

# Landslide Detection System: Based on IOT

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**Abstract**— Landslides or landslip occurs at the down slopes. Landslides are most common in the Asian countries. The movements of rock mass or soil under the gravity are causes due to both Natural and human activities. Increase in the hydrostatic pressure, by saturation of rain water, melting of snow, increase in groundwater level, increase of pore water pressure, volcanic eruptions and earthquakes are natural causes of the landslip. Human activities include the deforestation, cultivation, machinery vibrations, blasting mining etc. Decrease in the shear stress and increase in the shear strain borne by material cause the change in the stability of the slope. Landslide causes extensive loss to the human lives and properties this makes important to monitor and make early warning systems. An attempt is made to create low cost and effective warning system IOT based landslide detection system. Using Arduino, Wi-Fi module, Moisture Sensors and Vibration sensors. When data is collected it is uploaded by Arduino to the cloud ThingSpeak which help to monitor the real time data and send alert to the end user via SMS on the mobile phone about the Landslide when it happens.

**Keywords:** Landslide, Arduino, Wireless sensor network, soil, Sensor Development

## I. INTRODUCTION

Landslides or landslip occurs at the down slopes. Landslides are most common in the Asian countries. The movements of rock mass or soil under the gravity are causes due to both Natural and human activities. Increase in the hydrostatic pressure, by saturation of rainwater, melting of snow, increase in groundwater level, increase of pore water pressure, Volcanic eruptions and earthquakes are natural causes of the landslip. Human activities include the deforestation, cultivation, machinery vibrations, blasting mining etc. Decrease in the shear stress and increase in the shear strain borne by material cause the change in the stability of the slope. Landslide causes extensive loss to the human lives and properties this makes important to monitor and make early warning systems. In past years there are serious landslides that occurred in India are discussed in the Table 1.

Guwahati landslide, Assam	On September 18, 1948 due to heavy rain landslide is took place. Over 500 people died in the landslide.
Darjeeling landslide, West Bengal	On October 4, 1968 due to flood landslide was happened. Thousands of people died in the landslide and damaged to the highway occurred.
Malpa landslide, Uttarakhand	Two landslides occurred between August 11 and August 17, 1988 in the village Malpa. Over 380 people died and entire village washed away in landslide. This landslide slide has considered one of worst landslides in India.

Mumbai landslide, Maharashtra	In the month of July 2000, this landslide occurred due to the heavy rain and followed by the soil erosion. Around 67 people died in this landslide and local trains has affected.
Amboori landslide, Kerala	On November 9, 2001 a landslide occurred due to heavy rains and 40 people died in this incident.
Kedarnath landslide, Uttarakhand	On June 16, 2013 due to flood landslide occurred. Over 5700 people died and the flood and post flood landslides had affected 4200 villages.
Malin landslide, Maharashtra	On July 30, 2014 in a village in Malin. The landslide occurred due to heavy rainfall. Around 150 people died and missing people number was around 100.

Table 1: Serious Landslides occurred in India

Northwest Himalayan Mountain Ranges including Uttarakhand, Himachal Pradesh, Jammu & Kashmir are highest landslide hazard prone areas. Probably every year landslides occurred in this area due to heavy rainfall. From Table 1 we can conclude that India has higher risk of landslides. This becomes necessary to monitor the landslides with the help of Landslides detection systems. But generally in India the monitoring of landslides is not much popular, due to lack of monitoring systems real-time monitoring of landslides becomes difficult.

In this project, a low cost and effective warning system is made with the help of open source development board microcontroller Arduino, WIFI module, Moisture Sensors and Vibration sensors. The board and sensors are connected to the internet via GSM service provider and the real time data is monitored with the help of the ThingSpeak for IoT project cloud platform provided by Mathworks with advance data analysis that uses MATLAB. The version used in this project is free version with the limited functionality however; paid versions are also available for the commercial and academic with unlimited functions. ThingSpeak collect the real time data via connected sensors to it analyze and act according to the threshold values also it can communicate with the third party. Alert is also send to the user via SMS service on the registered mobile number. IFTTT execution service is used for sending the SMS. The targeted phone uses IFTTT android app whose SIM number is registered. This IFTTT is used as a third party with the ThingSpeak servers.

