LANDSLIDE MONITORING SYSTEM

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

Landslide is a natural disaster and it occurs due to natural or manmade activities. It is defined as the movement of a mass of rock, debris or wide range of ground movement. The aim of the proposed system is to detect the occurrence of landslide in advance and to monitor using RF module. The seriousness and effect of disasters are gradually increasing both in terms of magnitude and frequency because of deforestation. It is causing extensive loss of human life and property which sternly affects the development in mountain areas. Thus, landslide disaster mitigation is one of the priorities of India. To reduce the risk due to such disasters, a low-cost, energy efficient and most reliable "Landslide Monitoring System" is proposed in this project. This project consists of a landslide detection unit (LDU), data acquisition and analysis unit to track the feasibility of mudslide/landslip during rainy seasons.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

In India, the Himalayas are prone to landslides, particularly n monsoon season, from months of June to October. Various types of landslides occur in Himalayas, including block slumping, debris flow, debris slide, rock fall, rotational slip and slump. A landslide is the gravitational movement of a mass of rock, or mass of earth or debris, downwards on a slope. It generally occurs when a hilly slope becomes unstable due to natural reasons such as groundwater pressure acting to destabilize the slope, volcanic eruptions, earthquakes, erosion, etc.

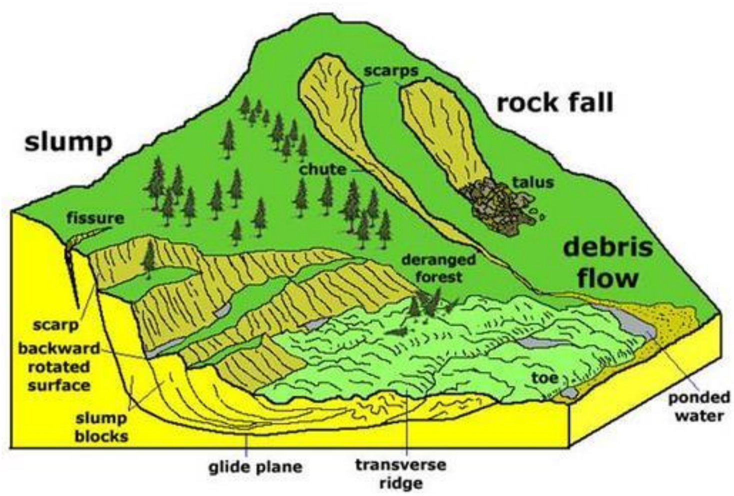


Fig 1. Flow of debris

1.2 Effects of Landslides in India:

Generally, Landslides are triggered by heavy or prolonged rainfall. Landslides cause severe damage to lives and property while also causing disruption in communication networks and movement of traffic.

- Every year, landslides in the Himalayan region kill people and cause damage to several villages leaving them unfit for habitation.
- Landslides create blockades in the road network and also in river system, which causes flood.
- The terraced farm fields that are destroyed by landslides, cannot be easily recovered or made productive again.
- Affected by landslides, the road network remains closed for long periods, hence, causing huge hardships to people inhabiting and dependent on the area for their basic supplies and provisions.
- Landslides disrupt water sources and chocked them by debris fall.
- Due to landslides, the river sediment load is increased considerably, which results in irregular courses of river and frequent breaching of banks also resulting in unexpected floods.
- The water channels are also affected due to disruption in previous channels, this leads to disturbance in water supply to dependent villagers for irrigation purposes. This then adversely affects agriculture production in the affected region.

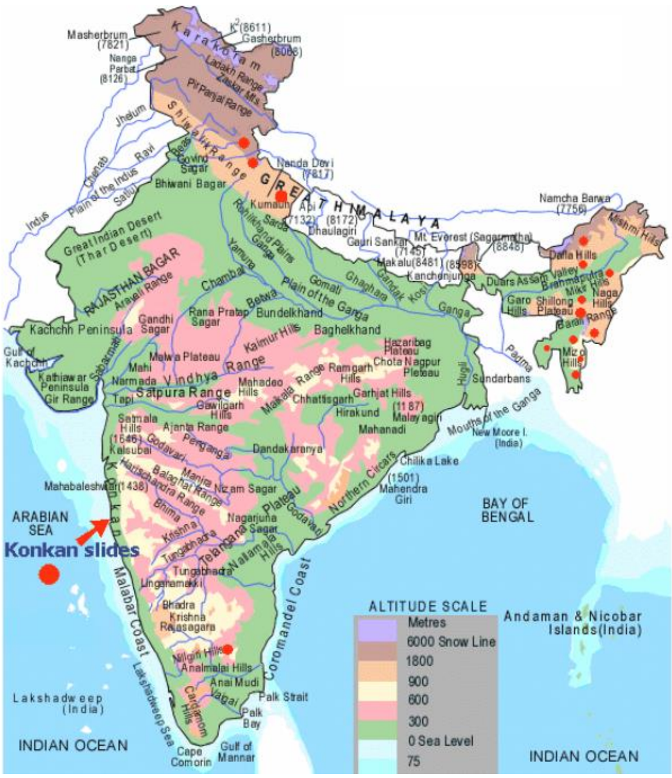


Fig 2. Landslide zones

1.3 Existing System:

The existing system has modules of Zigbee for remote correspondence and three sensors (Soil moisture sensor, Humidity sensor and Accelerometer sensor) for information retrieval. The information and monitoring unit which collects the different sensor values that is combined to a frame which is controlled by ARM7 controller. Sensing nodes are planted at linear slopes for detecting ground motion since most debris are triggered by intense rainfall or rapid snowmelt. Measured readings are sent to the base station through wireless using Zigbee that transfers all data which is further observed on terminal. It may be difficult to determine whether the slope is stable or not solely using these data because slope stability depends on soil type and soil condition.

1.4 Proposed System:

The proposed system has several specially designed Landslide Detection Unit (LDU) which consist of flex sensor enclosed in flexible pipes that measures the debris flow and transmits the data via an RF transceiver to the centralized controller. To make this design reliable, several LDUs are installed by drilling hole in different regions of the slope where landslide probably occur. This project employs microcontrollers, Rain drop sensor, DHT 11 sensor and LDUs. The data from several LDUs and the sensors, connected to the central unit are being processed. In normal condition, the data collected along with the decision will get transmitted to the centralized controller less periodically. In rainy season, the condition is watched closely by accessing the sensors data more frequently and send an alert using buzzer. Real time monitoring of the condition during rainy season can possibly prevent the huge loss that is happening during landslip.

CHAPTER 2

LITERATURE SURVEY

2.1 Landslide:

A landslide is a downward movement of rock, earth or debris. Landslides are caused by rain, earthquake, volcanic eruption, soil erosion or other human activities like mining, deforestation that makes the slope unstable.

