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EARLY LANDSLIDE DETECTION USING 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. 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, Temperature Sensors, Humidity Sensors, Tilt Sensors, Rain Gauge 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 also known as landslip, occurs at downslope. Landslides are the mostly common geological hazards during rainy seasons, which leads to death and destruction of property. The movements of rock mass or soil under the gravity are caused due to both natural and human activities. Increase in the hydrostatic pressure, by saturation of rainwater, melting of snow, increase in ground water level, increase of pore water pressure, volcanic eruptions and earthquakes are natural causes of the landslides or land slip. Human activities include the deforestation, cultivation, machinery vibration, blasting mining etc., Rock avalanches, debris flows, soil movement, mud flows are the various forms of landslide. Landslides occur in rocky mountainous regions like Himalayas, Konkan railways, lonavala ghats, marshy regions of Kerala and the areas like Somawarpet, Suntikoppa, Mukkodlu, Madapur, Karangi, Siddapur of Karnataka in India. Landslides are hazards all over the world. Hill slides with steep slopes are prone to landslides.

It is a real-time truth that we can't predict a landslide and stop it. But we could take necessary precautions before the occurrence by giving alert to the nearby localities and concerned authorities to take preventive measures. Landslides can completely destroy agricultural/forest lands, road transports, destroys earth's natural environment as a whole causing great loss to life. It also causes property damage, injury and death. Also, it adversely aspects a variety of resources such as water supplies, fisheries, sewage disposal systems, dams and roadways for years after a slide event. Hence, prior detection of landslide becomes a huge necessity so that prior alert can alarm the people which can reduce or prevent various damages to loss and property.

I. LITERATURE SURVEY

Many researchers have worked on the landslide detection system based on Internet of Things using development boards like Arduino 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, stain gauges and tiltmeters connected via the wireless system network. Their main aim was to detect the landslides that are

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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 Biansoongnerna, Boonyang Plungkanga , Sriwichai Susukb of aDepartment of Electrical Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi, Thailand and bThailand 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 el., 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 Kanchan1 , Juhi Naushin Shaikh2 , Hiba Shakeel3 , Mansi Nachankar4 , Prof. Sonali K. Suryawanshi5 of Computer Department, Rizvi College of Engineering, Mumbai, Maharashtra, India1 , 2,3,4 Assistant Professor, Computer Department, Rizvi College of Engineering, Mumbai, Maharashtra, India5 in their paper "Landslide Detection" published in International Journal of Advanced Research in Computer and Communication Engineering(et el.,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 el., 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 el.,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 el.,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

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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 el.,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.

I. 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. There are defined parameters for the threshold values based on the Vibration, Tilt 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.

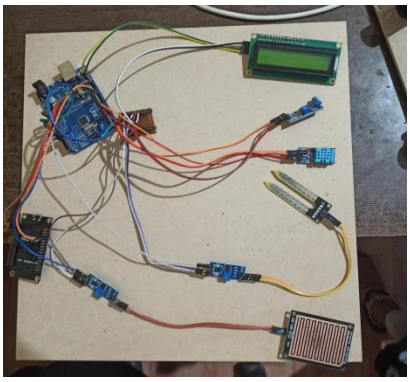

Fig. 1: IOT based landslide detection system.

II. COMPONENTS USED

1. **ARDUINO UNO:**

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 microcontroler which is programmed with the help of the Arduino programming language or with the Arduino software IDE.

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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

Fig.2 : Arduino Uno

2. **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

3. **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.

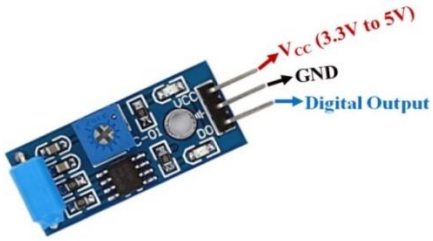

Fig.4 : Vibration Sensor

4. **LCD Display**:

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

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Fig.5 : LCD Display

5. **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).

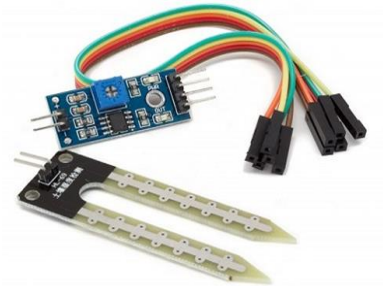

Fig.6 : Soil Moisture Sensor

6. **Rain Sensor:**

The rain sensor module includes a sensing pad which includes two series copper tracks coated with nickel. This pad includes two header pins which are connected internally to the copper tracks of the pad. The main function of these two header pins is for connecting the Sensing Pad with the rain sensor module with the help of two jumper wires. Here, the rain sensor module's one pin provides a +5v power supply toward the one path of the sensing pad, whereas the other pin gets the return power from another path of the pad.

Fig.7 : Rain Sensor

7. **Temperature sensor:**

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process this changed resistance values and change them into digital form.

For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers.

