DEPARTMENT OF MECHANICAL ENGINEERING

RV COLLEGE OF ENGINEERING®

(Autonomous Institution affiliated to VTU, Belagavi)

PROJECT REPORT

On

Arduino-Based Multi-Sensor Hazard Monitoring and Early Warning Unit

Submitted in partial fulfilment of First year IDEA Lab

Submitted by

1. Ankith Joshi	[RVCE25BAS051]
2.Ramanuja AK	[RVCE25BAS046]
3.Shreyas M	[RVCE25BAS038]
4.Mithun	[RVCE25BAS058]

Under the guidance of

[Guide's Name]
[Designation]

ABSTRACT

Disaster-related hazards such as fire outbreaks gas leakage,flooding,and unexpected structural vibrations pose serious threats to safety in residential commercial and industrial environments. Most conventional safety devices detect only one type of hazard ,leading to delayed response and increased vulnerability during emergencies

To address the need for unified, low-cost and reliable solution, this project presents an Arduino-based Multi-Hazard Early warning and Alert System capable of monitoring multiple risks simultaneously and providing fast, automated alerts

AIM

The project aim's to develop a compact and affordable multi-hazard detection system that integrates fire detection, gas leakage monitoring, water-level sensing and vibration detection into a single unit. The main objective is to create a system that provides real-time monitoring, immediate alerts and optional remote notifications, Enabling faster response during emergencies

Method

The proposed system uses an Arduino microcontroller as the central processor to manage four primary sensors:

- Flame Sensor

- MQ-135 Gas Sensor
- Water-level Sensor
- SW-420 Vibration Sensor

Each sensor continuously sends data to the Arduino , where predefined threshold values are used to assess whether a hazard is present

When a threshold is crossed, the system activates a multi-stage alert system consisting of a buzzer for audible warnings, LED indicators for visual alerts.

RESULTS

Once testing is carried out, the system is expected to accurately detect all four hazards with strong consistence. The flame sensor will likely respond almost instantly to fire sources while the MQ-135 sensor will detect variations in the gas concentration after its warm up period. The water level sensor is effective in detecting rising water levels for overflow monitoring and floods. The vibration sensor will be able to detect low intensity tremors and structural movements.

IMPACT

The project provides a practical,affordable and scalable solution for enhancing safety across homes, schools, small industries, storage areas and laboratories. By combining multiple sensors into one system, it reduces cost ,increases accessibility and significantly improves early detection capabilities. The modular design allows easy futures upgrades such as IoT integration, Mobile dashboards and additional sensors.

TABLE OF CONTENTS

INTRODUCTION

BACKGROUND AND PROBLEM DEFINITION

Disasters such as fire accidents, toxic gas leakage, flooding, and unexpected structural vibrations continue to pose major risks in both domestic and industrial environments. These hazards often occur without warning and can escalate rapidly, causing significant damage to property and endangering human life. In many houses, small scale industries,labs,workshops and storage units the safety systems are rather outdated or only designed to handle single type of hazards

MOTIVATION

The increasing accessibility of embedded systems and open-source hardware has created new opportunities to develop affordable, multi-functional safety devices. Microcontrollers like Arduino allow seamless integration of various sensors, enabling real-time monitoring of environmental conditions. By combining multiple detection mechanisms into a single, unified system, it becomes possible to provide faster alerts and reduce dependency on multiple standalone devices.

OBJECTIVE

This project aims to design and implement an Arduino-based Multi-Hazard Early Warning and Alert System that can simultaneously detect fire, hazardous gases, rising water levels, and abnormal vibrations. The system incorporates dedicated sensors for each hazard and provides instant alerts through visual indicators and audible alarms

FUTURE PROSPECTS

The multi-hazard early warning system developed in this project provides a strong foundation for more advanced and scalable safety solutions. Many New solutions can developed to enhance the performance of the system, reliability and real world application

One major future prospect is the integration of IoT connectivity using Wi-Fi, LoRa, or NB-IoT modules. This would allow the system to send alerts to cloud platforms, mobile applications, and dashboards. Another potential enhancement is the incorporation of additional sensors, such as temperature, humidity, smoke, or motion detectors, to increase the range of detectable hazards. The use of machine learning algorithms can further improve accuracy by analysing sensor patterns and predicting abnormal conditions before thresholds are crossed.

Overall, the project has strong potential to evolve into a commercial-grade safety product, contributing to safer homes, workplaces, and communities.

LITREATURE REVIEW

Early warning and hazard-monitoring systems have been widely studied across domains such as fire detection, gas sensing, flood monitoring, and structural vibration analysis, work includes *Electronic Sensor Circuits & Projects* by F. M. Mims , *Sensors and Transducers* by D. Patranabis , and *Sensors and Control Systems in Engineering* by R. K. Rajput which showcase environmental sensing principles and practical use of flame, gas and vibration sensors. These papers establish the technical foundation of building a multi sensor embedded system and highlights the importance of microcontrollers in real time applications

- Studies such as Sharma & Kumar (2019) presented Arduino-based fire alarm systems showing reliable indoor response times.
- Jain et al. (2020) developed an MQ-135–based air-quality monitoring system, though limited to single-parameter detection.
- Arduino-based flood alert systems, such as those by Suresh & Thomas (2021), primarily focus on single hazards.
- Vibration detection using SW-420 or MPU6050 modules has been explored for machinery and structural monitoring, but studies usually target isolated mechanical environments.

