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IOT-Based Landslide Detection and Indication

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***Abstract*— Hazards from landslides are everywhere. Landslides are more likely to occur on steeply sloped hillsides. For several case studies throughout the globe, researchers have performed landslide prediction, detection, and monitoring. The major goal of researching landslide detection is to stop natural disasters by seeing their early movement. This will lessen or prevent the landslide's fatalities among humans. Finding a method for the sensing components to react promptly to data changes and transmit the perceived data to the data analysis centre is another goal. The Wireless Sensor Network (WSN) and the Internet of Things serve as the foundation for the Implemented system (IoT). This technology is inexpensive, reliable, and delay-effective. The suggested system makes use of accelerometer and soil moisture sensors. While the accelerometer measures ground movement, moisture sensor data reveal the amount of moisture in the soil. The measurements that exceed the established criteria warn nearby residents to take precautions.**

***Keywords*— Landslide detection, WSN, IoT, inexpensive.**

I. INTRODUCTION

Rock, rubble, or soil sliding down a slope is referred to as a landslide. When it rains during the monsoon, the water percolates and builds up hydraulic pressure that is greater than the elastic limit of the soil or rocks. As a result, the stress builds up, causing the rocks and soil to lose some of their adhesion properties and resulting in landslides. Landslides result in considerable loss of life by destroying agricultural and forest areas, roadways, and the earth's natural ecosystem. Landslides are sometimes referred to as "Mass Wasting," which is any gravity-driven downward movement of earth and rock. It results in injury, death, and property damage. Additionally, it has a negative impact on many resources for years following a slide occurrence, including water supplies, fisheries, sewage disposal systems, dams, and roads. When the slope transitions from a stable to an unstable state, landslides happen. Numerous causes, both collectively and separately, may be to blame for this shift in the stability of a slope.

When earth, rock, or other material slides down a hill, it is called a landslide. Rainwater percolates during the monsoon and builds up hydraulic pressure that is greater than the elastic limit of the soil or rocks. As a result, the stress builds up, causing the rocks and soil to lose their ability to adhere to one another and resulting in landslides. Landslides result in substantial loss of life by destroying agricultural and forest areas, roadways, and the natural ecology of the planet. As a term for any downward movement of soil and rock caused by gravity, "mass wasting" is frequently used to describe slides. Property is harmed, people are hurt, and people die. Additionally, it has a negative impact for years following a slide event on a number of resources, including water supply, fisheries, sewage disposal systems, dams, and roads. The slope shifts from a stable to an unstable state, causing the landslides. Numerous elements may work together or separately to influence how stable a slope is.

This paper is organized as follows; the State of art methods for the analysis of landslide detection in section II. The Implemented system is explained in section III. The results in terms of analysis are discussed in section IV, and the paper is concluded in section V.

II. LITRETURE SURVEY

The incidence of landslide deaths has increased owing to numerous time-consuming and inaccurate forecast approaches, according to Mrunal Jaywalker et al. [1]. According to academics, the only way to lessen these negative impacts is to anticipate landslides quickly and precisely. Since it offers thorough scale monitoring, WSN (Wireless Sensor Network) is most often employed in the majority of the papers under study that make use of sensor technology. Following the forecast, an alarm is issued to the disaster management agency when the likelihood of a landslide is high. The accuracy rates for each of these techniques vary.

In order to prevent or minimise human casualties, Pawar Pitamber et al. [2] presented a method to recognise the circumstances that contribute to the formation of landslides and alert it well in advance. The system makes use of accelerometer and soil moisture sensors. While an accelerometer measures ground movement, a moisture sensor measures the moisture level of the soil. Local residents are advised to take precautions when readings exceed the established levels. The ESP32 utilised in the control room also receives the sensed data through the MQTT protocol. The SAFE, MIDDLE, and DANGER zones are shown via an interface between an ESP32 and a laptop. To analyse the data and notify the rescue team in case of MIDDLE and DANGER

zones, all ESP32 measurements are also sent to the cloud. The system needs 10 milliseconds to gather data from the sensor and send it via MQTT to the ESP32. Additionally, it takes an extra 20 Ms for the ESP32 to upload data to the Thing Speak cloud.

A method to monitor and track landslide abuse was suggested by K. Elavarasi et al. [3] and uses an Arduino UNO. It does a quantity study of the hilly area, works with IoT sensors that monitor landslides, notifies parents in the area through alert message using GPS and GSM, and notifies them by buzzer just in case network connectivity is lost. To obtain data to the system, sensors are put in the risky region.

