unpredictable weather, fragmented landholdings, low productivity, and inadequate access to modern technology. Climate change has also emerged as a serious concern, affecting crop yields and increasing the frequency of extreme weather events. Issues like soil degradation, water scarcity, and pest infestations further complicate agricultural production.

To tackle these challenges, the government and private sector are increasingly focusing on modernizing agriculture. The use of data-driven solutions, such as crop monitoring through satellites, weather forecasting systems, and mobile-based advisory services, is becoming more common. Technological advancements in precision farming, machine learning, and IoT-based solutions are helping farmers make informed decisions to enhance productivity and sustainability. Additionally, organic farming and sustainable practices are gaining traction, catering to both domestic and international markets.

II. KDD: Uncovering Patterns and Insights from Data

The KDD process focuses on identifying valuable information hidden within large data collections. In the agricultural domain, KDD can help identify hidden patterns and trends in crop cultivation,facilitating farmers in making decisions that are better informed and more strategic.

This process is particularly useful for addressing the challenges experienced by farmers, for example, fluctuatingyieldsand unpredictable environmental conditions. Through KDD, it is possible to uncover useful knowledge that can assist farmersinoptimizingtheiragriculturalpractices. In recent years, the role of machine learning has become more prominent in agriculture, especially with the need to work with and evaluate large-scale data collections. Machine learning techniques can be applied in various agricultural areas, such ascrop management, soil analysis, water management, and live stock management. These techniques help to predict outcomes, manage resources, and improve overallagricultural productivity. The combination of KDD and machine learning offers a powerful tool for enhancing agricultural practices.

III. Recommendation System

Recommender systems, which are commonly used in e- commerce to suggest products to consumers based on their preferences, can also be applied in agriculture to provide tailored recommendations to farmers.

In this context, a recommender system can offer suggestions on the best crops to cultivate, taking into consideration factors like soil quality, weather, and historical crop data.. This system can also provide advice on cultivation techniques, fertilizers, pesticides, and hybrid seeds to improve crop yield and quality .The recommender system works by analyzing data on natural factors, user queries, and climatic conditions to generate recommendations. By incorporating both collaborative and content-based filtering approaches, the system can offer personalized advice to farmers.

This approach ensures that farmers receive relevant and timely recommendations, helping them make better decisions regarding crop cultivation.

IV. Approaches to Agricultural Recommendation Systems

A variety of crop yield prediction models have been created by applying machine learning and data mining approaches. For example, clustering algorithms like k-means and k-means++ are utilized to categorize data into meaningful groups, enabling the estimation of crop yields based on multiple influencing factors.Techniques from data mining are utilized to studyagricultural factors, such as soil composition, weather patterns, and pest infestations, to provide accurate crop recommendations. Prediction of crop yields was traditionally based on farmers' experience and knowledge, passed down through generations. However, as environmental conditions have become more variable, there is a growing need to apply engineering principles to crop prediction. Data mining offers a new approach to agricultural research by using historical data to make predictions.

Approaches like neural networks, k-nearest neighbors, and clustering algorithms are being widely adopted to examine agricultural data and forecast crop production outcomes. Additionally, technologies such as artificial neural networks (ANNs) and spatiotemporal analysis models are being employed to analyze environmental and biotic factors that influence crop production.

These advanced techniques allow for more accurate and efficient predictions, enabling farmers to plan their cultivation activities accordingly.

