iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: XI Month of publication: November 2025

DOI: https://doi.org/10.22214/ijraset.2025.75535

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XI Nov 2025- Available at www.ijraset.com

Smart Earthquake Early Warning System Using Internet of Things

Subhankar Sarkar
Ph.D Enrolled, Department of CSE, MAKAUT, Dist.-Nadia, West Bengal. India
Member, Disaster Management and Civil Defence - Murshidabad, West Bengal, India

Abstract: The environment and climatic changes continue to take their toll as natural disasters occur with greater frequency and more force. Apart from all other natural disasters, earthquakes prove to be very alarming because of their sudden occurrence and largeness of impact. India lies in an earthquike zone of active movement. There are frequent earthquakes in India, particularly in the Northeastern States, causing great human as well as economic losses. Methods It reviews old earthquake trends in India, looking at places of great danger and the strength of shaking. It also looks into the use of IoT tools, sensor groups, and cloud server that can collect data right away and keep studying it. This works to suggest a plan for a many-layered early alert system.This study aims to analyze the causes of earthquakes and propose the development of a Smart Earthquake Early Warning System utilizing Internet of Things (IoT) technologies. The objective is to play down casualties and property harm by giving convenient cautions. Findings indicate that most of the devastating earthquakes in India are above 5.0 magnitude on the Richter scale. Gujarat and Nepal earthquakes have shown us very clearly that we need to take measures in advance. This proposed Smart Earthquake Early Warning System shall detect early seismic signals and send out alerts within seconds, so that emergency response and public safety measures can be accelerated. High seismic risk in India calls for advanced technological solutions. A Smart Earthquake Early Warning System implemented through IoT and sensor-based technologies shall go a long way in disaster preparedness as such lifeline systems—not just in terms of saving lives but also appraised to reduce economic loss during seismic events.
Keywords: Earthquake, Early Warning Systems, Internet of Things, Sensors, Monitoring, Results.

I. INTRODUCTION

Seismic tremors are one of the foremost unexpected normal calamities within the world that bring incredible annihilation. This is caused by sudden movements within the Earth's outer crust. Changes within the Earth's crust due to the collision of tectonic plates, volcanic eruptions, and landslides are all forms of natural earthquakes. Human activity can cause them too, for instance, a heavy blast under a nuclear power plant, detonation of ballistic explosives, or massive dam construction can induce seismic movements. Earthquakes whatever their origin can inflict immense destruction of human life, social infrastructure and create an long term economic hardship.

India has a complex geological structure that makes it particularly susceptible to seismic shifts. Northeastern regions in India, together with northern Indian regions spend a big share of their resources on activities associated with disaster preparedness and mitigation responses could be said to be placed under Zone IV and V which is the high risk zone. The demolition of supporting structures for the 2001 Gujarat earthquake and the shocks felt across northern India during the 2015 Nepal earthquake emphasize the need for a stun moderation frameworks adapted towards diminishing the affect of stunning occasions within the future.

Due to recent advancements in sensor and Internet of Things (IoT) technologies, intelligent real-time monitoring systems for natural disasters are now achievable. IoT-enabled systems integrate various inexpensive sensors with microcontroller platforms to facilitate the detection and analysis of seismic signals. Through cloud-based platforms, these devices can send out early notifications, enabling prompt actions that could prevent property damage and save lives.

This research paper is responsible for developing a Smart Earthquake Early Warning System through IoT. The proposed system takes advantage of a network of cheap and easy-to-get sensors which are attached to microcontrollers. These sensors can distinguish vibrations on the ground and send their information to a cloud server for investigation. Warnings are then sent to users through emails, LCD screens, and other channels of real-time notifications. Moreover, the system exploits wireless communication to further improve scalability as well as availability especially in remote or high-risk places.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XI Nov 2025- Available at www.ijraset.com

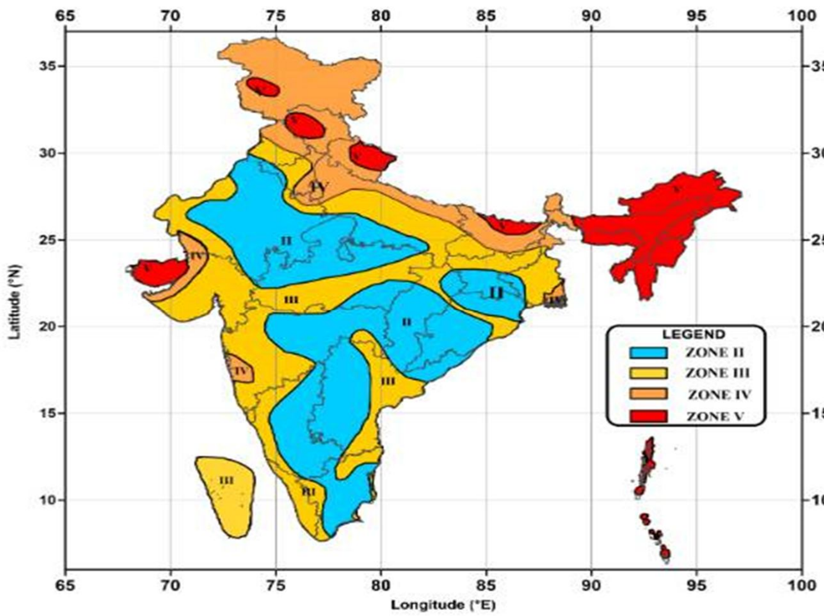

Figure-1. Earthquake Zone of India.

The main objective of this research paper is to provide a rapid, cost-effective early earthquake warning. And to increase advance preparedness to deal with disasters such as earthquakes. The proposed system attempts to detect early earthquakes by integrating the use of cloud servers and modern IOT technologies.

