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Cloud based Landslide Detection and Alerting Nearby People by using IoT Technology

B. Gopi
Department of Electronics and Communication Engineering, Muthayammal Engineering College (Autonomous),
Chennai, Tamil Nadu, India
bgbalasampath@gmail.com

J. Premalatha
Department of Electronics And Communications Engineering, Chennai Institute of Technology,
Chennai, Tamil Nadu, India
kalairamesh81@gmail.com

R. Kalaivani
Department of Biotechnology, MIT College of Arts and Science for Women,
Musiri, Trichy, Tamil Nadu, India
kalairamesh81@gmail.com

Ravikumar D
Department of Electronics and Communications Engineering, Kings Engineering College,
Chennai, Tamil Nadu, India
ravikumar.dinakaran@gmail.com

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***Abstract*—Landslides are one of the most devastating natural disasters that can strike a region. They are caused by the movement of large amounts of earth, rock, and other material down a slope. Landslides are caused by rain, snow, and other precipitation that causes soil to become saturated and unable to support the loads that are placed on it. Landslides can also be triggered by earthquakes or human activities such as mining, construction, and quarrying. Internally generated Internet of Things network and system acquisition generation Landslides were detected using humidity sensors, accelerometers, and vibration sensors, as well as GPS and a siren to inform people. You may charge a little price for this sensor, and if the fee surpasses the basic cost, you can approximately watch people in preparation of an imminent landslide, and big losses are avoided. The microcontroller collects and updates statistics from websites using the MQTT protocol. These telemetry flights can assist folks become aware of an oncoming crisis and have a better understanding of the situation.**

Keywords— Landslide detection, Cloud server, Internet of Things, Message Queuing Telemetry Transport, Disaster management

I. INTRODUCTION

Our world is full of natural wonders that make us gasp in awe. From the Grand Canyon to the Great Barrier Reef, the landscapes and seascapes of our planet have a beauty that is unmatched. But our landscapes aren't just pretty to look at — they also provide the things required to survive, such as food, water, and shelter. While people take landscapes for granted, they can also cause a lot of problems if they're not in good condition [1].

The moving of a volume of rock, rubble, or soil along a slope is referred to as a landslide. Rainwater seeps in during the rainy season, producing hydrodynamic stresses that surpass the flexible limitations of the soil mass. This raises the pressure and decreases the soil's adherence to the stone, resulting in landslides [2]. Landslides disturb commercial forests and access roads, as well as destroying the entire plant ecology of the area, resulting in massive human casualties. Landslides are also known as "mass depletion," which refers to the movement of soil and rocks downward owing to gravity. As a result, property loss, physical injury, and death occur. In the ensuing years a landslide, it also has a negative impact on various sources of water, notably water supply, fishery, water disposal, dams, and roadways [3].

The most common cause of a landslide is rain. During heavy rain, small quantities of water can accumulate on the surface of the earth, sometimes causing the ground to give way. However, not all landslides are caused by rain. Many occur after periods of heavy rain, but before the rainwater has a chance to drain away [4].

Landslides occur when the side of a mountain, hill, or slope becomes so saturated with earth that it develops a failure plane [5]. When this happens, gravity causes the slope or hillside to collapse, sending a mass of soil and rock down the slope. The largest landslides are the result of catastrophic human activity, such as the 2004 Indian Ocean tsunami or the 2015 earthquake in Nepal that killed thousands. In other cases, landslides are the direct result of natural causes, such as heavy rain or earthquakes [6].

The entire continent of America, as well as humanity, are now exposed to grass and manufactured calamities. Natural calamities such as earthquakes, fires, storms, and floods can be predicted in advance, allowing for the protection of a large number of people. All cloud-sourced data gives a record of a specific geographic region that is evaluated on the cloud platform. More than 1,000 lives are lost as a result of a cloud of information about stocks becoming available for research. Fog computing is a novel and more environmentally friendly method of cloud-based discovery for IoT applications [7].