V. Experimental Results

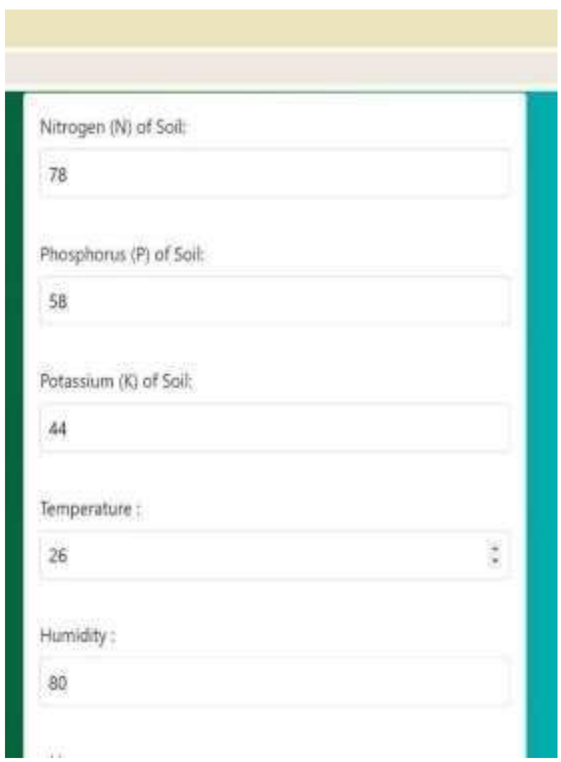
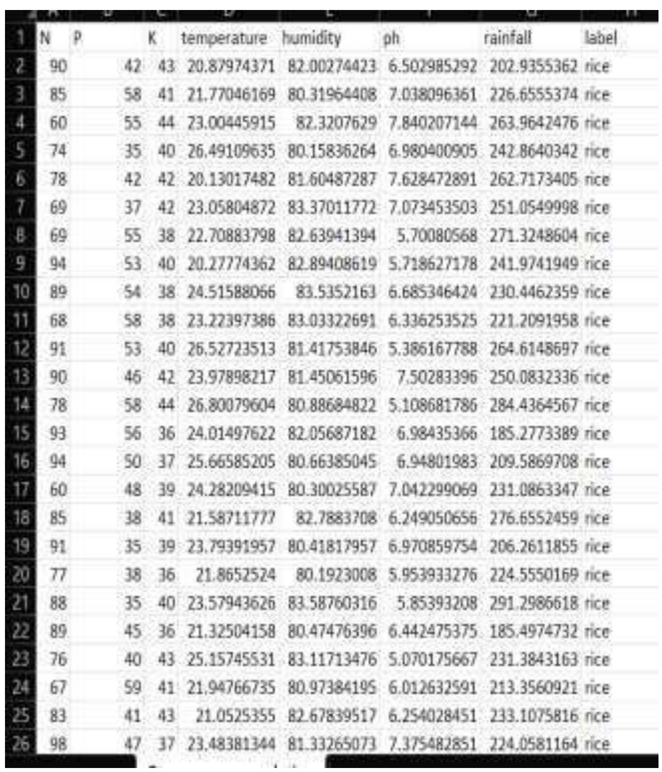


Fig. 1.result

ISSN:1581-5374E-ISSN:1855-363X
VOL. 23, NO. S3(2025)

VI. Crop Recommendation Based on Production

Fig. 2.result



	N	P	K	temperature	humidity	ph	rainfall	label
1	N	P	K	temperature	humidity	ph	rainfall	label
2	90	42	43	20.87974371	82.00274423	6.502985292	202.9355362	rice
3	85	58	41	21.77046169	80.31964408	7.038096361	226.6555374	rice
4	60	55	44	23.00445915	82.3207629	7.840207144	263.9642476	rice
5	74	35	40	26.49109635	80.15836264	6.980400905	242.8640342	rice
6	78	42	42	20.13017482	81.60487287	7.628472891	262.7173405	rice
7	69	37	42	23.05804872	83.37011772	7.073453503	251.0549998	rice
8	69	55	38	22.70883798	82.63941394	5.70080568	271.3248604	rice
9	94	53	40	20.27774362	82.89408619	5.718627178	241.9741949	rice
10	89	54	38	24.51588066	83.5352163	6.685346424	230.4462359	rice
11	68	58	38	23.22397386	83.03322691	6.336253525	221.2091958	rice
12	91	53	40	26.52723513	81.41753846	5.386167788	264.6148697	rice
13	90	46	42	23.97898217	81.45061596	7.50283396	250.0832336	rice
14	78	58	44	26.80079604	80.88684822	5.108681786	284.4364567	rice
15	93	56	36	24.01497622	82.05687182	6.98435366	185.2773389	rice
16	94	50	37	25.66585205	80.66385045	6.94801983	209.5869708	rice
17	60	48	39	24.28209415	80.30025587	7.042299069	231.0863347	rice
18	85	38	41	21.58711777	82.7883708	6.249050656	276.6552459	rice
19	91	35	39	23.79391957	80.41817957	6.970859754	206.2611855	rice
20	77	38	36	21.8652524	80.1923008	5.953933276	224.5550169	rice
21	88	35	40	23.57943626	83.58760316	5.85393208	291.2986618	rice
22	89	45	36	21.32504158	80.47476396	6.442475375	185.4974732	rice
23	76	40	43	25.15745531	83.11713476	5.070175667	231.3843163	rice
24	67	59	41	21.94766735	80.97384195	6.012632591	213.3560921	rice
25	83	41	43	21.0525355	82.67839517	6.254028451	233.1075816	rice
26	98	47	37	23.48381344	81.33265073	7.375482851	224.0581164	rice

Fig. 3.Dataset

As when we provide the all details based on the condition it predict the suitable crop, which is rice.

Given India's diverse geography and a gro-climaticzones,crop production varies significantly across regions. Recommending suitable crops based on production trends, soil conditions, and seasonal factors helps farmers optimize yields and manage resources effectively. With 15 distinct agro-climatic zones, crops are cultivated according to regional and environmental suitability. For instance, rice thrives in water-rich states like West Bengal and Assam, while wheat is dominant in northern states like Punjab and Uttar Pradesh.

Crop recommendations also depend on market demand, historicalyielddata,andenvironmentalconditionslikerainfall patterns and soil fertility. In rainfed regions such as parts of MaharashtraandMadhyaPradesh,drought-resistantcropslike millets and pulses are more suitable. Conversely, regions with irrigation infrastructure—such as the Indo-Gangetic plains— can support high-yield cash crops like sugarcane and cotton.

