**Enhancing Environmental Safety through Offline Air Quality Monitoring in Conflict Zones**

**Problem Statement**

Air pollution in conflict-affected regions like Gaza poses not only health but also security risks. The ongoing war has resulted in extensive infrastructure destruction, uncontrolled emissions from burning debris, and overcrowded shelters—all contributing to hazardous air quality. Traditional air monitoring systems that rely on internet connectivity and centralized cloud storage are impractical in such unstable environments.

A critical security gap arises from the absence of real-time environmental alerts for residents in shelters, schools, or field hospitals. Exposure to toxic gases, high PM2.5 levels, and extreme temperatures without timely warnings can lead to mass casualty incidents, panic, and further strain emergency response systems.

The core security challenge is ensuring localized, immediate alerts without relying on digital infrastructure—thereby protecting human life and enhancing environmental situational awareness during conflicts.

## ****Previous Studies****

### [1] Moharana et al. (2020)

Developed a cloud-connected air quality monitoring system using ESP32 and MQ-135 sensors. While effective in normal environments, it depends on cloud transmission and does not support offline deployment, making it unsuitable for war zones​.

### [2] Borade and Prakasarao (2018)

Proposed a low-cost system using REST APIs and ESP32 to monitor gases (CO, CO2) and environmental data. Despite its efficiency, it relies on internet infrastructure and fails to address disconnected environments​.

### [3] Azman et al. (2024)

Presented an IoT system with automated ventilation triggered by gas detection. Powered by solar energy, it shows innovation in autonomous responses but still requires consistent power and network access​.

### [4] Mahetaliya et al. (2021)

Designed an ESP32-based AQI monitoring system integrated with ThingSpeak. Alerts are only available via cloud, making it unfit for blackout scenarios in Gaza​.

## ****Objectives.****

1. **To design a real-time, offline air quality monitoring system** using ESP32 and low-cost sensors to detect environmental threats (gas leaks, high PM2.5, heat stress).
2. **To provide immediate localized alerts** (audio-visual) when air quality thresholds are exceeded—without reliance on internet or mobile apps.
3. **To enhance public safety in conflict areas** by ensuring environmental hazard detection even under power and connectivity outages.
4. **To build a scalable, portable, and cost-effective model** that can be replicated across other conflict-affected or remote regions.

**Proposed Solution**

The proposed solution is an offline, microcontroller-based air quality monitoring system designed specifically for deployment in high-risk, low-infrastructure environments like Gaza. The system will:

* Use ESP32, selected for its analog/digital interface capabilities and low power consumption.
* Include DHT22 (temperature & humidity), MQ-2 (gas), and PM2.5 sensors, calibrated to detect dangerous environmental conditions.
* Trigger a local buzzer and display warning messages on a 20x4 I2C LCD when danger thresholds are met (e.g., Temp > 35°C, Gas > 716 ppm, PM2.5 > 100 µg/m³).
* Be completely independent of the internet or cloud services, ensuring reliability during blackouts.
* Be portable and modular, easily deployable in homes, schools, and emergency shelters.

This offline alert mechanism enhances environmental security by reducing response time and preventing secondary crises due to undetected air pollution.