RESEARCH GAPS

- **Multi-hazard, multi-sensor integration:** Most systems detect only one type of threat. There exists no such system which integrates multiple sensors to detect various kind of threats rather just focusing on only type of hazards
- **Smart monitoring with AI/ML:** Most systems use static thresholds; there is limited application of machine learning models for early hazard prediction and adaptive alerts.
- **Cost-effectiveness:** High-end sensor solutions are often expensive, restricting adoption in homes and small industries.
- **Validation in real-world environments:** Many studies remain at lab-scale; field testing under realistic disaster conditions is scarce.

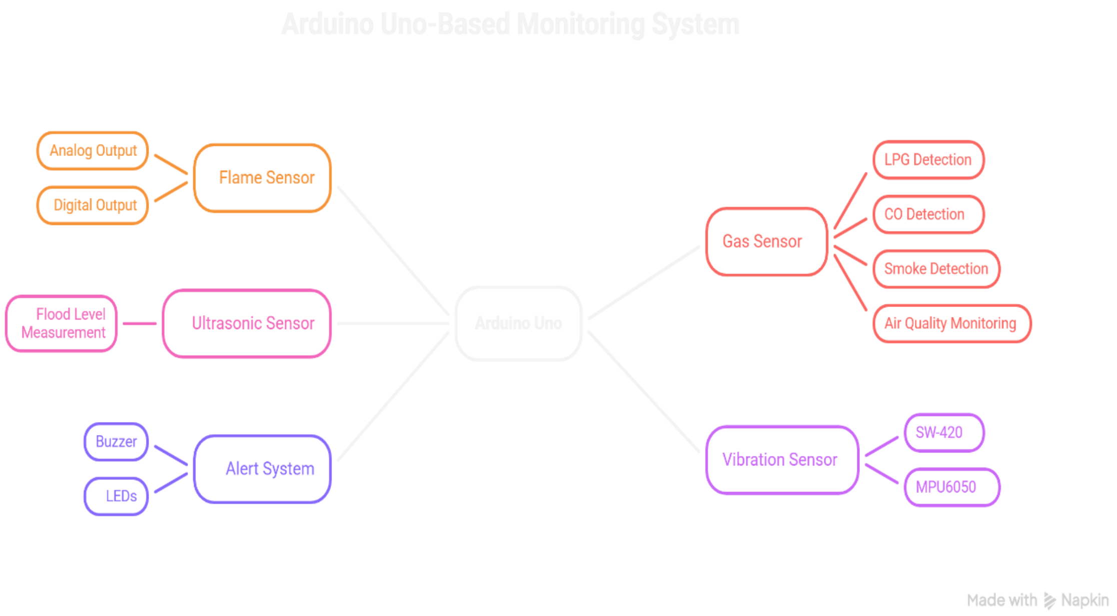
System Design and Architecture

OVERVIEW

The proposed Multi-Hazard alert system integrates multiple sensors such as flame, vibration, gas and water level sensor to monitor and predict and alert incoming hazards. The system is designed on Arduino-Microcontroller platform which processes sensor data and triggers alerts locally. The design emphasizes modularity, scalability, and cost-effectiveness for deployment in homes or small industries.

BLOCK DIAGRAM

The block diagram illustrates the overall system architecture. Each sensor is connected to the Arduino, which acts as the central processing unit. Based on sensor readings, the Arduino triggers local alarms such as Buzzers and LEDs