Scientists who deals with the physical formations of the Earth, describes landslides are one of the mass wasting. A mass wasting is downward movement in which the Earth's surface is worn away.

2.2 Causes for Landslides:

Landslides occurs due to three major reasons:

- Geology
- Morphology
- Human activity

2.3 Geology:

It refers to the characteristics of the material itself. The earth or rock might be weak or fractured since different layers may have different strengths and stiffness.

Slopes that lose their vegetation to fire and drought are more vulnerable to landslides. Vegetation holds soil in place and without the root system of trees and bushes, the land is more likely to slide away.

2.4 Morphology:

A classic morphological cause of landslides is erosion or weakening of earth due to water.

2.5 Human Activity:

Human activity such as improper agriculture and construction can increase the risk of a landslide. Irrigation, deforestation, excavation, and floods are some of the common activities that can help destabilize and weaken the slope.

Another factor that might be important for describing landslides is the speed of the movement of the fall. Some landslides slips many meters per second, while others creep slowly. Some landslides include toxic gases from deep in the Earth expelled by volcanoes whereas other landslides called mudslides, contain a high amount of water and slides very quickly. Complex landslides consist of a combination of different material.

Fig 3. Hill landslide

2.6 Types of Landslides:

Landslides are classified according to the particular method of slope failure, which is grouped into characteristic failure types.

There are different types of movement associated with a particular landslide. These movements can be

- Fall
- Topple
- Slide
- Spread or flow.

2.6.1 Fall Landslides:

These are the decoupling of soil and rock from a steep slope surface where there is minimal shear displacement of the material fall. They also occur on vertical slopes. Other than undercutting by water bodies, fall landslides can occur due to weathering, disturbances due to natural events like earthquakes and by human activities such as excavations and building constructions.

Mitigation measures for fall landslides can include installing protective covers such as metal meshes over the sensitive zone, blasting with explosives of hazardous zones and the removal of materials from anchoring of cliffs with rock bolts or scaling.

2.6.2 Topple Landslides:

These usually occur in volcanic terrain or at banks of water bodies that are steep. In this form of landslide, a mass of soil or rock rotates outwards from a slope such that the mass does not fall directly downward, where the axis is situated at less than the center of gravity of mass, triggered by water flowing through cracks in the mass. Topple landslides can also be caused by gravitational forces acting through objects above the mass, undercutting, vibration, differential weathering, erosion and human excavations.

Mitigation efforts should focus on checking the stability for such masses, and look for contributory factors such as seepage and drainage networks. Mechanical methods of securing these masses such as rock bolts and metal meshes can be useful.

2.6.3 Slide Landslides:

These types of landslides occur due to rupture over thin sheets with characteristically intense shear strain. This form of landslide gathers material as it ruptures from the point of origin. Slide landslides are usually caused due to the action of water through intense rainfall or snowfall, excess groundwater at the base of the slopes. Another trigger for this form of landslide can be earthquakes.

Mitigating this form of landslide is extremely difficult as it is difficult to predict exactly where such a rupture could take place. Measures such as construction of retaining walls can be taken in areas with an expectation of risk, analysing large swathes of area for detecting risks and predicting the exact point of rupture is a very difficult task.

2.6.4 Translational Landslides:

A translational or planar landslide is a down slope movement of material that occurs along a distinctive planar surface of weakness such as a fault, joint or bedding plane. Some of the largest and most damaging landslides on earth are translational. These landslides occur at all scales and are not self-stabilizing. They can be very rapid where discontinuities are steep, provided that there are no barriers and the plane is sufficiently inclined, the mass in this form of landslides can travel a considerable distance. The trigger mechanisms are similar to slide landslides as due to action of water or vibrations by earthquakes.

Mitigation efforts are similarly difficult as for slide landslides, although managing drainage problem areas could help mitigation efforts to a great extent.

2.6.5 Spread Landslides:

They occur due to the subsidence of cohesive soil or rock masses into softer less cohesive or vacant areas and masses. Its triggers include **liquefaction**, gravitational forces due to exerted weight above changes in the underlying layer that cause them to subside or dissipate and liquefaction of underlying layer.

Its mitigation efforts are focused on mapping liquefaction in soil and in underground levels below the surface soil.

2.6.6 Flow Landslides:

These are the flowing motion of masses of soil and rock in manner similar to the flow of liquids frequently due to the presence of high amounts of liquids in the mass. These landslides are triggered by intense surface water flows and can also be by-products of previous landslides. These landslides due to their sudden nature, are extremely unpredictable, except in places of likely or frequent occurrence where canals and basins can be built to mitigate the event of a flow landslide. Volcanic lava flows can also be categorized as a form of flow landslide.

S.NO	PLACE	TIME	VOLUME	COMMENTS	CASUALTIES
1.	Amboori, Kerala, India	9 Nov 2001		Supposedly worst landslide in Kerala state's history	40
2.	La Conchita, California, United States	10 Jan 2005	200,000 m^3	Remobilization of colluvium from 1995 slide into a debris flow	10
3.	Siaolin Village, Kaohsiung, Taiwan	9 Aug 2009	30–45 MCM	Resulted from Typhoon Morakot	600
4.	Hpakant, Myanmar	21 Nov 2015		A 60-metre (197 ft) man-made heap of waste soil mined out of a nearby jade mine collapsed, burying about 70 huts in a nearby village	113
5.	Pettimudi, Rajamalai, MunnarIdukki Kerala India	7 Aug 2020		Heavy rainfall in parts of Kerala, torrential rains pounded Idukki district, resulting in a major landslide	66

Table 1. History of landslides

2.7 Technologies for Landslide Mitigation:

There are a wide range of technologies available for landslide mitigation. These include equipment's for emergency response,

- Geological reconnaissance of landslide-prone areas,
- Local monitoring services,
- Site investigation with borings and test pits,
- Slope stability analyses,
- Seismic analysis of slopes,
- Technical assistance in construction of buildings, roads, pipes, etc,
- Design assistance for drainage systems, and erosion modelling.

Indian National Disaster Management Agency (NDMA) has a focus on site-specific landslide mitigation that involves making geological investigations on selected sites. Its approach is based on co-operation with various government agencies such as the Geological Survey of India to designate certain areas as landslide-prone areas. India has not yet witnessed a comprehensive hands-on technological approach to landslide mitigation. However, technology for this is available and the problem is a matter of managing costs with the possibility of a high failure rate. On the other side however, a few timely evacuations might open a new vista for the NDMA in terms of disaster preparedness.

