



SCEMS – Smart Community Environment Monitoring System

A Software-Only IoT Simulation Project

UFTB Robotics Club – Monthly IoT & Robotics Contest 2025
(Senior Category)

Submitted By:
Mst. Esat Jahan Akhi

ID:2201022

Session:2022-2023

GitHub: <https://github.com/Esatjahan/SCEMS-Environment-Monitoring>

Wokwi Simulation:
<https://wokwi.com/projects/448685686274316289>

Submission Date:11/28/2025

Contents

1. Introduction	3
The Hi-Tech industrial area in Gazipur is facing several environmental and public safety issues:	3
❖ Poor air quality.....	3
❖ Rapid temperature rise & heat stress	3
❖ Unstable soil moisture	3
❖ Crowd congestion at public points.....	3
❖ Night-time security problems.....	3
❖ Wasted electricity due to non-adaptive street lights	3
To solve these challenges, I built SCEMS – Smart Community Environment Monitoring System , a fully software-based simulation system that replicates:.....	3
○ Soil moisture monitoring.....	3
○ Temperature & humidity tracking	3
○ AQI monitoring	3
○ Crowd density detection.....	3
○ Security event detection	3
○ Adaptive lighting system.....	3
All sensors are implemented using Wokwi simulation , while analytics, alerts, and logs are generated using a Python backend and Streamlit dashboard	3
2. System Architecture	3
2.1 Sensor Simulation Layer (Arduino/Wokwi)	3
2.2 Backend Processing Layer (Python).....	5
2.3 Dashboard & Visualization Layer (Streamlit)	5
3. Algorithm Overview (Simplified)	7
4. Test Results.....	8
5. Conclusion.....	9
6. Important Links	10
END OF REPORT	10

1. Introduction

The Hi-Tech industrial area in Gazipur is facing several environmental and public safety issues:

- ❖ Poor air quality
- ❖ Rapid temperature rise & heat stress
- ❖ Unstable soil moisture
- ❖ Crowd congestion at public points
- ❖ Night-time security problems
- ❖ Wasted electricity due to non-adaptive street lights

To solve these challenges, I built **SCEMS – Smart Community Environment Monitoring System**, a **fully software-based simulation system** that replicates:

- Soil moisture monitoring
- Temperature & humidity tracking
- AQI monitoring
- Crowd density detection
- Security event detection
- Adaptive lighting system

All sensors are implemented using **Wokwi simulation**, while analytics, alerts, and logs are generated using a **Python backend** and **Streamlit dashboard**.

2. System Architecture

SCEMS consists of three major layers:

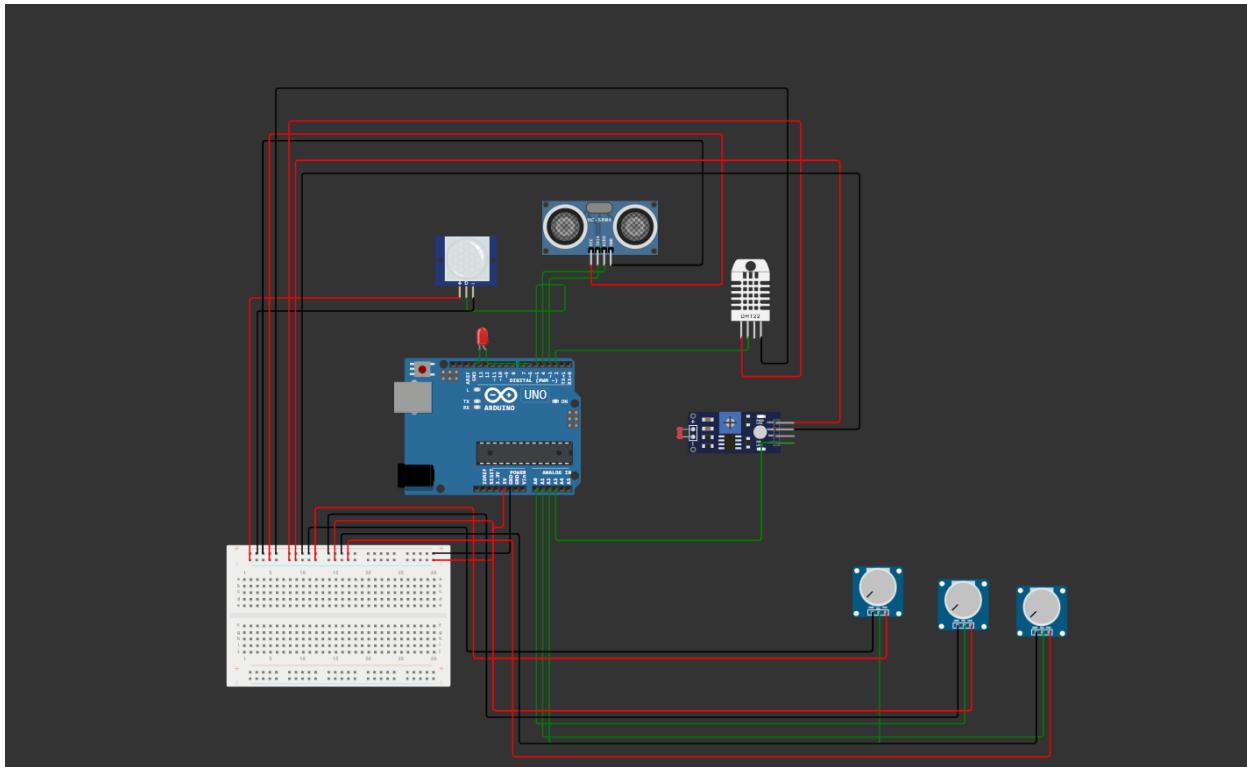
2.1 Sensor Simulation Layer (Arduino/Wokwi)