According to Xianguo Tuo et al. [4], The system stores crucial restrictions of the components that might cause landslides. Warning SMS messages are automatically delivered to the appropriate individuals when the system determines that it is exceeding the limitations.

Data mining will be possible thanks to the "Landslide Detection System" presented by Matteo Lucchi et al [5]. As part of the Asian Joint Research Project and the Sensor Asia Initiative, the "Landslide Early Warning System for Rural Community as an Application of Sensor Asia" was created and put into use in the Indonesian province of Banjarnegara. Data from several sensors was gathered by a field server and displayed in real time on a web page. Another benefit is that a graphical interface is also offered at the local location so that locals may see the movement and the degree of alert.

A method that enables the use of any operating system platforms and SMS messaging was suggested by Fang Y.M. et al. [6]. "Development of Macro-Bending Loss Based Optical Fiber Sensor Based Landslide Early Warning System". A polymer optical fibre was wrapped for this study's use in fibre optic sensors.

The mechanical displacement converter, siren-equipped SMS gateway, and displacement fibre sensor were suggested by Vaibhav Pandurang Gund et al. [7].

T.N.P. Withana et al. created and put into use a landslide early warning system [8]. It is an early warning system for rock slides that takes into account geological information, risk scenarios, kinematic characterization of the landslide, choosing and installation of a monitoring system, setting of suitable alert levels, and the creation of civil protection strategies. It did not provide an SMS or a ground displacement sensor.

"Landslide Warning System Using Zigbee and Global Positioning System (GPS), which is a mix of GSM wireless communication technology and Wireless Sensor Network," was created by K. Raghava Rao et al. [9].

Marco Birla and others [10] This study uses a landslide monitoring system and SMS. Three sensors were employed via Zigbee: an angle sensor, a liquid level sensor, and a liquid level sensor that measures the depth of water in the mountains. The angle sensor measures the slope angle if a landslide occurs. A temperature sensor reports temperature changes.

The "IoT based landslide detection system" described by Francesco Mugnai et al. [11] would enable the use of several sensors to detect ground movement and warning notifications. Two sensors—a moisture sensor and a vibration sensor—are used in a system for precisely detecting landslides. The sensors are integrated using a microprocessor. RFID stands for radio frequency identification technology. The components of RFID technology are readers and tags. The tags use radio waves to store and send data to readers. The readers collect data from various tags and then transmit it back to the server for further processing and analysis.

An information retrieval system with three sensors and Zigbee modules for remote communication was suggested by Pranav Pravin Garje et al. [12]. The sensors that are used include the accelerometer, humidity, and soil moisture sensors. When the sensor readings exceed the threshold value, a warning system will be initiated at the distant location. The information collection and monitoring equipment uses several sensors to collect data and an LPC 2148 microcontroller for control. A system with several sensors was presented by Ankit Suthar et al. for the purpose of detecting landslides. Many sensors have been installed in landslide-prone locations. Acceleration sensors are used here. The acceleration sensor detects the motions of dirt and rocks as well as the vibrations they produce as they fall. A system with two primary components was presented by Amrutha Joshi and others. The two components of a sensor column are a receiver station and a sensor column, respectively. Flex sensors, MEMS, and/or accelerometers are all included in each sensor column. The sensor column transmits and receives data via UDP. The first step in this system's operation is to initialise the required peripherals. The state of the sensors used to detect landslides had to then be read.

VS Kulkarni and others [13] If the value of the flex sensor changes, it displays the tilt's intensity before MEMS detects the tilted direction. These detected data are used to determine the warning time, which is then sent to UART for transmission.

Pooja Bahirat et al. [14] spoke about how Field Server was used to gather data from various sensors and show it in real time on a web page. Another benefit is that a graphical interface is also offered at the local location so that locals may see the movement and the degree of alert. Their idea has several drawbacks, such as the system's reliance on Linux for data storage and absence of SMS. Any operating system platform may be used with the Implemented system to transmit SMS messages. "Development of Macro-Bending Loss Based Optical Fiber Sensor Based Landslide Early Warning System". This research was supported in part by the Department of Science and Technology (DST) of India's "Monitoring and Detection of Rainfall Induced Landslide Using an Integrated Wireless Network System" project and the "Advanced Integrated Wireless Sensor Networks for Real-time Monitoring and Detection of Disasters" project funded by the Ministry of Earth Science.