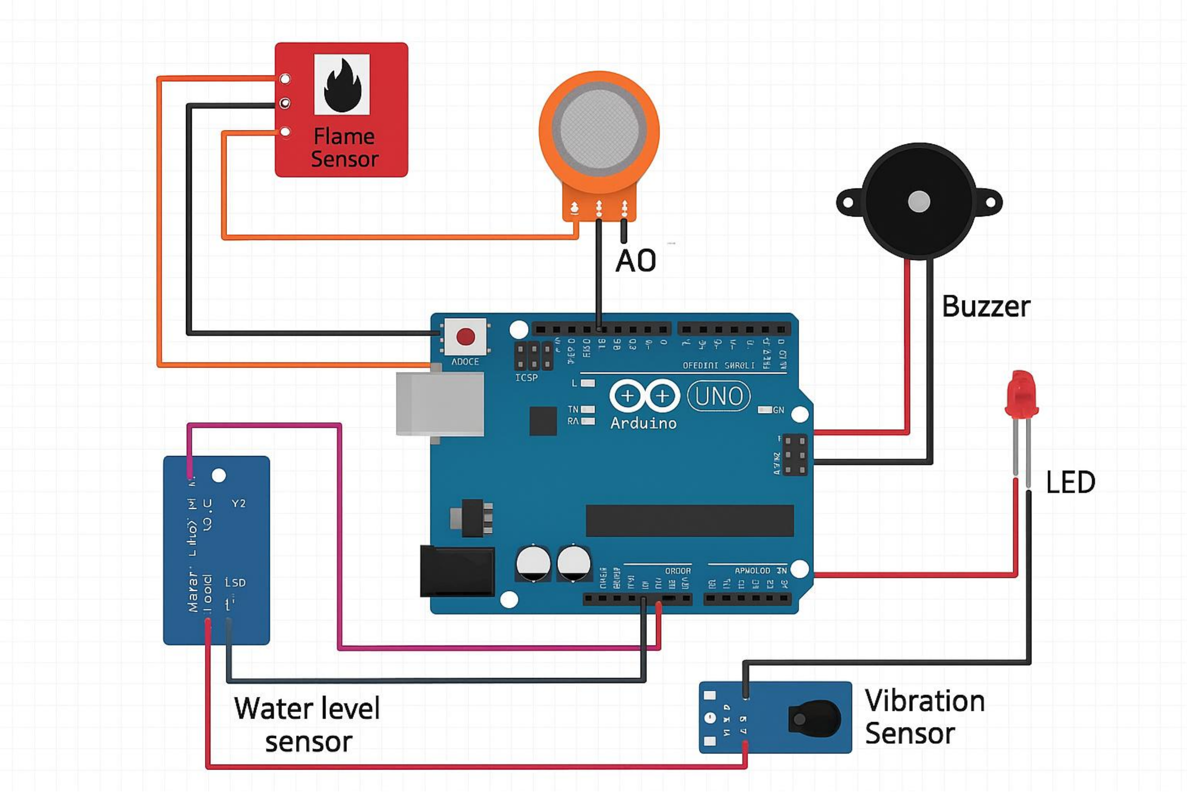


COMPONENTS

COMPONENTS	PURPOSE	DETAILS
Arduino Uno / Mega	Central controller	Processes sensor data and controls outputs
Flame Sensor	Fire detection	Detects flame intensity, analog/digital output
MQ-2 / MQ-135 Gas Sensor	Gas leakage detection	Detects LPG, CO, smoke, air quality
Ultrasonic Sensor / Float	Water-level monitoring	Measures flood level accurately
SW-420 / MPU6050	Vibration monitoring	Detects structural vibrations
Buzzer / LEDs	Local alerts	Immediate alarm signaling
Power Supply	System operation	5V regulated supply for Arduino and sensors

SCHEMATIC DIAGRAM

The circuit schematic shows exact wiring between sensors, Arduino pins, and output devices. Each sensor is connected to analog or digital pins based on signal type. Buzzer and LED indicators are connected to digital pins with proper current-limiting resistors. GSM/Wi-Fi module is interfaced using UART pins for serial communication.



Working Principle

1. **Sensor Detection:**
   - Fire sensor detects flames or high temperature.
   - Gas sensor continuously monitors air quality for harmful gases.
   - Water-level sensor monitors flood risk.
   - Vibration sensor detects abnormal structural movements.

2. **Data Processing:**
   Arduino reads sensor data and compares it with predefined thresholds. Advanced designs may include ML models to detect anomalies and reduce false alarms.

3. **Alert Generation:**
   - If a hazard is detected, the system activates local alarms (buzzer, LED).

HARDWARE AND SOFTWARE IMPLEMENTATION OF THE PROJECT

This chapter will review all of the hardware and software components that will be used in the Natural Disaster Management System (NDMS), and how these various components will work together to provide a complete solution for disaster management.

4.1 HARDWARE USE IN NDMS

1.Arduino UNO

The Arduino UNO is a microcontroller. This microcontroller communicates with all of the sensors in the NDMS. The sensors that will be used in the NDMS will be continuously monitored by the Arduino UNO using the microcontroller’s programming environment, which allows for multiple sensors to be programmed at once without complications.

2.Water Level Sensor

A Water Level Sensor is installed in all NDMS locations; this sensor detects water levels rising due to flooding. When the Water Level Sensor is activated, the increase in water level will trigger the Water Level Sensor to transmit data to the NDMS to inform the NDMS of the increased water level.

3. Vibration Sensor (SW-420)

The vibration sensor detects tremors caused by earthquakes; it generates a digital output indicating a sudden movement or shaking, used by Arduino as a warning signal.

4. Buzzer and LED Indicators

A buzzer provides audible sound alerts at the location, and LEDs provide visual warnings of different levels of warning: normal, moderate, and danger.

