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Smart Disaster Detection and Evacuation Alert System Using WSN & IOT

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Abstract- Landslides in hilly regions cause severe property damage and threaten lives, with traditional monitoring often limited to post-disaster analysis. To overcome this, our project introduces a Smart Disaster Detection and Evacuation Alert System using Wireless Sensor Networks (WSN) and the Internet of Things (IoT). The system monitors key environmental factors like soil moisture, rainfall, and ground vibrations in real time. When these parameters cross danger thresholds, alerts are triggered via buzzer alarms and IoT notifications, enabling timely evacuation. Authorities can access live data remotely, allowing proactive disaster management. This integrated approach ensures early warnings, faster response, and improved safety for communities in landslide-prone areas

1. INTRODUCTION

Landslides are a major natural hazard, predominantly occurring in hilly regions due to factors such as heavy rainfall, soil erosion, deforestation, and seismic activity. These events pose severe risks to human lives, infrastructure, and the economy. Despite technological advancements, current methods largely rely on historical data and manual observations, resulting in a lack of real-time monitoring and delayed disaster responses. Our project aims to develop an IoT-based disaster detection system that offers automated, real-time monitoring of critical environmental parameters to predict landslides. By leveraging Wireless Sensor Networks, we enable continuous data collection, analysis, and early warning alerts to prevent loss of life and property damage.

1.1 OBJECTIVE

The primary goal of this project is to develop an intelligent disaster detection system capable of providing real-time monitoring and early warnings for landslides. The system achieves this by:

Continuously monitoring soil moisture levels, rainfall intensity, and ground vibrations through sensor networks. Generating alerts via buzzer and IoT notifications when risk levels exceed predetermined safety thresholds. Transmitting data to an IoT-enabled remote monitoring platform, allowing government agencies and emergency responders to assess risks in real time. Enabling proactive disaster management to minimize casualties and property damage through timely evacuation and preparedness measures. By integrating automated sensing technologies, the system offers faster and more efficient disaster prevention strategies for regions prone to landslides.

1.2 ADVANTAGES

The system offers real-time monitoring of soil moisture, rainfall, and vibrations to detect landslides early. It triggers automated alerts via buzzers and IoT notifications when danger thresholds are exceeded, enabling rapid responses. Authorities can access data remotely, facilitating quick, coordinated decision-making. By providing early warnings, it helps with evacuations and road closures, reducing casualties and damage. The system is scalable for urban, rural, and remote areas, requiring minimal infrastructure. It is cost- effective, using wireless sensors and cloud monitoring to replace manual surveys. The sensor-based data ensures accuracy and reliability, with potential for AI integration to enhance prediction capabilities.

2. LITERATURE REVIEW

The development of landslide detection and early warning systems has been the focus of several research efforts, utilizing a range of technologies such as wireless sensor networks (WSN) and the Internet of Things (IoT). Below are some key studies and their contributions to this field:

1. Landslide Early Warning Systems (2024) – Werthmann et al. This study presents the Inform@Risk project, a prototype early warning system developed for landslide prediction. The system uses real-time environmental monitoring to detect potential landslide risks and send alerts in advance. Merits: Preventive, cost-effective early warning system using real-time monitoring. Demerits: Sensor coverage and reliability issues may cause false alerts or missed warnings.
2. Wireless Sensor Networks for Landslide Detection (2023) – Bhandari et al. Bhandari et al. explore the use of wireless sensor networks for real-time landslide detection. They address several technical challenges, including data transmission delays, the need for accurate sensor calibration, and ensuring reliable remote monitoring in harsh environments. *Merits:* Real-time monitoring, scalability, and automated alerts enhance disaster preparedness. *Demerits:* Challenges with network reliability, sensor calibration, and limited bandwidth, especially in remote areas.
3. IoT-Based Disaster Monitoring System (2023) – Abraham et al. Abraham et al. developed a multi-hazard IoT-based disaster monitoring system that is capable of detecting landslides, earthquakes, and fires. This system integrates sensors for environmental monitoring and IoT platforms for real-time data transmission and analysis. Merits: Detects multiple hazards real-time data and remote accessibility improve response. Demerits: Dependent on stable networks, which may disrupt data transmission during crises.
4. IoT-Based Disaster Alerting System (2022) – Jawalkar et al. This research discusses a predictive IoT-based disaster alerting system designed for urban areas, focusing on integrating multiple sensors to detect risks and send alerts to local authorities and residents. Merits: Integrates multiple sensors (temperature, humidity, soil moisture) for comprehensive early warnings. Demerits: Faces privacy/security risks and potential data overload due to high sensor input.
5. Landslide Detection Using Multi-Parameter Sensor Networks (2021) – Liu et al. Liu et al. explore the use of multi-parameter sensor networks that monitor ground displacement, soil moisture, and seismic activities to predict landslides. Merits: Combines soil, seismic, and displacement data, improving prediction accuracy. Demerits: Requires complex sensor integration and data processing, raising cost and system complexity.

