Mitigating Losses In Landslide Detection For An Early Warning System With Wireless Sensor Networks

Sumathi M. S,[1]Shruthi J,[2]Gagana Jadhav,[3]Kritika Sharma,[4]Nischitha GV, [5]Samruddhi Patil1

1,3,4,5Department of ETE, BMS Institute of Technology and Management, Bengaluru, Karnataka, 560097, India
2Department of CSE, BMS Institute of Technology and Management, Bengaluru, Karnataka, 560097, India

[1]sumathi.m@bmsit.in

Abstract

Landslide is a catastrophic movement of the soil and rock in a downward slope. It is usually an after-effect of earthquakes, heavy rains, volcanic eruptions, or soil erosion. It might lead to injury, death, or damage of property ultimately resulting in financial loss. In order to reduce colossal destruction, it is important to detect landslides before they occur. Typically, a wireless sensor network comprises sensor nodes that are spatially dispersed over an area. The nodes can transmit data with each other wirelessly and also gather data about the variations in physical parameters such as temperature, pressure, etc. Since nodes have restricted or limited resources such as power and sense, they need to be used in an efficient manner in order to improve a network's lifetime. In this paper, we use the LEACH protocol for clustering and the AODV protocol for routing. NS-2 is a software that predicts the behaviour of computer networks to provide accurate analysis of system performance. The paper aims to evaluate performance through a network simulator for the existing system. The enhanced system shows an improvement in energy efficiency, throughput, packet delivery ratio, overhead and delay through simulation results. Additionally, features like fault tolerance, faster data processing rate, and higher transmission range have been incorporated in the system. In this paper, the enhanced WSN is designed using NS-2 tool for landslide detection.

Keywords—Landslide detection, LEACH protocol, NS-2 Simulation, WSN

1. INTRODUCTION

The violent movement of debris, rock and soil down a slope of a mountain is called a landslide. They are usually caused by earthquakes, rain, volcanoes, soil erosion and other man-made factors contributing to the instability of the rock mass. It might lead to injury, death, or damage of property ultimately resulting in financial loss. In order to reduce colossal destruction, it is important to detect landslides before they occur. [1]This paper aims to design an early warning energy-efficient Wireless Sensor Network using NS-2 simulation for landslide detection. A wireless sensor network comprises sensor nodes that are spatially dispersed over an area. Sensor nodes can transmit data with each other wirelessly and also gather data about the variations in physical parameters such as temperature, pressure,etc.The changes in the environment are sensed and reported to the other nodes. The sensor nodes are essentially planted in hostile environments or over geographically big areas. [2] Since sensor nodes have limited resources such as power and sense, they need to be used in an efficient manner in order to improve a network's lifetime. The LEACH protocol has been used for clustering and the AODV protocol for routing. Clustering is used in order to make the network energy-efficient as it aims to reduce the transmission power. A cluster head is assigned to each cluster which is made up of a group of cluster members or sensor nodes. One of the primary functions of the cluster head is to transmit the gathered data over to the base station or the sink node. [3] The LEACH protocol is used in the implementation of this network. It uses cluster-based routing in order to achieve minimum energy consumption, higher throughput, and a longer network lifetime. The prime focus of LEACH is to use the process of cluster head election where the cluster member nodes sense any changes in the environment and transmit this data to the cluster head where data is aggregated and compressed. Compared to traditional routing protocols LEACH is more efficient than other protocols as the vitality and proficiency of the WSN improves through the cluster-based hierarchical approach. [4,5].

