AI-POWERED AGRICULTURAL APPLICATION: CROPMax
"OPTIMAL CROP PREDICTION FOR MAXIMUM PROFIT"

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Step 1: Prototype Selection

1.0 Abstract

CropMax is an AI-driven platform designed to assist small and medium-sized farmers in optimizing crop selection for maximum profitability. By analyzing land characteristics, climate data, and cost factors, the platform predicts the most suitable crops for specific conditions. This report details the objective, methodology, results, and conclusions of the CropMax project, highlighting its potential to revolutionize agricultural decision-making and enhance farm productivity through advanced machine learning techniques. The platform aims to provide actionable insights, contributing to sustainable and efficient farming practices.

2.0 Introduction

Agriculture, a cornerstone of the nation's economy, supports nearly half of the country's workforce and significantly contributes to its GDP. Despite its critical role, the sector faces numerous challenges, including unpredictable weather patterns, fluctuating market prices, and suboptimal resource utilization. Traditional farming practices often rely on historical data and intuition, which can lead to inefficiencies and lower yields.

CropMax aims to address these challenges by leveraging artificial intelligence (AI) to provide precise crop recommendations. This innovative application analyzes a range of factors, including soil nutrients, weather conditions, and local agronomic practices, to predict the most suitable crops for specific plots of land, maximizing profitability and sustainability for farmers.

3.0 Problem Statement

Small and medium-sized farmers often struggle with selecting the most profitable crops to cultivate due to varying soil conditions, unpredictable climate patterns, and fluctuating market prices. This lack of informed decision-making can lead to suboptimal yields and financial losses. There is a need for an AI-powered tool that provides precise crop recommendations by analyzing soil quality, climate data, and input costs. Such a solution would empower farmers to make data-driven decisions, optimize their crop selection, enhance productivity, and maximize profits, thereby promoting sustainable agricultural practices.

4.0 Market/Customer/Business Need Assessment

4.1 Market Assessment

The agricultural sector is vital to the global economy, with small and medium-sized farms constituting a significant portion of food production. However, these farmers often face challenges such as unpredictable weather patterns, soil degradation, and fluctuating market prices. According to the Food and Agriculture Organization (FAO), around 80% of the world's food is produced by small-scale farmers (FAO, 2021). Despite their critical role, these farmers frequently lack access to advanced tools and technologies that can enhance their productivity and profitability.

4.2 Customer Needs

Small and medium-sized farmers need reliable, data-driven insights to make informed decisions about crop selection. Key customer needs identified through interviews and observations include:

- **Ease of Use:** Farmers require a user-friendly platform that does not require extensive technical knowledge.
- **Accuracy:** The crop recommendations must be highly accurate to ensure trust and reliability.
- **Cost-Effectiveness:** The solution should be affordable, considering the limited financial resources of many small-scale farmers.
- **Comprehensive Data Analysis:** The platform must analyze multiple factors such as soil quality, climate conditions, and input costs.
- **Accessibility:** The tool should be accessible via both mobile and web applications to accommodate different user preferences.
- **Regulatory Compliance:** The solution must comply with local agricultural regulations and data privacy laws.
- **Support and Training:** Adequate support and training must be provided to help farmers effectively use the platform.

4.3 Business Need

From a business perspective, there is a significant opportunity to address the technological gap in agriculture by providing an AI-powered platform that can assist farmers in optimizing crop selection. The global market for agricultural technology is growing, with an increasing demand for precision farming tools. By leveraging AI and machine learning, businesses can offer innovative solutions that not only enhance farm productivity but also contribute to sustainable agricultural practices.

5.0 Target Specifications and Characterization

5.1 Customer Characteristics

The primary users of CropMax are small and medium-sized farmers who seek to optimize their crop selection process through data-driven insights. These farmers typically have limited access to advanced agricultural technologies and require user-friendly, cost-effective solutions that provide reliable recommendations.

5.2 Target Specifications

Based on the customer needs assessment, the following target specifications and characterizations have been defined for CropMax:

5.2.1 User-Friendly Interface

•**Specification:** The platform should have an intuitive and easy-to-navigate interface.

•Metric: User satisfaction score of at least 8/10 in usability tests.

•**Rationale:** Ensures accessibility for farmers with varying levels of technical expertise.

5.2.2 High Accuracy

•**Specification:** Crop recommendations should achieve at least 95% accuracy based on historical data.

•**Metric:** Percentage of correct crop recommendations in test scenarios.

•**Rationale:** Builds trust and reliability in the system.

5.2.3 Cost-Effectiveness

•**Specification:** The subscription cost should not exceed $10 per month.

•Metric: Monthly subscription fee.

