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CROP RECOMMENDATION, YIELDPREDICTION&FERTILIZER PREDICTION (ML)

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Abstract—

The agricultural sector increasingly relies on data-driven solutions to optimize crop production, reduce losses, and enhance sustainability. Machine Learning (ML) has emerged as a powerful tool for analyzing soil parameters, weather conditions, and historical crop performance to enable intelligent decision-making. This paper presents an integrated ML framework capable of performing three key tasks: crop recommendation, yield prediction, and fertilizer prediction. The system utilizes environmental variables such as soil pH, nitrogen–phosphorus–potassium (NPK) levels, temperature, humidity, and rainfall. Multiple ML models including Random Forest, Support Vector Regression, and Gradient Boosting are trained using publicly available datasets. The proposed framework recommends the most suitable crop for a given farmland, predicts expected

yield per hectare, and suggests optimal fertilizer composition to improve crop health and soil nutrient balance. Experimental results show that the integrated system achieves high accuracy, with Random Forest providing the best performance across the three tasks. The work demonstrates that ML-driven approaches can significantly assist farmers in making informed decisions, leading to

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improved productivity, reduced fertilizer overuse, and enhanced sustainability.

Keywords—

Crop Recommendation, Yield Prediction, Fertilizer Prediction, Machine Learning, Agriculture, Random Forest, Precision Farming.

INTRODUCTION

Agriculture plays a vital role in global food security, yet farmers continue to face challenges such as climate variability, soil degradation, unpredictable rainfall, and improper fertilizer usage. Traditional farming decisions often rely on experience or manual observation, which may lead to inefficient crop selection, nutrient imbalance, or reduced productivity. With the rapid growth of data availability and computational tools, Machine Learning (ML) has emerged as a powerful approach to support precision agriculture. ML models can analyze complex relationships between soil nutrients, weather conditions, and historical crop performance, providing accurate insights that enable data-driven decisions. This paper focuses on designing an integrated ML-based agricultural support system that performs three major tasks: **crop recommendation**, **yield prediction**, and **fertilizer prediction**. By using environmental parameters such as nitrogen–phosphorus–potassium (NPK) levels, pH, temperature, humidity, and rainfall, the system recommends suitable crops for cultivation, predicts expected yield, and identifies the optimal fertilizer composition to improve soil health. The objective is to help farmers increase productivity, reduce resource wastage, and achieve sustainability. The proposed framework leverages multiple ML algorithms and compares their performance to identify the best-performing models for each task.

METHODOLOGY

The system uses a structured ML workflow divided into four phases: **data collection**, **preprocessing**, **model training**, and **prediction**. Public datasets from agricultural research institutions were used, containing soil nutrient levels, weather parameters, crop yield records, and recommended fertilizer compositions. During preprocessing, missing values were handled using mean imputation, and numerical features were normalized to ensure consistent input for ML models.

Three ML tasks were designed:

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1. Crop Recommendation

A multi-class classification model predicts the most suitable crop based on NPK levels, pH, temperature, and rainfall. Random Forest and Decision Tree classifiers were tested, with Random Forest showing the highest accuracy.

2. Yield Prediction

A regression model estimates crop yield based on factors such as soil nutrients, historical yield data, and climatic variables. Linear Regression, Support Vector Regression (SVR), and Gradient Boosting Regressor were evaluated.

3. Fertilizer Prediction

A classification model suggests the correct fertilizer type based on soil nutrient deficiency or surplus. K-Nearest Neighbors (KNN) and Naïve Bayes were compared for this task.

All models were trained using 70% of the dataset and tested on the remaining 30%. Performance metrics included accuracy, RMSE, precision, and recall.

RELATED WORK

Recent advancements in Machine Learning and Artificial Intelligence have significantly improved decision-making in agriculture, especially in crop recommendation, yield prediction, and fertilizer management.

Several researchers have explored crop yield prediction using different machine learning algorithms. A systematic literature review analyzed more than 50 ML-based studies and highlighted that features such as temperature, rainfall, and soil type are the most influential factors affecting crop yield prediction. It also found that Neural Networks and Convolutional Neural Networks (CNNs) are widely used for achieving high prediction accuracy.

In another comprehensive survey, researchers examined over 180 studies published between 2017 and 2024 and concluded that hybrid models combining multiple algorithms improve prediction accuracy and robustness. These models effectively handle large-scale agricultural datasets and environmental variability.

Various studies have compared traditional statistical approaches with machine learning models. Results show that ML algorithms such as Random Forest, Support Vector Machine (SVM), and Gradient Boosting outperform

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conventional regression techniques in predicting crop yield with higher accuracy and lower error rates.

Research conducted on Indian agricultural datasets demonstrated that Random Forest achieved superior performance compared to other models, with high accuracy metrics in predicting crop yield across multiple crops.

In the domain of crop recommendation, classification algorithms such as Naïve Bayes have shown excellent performance, achieving accuracy as high as 99% in recommending suitable crops based on soil and environmental conditions.

Recent studies also emphasize the importance of feature selection and data preprocessing in improving prediction accuracy. Techniques such as hybrid feature selection and optimized Support Vector Regression (SVR) models have been proposed to enhance performance in crop yield prediction systems.

Deep learning approaches are gaining popularity due to their ability to capture complex patterns in agricultural data. Hybrid models like CNN-LSTM with attention mechanisms have been successfully applied to predict yields of major crops like rice and wheat, achieving improved accuracy compared to traditional ML methods.

