VIETNAM NATIONAL UNIVERSITY - HO CHI MINH CITY
HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY
Faculty of Computer Science and Engineering

REPORT: LOGIC DESIGN PROJECT
TOPIC: SMART GARDENING PROJECT
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Group 3 - CC04

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1 EXECUTIVE SUMMARY

1.1 Goal

Automate tree washing/irrigation based on real conditions and schedules; reduce human effort; water versus manual methods; keep foliage clean for better photosynthesis and urban aesthetics.

1.2 KPIs

- System up time high speed
- Correct alert rate (low tank, dry-run, leakage)
- Water saving
- Launching flexibility

2 CONTEXT - PROBLEM - SCOPE

2.1 Context and Need

- Dusty urban areas: require periodic washing of leaves and trunks to improve photosynthesis and appearance.
- Campuses/parks/farms: require irrigation optimized by soil moisture and weather.

2.2 Use Cases

1. Home - Balcony: 1-4 pots; mini pump + mist nozzles; app on/off; morning/evening schedule; rain skip
2. Campus/Park: 10-50 watering points; zoning; per-zone water statistics; alert for low tank/pump jam
3. Urban washing: light-pressure wash cycles at night/off-peak; prioritize cleaning leaves/trunks without wasting water.

2.3 In scope & Out scope

- In scope: washing/irrigation automation, remote monitoring, scheduling, alerts, OTA updates, dashboard.
- Out scope: computer vision, autonomous tanker vehicles, automated fertilization (placed on roadmap).

3 SYSTEM REQUIREMENTS

3.1 Function Requirements

- Read sensors: soil moisture, rain, light, flow, ambient temperature/humidity.
- Control pump/valves by thresholds, schedule, and manual command from app/web.
- Skip washing/irrigation when it rains; stop on detecting leaked water in the dry environment.
- Scheduling (cronlike), multizone control, manual override with safe time-out.
- Log data & send telematry (MQT/HTTPS); buffer when offline
- OTA firmware; remote configuration (Wi-Fi, threshold, schedules, zones,...)
- Alert: tank low/dry-run/unusual pressure-flow/disconnect.

3.2 Non-Functional Requirements

- Outdoor durability; UV-resistant; waterproof cabling and rust protection
- Security: TLS, key-management, source boot,...
- Control latency (delay) < 2s via LAN and < 5s via cloud
- Power: battery/solar on 12V adapter; deep-sleep, watchdog, auto recovery
- Maintainable: replace filters/nozzles; check valves/pump; hot-swap node

3.3 CONSTRAINTS and ASSUMPTION

- Stable water source; pressure compatible with selected nozzles
- Wi-Fi coverage

4 SYSTEM ARCHITECTURE

4.1 Logic Flow

1. **Sensor reading:** Soil moisture, rain detection, light, temperature & humidity.
2. **Condition check:**
   - If soil moisture $< threshold$ (e.g. 40%).
   - AND rain sensor indicates "dry".
3. **Decision:** ESP32 triggers MOSFET → pump ON.
4. **Water amount:**
$$T_{on} = \frac{V_{water,need}}{Q_{pump}}$$
   Example: $V_{water,need} = 0.6L$, $Q_{pump} = 1.2\,L/min \Rightarrow T_{on} = 30s$.
5. **Update:** After watering, pump OFF, ESP32 logs data and returns to deep-sleep.
6. **Repeat cycle:** Re-check every T_{check} (e.g. 10–15 minutes).

4.2 Flow chart

The overall schematic of the proposed irrigation system is shown in Figure 1.

