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SmartCrop: Intelligent Crop Suggestion Based on Soil Health

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Problem Statement

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Crop selection is usually trial and error; farmers have no way to adjust to changing conditions (soil quality, climate, seasonal changes), which can lead lower productivity, inefficient resource use, and unsustainable agriculture.

Proposed Solution

Our Machine Learning–based Crop Recommendation System provides farmers with intelligent, data-informed recommendations. It uses soil parameters (N, P, K, pH), climate (temperature, rainfall, humidity) to provide recommendations on potential crops for those conditions. The Crop Recommendation System will produce higher yield, sustainable use of resources, and allow farmers to make more informed decisions through adaptive decision support.

Introduction

Objective

Develop a crop recommendation system that analyzes soil and weather parameters to suggest the most suitable crops.

Functionality

- Identify suitable crops using soil health data (pH, NPK, moisture, temperature).
- Incorporate weather and seasonal insights for accurate predictions.
- Use machine learning models like Random Forest & KNN for crop suggestion.

Key Benefit

Improves crop yield, reduces resource wastage, and ensures long-term soil fertility.

Target Users

- Small and marginal farmers
- Agricultural experts
- Policymakers
- Agritech developers

Purpose

Transform traditional farming into smart farming by providing data-driven crop recommendations.

Methodology

1.Data Collection & Preprocessing

Utilize publicly available crop dataset (soil & climate data: N, P, K, pH, temp, rainfall, humidity).
Missing value handling (mean/mode imputation).
Categorical feature encoding (one-hot encoding).
Normalization of numerical features (MinMax scaling).
Splitting the dataset: 80% training, 20% test with stratification.

2.Feature Selection & Engineering

Most important soil & climate attributes.
Ranking attribute importance.
Minimizing bias and increasing interpretability.

3. Model Selection & Training

Algorithms: Random Forest Classifier (main) + Neural Network (Keras).
Hyperparameter tuning, early stopping to avoid overfitting.
Train on 80:20 train-validation split.

4. Testing & Evaluation

Test with accuracy, precision, recall, F1-score.
Apply confusion matrix for detailed error analysis.
Reached ~99% accuracy.

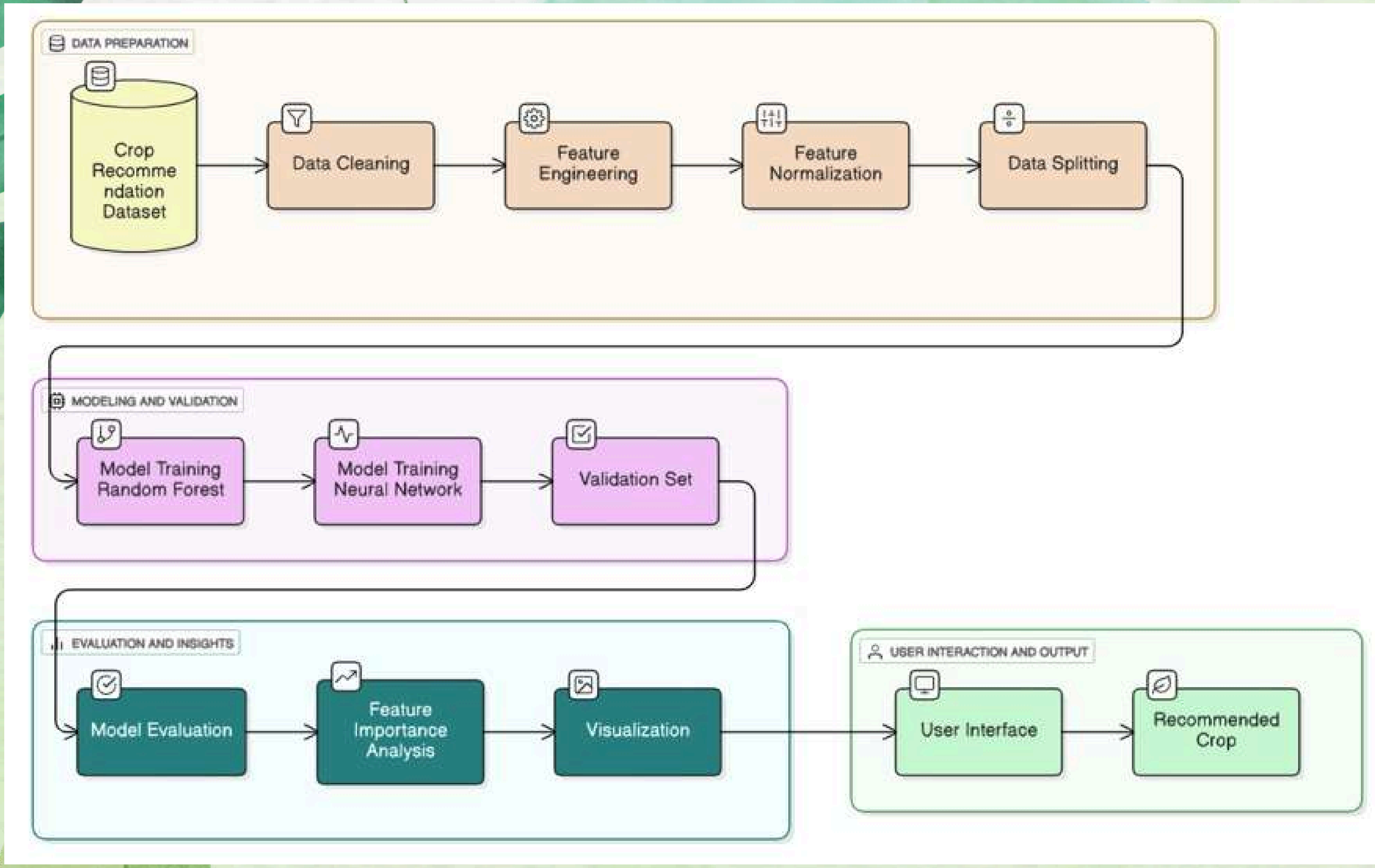
5. Recommendation System (User Interface)