## II. LITERATURE REVIEW

Many researchers have worked on the landslide detection system based on Internet of Things using development boards like Arduino and Raspberry pi mostly.

- 1) Maneesha V. Ramesh of Department of Computer Science, Amrita School of Engineering, Amrita Vishwa Vidyapeetham (AMRITA University), Kollam, Kerala,

- India published paper on “Real-time Wireless Sensor Network for Landslide Detection” published in 2009 *Third International Conference on Sensor Technologies and Applications*. They have used pore pressure transducers, soil moisture sensors, geophones, strain gauges and tiltmeters connected via the wireless system network. Their main aim was to detect the landslides that are caused due to the heavy rainfall. The collected data is transfer with the help of WIFI network to the FMC that uses external antenna and access point. They have used the VSAT satellite for the communication to the database server at Amrita University's Amritapuri campus. They have shown in their paper that during 2008 monsoon the sensors were able to receive the data in heavy rainfall of the soil. Their system is efficient in analyzing the real time data over the internet about the landslide.
- 2) Somchai Biansoongnern<sup>a,\*</sup>, Boonyang Plungkang<sup>a</sup>, Sriwichai Susuk<sup>b</sup> of <sup>a</sup>Department of Electrical Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi, Thailand and <sup>b</sup>Thailand Institute of Scientific and Technological Research (TISTR), Thailand in their paper “Development of Low Cost Vibration Sensor Network for Early Warning System of Landslides” published in *Elsevier Science direct (et al., 2015)* used microcontroller PIC12F683 and ATmega328 based on low cost WIFI sensor networks for landslide early warning system. In this paper, they have concluded the results of the real time data is obtained over WIFI network that transmit the data to the server system when there is change in the threshold values. Different master nodes are used for different area that uses vibration sensors and transmit the real time data over the server that can be accessed from anywhere and analyzed. This results in very efficient and cheap development option for the landslide early warning system using the vibration sensors.
  - 3) Shrishti Kanchan<sup>1</sup>, Juhi Naushin Shaikh<sup>2</sup>, Hiba Shakeel<sup>3</sup>, Mansi Nachankar<sup>4</sup>, Prof. Sonali K. Suryawanshi<sup>5</sup> of Computer Department, Rizvi College of Engineering, Mumbai, Maharashtra, India<sup>1,2,3,4</sup> Assistant Professor, Computer Department, Rizvi College of Engineering, Mumbai, Maharashtra, India<sup>5</sup> in their paper “Landslide Detection” published in *International Journal of Advanced Research in Computer and Communication Engineering(et al.,2017)* has used ultrasonic sensor, Android app, IoT intranet, Rainfall sensor, Arduino and Android app notification for the landslide detection system. They have shown in their paper that WSN (Wireless Sensors Network) are very low power consumption instruments that just only run on 4 AA size batteries. These sensors are buried in the earth hole to detect the landslide movements. The use of Arduino UNO as an open source development board make this project more low cost and efficient. WIFI sensor is used to commute with the receiving devices. They have concluded the results that by monitoring the landslide measuring parameters the device is capable of predicting the landslide in the particular region and can save the loss of human lives and property.
  - 4) Gunarathna W, A.S.R.,Dissanayake, S.A.,Darshana, D.G.T.3,Bandara, H.M.P.M. and D. Dhammearatchi of Sri Lanka Institute of Information Technology, Colombo, Sri Lanka have developed efficient and low cost warning system published in their paper “Suraki Bhoomi: Landslide Early Warning System” in *International Journal of Scientific and Research Publications (et al., 2017)*. They have used Arduino UNO MCU, rain sensor and soil moisture sensor connected to the network module and developed their own android based and desktop application user interface, they have used the GSM (Global System for Mobile communication) service to send the text message (SMS) alert to the end user.
  - 5) Madhusudhan.Y.V, Renuka.H.C , Bhavya.S.S, Alfred D'souza, Kavyashree.B of Department of ECE, Vidyavardhaka college of engineering, Mysuru, Karnataka, India and Manjunatha.M.N, CAM Engineer, of Wuerth Electronik India Pvt Ltd, Mysuru, Karnataka, India in their paper “Landslide and Rockslide Detection System with Landslide Early Warning System for Railways” published in the “*International Journal of Engineering Research & Technology (IJERT)*” (et al.,2018) . Their aim is to developed safety for passengers of railways by detecting the landslides in the area using their landslide early warning system. They have used ArduinoUNO MCU and camera that uses the code developed with the help of MATLAB. This also include GSM 800 Module, Vibration sensor. Their early warning system detects the vibration in the earth surface with the help of vibration sensor and send it to the ArduinoUNO that sends the signal to the buzzer. Buzzer will start generating sound and alert is shown on the LCD screen and SMS is send to the regulating authority about the landslide.
  - 6) Alexandre Melo Delfim, Elton Guilherme Rodrigues, Marcelo Bender Perotoni of Federal University of ABC (UFABC) published paper on “Landslide Detection System: Design and Development” in *Journal of Production and Automation (et al.,2018)* they have used ArduinoUNO MCU and an accelerometer for the ground motion detection. Data is processed and an alert is send to the end user before the actual landslide occurs. Including with the accelerometer , soil moisture sensor is used to determine the present moisture in the soil this ensures the higher reliability assessment. Their wireless network system is based on the chip nRF24L01 which operates on 2.4 Ghz band. The test results includes the different angles 30°, 15° and 10 ° for fast and slow movements. Their wireless channels have proved operational, alerts shown on LCD screen, and alarm.
  - 7) Pawar Pitambar, Patil Akshay, Rathod Hardik, Hadale Ravi, and Kharche Shubhangi Of SIES Graduate School of Technology, Nerul, Navi Mumbai in their paper “IoT Based Landslide Detection and Monitoring” published in *IJRAR (et al.,2019)* used soil moisture sensor and accelerometer sensors. All the real time data is send to the server via MQTT protocol that uses Raspberry Pi (Rpi). They have split the interface in the SAFE,MIDDLE and DANGER zones based on the real time data collected by the connected accelerometer and