Simulated Components:

- Soil moisture (Potentiometer → A0)
- AQI mock sensor (Potentiometer → A1)
- Sound sensor (Potentiometer → A2)
- LDR light sensor (LDR + 10k → A3)
- DHT22 (D2)
- Ultrasonic Sensor HC-SR04 (D3 / D4)
- PIR Motion Sensor (D5)

- Street Light LED (D6)

Wokwi Circuit Overview



Wokwi Serial Monitor Frame Output

WOKWI SAVE SHARE Contest Project

sketch.ino diagram.json libraries.txt Library Manager

Simulation 00:14.654 100%

```

1 #include <DHT.h>
2
3 // -----
4 // Pin Definitions
5 //
6 #define SOIL_PIN A0 // Potentiometer + Soil moisture
7 #define AQI_PIN A1 // Potentiometer + AQI (mock)
8 #define SOUND_PIN A2 // Potentiometer + sound level
9 #define LDR_PIN A3 // LDR + 10k resistor divider
10
11 #define DHTPIN 2
12 #define DHTTYPE DHT22
13
14 #define TRIG_PIN 3 // Ultrasonic TRIG
15 #define ECHO_PIN 4 // Ultrasonic ECHO
16 #define PIR_PIN 5 // PIR output
17 #define LIGHT_PIN 6 // LED for adaptive lighting
18
19 DHT dht(DHTPIN, DHTTYPE);
20
21 // -----
22 // Helper functions
23 //
24
25 float readSoilPercent() {
26     int raw = analogRead(SOIL_PIN); // 0-1023
27     // map raw to 0-100% (you can adjust later if needed)
28     float percent = map(raw, 0, 1023, 0, 100);
29     return percent;
30 }
31
32 int readAQI() {
33     int raw = analogRead(AQI_PIN);
34     // Map raw analog to AQI range 0-500 (approx)
35     int aqi = map(raw, 0, 1023, 0, 500);
36     return aqi;
37 }
38
39 int readSoundLevel() {
40     int raw = analogRead(SOUND_PIN);
41     // 0-1023 + 0-100 arbitrary level
42     int level = map(raw, 0, 1023, 0, 100);
43 }
```

PIR: NO MOTION | Sound level: 0 | Security: NO_ALERT
LDR value: 250 | Night: YES | StormDarkDay: NO | Light status: NIGHT_MODE_LIGHT_ON

----- SCENS FRAME -----
Soil: 0.00% | Status: IRRIGATION_ALERT
Temp: 24.00 C | Humidity: 40.00 % | HeatIndex: 24.40 | HeatStatus: NORMAL
AQI: 0 | AQI Status: GOOD
Ultrasonic distance: 403 cm | Crowd estimate: 5 | Crowd status: NORMAL_CROWD
PIR: NO MOTION | Sound level: 0 | Security: NO_ALERT
LDR value: 250 | Night: YES | StormDarkDay: NO | Light status: NIGHT_MODE_LIGHT_ON

----- SCENS FRAME -----
Soil: 0.00% | Status: IRRIGATION_ALERT
Temp: 24.00 C | Humidity: 40.00 % | HeatIndex: 24.40 | HeatStatus: NORMAL
AQI: 0 | AQI Status: GOOD
Ultrasonic distance: 403 cm | Crowd estimate: 5 | Crowd status: NORMAL_CROWD
PIR: NO MOTION | Sound level: 0 | Security: NO_ALERT
LDR value: 250 | Night: YES | StormDarkDay: NO | Light status: NIGHT_MODE_LIGHT_ON