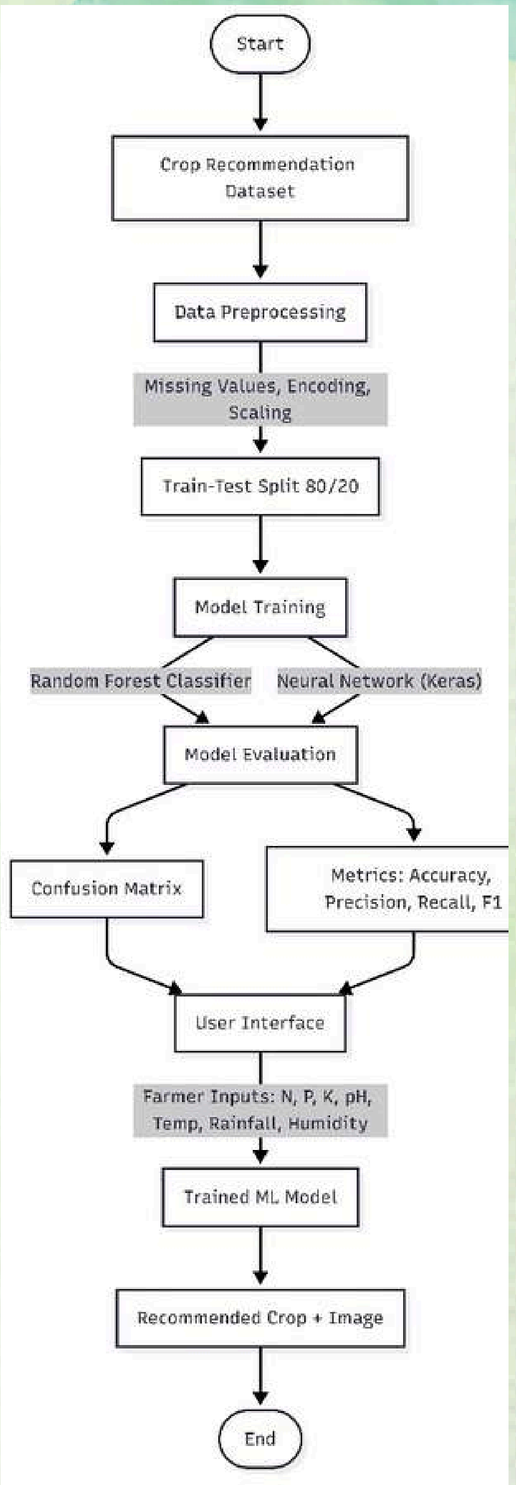
GUI where users enter soil & climate features.
System recommends best crop and displays crop image.
"Get Recommendation" button for easy use.

