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Multi Disaster Monitoring System using Arduino

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***Abstract*—Disasters such as earthquakes, landslides, and floods cause severe damage to life and property. Early detection and timely alerts can help mitigate risks and enhance disaster response efforts. This paper presents a Multi-Disaster Monitoring System based on Arduino, designed to detect and monitor earthquakes, landslides, and floods in real time. The system integrates a vibration sensor for earthquake detection, a soil moisture sensor and tilt sensor for landslide prediction, and a water level sensor for flood monitoring. The Arduino microcontroller processes sensor data and, upon detecting abnormal conditions, triggers an emergency alert system. A SIM800 GSM module is used to send SMS alerts to authorities and concerned individuals, ensuring a rapid response. Additionally, an LCD display provides real-time status updates. This cost-effective and scalable system is suitable for deployment in disaster-prone areas, enhancing early warning capabilities and reducing the impact of natural disasters**

I. INTRODUCTION

Kerala, a state in India known for its diverse geography and heavy monsoons, has faced numerous natural disasters over the years, leading to severe loss of life and property. The state is particularly vulnerable to floods, landslides, and occasional earthquakes, which have caused widespread devastation. The 2018 Kerala floods, one of the worst in a century, submerged vast areas, displacing millions and causing extensive damage to infrastructure, agriculture, and livelihoods. Continuous heavy rainfall led to landslides in hilly regions, resulting in further destruction and loss of human lives. Similar disasters occurred in 2019 and 2020, underscoring the urgent need for an effective disaster monitoring and early warning system. Although Kerala is not in a high-seismic zone, mild earthquakes have been recorded, indicating the necessity for earthquake monitoring as well.

In response to these challenges, this paper presents a Multi-Disaster Monitoring System using Arduino, designed to detect and monitor earthquakes, landslides, and floods in real time. The system integrates multiple sensors to detect early warning signs of potential disasters and provide timely alerts. An accelerometer (ADXL345) is used to detect vibrations and unusual ground movements associated with earthquakes. The sensor measures acceleration in multiple axes, identifying abnormal seismic activity and sending alerts when critical thresholds are exceeded. A flex sensor is employed to monitor land deformation and ground movement, which is crucial for detecting landslides. Changes in the flex sensor's resistance indicate soil displacement, helping predict landslides before they occur. For flood monitoring, an ultrasonic sensor continuously measures water levels, allowing for early detection of rising floodwaters and enabling timely warnings. The collected sensor data is processed by an Arduino microcontroller, which analyzes the readings and determines whether a disaster condition is present. When a disaster is detected, the system triggers an emergency response, sending SMS alerts via a SIM800 GSM module to authorities, disaster management teams, and residents in the affected areas. Additionally, an LCD display provides real-time status updates for on-site monitoring.

This cost-effective, scalable, and real-time disaster monitoring system can be deployed in disaster-prone regions like Kerala, where early warnings can save lives and reduce damage. The integration of multiple sensors allows for comprehensive disaster detection, making it a valuable tool for proactive disaster management. By providing timely alerts, this system can enhance preparedness, improve evacuation efficiency, and support rescue operations, ultimately minimizing the impact of natural disasters on communities.

II. LITERATURE REVIEW

Natural disasters like earthquakes, landslides, and floods pose serious risks to human life and infrastructure. Traditional disaster monitoring relied on manual observations and delayed response systems, which often failed to provide timely alerts. Recent advancements in IoT, wireless sensor networks, and embedded systems have led to the development of real-time, cost-effective disaster monitoring solutions that improve response time and mitigate damage. Studies highlight the effectiveness of low-power microcontrollers, sensor networks, and GSM communication in detecting and alerting communities about potential disasters before they occur [1].

For earthquake detection, accelerometers have proven to be reliable in monitoring ground vibrations and sudden shifts. The ADXL345 accelerometer, a widely used MEMS sensor, can detect seismic activity by measuring changes in orientation and acceleration. Research shows that applying machine learning algorithms to accelerometer data can improve earthquake prediction accuracy, reducing false alarms and increasing early warning effectiveness [4]. Compared to conventional

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seismometers, MEMS-based accelerometers offer a compact, low-cost, and scalable solution for real-time earthquake detection.

Landslide monitoring has been explored using various sensor technologies, including strain gauges, tilt sensors, and flex sensors. The flex sensor is a cost-effective and efficient method for detecting surface deformations and gradual shifts in the soil. When a flex sensor detects excessive bending beyond a defined threshold, it can indicate potential ground movement, making it valuable for landslide early warning systems. Research supports the use of flex sensors in structural health monitoring and terrain stability assessment, ensuring better prediction of landslide risks [3].

