

1. User Registration/Login:

- Users (farmers or agronomists) sign up or log in via the app or web portal.
- Authentication is handled using Firebase Authentication or Auth0.
- Supports secure login and optional multi-factor authentication (MFA).
- Session management is handled using JWT tokens for secure communication.

2. Profile Completion & Location Access:

- After login, users complete their profile:
 - Name, phone number
 - Farm location using GPS
 - Type of crops grown and irrigation method
- Location is validated via geofencing to ensure accurate weather and soil recommendations.

3. Weather Data Fetching (API-Based):

- Real-time weather data is fetched using the Open Weather Map API based on the user's GPS location.
- The following parameters are retrieved:
 - Temperature (°C)
 - Humidity (%)
 - Rainfall (mm)
 - 7-day forecast (for advisory planning)

4. Input of Soil Parameters:

- Users manually enter key soil data or use IoT sensors:
 - pH level (ideal range: 6.2–7.8)
 - NPK values (Nitrogen, Phosphorus, Potassium)
 - Moisture percentage
- Optional: Integration with Bluetooth soil sensors for auto-fetching values.
- Historical soil data is retrieved from SQLite for context-aware prediction.

5. Data Preprocessing and Normalization:

- Input values are validated and pre-processed:
 - Missing values are handled using default thresholds or imputation.
 - Normalization is applied to bring all features to a uniform scale.
- Categorical data (e.g., crop type) is encoded using Label Encoding or One-Hot Encoding.

6. ML Model Input and Fertilizer Prediction:

- A trained XGBoost model (or Random Forest in alternate versions) is used.
- Input Format:

python

```
input_data = [[N, P, K, pH, moisture, crop_code, rainfall, farm_area]]
```

- Model predicts:
 - Best-suited fertilizer type (e.g., Urea, DAP, NPK blend)
 - Recommended quantity based on area
 - Application timing (e.g., pre- or post-monsoon)

7. Report Generation (Optional):

- A detailed PDF report is generated using ReportLab or PDFKit, including:
 - Soil Health Analysis
 - Recommended Fertilizer Plan
 - Weather Impact Advisory
 - Sustainability Score (e.g., CO₂ emission reduction)
- Share options include WhatsApp or Email.

8. Output Display to User:

- An interactive dashboard display:
 - Current vs Optimal Soil Nutrient Comparison
 - Recommended Fertilizer Type, Amount, and Timing
 - Estimated Cost vs Yield Gain
- Users can give feedback (thumbs up/down) to improve future model predictions.