6. Future Enhancements

Incorporate IoT-based soil & weather sensors.
Host on cloud for scalability.
Partner with agricultural boards for more richer datasets.
Include sustainability & resource optimization reports.

Architecture and Flow Diagram





Implementation Details

Tech Stack:
Programming Language: Python
Frameworks: Scikit-learn, TensorFlow, Keras
Libraries: Pandas, NumPy, Matplotlib, Seaborn, Flask
Frontend: HTML, CSS, JavaScript,
Environment: VS Code, Jupyter Notebook

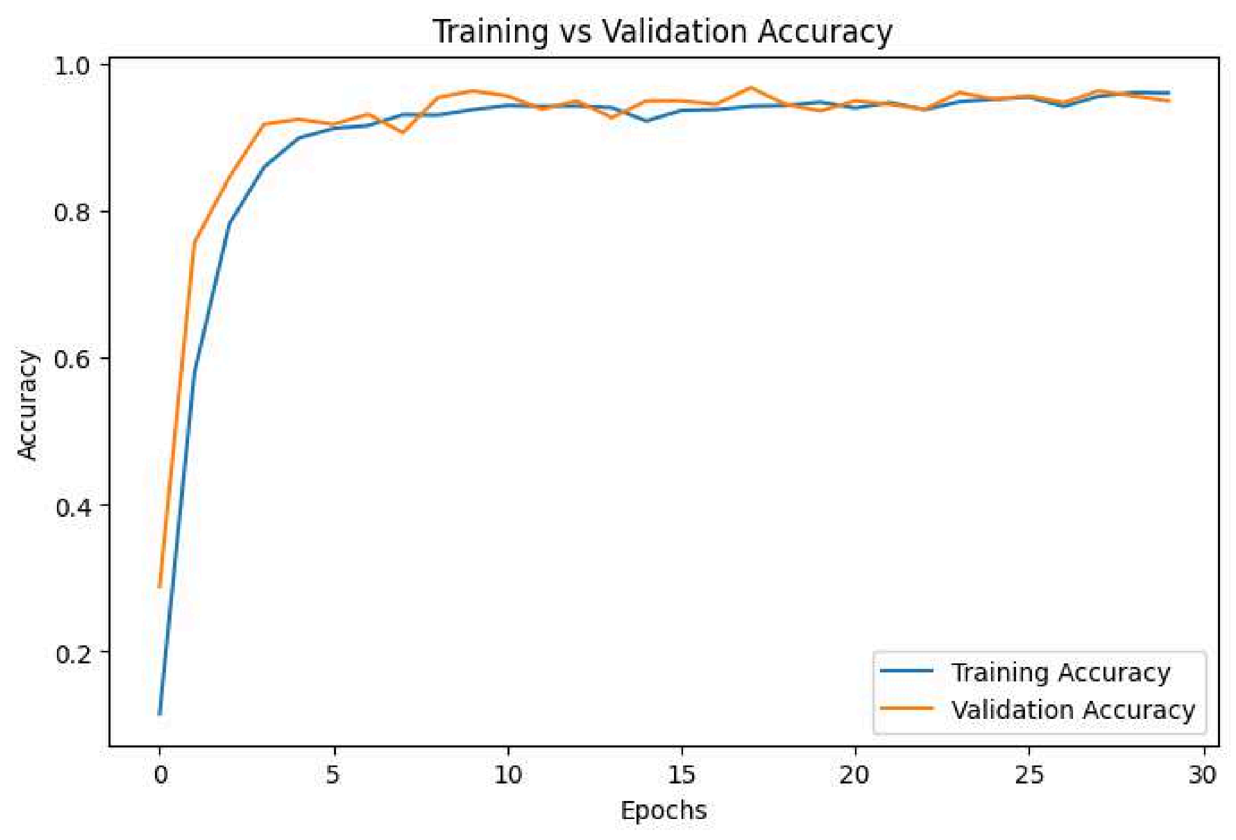
Dataset Details:
Source: Kaggle Crop Recommendation Dataset
Features: N, P, K, pH, temperature, humidity, rainfall
Target: Crop type (22 categories)

Preprocessing:
Missing values treated (mean/mode imputation)
One-hot categorical encoding
Feature scaling with MinMax normalization (0–1)
Dataset split: 80% training, 20% testing with stratification