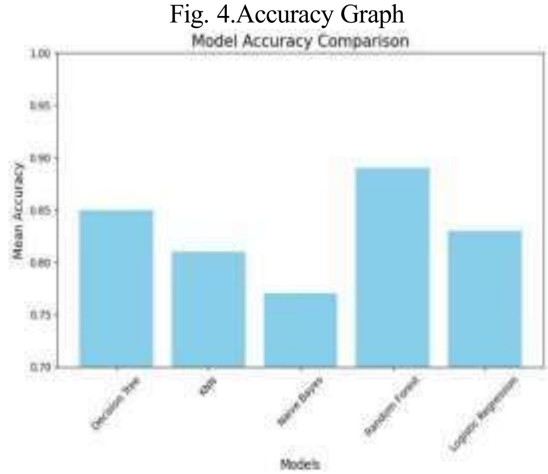
This dataset consists of essential agricultural parameters influencing rice cultivation, including:

Nutrient concentrations such as Nitrogen (N), Phosphorus (P), and Potassium (K), along with environmental factors including temperature, humidity, soil pH, and rainfall levels.

It aids farmers in planning when to plant and identifying which crops will yield the best results.

Integrating modern data analytics and machine learning tools further enhances crop recommendations. These tools analyze historicalproductiontrends,weatherforecasts,andsoildatato provide farmers with actionable insights. For instance, in TamilNadu and Kerala, recommendations may focus on crops like bananas and coconuts due to favorable climatic conditions throughout the year, while in Rajasthan, the focus shifts to crops like bajra and mustard, which require minimal water.

Fig. 4.Accuracy Graph



The chart illustrates the average accuracy of five machine learning algorithms: Decision Tree, K-Nearest Neighbors (KNN), Naive Bayes, Random Forest, and Logistic Regression. Notably, the Random Forest algorithm achieves the highest accuracy—approaching 90%—highlighting its effectiveness in managing data complexity and variability through its ensemble-based methodology.

The Decision Tree model also performs well, with a mean accuracy slightly above 85%, benefiting from its simplicity and ability to handle non-linear data. Logistic Regression achieves moderate accuracy, suggesting that it is useful for tasks where relationships between features are linear. KNN demonstrates slightly lower accuracy, which could be due toits sensitivity to noisy data or parameter tuning challenges. Naive Bayes shows the lowest performance, with an accuracy near 75%, possibly because of its assumption of feature independence, which may not hold for the dataset used.

The assumption of independence may not be valid for the dataset in question. Overall, the Random Forest model emerges as the most appropriate choice for the task based on the results obtained, while simpler models like Naive Bayes may not perform as well in capturing the data's complexity.

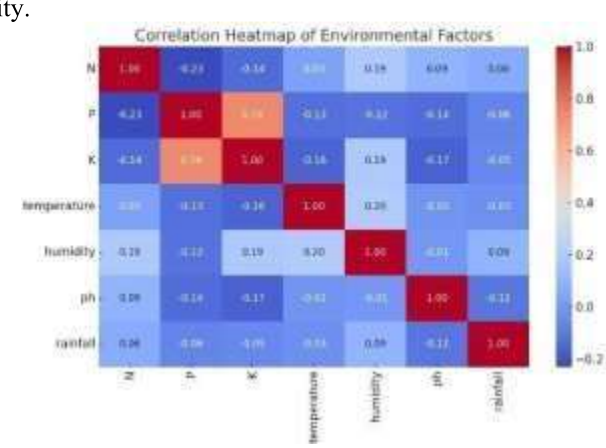


Fig.5.Heatgraph

The heat map shows the correlation between various environmental factors and soil nutrients. Key observations include a strong positive correlation between phosphorus (P) and potassium (K) with a value of 0.74, indicating they often increase together. With most correlation coefficients nearing zero, this points to a lack of significant linear connections between the factors like nitrogen (N), temperature, humidity, pH, and rainfall. This implies that these variables are relatively independent of one another, with only a few moderate associations.

By tailoring crop recommendations based on production patternsandregionalfactors,farmersacrossIndiacanimprove productivity and mitigate risks related to climate change and fluctuating market prices. This targeted approach ensures better planning, resource optimization, and sustainable agriculture practices, benefiting both the farmers and the economy as a whole.

I. CONCLUSION

The use of technology in agriculture, particularly machine learning and data analytics, plays a crucial role in helping farmersmanagetheircropsmoreeffectively.Byanalyzing data on crop production and seasonal factors, personalized recommendations can be provided to farmers, helpingthem increase their yields and improve their productivity. Approaches in machine learning, for example neural networks andclustering algorithms, offer powerful tools for predicting crop yields and making informed decisions about crop cultivation. The integration of these techniques into agriculture is essential for ensuring the futuresustainability of farming practices.

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