•**Rationale:** Ensures affordability for small-scale farmers.

5.2.4 Comprehensive Data Analysis

•Specification: The platform should integrate data on soil quality, climate conditions, and input costs.

•**Metric:** Number of data sources integrated.

•**Rationale:** Provides holistic recommendations for crop selection.

6.0 External Searches

6.1 Applications of Machine Learning

Machine learning (ML) has transformative potential in agriculture, including applications such as precision farming, crop health monitoring, yield prediction, and automated irrigation. ML algorithms can analyze large datasets from sensors, satellite images, and climate models to provide actionable insights, optimize resource use, and increase crop.

6.2 Machine Learning-Based Prediction

Machine learning-based prediction models, such as Random Forest, Support Vector Machines, and Neural Networks, are used to predict crop yields and suitability. These models can incorporate diverse variables like soil properties, weather conditions, and historical crop data to generate accurate and reliable predictions.

6.3 Dataset

The dataset for CropMax includes variables such as soil quality (N, P, K levels), temperature, humidity, pH, and rainfall. This data can be sourced from various public databases, sensor networks, and weather stations to ensure comprehensive and accurate analysis. A specific (small-scale) example dataset is the "Crop Recommendation Dataset" from Kaggle, which provides detailed environmental and soil parameters for different crops.

6.4 Machine Learning is the Future

Machine learning is poised to revolutionize agriculture by enhancing decision-making processes, reducing risks, and improving efficiency. The integration of ML in agriculture supports sustainable farming practices, helps mitigate the impacts of climate change, and meets the increasing food demand of the growing global population. The continued advancement of ML technologies will drive innovation and efficiency in the agricultural sector.

7.0 Benchmarking Alternate Products

In our proposed project for the AI-powered agricultural application CropMax, we aim to develop a tool that significantly improves crop selection for small and medium-sized farmers. To ensure CropMax meets its objectives, it is crucial to benchmark it against existing products and services. This section outlines a comparison with three notable platforms: FarmLogs, Climate FieldView, and Agrivi, highlighting how CropMax plans to differentiate itself.

7.1 Comparison of AI-Powered Agricultural Tools

7.1.1 FarmLogs

- Features: Offers crop health monitoring, soil data analysis, weather tracking, and financial management tools.
- Strengths: Provides a comprehensive suite of tools with a user-friendly interface and strong focus on financial management.
- Weaknesses: Primarily targets larger farms with high subscription costs, making it less accessible for small-scale farmers.

7.1.2 Climate FieldView

- Features: Includes detailed field mapping, variable rate seeding, and weather tracking.
- Strengths: Known for advanced field mapping and strong data integration capabilities.
- Weaknesses: High costs and a steep learning curve can be challenging for beginners and small-scale farmers.

7.2 Key Differentiators for CropMax

- Features: AI-driven crop recommendations based on comprehensive data analysis (soil, climate, costs), user-friendly interface, cross-platform accessibility (web and mobile).
- Strengths: Targeted at small and medium-sized farms, offering affordability, high accuracy in crop prediction, regulatory compliance, and comprehensive support and training.
- Affordability: Designed to be cost-effective for small and medium-sized farmers, with a subscription model that is significantly lower than competitors.
- Ease of Use: Emphasizes a user-friendly interface that requires minimal technical expertise, making it accessible to farmers with varying levels of technology familiarity.
- Specialized Recommendations: Utilizes AI to provide specific crop recommendations tailored to individual land and climate conditions.
- Regulatory Compliance: Ensures adherence to local agricultural regulations and data privacy laws, providing a secure and compliant platform.
- Comprehensive Support and Training: Includes detailed documentation, tutorials, and responsive customer service to help farmers effectively use the platform.

8.0 Applicable Regulations :

- Compliance with data privacy laws (e.g., Personal Data Protection Bill)
- Adherence to agricultural data standards set by the Indian Council of Agricultural Research (ICAR) and environmental regulations by the Ministry of Environment, Forest and Climate Change (MoEFCC)

9.0 Applicable Constraint :

9.1 Space:

- Cloud-based platform requiring minimal physical space for servers and data storage.

9.2 Budget:

- Initial development costs ranging from INR 70 lakhs to 1.4 crores.
- Operational costs estimated at INR 5 to 10 lakhs per month.
- Annual marketing and outreach budget of approximately INR 35 lakhs.

9.3 Expertise:

- Requires expertise in machine learning, data science, and agronomy.
- Collaboration with Indian agricultural research institutions and universities.
- Collaboration with agronomists, agricultural researchers, and software developers within India.