5. Power Supply

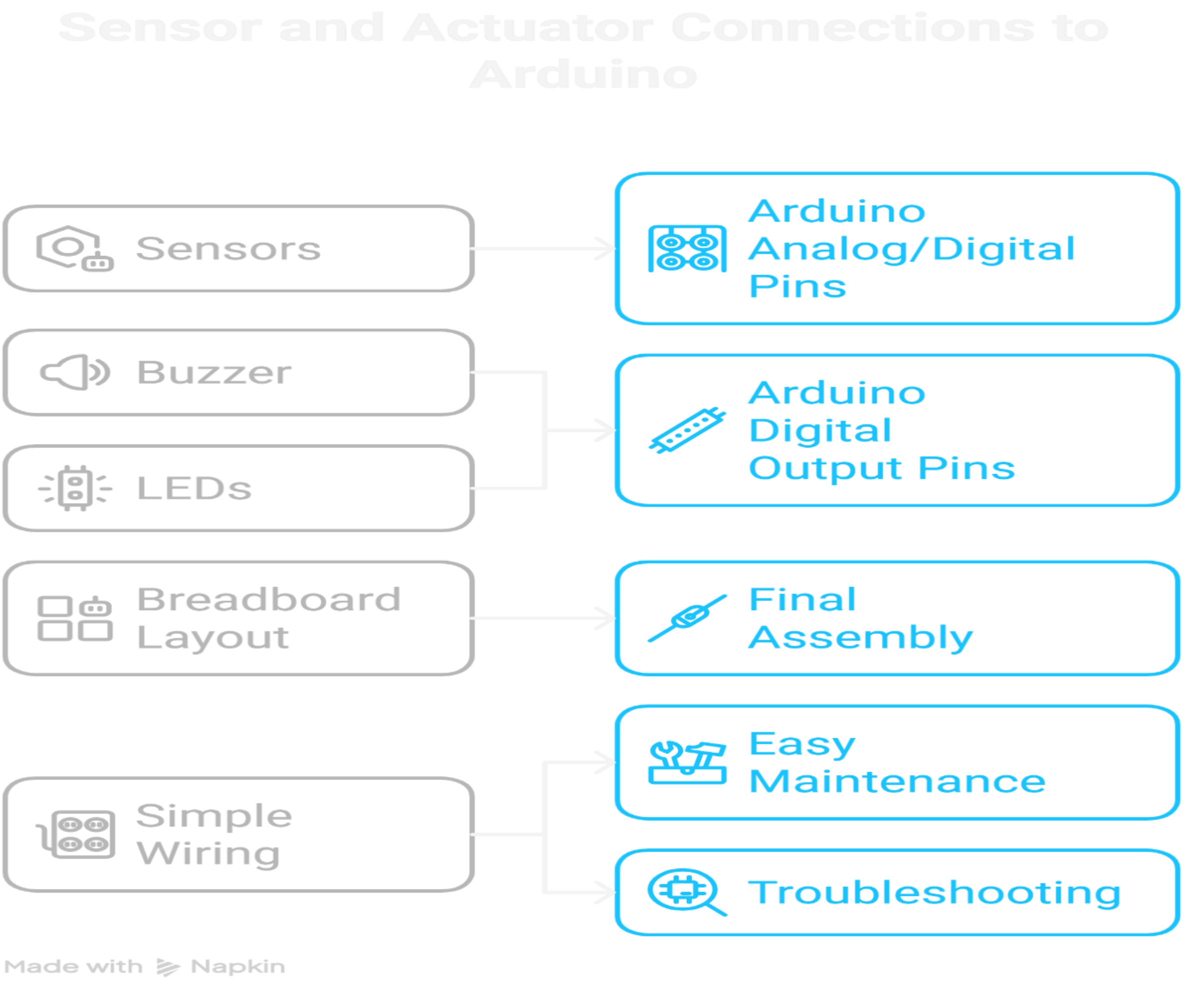
A 9V battery or USB power is used to power Arduino and sensors.

