# Mount HIRA Matriculation School

## Nellikuppam

**STUDENT NAME**

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**CLASS**

## GRADE 7

**PROJECT TITLE**

# SMART URBAN SAFETY HAZARD DETECTION SYSTEM MANHOLE ACCIDENT PREVENTER

## Title of the Project:

# Smart Urban Safety Hazard Detection System for Manhole Accident Prevention

## INTRODUCTION

### Engineering problem and goal

Urban infrastructure, while essential for modern living, often presents hidden dangers. Among these, open or damaged manholes pose significant threats to public safety, leading to serious accidents, injuries, and even fatalities. Traditional methods of detecting and addressing these hazards are often reactive, relying on citizen reports or routine inspections, which are often inefficient and slow. This project proposes a proactive, smart urban safety hazard detection system specifically designed to prevent manhole-related accidents, utilizing advanced sensor technology and real-time data analysis. The aim is to create a safer urban environment, particularly in areas with high pedestrian traffic like those surrounding schools.

### Current Knowledge and Project Justification

### The Problem: Manhole Hazards

Manholes provide access to critical underground utilities such as sewage, water, telecommunications, and electricity. However, several issues can turn them into safety hazards:

- **Missing or Damaged Covers:** The most obvious danger, often due to theft, wear and tear, or improper placement.
- **Structural Integrity Issues:** Cracks, collapses, or subsidence around the manhole structure can weaken the surrounding pavement.
- **Obstructions:** Debris, water accumulation, or overgrown vegetation can obscure manholes, making them hard to see.
- **Gas Leaks:** Underground utility failures can release hazardous gases, which can accumulate in manholes and pose an explosion risk or health hazard.
- **Vandalism:** Intentional damage to manhole covers or structures.

These hazards are particularly dangerous for children, the elderly, and individuals with visual impairments, who may not easily detect them. The consequences can range from minor injuries to severe fractures, head trauma, and even drowning in extreme cases.

# 2.METHODS

**Proposed Solution: Smart Urban Safety Hazard Detection System**Our system integrates various sensors, communication technologies, and data processing capabilities to continuously monitor the status of manholes and provide real-time alerts. The core components of the system are:

**1. Sensor Module**

This module, installed beneath each manhole cover, is equipped with multiple sensors:

- **LiDAR (Light Detection and Ranging) Sensor:** Measures the depth to detect if a cover is missing or displaced. It can also monitor changes in the ground level around the manhole, indicating subsidence.
- **Thermal Camera/Infrared Sensor:** Detects temperature anomalies, which can indicate gas leaks (some gases have distinct thermal signatures) or overheating of underground electrical components. It can also identify missing covers in low light conditions.
- **Gas Sensors (Methane, Carbon Monoxide, H2S):** Detects the presence and concentration of hazardous gases that may accumulate within the manhole, indicating leaks from utility lines.
- **Humidity/Water Level Sensor:** Monitors for water accumulation, which can be a sign of flooding or pipe bursts, and also poses a drowning risk in open manholes.
- **GPS/NFC Module:** Provides precise location data for each manhole and facilitates easy identification and maintenance using NFC-enabled devices.

1. **Communication Module**

   The data collected by the sensors needs to be transmitted reliably to a central monitoring station. This module ensures efficient and low-power communication:

- **Ultra-Low Power LoRaWAN (Long Range Wide Area Network):** Ideal for transmitting small packets of data over long distances with minimal power consumption, making it suitable for battery-operated sensors.
- **Cellular (4G/5G) & Satellite Backup:** Provides robust connectivity in areas where LoRaWAN coverage might be intermittent or for critical alerts. Satellite backup ensures communication even in widespread network outages.
- **Mesh Networking:** Allows sensors to communicate with each other and relay data, extending the network's reach and improving redundancy.
- **Real-time Data Transmission:** Ensures that any detected hazard is reported instantly, enabling rapid response.

**3. Data Processing and Analytic**

All incoming data from the sensors is processed by a central system:

- **Cloud-Based Platform:** Stores and processes vast amounts of sensor data, providing scalability and accessibility from anywhere.
- **AI/ML Anomaly Detection:** Machine learning algorithms continuously analyze sensor data for patterns that indicate anomalies. For example, a sudden change in LiDAR readings or an unexpected increase in gas concentration triggers an alert. The system can learn normal operating conditions and identify deviations.
- **Predictive Maintenance:** By analyzing long-term trends (e.g., gradual subsidence, intermittent gas spikes), the system can predict potential failures or maintenance needs before they become critical hazards.
- **Real-time Dashboard & Alerts:** A user-friendly dashboard provides a live overview of all monitored manholes, displaying their status and any active alerts. Alerts are automatically dispatched via SMS, email, or a dedicated mobile application to relevant authorities.

**4. Alert & Response System**

When a hazard is detected, the system initiates a multi-pronged response:

- **Instant SMS/Email/App Notifications:** Key personnel (e.g., city maintenance, emergency services) receive immediate notifications with precise hazard location and type.
- **Automated Dispatch to Field Teams:** The system can automatically create work orders and dispatch the nearest available field team, optimizing response times.
- **Real-time Location Tracking:** Field teams can use a dedicated app to navigate directly to the hazard location, improving efficiency.
- **Visual & Audible Street-Alerts:** For critical hazards (e.g., open manhole in a busy area), the system could potentially activate localized visual (e.g., flashing lights) or audible alerts on smart street furniture or directly on the manhole cover itself (if equipped with such features), warning nearby pedestrians.
- **Incident Management & Reporting:** All incidents are logged, and detailed reports are generated for analysis, compliance, and future planning.