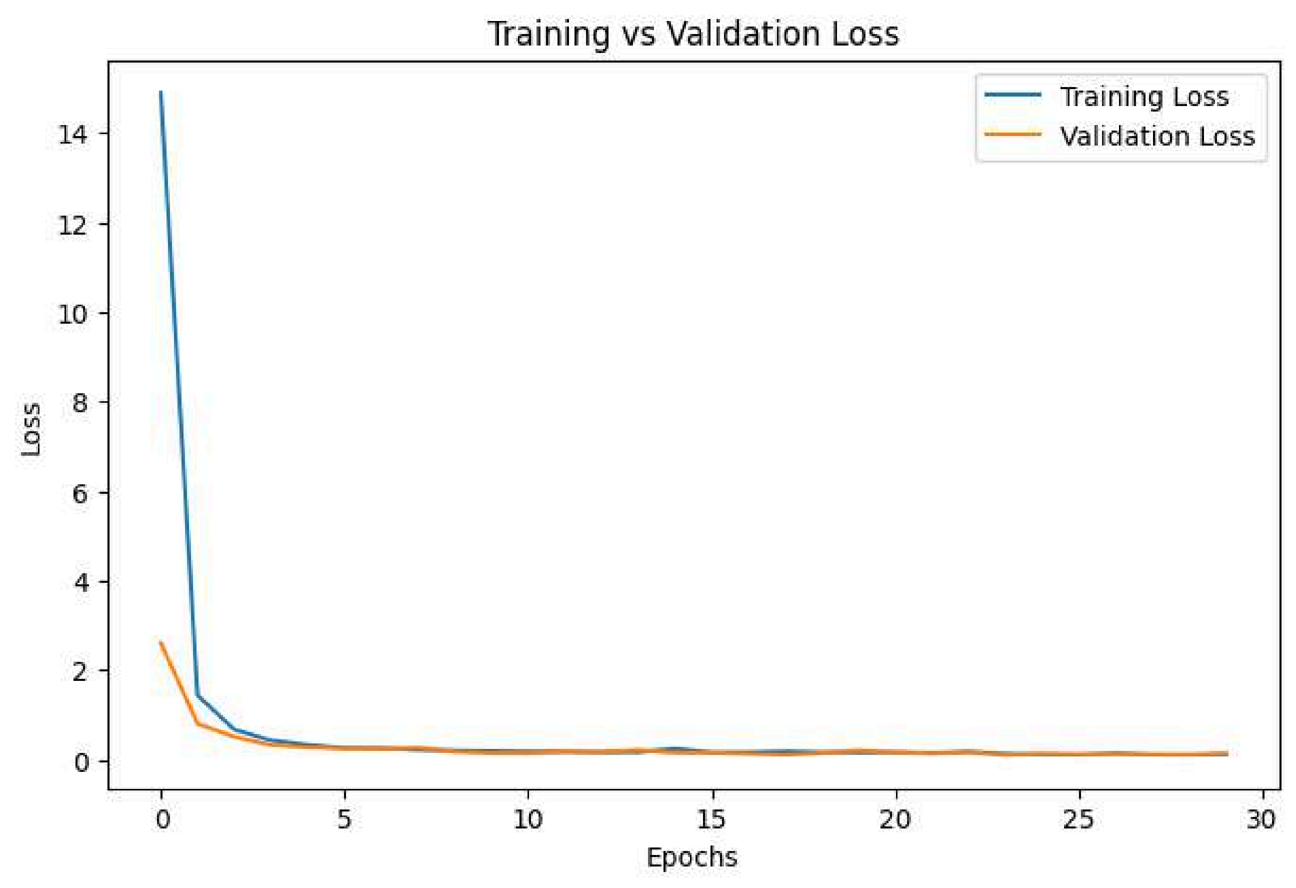
Model Training:
Algorithms Used: Random Forest Classifier, Neural Network (Keras)
Loss Function: Cross-Entropy Loss
Optimization: Adam optimizer (learning rate = 0.001)

Hyperparameters:
Epochs: 50–100 (with Early Stopping)
Batch Size: 32
Evaluation Metrics: Accuracy, Precision, Recall, F1-score, Confusion Matrix
Performance: Accuracy ~ 0.9608