III. SYSTEM ARCHITECTURE

Fig. 1 displays the suggested system's block diagram. Sensor nodes, a controller at the landslide site, and an ESP32 at the monitoring station make up the system. To fully cover a region, often many sensor nodes are required. All of these sensors gather data on the criteria used to monitor landslides, including tilt angle, soil moisture, and displacement. The suggested system makes use of a 3.3 to 5 V soil moisture sensor. It contains two plates that measure the soil's water content. The electric current flowing across the plates varies in direct proportion to the water content. More moisture surrounding the sensor causes it to draw more current, which reduces output resistance and lowers the output voltage.

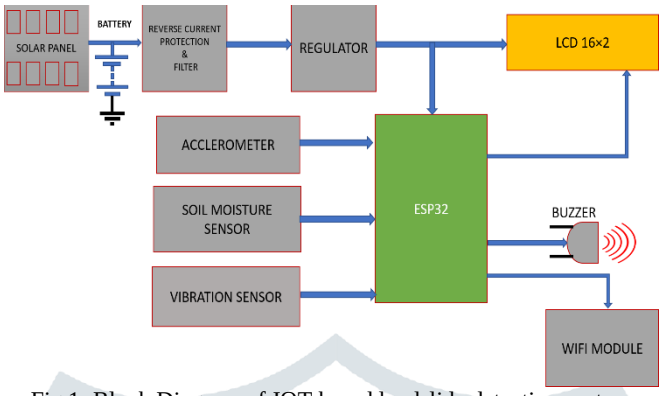

Fig 1: Block Diagram of IOT based landslide detection system

Another scenario is when the sensor draws less current when there is less moisture surrounding it, leading to a high output resistance and a corresponding output voltage of People who live nearby are at risk from landslides in places with high rainfall. Additionally, making predictions regarding it becomes challenging. In order to create a new prediction tool that can be used to analyse the movement of an area using sensors, telecommunication is joining with a collaboration of professional labs, including IS Terre: earth science and LCIS: embedded electronics. The primary idea is that the sensors will use the least amount of money and energy possible to detect movement in the field. The monitoring methods rely on wireless sensor networks for geolocation and IoT-based transmission. A frequent method is to have a collection of permanent (non-mobile) nodes and anchors whose locations are previously known in order to accomplish geo location utilising a network of sensors. Several methods are used to calculate the position of the sensor node.

One anchor is chosen to play the role of master in one such strategy while it gathers data from the other anchors. Another survey is based on a severe human loss landslide that happened in China's Guizhou region. After rain, the danger grows there. There are servers, base stations, and acquisition nodes in this system. A WSN is made up of many nodes that work together to gather data on landslide characteristics such displacement, temperature, moisture, tilt angle, and local rainfall. The network's self-organizing, fault-tolerant, and adaptive features are notably facilitated by the sensor nodes and communication protocols.

In this block diagram of Landslide Detection System there are various components connected to each other to complete the system. There are two types of sensors Accelerometer and Soil moisture sensor which can sense the environmental conditions. Soil moisture sensor sense the moisture content in the soil and Accelerometer sensor sense the vibrations and send the data to the ESP32. We are using ESP32 model it requires 5V and 30 mA current. We are added Battery and for emergency when battery is not working, we are added Solar Panel with the help of this system has to take power supply. ESP32 process the data and send to the ThingSpeak server with the help of Wi-Fi module in it. All the readings from ESP32 are also uploaded on ThingSpeak cloud to analyze them and alert the rescue team in case of MIDDLE and DANGER zones.

The sensor nodes' data are accepted by the controller. These detected data trigger an alarm if they exceed threshold levels. Three classes—SAFE zone, MIDDLE zone, and DANGER zone—are used to categorise the full data range. For the MIDDLE and DANGER zones, an alert is sent. Both classes have distinct warning patterns that serve distinct purposes. When detected readings fall inside the MIDDLE zone, the first alarm is sent. This warning warns nearby residents to be on the lookout for potential landslides in the future. Additionally, this advisory reminds residents to maintain emergency supplies on hand, including a first aid kit, clothing, water bottle, and food. These items are essential in dangerous circumstances.

As the detected values are in the DANGER zone, the second and final alarm is sent. Citizens are instructed to vacate the area immediately by this notice. The controller communicates all the detected data to the monitoring station in addition to sending notifications to the nearby residents. The task of monitoring and data analysis is carried out by the monitoring station. Node MCU is used to transmit the detected data to the monitoring station. It also alerts the rescue crew while in the DANGER zone. The IoT platform is "Thing Speak" (cloud storage). At the Thing Speak website, the detected data is visually depicted, making analysis simple.

