PROJECT ABSTRACT

IoT Vertical Farm Monitor with Dashboard

An ESP32-based monitor for rack-based vertical farms: air climate, per-rack soil moisture, automated drip irrigation, grow-light scheduling and a web dashboard.

Project type: Hardware + Software (Hybrid)

Availability: Built to order

Suitable branches: IoT & Embedded, Electronics / E&TC

Technologies: ESP32, DHT22, capacitive soil moisture sensors, relay, mini pump, web dashboard

Price: Request a quotation

1. Introduction / Background

Vertical farming stacks crops on tiered racks under grow lights, using far less land and water than field agriculture - but the dense, enclosed environment punishes neglect quickly: one missed watering dries a rack in hours, and still air invites fungal disease.

This project builds an ESP32-based monitor for a 4-tier, 2-rack demo farm. A DHT22 tracks air temperature and humidity, capacitive soil-moisture probes watch each rack zone, and the controller runs drip irrigation automatically when a zone falls below threshold, schedules the grow LEDs, and reports everything to the VerdaSense web dashboard with climate charts, per-rack moisture bars and an event log.

2. Problem Statement

Small vertical-farm and hydroponic setups are usually watered and lit by hand on a fixed schedule. Fixed schedules ignore actual soil moisture - overwatering some racks while underwatering others - and there is no record of what the climate did overnight.

This project replaces the fixed schedule with sensor-driven control: irrigate a rack only when its soil moisture drops below 30%, run the vent fan when humidity peaks, keep the 06:00-22:00 light schedule, and log every action on a dashboard the grower can check from a phone.

3. Objectives

- Monitor air temperature and humidity with a DHT22 sensor.
- Measure soil moisture per rack zone with capacitive probes.
- Automate drip irrigation with hysteresis (start below 30%, stop with 8% hysteresis, max 6-minute run).
- Schedule grow LEDs 06:00-22:00 and run a vent fan on high humidity.
- Present climate charts, rack-zone moisture levels, actuator states and an event log on a web dashboard.

4. Proposed Methodology

- Wire the DHT22, four capacitive soil-moisture probes, a relay-driven mini DC pump with drip tubing, grow LED strips and a vent fan to the ESP32.
- Calibrate each moisture probe in dry and saturated soil to map raw readings to percentage.
- Implement the control loop: per-zone irrigation with hysteresis and run-time cap, humidity-triggered ventilation, and the LED schedule.
- Publish readings over Wi-Fi; render the 24-hour climate chart with irrigation markers, rack-zone bars and the event log on the dashboard.
- Run a 48-hour observation: verify irrigation triggers at the threshold and moisture recovers after watering.

5. System Architecture / Working

The edge layer is the ESP32 node with all sensors and actuators, running the control loop locally so plants are protected during network outages. The application layer is the VerdaSense dashboard: KPI cards (air temperature vs 22-27 C target, humidity, average soil moisture, light hours), a 24-hour climate chart with irrigation-event markers, per-rack moisture bars with pump states, actuator tiles and a timestamped event log.

Thresholds and schedules are configurable; the firmware enforces safety caps (maximum pump run time) regardless of configuration.

6. Hardware / Software Requirements

- Hardware: ESP32 development board, DHT22 sensor, 4x capacitive soil-moisture probes, 5 V relay module, mini DC water pump with tubing, grow LED strip + 12 V supply, small DC vent fan, rack/pot mock-up with seedlings, breadboard and jumper wires.
- Software: Arduino IDE with DHT library, Wi-Fi network, web dashboard (single-file HTML/JS app included).

7. Expected Outcomes

- Sensor-driven irrigation per rack zone with hysteresis and safety run-time cap.
- 24-hour climate history with irrigation events marked on the chart.
- Grow-light scheduling and humidity-triggered ventilation running automatically.
- Dashboard with per-rack moisture levels, actuator states and a full event log.
- A documented build: wiring diagram, firmware, dashboard and probe-calibration procedure.

8. Applications

- Home and terrace vertical-farm setups.
- School/college polyhouse and hydroponic teaching rigs.
- Nursery seedling racks needing consistent moisture.
- Urban microgreen production units.
- Research plots studying irrigation scheduling.

9. Future Scope

- Per-zone nutrient (EC/pH) sensing and dosing.
- Camera-based growth monitoring and leaf-area estimation.
- Weather-aware ventilation using forecast data.
- Solar-powered outdoor deployment with deep sleep.
- Multi-rack mesh networking for commercial grow rooms.