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Crop Recommendation System using Machine Learning

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***Abstract*— Modern agriculture faces the challenge of optimizing crop yield while minimizing resource usage. This project addresses this challenge by presenting a Crop Recommendation System utilizing machine learning techniques. The system considers user-inputted soil parameters, including nitrogen, phosphorus, potassium, humidity, pH value and also incorporates temperature and rainfall data based on the geographical area. The problem at hand is the need for a personalized and data-driven approach to crop selection, accounting for both soil characteristics and climate conditions. Traditional methods often lack adaptability to changing environmental factors, leading to suboptimal crop recommendations. The methodology involves the development of a machine learning model trained on a comprehensive dataset encompassing soil and climate information for diverse crops. This model processes user inputs to generate tailored recommendations. The temperature and rainfall data enhances the system's adaptability, providing accurate suggestions for crop cultivation. The results demonstrate the system's efficacy in providing precise crop recommendations. By considering both soil properties and climatic factors, the model outperforms traditional methods, offering farmers a valuable tool for informed decision-making in crop selection. In conclusion, this project contributes to precision agriculture by introducing a user-friendly Crop Recommendation System. The integration of machine learning ensures the system's adaptability to varying environmental conditions, providing farmers with accurate and timely suggestions for optimizing crop productivity. This approach holds promise for sustainable and resource-efficient agricultural practices.**

***Index Terms*— Crop Recommendation System, Machine Learning, Soil Parameters, Crop Productivity, Supervised Algorithms, Naïve Bayes, Random Forest.**

I. INTRODUCTION

In the contemporary agricultural landscape, the pursuit of increased crop yield and sustainable farming practices has led to a growing reliance on advanced technologies. Precision agriculture, a paradigm that seeks to optimize resource utilization while maximizing productivity, has become pivotal in addressing the challenges faced by the agricultural sector. This project endeavours to contribute to the realm of precision agriculture by introducing a sophisticated Crop Recommendation System that harnesses the power of machine learning models. The agricultural sector is confronted with the intricate task of aligning crop cultivation practices with the specific characteristics of the soil and the dynamic nature of climate conditions. Traditional methods of crop selection often

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fall short in adapting to the nuanced interplay between soil parameters and real-time climatic variations. Recognizing this gap, our project aims to bridge it by offering a comprehensive and user-friendly solution. The core problem this project addresses is the need for a personalized and data-driven approach to crop recommendation. Farmers often grapple with the complexities of making optimal choices for crop cultivation, considering factors such as soil composition, nutrient levels, and varying climatic conditions. The proposed Crop Recommendation System seeks to empower farmers by seamlessly integrating machine learning algorithms with user-provided soil data and climate information. The methodology employed involves the development of a robust machine learning model. Trained on an extensive dataset encompassing diverse soil and climate information for various crops, this model becomes adept at recognizing intricate patterns and relationships. By considering vital soil parameters, such as nitrogen, phosphorus, potassium, soil humidity, and pH value, in conjunction with temperature and rainfall data based on the geographical area, the system aims to provide precise and tailored crop recommendations. As we embark on this journey into precision agriculture, the promise of optimized resource utilization, increased crop yield, and sustainable farming practices beckons. The subsequent sections of this project will delve into the procedural intricacies, the development and application of the machine learning model, and the compelling results that position our Crop Recommendation System as a valuable tool for informed decision-making in contemporary agriculture.

II. Discussion And Related Work

Agriculture, especially in developing nations like India, is undergoing a transformative phase through the integration of information technology. This literature survey explores the current state of data mining systems, machine learning applications, and automated techniques in agriculture.

The papers address the slow adoption of technology in agriculture and highlight the potential of data mining and machine learning [1,2]. They evaluate the impact of these technologies on the decision-making processes of farmers, emphasizing their effectiveness in precision farming. They also introduce automated systems for weed detection and crop prediction using machine learning algorithms [3, 4]. The paper also discusses the challenges of indiscriminate fertilizer use and repetitive crop cultivation, proposing decision tree algorithms for crop prediction [4]. Furthermore, they provide reviews of decision tree classifiers and their applications in diverse fields [5]. The focus on crop production forecasting in Bangladesh is highlighted, introducing an ensemble machine learning approach [6]. Moreover, an insightful overview of machine learning is provided, exploring its differentiation from statistical inference and specifically highlighting Scikit-learn in Python [7]. Finally, the comparison of popular algorithms like k-nearest neighbour, decision tree, and random forest classifier using Gini and entropy criteria is discussed [8].