The AODV(Ad Hoc On-Demand Distance Vector) routing protocol provides adaptability to altering conditions, memory overhead, low network implementation and determines routes to destinations. AODV helps with routing table management. It also aids in solving link breakages and changes in network topology in a timely manner by allowing sensor nodes to respond accordingly. When the link breaks, AODV notifies the sensor nodes to allow them to negate the routes using the lost link. The routing table is checked for packets to be sent to their destinations and to check if it has the route to the destination. The node then sends the data to the next-hop node if it is true. The two features of AODV are Route Discovery and Route Maintenance where RREQ is broadcasted and the routing table is checked to the destination. If it is true, it will send RREP to the source. RREQ or the route request packet is broadcasted to discover the route whereas the RREP or the route reply packet establishes the forward path [6, 7].

This paper is divided into the following modules based on the chronology of the simulation code as topology module, energy module, cluster formation module,virtual CH selection, fault tolerance mechanism and performance analysis module. The NS-2 simulation tool is used to implement the five modules. A network simulator is an event-driven simulation tool which does not run in real-time and helps in mimicking the mechanism of various protocols in wireless sensor networks. An animation tool called NAM or the network animator helps in visualizing the transportation of packets graphically which in turn helps in analyzing the execution of the system in a more comprehensible fashion. OTcl or the object-oriented version of the Tool Command Language is used for object creation and procedure definition [8]. The paper aims to evaluate performance through a network simulator for the existing system. The enhanced system shows an improvement in energy efficiency, throughput, packet delivery ratio, overhead and delay through simulation result.Additionally, features like fault tolerance, faster data processing rate, and higher transmission range have been incorporated in the system. In this paper, the enhanced wireless sensor network is designed using NS-2 simulation for landslide detection.

2. IMPLEMENTATION MODEL

- **Topology Module*:***

  *T*his module explains the working of the code snipers used in building the network topology which comprises mobile nodes where each node functions with multiple channels. Initially, the topology module concentrates on the node configurations, the creation of a topology and the environmental conditions. A bandwidth and threshold value is assigned to every node in the network. To find the neighbors for each node the concept of Euclidean distance is implemented. Specification of the source node, the destination node and the time interval for data transmission determined. In NS-2, the full process takes a fraction of seconds to execute. The user can view this through a NAM window at any given second. The whole process has a start time and end time defined

- **Energy Module:**
  In wireless sensor networks, there are several sensor nodes which have constrained power of data transmission and processing competence. A dynamic method has to be designed to send information from the sensor nodes to the base station. This method can be implemented using hierarchical cluster-based routing protocol.

  In this paper, K-means method of clustering in the cluster formation module is considered to estimate a weight function to elect a cluster head. This clustering technique is utilized to regulate the sensor nodes into cluster members as while CH selection takes place, nodes with the highest amount of energy in the cluster group are selected to perform the transmission of data followed by aggregation of data in the most effective manner. The weight function uses the primary/initial energy of each node and their respective distances from the neighbouring nodes so as to elevate the value of throughput of the entire system and the lifetime of the sensor nodes. While transmission of data occurs, the multi objective weight function is implemented through link cost by applying the conventional Dijkstra algorithm. This method gives an efficient and equalized consumption of energy in each of the nodes present in the network. The movement of nodes to a position for cluster formation is known as Node Deployment. The deployment of nodes can be random or known beforehand. When its random it's deployed in a random fashion and when its pre-determined to us, the location of nodes is known prior to the deployment.

Algorithm 2: *Node Deployment*

Input: Number of nodes.

Output: Nodes are deployed to their position.
1: Calculate the distance between the nodes using Euclidean distance.
2: while l=d: number of nodes
3: First node position = 0
4: Next node position = previous node position + the distance.
5: Node ID <- i
6: map <- node position + Node ID
7: d<-i+1
8: End while