CHAPTER 3

HARDWARES USED

3.1 Arduino Uno R3:

The Arduino Uno R3 is one kind of ATmega328P based microcontroller board. It includes the whole thing required to hold up the microcontroller; just attach it to a PC with the help of a USB cable, and give the supply using AC-DC adapter or a battery to get started. The term Uno means “one” in the language of “Italian” and was selected for marking the release of Arduino’s IDE 1.0 software. The R3 Arduino Uno is the 3rd as well as most recent modification of the Arduino Uno. Arduino board and IDE software are the reference versions of Arduino and currently progressed to new releases. The Uno-board is the primary in a sequence of USB-Arduino boards, & the reference model designed for the Arduino platform.

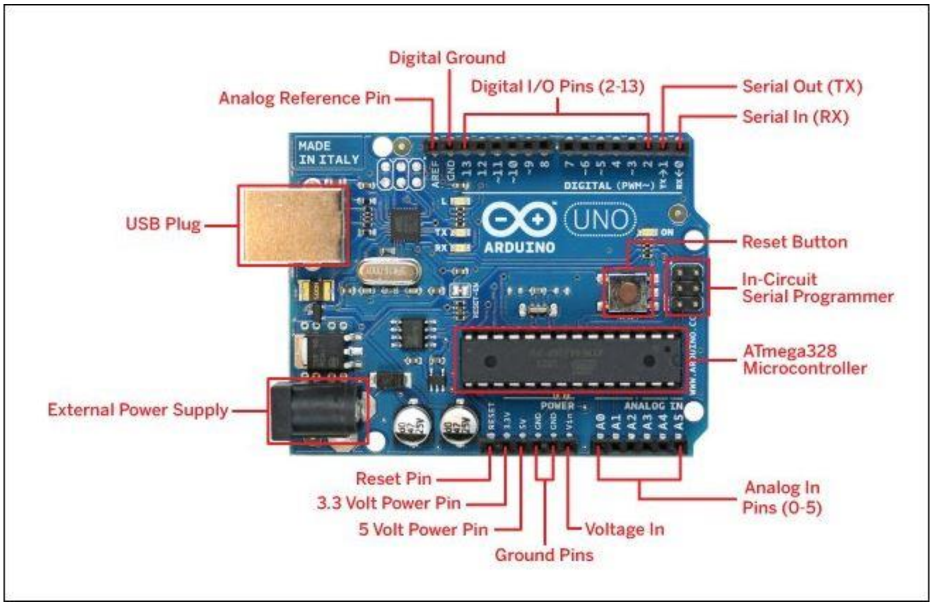


Fig 4. Arduino uno

The **Arduino Uno R3 board** includes the following specifications.

- It is an ATmega328P based Microcontroller
- The Operating Voltage of the Arduino is 5V
- The recommended input voltage ranges from 7V to 12V
- The i/p voltage (limit) is 6V to 20V
- Digital input and output pins-14
- Digital input & output pins (PWM)-6
- Analog i/p pins are 6
- DC Current for each I/O Pin is 20 mA
- DC Current used for 3.3V Pin is 50 mA
- Flash Memory -32 KB, and 0.5 KB memory is used by the boot loader
- SRAM is 2 KB
- EEPROM is 1 KB
- The speed of the CLK is 16 MHz
- In Built LED
- Length and width of the Arduino are 68.6 mm X 53.4 mm
- The weight of the Arduino board is 25 g

3.1.1 Power of Arduino Uno:

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm centre-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and VIN pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

VIN: The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 – 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3V3: A 3.3volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND: Ground pins.

3.1.2 Memory of Arduino Uno:

The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library). Input and Output each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode (), digital Write (), and digital Read () functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX): Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 2 and 3: These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

PWM: 3, 5, 6, 9, 10, and 11: Provide 8-bit PWM output with the analog Write () function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK): These pins support SPI communication using the SPI library.

LED: 13: There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it’s off. The Uno has 6 analog inputs, labelled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference () function. Additionally, some pins have specialized functionality:

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library. There are a couple of other pins on the board:

AREF: Reference voltage for the analog inputs. Used with analog Reference ().

Reset: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board. See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

3.1.3 Communication of Arduino Uno:

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The ’16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .in file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno’s digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus. For SPI communication, use the SPI library.

3.1.4 Arduino Uno Pin Description:

Pin Category	**Pin Name**	**Details**
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external power source. 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: ground pins.
Reset	Reset	Resets the microcontroller.
Analog Pins	A0 – A5	Used to provide analog input in the range of 0-5V
Input/output Pins	Digital Pins 0 – 13	Can be used as input or output pins.
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt.
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.
AREF	AREF	To provide a reference voltage for input voltage.

Table 2. Arduino uno pin configuration

3.2 Transceiver (NRF24L01) Module:

The nRF24L01 is a wireless transceiver module, meaning each module can both send as well as receive data. They operate in the frequency of 2.4GHz, which falls under the ISM band and hence it is legal to use in almost all countries for engineering applications. The modules when operated efficiently can cover a distance of 100 meters (200 feet) which makes it a great choice for all wireless remote-controlled projects.

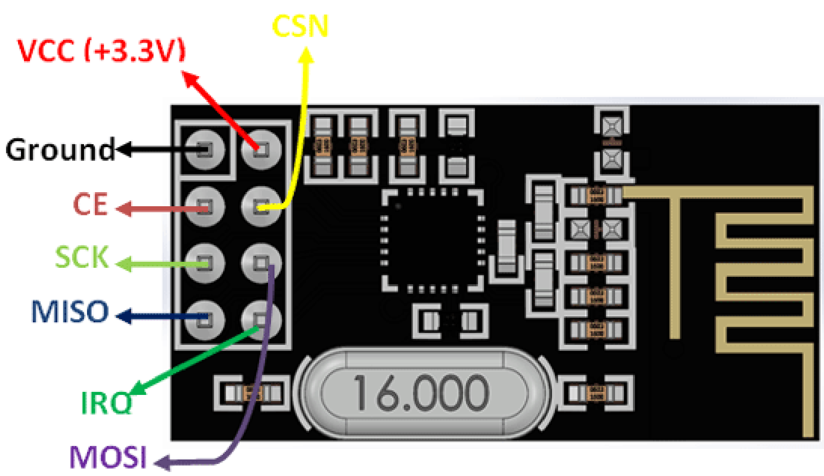


Fig 5. NRF24L01 module

The module operates at 3.3V hence can be easily used with 3.2V systems or 5V systems. Each module has an address range of 125 and each module can communicate with 6 other modules hence it is possible to have multiple wireless units communicating with each other in a particular area. Hence mesh networks or other types of networks are possible using this module.