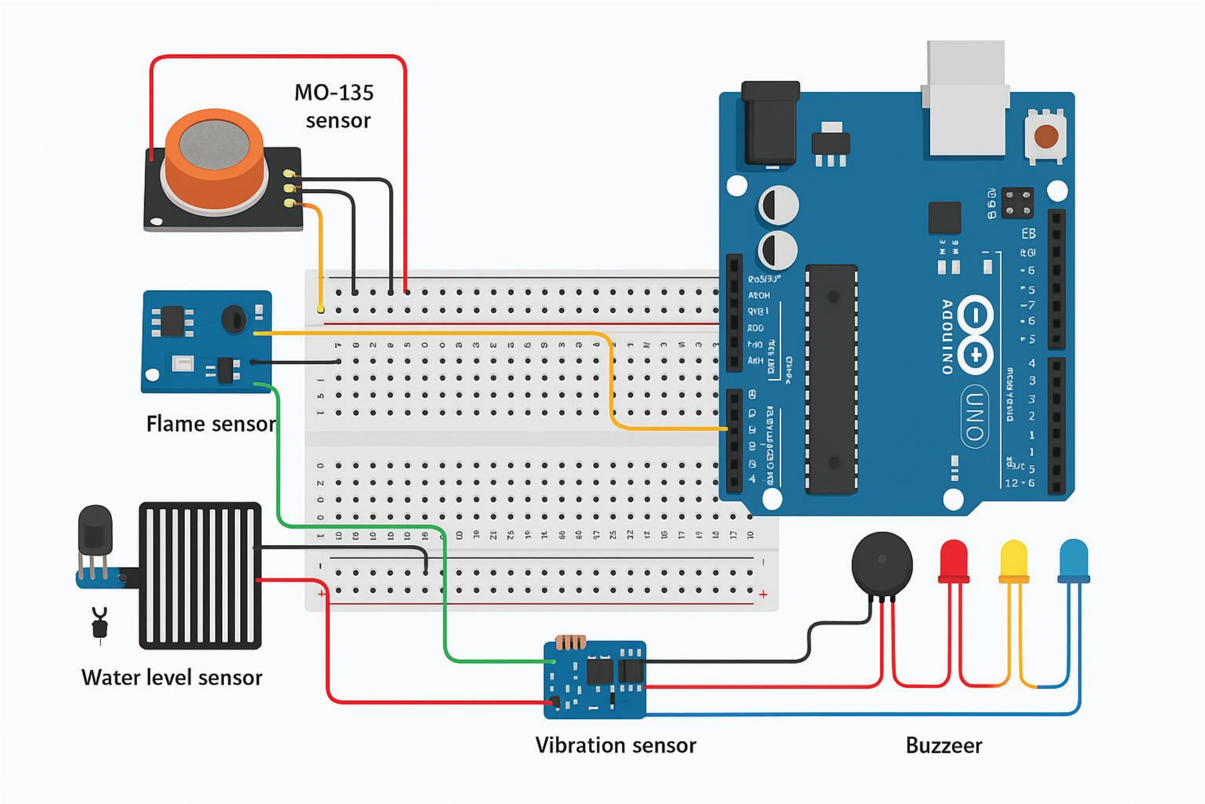
4.2 Circuit Connections

All sensors are connected to the Arduino analog/digital pins;, and the buzzer and LEDs are connected to digital output pins for signaling.

A simple breadboard layout was used for testing before final assembly.

Wiring was kept simple for easy maintenance and troubleshooting.





4.1 Software Implementation

1.Arduino IDE

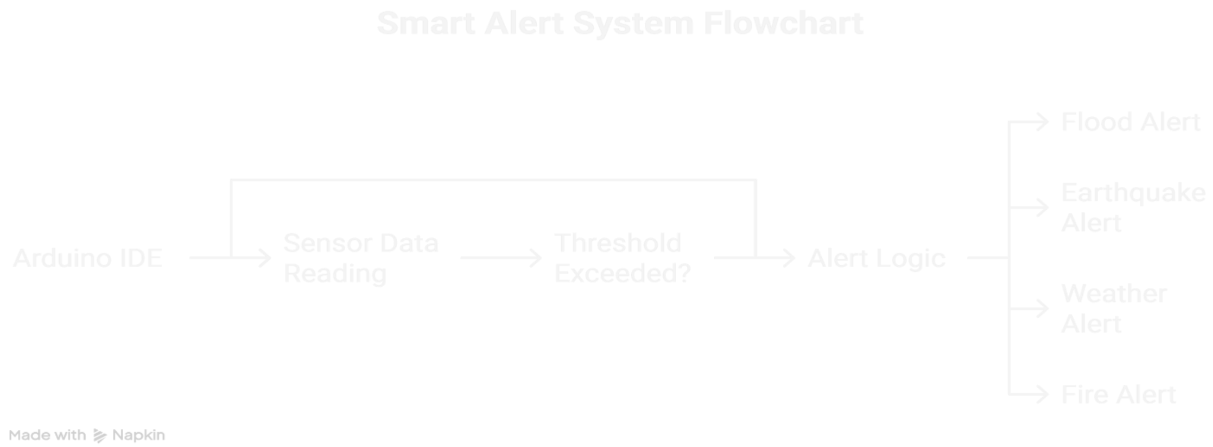
Arduino IDE supports C/C++-based programming and allows you to upload code and monitor the serial output in real time.

2.Sensor Data Reading

Each sensor value is read periodically; fixed threshold values are defined for water level, vibration, temperature, Fire and humidity. When an individual reading passes the threshold value(s), the system enters alert mode.

3.Alert Logic

Flood alert if water level rises above threshold; earthquake alert if there is a spike in vibration; weather alert if temperature/humidity levels are above normal.



Experimental Setup

This chapter describes how the system was validated in experiments, including the experimental setup, and the observations made during the experiments.

- The entire system was assembled on a wooden baseboard. In the experiments, the system's sensors were arranged in a configuration similar to that of real life:

- The water level sensor was positioned within a container of water simulating a rise in the water level of a flood.

- The vibration sensor was placed on the tabletop so that controlled shaking could be applied.

- The Arduino IDE was used on a laptop to retrieve the values of the sensors via Serial Monitor.