Results

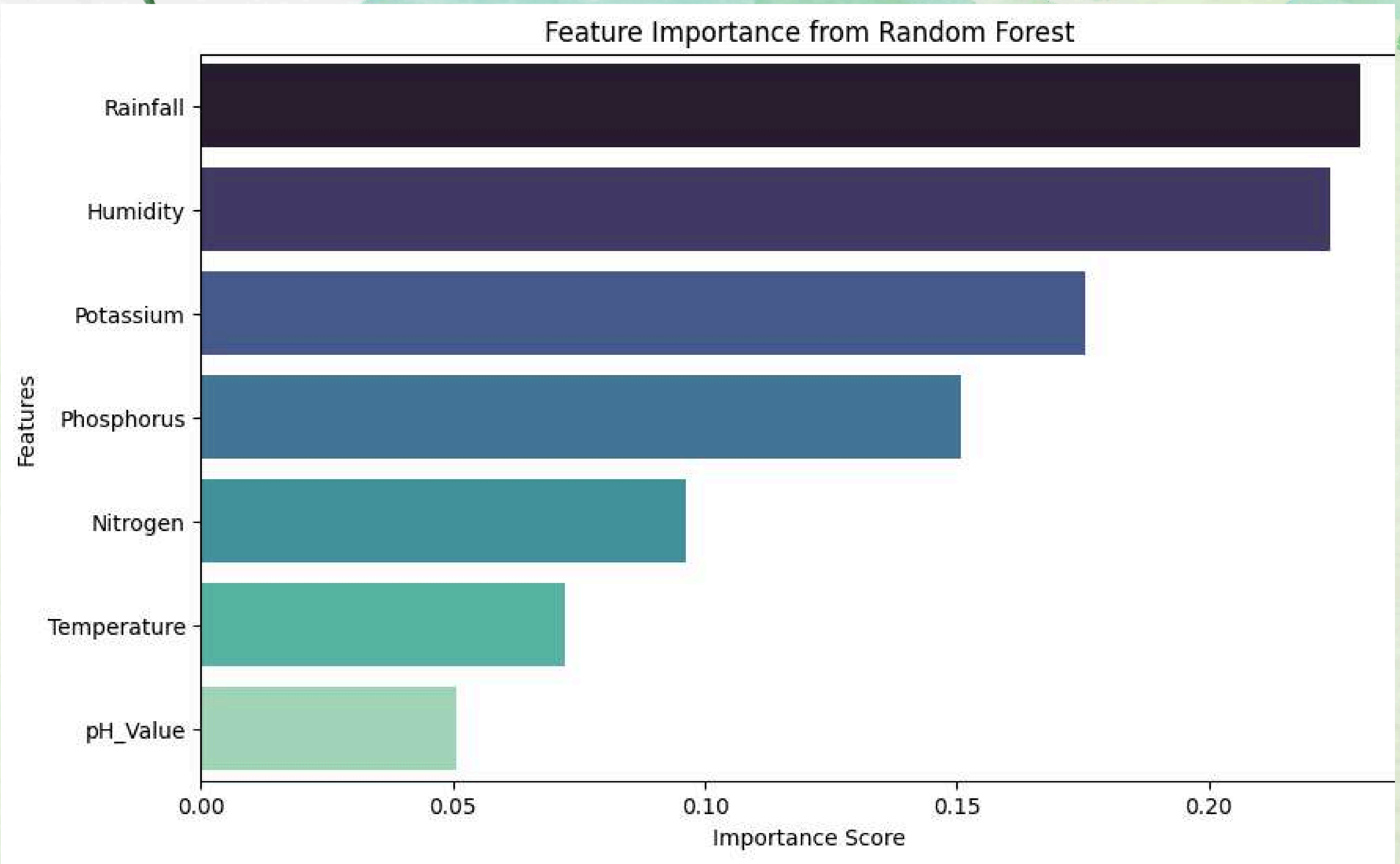


Training & Validation Accuracy (Fig. 6):
Model achieved 95–97% accuracy after 5 epochs, maintaining stable performance with minimal overfitting.