A. Earthquake

An earthquake is when the earth's surface suddenly shakes due to natural causes, especially when tectonic plates collide. Or other natural and slightly unnatural causes. Other geological forces that play a part in causing earthquakes include volcanic eruptions, strong internal compressions of magma, and temporary magma movements. Furthermore, an earthquake can also happen if an area has been filled up with water to its maximum capacity because then it puts pressure on the crust of the Earth and shearing off pieces of it. If this event happens to take place underwater, then those huge tsunamis happen which are very destructive for riverside. In most cases, earthquakes happen due to natural factors but they can also be produced from human factors such as the setting off of bombs, blasting dynamite, coal mine collapsing, and construction or mining replacement. These activities tend to disturb a specific region in geological terms, which defines an Earthquake. The phenomena’s intensity is best measured through the Richter scale as it is used to calculate earthquakes. Most of them are minor and no one feels them. But, a magnitude greater than 5.0 can seriously damage buildings and kill people. Major earthquakes are accompanied by aftershocks which themselves can be equally destructive particularly when they occur in close succession or are strong. In this regard, monitoring aftershocks is equally important as detecting the main shock since they significantly add to the total impact.

Figure-2 Damages of Earthquake Damage.

TABLE 1. GLOBAL FREQUENCY OF EARTHQUAKES BY MAGNITUDE

Descriptor	Magnitude	Average annually
Great	8 and higher	1*
Major	7–7.9	17†
Strong	6–6.9	134†
Moderate	5–5.9	1319†
Light	4–4.9	13,000 (est.)
Minor	3–3.9	130,000 (est.)
Very minor	2–2.9	1,300,000 (est.)

Note: From U.S. Geological Survey (http://neic.usgs.gov/neis/eqlists/eqstats.html).
*Based on observations since 1900.
†Based on observations since 1990.

Figure-3 Global frequency Parameter earthquake.

Different regions are divided according to the intensity of earthquakes. The classification of earthquakes and a rating of their magnitudes are shown in *Figure 3*, according to the U.S. Geological Survey (USGS) and as per their description, for Earthquakes, there are seven levels.

B. Internet of Things (IoT)

The Internet of Things refers to a modern network of connections that includes various types of sensor technology, from which necessary data can be obtained. This allows real-time data to be collected, stored, transmitted, and analyzed as needed. Using such a structure-like apparatus, IoT makes intelligent decisions and automation possible through various implementations of the technology. IoT is a technology that continues being integrated into our lives and continues to alter how you interact with your surroundings, everything from smart homes and smart cities, to industrial automation and health care. Among a large range of applications, IoT is essential when it comes to disaster management, collecting data, and responding as an early warning system in natural disasters trying to mitigate tragedies like earthquakes. Specifically, in this example, IoT systems would collect seismic data in real-time and would send data instantaneously, open a warning signal, and give users an early warning signal. In this research paper, an advanced technology using Internet of Things has been designed to provide early warning systems about earthquakes. There are many new uses for IoT technology to assist the environment we operate in evolve.

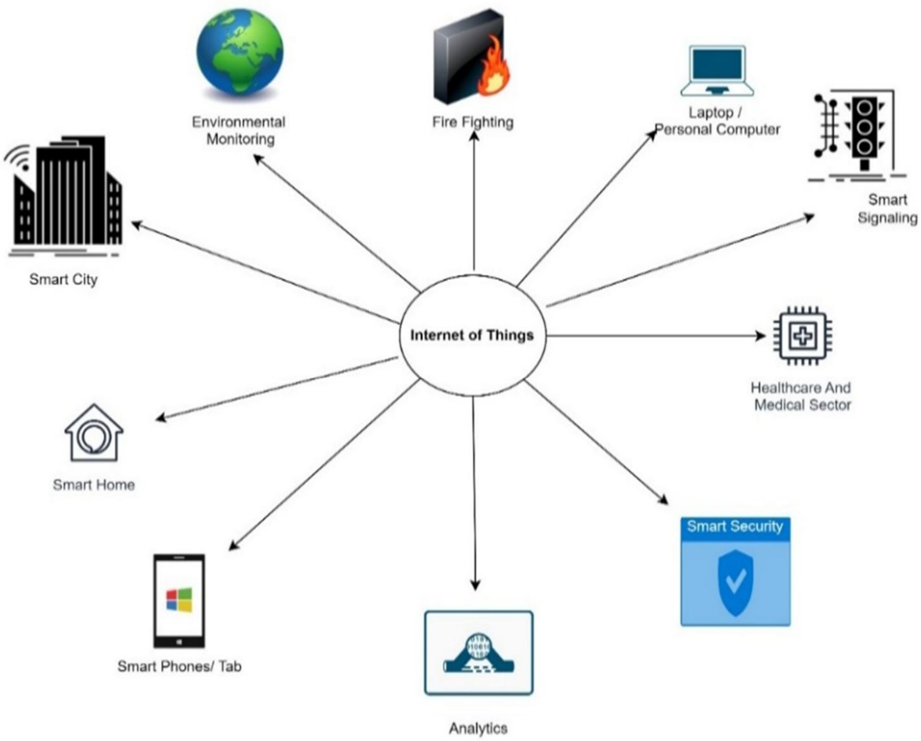

Figure-4 Internet of Things (IoT) applications.

C. Earthquake Early Warning System (EEWs)

An Earthquake Early Warning (EEW) system is capable of recognizing the accelerating indicators of seismic activity and forewarning affected areas before the damaging seismic waves arrive. The purpose of these systems is to enable some form of way to be taken that would relieve or reduce the loss that can be incurred. EEW systems are of great Importance where frequent seismic activity occurs, and where even small tremors pose a serious threat. With the aid of this system, rapid response both during and after an earthquake is possible, since alerts are issued seconds to minutes before ground shaking starts. Each individual Earthquake Early Warning system has a distinct set of technological features. Those features include more complex methods that include studying the history of earthquakes to estimate future ones. In expansion, an arrange of seismic sensors is set to capture essential (P) waves, which are less damaging compared to the auxiliary (S) waves. When P-waves are detected, the system has the capability to send out early warning signals, enabling impacted areas to mobilize and take protective steps immediately.

II. LITERATURE REVIEW

Alphonsa A. and Ravi G. (2016): This research put forward an IoT-based earthquake early alert system by using a WSN with ZigBee talk. The gadgets spot the P-waves on the ground and send warning signals via ZigBee modules to a central gateway. This portal serves as an IoT center that transfers notices to smartphones so that individuals can clear in time and take preventive measures some time recently the harming S-waves hit. The LABVIEW application is used to connect with the sensors for three-axis shake detection making sure truthful seismic data is captured.