----- SCENS FRAME -----
Soil: 0.00% | Status: IRRIGATION_ALERT
Temp: 24.00 C | Humidity: 40.00 % | HeatIndex: 24.40 | HeatStatus: NORMAL
AQI: 0 | AQI Status: GOOD
Ultrasonic distance: 403 cm | Crowd estimate: 5 | Crowd status: NORMAL_CROWD
PIR: NO MOTION | Sound level: 0 | Security: NO_ALERT
LDR value: 250 | Night: YES | StormDarkDay: NO | Light status: NIGHT_MODE_LIGHT_ON

2.2 Backend Processing Layer (Python)

Files implemented:

- threshold_engine.py – All threshold rules
- sensors_simulation.py – Synthetic sensor data generator
- log_to_csv.py – Historical log generator
- dashboard_app.py – Streamlit real-time dashboard

Key features:

- ✓ Heat index & emergency detection
- ✓ AQI classification
- ✓ Security escalation (night + sound + PIR)
- ✓ Lighting control (night/storm logic)
- ✓ Global priority generation (CRITICAL → LOW)
- ✓ Historical CSV logs saved in logs/system_logs.csv

2.3 Dashboard & Visualization Layer (Streamlit)

The dashboard provides:

- Real-time data table
- Temperature, Soil, AQI & Crowd graphs
- Alert priority chart

- Latest alert snapshot

Dashboard – Main View

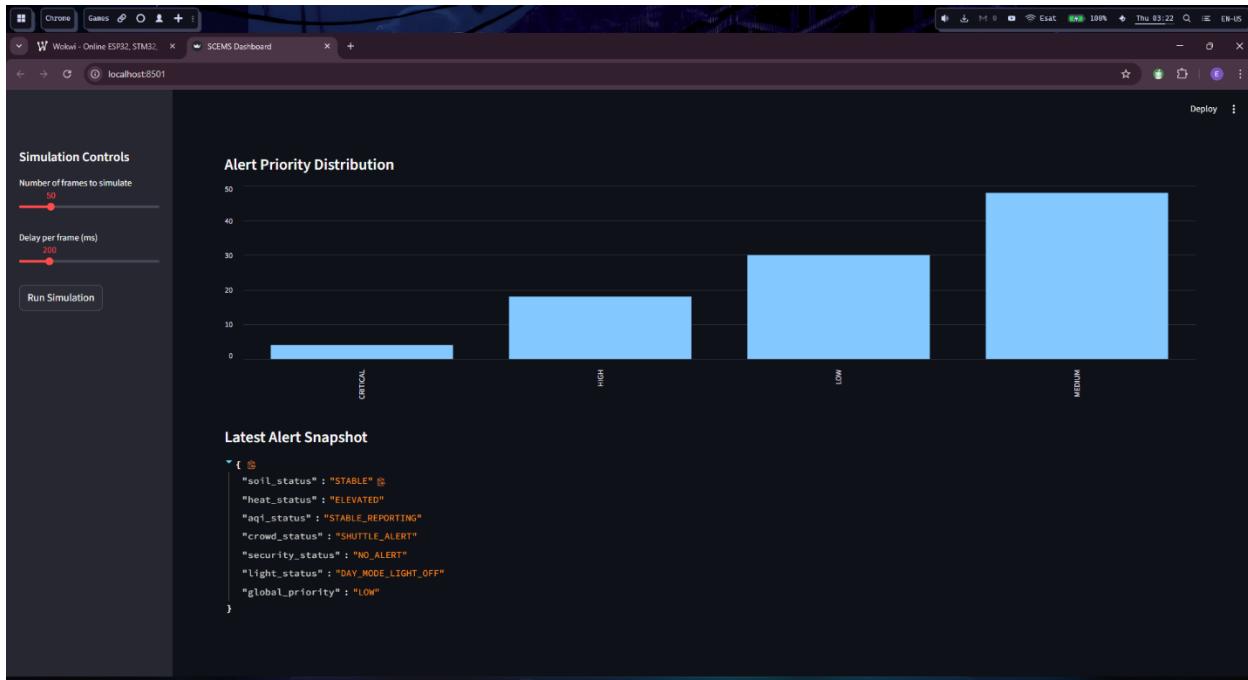
The screenshot shows the main view of the SCEMS dashboard. On the left, there is a "Simulation Controls" panel with sliders for "Number of frames to simulate" (set to 50) and "Delay per frame (ms)" (set to 200), and a "Run Simulation" button. The main area features a title "SCEMS - Smart Community Environment Monitoring System" and a subtitle "Simulation-based Community Environment Monitoring (Gazipur)". Below this is a "Real-time Data Table" containing 39 rows of environmental data. The table includes columns for soil_moisture, temperature, humidity, aqi, crowd_estimate, pir_active, sound_level, ldr_raw, is_night, storm_dark_day, soil_status, soil_value, heat_status, heat_index, aqi_status, aqi_value, crowd_status, and security. The data spans from row 30 to 39, with various status codes like STABLE, ELEVATED, EMERGENCY, and IRRIGATION. At the bottom, there are two line graphs: "Temperature vs Time" and "AQI vs Time".