- **Cluster Formation:**
  The topology of this network is based on the clustering architecture. Here, each cluster has a set of nodes amongst which they elect the cluster head (CH) and the other sensor nodes comprise of the cluster members (CM).Prior to joining any network it is essential for the node to have the valid certificate from the cluster agent (CA) that manages and distributes certificates to all the nodes to enable the communication of nodes with one another. [3]In the system that is proposed when a node appears to be a Cluster head (CH), it gives out a CH hello packet (CHP) to notify the neighbor nodes in a periodic manner.All nodes present in the vicinity of the transmission range of the cluster head (CH) grant them permission to become the cluster members. Alongside that, when a node is assigned as a cluster member (CM), it must wait for the cluster hello packet as a word for its acknowledgment. Next, the CM joins the cluster; alongside, CH and CM maintain a relationship with each other by sending Cluster Hello Packet and cluster member packet in the time period

ALGORITHM 2 *Cluster Formation Method*

Input: Number of clusters, endpoints of clusters,
Number of nodes (in each cluster)

Output: Clusters formation

1:for:i< = number of clusters
2:pick appropriate x endpoints for theith cluster
3:pick appropriate y endpoints for the ith cluster
4: place the nodes in the clusters
5: Generate thecluster-ID
6:i=i+1
7:End for

- **Virtual CH Selection:**
  The cluster head (CH) failure can be identified by the faulty CH members and the sink. Here, firstly the faulty-free CH members analyse that they stop receiving acknowledgement of the data sensed from the environment or signal from the faulty CH and then detects the CH failure. Secondly, faulty CH can be detected by the sink node in the absence of the data sensed from the faulty cluster head for a particular time interval. Depending on the cluster routing technique, the data sensed is appended with the energy information of the CHs and is forwarded to the base station. In our system, we reasonably develop a virtual CH within the cluster depending on the total energy available of all faulty-free cluster members and cluster heads. The virtual CH bears the data originally sensed by the faulty-free cluster members. A constructive keen framework is maintained to portray all the data sensed by the faulty free and the faulty members within their respective clusters.

- **Fault Tolerance Mechanism:**
  In this paper, we've enhanced the existing system by introducing a new mechanism called the Fault-tolerance. The prime focus of this mechanism is to achieve run-time restoration of the nodes from the clusters in which the gateway has cultivated some faults. This mechanism has two phases namely; detection and recovery. In order to recover the data aggregated from the failed cluster head, it is necessary to foresee the faults that can occur in the network on the cluster head. It can be from the environment, through the transmission line, hardware or software faults, energy insufficiency etc. Once the fault is detected, the main cluster head goes down and the second cluster head is chosen with the second highest residual energy functioning as the backup CH. Now, the backup CH performs the second phase of fault tolerance by recovering the data sensed from damaged-free cluster heads and cluster members. The data recovered is compressed, processed and forwarded to the sink node within fraction of micro seconds. This mechanism saves bandwidth, makes the system highly secure, steadfast and accessible to the end users without considering the aftermath of a fault and thus increases network's life. [15] In the proposed system, the transmission range is extended and the data rate is increased with the help of Mac IEEE 802.11 b which plays a dynamic role in the performance and the lifetime of the network.

- **Performance Analysis Module:**
  Performance metrics is the criterion of collecting, analyzing and reporting numeric data based on the performance of the network. This module, specifically for this system, processes the output to compute various performance metrics being throughput, end-to-end delay, PDR, overhead and the average energy consumed by the entire network.

  This information helps analyze the overall efficiency of the network. AWK scripts for the computation process of compute discrete metrics depending on the performance of the network. Graphs are plotted which is further used for the visual analysis. The trace.tr file is obtained to act as a track record file which contains information about all the events taking place in the network. The trace file format also performs a substantialtask in computing the functioning metrics of the network. Using this, the data is processed and the required performance metric is obtained. The performance metrics then lead us to formulate parameters.