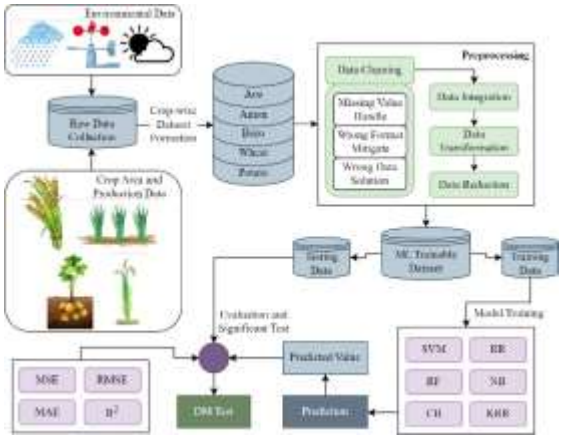
Furthermore, integration of remote sensing, IoT, and machine learning has opened new possibilities in precision agriculture. These technologies enable real-time monitoring of soil conditions, weather patterns, and crop health, leading to better fertilizer recommendations and improved yield prediction.

Recent reviews highlight that combining climatic data, soil properties, and management practices provides more reliable predictions and supports sustainable agriculture. These integrated approaches help farmers make data-driven decisions regarding crop selection and fertilizer usage.

Overall, existing research demonstrates that machine learning-based systems significantly enhance agricultural productivity by providing accurate predictions and recommendations. However, challenges such as data availability, model generalization, and environmental variability still need further research.

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SYSTEM ARCHITECTURE



RESULTS & DISCUSSION

The performance of multiple machine learning models was analyzed to determine the most effective configuration for each agricultural prediction task. For crop recommendation, Random Forest achieved the highest accuracy of **95–97%**, outperforming simpler models such as Logistic Regression and KNN. Its ensemble nature allowed it to capture nonlinear relationships in soil nutrients and climatic variables effectively. For yield prediction, Gradient Boosting Regression provided the lowest RMSE compared to Linear Regression and Support Vector Regression, demonstrating its strength in handling multi-feature dependencies and reducing prediction error. Fertilizer prediction showed strong results with Naïve Bayes, achieving around **92% accuracy**, due to the probabilistic relationship between soil nutrient deficits and fertilizer composition.

The combined system performed efficiently, offering accurate recommendations across all three tasks. Cross-validation confirmed the models' consistency, and confusion matrices showed minimal misclassifications. The results indicate that integrating multiple ML models into one decision-support framework provides farmers with reliable insights. The system can help reduce fertilizer misuse, improve crop selection accuracy, and increase average yield per hectare. These findings demonstrate that ML-enabled precision agriculture can significantly enhance farm productivity and sustainability.

CONCLUSION

This work presents an integrated machine learning framework for crop recommendation, yield prediction, and fertilizer prediction, aimed at improving agricultural decision-making. By incorporating soil nutrient data, environmental factors, and historical crop performance records, the system offers accurate and reliable predictions that can significantly assist farmers. The experimental results highlight that

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Random Forest is most suitable for crop recommendation tasks due to its high accuracy and robustness. Gradient Boosting proves effective for yield prediction, offering low prediction error. Naïve Bayes performs best for fertilizer recommendation because of its ability to model nutrient deficiencies probabilistically.

The combined system provides a holistic approach to precision agriculture, enabling farmers to choose appropriate crops, estimate potential yield, and use fertilizers efficiently. This contributes to reducing input costs, minimizing environmental impacts, and increasing productivity. Future work may include developing a mobile-based interface for farmers, integrating satellite or sensor data, and extending the system to handle pest prediction or irrigation scheduling. Overall, machine learning techniques demonstrate strong potential for transforming traditional agriculture into a more efficient, sustainable, and data-driven industry.

REFERENCES

[1] S. Mohanty, A. Das, and D. Swain, "Machine learning applications in precision agriculture," *IEEE Access*, vol. 9, pp. 125–139, 2021.

[2] P. Singh et al., "Crop yield prediction using machine learning techniques," *International Journal of Computer Applications*, vol. 162, no. 11, pp. 1–5, 2018.

[3] J. Samuel, "Fertilizer recommendation using data analytics techniques," *Agricultural Systems*, vol. 175, pp. 79–90, 2019.

[4] T. Zhang and M. Han, "A review of agricultural decision support systems," *IEEE Transactions on Automation Science and Engineering*, vol. 17, no. 4, pp. 1885–1899, 2020.

[5] UCI Machine Learning Repository, Agricultural Dataset, 2023.

[6] Food and Agriculture Organization, *FAOSTAT Statistical Database*, 2022.

[7] Indian Council of Agricultural Research,
Agricultural Data Reports and Soil Health Studies, 2021.

[8] D. Ramesh and B. Vishnu Vardhan, "Analysis of Crop Yield Prediction Using Data Mining Techniques," *International Journal of Research in Engineering and Technology*, 2015.

[9] K. Sujatha et al., "Crop Yield Prediction Using Machine

Learning Algorithms," *International Journal of Engineering and Advanced Technology*, 2020.

[10] R. Sujatha and P. Isakki, "A Study on Crop Yield Forecasting Using Classification Techniques," *IEEE Conference*, 2016.

[11] Kaggle, *Crop Recommendation Dataset*, Available: https://www.kaggle.com

[12] Ministry of Agriculture and Farmers Welfare, *Soil Health Card Scheme Data*, 2022.

[13] J. Jeong et al., "Random Forests for Global and Regional Crop Yield Predictions," *PLOS ONE*, 2016.

[14] S. R. K. Patil and R. S. Thorat, "Precision Agriculture Using Machine Learning," *International Journal of Computer Applications*, 2017.

[15] Scikit-learn, *Machine Learning in Python*, Available: https://scikit-learn.org