	soil_moisture	temperature	humidity	aqi	crowd_estimate	pir_active	sound_level	ldr_raw	is_night	storm_dark_day	soil_status	soil_value	heat_status	heat_index	aqi_status	aqi_value	crowd_status	security
30	40.7376	31.4675	76.8284	223	25	□	66	499	□	□	STABLE	40.7376	ELEVATED	32.2358	POOR_AIR	223	SHUTTLE_ALEI IGNORE	
31	58.5581	27.8813	56.2673	143	3	□	64	890	□	□	NO_WATERI	58.5581	ELEVATED	28.444	GOOD	143	NORMAL_CROI IGNORE	
32	46.1408	34.1327	62.4333	290	5	□	25	183	□	□	STABLE	46.1408	ELEVATED	34.7571	POOR_AIR	290	NORMAL_CROI IGNORE	
33	64.0524	39.8776	48.2486	49	5	□	47	947	□	□	STABLE	64.0524	HEAT_STRES	40.3601	STABLE_REL	49	NORMAL_CRO IGNORE	
34	37.0673	41.6008	79.9276	172	20	□	36	637	□	□	STABLE	37.0673	HEAT_STRES	42.4	GOOD	172	SHUTTLE_ALEI IGNORE	
35	35.6414	45.5125	63.5453	163	3	□	23	388	□	□	STABLE	35.6414	EMERGENCY	46.1479	GOOD	163	NORMAL_CROI IGNORE	
36	21.7272	35.3982	60.9396	137	25	□	20	463	□	□	WARNING	21.7272	ELEVATED	36.0076	GOOD	137	SHUTTLE_ALEI IGNORE	
37	14.4311	34.4525	40.4788	341	10	□	97	341	□	□	IRRIGATION	14.4311	ELEVATED	34.8573	HEALTH_RIS	341	MEDIUM_CROV SECURIT	
38	66.1852	31.8686	44.7157	254	3	□	16	268	□	□	STABLE	66.1852	ELEVATED	32.3157	POOR_AIR	254	NORMAL_CROI NO_ALE	
39	20.079	30.4265	51.9307	50	25	□	23	207	□	□	WARNING	20.079	ELEVATED	30.9458	STABLE_REL	50	SHUTTLE_ALEI NO_ALE	

Dashboard – Graphs (Temperature, Soil, AQI, Crowd)



Dashboard – Alert Priority Distribution



3. Algorithm Overview (Simplified)

Soil Moisture Logic

- $\leq 15\%$ → IRRIGATION_ALERT
- $\leq 30\%$ → WARNING
- 50–60% → NO_WATERING_NEEDED

Heat Stress Logic

- $\geq 45^\circ\text{C}$ → EMERGENCY
- $\geq 36^\circ\text{C}$ → HEAT_STRESS_ALERT
- Heat Index Warning if Temp $\geq 32^\circ\text{C}$ & Humidity $\geq 70\%$

AQI Logic

- 40–80 → STABLE
- ≥ 180 → POOR AIR
- ≥ 300 → HEALTH_RISK_ALERT

Crowd Logic

- $\geq 20 \rightarrow \text{SHUTTLE_ALERT}$
- $\leq 5 \rightarrow \text{NORMAL}$

Security Logic

- PIR + Sound > 60 → SECURITY_ALERT
- Night escalation → SECURITY_ALERT_ESCALATED

Lighting Logic

- Night → LED ON
- Storm Dark Day → LED ON
- Day → LED OFF

4. Test Results

The system was tested under all 6 required Section A test scenarios:

- Soil dry/wet ranges
- Temperature + humidity + heat index
- AQI thresholds
- Crowd density cases
- Motion + sound based security
- Dark/light environmental transitions

CSV Log Preview

All test cases matched the expected outputs.

5. Conclusion

SCEMS successfully demonstrates:

- ✚ Accurate multi-sensor simulation
- ✚ Real-time monitoring dashboard
- ✚ Automated thresholds & priority alerts
- ✚ Historical logging for analytics
- ✚ Fully software-based approach
- ✚ Practical relevance for industrial & community monitoring

This project satisfies all requirements of **Section A, B, C, D**, and demonstrates potential for **Section E (future enhancement)**.

6. Important Links

 **GitHub Repository:**

<https://github.com/Esatjahan/SCEMS-Environment-Monitoring>

 **Wokwi Simulation:**

<https://wokwi.com/projects/448685686274316289>

 **Demo Video (Google Drive):**

<https://drive.google.com/drive/folders/1hMPIVeWZghY3mUDQZwAU2zho7XbX1x9D>

 END OF REPORT

Thank You!