3. PERFORMANCE ANAYLSIS AND RESULTS

Simulation Parameter Table

Description of Simulation Parameters

- Throughput:Is the total number of bits or packets delivered successfully to the destination over the entire period of time. Its unit is kilobits per second (kbps).
- Average Energy:It's the ratio of the sum of all the individual energies of each node in the network to the total number of nodes. Its unit is joules.
- End to End Delay:The time taken by a packet to be transmitted across a network from its origin to target. It is measured in millisecond (). Delay may be caused due to buffering during route discovery, waiting in interface queues, retransmission delay at MAC, etc.
- Overhead:To keep the revived data of network routes, routing algorithms generate small-size packets, called HELLO packets. The routing packets are considered to be an overhead in the wireless sensor network since the routing and the data packets are shared within the same network bandwidth most of the time. It's calculated using the AWK script which processes the trace file and produces the final result.
- Packet delivery ratio (PDR): It's the ratio of the number of packets received successfully at the base location to the total number of packets transmitted (including re-transmission).

Performance Evaluation:
This paper focuses at analyzing the performance of each parameter between the proposed and the existing system. The following figures show the graphical representation of the simulation results we have achieved.

The relationship between the throughput and time is shown in figure 1. This data represents a gradual increase in the throughput of the proposed system when the proposed system is compared with the existing system due to the increment in the quantity of packets transmitted to the base station in the same time intermission. The relationship between the average energy and time is depicted in figure 2. This data illustrates the steady decrease of the average energy computed in the proposed system when compared with the existing system as the energy consumed per node is diminished.

The relationship amidst the end-to-end delay and time is shown in figure 3. This data portrays a sharp decline in the delay time of sent packets from one end to the other in the proposed system. The relationship between the overhead and time is shown in figure 4. This data describes that as time progressesin the proposed system, the overall routing overhead is moderately decreased. The relationship amidst the PDR and time is shown in figure 5. This data represents a significant hike in the PDR of the proposed system. Therefore, with the benefit of LEACH protocol, extended transmission range and enhanced data rate, we can visually apprehend from the simulated output that the performance of the proposed system is rapidly increased when examined and compared with the existing system.