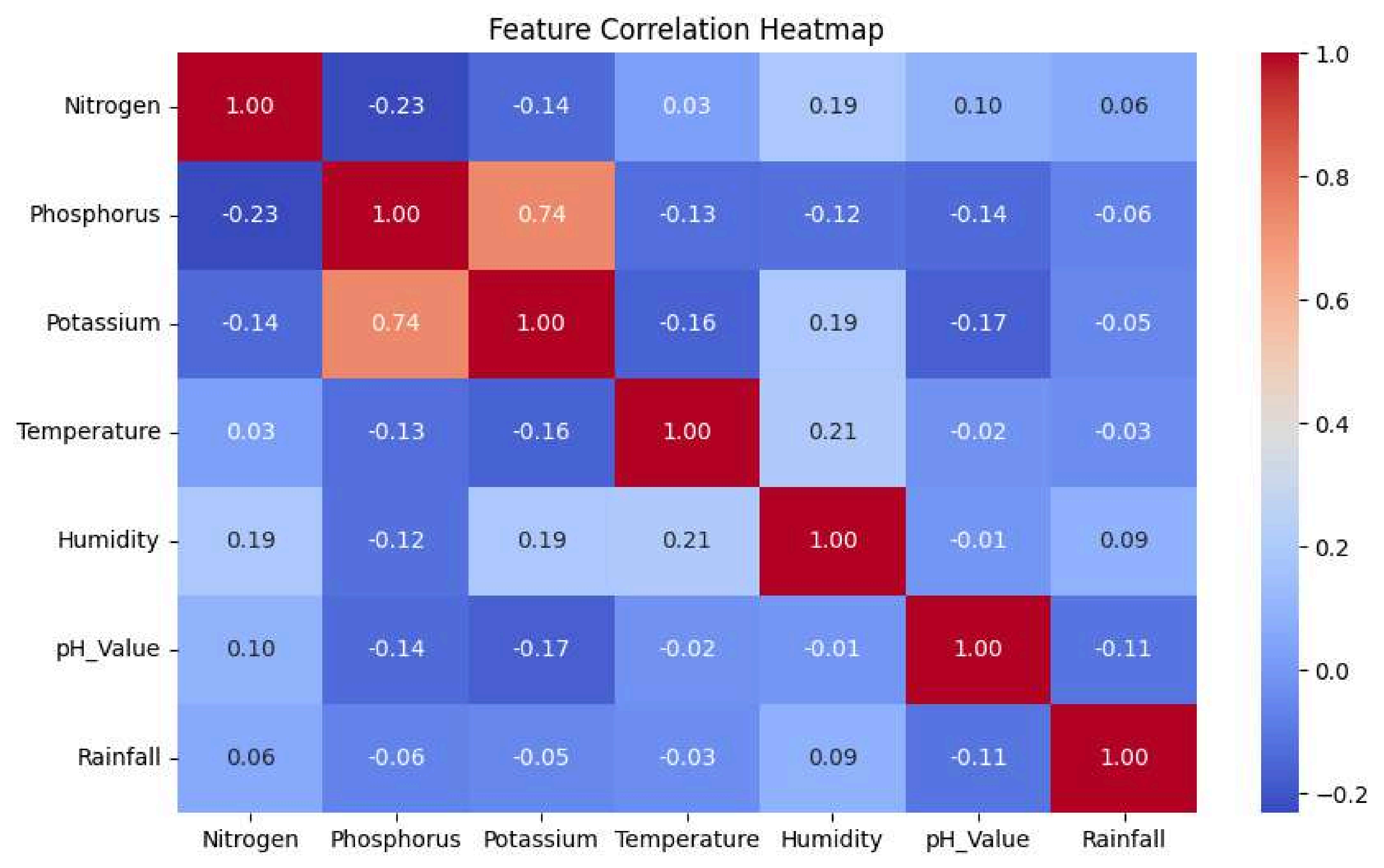
Training & Validation Loss (Fig. 3):
Loss curves converged within 30 epochs, showing the model was well-trained without overfitting and generalized effectively to unseen data