I. IMPLEMENTATION

The circuit diagram of the Implemented system which is used to detect landslide is shown in Fig. 2.

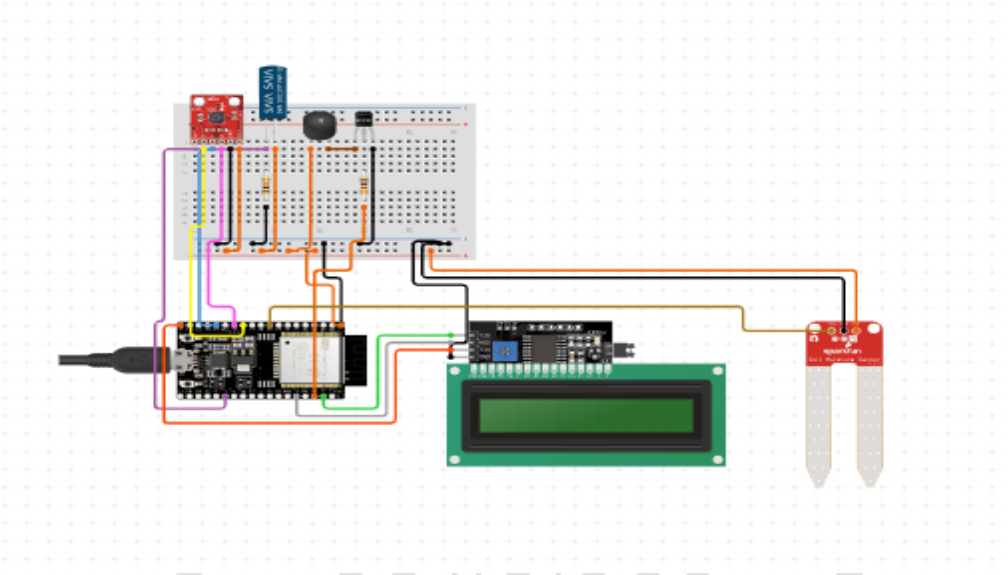

Fig.2. Circuit Diagram of the Implemented landslide detection system

In the diagram above we have implemented the circuit for landslide detection with the help of ADXL gyroscope sensor, Vibration sensor and soil moisture sensor. The details of the sensor will be shown in the 16x2 lcd which is I2c based.

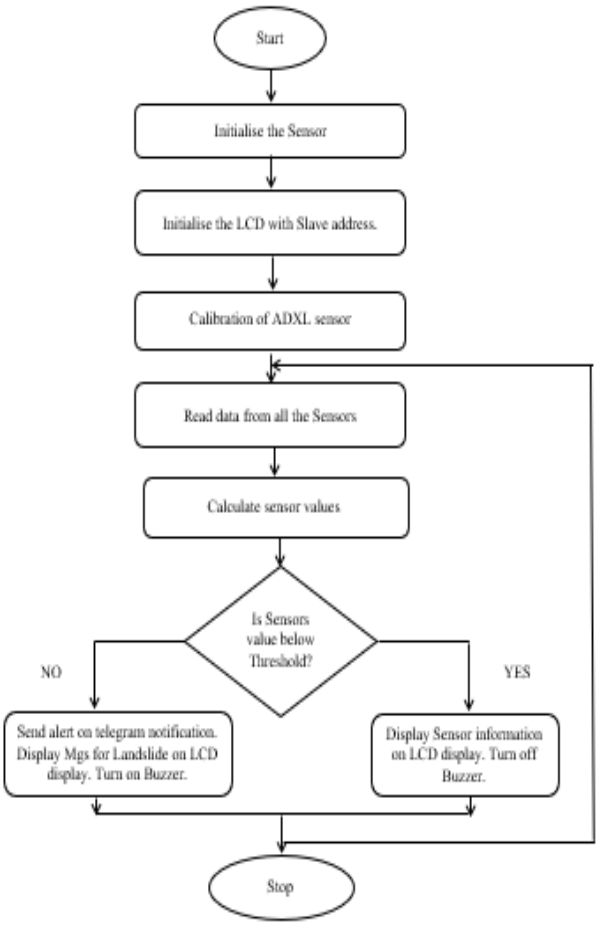

Fig.3. Flowchart of the Implemented landslide detection system

II. RESULT

Simulation diagram of the Implemented system is shown in Fig.4.