III. Proposed Architecture And Methodology

A. Algorithms used

It is the inevitable need for good production of the crop to have a certain amount of Nitrogen, Phosphorus, Potassium, Soil pH, Temperature, and Humidity. Different varieties of crops have different needs for these nutrients and nature's attributes. The initial dataset has been collected from online sources along with which fine machine learning algorithms have been used to give this model a boost in reliability and accuracy, empowering the users with a precise suggestion/ recommendation of the crop to be planted.

The algorithms used are:

1) *Random Forest*: Due to its nature of handling complex data this is a keen choice to be concerned for the model. Random forest algorithm provides Ensemble learning and aggregating predictions from multiple decision trees, handling non-linear relationships, offering feature importance insights, and mitigating overfitting. Its scalability and ability to handle missing data contribute to robust and accurate crop selection guidance.
2) *Decision Tree*: The decision tree algorithm in a crop recommendation system models decision paths based on factors like soil quality and climate. It provides a transparent framework for understanding feature importance, aiding farmers in informed crop selection.
3) *Naive Bayes*: In a crop recommendation system, the Naive Bayes algorithm leverages probability and statistical independence assumptions to assess the likelihood of crop success given environmental factors. It efficiently categorizes and recommends crops based on available data.
4) *Support Vector:* The Support Vector Machine (SVM) algorithm in a crop recommendation system identifies optimal decision boundaries, considering factors like soil nutrients and weather properties like temperature and humidity. It classifies crops, aiding farmers in choosing suitable varieties for specific conditions.

5) *Logistic Regression*: This algorithm in a crop recommendation system assesses the probability of successful crop outcomes based on input variables. It aids decision-making by predicting and categorizing suitable crops for specific agricultural conditions with efficiency.

B. System Architecture

The suggested architecture is shown in Figure 1. Here is a step-by-step description of the architecture:
1) It starts with a "user" interacting with a "User Interface".
2) The information flows into a "Data Set".
3) The data undergo "Data Pre-Processing" and are then transformed into "Training Data".
4) This training data is fed to "Machine Learning Algorithms".
5) The recommendation system, which is labelled as "Recommended System", employs the data processed by the machine learning algorithm.
6) Finally, the recommendation system provides a "Result Prediction" that feeds back to the user interface.

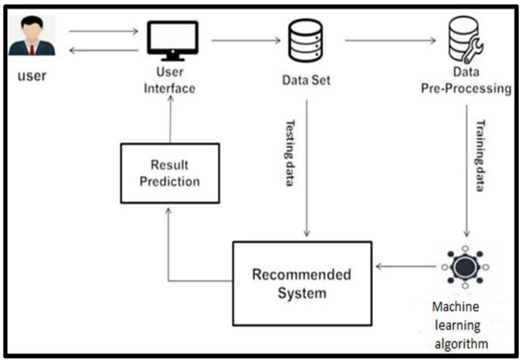


Figure 1. Architecture of the Model

C. Data pre-processing

Here's a step-by-step process for the described data pre-processing:
1) Metadata Initialization:
a. Assign unique numbers to each crop name.
b. Ensure no duplication of numbers; each crop has a distinct number identifier.
2) Cleaning Raw Crop Data: Remove any missing values, inconsistencies, or irrelevant information from the raw crop data.
3) Load Metadata: Load the metadata containing the crop names mapped to their respective unique numbers.
4) Merge Metadata with Raw Data: Attach the metadata to the cleaned crop data by mapping the crop names to their assigned numbers.
5) Replace Crop Names with Numbers: Replace the actual crop names in the dataset with the unique numbers from the metadata.
6) Split Data into Training and Testing Sets: Segregate the pre-processed data into separate sets for training and testing the algorithm. The training set is used to train the model, while the test set evaluates its performance.

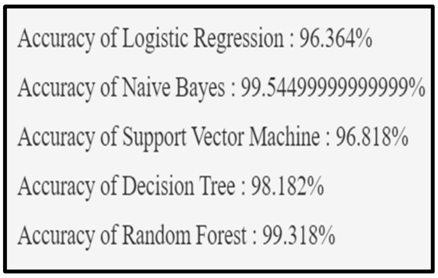
IV. RESULTS AND DISCUSSION

Various machine learning algorithms namely, Decision Tree, Naïve Bayes, SVM, Logistic Regression, and Random Forest were employed to predict crop outcomes. The accuracy of five algorithms is shown in Fig. 2. All the algorithms exhibited impressive accuracy rates exceeding 90 percent.