II. LITERATURE REVIEW

Landslide detection and monitoring are critical for infrastructure such as roads, buildings, and pipelines. Traditional methods for detecting landslides often involve searching for unusual activity in satellite images or on the ground. However, these methods are slow, and it is often difficult to know when a landslide has occurred. Machine learning has led to new methods that can detect landslides at an early stage and provide a heads up so that appropriate action can be taken [8].

In most circumstances, the formation of a landslide is caused by a breakdown of equilibrium of the soil mass as a result of changes in one or more parameters, which contribute to the mass remaining stable. The geometry of a

landslide, such as its depth and impacted volume, as well as its behavior, such as typology and kinematic properties, may be correctly predicted using detailed geological and geotechnical soil characterization and the use of specialized mathematical models [9].

Landslides are one of the most dangerous natural dangers in hilly areas. Communities can better prepare for natural disasters, respond to them, and recover thereafter with the aid of land slide detection and monitoring technologies. The effects of landslides on the environment can also be studied via landslide monitoring systems [10]. The fundamentals of landslide detection and monitoring systems, as well as some of their uses, are covered in this note [11].

Although the velocity threshold was chosen as the primary warning threshold for landslide occurrence, expert judgment is included in the EWS to reduce false alarms. A case study demonstrates the applicability and dependability for landslide risk management, and advice for other comparable projects are provided [12].The field management centre relays data to a remote central data management centre for deep data analysis and the generation of early warnings prior to a catastrophic catastrophe using multiple fault-tolerant WAN networks. This article shares lessons from our successful deployment of a WSN system, as well as real-time measurements conducted in the field to ensure network resilience [13].

The most popular sensor technology in the papers under review is the Wireless Sensor Network (WSN), which offers extensive monitoring. If there is a high likelihood that a landslide will occur following the prediction, a warning is sent to the disaster management department. These techniques all have varying degrees of accuracy.

Cloud-based discovery employing weather and catastrophe monitoring via wireless sensor networks provides a more resilient design. The climate forecasting industry's projections are quite close to the atmospheric climate [14]. Weather forecasts for rain, tsunamis, earthquakes, winds, and other events. Weather divergence can not always indicate when natural catastrophes will occur. The best defence for a human presenting a Wi-Fi sensor is to display a message [15].

Data-driven methods for detecting landslides are an additional choice and can be implemented via wireless sensor networks (WSNs). By spotting landslides early on and preventing or limiting human casualties, the study of landslide detection aims to prevent natural disasters. The objective is to determine how the sensing components should convey the sensed data to the data analysis centre and react promptly to data changes. Based on the Internet of Things, a low-cost, reliable, and effective landslide detection and monitoring system is being presented (IoT).

Landslides are also detected using machine learning, image processing, and video processing algorithms. The Konkan regions of India’s landslides are mentioned in relation to one such image processing effort. The railway rails shift as a result of these landslides, causing damage. In order to monitor the situation, a dependable and affordable landslide detection system was created using image processing and a low-resolution webcam to gather sample video frames. They were located using coding as well as diverse techniques like correlation, block processing, Hamming distance, entropy, and Euclidean distance. The system's average efficiency for the set of photos under examination was found to be 86.67 percent, with a threshold margin of roughly 80.24 percent.

It focuses on landslide monitoring via remote sensing, ground-based monitoring in situ, and runout evaluation using a dynamic and volume-based model. This research proposes affordable, delay-efficient, and WSN-IoT-based landslide detection and monitoring system. Only after a landslide has happened safety precautions are to be implemented and human help is required to check the location to determine if a fall can occur or not, which limits efficiency.

III. PROPOSED METHODOLOGY

According to studies, a time-consuming and unreliable prediction mechanism is to blame for the increase in landslide fatalities. The only option to decrease the severity of these effects is to predict landslides as soon as possible and with high accuracy. The most popular sensor technology in the papers under review is the Wireless Sensor Network (WSN), which offers extensive monitoring. If there is a high likelihood that a landslide will occur following the prediction, a warning is sent to the disaster management department. These techniques all have varying degrees of accuracy. The approaches for lowering mortality by detecting and predicting landslides are covered in this survey article.

