🕮 SmartFert Recommendation System — User Manual & Documentation

1. Introduction

SmartFert is an advanced AI-powered agricultural tool designed to calculate the exact amount of fertilizer required for a crop. It replaces guesswork with science by using two methods:

1. **NPK Mode (Standard):** Based on regional government recommendations.
2. **STCR Mode (Precision):** Based on the "Soil Test Crop Response" scientific formula targeting a specific yield.

It creates a complete nutrition plan including **Chemical Fertilizers (Urea, DAP, MOP)**, **Organic Inputs**, **Cost Estimation**, and **Application Schedule**.

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2. ❁ How the Engine Works (Backend Logic)

The engine (smart_fertilizer_engine.py) follows a 5-step process to generate results.

Step 1: Data Loading

The engine loads four key databases:

- **Master Database:** Contains crop standards and STCR equations for every state.
- **Organic Rules:** Nutrient content of manures (FYM, Vermicompost, etc.).
- **Thresholds:** Rules to classify soil as Low, Medium, or High fertility.
- **Special Rules:** Logic for pH correction, salinity, and drip irrigation.

Step 2: Calculation Method (The Math)

- **If NPK Mode is selected:**
  - The engine looks up the standard dose from the database based on State, Crop, Season, and Soil Type.
  - *Example:* Andhra Pradesh → Rice → Kharif = 120 kg N, 60 kg P, 40 kg K.
- **If STCR Mode is selected:**
  - The engine uses a mathematical equation:

    $$\text{Fertilizer Dose} = (A \times \text{Target Yield}) - (B \times \text{Soil Test Value}) - (C \times \text{Organic Input})$$
  - *Logic:* It calculates what the plant needs for the target yield, subtracts what is already in the soil, and gives the remaining deficit as the fertilizer requirement.

Step 3: Organic Credit Adjustment

If the user adds organic manure (e.g., 5000 kg FYM), the engine calculates how much N-P-K that manure provides and **subtracts** it from the chemical requirement.

- *Benefit:* Saves money and prevents over-fertilization.

Step 4: Special Agronomy Rules (The AI Logic)

The engine checks specific conditions to refine the dose:

1. **Soil pH Check:**
    - If pH < 5.5 (Acidic) → Recommends Lime.
    - If pH > 8.5 (Alkaline) → Recommends Gypsum.
2. **Salinity (EC) Check:**
    - If EC > 2.0 (Saline) → Reduces the Target Yield (e.g., by 30%) automatically because crops cannot grow fully in salty soil.
3. **Legume Effect:**
    - If the previous crop was a Legume (Pulses), it reduces the Nitrogen dose by ~20-30 kg/ha (Nature's gift).
4. **Drip Irrigation (Fertigation):**
    - If selected, reduces the fertilizer dose by 20% because drip is more efficient than flood irrigation.

Step 5: Bag Conversion

Finally, it converts the required pure nutrients (kg/ha) into commercial bags (50kg):

- **Phosphorus (P)** is fulfilled first using **DAP**.
- **Remaining Nitrogen (N)** is fulfilled using **Urea**.
- **Potassium (K)** is fulfilled using **MOP**.

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3. 💻 How to Use the UI (Frontend Guide)

Mode Selection

- **Choose NPK Mode:** If you **don't** have a soil test report. This gives a general recommendation for your region.
- **Choose STCR Mode:** If you **have** a soil test report (N, P, K values) and want a precise yield target.

Input Fields Explained

Input Field	Description	Mandatory?
State	Select your state (e.g., Andhra Pradesh).	☑ Yes
Crop	Select the crop you want to grow.	☑ Yes
Season	Kharif (Monsoon), Rabi (Winter), or Zaid (Summer).	☑ Yes
Soil Type	Select your soil texture (e.g., Alluvial, Black, Red).	☑ Yes
Target Yield	Expected production in Quintals/hectare (q/ha). *(Only for STCR)*	⚠ **STCR Only**

Input Field	Description	Mandatory?
Soil Test (N, P, K)	Values from your Lab Report.	⚠ **STCR Only**
pH, EC, OC	Additional soil parameters for health check.	❌ Optional
Irrigation Type	Flood (Normal) or Drip (Fertigation).	❌ Optional
Previous Crop	What did you grow last season?	❌ Optional

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4. 🌾 Input Reference Guide (What values to enter?)

