

PROCEDURE MANUAL

REAL-TIME SMART AGRICULTURE SYSTEM

ON μ T-KERNEL 3.0

Entry ID : 34686

❖ Sensors & Components in our System

1. Capacitive Soil Moisture Sensor v2.0



About: A soil moisture probe that measures the water content in the soil. Unlike older resistive types, it uses capacitance, so it doesn't corrode quickly.

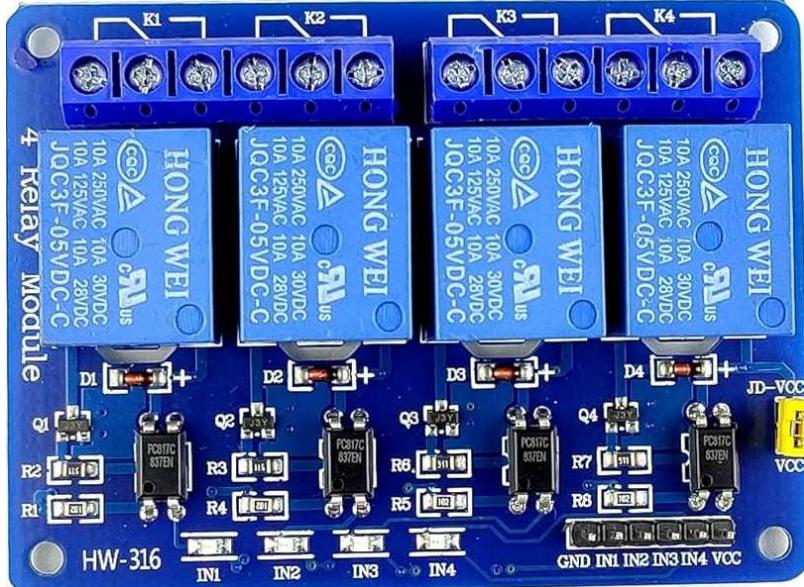
- **How it works:**
 - The sensor has copper traces forming a capacitor.
 - Soil acts as a dielectric: wet soil increases capacitance, dry soil decreases capacitance.
 - The onboard circuit converts this change into an analog voltage output (proportional to moisture level).
- **Why it's important:**
 - Gives real-time soil water content.
 - Prevents overwatering or under watering.
 - Can be calibrated for different crops (each crop needs different soil moisture range).
- **DELIVERABLES:**
 1. Monitors the farm's climate conditions.
 2. Helps decide when and how much to irrigate.
 3. Prevents overwatering during high humidity.
 4. Sends data to the cloud for farmer monitoring

2. SHT31 (Temperature & Humidity Sensor)



- **About :** A digital sensor that measures air temperature and relative humidity.
- **How it works:**
 - Inside the chip, a polymer dielectric absorbs/desorbs water vapor → changing capacitance, which maps to humidity.
 - Temperature is measured using a precision band-gap sensor.
 - Communicates via I²C (digital output).
- **Why it's important in agriculture:**
 - Temperature and humidity directly affect crop transpiration, soil drying rate, and disease risk.
 - Example: high humidity + warm temperature → higher risk of fungal diseases.
 - Used to decide when and how much to irrigate, and whether to alert farmers about environmental stress.
- **DELIVERABLES:**
 1. Detects soil wetness/dryness using capacitance (no corrosion issues).
 2. Sends real-time soil data to ESP32 for irrigation decisions.
 3. Helps prevent overwatering or underwatering.

3. 4-Channel Relay Module



- **About:** An electromechanical/electronic switch controlled by the MCU.
- **How it works:**
 - The relay has a coil that, when energized, pulls a switch to connect/disconnect a circuit.
 - The 4-channel version allows you to independently control four devices (pump, lights, fans, valves, etc.).
- **Why it's important:**
 - Provides isolation between low-voltage MCU and high-power devices.
 - Allows safe switching of 12V DC loads.

DELIVERABLES:

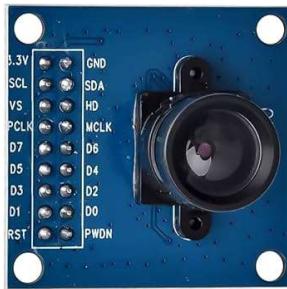
1. Acts as a switch between ESP32 (low voltage) and pump (high voltage).
2. ESP32 controls the pump safely.
3. It supports multiple devices if needed (4-channel relay)

4.12V DC Water Pump



- **About:** A small DC motor-driven pump.
- **How it works:**
 - Motor rotates an impeller, pushing water through drip pipes.
 - Powered by 12V supply, switched ON/OFF via relay.
- **In our system:**
 - When soil moisture < threshold → relay closes → pump ON → irrigation starts.
 - Stops when soil moisture reaches required level.
- **Why it's important:**
 - Automates irrigation → saves water, reduces labor.
 - Ensures crops get just the right amount of water.
- **DELIVERABLES:**
 - Provides water to crops via drip lines.
 - Controlled automatically by relay based on soil moisture.
 - Ensures efficient water usage for healthy plant growth.