3.2.1 NRF24L01 Features:

- 2.4GHz RF transceiver Module
- Operating Voltage: 3.3V
- Nominal current: 50mA
- Range: 50 – 200 feet
- Operating current: 250mA (maximum)
- Communication Protocol: SPI
- Baud Rate: 250 kbps - 2 Mbps.
- Channel Range: 125
- Maximum Pipelines/node: 6

3.2.2 NRF24L01 Pin Configuration:

Pin Number	Pin Name	Abbreviation	Function
1	Ground	Ground	Connected to the Ground of the system
2	Vcc	Power	Powers the module using 3.3V
3	CE	Chip Enable	Used to enable SPI communication
4	CSN	Ship Select Not	This pin has to be kept high always, else it will disable the SPI
5	SCK	Serial Clock	Provides the clock pulse using which the SPI communication works

6	MOSI	Master Out Slave In	Connected to MOSI pin of MCU, for the module to receive data from the MCU
7	MISO	Master In Slave Out	Connected to MISO pin of MCU, for the module to send data from the MCU
8	IRQ	Interrupt	It is an active low pin and is used only if interrupt is required

Table 3. NRF24L01 pin configuration

3.2.3 Interfacing with Arduino:

The **NRF24L01 module** works with the help of **SPI communications**. These modules can either be used with a 3.3V microcontroller or a 5V microcontroller but it should have an SPI port. The circuit diagram shows how the module should be interfaced with a microcontroller.

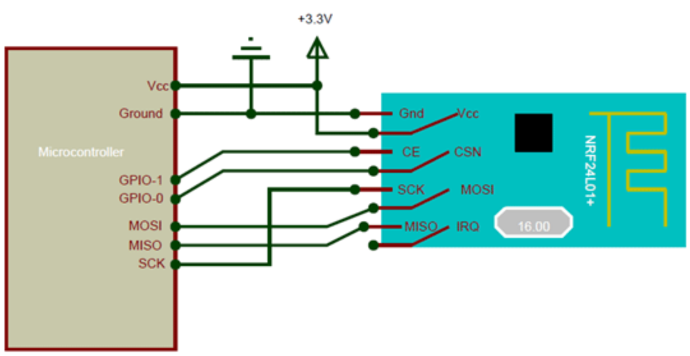


Fig 6. Interfacing NRF24L01 with microcontroller

3.3 Raindrop Sensor:

Raindrop Sensor is a tool used for sensing rain. It consists of two modules, a **rain board** that detects the rain and a **control module**, which compares the analog value, and converts it to a digital value. The raindrop sensors can be used in the automobile sector to control the windshield wipers automatically, in the agriculture sector to sense rain and it is also used in home automation systems.

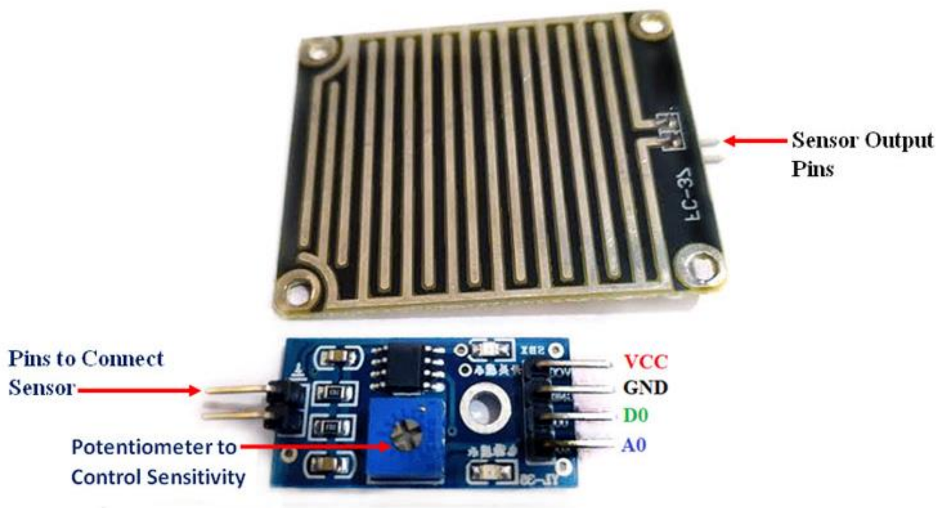


Fig 7. Rain drop sensor

3.3.1 Raindrop Sensor Features:

- Working voltage 5V
- Output format: Digital switching output (0 and 1), and analog voltage output AO
- Potentiometer adjust the sensitivity
- Uses a wide voltage LM393 comparator
- Comparator output signal clean waveform is good, driving ability, over 15mA

- Anti-oxidation, anti-conductivity, with long use time
- With bolt holes for easy installation
- Small board PCB size: 3.2cm x 1.4cm

3.3.2 Pin Configuration of Rain Sensor:

S.No.	Name	Function
1	VCC	Connects supply voltage- 5V
2	GND	Connected to ground
3	D0	Digital pin to get digital output
4	A0	Analog pin to get analog output

Table 4. Rain drop sensor pin configuration

3.4 16x2 LCD Module:

LCD modules are very commonly used in most embedded projects, the reason being its cheap price, availability and programmer friendly. Most of us would have come across these displays in our day-to-day life, either at PCO’s or calculators.

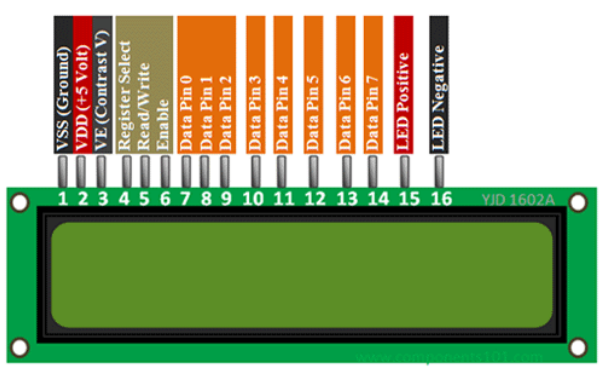


Fig 8. 16×2 LCD

16×2 LCD is named so because it has 16 Columns and 2 Rows. There are a lot of combinations available like, 8×1, 8×2, 10×2, 16×1, etc. but the most used one is the 16×2 LCD. So, it will have (16×2=32) 32 characters in total and each character will be made of 5×8 Pixel Dots.

Further, the LCD should also be instructed about the Position of the Pixels. Hence it will be a hectic task to handle everything with the help of MCU, hence an **Interface IC like HD44780**is used, which is mounted on the backside of the LCD Module itself. The function of this IC is to get the **Commands and Data** from the MCU and process them to display meaningful information onto our LCD Screen.

3.4.1 Features of 16x2 LCD module:

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is built by a 5×8 pixel box.
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters
- Available in Green and Blue Backlight.