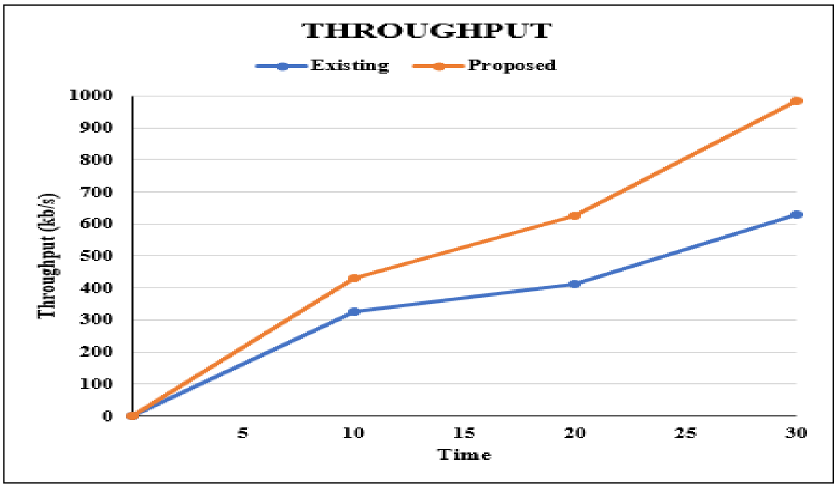

Fig 1: Throughput Vs Time Graph of Proposed Vs Existing System

Fig 1: Throughput Vs Time Graph of Proposed Vs Existing System

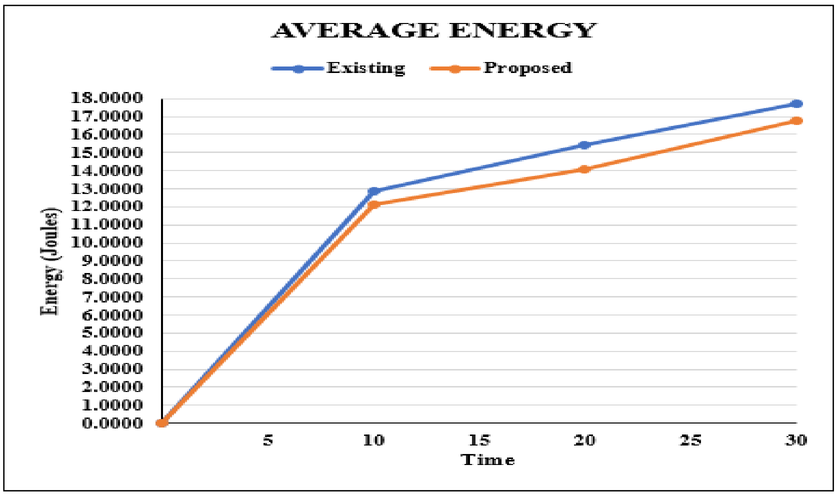

Fig 2: Average Energy Vs Time Graph of Proposed Vs Existing System

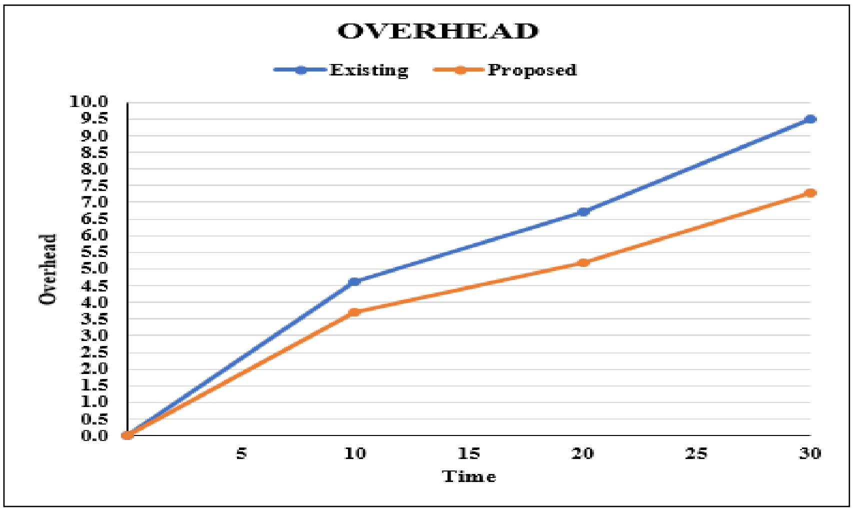

Fig 3: Overhead Vs Time Graph of Proposed Vs Existing System

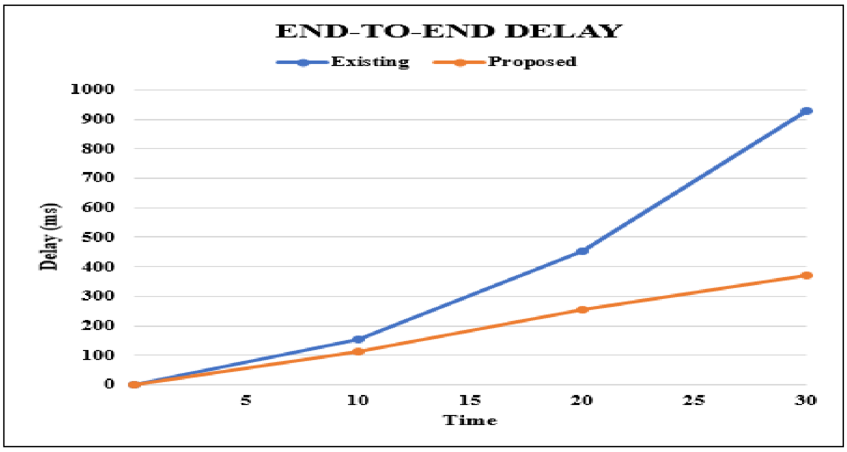

Fig 4: Delay Vs Time Graph of Proposed Vs Existing System

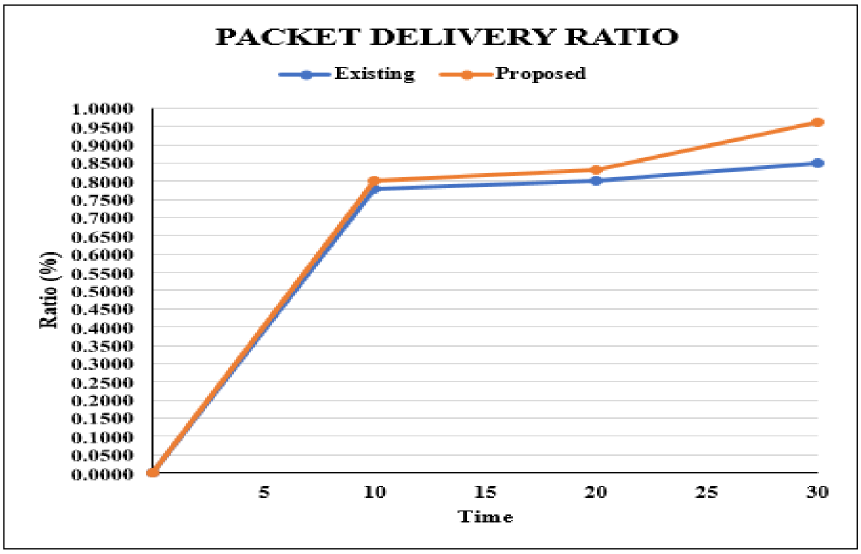

Fig 5: Ratio in % Vs Time Graph of Proposed Vs Existing System.

Table 1: Descriptive Statics

Parameter Name	**Parameter Value**
Simulation Tool	NS-2
Channel Type	Wireless
Radio Propagation Model	TwoRayGround
MAC Type	802.11
Initial Energy	Energy Model
Link Layer Type	LL
Number of Nodes	50
Routing Protocol	AODV
Simulation Area	1000 x 1300
Connection Type	CBR

4. CONCLUSION

WSNs are predominantly responsible in many of applications like disaster management, precision agriculture, security, and for military surveillance. In this paper, NS-2 tool was used for the simulation of energy-efficient WSN for landslide detection. LEACH protocol was implemented during the sensor node clustering process, while AODV was implemented as an optimal routing protocol. Here, the network performance of the existing system is compared with the enhanced system and then simulated using the tool. The simulation results