Contrary to those that are now in use, the solution suggested by this study is scalable, affordable, and extremely reliable. It can leverage IoT on the embedded device, report extremely precise sensory data in near real time and continuously, and send alerts to users' mobile phones in real time.

There are currently no mechanisms in place that can monitor and provide early warning warnings to help reduce the effects of landslides. Among the stated causes of landslides were steep slopes, soil type, and incorrect land use. However, some of the control mechanisms that have been put in place include planting trees, agroforestry, rainwater gathering, and building terraces to lessen soil erosion. This supports the need for our solution as well.

The goal of the landslide monitoring system is to make it easier to identify potentially dangerous slope movements early on. The system will immediately warn individuals of potential landslides if it detects pre-failure slope deformations. Relevant parameters taken from the observed slope are continuously kept and available for detailed diagnosis of the movements. The landslide monitoring system automatically calculates the inverse velocity and uses the results to determine whether and when landslides are likely to occur. The two subsystems of the system are the server system and the wireless sensor network.

The main components of the proposed system are the accelerometer, soil moisture, and vibration sensors. The 6-pivot accelerometer sensor produces the straightforward result of action land dislodging and slant point. A corrosion-resistant soil moisture sensor will then be used to measure the soil's moisture content precisely. Along with the message delivered to the register phone numbers, an avalanche warning system with lighting and signals is provided.

The system uses soil sensor to monitor the moisture present in the soil. Plates are used to spread the soil's

moisture content. The power delivered by the current plate is proportional to the amount of water-containing material present. Excess moisture entering the sensor attracts more moisture, dramatically decreasing the output impedance and related output voltage. As indicated in Figure 1, the machine has a sensor node, a controller for the avalanche website, and a controller for the tracking station. How much water is present on the plates affects how much electric current passes through them. When there is more moisture around, the sensor draws more current and experiences lower output resistance and voltage. Another possibility is that the sensor consumes less current when the environment is dry, which causes high output resistance and high output voltage. Although the multiplexer's analogue input channel favors the analogue output, the soil moisture sensor's utilized output can be either analogue or digital.

Internet of Things network and system generation produced internally in order to alert people, landslides were discovered utilizing GPS, accelerometers, vibration sensors, humidity sensors, and accelerometers. If you charge a little fee for this sensor and the revenue exceeds the initial investment, you may roughly monitor individuals in advance of an impending landslide, preventing significant losses. Using the MQTT protocol, the microcontroller gathers and updates statistics from websites. These telemetry flights can help people learn more about the situation and become alert of impending crises.

One of the most commonly known ways to detect a landslide is through the use of soil moisture sensors. These small sensors are placed in the soil around buildings and other structures to detect changes in soil moisture levels. When the soil is saturated with water, as occurs in heavy rainfall, the sensors activate and send a signal to the monitoring station. This allows forecasters to predict landslides in advance and issue warnings to residents in danger.

The most common type of sensor used to detect landslides is a vibration sensor. These sensors are attached to the ground or to a structure in the ground and detect the vibrations that are caused by landslides. These sensors are generally very sensitive, allowing them to detect very small landslides. Some sensors can even detect the sounds that landslides make as they occur, allowing them to be triggered even when there is no visible movement. Figure 1 shows the proposed model.

The brain of the system in these uses Arduino. All of the operations of the suggested framework are supervised and managed by it. The fact that Arduino consumes so little energy is its main advantage over other controllers. It is more reliable, uses less energy, and is especially beneficial for programs that are user-accessible. The system is worn on the body in this situation. It also provides stability for the system and is developed and controlled for connecting to the Wi-Fi module.