3.5 DHT11 Sensor:

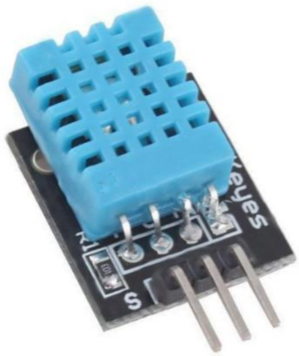


Fig 9. DHT11 Sensor

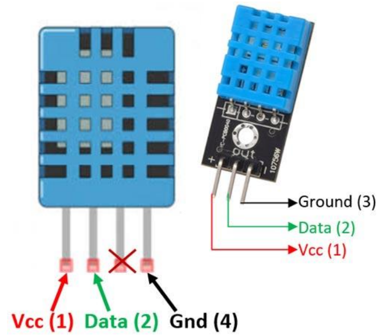


Fig 10. DHT11 Sensor Pinout

DHT11 is a digital temperature and humidity sensor. It is a low-cost digital sensor for sensing temperature and humidity. This sensor can be easily interfaced with any micro-controller such as Arduino, Raspberry Pi etc… to measure humidity and temperature instantaneously. DHT11 humidity and temperature sensor is available as a sensor and as a module. The difference between this sensor and module is the pull-up resistor and a power-on LED. DHT11 is a relative humidity sensor. To measure the surrounding air this sensor uses a thermistor and a capacitive humidity sensor.

3.5.1 DHT11 Specifications:

- ✓ Operating Voltage: 3.5V to 5.5V
- ✓ Operating current: 0.3mA (measuring) 60uA (standby)
- ✓ Output: Serial data
- ✓ Temperature Range: 0°C to 50°C

- ✓ Humidity Range: 20% to 90%
- ✓ Resolution: Temperature and Humidity both are 16-bit
- ✓ Accuracy: ±1°C and ±1%

No:	**Pin Name**	**Description**
For DHT11 Sensor		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	NC	No Connection and hence not used
4	Ground	Connected to the ground of the circuit

Table 5. DHT11 pin configuration

3.6 Buzzer:

A **Buzzer** is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure hence can be easily used on breadboard, Perf Board and even on PCBs which makes this a widely used component in most electronic applications.

Fig 11. Buzzer

This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V. A simple 9V battery can also be used, but it is recommended to use a regulated +5V or +6V DC supply. The buzzer is normally associated with a switching circuit to turn ON or turn OFF the buzzer at required time and require interval.

3.6.1 Buzzer Pin Configuration:

Pin Number	Pin Name	Description
1	Positive	Identified by (+) symbol or longer terminal lead. Can be powered by 6V DC
2	Negative	Identified by short terminal lead. Typically connected to the ground of the circuit

Table 6. Buzzer pin configuration

3.6.2 Buzzer Features and Specifications:

- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA

- Sound Type: Continuous Beep
- Resonant Frequency: ~2300 Hz
- Small and neat sealed package
- Breadboard and Perf board friendly

3.7 LANDSLIDE DETECTION UNIT(LDU):

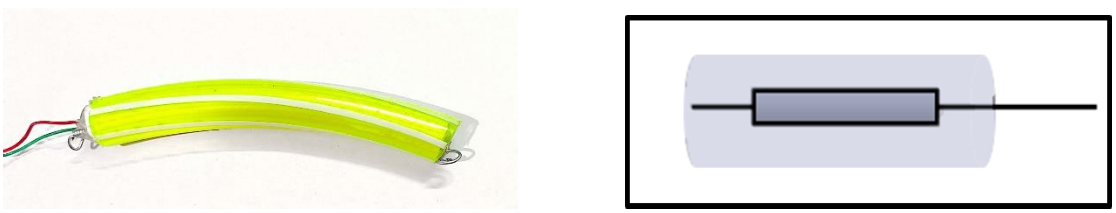


Fig 12. Landslide Detection Unit (LDU)

Landslide detection unit has been constructed with help of Flex sensor. A flex sensor has been mounted on a spring like string which has been held inside a flexible pipe. The flex sensor is connected to the Arduino which processes and transmits the data i.e., the bend angle, voltage and the resistance through radio frequencies.

When the flex sensor is bent, the resistance of the flux sensor changes, it may increase or decrease according to the bend angle. When the bend is higher, the resistance will be high and the voltage through it will be low.

This sensor connected with Arduino transmits the bend angle, voltage, and resistance to the receiver through radio frequencies. Since the setup was made inside a flexible pipe it has been used to detect the change in slope when LDU is buried inside a slope of land.