10.0 Business Model for CropMax:

10.1 Monetization Idea:

- Subscription-based model with tiered pricing (Basic, Pro, Premium) offering varying levels of features and support.

- Freemium model providing basic features for free, with premium features requiring payment.

- Partnerships with agricultural supply companies for sponsored recommendations and advertisements.

10.2 Revenue Streams:

- Subscription fees from farmers for access to advanced features and insights.

- Revenue sharing with agricultural supply companies for sponsored recommendations and advertisements.

- Potential consulting services for custom data analysis and insights.

10.3 Key Partnerships:

- Agricultural supply companies for sponsored recommendations and advertisements.

- Data providers for access to soil, climate, and market price data.

- Agricultural research institutions for collaboration on data analysis and model optimization.

11.0 Concept Generation:

The idea is to optimize the farming practices using AI.Effective crop cultivation requires detailed insights into soil conditions, climate patterns, and market trends. By leveraging AI and machine learning, CropMax aims to provide farmers with actionable recommendations to optimize crop selection and maximize profitability.

12.0 Final Prototype for CropMax:

12.1 Data Collection and Preparation:

- Collected comprehensive agricultural data, including soil quality metrics, climate data, and market prices. This data is obtained from various sources such as agricultural research institutions, weather services, and market databases.
- Data sources include soil samples, climate records, historical yield data, and real-time market prices, stored in CSV format for easy handling.

12.2 Data Import and Environment Setup:

- The dataset is imported into a machine learning environment such as Jupyter Notebook, using Python programming language.
- Python libraries such as Pandas, Scikit-learn, TensorFlow, and Seaborn are utilized for data analysis, visualization, and model training.

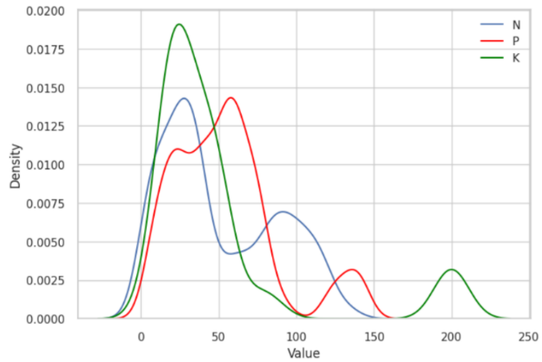
```
In [86]: import numpy as np
         import pandas as pd
         import seaborn as sns
         import matplotlib.pyplot as plt

         import warnings
         warnings.filterwarnings('ignore')
```

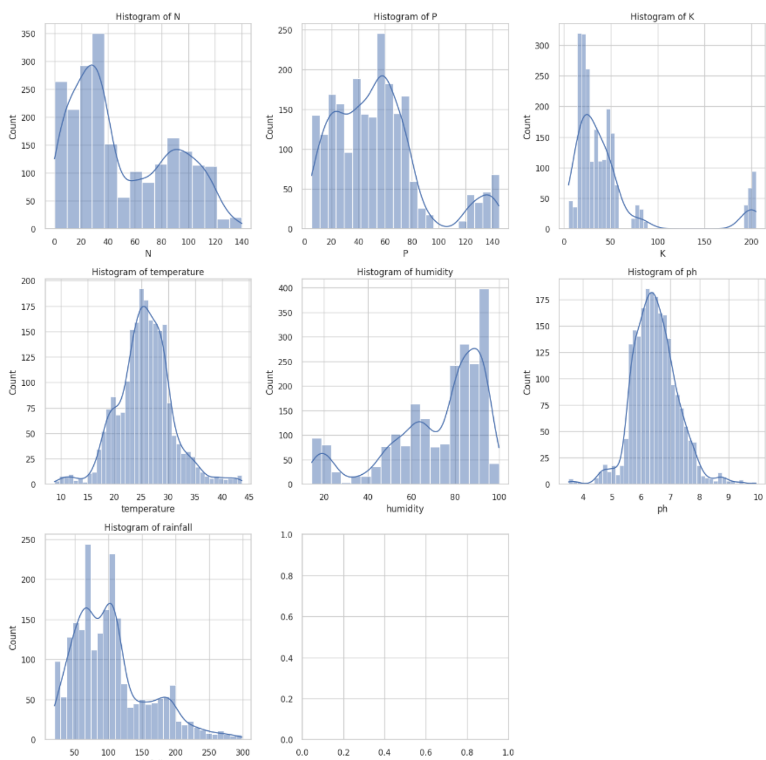
```
In [87]: crop = pd.read_csv('Crop_recommendation.csv')
         crop
```