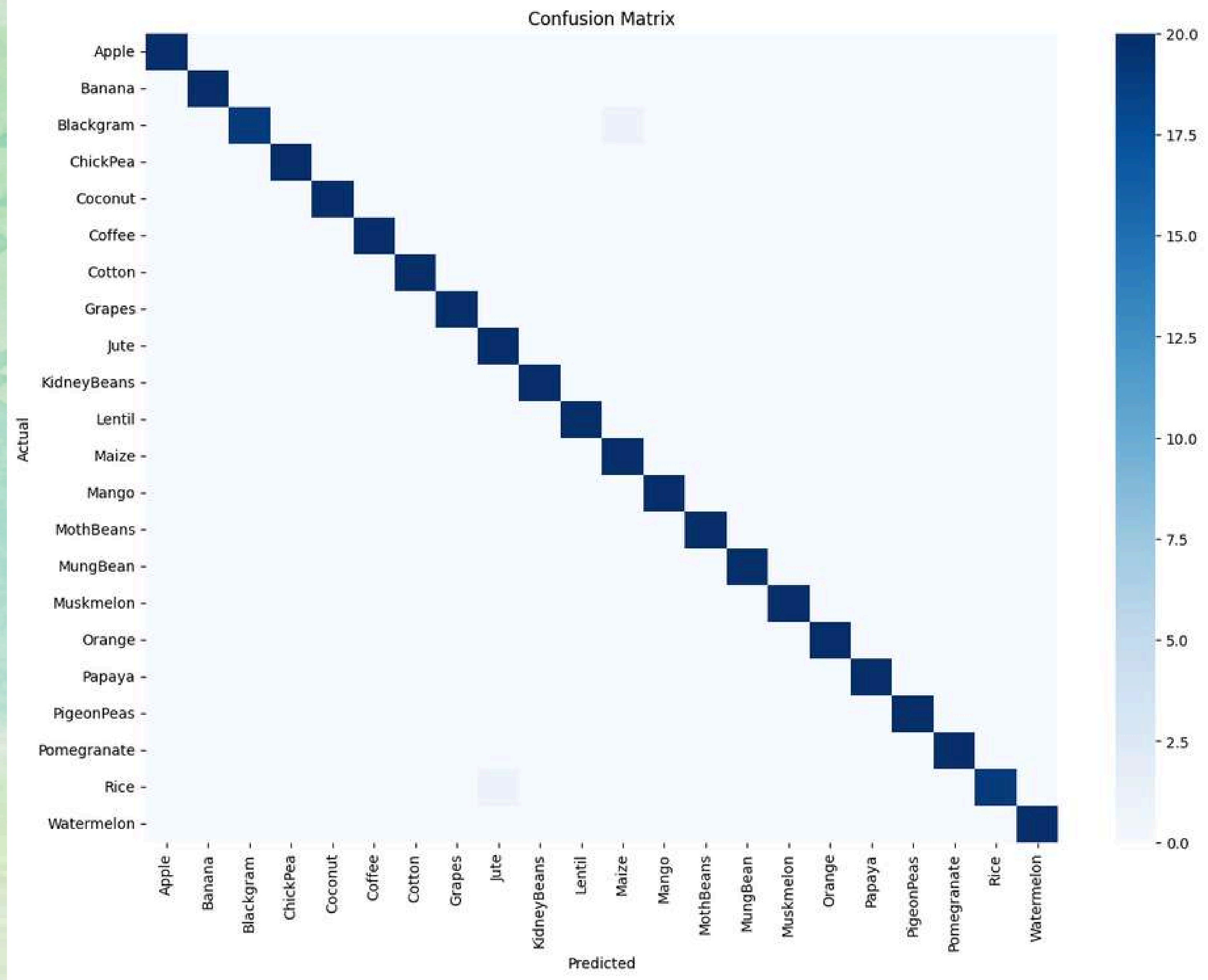
Results



Feature Importance :
Rainfall and humidity were the strongest predictors, while nutrients like Potassium and Phosphorus contributed moderately.