Ray, Mukherjee, and Shu (2017): This paper conducts a thorough review of IoT applications in disaster management, especially focusing on earthquakes. It elaborates the enabling technologies for early warning, remote monitoring, victim localization, and real-time analytics. The authors recognize the features of IoT—heterogeneity and interoperability—that attribute to it a privileged position in the management of disasters that usually present very complex environments. They also provide an overview of the related protocols and present an emergency response system solution based on commercially available products.

Prasad, Mahajan, and Priyadarshini (2019): The authors investigated the use of cutting-edge technologies comprising seismic sensors, WSNs, and cloud computing for earthquake indication. They concentrated on how IoT-enabled protocols improve the efficiency of EEWS through real-time monitoring and data exchange. This paper talks about the generation of P-waves and S-waves during an earthquake and the importance of detecting P-waves for timely alerts. Also, it will highlight cheap and scalable IoT solutions available in the market that can help in disaster mitigation.

Arunkumar et al. (2019): In the following paper, an IoT system that utilizes a WSN (Wireless Sensor Network) for the purpose of early earthquake detection has been developed. Their approach implements a system of sensors on the surface for the identification of P-waves, as these waves precede the destructive S-waves and enabling early warning dissemination. The implementation is based on the real-time processing technology provided by Arduino platforms that captures motion data from the ground using three-axis accelerometer sensors. This makes it possible to generate alerts prior to the arrival of more destructive seismic waves to populated areas. This research highlights the usefulness of simple and inexpensive life-saving hardware to maximize response time through early warning notifications.

Raja et al. (2021): This paper is about an IoT-based EEWS that has been developed via the use of NodeMCU microcontrollers and MEMS sensors. The sensors obtain data from the environment and upload it to a ThingSpeak cloud account for processing, visualization, and analysis. In the case of an earthquake occurrence, the W-iFi module sends the alerts immediately. The set-up provides a fast and affordable early warning system using the internet (cloud services). The internet is a valuable technological to technical solution to acquire, store, and analyze earthquake activity data, improving collective situational awareness and lowing reaction times.

Chen, Shieh, and Tu (2023): Due to continuous seismic activities in Taiwan, this study developed a comprehensive sensing system by using Arduino platform hardware with sensors as part of security alarm system. The sensing system is designed with ADXL345 accelerometers for detecting vibrations, MQ sensors for detecting gas leakage, and IR flame detectors for detecting fire. The system generates alerts using alarms and automated alarm systems that can operate automated fans to extract toxic gas. The solution is economical, deployable in a variety of configurations, and can be easily configured to offer a comprehensive safety response to a multitude of hazards related to earthquakes in Taiwan.

Pierleoni et al. (2023): The examination of communication protocols in IoT based EEWS is assessed, with emphasis on the Message Queue Telemetry Transport (MQTT) protocol. The authors compare MQTT against SeedLink protocols, and do so with real earthquake data. They report a mean alert time reduction of about 1.6 seconds. The authors show the significance of reliable low-latency communication to a real-time earthquake detection system.

Abdalzaher et al. (2023): This recent work offers an in-depth exploration of sustainable EEWS leveraging IoT and cloud computing. It discusses how advanced technologies—such as machine learning, edge computing, and drone-based monitoring—can enhance the functionality and scalability of EEWS. The study also proposes a taxonomy of emerging system architectures and emphasizes the need for proper verification and validation procedures. It concludes with bits of knowledge into maintainability contemplations and future investigate headings in IoT-enabled catastrophe administration.

Pierleoni et al. (2023): Propose an IoT-based Earthquake Early Warning System (EEWS) leveraging MQTT for waveform transmission. Their solution is benchmarked against the widely used SeedLink protocol with real earthquake datasets. The consider too proposes a scientific classification of rising framework designs and emphasizes the require for appropriate confirmation and approval strategies. It concludes with bits of knowledge into supportability contemplations and future investigate bearings in IoT-enabled fiasco administration.

Kafadar et al. (2024): Build an on-site EEWS called ESenTRy, by adding accelerometer and GPS modules. The system calculates several strong-motion indices and sends out alerts through Modbus. Simulations based on recent Turkish earthquakes indicate a variable but reliable time margin between the moment of alarm issuance and the subsequent arrival of seismic waves. It underlines ESenTRy's potential for localized earthquake risk mitigation.

Abdalzaher et al. (2023): This Research paper mainly focused centers on the application of IoT and machine learning (ML) in shrewd cities Seismic tremor Early Caution Frameworks (EEWS). It offers a classification of ML models nearby assessment measurements and proposes an EEWS design. The study highlights the importance of ML algorithms in analyzing the seismic data captured by IoT sensors to facilitate advanced and automated disaster management systems.

Akhavan, Rashvand, and Razzaghi (2024): This study concentrates on developing an integrated scheme for post-disaster utility management of an urban area prerequisite Internet of Things (IoT) and fuzzy logic systems for the sharp need of gas and electricity disconnection after earthquakes. Their case study is focused on the non-favorable Tehran, which is a highly seismic zone since the rapid disconnection of utilities and in the case of turns out too is important to avert secondary disasters like fire or explosion. The system in question was able to command the disconnection of gas or electricity utilities in ten seconds from the time of the earthquake. Considering that it was done against the JICA Seismic Hazard Assessment it is remarkable that such a short interval from the issue of the command to the disconnection was presented. It is stated that without these measures, the damage to vital infrastructure and loss of human life would be much greater than that figure which it hopes to achieve. Their research puts emphasis on the need to include not only the early warning but also efficient decision making in disaster management systems.

Muthahhari and Firdaus (2024): The Kalimantan region on the rugged island of Borneo, traditionally perceived as tectonically stable but recently influenced by tectonic activities, has been studied in detail by Muthahhari and Firdaus regarding its seismic vulnerability. The authors push forward the idea of creating an EWS (Earthquake Early Warning System) which is IoT-based and specifically designed for Kalimantan's topology and environment. This system is based on the premise that economical sensor networks could achieve coverage at the periphery with very quick responses. IoT technologies integrated into subduction seismic monitoring systems will provide enhanced accuracy of monitoring as well as faster alerting which can be used for other regions having low to moderate seismic risk- a few examples where localized designs are critical to effective earthquake response strategies.