From Fig. 3, it is clearly visible that both Random Forest and Naïve Bayes algorithms achieved exceptional accuracy rates exceeding 99 percent. Given the highest accuracy achieved by the Naïve Bayes algorithm, it was chosen as the model to predict crop yields.

Table 1 compares the performance of our proposed study with previous studies in this field. According to the table, our final model (Naïve Bayes) achieved an accuracy score approximately 7.54% and 11.54% higher than model results in Ref. [15] and Ref. [20] respectively.

Also, as shown in table 1, we have achieved higher accuracy in all the individual algorithm models from previous studies.



Accuracy of Logistic Regression : 96.364%

Accuracy of Naive Bayes : 99.54499999999999%

Accuracy of Support Vector Machine : 96.818%

Accuracy of Decision Tree : 98.182%

Accuracy of Random Forest : 99.318%

Figure 2. Accuracy of Algorithms Used for Crop Recommendation

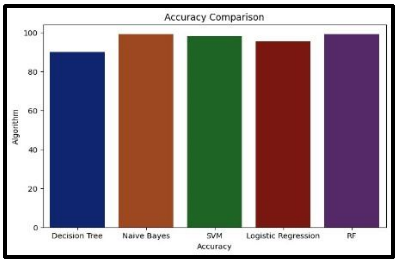


Figure 3. Graphical Representation of Accuracy of Different Algorithms

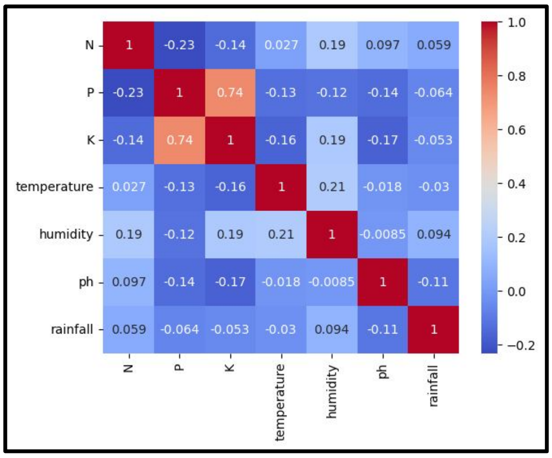


Figure 4. Heat map showing correlation between attributes of the crop dataset

TABLE I. COMPARISON WITH PREVIOUS STUDIES

Reference	Machine learning algorithm	Accuracy (%)
[15]	Naïve Bayes	92
[18]	Decision Tree Logistic Regression	90 95.22
[20]	Decision Tree Naïve Bayes Random Forest Logistic Regression Support Vector Machine	86.80 88.00 88.00 86.04 89.66
Our study	Decision Tree Naïve Bayes Random Forest Logistic Regression Support Vector Machine	98.182 99.544 99.318 96.364 96.818

V. CONCLUSION

In conclusion, the development and implementation of the Crop Recommendation System represent a significant leap forward in precision agriculture, offering farmers a tailored and data-driven approach to crop cultivation. The integration of machine learning algorithms, trained on a diverse dataset encompassing soil and climate information, enables the system to provide personalized recommendations based on specific soil characteristics and climatic conditions. The advantages of this system, including personalized recommendations, data driven decision-making, a user-friendly interface, optimized resource utilization, increased crop productivity, and sustainability, collectively contribute to the advancement of agricultural practices. The system's success lies in its ability to empower farmers with insights beyond traditional methods, allowing them to make informed decisions that align with the natural attributes of their land. The personalized nature of the recommendations ensures that farmers receive advice tailored to their unique agricultural context, fostering a more efficient and productive farming environment.

REFERENCES

[1] Geetha, M. C. S. "A survey on data mining techniques in agriculture." International journal of innovative research in computer and communication engineering 3.2 (2015): 887-892

[2] Karandeep Kaur" Machine Learning: Applications in Indian Agriculture." International journal of innovative research in computer and communication engineering (2016)

[3] S. S. Athani and C. Tejeshwar, "Support Vector Machine-Based Classification Scheme of Maize Crop," 2017 IEEE 7th International Advance Computing Conference (IACC), Hyderabad, India, 2017, pp. 84-88, doi: 10.1109/IACC.2017.0032.