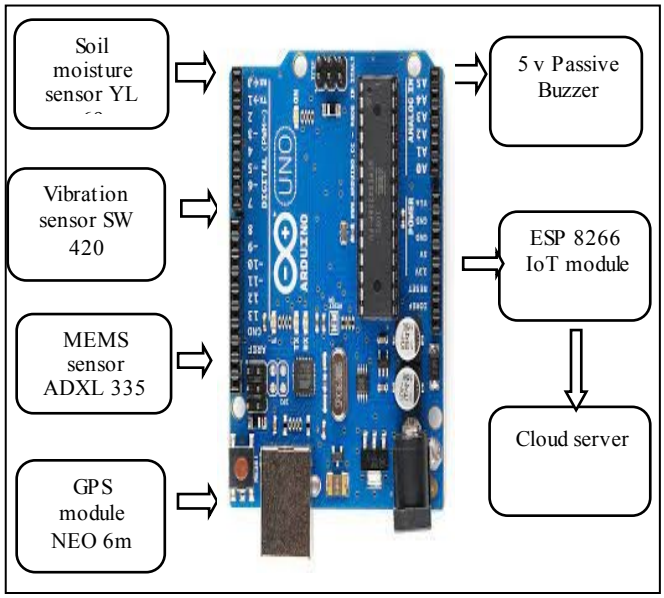

Fig. 1. Proposed Model

MEMS sensors are tiny electro-mechanical sensors used in a wide range of applications. MEMS sensors have many advantages over a normal sensor, such as being smaller and cheaper to produce, and are able to measure both mechanical and electrical properties.

It is believed that MEMS technology is a more advanced version of the way that integrated circuits are typically manufactured (ICs). MEMS allows for the creation of mechanical as well as electrical components like capacitors and inductors, which is the main contrast between MEMS and traditional IC manufacturing technique (VLSI). Conventional IC technology can only be used to create conductors, insulators, diodes, and transistors. Another crucial point to remember is that MEMS combines active and passive components on a single silicon substrate using cutting-edge IC fabrication technologies. The active components are made up of sensors and actuators, and the passive ones are made up of passive electronic and mechanical systems.

In other circumstances, the sensor's humidity may be low, but it is less attracted to the current date, resulting in an increased output resistance and associated output voltage. Sensory nodes provide information to controllers. An alert is displayed if the threshold changes as a result of this. This warning warns local neighbors to be on the lookout for potential landslides in the future.

Real-time landslide monitoring is one of the most challenging geophysical research fields at the moment. the field implementation of a wireless device network-based landslide detection system. This system makes use of remote sensor hubs and the MQTT protocol to efficiently deliver ongoing information to the system for monitoring, warning, and risk assessments to the local residents. This network will be used to understand the potential and suitability of wireless sensor networks for critical and emergency applications.

The software prototyping methodology was used as the software development strategy to create the IoT-based system for tracking landslides and providing notifications. This strategy was chosen because it was necessary to identify client needs early on and develop framework requirements.

Additionally, it was possible to obtain customer feedback, allowing the expert to understand how the arrangement is often expected to be constructed.