portrays that the enhanced system is better in terms of energy-efficiency, higher throughput, lower end-to-end delay, reduced overhead, and an increased PDR. These parameters are calibrated optimally in order to achieve an overall efficient system. Fault tolerance, faster data processing rate, and increased transmission range were also integrated into the wireless sensor network. All of the above factors contribute to the design of energy-efficient WSNs simulation for the detection of landslides.

REFERENCES

[1] N Ju, J. Huang, R. Huang, C. He, Y. Li, "A Real-time monitoring and early warning system for landslides in Southwest China", Journal of Mountain Science, 2015, vol. 12, no. 5, pp. 1219-1228. doi:10.1007/s11629-014-3307-7

[2] Maneesha V. Ramesh, "Real-time Wireless Sensor Network for Landslide Detection", Third International Conference on Sensor Technologies and Applications, 2009, doi: 10.1109/SENSORCOMM.2009.67

[3] Yi Ming Miao, "Cluster-head Election Algorithm for Wireless Sensor Network based on Leach Protocol", Department of Computer Technology and Applications, Qinghai University, Xining, Qinghai, 2015, Vol. 738-739., doi: 10.1109/SENSORCOMM.2009.67

[4] Akash Chandanse, Pratik Bharani, Sujoy Anchan, HemlataPatil, ". Performance Analysis of Leach Protocol in Wireless Sensor Network",2nd International Conference on Advances in Science & Technology (ICAST) 8th, 9th April 2019,doi: 10.26634/jwcn.3.1.2737.