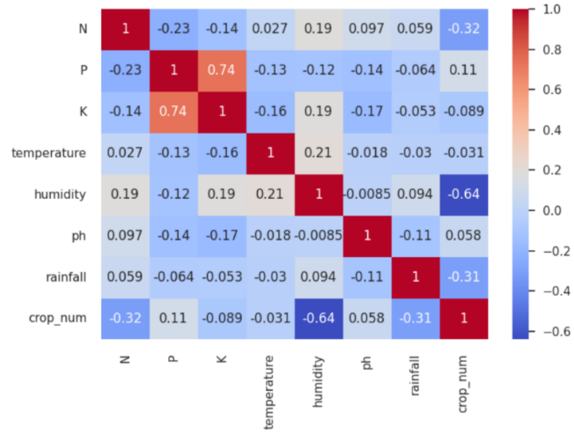
12.3 Exploratory Data Analysis (EDA):

- Conducting EDA to understand the data distribution, detect anomalies, and visualize relationships between different variables.
- Use visualization tools like Seaborn and Matplotlib to create graphs and charts for better data understanding.

In [95]:
```
sns.kdeplot(crop['N'], label='N')
sns.kdeplot(crop['P'], label='P', color='red')
sns.kdeplot(crop['K'], label='K', color='green')
plt.xlabel('Value')
plt.legend()
plt.show()
```

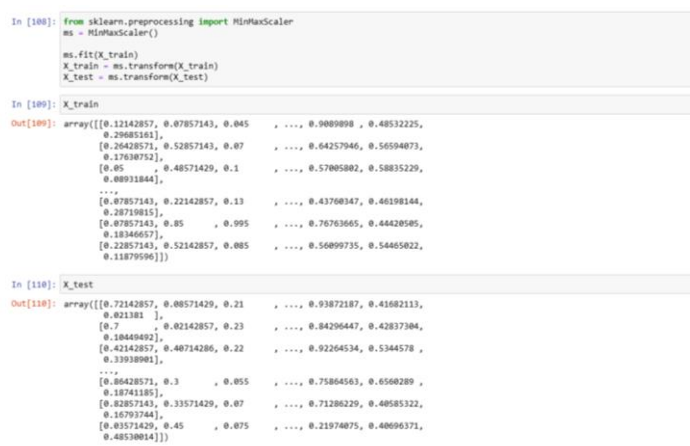






12.4 Feature Engineering:

- Extracting relevant features from the dataset, such as soil pH, Nitrogen, phosphorous levels, temperature patterns, rainfall, and historical market prices.
- Creating new features that may improve the model's predictive power, such as seasonal climate indices and derived soil properties.



```
In [108]: from sklearn.preprocessing import MinMaxScaler
          ms = MinMaxScaler()

          ms.fit(X_train)
          X_train = ms.transform(X_train)
          X_test = ms.transform(X_test)

In [109]: X_train

Out[109]: array([[0.12142857, 0.07857143, 0.045     , ..., 0.9089898 , 0.48532225,
                  0.29685161],
                 [0.26428571, 0.52857143, 0.07      , ..., 0.64257946, 0.56594073,
                  0.17630752],
                 [0.05      , 0.48571429, 0.1       , ..., 0.57005802, 0.58835229,
                  0.08931844],
                 ...,
                 [0.07857143, 0.22142857, 0.13      , ..., 0.43760347, 0.46198144,
                  0.28719815],
                 [0.07857143, 0.85      , 0.995     , ..., 0.76763665, 0.44420505,
                  0.18346657],
                 [0.22857143, 0.52142857, 0.085     , ..., 0.56099735, 0.54465022,
                  0.11879596]])

In [110]: X_test

Out[110]: array([[0.72142857, 0.08571429, 0.21      , ..., 0.93872187, 0.41682113,
                  0.021381  ],
                 [0.7       , 0.02142857, 0.23      , ..., 0.84296447, 0.42837304,
                  0.10449492],
                 [0.42142857, 0.40714286, 0.22      , ..., 0.92264534, 0.5344578 ,
                  0.33938901],
                 ...,
                 [0.86428571, 0.3       , 0.055     , ..., 0.75864563, 0.6560289 ,
                  0.18741185],
                 [0.82857143, 0.33571429, 0.07      , ..., 0.71286229, 0.40585322,
                  0.16793744],
                 [0.03571429, 0.45      , 0.075     , ..., 0.21974075, 0.40696371,
                  0.48530014]])
```