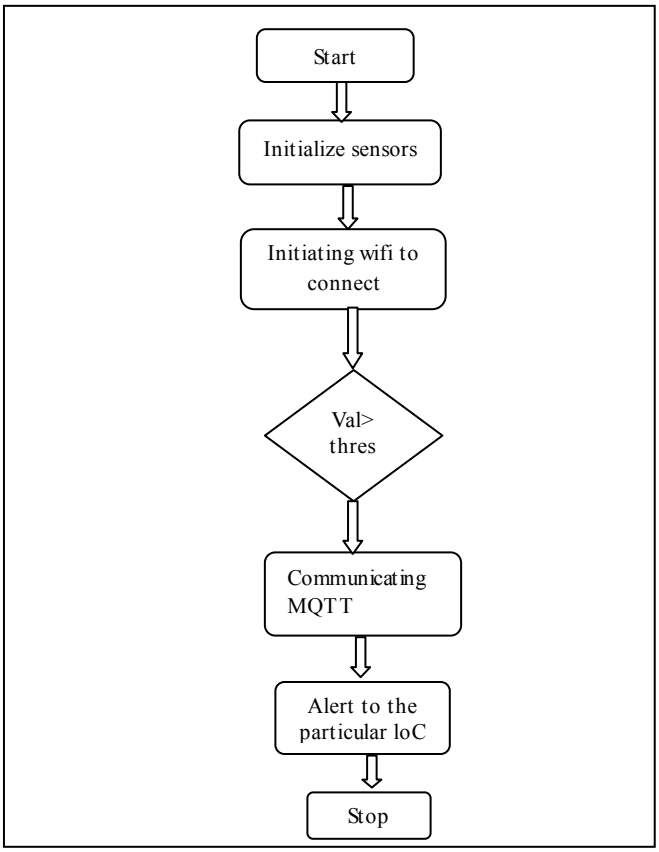

Fig. 2. Workflow of the system

1. Step 1: Data acquisition from sensor
2. Step 2: Initiating sensors and wi-fi module to connect to the server
3. Step 3: If sensor value greater than threshold the systemwill create an alert to the user.
4. Step 4: Communicate the MQTT protocol to the alert systemand data monitoring in cloud server.
5. Step 5: Alert to the user via smartphone

IV. Results And Discussions

Landslides are a geographical catastrophe that quickly destroy agricultural holdings and human lives because of variances in environmental activity. In contrast to other regions of the world, India regularly encounters landslides during the rainy season. The IoT-based technology is scalable and can identify landslide losses instantly. Because of the few causes, such as dielectric wetness, pore pressure, etc. that may occur during an avalanche, IOT-based networks are able to detect even the tiniest developments of ground or inclination trembling.

Landslides are often detected before they cause serious damage by detecting changes in the ground. This is usually done using sensors that are embedded in the ground or that detect changes in the ground's surface. In some cases, however, it is necessary to monitor the ground continuously in order to detect landslides as they are happening. This is done using on the ground sensors, which use a number of different methods to detect changes in the ground's surface. Figure 2 shows the workflow of the system.

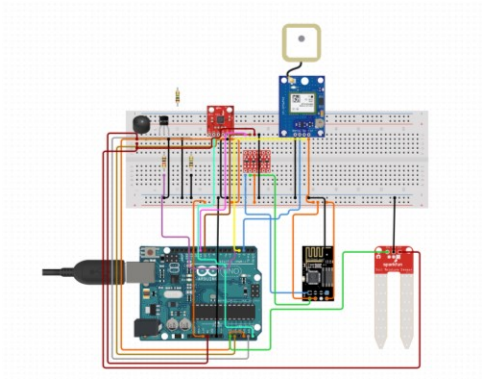

Fig. 3. Circuit diagram

The zone is determined using soil moisture sensor measurements. The threshold is determined by the soil's variety and features. Accelerometers are used to detect floor movement induced by vibrations in the floor. Here Figure 4 shows the soil moisture sensor reading in a graph for a several date and time. Here, the moisture value of particular location in a time frame is obtained. In algorithm, the system is created with some threshold values of sensor. Whenever it exceeds the threshold value, the system will an alert to the location regarding the situation. These graphs are automatically plotted in a clous server in a time intervals.

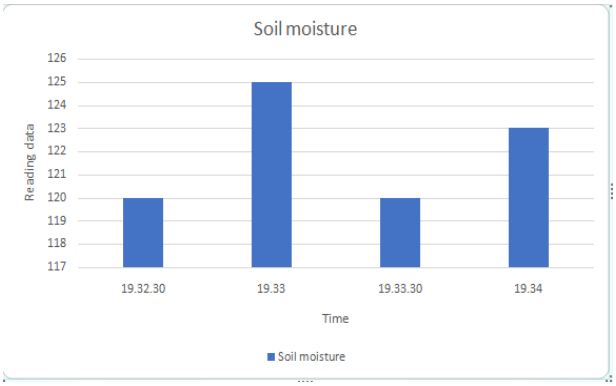

Fig. 4. Soil moisture reading

All accelerometer output values are presented in accordance with the acceleration columns indicated in Table 1, and their depths are relayed to the tracking station.