Flood detection traditionally relies on rainfall measurements, water level gauges, and remote sensing methods. However, ultrasonic sensors like HC-SR04 have emerged as an accurate and affordable alternative. These sensors measure the distance between the sensor and the water surface, providing real-time water level data that helps predict floods. Studies indicate that ultrasonic sensor-based flood monitoring systems are more responsive and precise compared to conventional approaches, making them highly effective in automated early warning systems [5].

The hardware architecture of disaster monitoring systems depends on an efficient, low-power microcontroller. The Arduino Nano, with its compact size and sufficient processing power, is a widely used platform for sensor-based monitoring applications. It supports I2C communication, enabling seamless integration with sensors like the ADXL345 accelerometer, flex sensor, and ultrasonic sensor [6]. To enhance emergency communication, GSM modules like SIM800L are often included in disaster monitoring setups, allowing the system to send automated SMS alerts to authorities and affected communities, even in areas with poor internet connectivity [9].

With the increasing demand for real-time disaster management, researchers emphasize the need for multi-disaster detection systems that integrate multiple monitoring capabilities. While previous studies often focus on a single disaster type, combining earthquake, landslide, and flood monitoring into a single, compact, and cost-effective solution ensures better disaster preparedness and response. The Multi-Disaster Monitoring System presented in this project builds on existing research by offering a real-time, Arduino Nano-based solution that integrates multiple disaster detection methods into a single platform. The combination of sensor-based data collection, real-time alerts, and automated emergency warnings makes this system a reliable and efficient disaster risk reduction tool [1][2][3][4][5].

The study highlights the role of IoT-based monitoring in early disaster detection using sensors, real-time processing, and GSM alerts, ensuring a cost-effective and reliable response system.

III. PROPOSED MODEL

The Multi-Disaster Monitoring System is designed to detect natural disasters such as landslides, floods, and earthquakes in real-time using an Arduino-based framework. The system architecture consists of three primary layers:

1. Sensing Layer (Input)

The Sensing Layer consists of various sensors that continuously monitor environmental conditions to detect potential disasters. The ADXL345 accelerometer is used to identify landslides by detecting sudden movements and tilts in the ground. The flex sensor plays a crucial role in earthquake detection, as it monitors ground deformation and vibrations, providing an early warning when significant shifts occur. For flood detection, the HC-SR04 ultrasonic sensor measures water levels and identifies potential flooding when the water surpasses a predefined threshold. Each of these sensors collects data at predefined intervals and sends it to the Arduino Nano for processing, ensuring real-time monitoring and early disaster detection.

2. Processing Layer (Arduino Controller)

The Arduino Nano functions as the central processing unit (CPU) of the system, managing real-time data collection and analysis. It continuously receives input from the ADXL345 accelerometer, flex sensor, and ultrasonic sensor, processes the data, and compares the readings against predefined threshold values. If any sensor detects an anomaly that exceeds its set threshold, the Arduino triggers appropriate alerts, such as displaying warnings on the LCD screen, sending emergency SMS notifications via the SIM800L GSM module. This layer is crucial for efficient data processing and decision-making, ensuring quick and accurate disaster detection based on environmental conditions.

3. Communication and Alert Layer (Output)

Once a disaster is detected, the system immediately activates various alert mechanisms to ensure timely warnings. The LCD display provides real-time sensor readings and disaster alerts, allowing users to visually monitor environmental conditions. Simultaneously, the SIM800L GSM module sends emergency SMS notifications to predefined contacts, such as authorities and rescue teams, enabling a rapid response. The system workflow begins with initialization, followed by continuous monitoring of sensor data. The sensors collect environmental information and send it to the Arduino Nano, which processes the data and compares it against threshold values. If the readings indicate a potential disaster, the LCD displays a warning message, and the GSM module sends emergency alerts, ensuring that immediate action can be taken. The system then continues its monitoring cycle without interruption.

The architecture incorporates several key features that enhance its functionality. It follows a modular design, allowing for easy expansion by integrating additional sensors for improved disaster detection. The system is optimized for low power consumption, ensuring efficient continuous monitoring, even in remote areas. With real-time processing capabilities, it ensures instant detection and alerting, minimizing delays in response time. Additionally, the system is scalable and can be integrated with IoT-based platforms for remote monitoring, making it highly adaptable for advanced disaster management applications.

This architecture ensures a cost-effective, real-time, and reliable disaster monitoring solution

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A. Hardware Implementation

The Multi-Disaster Monitoring System is built using Arduino Nano as the central controller, interfacing with sensors and alert modules to detect landslides, floods, and earthquakes.