soil moisture sensor on the cloud storage facility servers. Rpi is an open source and very cheap alternative to the costly computers available in the market. The cloud storage server used in their project based on the ThingSpeak available for the IoT platform instruments. Their prototype landslide detection system is very efficient and low cost approach. NodeMCU detects the vibration and moisture in the soil than transfer the data to the Rpi and later to the ThingSpeak Cloud service. They have showed that for a 1000 sq.ft area approximately 375 nodes are required to cover the desired area. The future scope of their prototype can be use with the machine learning process by using python for more accurate analysis.

### III. METHODOLOGY

This project focus on the development of low cost and efficient IoT based system for the landslide detection and warning system. The system shown here is prototype and number of nodes can be use to cover large area. Arduino board is used in the development of the system along with the vibration sensors, soil moisture sensors and WiFi module. WiFi enables the sensors and board connect to the Internet Service Provider (ISP). All the sensors collect the real time data and with the help of Arduino development board the data is send to the cloud storage ThingSpeak. ThingSpeak by Mathworks uses MATLAB as a powerful tool to analyze the data and present it in the form of graph that can be easily readable. ThingSpeak can act when threshold values reaches and can commute with the third party. The alert is send in the form of SMS to the end user via registered mobile number. IFTTT execution service is used for sending the SMS. The targeted phone uses IFTTT android app whose SIM number is registered. This IFTTT is used as a third party with the ThingSpeak servers. There are defined parameters for the threshold values based on the Vibration and the moisture present in the soil.

It observed that most of the landslides are cause due to the excess pore water pressure present in the soil during heavy rainfall. The expansion and contraction in the soil causes it to fall apart the material on slope due to the gravity and vibrations. These vibrations can be in form of Natural like Earthquakes and can be Human induced like blasting.