Results

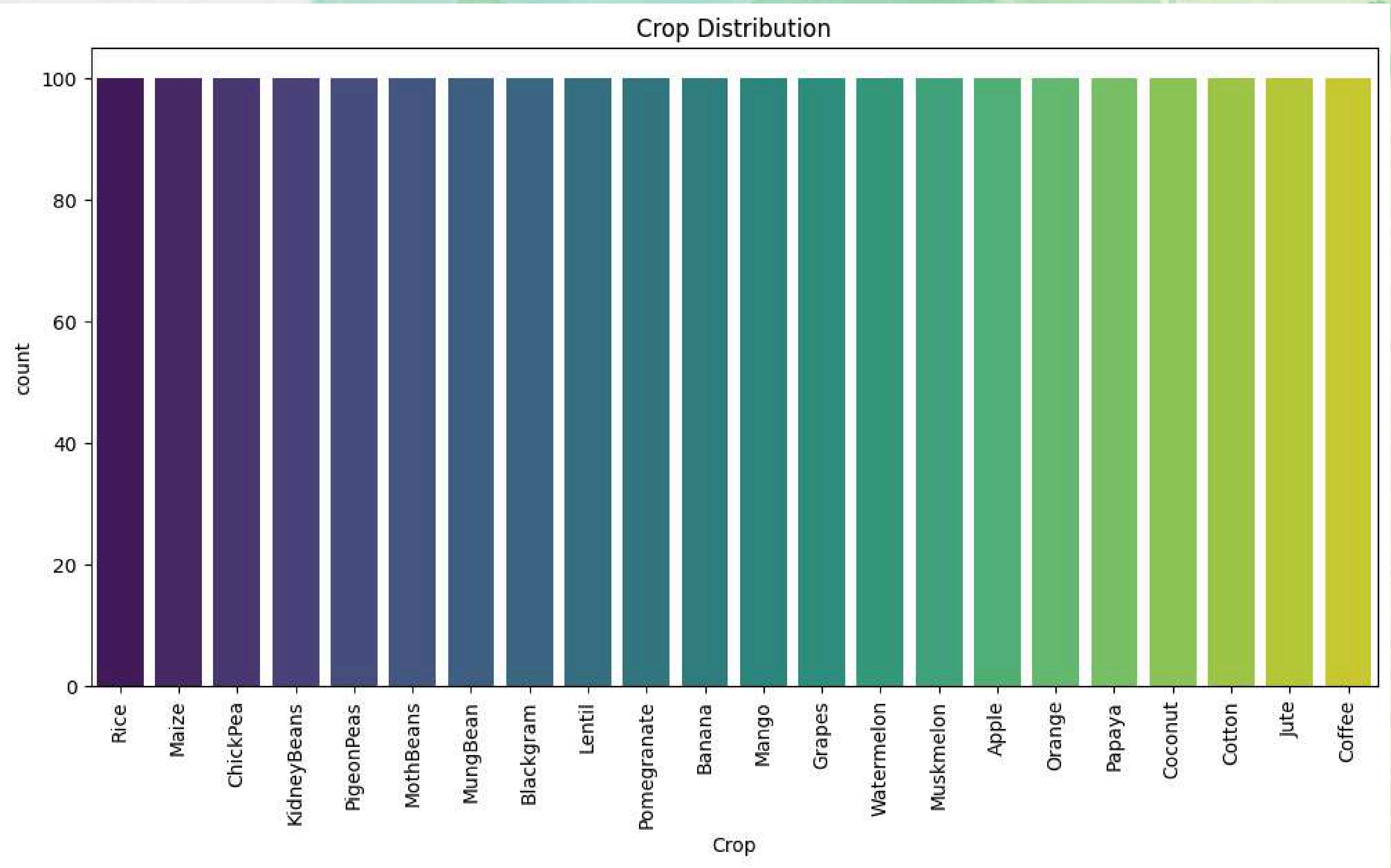




Correlation Heatmap
Strong correlation was found between Phosphorus and Potassium, while rainfall and temperature showed weaker links to soil nutrients.

Confusion Matrix
Predictions were mostly correct with few errors among crops having similar soil and climate needs (e.g., Jute and Rice).

Results



Crop Distribution :
Dataset was evenly balanced across 22 crop types (~100 samples each), ensuring fair and unbiased predictions.

Conclusion

Impact:

Converts crop choice into a data-driven, scientific process.
Enhances yield, farmer revenue, and sustainable agriculture.

Technology Used:
Machine Learning (Random Forest, Neural Networks)
Data preprocessing, feature selection & evaluation metrics

Core Functionality:

Predicts the best-suited crop given soil & climate parameters (N, P, K, pH, temperature, rainfall, humidity).
Offers high-accuracy suggestions (~99%).
Easy-to-use interface for farmers to enter data & receive crop suggestions

Target Users:

Farmers & Agricultural Experts – for crop decision-making.
Agricultural Boards & Researchers – for sustainable agriculture planning.

Benefits:

Reduces dependence on guesswork in farming.
Enhances productivity & food security.
Conserves soil health by limiting fertilizer misuse.
Cost-effective and accessible via web application.

Long-term Impact:

Promotes sustainable agriculture practices.
Supports economic stability of farming communities.
Contributes to global food security.

References

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