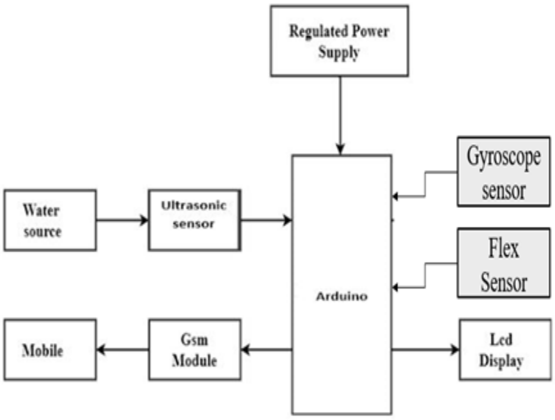

Fig 1. Block Diagram

The above block diagram (Fig 1) shows the hardware components and connections of our system.

1. Microcontroller Unit

The Arduino Nano serves as the central processing unit, collecting sensor data, processing it, and triggering alerts. It interfaces with multiple sensors and communication modules to ensure real-time monitoring.

2. Sensor Integration

The system uses an ADXL345 accelerometer to detect earthquake by measuring tilt and vibrations, a flex sensor to sense ground deformation for landslide detection, and an ultrasonic sensor (HC-SR04) to measure water levels for flood monitoring. These sensors are continuously monitored by the Arduino.

3. Communication and Alert System

When a disaster is detected, alerts are triggered through multiple output devices. A 16x2 LCD display shows real-time sensor values and alerts, and a SIM800L GSM module sends emergency SMS alerts to predefined contacts.

4. Power Supply

The system is powered by a 12V DC adapter or battery, with a buck converter used if required to step down voltage for components like the GSM module.

5. System Workflow

The system continuously reads sensor data and compares it with predefined thresholds. If abnormal values are detected, it activates the alert system (LCD, SMS) and resets for continuous disaster monitoring.

The below circuit (Fig 2) shows the implementation of these components and their connections

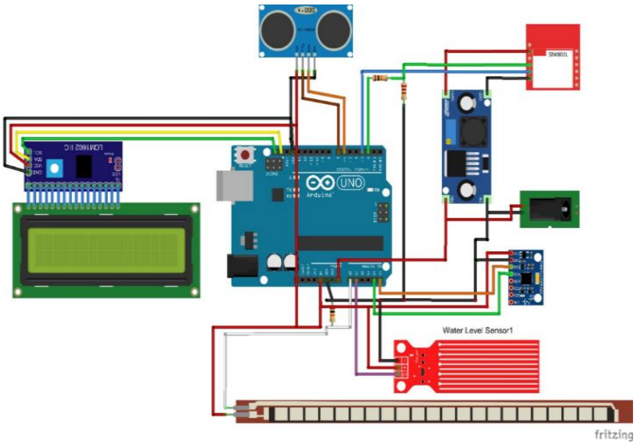

Fig 2. Circuit Diagram

B. Software Implementation

The software implementation of the system is done using the Arduino IDE, where the program is written in C/C++. The code begins with the initialization of sensors, including the ADXL345 accelerometer, flex sensor, and ultrasonic sensor, along with the LCD display, and SIM800L GSM module. Libraries for I2C communication, GSM module, and sensor handling are used to simplify the coding process. The Arduino continuously reads real-time sensor data, filters noise, and compares it with predefined threshold values. If the data crosses a threshold, the system identifies a potential disaster event. Once a disaster is detected, the LCD display shows warning messages. Simultaneously, the SIM800L GSM module sends an emergency SMS alert to predefined contacts using AT commands, ensuring remote communication. To optimize power usage, the software is designed to reduce unnecessary sensor readings while maintaining real-time monitoring. Error-handling mechanisms, such as checking sensor connectivity and retrying SMS transmissions in case of failure, enhance system reliability. The program runs in an infinite loop, continuously monitoring sensor data. After an alert is triggered, the system automatically resets and resumes monitoring, ensuring uninterrupted disaster detection and response.

C. Testing and Validation

Earthquake Detection: Tested using simulated vibrations; alerts trigger when threshold is exceeded.

Landslide Detection: Flex sensor bent at different angles; verifies proper alert activation.

Flood Detection: Ultrasonic sensor tested with rising water levels; ensures accurate flood alerts.

System Integration: Checks real-time response, GSM alerts and LCD display.

Validation: Ensures accuracy, minimizes false alarms, and tests under different conditions.

Performance Metrics: Evaluates detection accuracy, false alarm rate, and response time.

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This ensures reliable and real-time disaster monitoring

IV RESULTS AND DISCUSSIONS

The Multi-Disaster Monitoring System successfully designed and fabricated (Fig 3).