12.5 Model Selection and Training:

- Choose suitable machine learning algorithms, such as regression models, decision trees, and ensemble methods, to predict the most suitable crops for specific conditions.
- Train the model using historical data, splitting the dataset into training and testing sets to evaluate performance.
- Fine-tune the model parameters to improve accuracy and robustness.

```
In [114]: # create instances of all models
models = {
    'Logistic Regression': LogisticRegression(),
    'Naive Bayes': GaussianNB(),
    'Support Vector Machine': SVC(),
    'K-Nearest Neighbors': KNeighborsClassifier(),
    'Decision Tree': DecisionTreeClassifier(),
    'Random Forest': RandomForestClassifier(),
    'Bagging': BaggingClassifier(),
    'AdaBoost': AdaBoostClassifier(),
    'Gradient Boosting': GradientBoostingClassifier(),
    'Extra Trees': ExtraTreeClassifier(),
}

for name, md in models.items():
    md.fit(X_train, y_train)
    y_pred = md.predict(X_test)

    print(f" {name} Accuracy : {accuracy_score(y_test, y_pred)}")
```

```
Logistic Regression Accuracy : 0.9204545454545454
Naive Bayes Accuracy : 0.9954545454545455
Support Vector Machine Accuracy : 0.9681818181818181
K-Nearest Neighbors Accuracy : 0.9704545454545455
Decision Tree Accuracy : 0.9818181818181818
Random Forest Accuracy : 0.9931818181818182
Bagging Accuracy : 0.9840909090909091
AdaBoost Accuracy : 0.1409090909090909
Gradient Boosting Accuracy : 0.9818181818181818
Extra Trees Accuracy : 0.8727272727272727
```

12.6 Validation and Testing:

- Validating the model using cross-validation techniques to ensure it generalizes well to unseen data.
- Testing the model on a separate testing set to evaluate its predictive accuracy and reliability.

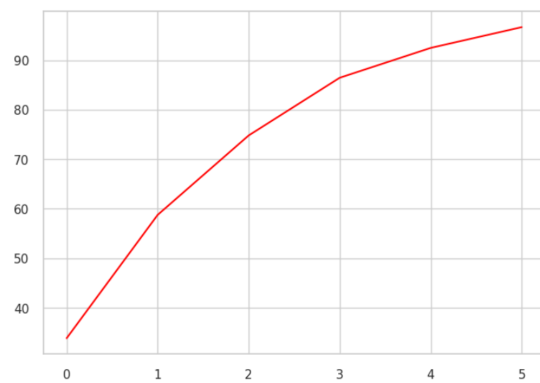
- OUTPUT:

```
Enter Nitrogen Amount: 12
Enter Phosphorous Amount: 45
Enter Potassium Amount: 67
Enter Temperature: 0
Enter Humidity: 23
Enter pH: 11
Enter Rainfall: 34
Apple is a best crop to be cultivated
```

13.0 Market Segementation:

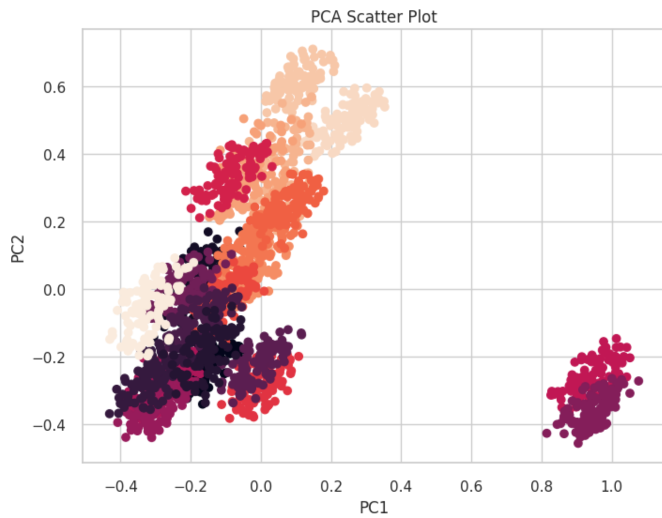
13.1 Principal Component Analysis:

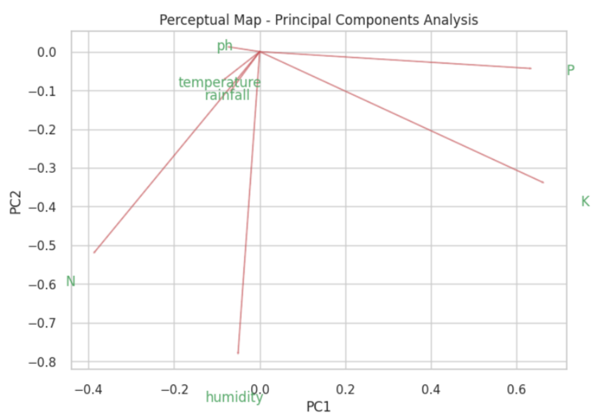
- Variance plot for PCA components obtained :