Nandy and Dubey (2024): They mainly introduce a new model for earthquake detection technique by integrating the Mexican Axolotl Optimization algorithm with Adjustable Support Vector Regression (MAO-ASVR). IoT integrated sensors monitor seismic activity and relevant data is collected in real-time; noise filtering techniques are applied to enhance the quality of the signals. As a result, this framework can increase the accuracy of earthquake detection because it optimizes the SVR model with MAO. This system proved to be more effective than traditional models. It improved or increased the performance metrics—MAE, PMRE, and RMSE. In this study, technology is merged with public health prevention by showing how timely alerts, leveraged through intelligent algorithms, can reduce impacts on health and safety during earthquakes.

Prakash, Chandra, and Shivanesh (2025): This research proposes a personal safety solution in the earthquake safety bed that will be equipped with seismic sensors and GPS tracking capabilities. Not only will it provide immediate safety measures against seismic activity by automatically shielding and restraining the user, but it will also have alert elements that contact responders and provide the bed's location information via GPS to support any future rescues. This proposal uses the ATmega328p microcontroller with piezo sensors to not only provide real-time protection, but will also allow for recovery operations afterwards. This research creates a relationship between personal safety technology and emergency response coordination, while also adding an innovative user-centered component.

III. PROBLEM STATEMENTS

Lack of prior indication makes earthquakes one of the most life-endangering natural calamities. The degree of property damage accompanying death tolls is devastating. Most technologies for monitoring seismic activities have claimed that they can provide a level of preliminary indication, but lack of real-time data, geographic specifics, and alerting timelines are some of the many limitations systems in place today face. This is mostly problematic in areas around the Indian subcontinent where the region's geological structures are incredibly complicated. The vast majority of current procedures make use of approximated frameworks and IoT enabled sensor networks in addition to traditional seismometers, which only further cement centralized limb structures bound by low inter-device communication speeds. Sophistication offered by modern technology is overlooked entirely, without making use of farming tremors, subsiding land, and coupled with environmental foresight provided in the literature. The modern world is lacking in low-cost monitoring devices for seismic activity that can continuously and consistently provide real-time data.

Users should be able to set alerts on emails and their phones at the notification interfaces, making the warning system extensible on a subscription basis. Along with precise prediction capabilities, monitoring coverage can be amplified through the application of various sensors. This research paper these voids by suggesting a clever, IoT-based quake early alert system specially made to work well in the setting of the Indian subcontinent. The suggested system gathers sensor info at high speed sends it to a cloud-based platform for real-time checkup and makes early warnings using automatic communication ways thus bettering response time and disaster readiness.

IV. SYSTEM REQUIREMENTS

In this research paper, the hardware and software components required to build the main circuit of the Smart Earthquake Early Warning System are below:

A. Hardware Components

- ESP-32 Microcontroller: ESP-32

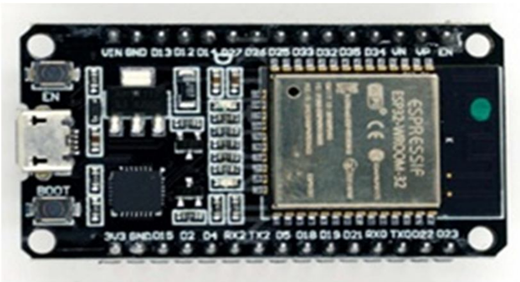

Figure-5 ESP 32 Microcontroller Board.

- Water Level Sensor.
- Moisture Sensor.
- Breadboard.
- Buzzer.
- LCD Screen / Output Monitor.
- Accelerometer.

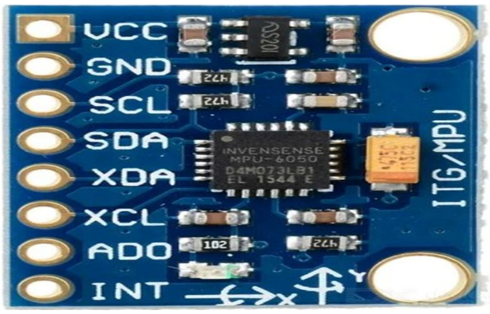

Figure-6 Accelerometer.

- Dust Smoke Particle Sensor.
- Connecting Wires.
- Power Supply.

B. Software Requirements

- Python.
- Arduino.
- Cloud application server.
- AWS SES.

V. PROPOSED SYSTEM AND SYSTEM FUNCTIONING

The scope of this paper is to develop a Smart Earthquake Early Warning System that can adequately prepare individuals for the onset of seismic activity. The system's purpose is to identify both natural and artificial signs of earthquakes to facilitate proactive responses. In the context of an earthquake region, there are phenomena like sudden elevation of sea or river water levels. This stratum may be accompanied by abnormal variations of water level in rivers and may strain the sea for sudden change in level. In the case of hilly areas, rainfall and mixing of soil and water give rise to landslides, which are further responsible for tremors in the ground – volcanic tremors as well. Tremors can also be caused by the activel-maintained compressing and build up of lava on the surface of the earth. In light of these considerations, the suggested system makes use of a network of sensors positioned in key areas susceptible to these kinds of natural disasters. These sensors assess the probability of an earthquake or other related event by gathering environmental data in real time.

The system does more than just detect earthquakes. To anticipate possible landslides, it also keeps an eye on the moisture content in rocky or mountainous areas and the water levels in rivers. Through the usage of an ESP-32 microcontroller, all gathered data is sent to a cloud server for analysis and distribution to users in the form of early warning notifications. This integrated, sensor-based method helps to improve community safety and readiness by providing a complete solution for early warning and disaster prediction.