CHAPTER 4

SYSTEM ARCHITECTURE

4.1 Block Diagram:

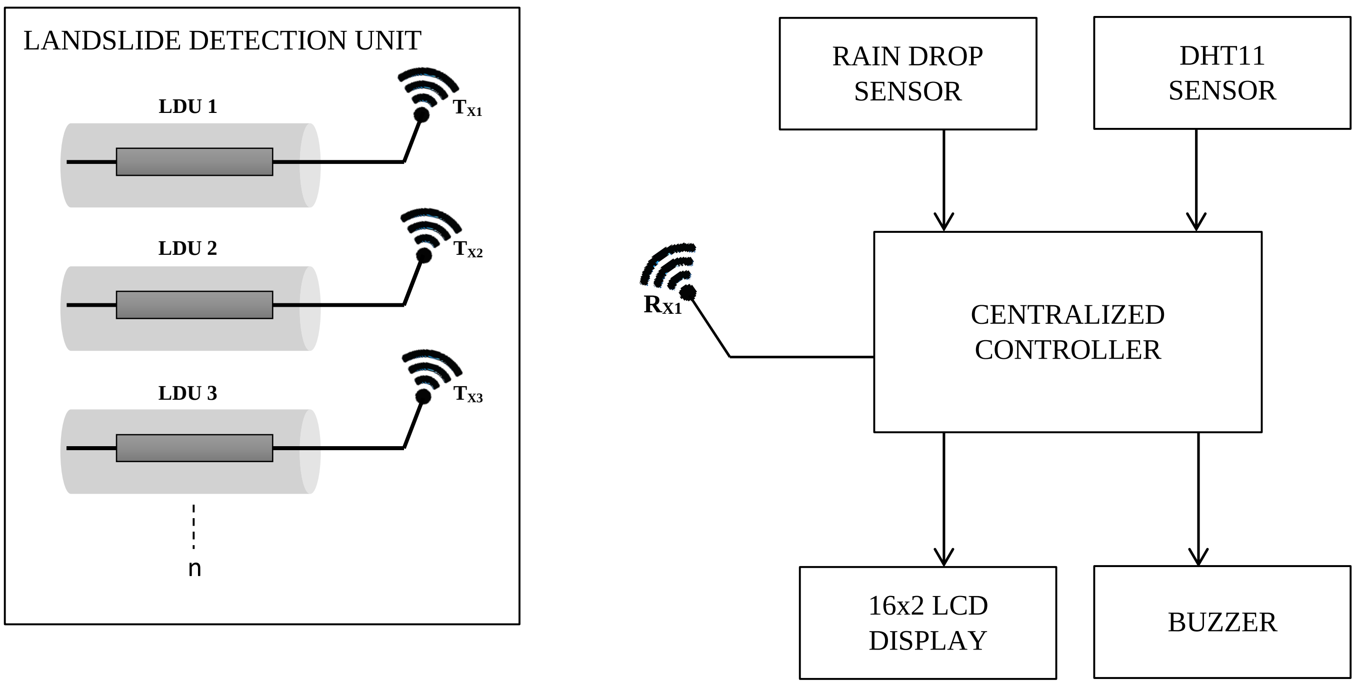
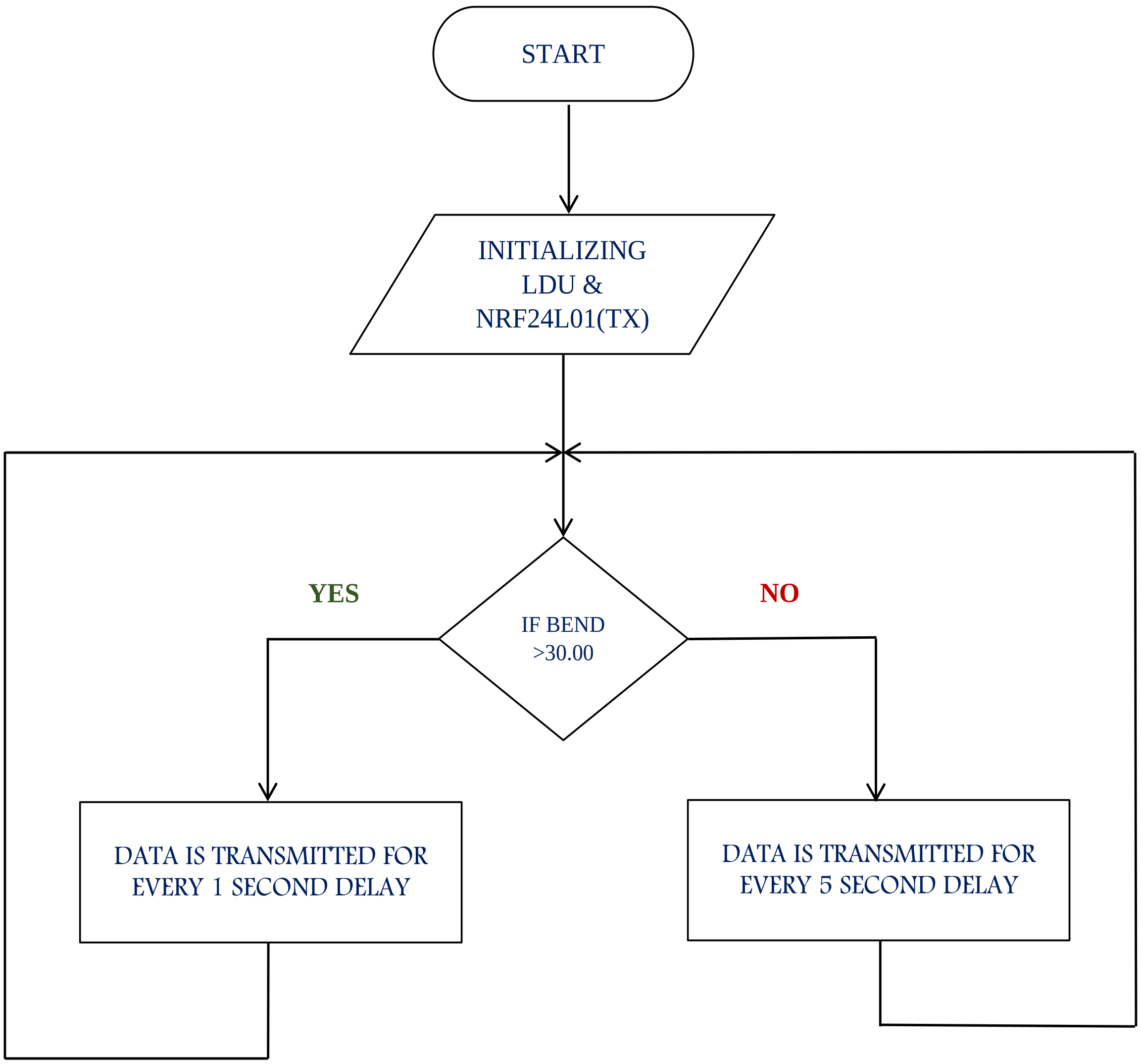


Fig 13. Block Diagram

LDU has been developed using a string on which the flex Sensor is mounted and this whole setup is enclosed in a flexible pipe and the ends of this pipe are sealed in order to prevent rusting. During Landslide, the slope of the debris changes so that the arc length of the LDU changes accordingly and this data is transmitted via an RF transceiver. The transmitted RF data is received by the centralized controller. In addition, the centralized controller also measures the rain drop, temperature and humidity. All these data are processed and creates an alert using a 5v buzzer.