Farmers often ask: *"What is a realistic Target Yield?"* or *"Is my soil value High or Low?"*. Use these tables as a guide.

A. Realistic Target Yields (q/ha)

Enter values within these ranges for best results in STCR mode.

Crop Type	Crop Name	Typical Yield (q/ha)	High Yield (q/ha)
Cereals	Rice (Paddy)	40 - 60	70+
	Wheat	35 - 50	60+
	Maize (Corn)	50 - 70	90+
Vegetables	Tomato	250 - 400	600+
	Potato	200 - 300	400+
	Brinjal / Cauliflower	200 - 300	400+
Cash Crops	Cotton	20 - 30	40+
	Sugarcane	800 - 1000	1200+
Pulses	Chickpea / Lentil	10 - 20	25+

B. Soil Test Value Reference (Nutrient Status)

This helps you understand if your soil is Deficient or Sufficient.

Parameter	Low (Deficient)	Medium (Normal)	High (Sufficient)
Nitrogen (N)	< 280 kg/ha	280 - 560 kg/ha	> 560 kg/ha
Phosphorus (P)	< 10 kg/ha	10 - 25 kg/ha	> 25 kg/ha
Potassium (K)	< 110 kg/ha	110 - 280 kg/ha	> 280 kg/ha
Organic Carbon (OC)	< 0.5 %	0.5 - 0.75 %	> 0.75 %
pH (Acidity)	< 6.0 (Acidic)	6.5 - 7.5 (Neutral)	> 8.5 (Alkaline)

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5. 📊 Understanding the Output Results

When you click **"Generate Recommendation"**, the system provides:

1. **Target Final Dose:**
   - The exact amount of pure N, P, and K required per hectare.
   - *Note:* If P or K is 0.0, it means your soil already has enough, saving you money.
2. **Nutrient Balance Graph:**
   - A visual bar chart showing the ratio of N:P:K needed.
3. **Required Fertilizer Bags (The Shopping List):**
   - Calculates exactly how many **50kg bags** you need to buy.
   - **Urea:** For Nitrogen.
   - **DAP:** For Phosphorus (and some Nitrogen).
   - **MOP:** For Potassium.
4. **Estimated Cost Calculator:**
   - Shows the approximate cost based on government rates.
   - *Feature:* You can edit the price per bag if your local market rates are different.
5. **Application Schedule (When to apply?):**
   - **Basal:** Put full Phosphorus (DAP) and Potash (MOP) + 50% Urea at the time of sowing.
   - **Vegetative:** Put 25% Urea after 25-30 days.
   - **Flowering:** Put remaining 25% Urea when flowers appear.
   - *Reason:* Nitrogen evaporates easily, so it must be split. P and K stay in the soil, so apply once.
6. **Expert Advisories:**
   - **Red Warning (⚠):** Critical issues like High Salinity or extreme pH.
   - **Yellow Warning (🩹):** Nutrient deficiencies.
   - **Blue Info (ⓘ):** General advice like organic credit applied.

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6. Technical Setup (For Developers)

To run this project on a local machine:

1. Prerequisites:

- Python 3.8+
- Streamlit
- Pandas

2. Folder Structure:

Ensure your files are arranged exactly like this:

Plaintext

```
/smart_farmer/
  ├── app.py
  ├── data/
  │    ├── __init__.py
  │    ├── smart_fertilizer_engine.py
  │    ├── final_hard_normalized.json
  │    ├── organic_rules.json
  │    ├── soil_fertility_thresholds.json
  │    └── stcr_equation_constants.json
  ├── pages/
  │    └── Fertilizer_Recommendation.py
  └── utils/
       └── language.py
```

3. Running the App:

Open terminal/command prompt and type:

Bash

```
streamlit run app.py
```