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Fig.8 : Temperature Sensor

8. **GSM Module:**

A customized Global System for Mobile communication (GSM) module is designed for wireless radiation monitoring through Short Messaging Service (SMS). This module is able to receive serial data from radiation monitoring devices such as survey meter or area monitor and transmit the data as text SMS to a host server.The UART interface consists of two pins: the Rx and Tx pin. The Rx pin is used to receive data. The Tx pin is used to transmit data. When two devices are connected using a UART, the Rx pin of one device is connected to the Tx pin of the second device.

Fig.9 : GSM Module

III. DEVELOPMENT OF LANDSLIDE DETECTION SYSTEM

a. Block Diagram :

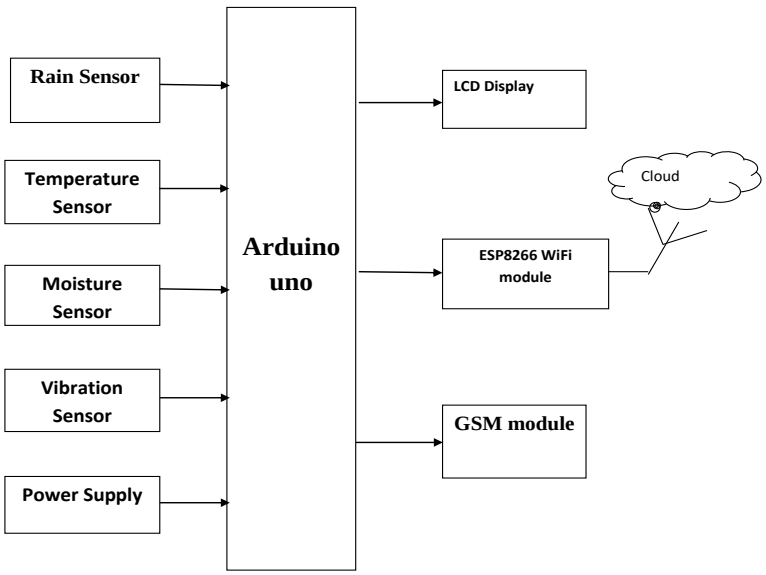

Fig. 10 : Block Diagram

The "Early Landslide Detection Using IoT" system likely includes a block diagram or system architecture that illustrates the various components and their interactions within the system. This diagram would visually represent the

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hardware and software elements, such as Arduino Uno, power supply, GSM module, WiFi module, vibration sensor, temperature sensor, and LCD display, and how they are interconnected to achieve the functionality of collecting real-time data from landslide-prone areas, analyzing the data, and sending alerts to authorities and individuals. The block diagram would provide a high-level overview of the system's architecture, showing the flow of data and control between the different components.

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 .

Sensors	Value	Threshold Value	Result
Vibration sensor	0 or 1	Value = 0	Alert is sent
Soil Moisture sensor	0% - 100%	Value > 80%	Alert is sent
Tilt sensor	0 or 1	Value = 0	Alert is sent

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 mobie number of the end user and also it is displayed on the LCD screen.