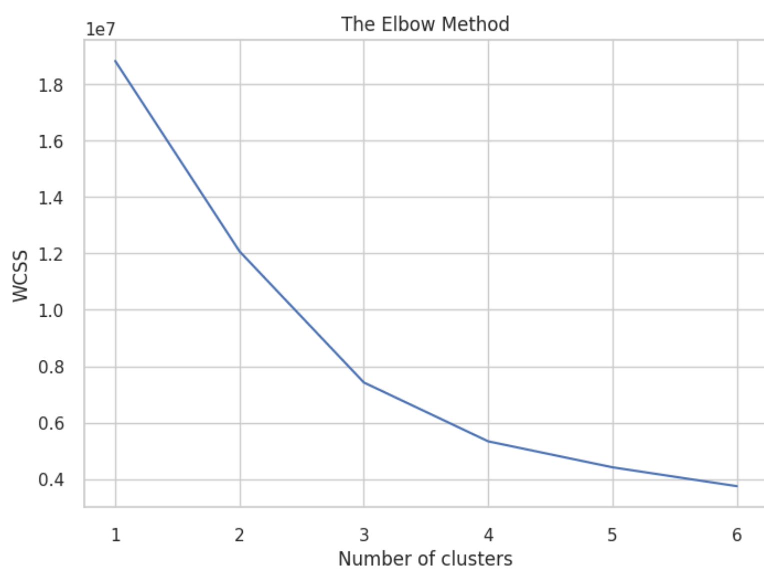

```
In [133]: print("Standard deviations (eigenvalues of the covariance matrix):")
print(pca.explained_variance_)
print("\nProportion of Variance:")
print(pca.explained_variance_ratio_)
print("\nCumulative Proportion:")
print(cumulative_variance_ratio)

Standard deviations (eigenvalues of the covariance matrix):
[0.11215848 0.0824962  0.0531428  0.03860255 0.01998531 0.01388607]

Proportion of Variance:
[0.3386283  0.24907209 0.16044848 0.11654863 0.06033953 0.04192476]

Cumulative Proportion:
[33.86 58.77 74.81 86.46 92.49 96.68]
```

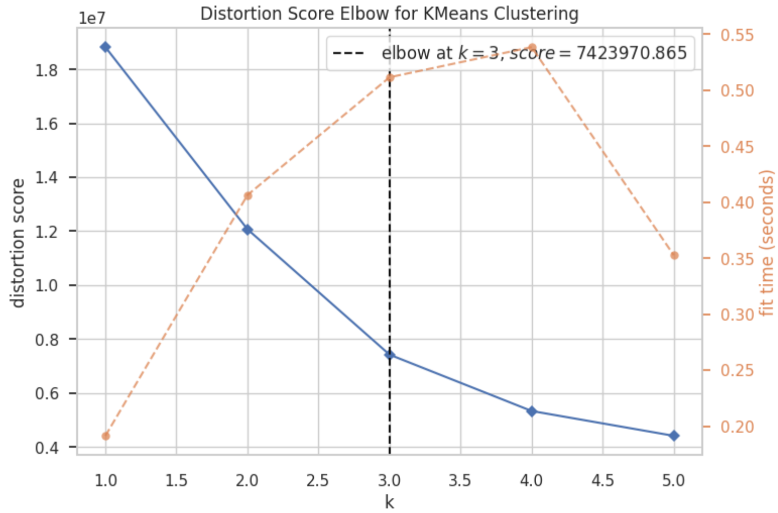
- PCA Results :





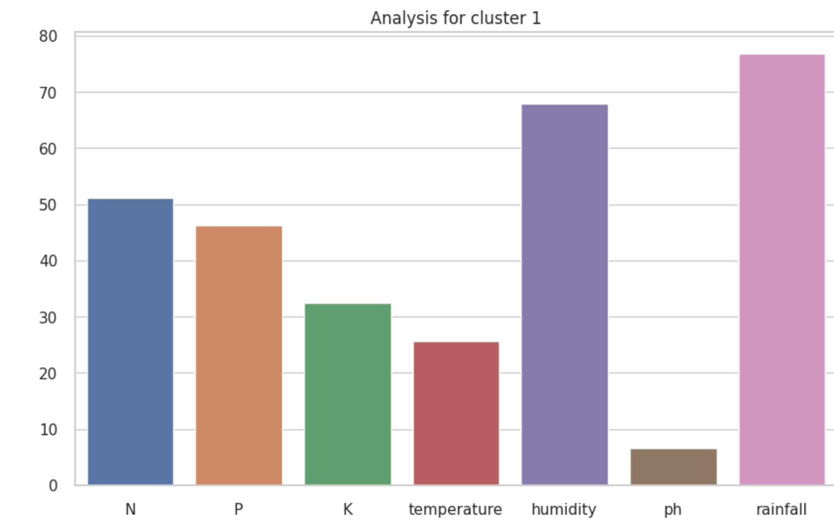
- Elbow graph to estimate the number of clusters :