3. EXISTING SYSTEM

In many hilly areas, landslides happen suddenly without warning. Traditional systems focus only on what happened after the landslide, not before. These systems use old data, weather reports, and human observations to study landslides. But these methods are not always correct and cannot give early warnings. There is no regular checking of important things like soil wetness and heavy rain, which are signs of a possible landslide. Because of this, people do not know when the ground is becoming unsafe. Also, there is no automatic system to warn people before a landslide. So, people and rescue teams can act only after damage has happened. This delay causes more loss of life and property. The current system does not help in early warning. So, a real-time, automatic landslide monitoring and alert system is needed to keep people safe.

4. PROPOSED SYSTEM

This project uses a real-time monitoring system to detect early signs of landslides in hilly areas. It checks soil moisture and rainfall levels using sensors. When the values go beyond safe limits, it sends an alert to warn people nearby. A microcontroller reads the sensor data and sends it to an IoT platform, so authorities can check it from anywhere. The system includes a soil moisture sensor, vibration sensor, and a buzzer. If any danger is found, the buzzer makes a loud sound to alert people. The vibration sensor checks for ground movements. The IoT platform stores all the data for future analysis. The system works using a power supply that keeps it running even in remote places.

This smart system helps save lives by giving early warnings before a landslide happens.

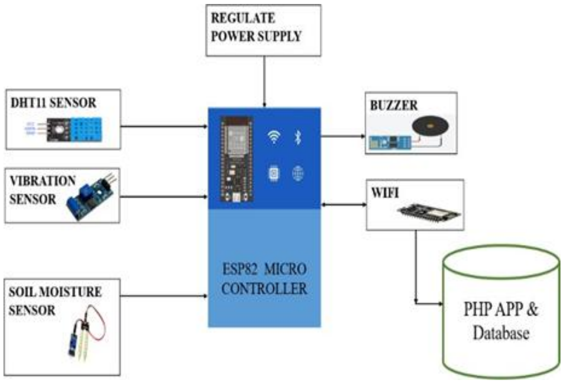
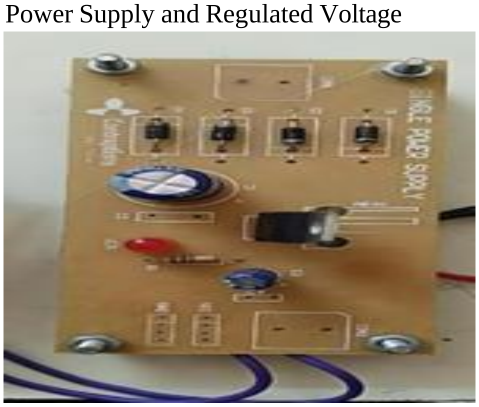


FIG 1. *PROPOSED BLOCK DIAGRAM*

5. SYSTEM REQUIREMENTS

5.1 Hardware Requirements

Power Supply and Regulated Voltage



A regulated power supply provides consistent voltage to protect electronic components from fluctuations. Key components include a step-down transformer to convert high-voltage AC to lower voltage and voltage regulators to maintain a stable output for sensitive devices like sensors and microcontrollers. Backup power options, such as batteries or solar panels, ensure uninterrupted operation, especially in remote locations.

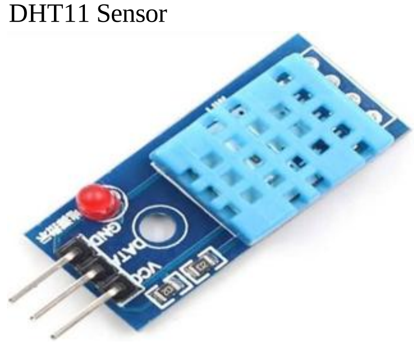
Wi-Fi Module (ESP32 Integrated)

The ESP32 is a low-cost, low-power microcontroller with built-in Wi-Fi and Bluetooth used for IoT projects. It operates up to 200 meters indoors and 500 meters outdoors, depending on antenna and environment.

Soil Moisture Sensor

A soil moisture sensor measures water content in soil using electrical resistance or capacitance. Its range typically spans 0% (dry) to 100% (fully saturated).

DHT11 Sensor



The DHT11 sensor measures temperature and humidity using a thermistor and capacitive sensor, providing digital output with a range of 0–50°C and 20–90% humidity.

Vibration Sensor

A vibration sensor detects ground or object vibrations, converting motion into electrical signals. It typically has a range of 1–80 Hz for landslide monitoring.

Development Tools
Software tools like Arduino IDE (for Embedded C) and web-based interfaces help in writing, uploading, and debugging code.

5.2 Software Requirements
Embedded C Programming: Used for developing firmware that runs on the ESP8266 to read sensor inputs, process data, and transmit information to the cloud.

PHP Web Application: Powers the backend logic of the web dashboard and handles requests from the frontend.