Methodology for Testing

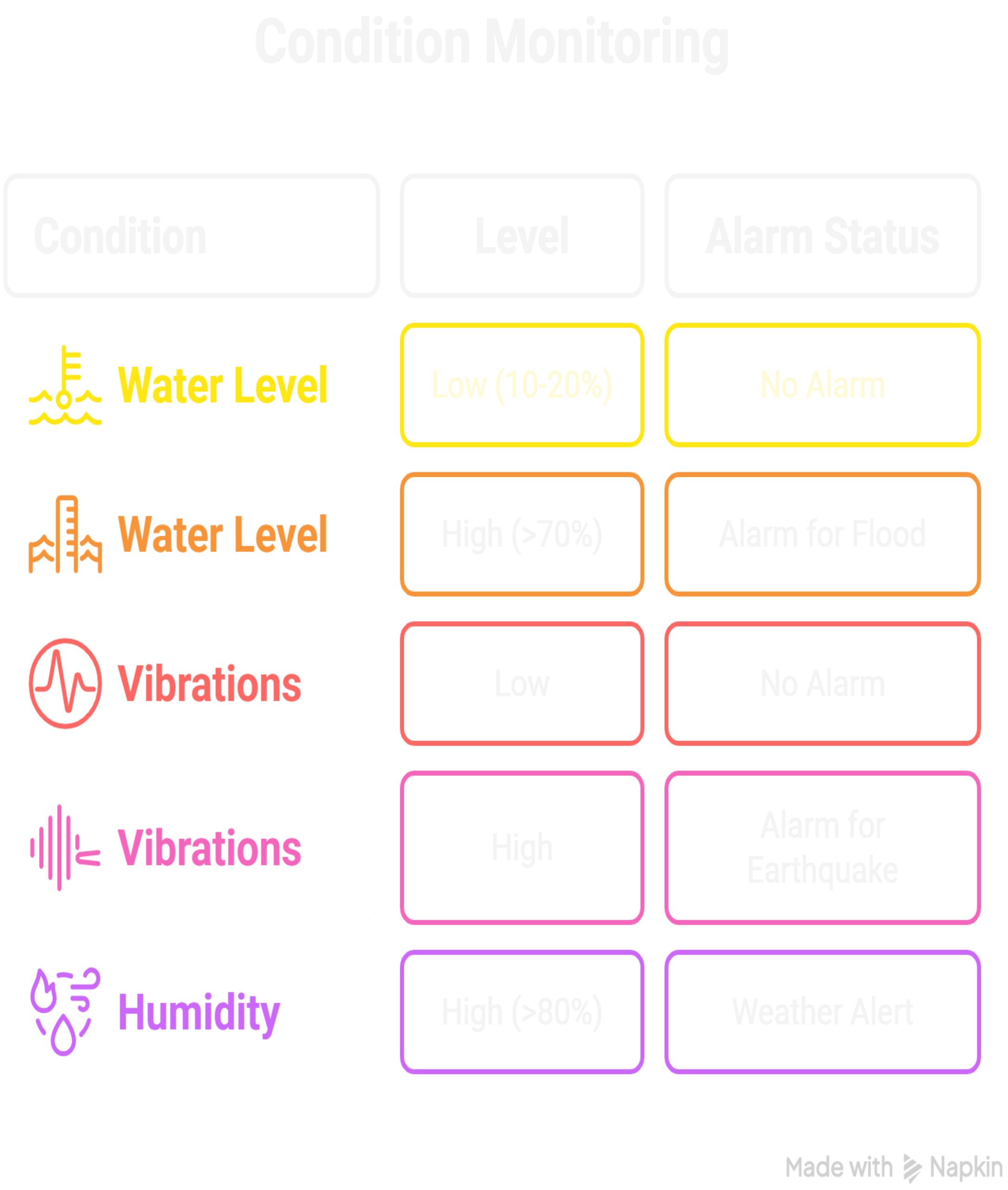
1.Water Level Detection

Water levels in the containment vessel were raised gradually. With each incremental rise of the water level, the sensor registered an increase in the sensor output, and the buzzer sounded an alarm when the threshold was exceeded. An SMS message was created.

2.Vibration Detection

To simulate the effects of minor vibrations the sensor was subjected to gentle tapping and gentle shakes. Each time a gentle tap/shake was applied to the sensor, it was easily detected as sudden movement by the vibration sensor. As a result, the Arduino was activated and generated an alert.

Data Collected



Condition Monitoring

Condition	Level	Alarm Status
Water Level	Low (10-20%)	No Alarm
Water Level	High (>70%)	Alarm for Flood
Vibrations	Low	No Alarm
Vibrations	High	Alarm for Earthquake
Humidity	High (>80%)	Weather Alert

Made with Napkin

RESULTS AND DISCUSSION

Quantitative Results

- **Fire Sensor:** The flame sensor registered the presence of an open flame within fractions of a second at close range.
- **Gas Sensor:**MQ-135 outputs required the standard warm-up (stabilization) time; after warm-up the module detected concentration changes reliably
- **Water-level sensor:** The water-level sensor worked as expected, When the water level rose above a certain pre-defined threshold limit, A alert was triggered to warn the rise in water-level
- **Vibration Sensor:** SW-420 reliably toggled its digital output on light taps and stronger shakes.

ALERTING

The hazard detection system activated the specific LEDs and the Buzzer almost instantly for the flame and vibration sensor but was slightly delayed for the Gas and Water-level sensor based on speed on immersion

CONCLUSION AND FUTURE PROSPECT

This project successfully developed a low-cost Arduino-based Multi-Hazard Early Warning System integrating flame, gas, water-level, and vibration detection. The prototype demonstrated reliable local alerting through LEDs and a buzzer

The unified approach reduces the need for multiple standalone detectors and provides a practical, extensible foundation for improved safety in households, small industries, and institutional environments.

FUTURE PROSPECTS

- **IoT Integration:** Use ESP32/Wi-Fi or LoRaWAN to send sensor telemetry to cloud dashboards and mobile apps for remote monitoring, historical logging, and analytics.

- **Machine Learning & Analytics**: Apply edge or cloud-based ML to multi-sensor patterns for predictive alerts (reducing false positives) and anomaly detection
- **Hardware Robustness:** Design a custom PCB, rugged connectors, and IP-rated enclosure for field deployment; include hardware watchdogs and RTC-backed logging.

