NPK Alternate Pipeline

🌱🔧 Final Hardware + Sensor Pipeline

🛠️ Hardware Components:

Component	Purpose	Placement	Estimated Cost (INR ₹)
RGB Sensor (or) NIR	Estimate **Nitrogen (N)** and **Phosphorus (P)** via light reflectance	Above soil (inside light-proof chamber with LED)	₹300–₹900
EC Sensor (DFRobot Gravity EC)	Estimate **Potassium (K)** and Total Nutrient Salts	Under soil (5–10 cm)	₹800–₹1200
DFRobot pH Sensor (SEN0161)	Detect **soil acidity/alkalinity**	Under soil	₹1,200–₹1,500
Capacitive Soil Moisture Sensor	Helps correct EC/pH readings; monitors **soil water level**	Under soil	₹150–₹250
White LED Array	Uniform lighting for multispectral sensor	Inside chamber above soil	₹50
ESP32 / Raspberry Pi Pico W	Microcontroller with WiFi/BLE for sensor control and ML inference	Inside waterproof housing	₹300–₹600
3.7V Li-ion Battery + Solar Charging Module (optional)	Power source	Enclosed	₹250–₹400
Waterproof Enclosure + Probe Housing (3D printed or PVC)	Housing & protection	One end above, other buried	₹200–₹300

💰💵 Estimated Total Cost:

Tier	Description	Total Cost (INR ₹)

Basic Version	All sensors + MCU + wired power	₹2,500 – ₹3,200
Field-Ready (Waterproof + Battery + Enclosure)	Full automated probe with solar + WiFi	₹3,800 – ₹4,500

🔁 **Bulk production cost** can reduce it by 30–40%.

🧠🚀 Final Working Pipeline (End-to-End)

🪛 Step 1: Sensor Setup

- Insert the probe in the field.
- Top of the probe (above soil) has **multispectral sensor in a covered box**.
- Bottom (under soil) has **pH, EC, and moisture sensors** close together at 5–15 cm depth.

📊 Step 2: Data Collection

1. Multispectral sensor shines internal LED, scans light reflected from soil surface.
2. EC sensor measures conductivity (linked to K and TDS).
3. pH sensor measures acidity (affects P/N availability).
4. Moisture sensor helps correct EC readings.

🧠 Step 3: ML-Based NPK Prediction

- All sensor values fed to an **ML model (random forest/regression)** onboard or in the cloud.
- Model outputs approximate **Nitrogen, Phosphorus, Potassium (NPK) values**.

- It also classifies **soil health status** (e.g., N-Deficient, Ideal, K-Surplus).

📩 Step 4: Fertilizer Recommendation

- Based on predicted NPK values and crop type (optional input), the system recommends:
    - **What fertilizer to apply**
    - **How much to apply**
    - **When to apply it**

🌐 Step 5: Output/Communication

- Send result via:
    - **OLED display** (optional)
    - **WiFi/Bluetooth to phone**
    - **Upload to cloud (Firebase, MQTT, ThingsBoard)**

✅ Summary: Features You're Building

Feature	Description
💰 **Low-Cost**	~₹3.5K total for near-NPK accuracy
📡 **IoT Enabled**	WiFi or BLE output (ESP32)
🧠 **ML Smart**	Accurate estimation without NPK sensor
🔋 **Field-Ready**	Solar or battery powered
🛠️ **DIY Friendly**	Can be scaled or customized

🌾 **Actionable Output** Fertilizer + dosage + alert