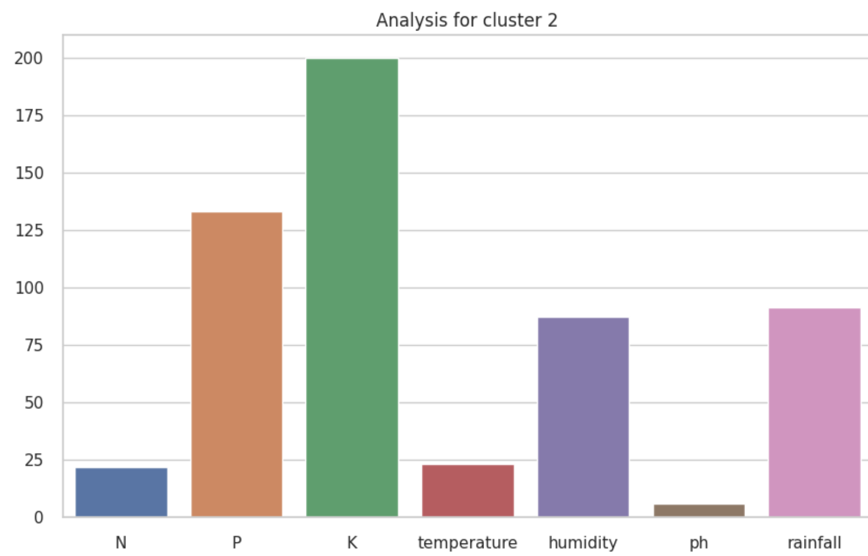


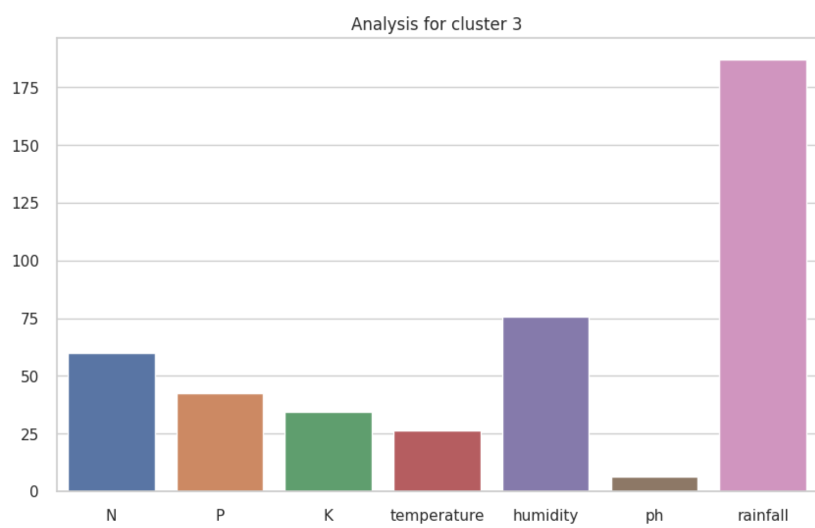


- It can be inferred from the above that the number of clusters is 3. The required K-Means Clustering is given below

- Analysis of each clusters :


Analysis for cluster 1
80
70
60
50
40
30
20
10
0
N
P
K
temperature
humidity
ph
rainfall


Analysis for cluster 2
200
175
150
125
100
75
50
25
0
N
P
K
temperature
humidity
ph
rainfall


Analysis for cluster 3
175
150
125
100
75
50
25
0
N
P
K
temperature
humidity
ph
rainfall

13.5 Cost Estimate:

13.5.1 Initial Development:

- ₹82,00,000 - ₹1,64,00,000 (approx. $100,000 - $200,000)
- Operational Costs: ₹8,20,000 - ₹16,40,000 per month (approx. $10,000 - $20,000 per month)
- Annual operational costs: ₹98,40,000 - ₹1,96,80,000

13.5.2 Marketing and Outreach:

- ₹41,00,000 annually (approx. $50,000)

13.6 Estimated Profit:

13.6.1 Subscription-Based Model:

- Basic Plan: ₹1,000 per month per user
- Pro Plan: ₹2,500 per month per user
- Premium Plan: ₹5,000 per month per user