- **Standards & Interoperability**: Align with multi-hazard early warning frameworks and consider integration with municipal emergency services for automated escalation.

REFERENCES

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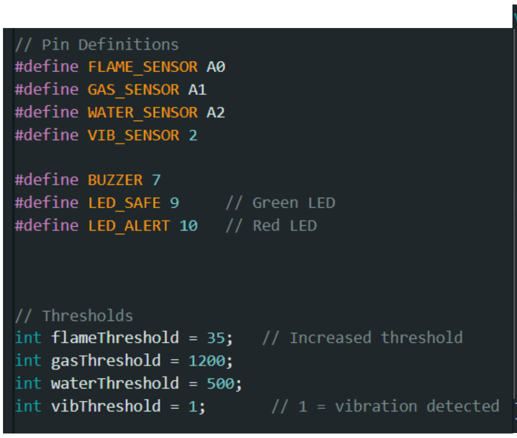
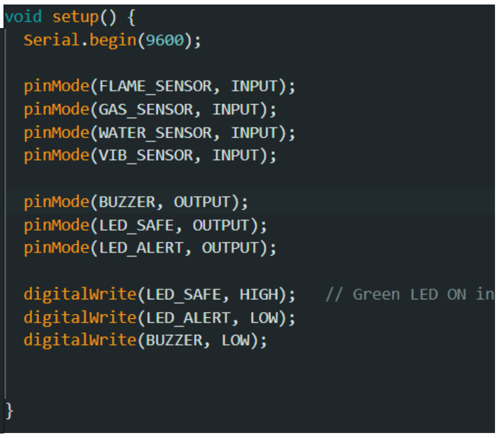
3. R. K. Rajput, *Sensors and Control Systems in Engineering*, S. Chand & Company, New Delhi, India, 2014.
4. A. Sharma and R. Kumar, "Arduino-Based Fire Detection and Alarm System," *International Journal of Engineering Research & Technology (IJERT)*, vol. 8, no. 6, pp. 245–249, 2019.
5. R. Suresh and J. Thomas, "Arduino-Based Flood Monitoring and Alert System," *International Journal of Scientific Research in Engineering and Technology*, vol. 10, no. 4, pp. 89–93, 2021.

APPENDICES



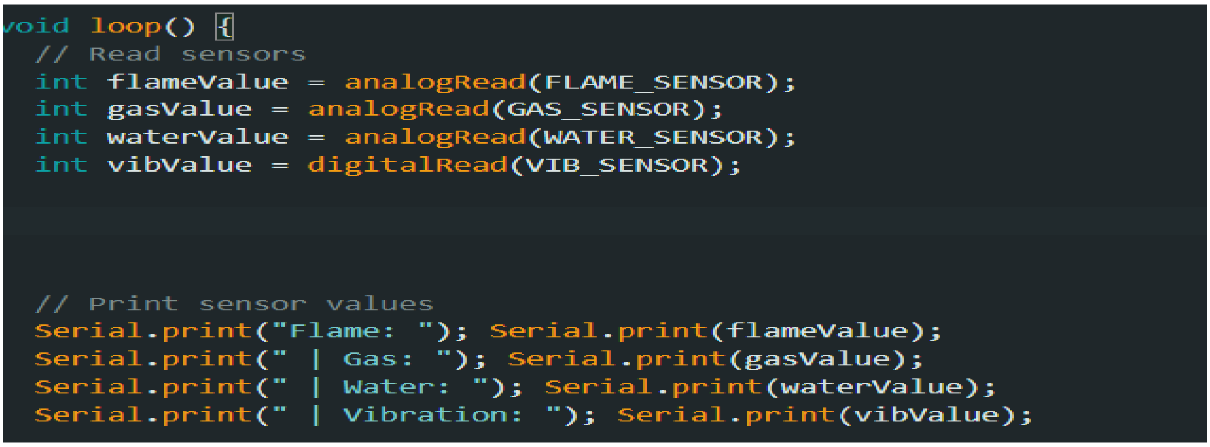
```
// Pin Definitions
#define FLAME_SENSOR A0
#define GAS_SENSOR A1
#define WATER_SENSOR A2
#define VIB_SENSOR 2

#define BUZZER 7
#define LED_SAFE 9      // Green LED
#define LED_ALERT 10    // Red LED


// Thresholds
int flameThreshold = 35;   // Increased threshold
int gasThreshold = 1200;
int waterThreshold = 500;
int vibThreshold = 1;       // 1 = vibration detected
```



```
void setup() {
  Serial.begin(9600);

  pinMode(FLAME_SENSOR, INPUT);
  pinMode(GAS_SENSOR, INPUT);
  pinMode(WATER_SENSOR, INPUT);
  pinMode(VIB_SENSOR, INPUT);

  pinMode(BUZZER, OUTPUT);
  pinMode(LED_SAFE, OUTPUT);
  pinMode(LED_ALERT, OUTPUT);

  digitalWrite(LED_SAFE, HIGH);   // Green LED ON in
  digitalWrite(LED_ALERT, LOW);
  digitalWrite(BUZZER, LOW);

}
```