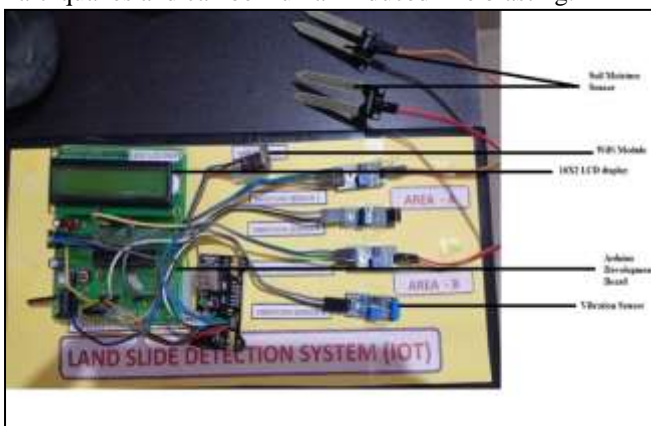


Fig. 1: IOT based Landslide Detection System

There is a decrease in the shear stress and increase in the shear strain borne by material cause the change in the stability of the slope this results in the Landslide.

### IV. COMPONENTS USED

Low cost and effective sensors are used to detect the moisture in the soil as well as the earthquake with the help of vibration sensors connected to the arduino development board. The list of the components are explain in detail given below –

#### A. Arduino Development Board :

Arduino is an open source and easy to use development board. It can be use with the arduino programming language and arduino software IDE (Integrated Development Environment). The software use for arduino is an open source software. The easy to use and low cost with open source feature makes the arduino widely popular in academic students and researchers. Lots of student use this development board in their project because of its low cost and powerful features. Arduino is capable to detect the surroundings from input. Input can be provided by using wide range of sensors and can control motors, lights, etc. Arduino development board uses ATmega328 microcontroller which is programmed with the help of the Arduino programming language or with the Arduino software IDE.



Fig. 2: Arduino Development Board

Features of Arduino Uno:

- 1) The operating voltage is 5v.
- 2) The recommended input voltage will range from 7v to 12v.
- 3) The input voltage ranges from 6v to 20v.
- 4) Digital input/output pins are 14.
- 5) Analog i/p pins are 6.
- 6) DC current for 3.3v Pin is 50 mA.
- 7) Flash Memory is 32 KB.
- 8) CLK Speed is 16 MHz

#### B. ESP8266 Wi-Fi Module:

ESP8266 is best module for IoT based project that can easily connect with arduino. This Wi-Fi module allows microcontroller to access Wi-Fi network but you can also program it to act as a microcontroller as well. This module uses SOC (System On Chip) that does not require any type of microcontroller for manipulating the inputs.

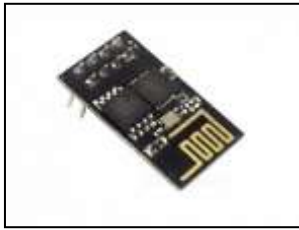


Fig. 3: ESP8266 Wi-Fi Module

C. Vibration sensor module:

This module is based on the vibration sensor switch SW-420 and comparator LM393 to detect if there is any vibration beyond the threshold values. On board potentiometer is available for adjusting the threshold values.

Features:

- 1) Using SW-420 normally closed type vibration sensor.
- 2) Comparator output, clean signal, good waveform, strong driving ability, >15mA.
- 3) Using a wide voltage LM393 comparator.
- 4) With bolt holes for easy installation.

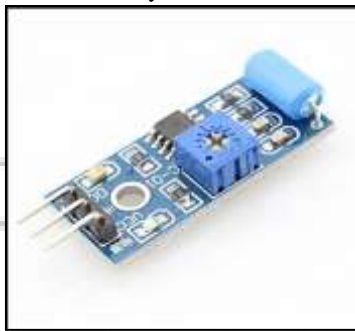


Fig. 4: Vibration sensor module

D. LCD 16x2 Display

The LiquidCrystal library allows you to interface the LCD on arduino boards that is used for the output such as values or warnings.