13.6.2 Freemium Model:

- Basic features free, premium features at ₹2,000 per month per user

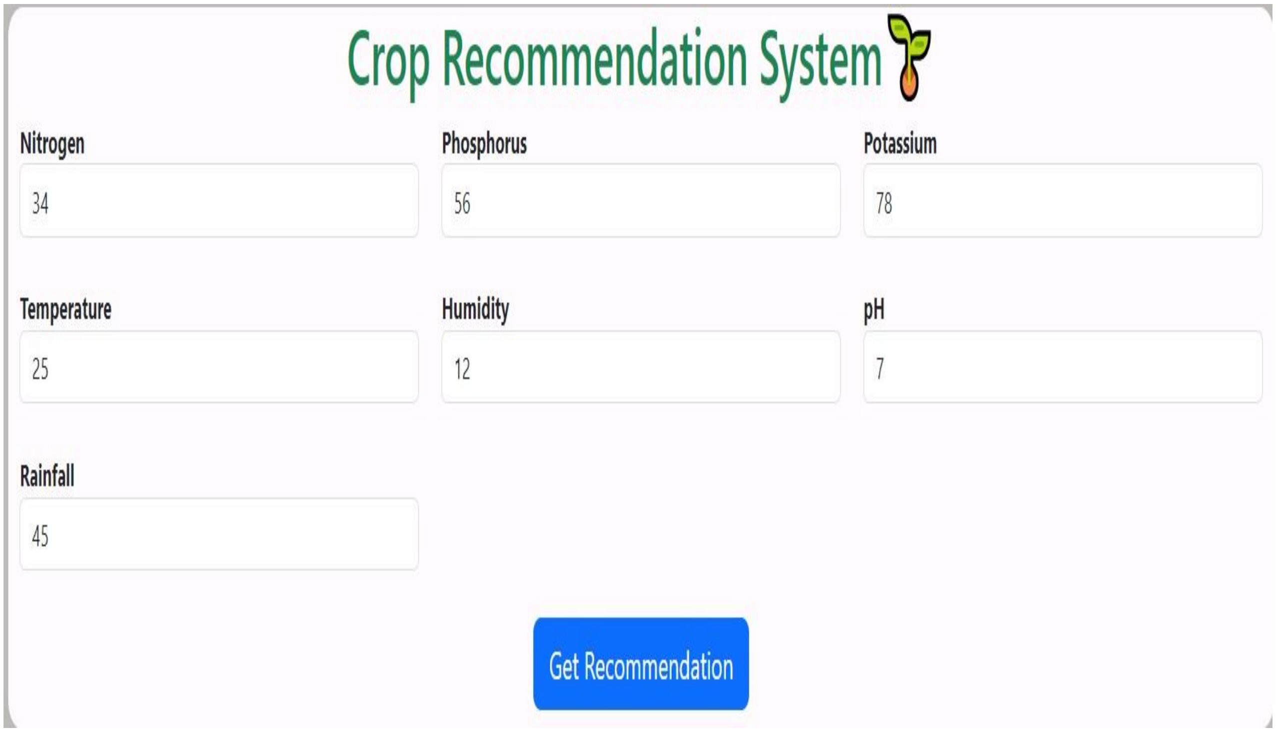
13.6.3 Partnerships and Sponsored Recommendations:

- Revenue from agricultural supply companies: ₹10,00,000 annually

15.0 Conclusion:

The proposed CropMax application aims to revolutionize agricultural practices for small and medium-sized farms by leveraging the power of AI and machine learning. By providing accurate and actionable crop recommendations based on various environmental and soil parameters, CropMax can help farmers maximize their profits and optimize resource usage. The initial implementation demonstrates the feasibility of using a RandomForestClassifier to predict optimal crops, with promising accuracy. Future enhancements, including real-time data integration, advanced modeling techniques, and user-friendly interfaces, will further refine the product, making it an invaluable tool for the agricultural sector. With continued development and support, CropMax has the potential to significantly impact sustainable farming and economic growth in the agricultural industry.

Also by utilising SmartRisk's AI capabilities to procure agri-data for a farmer, loan officers can avoid spending several weeks visiting farmers to gather data and audit farm plots for the loan application. As a result, banks can bring down the time required to complete this process to less than 30 minutes, without having to send anyone to the fields. Consequently, this also minimises the cost of processing one loan by at least 20%



Github:
https://github.com/PritijaBhapkar/Crop_Recommendation_System/blob/main/Crop_Recommendation.ipynb

Inspired by : Cropin Technology Startup

Report by : Nakshatiraa kn

Code by : Pritija, Nagendra, Gowthami, Adarsh