MySQL Database: Stores sensor readings and system logs for historical access and trend analysis.

HTML/CSS/JavaScript: Frontend technologies used to build the user interface of the monitoring dashboard.

XAMPP Server:
- Apache – Serves the web pages.
- MySQL – Manages the database.
- PHP – Executes server-side code.
- IoT Communication Protocols:

MQTT or HTTP: Used for lightweight and reliable transmission of data between microcontroller and cloud.

IoT Platform: Such as ThingSpeak or Google Cloud IoT Core, for cloud integration, data storage, and visualization.

5.3 Hardware Descriptions
The Smart Disaster Detection and Evacuation Alert System employs a combination of sensors and electronic components to monitor environmental parameters in real time and provide early warnings of landslides. At the core of the system is the ESP8266 microcontroller, which functions as the central processing unit by collecting, processing, and transmitting data to the IoT platform via its built-in Wi-Fi capabilities, all while maintaining low power consumption. To assess soil saturation levels that often precede landslides, the system incorporates a soil moisture sensor known for its high sensitivity and durability in outdoor environments. Complementing this is the SW-420 vibration sensor, which detects minor ground movements that could indicate early signs of instability. Environmental conditions such as temperature and humidity, which influence soil behavior, are continuously monitored using the DHT11 sensor, valued for its affordability and ease of integration. A buzzer serves as a local alert mechanism, emitting a loud warning when hazardous conditions are detected. For stable and reliable operation, the system includes a regulated power supply that protects all components from voltage fluctuations and supports multiple power sources. A step-down transformer is used to convert high voltage levels to those suitable for the system, enhancing safety and energy efficiency. Additionally, the Wi-Fi module ensures seamless remote data transmission, enabling real-time monitoring and alerts. Together, these hardware components form a compact, energy-efficient, and responsive system capable of detecting landslide risks and alerting users promptly to support early evacuation and disaster mitigation efforts.

6. RESULT ANALYSIS

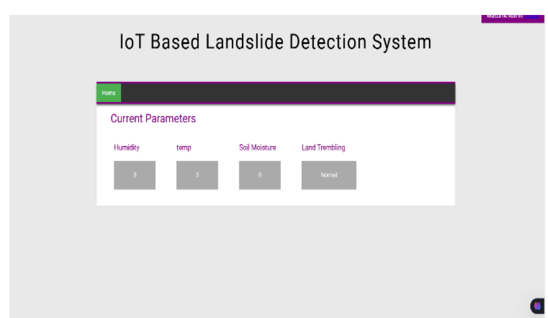


FIG : 6.1 Interface Page

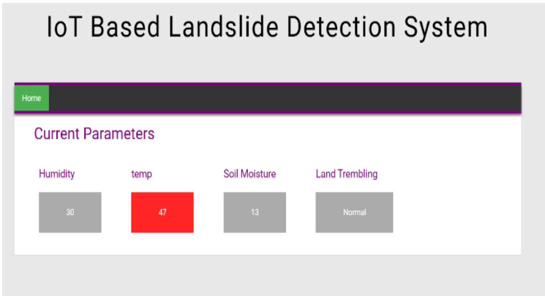


FIG : 5.3 IOT Detect the Parameter Values

7. CONCLUSION

The Smart Disaster Detection and Evacuation Alert System improves disaster management for landslide-prone areas by integrating Wireless Sensor Networks (WSN) and IoT. It continuously monitors key environmental parameters like soil moisture, ground vibration, and atmospheric conditions, which are critical for landslide detection. The system provides real-time alerts through local buzzer alarms and IoT notifications, ensuring quick responses from affected communities and emergency responders. Unlike traditional methods, which rely on historical data, this system offers faster and more accurate disaster detection. IoT-enabled remote monitoring allows authorities to access critical data for informed decision- making and proactive evacuation planning. The system is scalable, cost-effective, and adaptable, suitable for deployment in various regions.

7.1 FUTURE ENHANCEMENT

The integration of AI and machine learning enhances landslide prediction by combining historical and real-time data through predictive analytics using environmental, geological, and weather parameters. Mobile applications can support early warning efforts by delivering push notifications, evacuation maps, and distress signal features to residents. Advanced sensor technologies such as GPS for precise location tracking, tilt sensors for detecting terrain displacement, and high-precision rainfall detectors contribute to accurate monitoring. Drones provide real-time imagery from inaccessible areas, while LoRaWAN ensures network redundancy for uninterrupted communication during failures. Integration with government disaster management systems enables coordinated response efforts. Satellite data further enriches the system by offering insights into terrain shifts, vegetation cover, and rainfall patterns. The system's scalability allows flexible sensor deployment based on regional risk levels and can be extended to monitor additional natural disasters like floods and earthquakes. A cloud-based analytics platform supports real-time data aggregation, automated alerts, and long-term analysis, which collectively aid in proactive planning and rapid response.

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