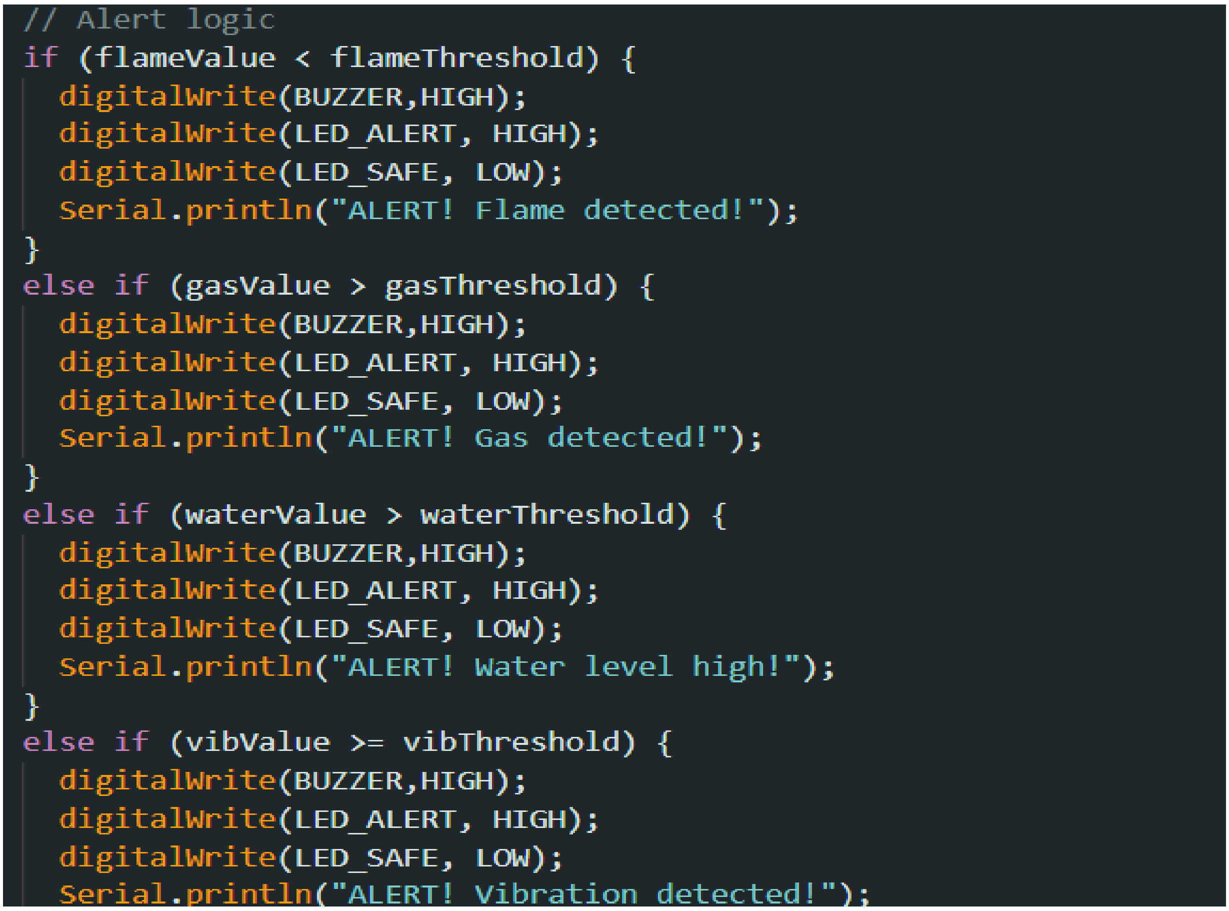
PIN DEFINITION   SETUP

INPUT



```
void loop() {
  // Read sensors
  int flameValue = analogRead(FLAME_SENSOR);
  int gasValue = analogRead(GAS_SENSOR);
  int waterValue = analogRead(WATER_SENSOR);
  int vibValue = digitalRead(VIB_SENSOR);



  // Print sensor values
  Serial.print("Flame: "); Serial.print(flameValue);
  Serial.print(" | Gas: "); Serial.print(gasValue);
  Serial.print(" | Water: "); Serial.print(waterValue);
  Serial.print(" | Vibration: "); Serial.print(vibValue);
```

DETECTION CONDITIONS



```
// Alert logic
if (flameValue < flameThreshold) {
  digitalWrite(BUZZER,HIGH);
  digitalWrite(LED_ALERT, HIGH);
  digitalWrite(LED_SAFE, LOW);
  Serial.println("ALERT! Flame detected!");
}
else if (gasValue > gasThreshold) {
  digitalWrite(BUZZER,HIGH);
  digitalWrite(LED_ALERT, HIGH);
  digitalWrite(LED_SAFE, LOW);
  Serial.println("ALERT! Gas detected!");
}
else if (waterValue > waterThreshold) {
  digitalWrite(BUZZER,HIGH);
  digitalWrite(LED_ALERT, HIGH);
  digitalWrite(LED_SAFE, LOW);
  Serial.println("ALERT! Water level high!");
}
else if (vibValue >= vibThreshold) {
  digitalWrite(BUZZER,HIGH);
  digitalWrite(LED_ALERT, HIGH);
  digitalWrite(LED_SAFE, LOW);
  Serial.println("ALERT! Vibration detected!");
```

FINAL OUTPUT