Plant Health TinyML - Hardware Integration Guide

Overview

Deploy the plant health classification model on ESP32 with:

- **Real sensors:** Soil moisture + Temperature
- **Simulated sensors:** NPK (3 potentiometers) + pH (1 potentiometer)

---

1. Hardware Components

Component	Quantity	Purpose
ESP32 DevKit V1	1	Microcontroller
Capacitive Soil Moisture Sensor v1.2	1	Soil moisture reading
DHT22 (or DHT11)	1	Temperature + Humidity
10kΩ Potentiometer	4	Simulate N, P, K, pH
Breadboard	1	Prototyping
Jumper Wires	~20	Connections

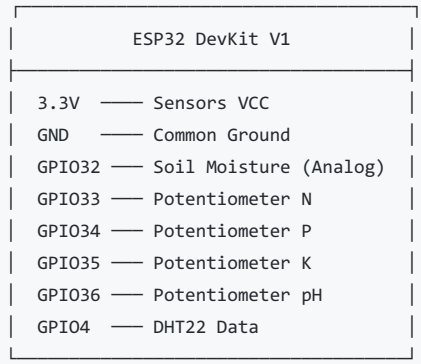
Alternative Temperature Sensors

- DS18B20 (waterproof) - better for soil temperature
- DHT11 (cheaper, less accurate)

---

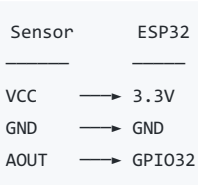
2. Pin Connections

ESP32 Pinout Summary



Detailed Wiring

A. Soil Moisture Sensor (Capacitive v1.2)



B. DHT22 Temperature/Humidity Sensor

```
DHT22        ESP32
─────        ─────
VCC    ──► 3.3V
GND    ──► GND
DATA   ──► GPIO4
(Add 10kΩ pull-up resistor between DATA and VCC)
```

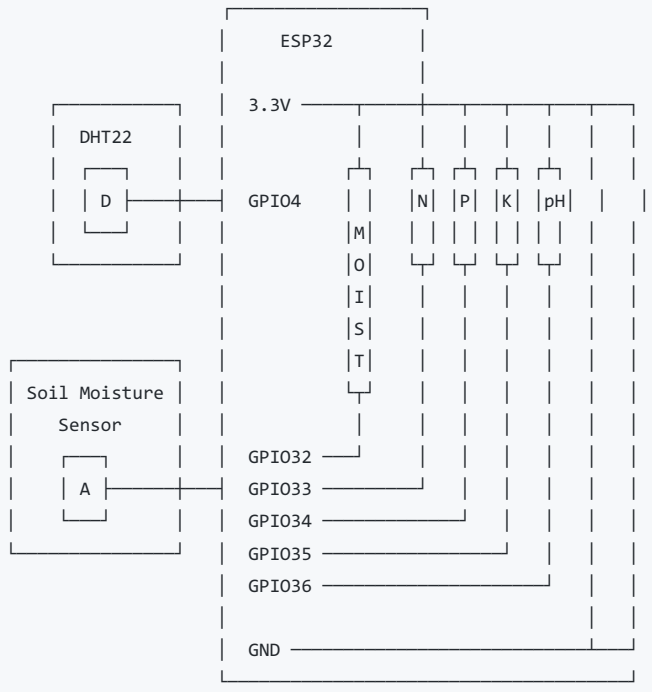
C. Potentiometers (x4) - NPK + pH Simulation

```
Each Potentiometer:
┌─────────┐
│    2    │ ──► ESP32 ADC Pin
│   ┌─┐   │
│ 1 │ │ 3 │
└───┴─┴───┘
  │   │
  │   └──► GND
  └──────► 3.3V

Pot N  (pin 2) ──► GPIO33
Pot P  (pin 2) ──► GPIO34
Pot K  (pin 2) ──► GPIO35
Pot pH (pin 2) ──► GPIO36
```

---

3. Wiring Diagram




```
MOIST = Soil Moisture Sensor
N/P/K/pH = Potentiometers
```

---

4. Sensor Calibration Values

Soil Moisture Sensor

Condition	ADC Value	Percentage

Condition	ADC Value	Percentage
Dry Air	~3500	0%
Dry Soil	~3000	20%
Moist Soil	~1500	60%
Water	~1200	100%

Potentiometer Mapping

Sensor	Min Value	Max Value	Unit
N (Nitrogen)	0	150	mg/kg
P (Phosphorus)	0	150	mg/kg
K (Potassium)	0	200	mg/kg
pH	3.5	9.0	pH

DHT22 Specifications

Parameter	Range	Accuracy
Temperature	-40 to 80°C	±0.5°C
Humidity	0-100%	±2-5%

---

5. Software Dependencies

Install these libraries in Arduino IDE:

1. **Chirale_TensorFlowLite** - TinyML runtime
2. **DHT sensor library** by Adafruit
3. **Adafruit Unified Sensor** - DHT dependency

Arduino IDE → Sketch → Include Library → Manage Libraries:

- Search "DHT sensor library" → Install (by Adafruit)
- Search "Adafruit Unified Sensor" → Install
- Search "Chirale_TensorFlowLite" → Install

---

6. Expected Model Behavior

Condition	Expected Prediction
All normal	healthy
N < 20 mg/kg	nitrogen_deficiency
P < 15 mg/kg	phosphorus_deficiency
K < 15 mg/kg	potassium_deficiency
Moisture < 20%	water_stress
pH < 5.5	ph_stress_acidic
pH > 7.5	ph_stress_alkaline

7. Testing Procedure

Step 1: Verify Wiring

Upload a simple analog read sketch to check all connections

Step 2: Calibrate Sensors

- Note ADC values for dry/wet soil moisture sensor
- Verify potentiometer full range (0-4095)

Step 3: Test Each Condition

1. Set all potentiometers to mid-range, ensure good moisture
2. Turn N potentiometer to minimum → expect "nitrogen_deficiency"
3. Reset N, turn P to minimum → expect "phosphorus_deficiency"
4. Continue for each stress condition

Step 4: Integration Test

- Simulate real conditions
- Verify predictions match expectations

---

8. Troubleshooting

Issue	Solution
ADC reads 0	Check 3.3V connection
ADC reads 4095	Check GND connection
DHT read fails	Add 10kΩ pull-up resistor
Model init fails	Increase tensor arena size
Wrong predictions	Verify calibration ranges