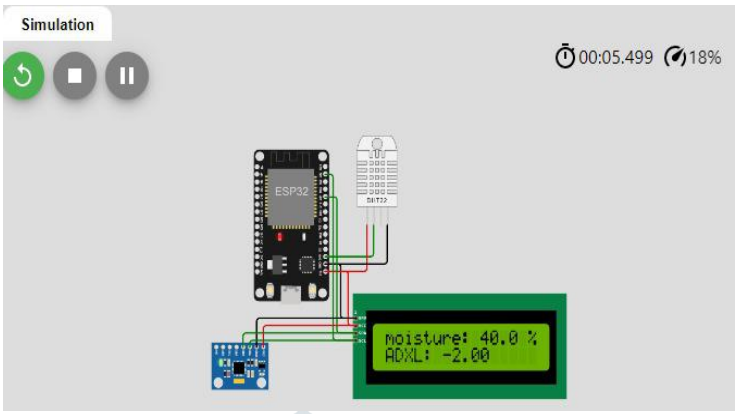

Fig.4 Simulation Using WOKWI.COM

In the Fig. 4 we have used a Simulation website to interface sensors and display. According to the implementation of our project we will monitor the ADXL and soil moisture sensor.

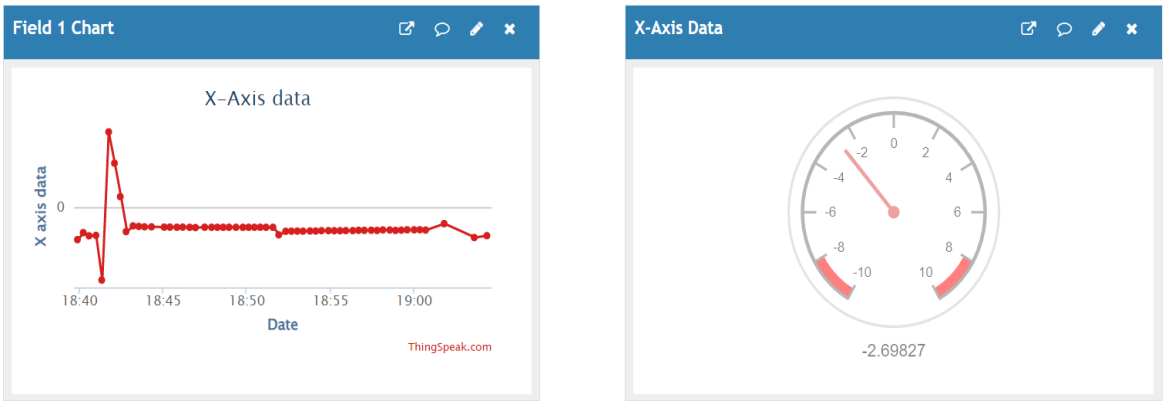

Fig.5 Output from ADXL sensor

The output shown in the Fig. 5 is the output on Thing Speak Cloud with Vibration sensor and the data is been converted to percentage and this percentage will be shown on lcd and Thing Speak

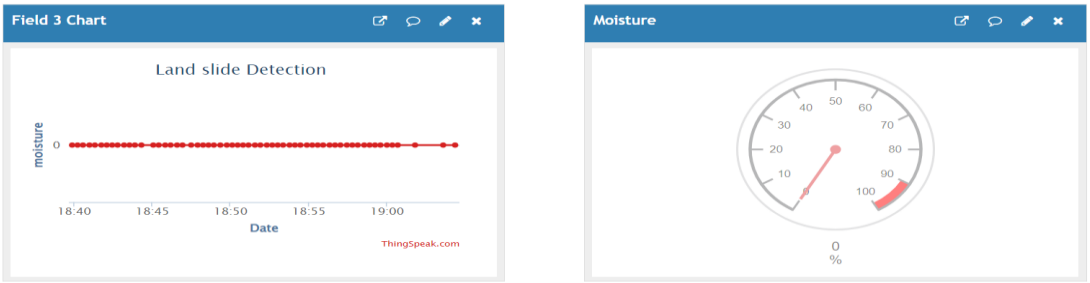

Fig.6 Output from Moisture Sensor

The output shown in the Fig.6 is the output on Thing speak Cloud with Moisture sensor and the data is been converted to percentage and this percentage will be shown on lcd and Thing Speak.