4.2 TRANSMITTER:



4.2.1 ALGORITHM:

Step 1: Initialization

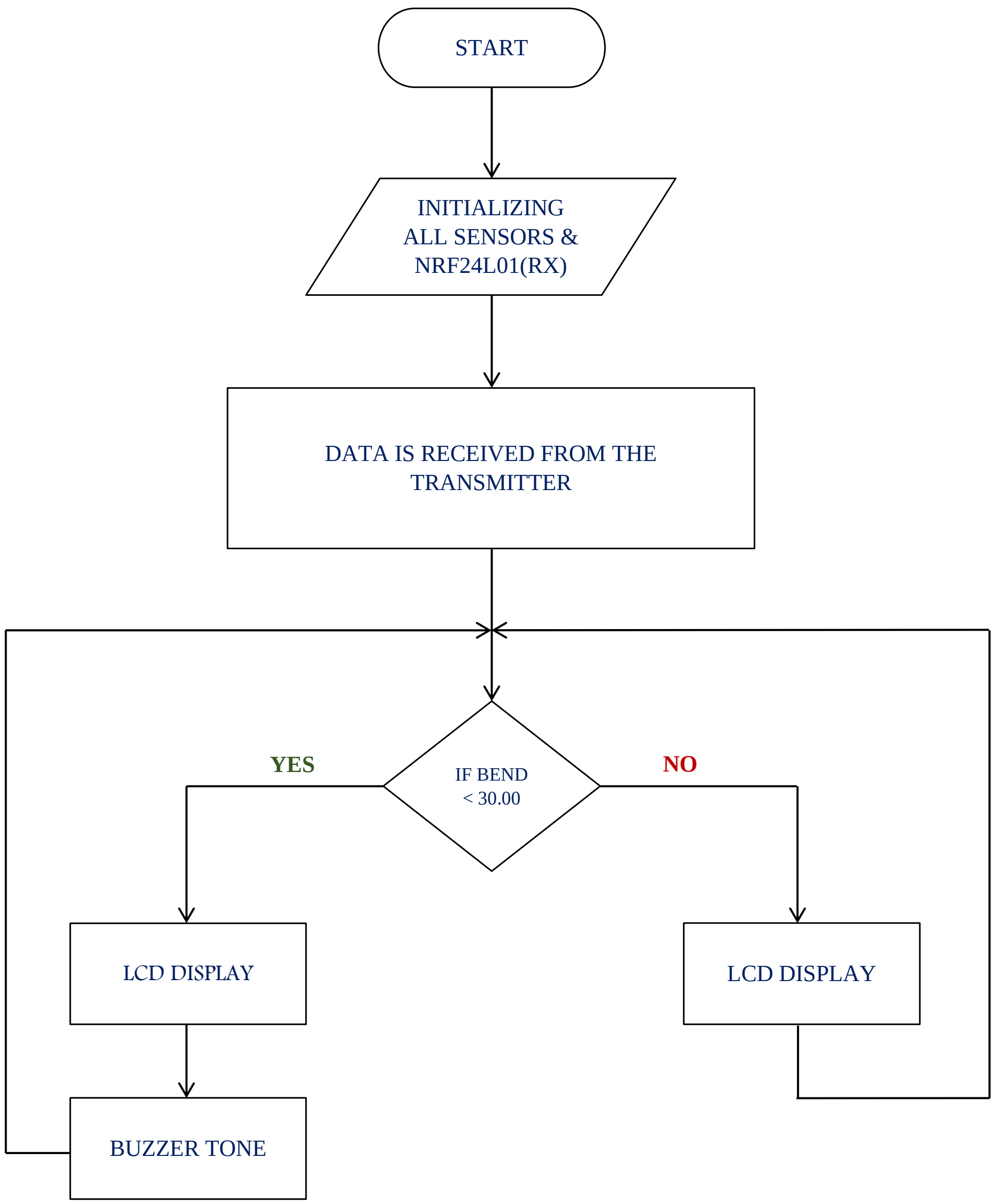
Step 2: After initialization of LDU and NRF24L01, the bend angle from the LDU has been read.

Step 3: The value obtained is compared with a predefined threshold value (here >30,000).

Step 4: If the bend angle is greater than 30,000 the data is transmitted for every one second.

Step 5: Else the data is transmitted in a 5 second delay.

4.3 RECEIVER:


START
INITIALIZING
ALL SENSORS &
NRF24L01(RX)
DATA IS RECEIVED FROM THE
TRANSMITTER
IF BEND
< 30.00
YES
NO
LCD DISPLAY
LCD DISPLAY
BUZZER TONE

4.3.1 ALGORITHM:

Step 1: Initialization

Step 2: In the receiver section after initialization of all sensors, the data transmitted by the receiver has been read.

Step 3: It compares the received value with a predefined threshold value (here 30,000).

Step 4: If the value exceeds the threshold value then the voltage, resistance and the bend angle has been displayed on the LCD display and buzzer will be turned on.

Step 5: Else the values of voltage, resistance and bend angle will be displayed in the LCD display.

CHAPTER 5

RESULT AND CONCLUSION

5.1 Result:

- ✓ The proposed model is protective and reliable, which helps in alerting during landslides.
- ✓ This system collects the data from LDU and transmit through NRF24L01 module followed by creating an alarm in the centralized controller.
- ✓ By using this technology, we can prevent destruction of lives and properties in an efficient manner.