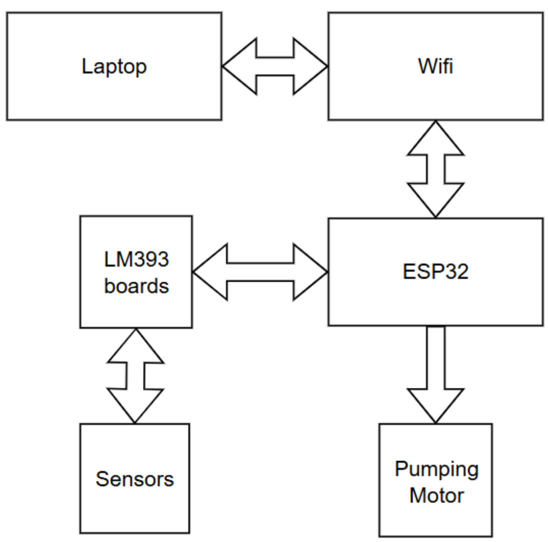

Figure 1: Overall Schematic (Demo)

5 HARDWARE DESIGN

5.1 Bill of material (BOM)

Type	**Device**	**Note**
MCU	ESP32-WROOM, ESP32-S3/NodeMCU	Wi-Fi, OTA, TLS
Soil sensor	Soil Moisture Sensor	More durable than resistance
Rain sensor	Rain Water Sensor	Detect the current weather
Light sensor	Photo-diode Light Sensor	Detect the light quality
Temp/Humid sensor	DHT22/11 Temperature Humidity Sensor	Detect the temperature and humidity
Driver	MOSFET (F5305S) or RELAY	Stop the machine when raining
Water Pump	R385 Water Pump 12VDC	Water pumping when match the right conditions
Power	12V-3A adapter or 12V LiFePO4 + 20–50W solar	Maintain the machine anytime
Conversion	12V → 5/3.3V	Power conversion
Enclosure	**IP65** box (at least), cable glands, PE tubing, nozzles, filter	Outdoor standard

5.2 Calculation

5.2.1 Assumption

- Power source: Battery/Source 12V
- Buck $12V \to 5V$, efficiency $\eta \approx 0.9$
- ESP32 NodeMcu-32S: $I = 120\,mA$ at $5V$ (Wi-Fi activated)
- Sensors go through MOSFET, turn on every $2sec/min$ ($\approx$ 3.33% duty cycle)
  - Rain board: $20\,mA - 5V$
  - Photo-diode light: $0.5\,mA - 5V$
  - Soil moisture: $35\,mA - 5V$
  - DHT11: $2.5\,mA - 5V$
- R385 Water pump: $12V - 0.7A$, Flow $\approx 1 - 2\,L/min$

- Battery: $12V - 60Ah$, usable depth of discharge (DoD) = 50% $\Rightarrow 360\,Wh$

5.2.2 Formulas

For a device powered at $5V$ through a buck from $12V$:

$$P_{12V} = \frac{V_{5V} \cdot I_{5V}}{\eta}, \quad E_{12V} = P_{12V} \cdot t \quad (Wh)$$

For a device powered directly at $12V$:

$$P_{12V} = V_{12V} \cdot I_{12V}, \quad E_{12V} = P_{12V} \cdot t \quad (Wh)$$

Total daily energy:

$$E_{total} = E_{ESP32} + E_{sensors} + E_{pump}$$

Battery runtime:

$$T_{days} = \frac{E_{usable}}{E_{total}}, \quad E_{usable} = V \cdot C_{bat} \cdot DoD$$

5.2.3 Results

- ESP32: $P \approx 0.667W \Rightarrow E \approx 16.0\,Wh/day$
- Sensors (duty-cycled): $P \approx 0.011W \Rightarrow E \approx 0.26\,Wh/day$
- Baseline (ESP32 + Sensors): $\approx 16.26\,Wh/day$
- Pump: $P \approx 8.4W$ $(12V \times 0.7A)$

Pump run (min/day)	Pump energy (Wh/day)	Baseline (Wh/day)	Total (Wh/day)	Days (12V–60Ah, 50% DoD)
0	0.0	16.3	16.3	22.1
10	1.4	16.3	17.7	20.4
30	4.2	16.3	20.5	17.6
60	8.4	16.3	24.7	14.6
120	16.8	16.3	33.1	10.9
240	33.6	16.3	49.9	7.2

Table 1: Daily energy consumption estimates under different pump durations.