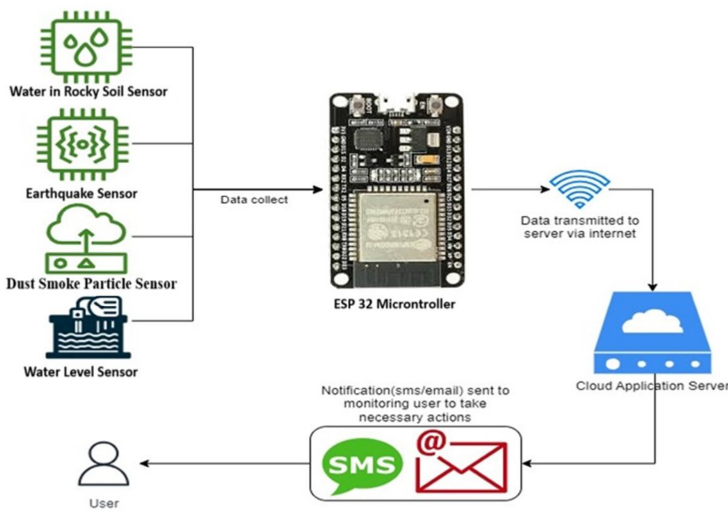

Figure-7 System Functioning.

VI. WORKING ALGORITHM FOR SMART EARTHQUAKE EARLY WARNING SYSTEM

The system starts by starting all the necessary parts which include a Wi-Fi connection for IoT-enabled communication, turning the LCD display on, and activating three auxiliary sensors: an accelerometer calibrated for earthquake detection, a dust/smoke particle sensor designed for the measurement of airborne particulates, and a soil moisture sensor calibrated for estimating the moisture content in rocky soil. After finishing initialization, the system goes into a perpetual runnable state. During each iteration, the system fetches real-time information from each sensor: a measurement of vibration or acceleration, concentration of dust or smoke, and moisture content in soil. The information that is collected is then evaluated against regulatory set threshold limits of the operating values for each parameter monitored. In the event where at least one the parameter monitored exceeds the set threshold value, for example: excessive vibration measured, high soil moisture registering which suggesting imminent collapse, or large concentration of dust/ash, an alert condition or state is entered.

As soon as the system detects such a condition, it examines whether an alert has already been given in the past five minutes. If within five minutes of an alert, the system goes into standby mode for a short period before continuing to monitor the scene. If no recent alerts were issued, the system sends out a notification through email to the relevant authorities, and then changes the saved time on the last alert issued to that time.

The real-time values of the sensors and any alerts are displayed on the LCD for the operators to see at all times. The system goes into standby for two seconds to repeat the cycle, allowing it to adjust response to changes in the surroundings and to promptly address changes in the conditions of the environment.

VII. WORKING FLOWCHART

This flowchart illustrates a Smart earthquake early warning system using IoT. The process begins by collecting earthquake data, smoke presence, and water levels in rocky soil. It checks three conditions: earthquake occurrence, abnormal water levels, and dust/ash detection. If one of those is true, the system checks if an event has been sent with this alert in the last 5 minutes. If not, it emails a human alert. If no abnormality is observed, the system will idle for 2 seconds then re-count. With this intelligent decision making system timely alerts are achieved, while reducing the number of false alarms, based on the analysis of real time IoT data for disaster preparedness.

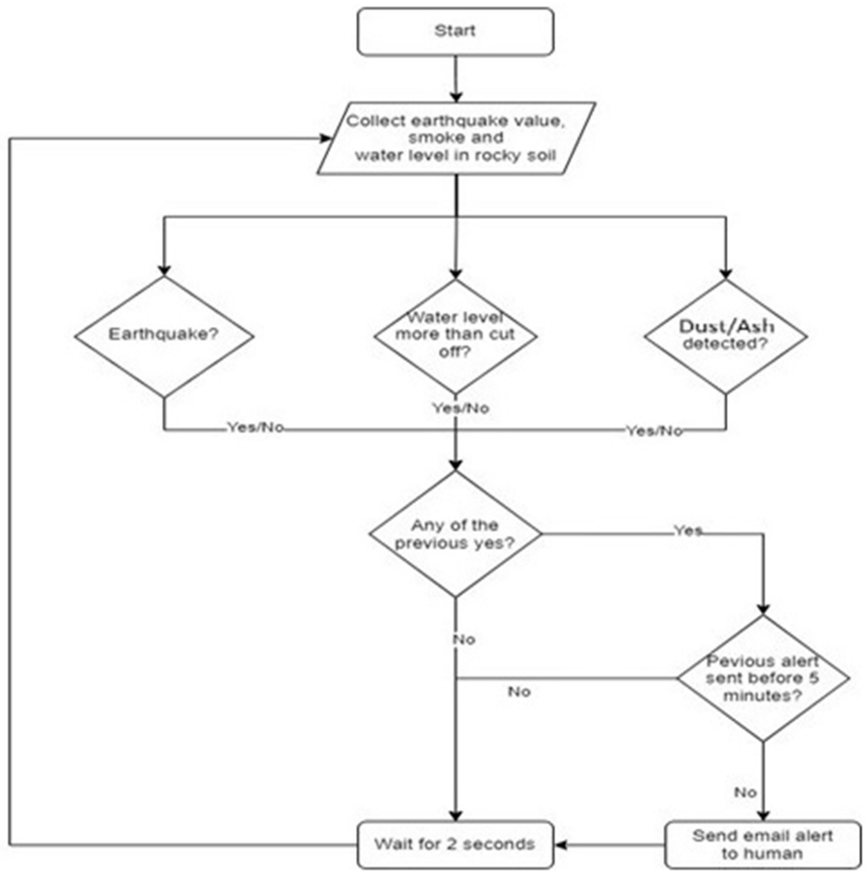

Figure-8 Flowchart Diagram.

VIII. CIRCUIT DIAGRAM

This circuit diagram illustrates a Smart Earthquake Early Warning System using IoT with an ESP32 microcontroller. It integrates multiple sensors to monitor environmental changes and detect seismic activity. A soil moisture sensor tracks ground conditions, while a dust smoke particle sensor monitors air quality. An accelerometer (e.g., MPU6050) detects ground vibrations and sudden movements, essential for identifying earthquakes. The ESP32 processes data from all sensors and communicates via Wi-Fi. A 16x2 I2C LCD displays real-time readings and alerts. A buzzer sounds an alarm during abnormal conditions, and a linear potentiometer may simulate displacement for testing. All components share a common power and ground connection, with I2C and analog pins used for communication. The system provides real-time local alerts and can send data to the cloud for remote monitoring, making it suitable for disaster preparedness and smart environmental monitoring.