5. Camera Module (OV7670)



- **About:** A low-cost VGA camera sensor (640×480).
- **How it works:**
 - Captures images through CMOS sensor.
 - Outputs raw parallel video data (needs MCU/DSP to process).
 - Controlled via SCCB (I²C-like) interface.
- **In agriculture use:**
 - Captures images of leaves, stems, or soil.
 - Can be processed locally (if MCU powerful enough) or sent to cloud/AI model.
 - AI/ML can detect diseases, pests, nutrient deficiencies by analysing leaf patterns, colour and texture.
- **Why it's important:**
 - Enables smart disease detection → early warning system for farmers.
 - Complements sensors (moisture, temp, humidity) by giving visual crop health feedback.

DELIVERABLES:

1. **Crop Monitoring:** Captures images of plants to monitor growth, detect stress, or identify diseases.
2. **Soil & Moisture Observation:** Helps visually check soil condition, water distribution, and whether the drip irrigation is effectively reaching plants.
3. **Automation & Smart Decisions:** When connected to an ESP32 or microcontroller with image processing, it can assist in automating irrigation decisions based on plant health or soil condition (e.g., delaying or increasing watering).

6.ESP32 Microcontroller



ABOUT:

- ESP32 is a low-cost microcontroller board made by Espressif Systems.
 - It's like the “brain” of your project.
 - It combines:
 - CPU → Processes data.
 - GPIO pins → Connect to sensors, relays, etc.
 - Wi-Fi + Bluetooth → Built-in wireless communication.
 - ADC (Analog-to-Digital Converter) → Reads analog signals (like soil sensor).
 - I²C, SPI, UART → Communication protocols to talk with digital sensors (like SHT31).

WORKING OF ESP32:

- It reads input signals from sensors (like soil moisture, temperature, humidity)
 - It processes that data (e.g., compare with thresholds)
 - It controls outputs (like relay modules → pumps)

- It sends data to the cloud (via Wi-Fi) for monitoring on a mobile app or web dashboard

DELIVERABLES:

- **Reads soil condition** - via soil moisture sensor.
- **Monitors weather** - via temperature & humidity sensor.
- **Controls irrigation** - via relay + water pump.
- **Captures plant images** - via camera module.
- **Connects to cloud** - sends sensor data, images, and pump status for remote monitoring and Disease monitoring
- **Makes decisions** - “Soil is dry → turn ON pump → run for 2 minutes → stop.”

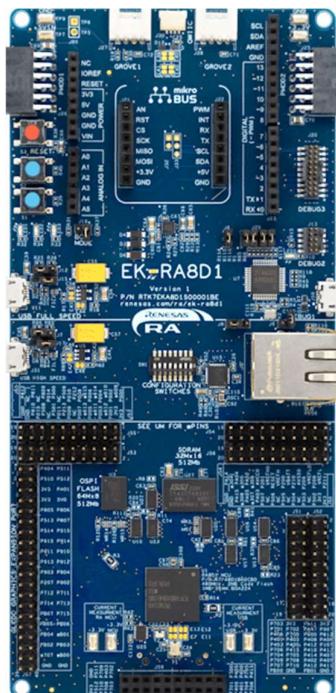
7. Renesas Board (EK-RAD81)

ABOUT:

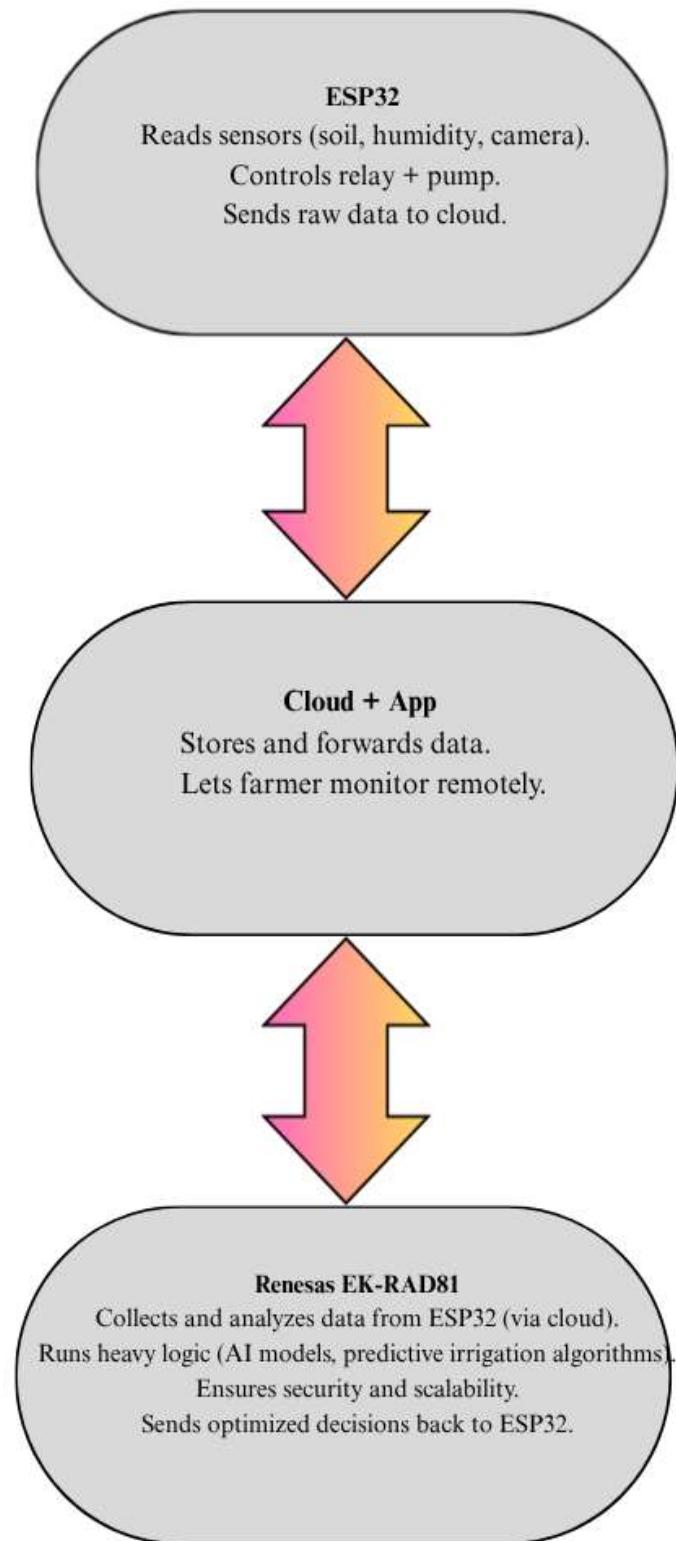
The Renesas EK-RAD81 is an evaluation kit for the RA8 series MCUs powered by the Arm Cortex-M85 core.

It offers high performance, security, and connectivity for automotive and industrial applications.

With built-in AI/ML support it enables real-time edge intelligence like detection and predictive maintenance.



FLOW:



🌐 Cloud App Role:

- Collects all sensor data (soil moisture, temperature, humidity, pump status)
Using the ESP32
- Stores and visualizes data in real-time dashboards.
- Sends alerts (SMS/app notifications) for conditions like:
 - Low soil moisture
 - High disease probability detected by camera AI
 - Extreme weather conditions.
- Can implement crop-specific irrigation profiles (e.g., rice needs standing water, tomatoes need periodic irrigation).

• **ROLE IN OUR SYSTEM:**

1. Stores and displays sensor data (soil, temp, humidity, pump status).
2. Allows farmer to monitor crops remotely through a mobile/web app.
3. Enables manual or automatic irrigation control from anywhere

⌚ System Workflow (Step-by-Step)

1. Soil moisture sensor continuously measures soil water level.
2. Temperature & humidity sensor tracks environment.
3. MCU checks thresholds (based on crop type settings).
4. If soil is dry → MCU activates relay → Pump ON → Irrigation begins.
5. Camera captures leaf images → Sent to cloud → AI detects disease symptoms.
6. Cloud app logs everything and gives farmer real-time insights.
7. Once soil moisture is adequate → Pump OFF.

OUTCOMES:

- Efficient irrigation (water only when needed).
- Crop-specific water management (different crops, different thresholds).
- Disease detection & prevention (via camera & cloud AI).
- 24×7 monitoring & control from anywhere (IoT cloud app).