[4] Nischitha, K., Vishwakarma, D., Ashwini, M.N. and Manjuraju, M.R., 2020. Crop prediction using machine learning approaches. International Journal of Engineering Research & Technology (IJERT), 9(08), pp.23-26.

[5] Charbuty, B. and Abdulazeez, A., 2021. Classification based on decision tree algorithm for machine learning. Journal of Applied Science and Technology Trends, 2(01), pp.20-28

[6] Moon, M.H., Marjan, M.A., Uddin, M.P., Ibn Afjal, M., Kadry, S., Ma, S. and Nam, Y., 2023. Ensemble machine learning-based recommendation system for effective prediction of suitable agricultural crop cultivation. Frontiers in Plant Science, 14, p.1234555.

[7] Hao, Jiangang & Ho, Tin. (2019). Machine Learning Made Easy: A Review of Scikit-learn Package in Python Programming Language. Journal of Educational and Behavioral Statistics. 44. 107699861983224. 10.3102/1076998619832248.

[8] Rao, M.S., Singh, A., Reddy, N.S. and Acharya, D.U., 2022. Crop prediction using machine learning. In Journal of Physics: Conference Series (Vol. 2161, No. 1, p. 012033). IOP Publishing.

[9] Sapre, A., & Vartak, S. (2020, December). Scientific Computing and Data Analysis using NumPy and Pandas. Irjet.net

[10] M. Kalimuthu, P. Vaishnavi and M. Kishore, "Crop Prediction using Machine Learning," 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, 2020, pp. 926-932, doi: 10.1109/ICSSIT48917.2020.9214190.

[11] Gupta, A., Nagda, D., Nikhare, P. and Sandbhor, A., 2021. Smart crop prediction using IoT and machine learning. International Journal of Engineering Research & Technology (IJERT), 9(3).

[12] Patil, P., Panpatil, V. and Kokate, S., 2020. Crop prediction system using machine learning algorithms. Int. Res. J. Eng. Technol.(IRJET), 7(02)

[13] Pant, J., Pant, R.P., Singh, M.K., Singh, D.P. and Pant, H., 2021. Analysis of agricultural crop yield prediction using statistical techniques of machine learning. Materials Today: Proceedings, 46, pp.10922-10926.

[14] Dharani, M.K., Thamilselvan, R., Natesan, P., Kalaivaani, P.C.D. and Santhoshkumar, S., 2021, February. Review on crop prediction using deep learning techniques. In Journal of Physics: Conference Series (Vol. 1767, No. 1, p. 012026). IOP Publishing.

[15] Bandara, P., Weerasooriya, T., Ruchirawya, T., Nanayakkara, W., Dimantha, M. and Pabasara, M., 2020. Crop recommendation system. International Journal of Computer Applications, 975, p.8887.

[16] S. Pudumalar, E. Ramanujam, R. H. Rajashree, C. Kavya, T. Kiruthika and J. Nisha, "Crop recommendation system for precision agriculture," 2016 Eighth International Conference on Advanced Computing (ICoAC), Chennai, India, 2017, pp. 32-36, doi: 10.1109/ICoAC.2017.7951740.

[17] Z. Doshi, S. Nadkarni, R. Agrawal and N. Shah, "AgroConsultant: Intelligent Crop Recommendation System Using Machine Learning Algorithms," 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA), Pune, India, 2018, pp. 1-6, doi: 10.1109/ICCUBEA.2018.8697349.

[18] Gosai, D., Raval, C., Nayak, R., Jayswal, H. and Patel, A., 2021. Crop recommendation system using machine learning. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 7(3), pp.558-569.

[19] Rajak, R.K., Pawar, A., Pendke, M., Shinde, P., Rathod, S. and Devare, A., 2017. Crop recommendation system to maximize crop yield using machine learning technique. International Research Journal of Engineering and Technology, 4(12), pp.950-953

[20] Kumar, A., Sarkar, S., & Pradhan, C. (2019). Recommendation System for Crop Identification and Pest Control Technique in Agriculture. 2019 International Conference on Communication and Signal Processing (ICCSP), 0185-0189.