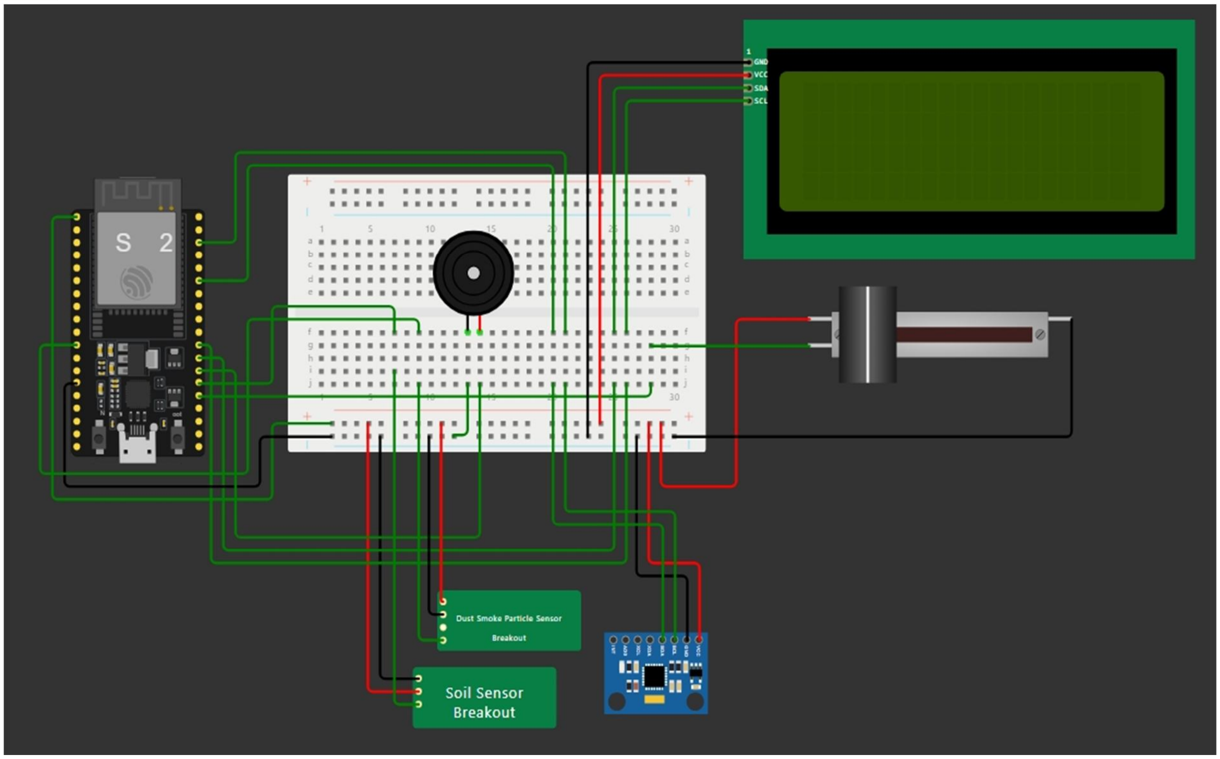

Figure- 9 Circuit Diagram.

IX. HARDWARE SPECIFICATIONS AND LIMITATIONS WITH OPERATIONAL RANGE

The Smart Earthquake Early Warning System integrates the parts and units to watch shaking ground movements and related surrounding conditions in real-time. The setup is made for quick spotting and low-energy use, making it good for placing in both cities and country side. Below is a full detail of each small part, its functions, working range, and limitations.

A. ESP-32 Microcontroller

Function: The main processing unit responsible for gathering, generating, and internal or external communication.
Operational Range: 3.0V – 3.5V, and 100 meters if using wifi. If using GSM, according to tower signal location.
Limitations: Such features are constrained to only a few controlled analog input pins with careful power control required for sensor stability.

B. Breadboard

Function: Platform to prototype and test designs electronically by interconnecting building blocks of circuits.
Limitations: Not suited for use in permanent wiring applications where damage free connections are required; allows loose connections to form over time.

C. Smoke Particle Sensor

Function: Maintains air quality and scans the presence of dust and smoke particles in the surrounding air.
Operational Range: 0 — 500 µg/m³ .
Limitations: Affected by high humidity together with a number of pollutants.

D. Soil Moisture Sensor

Function: Sensas moisture within soil enabling assessment of ground stability.
Operational Range: Up to 100% moisture in the soil marked with analog voltage output.
Limitations: Flawed protective design can lead to corrosion; must be calibrated regularly to maintain set accuracy.

E. Water Level Sensor

Function: Measures the elevation of water in the soil which can show signs for liquefaction and other effects of seismic activities.
Operational Range: 0-5 levels which are discrete based on the conducting traces used.
Limitations: Non-continuous output is supplied; the measurements will depend on the height at which the sensor is placed.

F. Accelerometer

This device senses seismic waves by detecting acceleration and three-axis motion.
Sensitivity up to 16,384 LSB/g; operational range: ±2g to ±16g.
Cons: Low-cost MEMS sensor; may not be able to precisely detect very high-frequency vibrations or microtremors.

G. Buzzer

Operational Range: 3.3V to 5V; at 10 cm.
Limitations: ineffectual in noisy locations; restricted in outdoor settings.

H. 16x2 LCD Display with I2C Interface

Function: Shows warning alerts and sensor values in real-time Limitations: Not sunlight viewable; limited character display (maximum of 32 characters).

I. Power Supply (USB/Battery)

This device gives the ESP-32 and its accessories 5V of regulated power.
Operational Range: 5V ±10%; usually powered by a Li-ion or USB 2.0 battery.
Limitations: Systems that run on batteries have a short lifespan.

X. ESTIMATED COST

The total cost of "Smart Earth Quake Early Warning System using Internet of Things" are estimate is calculated below-

Component	Unit Price (USD)	Total (USD)
ESP-32 Microcontroller	6.00	6.00
Breadboard	3.00	3.00
Dust Smoke Particle Sensor	5.50	5.50
Soil Moisture Sensor	2.00	2.00
Water Level Sensor	2.50	2.50
Accelerometer (MPU6050)	3.00	3.00
Buzzer	0.50	0.50
LCD Display (I2C 16x2)	4.00	4.00
Connecting Wires	2.00	2.00
Power Supply (USB/Battery)	3.00	3.00
Total Estimated Cost		31.50

Table 1 - Total Cost for Proposed Smart Earthquake Early Warning System circuit.