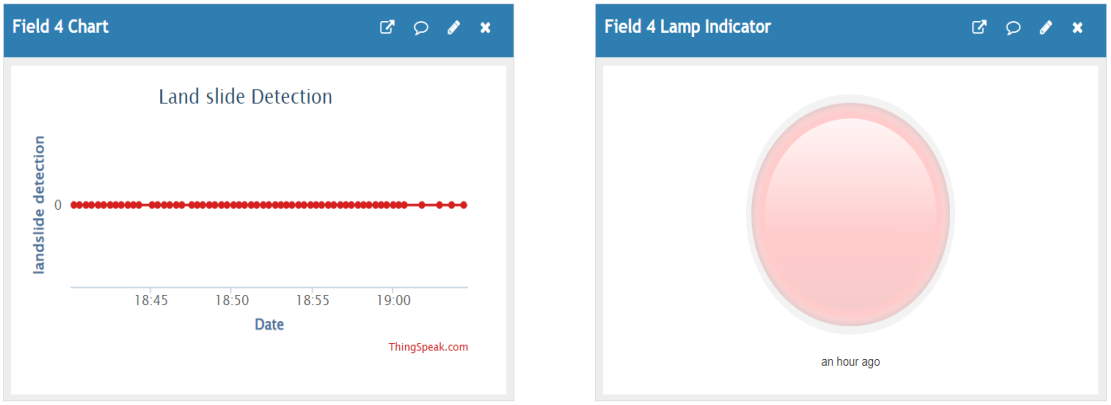

Fig.7 No Landslide detection

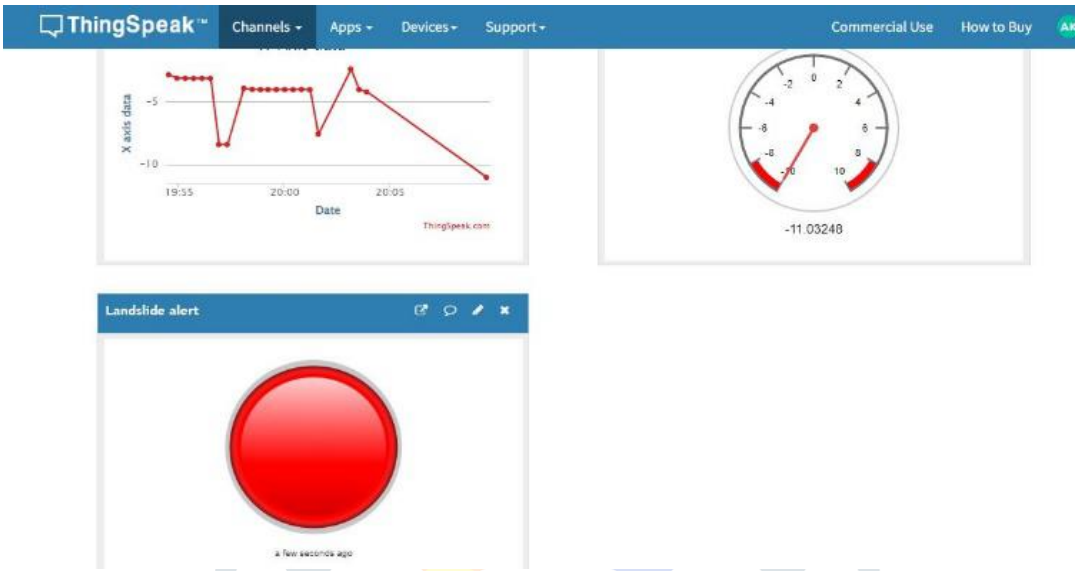

Fig.8. Landslide detected

Fig.8. shows the results of the indicator of landslide. With the help of Thing Speak we can monitor the sensor data as well as the data from the indication. This field is used to indicate for landslide. Here, for now landslide detection is shown.

III. CONCLUSION

One of the toughest study fields now accessible in the geophysical discipline is real-time monitoring of landslides. the real field deployment of a landslide detection system powered mostly by a wireless device network. To efficiently transmit real-time data to the system for monitoring and distributing alerts and risk assessments to the local population, this system makes use of wireless sensor nodes and the MQTT protocol. The capabilities and applicability of wireless sensor networks for critical and emergency applications will be understood using this network. The findings from the suggested system are encouraging

IV. FUTURE SCOPE

For new technology the system will adopt new changes to improve performance and it will more scalable. The system will use LoRa model for long distance communication.

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