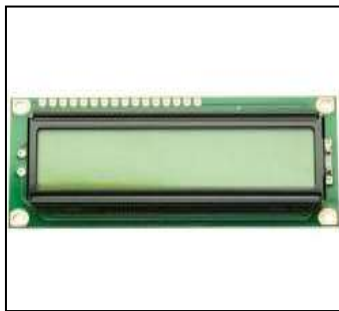


Fig. 5: LCD 16x2 Display

E. Soil Moisture Sensor:

The sensor contains a probe and electronic module that connects it to the arduino. There is a fork-shaped probe with two exposed conductors goes into soil for detecting the soil moisture. The probe acts as a variable resistor whose resistance varies according to the soil moisture. The electronic module connects the probe to the Arduino. The module produces an output voltage according to the resistance of the probe and is available at an Analog Output (AO) pin. It consist of LM393 compactor the single fed by and available at an Digital Output (DO) pin. For adjusting

threshold values potentiometer is available on board for Digital Output (DO).

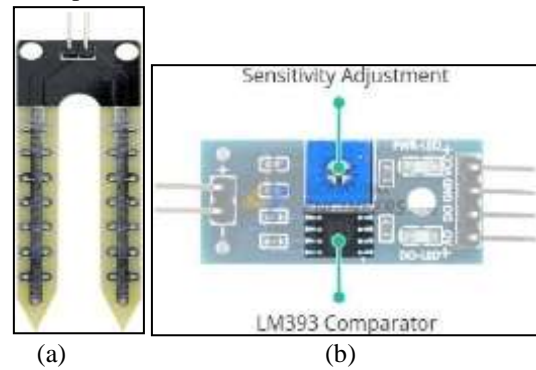


Fig. 6: (a) Probe (b) electronic component for soil moisture sensor adjustment

V. DEVELOPMENT OF LANDSLIDE DETECTION SYSTEM

A. Circuit:

The fig 7 shows the schematics of the landslide detection system. VS1 and VS2 are the vibration sensors connected to the D12 and D11 pin numbers whereas MS1 and MS2 are soil moisture sensor that are connected to the pin number D8 and D9.

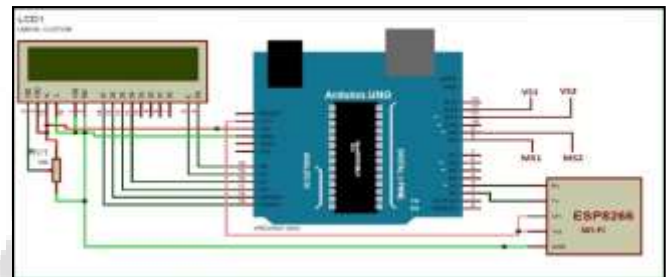


Fig. 7: Circuit for Landslide Detection System

B. The Process:

When system starts in the primary stage, the sensors get activated and Wi-Fi module helps the arduino and sensors to connect with the ISP. After connecting to the internet the on board sensors starts collecting the real time data and send it to the cloud storage ThingSpeak. ThingSpeak by Mathworks uses MATLAB as a powerful tool for analyzing and display the data in the form of graphs as well. The real time data can be seen by accessing ThingSpeak page Desktop or Smartphones. ThingSpeak can commute with the third party as well for sending alerts when threshold values reaches.

Some defined parameters are provided to act as a threshold values. When these threshold values reaches the alert is send in the form of SMS to the end user and display on the screen as well. These thresholds value are given in the Table 2.

Sensors	Value	Threshold Value	Result
Vibration sensor 'A'	0- 10,000 Hz	Value > 20 Hz	Alert is sent
Soil Moisture sensor 'A'	0% - 100%	Value > 35%	Alert is sent
Vibration sensor 'B'	0 - 10,000 Hz	Value > 20 Hz	Alert is sent

Soil Moisture sensor 'B'	0% - 100%	Value > 35%	Alert is sent
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Table 2. Different threshold values.