In this paper, the cost of developing the core circuit of the Smart Earthquake Early Warning System is estimated at $31, which is approximately Rs 2649 in Indian currency.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XI Nov 2025- Available at www.ijraset.com

XI. RESULTS

The results obtained in the form of a report after running the proposed circuit of the Earthquake Early Warning System are as follows -

```
ets Sept 29 2024 12:21:46
MPU6050 ready!
WiFi connected
IP address: 10.10.0.2
Air Dust: Not Detected
Water level: 0%
Moisture: WET
E (11330) ledc: ledc_get_duty(740):
LEDC is not initialized
Earthquake Alert
Sending data...
200
"Recorded!"
Air Dust: Not Detected
Water level: 0%
Moisture: WET
Earthquake Alert
Sending data...
Water level: 84%
Moisture: OK
```

Figure-10 Output Results.

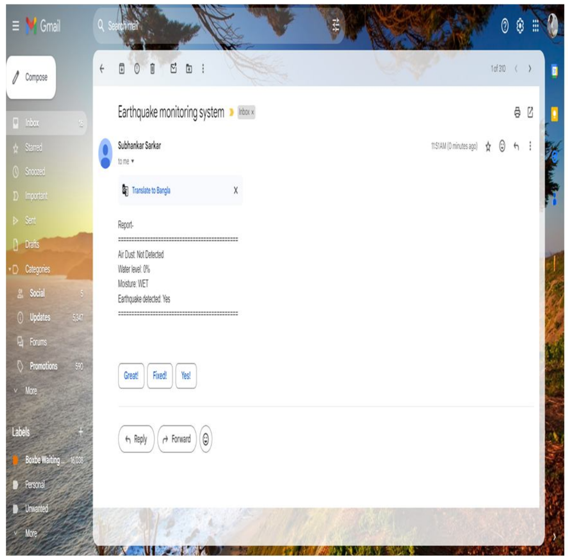

Figure-11 Email Notification alert.

A. *Result is Report Form*

Air Dust: Not Detected
Water level: 0%
Moisture: WET
Earthquake Alert
Sending data...
200
"Recorded!"
Air Dust: Not Detected
Water level: 0%
Moisture: WET
Earthquake Alert
Sending data...
200
"Recorded!"
Air Dust: Not Detected
Water level: 0%
Moisture: WET
Earthquake Alert
Sending data...

The output of the proposed Smart Earthquake Early Warning System model has been compiled into a comprehensive report. The model successfully executed its functions and provided consistent data readings. In addition, it transmitted the collected information to users at regular time intervals, with the results also being sent via email. Based on the recorded data, we can conclude the following: air dust levels remain undetected, indicating no signs of volcanic eruption; water levels are within normal parameters; moisture levels indicate wet conditions; and any detected vibrations trigger an immediate earthquake alert, which is communicated through an audible warning (buzzer).

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XI Nov 2025- Available at www.ijraset.com

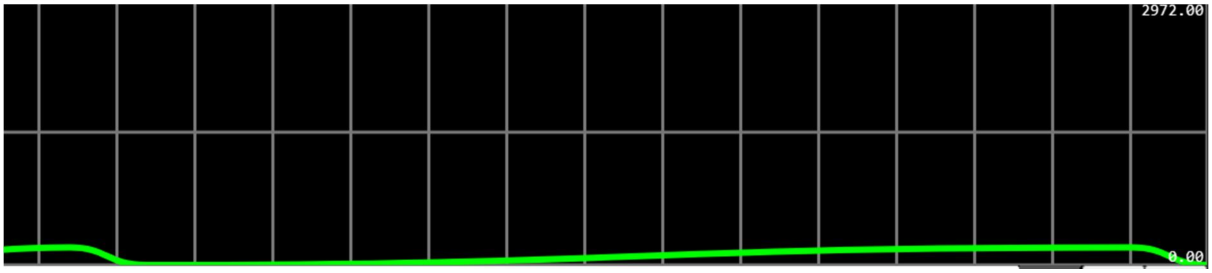

Figure-12 Water Moisture Level in Graphical View (Rockey Soil)

Graph (*Figure-15)* shows the moisture content of rocky soil in an online simulation environment using a calibrated water moisture sensor. The data shows the level of moisture is consistently low, with only roughly negligible increase over time. This is typical of rocky soil or rocky ground, which generally has very poor moisture retention, especially because rocky soil is often coarse and fragmented, rather than compacted organic material. From the stable, low moisture content values, we can reasonably deduce that, under the forged conditions of this simulation, there will be very little accumulation of moisture. This is a critical factor when assessing the possibility of geohazards that are likely to be the result of environmental conditions and soil moisture, such as landslides and earthquakes. For example, in hilly or mountainous areas, sudden increases in soil moisture will lead to instability and an increased risk of landslide; however, the data show at this moment in the simulation the soil is largely quite dry, which would indicate there is less risk involved in the environment. Then again it is important to understand that while moisture does not cause earthquakes by themselves, they often represent the gravity and influence of ground dynamics that occur when an earthquake occurs. For instance, dry rocky soil may act more freely if under stress, leading to possible ground displacement or landslide in the occasion of an earthquake.

XII. FUTURE WORK

This paper investigates the fundamental causes of seismic tremors and presents strategies for getting early caution signals utilizing progressed sensor advances. In expansion to the approaches talked about here, there are a few other methods for identifying seismic tremors and expecting characteristic fiascos. The taking after key focuses highlights a few of these methods-

1) Monitoring by Satellite: Satellites put in circle can give real-time perception of seismic action over inaccessible and earthquake-prone locales of the Soil. These frameworks are particularly profitable in regions that are blocked off to people or unacceptable for introducing ground-based sensors. In_addition, this method can be used to monitor volcanic eruptions through regular checking. In addition, it is possible to get early warning signals of earthquakes by going beyond other traditional systems.