[5] WalidAbushiba, Princy Johnson, SaadAlharthi, Colin Wright, "An Energy-Efficient and Adaptive Clustering for Wireless Sensor Network (CH-leach) using Leach Protocol",3th International Computer Engineering Conference (ICENCO), IEEE,2017, doi:10.1109/icenco.2017.8289762

[6] Vikash Kumar, Kashyap, Rani Astya, Dr. Parma NandAstya, Gaurav Pandey, "Comparative Study of AODV and DSR Routing Protocols in Wireless Sensor Network Using NS2 Simulator", International Conference on Computing, Communication and Automation (ICCCA),2017, doi:10.1109/ccaa.2017.8229889.

[7] Shumin Xu, Yatao Yang, "Protocols simulation and performance analysis in a wireless network based on NS2", International Conference on Multimedia Technology, 2011, doi:10.1109/icmt.2011.6003076.

[8] Asim Zeb, A.K.M. Muzahidul Islam,NafeesMansoor,SabariahBaharun,Shozo Komaki, "Fault Tolerance in Dynamic Cluster-Based Wireless Sensor Networks",12th International Bhurban Conference on Applied Sciences & Technology (IBCAST), IEEE,2015,doi:10.1109/ibcast.2015.7058576.

[9] MadihaRazzaq, Goo-Rak Kwon, Seokjoo Shin, "Energy Efficient Dijkstra-Based Weighted Sum Minimization Routing Protocol for WSN", Third International Conference on Fog and Mobile Edge Computing (FMEC), IEEE,2018, doi:10.1109/fmec.2018.8364074.

[10] Hassan Echoukairi, Amine Kada, Khalid Bouragba, Mohammed Ouzzif, "A Novel Centralized Clustering Approach based on K-Means Algorithm for Wireless Sensor Network.IEEE, 2017, doi:10.1109/sai.2017.8252252.

[11] D. Qin, S. Yang, S. Jia, Y. Zhang, J. Ma, Q. Ding, "Research on Trust Sensing Based Secure Routing Mechanism for Wireless Sensor Network. IEEE, 2017, vol. 5, pp. 9599-9609, doi:10.1109/access.2017.2706973.

[12] A. Ray and D. De, "Performance evaluation of tree-based data aggregation for real-time indoor environment monitoring using a wireless sensor network", Microsystem Technologies,2017, vol. 23, no. 9, pp. 4307-4318, doi: 10.1007/s00542-017-3339-3.

[13] L. Muduli, P. Jana, D. Mishra, "A novel wireless sensor network deployment scheme for environmental monitoring in a longwall coal mine", Process Safety and Environmental Protection,2017, vol. 109, pp. 564-576,doi: 10.1016/j.psep.2017.04.030.

[14] Sumathi M.S., Anitha G.S.Energy efficient wireless sensor network with efficient data handling for real time landslide monitoring system using fuzzy data mining techniqueInt. J. Mob. Netw. Des. Innov., 8 (3) (2018), pp. 179-193

[15] Shyama M, Dr. Anju S Pillai, "Fault Tolerance Strategies for Wireless Sensor Networks – A Comprehensive Survey", IEEE, 2017, doi: 10.1109/ICICT43934.2018.9034298

[16] M. S. Sumathi, G. S. Anitha, and N. H. Sridhar, "Efficient data handling of wireless sensor network for real time landslide monitoring system using fuzzy technique," in 2017 International Conference on Circuit ,Power and Computing Technologies (ICCPCT), 2017, pp. 1–4

[17] N. H. Sridhar, G. S. Anitha, & M. S. Sumathi. "Analysis of energy harvesting from multiple sources for wireless sensor networks with focus on impedance matching "2017 International Conference on Circuit, Power and Computing Technologies (ICCPCT), 2017. IEEE, 1-5.