TABLE I. Sensor Readings

Sensors	Threshold value	Result	Value
Vibration Sensors	0-10,000 HZ	Buzzer beeps and alert is sent to the authorities	>20 Hz
Soil moisture sensor	0-100%	Alert is sent	>35%
MEMS	x,y,z = decimal based on acceleration in area	If acceleration changes, then the alert will sent	>acceleration changes on x,y,z

Table 2 shows the predicted damage of a particular area with the Sensor parameters in a range with the help of GPS module.

TABLE II. DAMAGE EXPECTED READING

MEMS	Results	Expected damage
0.20-0.35	Very strong	Moderate
>1.25	Extreme	Very Heavy
0.015-0.040	Light	None
0.35-0.065	Severe	Moderate to heavy
0.090-0.20.	Strong	Light
<0.0002	Not Felt	None
0.040-0.090	Moderate	Very light
0.65-1.25	Violent	Heavy
0.0015-0.015	Weak	None

The acronym MQTT stands for Message Queuing Telemetry Transport. MQTT is a machine-to-machine communication protocol for the internet of things. It is a very light-weight publish-subscribe message transport protocol. This protocol is helpful for connecting to a distant site with constrained bandwidth. These features make it helpful in a range of situations, including recurring ones like machine-to-machine communication and internet of things scenarios. With the help of this publish-and-subscribe mechanism, we as clients can send and receive messages. Multiple devices can communicate with one another easily thanks to it. It is a great option for internet of things applications since it is a simple messaging protocol designed for devices with constrained resources and low bandwidth.

The MQTT protocol is the most popular way to get landslide alerts. A low-bandwidth communication protocol called MQTT is frequently used to send data between IoT devices. Because it is a "publish/subscribe" messaging protocol, you can set up a system where you will be notified when a specific condition is met. On your home IoT system, for instance, you might configure a MQTT topic that would alert you whenever a landslide was spotted nearby. Figure 5 shows the alert message.

Fig. 5. Proposed System Reading

This module is in charge of getting a threshold value, using sensors to confirm the current value, and operating the buzzer based on the values read. The sensor detects the calamity, and the sensor value is contrasted with the threshold value. In a manner similar to how earthquake and landslide sensors work, the administrator immediately sends a buzzer or text message to the user when the sensor values hit the threshold. And also, module's sole duty is to check whether the gadget is functioning correctly. All devices, such as ckt devices, which comprise all sensors, controllers, PCBs, and ICs, are controlled by device test modules. to manage every device Any device cannot execute the running systemto detect an unresponsive user.

Real-time landslide monitoring is one of the most challenging geophysical research fields at the moment. The goal of the Internet of Things-based landslide detection system is to spot the danger signs of landslides, warn people about them in advance, and stop any fatalities. The present landslide detection methods are less accurate. The suggested solution offers real-time monitoring and is more precise. Additionally, it's easy to set up. None of the systems in use today are fully automated. They all need human contact at some point. The mechanism here is absolutely free of human meddling. The method is dependable and efficient at cutting down on delays. It foresees a landslide's commencement at an earlier stage, reducing the amount of fatalities brought on by landslides.

V. CONCLUSION

Landslides are one of the most destructive natural phenomena. They can cause extensive damage and loss of life, and can occur without warning. They can be caused by a variety of natural and human-related causes, including earthquakes, weather events such as heavy rain, and human activities such as deforestation and construction. Landslides can also range in size from small slides that cause only minor damage to large ones that cause catastrophic destruction. Modern landslide detection designs are far less reliable. The technology suggested here is a real-time tracking device with a high degree of accuracy. The installation is also quite nice. Not all contemporary designs are fully automated. At some point, all of them require human engagement. The gadget suggested here is absolutely devoid of human intervention. This system employs wireless sensor nodes and the MQTT protocol to transmit real-time data to the system for monitoring and providing alerts and danger assessments to the residents of the region.

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