Steps involved in the process:

- 1) In the first step when the system is ON and threshold values are set.
- 2) The sensors start collecting data and monitored according to threshold values.
- 3) The collected data results are compared with the threshold values and the outcomes are accordingly.
- 4) If the output of the sensor is greater than the threshold value the conditions follow true and the alert is sent via SMS to the registered mobile number of the end user and also it is displayed on the LCD screen. IFTTT execution service is used for sending the SMS. The targeted phone uses IFTTT android app whose SIM number is registered. This IFTTT is used as a third party with the ThingSpeak servers.

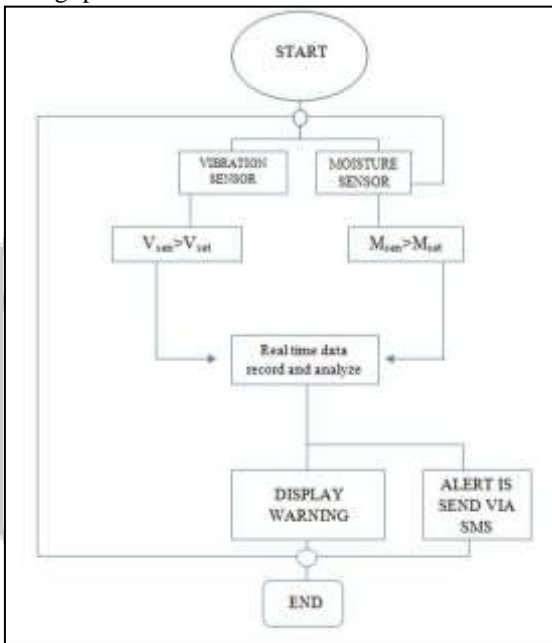


Fig. 8: Flowchart of the System

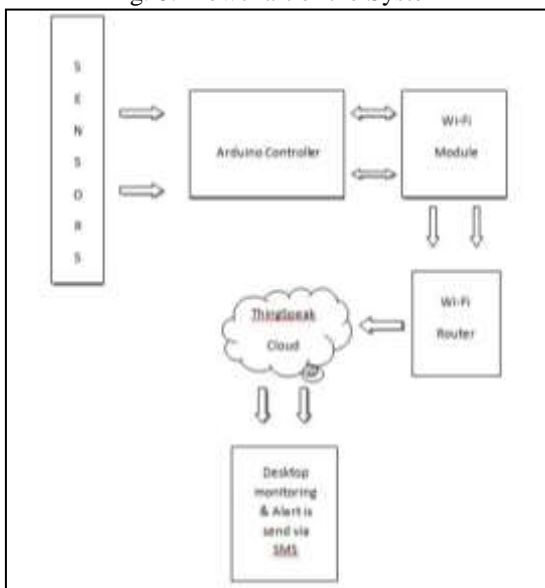


Fig. 9: Block diagram of the system

## VI. TESTING AND RESULTS

In testing phase, we took two sites name A and B for detecting the landslide. Moisture sensors as well as vibration sensors connected to the site. These sensors are connected to the arduino development board which is connected to the ThinkSpeak cloud service for monitoring the real time data. These sensors are adjusted to the programmed threshold values with the potentiometer available on the sensor boards. After turning ON the system the sensors on board Wif-Fi module get connected to the Wi-Fi router. After that the sensors get connected to the ThingSpeak cloud service for IoT based projects. ThingSpeak provides a powerful graphic tools that help you to analyze data and can also comute with the third party app from where it can send alerts to the end user. These alerts are sent in the form of SMS to the registered mobile number on the end user mobile phone. IFTTT execution service is used for sending the SMS. The targeted phone uses IFTTT android app whose SIM number is registered. This IFTTT is used as a third party with the ThingSpeak servers. The test shows that the system, is working properly and is able to detect the earthquake vibrations as well as moistures present in the soil and can act according to the threshold values. The observed values can be seen in the Figures 10,11,12,13. At the end SMS is send to the end user as shown in Figure 14.