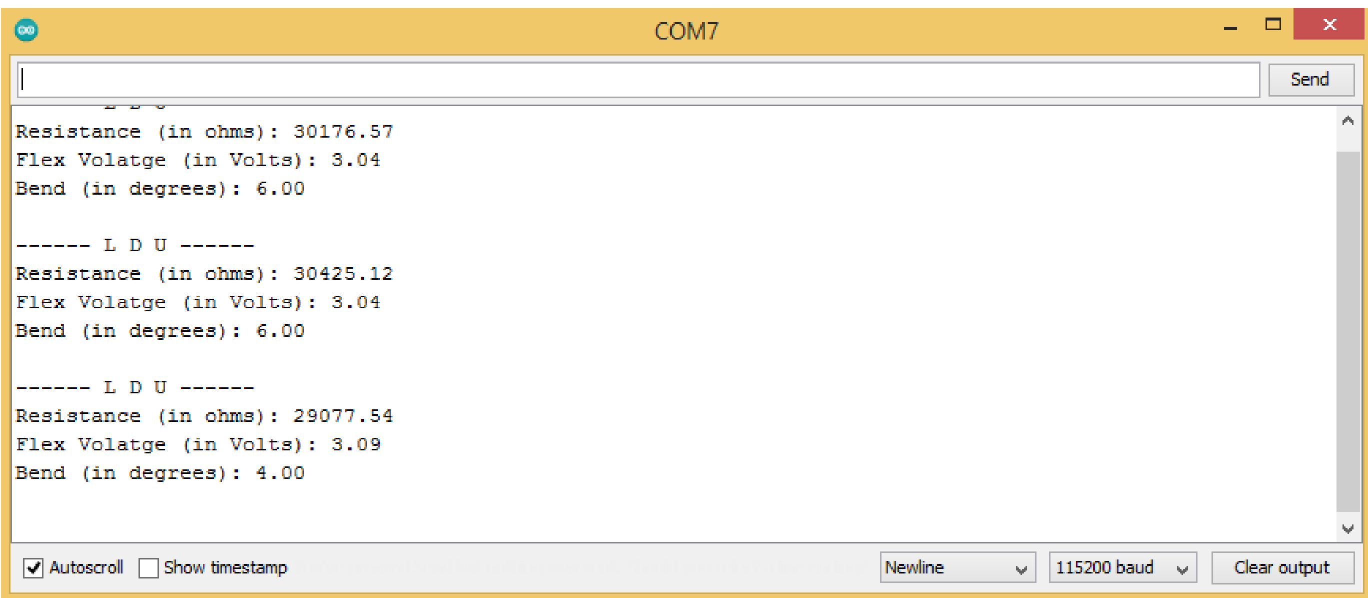


Fig 14. Transmitter output

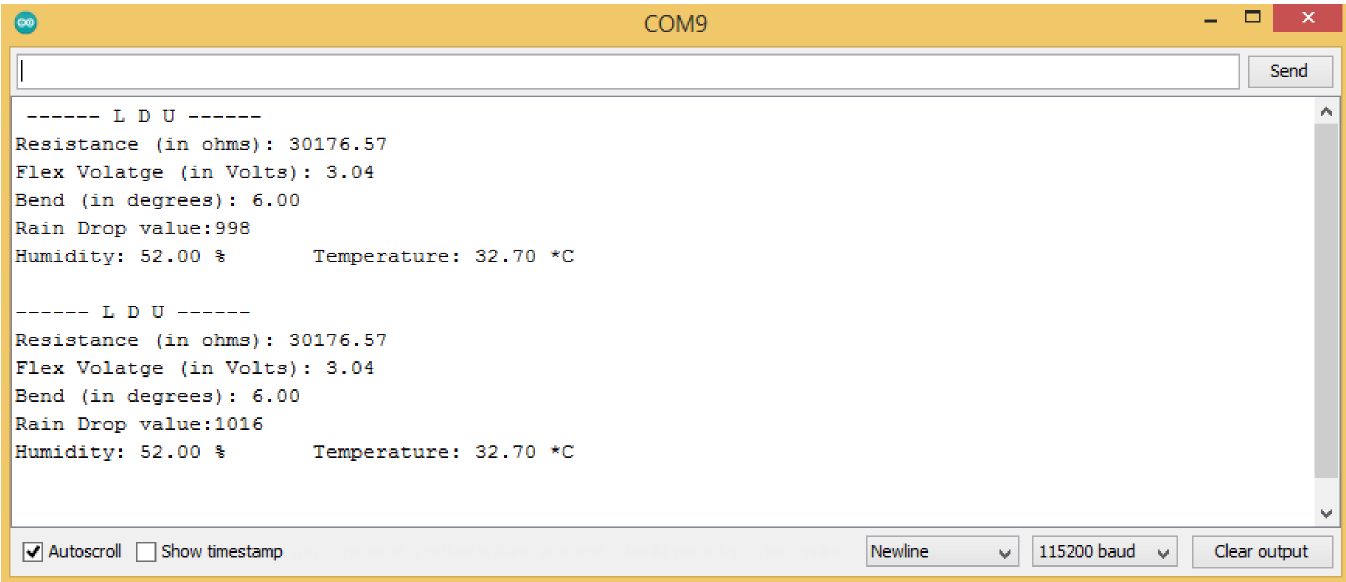


Fig 15. Receiver output

5.2 Conclusion:

Wireless sensor network for landslide detection is one of the challenging research areas available today in the field of geophysical domain. This project is designed using Landslide Detection Unit (LDU) that measures the arc length of the string and transmits the data to the centralized controller where all the sensor readings are compared with predefined threshold value, followed by creating an alert. The physical aspect of this design is reliable since it captures even a slight variation in the slope. The Landslide Monitoring System enables us to apprehend required data which in turn may be used to safeguard many lives and properties.

REFERENCES:

- **LDU:** Mr. K. Manogaran, M.E., $\overline{\text{Ph.D}}$,
  Assistant Professor**,**
  Government College of Engineering,
  Bargur-635104.

- **NRF24L01:** https://youtu.be/D40cgHyBLL4

- **DHT 11 Sensor:** create.arduino.cc

- **Rain Drop Sensor:** microcontrollerslab.com

APPENDICES:

Coding for Transmitter:

```
#include <SPI.h>
#include "RF24.h"

const int flexpin = A0;
const float VCC = 5;
const float R_DIV = 47000.0;
const float flatResistance = 25000.0;
const float bendResistance = 100000.0;

RF24 myRadio (9, 10);
byte addresses[][6] = {"0"};


struct ldu {

  float bend;
  float rflex;
  float vflex;
  char  text[300] = "------ L D U ------";
};


typedef struct ldu Package;
Package data;


void setup() {
  Serial.begin(115200);
  delay(1000);
```

```
  myRadio.begin();
  myRadio.setChannel(115);
  myRadio.setPALevel(RF24_PA_MAX);
  myRadio.setDataRate( RF24_250KBPS );
  myRadio.openWritingPipe(addresses[0]);

}


  void loop() {


readSensor();

  myRadio.write(&data,sizeof(data));

 Serial.println(data.text);

Serial.print("Resistance (in ohms): ");
Serial.println(data.rflex);

Serial.print("Flex Volatge (in Volts): ");
Serial.println(data.vflex);

Serial.print("Bend (in degrees): ");
Serial.println(data.bend);
Serial.println();




}
```

```
void readSensor() {



  int ADCflex = analogRead(flexpin);

  float Vflex = ADCflex*VCC/1023.0;


  float Rflex = R_DIV*(VCC/Vflex-1.0);


 float angle= map(Rflex,flatResistance,bendResistance,0,90.0);

if ( angle < 30.00 ){
data.vflex = Vflex;
data.rflex = Rflex;
data.bend = angle;
delay(5000);
}

else {
data.vflex = Vflex;
data.rflex = Rflex;
data.bend = angle;
delay(1000);
}
}
```

<u>Coding for Receiver:</u>

```
#include <SPI.h>
#include "RF24.h"
```

```
#include <LiquidCrystal.h>
#include "DHT.h"

#define DHTPIN 3
#define DHTTYPE DHT11

DHT dht(DHTPIN, DHTTYPE);

int buzzerpin = 8;

LiquidCrystal lcd(1, 2, 4, 5, 6, 7);

RF24 myRadio (9, 10);
byte addresses[][6] = {"0"};

struct ldu {

  float bend;
  float rflex;
  float vflex;
  char  text[300] ="empty";
};

typedef struct ldu Package;
Package data;


void setup() {

  Serial.begin(115200);
  delay(1000);

   pinMode (0 , INPUT);
```

```
  dht.begin();
  lcd.begin(16,2);

  myRadio.begin();
  myRadio.setChannel(115);
  myRadio.setPALevel(RF24_PA_MAX);
  myRadio.setDataRate( RF24_250KBPS );

  myRadio.openReadingPipe(1, addresses[0]);
  myRadio.startListening();

  lcd.clear();
  lcd.print("Starting....");
  delay(2000);
}


void loop()  {
  if ( myRadio.available()) {
    while (myRadio.available()){
      myRadio.read( &data, sizeof(data) );
    }



 Serial.println(data.text);

Serial.print("Resistance (in ohms): ");
Serial.println(data.rflex);


Serial.print("Flex Volatge (in Volts): ");
Serial.println(data.vflex);

Serial.print("Bend (in degrees): ");
```

```
Serial.println(data.bend);

int value = analogRead(A0);
float h = dht.readHumidity();
float t = dht.readTemperature();


 Serial.println ("Rain Drop value:" + String(value));

 Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.print(" *C ");

Serial.println("\n");


lcd.clear();
delay(500);

lcd.setCursor(0,0);

lcd.print("Bend:");
lcd.setCursor(1,0);
lcd.print(data.bend);
lcd.print("deg");

float ang = data.bend;

if (ang > 30.00){
tone(buzzerpin, 10000, 500);
 delay(1000);
}
```

```
else {
noTone(buzzerpin);

}
  }
}
```