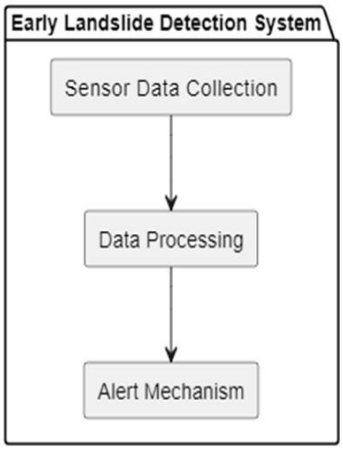

Figure 11.1 : Level 1

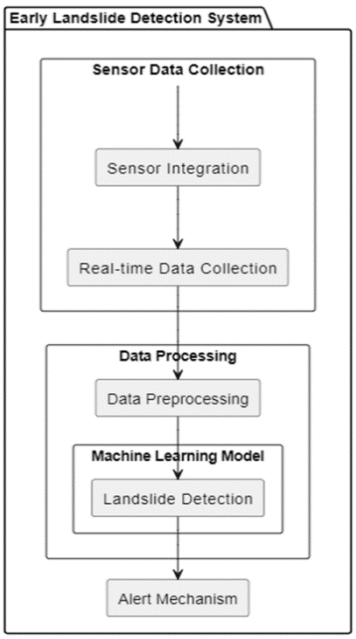

Figure 21.2 : Level 2

Fig.11 : Flow Chart of the system

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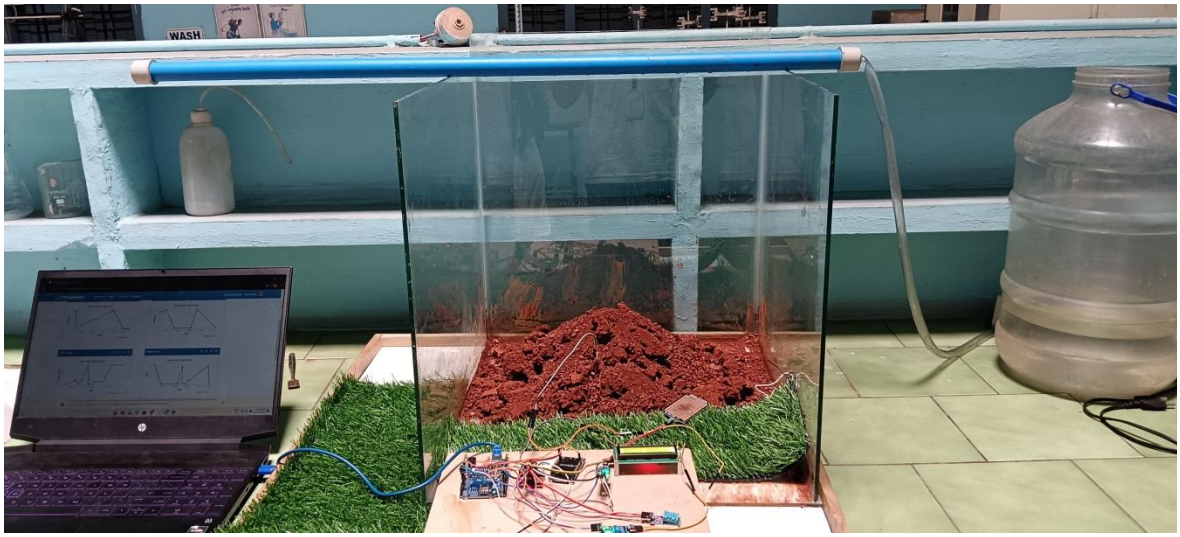
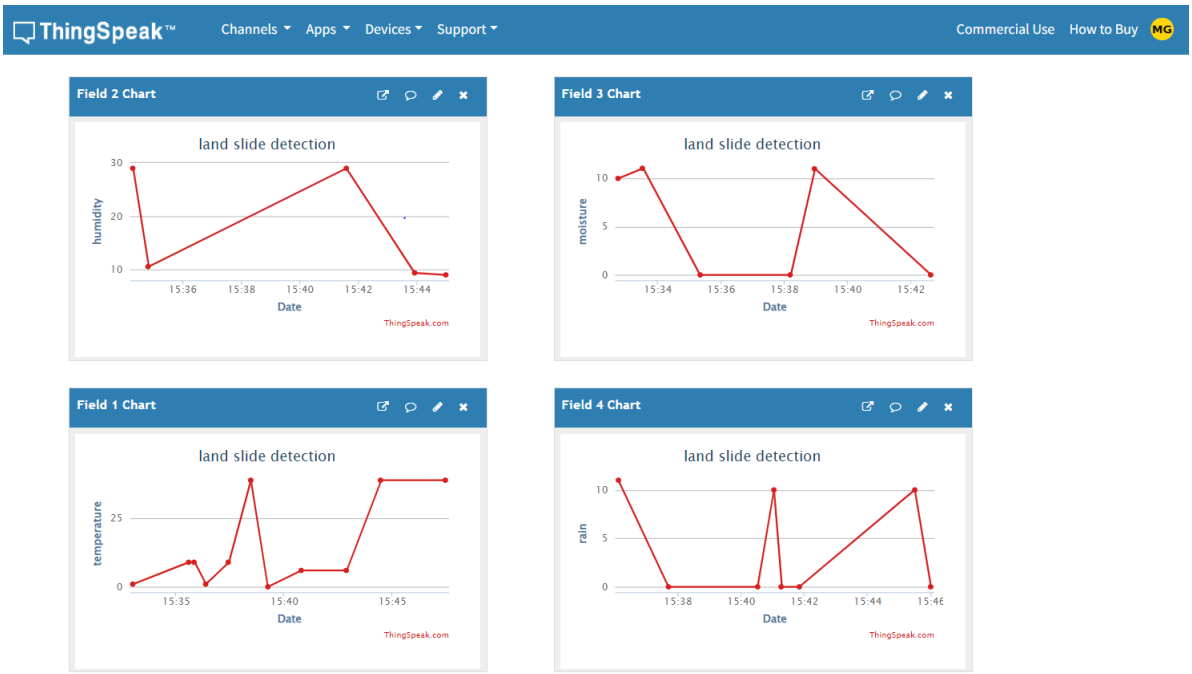
IV. TESTING AND RESULTS

Moisture sensors, Tilt 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 Wi-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. 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.





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V. CONCLUSION

Real time monitoring of landslides is one of the challenging research areas available nowadays within the field of geophysical research. The event of an actual field deployment of a wireless device network primarily based landslide detection system. This system uses wireless sensor nodes, MQTT protocol for efficient delivery of real time data to the system for monitoring and provide warning and risk assessments to the inhabitants of the area. This network will be used for understanding the capability and usability of wireless sensor network for critical and emergency application.

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