**5. User Interface & Public Engagement**

- **Interactive Public Kiosks:** Located in key areas, these kiosks could display general safety information and potentially highlight areas with reported issues (without revealing specific, sensitive locations).
- **Mobile App (iOS/Android):** A public-facing app allows citizens to view reported hazards, receive localized safety alerts, and report new issues themselves (crowdsourced reporting), augmenting the sensor network.

- **Crowdsourced Reporting:** Integrates citizen reports directly into the system, allowing manual verification and combining with sensor data for a comprehensive view.
- **Automated Management & Reporting:** Streamlines the entire process from detection to resolution, providing transparent and accountable management of incidents.

### Why the Problem Has to be Solved

- **Proactive Accident Prevention:** Moves from reactive to proactive safety management, significantly reducing the risk of manhole-related accidents.
- **Enhanced Public Safety:** Creates a safer urban environment, especially for vulnerable populations around schools.
- **Rapid Response Times:** Real-time alerts and automated dispatch ensure immediate action, minimizing the duration of hazards.
- **Cost Savings:** Reduces costs associated with accident claims, emergency services, and inefficient manual inspections. Predictive maintenance also extends the lifespan of infrastructure.
- **Improved Infrastructure Management:** Provides valuable data for urban planning, infrastructure maintenance scheduling, and resource allocation.
- **Environmental Monitoring:** Gas sensors can also aid in detecting environmental issues like methane leaks, contributing to broader urban sustainability goals.
- **Smart City Integration:** Seamlessly integrates with broader smart city initiatives, contributing to a more connected and responsive urban ecosystem.

## Step-by-Step Procedure

For a school project, you could focus on a scaled-down prototype demonstrating the core principles:

- **Miniature Manhole Model:** Create a small model of a manhole.
- **Basic Sensors:** Use simple, affordable sensors like ultrasonic sensors for depth detection (simulating a missing cover) and a basic gas sensor (e.g., MQ series for combustible gas).
- **Microcontroller:** An Arduino or ESP32 board would be ideal for reading sensor data.
- **Communication:** Use Wi-Fi (ESP32) or a simple serial connection to send data to a computer.
- **Simple Dashboard:** Develop a basic interface (e.g., using Python with Tkinter or a simple web page) to display sensor readings and trigger a simulated alert (e.g., an LED flashes, or a message pops up) when a "hazard" is detected.
- **Battery Power:** Emphasize the low-power consumption aspect by running the sensor module on a small battery.
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**Independent Variable**

Presence or absence of the manhole cover

Concentration of gas in the air

**Dependent Variable**

Distance reading from the ultrasonic sensor (changes if cover is missing or present)

Gas level readings from the gas sensor (changes with gas concentration)

Alert status (LED on/off, buzzer, UI message)

| **Controlled Variable** | |
|---|---|
| Height/position of the ultrasonic sensor | To ensure accurate and consistent distance readings for detecting the cover |
| Power supply (battery or USB) | To avoid variation in sensor readings due to inconsistent voltage |
| Ambient lighting and temperature | Sudden changes may affect sensor performance (especially gas sensors) |
| Gas sensor warm-up time | Ensures accurate readings; MQ sensors need 1–2 minutes to stabilize |
| Enclosure size of the manhole model | Keeps environment consistent for all tests |
| Sensor calibration | |

# 3.SCOPE OF PROJECT

## Case Study: A Conceptual Scenario

Imagine the Municipality of **NELLIKUPPAM** implements this smart manhole system in a pilot program around a major school district.

1. **Detection:** Late at night, a manhole cover is stolen. The **LiDAR sensor** on the installed module instantly detects the missing cover because the distance to the open air is now significantly greater than the pre-programmed "cover present" distance. Simultaneously, a **gas sensor** inside the manhole detects a slight rise in methane, indicating a potential leak.
2. **Alerting:** The sensor module, running on its internal battery, sends a low-power LoRaWAN signal to the nearest network gateway. The data is then transmitted to the cloud platform. The AI/ML system immediately flags a **critical hazard** due to both the missing cover and the gas anomaly.
3. **Response:** The system automatically dispatches an alert to the nearest municipal maintenance team's mobile app. The alert includes the exact GPS coordinates and a description of the hazard (missing cover and gas leak). A work order is automatically created in the system.
4. **Resolution:** The maintenance team, guided by the app, arrives at the location in minutes. They place a temporary barricade and a warning light to secure the area, protecting pedestrians. They then report the issue as resolved within the app, and a crew is scheduled to replace the cover and address the gas leak the next day. This proactive approach prevents a potential fall and gas-related incident, which could have been fatal, especially given the school's proximity.

# References and Related Work


"A Smart Manhole Monitoring and Detection System" — Ashutosh Singh, Kartikeya Mishra, Sourav Kumar, Chandra Shankar (IJRASET, 2023)

"Research and Implementation of Low-Power Anomaly Recognition Method for Intelligent Manhole Covers" — Guo, J., Wang, K., Sun, J., & Jia, Y. (2023)

"Performance Analysis Of Neuro Genetic Algorithm Applied On Detecting Proportion Of Components In Manhole Gas Mixture" — Ojha, Dutta, Saha (2012)