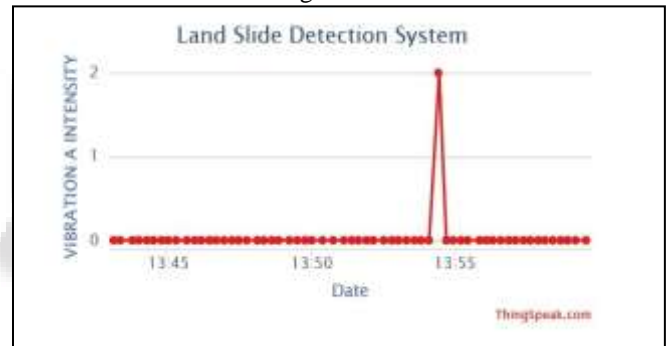


Fig. 10: Vibration observed at A site

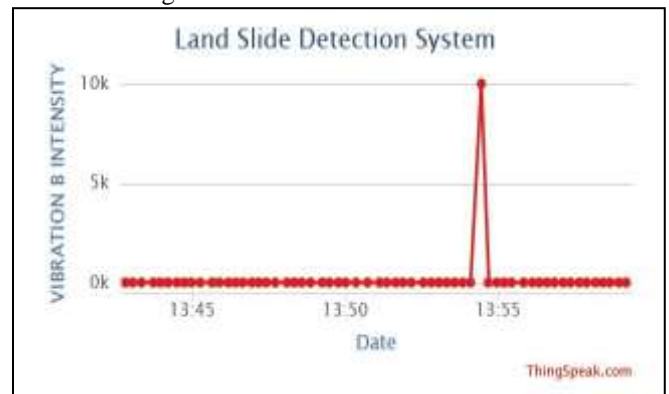


Fig. 11: Vibration observed at B site

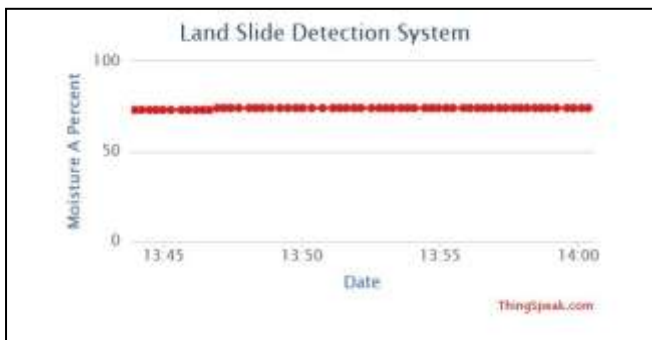


Fig. 12: Moisture observed at A site

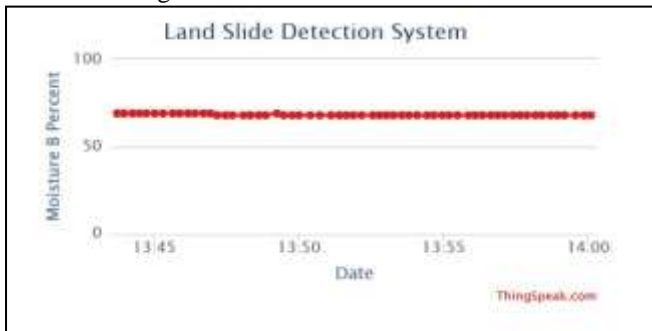


Fig. 13: Moisture observed at B site

## VII. CONCLUSION

The monitoring and detection of landslide is possible using this prototype. This is a low cost and effective Landslide system for early warning of the landslide and real time monitoring of the data. In order to assign the parameters for landslide the threshold values are set for both vibration and moisture sensor. It is found that when threshold values exceeded the system is capable of sending the alert to the end user. This prototype can be use for large area as well by increasing the number of sensors to the arduino. Early warning system for landslides can save human lives and property.

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