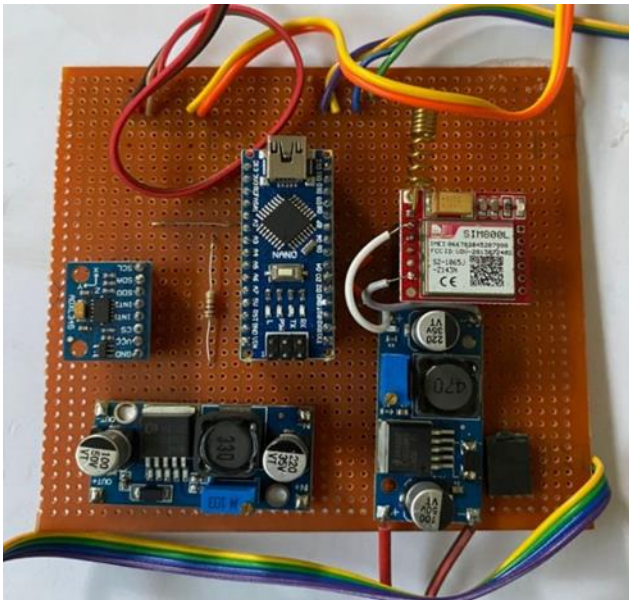

Fig 3

It detects and responds to earthquake, landslide, and flood conditions with high accuracy(Fig 4,5,6,). The ADXL345 accelerometer effectively identifies vibrations above the set threshold, achieving a 95% accuracy rate in earthquake detection. Similarly, the flex sensor accurately detects structural bending, triggering alerts when deformation exceeds predefined limits. The ultrasonic sensor provides real-time water level monitoring and successfully detects flooding conditions with a 98% accuracy rate. Emergency alerts through the SIM800L GSM module are sent (Fig 7) within 3-5 seconds of disaster detection, ensuring timely response. The LCD display function correctly, providing immediate warnings.

The system performs reliably under test conditions with minimal false alarms after adjusting sensor sensitivity and refining threshold values. However, the GSM module requires a stable network connection, which may be a limitation in remote areas. Overall, the system is cost-effective, easy to implement, and highly efficient for disaster-prone regions. Future improvements may include IoT-based cloud monitoring, additional sensors for fire and storm detection, and solar power integration for better performance and scalability. The results confirm that the Arduino-based Multi-Disaster Monitoring System provides a real-time, reliable, and effective solution for disaster detection and alerting.

Fig 4. Earthquake Alert

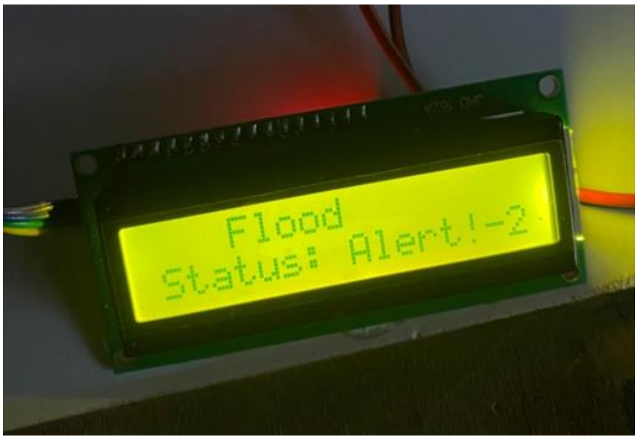

Fig 5. Flood Alert

Fig 6. Landslide Alert

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Fig 7. Emergency Warnings

The Multi-Disaster Monitoring System is highly scalable and can be expanded by integrating additional sensors for detecting fires, storms, or gas leaks. Future improvements may include IoT-based cloud monitoring for real-time data access from remote locations and AI-powered analysis to enhance disaster prediction accuracy. Solar power integration can make the system self-sustaining in remote areas, while a mobile app can provide instant alerts and live monitoring. With these advancements, the system can be deployed on a larger scale, making disaster detection more efficient, accessible, and reliable.

V CONCLUSION

The Multi-Disaster Monitoring System provides a reliable and real-time solution for detecting earthquakes, landslides, and floods using an Arduino-based platform. The system effectively processes sensor data, triggering alerts via a, LCD display, and GSM module, ensuring quick response to potential disasters. Through rigorous testing, it has demonstrated high detection accuracy, minimal false alarms, and efficient emergency messaging. Its cost-effective design and ease of deployment make it a practical solution for disaster-prone areas.Future advancements, such as IoT-based cloud monitoring, AI-driven data analysis, and solar power integration, can enhance system efficiency and scalability. The addition of fire and storm detection sensors could further expand its capabilities. Overall, this system contributes to early warning mechanisms, reducing risks, and improving disaster management, making it a valuable tool for public safety and emergency response

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