PLANT DISEASE DETECTION SYSTEM FOR SUSTAINABLE AGRICULTURE

In the face of growing global food demand and environmental challenges, there is an urgent need to enhance agricultural productivity while promoting sustainability. This project aims to design an intelligent, machine learning-powered system that serves dual purposes: early plant disease detection and personalized crop-fertilizer recommendations.

The system will analyze key parameters such as soil properties (pH, NPK levels), weather conditions (temperature, rainfall, humidity), and historical crop data to recommend the most suitable crops and fertilizers for a given piece of land. In addition, a deep learning-based image recognition module will identify plant diseases from leaf images, allowing for early diagnosis and timely intervention.

The goal is to empower farmers with actionable insights, optimize input usage, improve yield, and minimize environmental impact—ultimately contributing to the vision of smart and sustainable agriculture.

**1. Problem Statement**

Design a system that recommends the most suitable **crops** and **fertilizers** based on input features like **soil properties**, **weather conditions**, and other **environmental parameters**, using machine learning.

**Step 1: Data Collection**

* **Soil Data**: pH, nitrogen (N), phosphorus (P), potassium (K), organic matter
* **Weather Data**: temperature, rainfall, humidity, sunlight hours
* **Crop Data**: crop type, growing season, ideal conditions
* **Fertilizer Data**: recommended fertilizers per crop/soil combination

**Sources**:

* Kaggle datasets
* Indian government agriculture datasets
* FAO/ICRISAT data
* Weather APIs (e.g., OpenWeatherMap)

**Step 2: Data Preprocessing**

* Handle missing values
* Normalize features (e.g., MinMaxScaler)
* Label encode categorical data (e.g., crop names)
* Create feature matrix **X** and label vector **y**

**Step 3: Model Building**

**3.1 Crop Recommendation**

* Classification task
* Algorithms: Decision Tree, Random Forest, SVM, or XGBoost
* Input: Soil and weather features
* Output: Recommended crop

**3.2 Fertilizer Recommendation**

* Classification or regression task (based on formulation)
* Input: Soil nutrients + selected crop
* Output: Fertilizer type or quantity

**Step 4: Model Evaluation**

* Use cross-validation
* Accuracy, F1-score for classification
* RMSE or MAE for regression

**Step 5: Deployment (Optional)**

* Use Flask or Streamlit to build a web app
* Let users input soil and weather parameters
* Display recommended crops and fertilizers

**Future Enhancements:**

**1. Disease Detection Using Leaf Images**

* Integrate Computer Vision using CNNs (Convolutional Neural Networks).
* Allow users to upload images of leaves.
* Detect common plant diseases (e.g., leaf blight, powdery mildew).
* Tools: TensorFlow, Keras, OpenCV, PyTorch.

**2. Soil Health Monitoring Score**

* Compute a "Soil Health Index" based on nutrient levels, pH, and organic matter.
* Use color-coded visualizations (green = good, red = poor).
* Recommend soil improvement strategies (e.g., compost, lime, crop rotation).

**3. Voice-Enabled Chatbot Assistant (Optional UI Feature)**

* Use voice recognition (e.g., Google Speech-to-Text) for illiterate farmers.
* Chatbot answers crop and fertilizer queries in local languages.
* Tech stack: Dialogflow + Flask API + Python NLP models**.**

**4. Yield Prediction Module**

* Use regression models (like XGBoostRegressor or Linear Regression).
* Predict estimated yield (kg/ha) based on soil, crop, and weather inputs.
* Helps farmers plan harvest and market prices.

**5. Seasonal Forecasting Using Time-Series Data**

* Predict future weather patterns (rainfall, temperature) using LSTM or ARIMA.
* Helps in better crop planning and risk management.

**6. Geolocation-Based Recommendations**

* Integrate GPS data to auto-fetch local soil/weather info via APIs.
* Provide localized recommendations tailored to the user's region.

**7. Sustainability Score**

* Assign a score to each recommendation based on:
  + Water usage
  + Fertilizer environmental impact
  + Soil degradation risk
* Promotes eco-friendly farming.

**8. Explainable AI (XAI)**

* Use tools like SHAP or LIME to explain why a crop or fertilizer was recommended.
* Improves trust and interpretability for users.

Ultimately, this intelligent system will support farmers in making data-driven decisions, minimize crop losses due to disease, and promote long-term sustainability in agriculture—paving the way for smarter, more efficient, and eco-friendly farming practices.