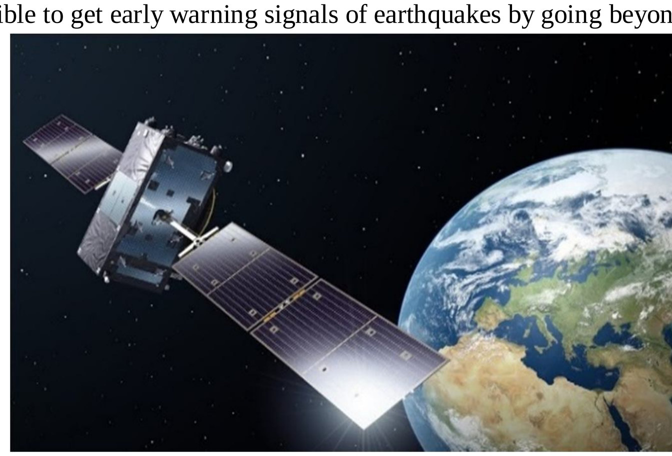
Figure – 13 Satellite Monitoring.

2) Installation of seismograph or sensor technology in the deep sea: In deep-sea situations where coordinate perception is challenging, seismometers and movement sensors can be introduced on the sea floor. These gadgets empower the location of undersea seismic tremors, advertising early notices that can offer assistance secure coastal communities from tsunamis and other related hazards.

3) Observation of Earth's interior tectonic plates: The Earths hull is composed of numerous structural plates, such as the Indian Plate and the Burma Plate. By inserting sensors profound underground, researchers can screen the developments of these plates. Varieties in their movement can serve as basic markers of potential seismic occasions, permitting for convenient expectations and readiness.

Figure-14 Plate movement.

4) Earthquake Aftershock Monitoring: The later seismic occasion highlighted the potential chance of noteworthy consequential convulsions taking after a major seismic tremor. Consequential convulsions frequently contribute to broad harm and disturbance. To superior expect these auxiliary occasions, machine learning models can be utilized to analyze complex designs inside seismic information. These models upgrade our capacity to survey the probability of post-quake tremors, advertising profitable experiences that can progress early caution frameworks and preparedness.
5) Earthquake Detection Technique: Modernizing seismic tremor discovery strategies is basic. Developing innovations such as the Web of Things (IoT), machine learning, information science, and progressed sensor systems can essentially make strides the exactness and speed of seismic tremor discovery. Real-time information collection and investigation are fundamental components of a more viable seismic tremor observing framework, empowering opportune cautions and responses.
6) The Require for Advance Inquire about and Open Awareness: In expansion to innovative progressions, advance inquire about is basic to create dependable early caution signals for seismic tremors. Numerical modeling and data-driven approaches can give modern bits of knowledge into seismic action. In addition, open mindfulness and instruction on seismic tremor readiness are vital. Analysts and teach must prioritize continuous considers, especially in high-risk ranges, and guarantee that their discoveries are deciphered into viable applications. This term paper was created with these objectives in to offer assistance minimize harm and spare lives amid seismic fiascos.

XIII.CONCLUSION

This is the first research paper that takes a Smart Earthquake Early Warning System with IoT technology-integrated approach toward minimizing damage caused by earthquakes and earthquake-related natural calamities. The system encompasses the multi-sensor deployment framework with accelerometers, water moisture, dust and smoke particle, and water level sensors for real-time monitoring pertaining environmental changes monitoring with respect to earthquake.

The wires for the sensors are distributed on various terrains and high-risk zones for collecting data. The microcontroller ESP32 is capable of processing the received data locally and is capable of wireless communication with the IoT servers hosted in cloud. The parameters which have to be observed are ground vibrations, soil moisture increase, water level elevation, and smoke emission. In case of anomalies in any of these values, the system is capable of issuing alerts. With the various capabilities offered by Amazon SES, the notifications can reach the users through more than one platform which includes emails, SMS, and monitoring systems. Widespread notice enables people, societies, and governing bodies to act instantly.

Moreover, the system is set up to detect additional hazards including landslides and tsunamis. In hilly areas, greater soil moisture poses a greater risk for landslides to occur and tsunami triggering factors consist of rapid changes in sea level. Specialized sensors to monitor these events can greatly mitigate their impacts through early detection. The dust and smoke particle detectors also help diagnose the onset of volcanic activity by monitoring particles and gases released to the atmosphere prior to an eruption.

In the scope of this study, the implementation of IoT along with the sensor networks clearly depicts the possibility of foreseeing volcanically eruptions or providing sufficient warning time. Although still at the initial model stage, this research showcases the possibilities of using modern technological innovations in disaster prevention and mitigation. For the next phases, improvements will be made in conjunction with the wider network of sensors and build them into local systems along with other regional disaster response systems.

XIV. ACKNOWLEDGMENTS

First of all, I thank and gratitude to my respected parents, as they have given me encouragement and other support to write this paper. Secondly, I would like to thank the Dept of CSE - MAKAUT. Haringhata, Nadia, W.B. lastly thanks to the Department of Disaster Management and Civil Defence – Murshidabad, W.B. Govt. of West Bengal and Govt. of India. as the northeastern region of our country is earthquake-prone. And a member of the Disaster Management Civil Defence Department. This is why we always have to be prepared to face earthquakes or any such natural or manmade calamities. Therefore, early warning signals can be received and measures can be taken to deal with natural disasters like earthquakes. Chances of loss of life and property are reduced. That's why I tried to show this work using this online simulator platform. Finally, if this research work of mine is of any use in dealing with natural calamities like earthquakes in my country, then I think that work will be worthwhile.

A. Declaration

1) Funding: Smart Earthquake Early Warning System Using Internet of Things As the main work in this research paper is done by the author. Here no grant or funding money of any kind has been used or required for the preparation of this manuscript.
2) Competing Interest: The author has no financial or non-financial interest in publishing the manuscript titled Smart Earthquake Early Warning System Using Internet of Things.

REFERENCES

[1] P. P. Ray, M. Mukherjee and L. Shu, "Internet of Things for Disaster Management: State-of-the-Art and Prospects," in IEEE Access, vol. 5, pp. 18818-18835, 2017, doi: 10.1109/ACCESS.2017.2752174.

[2] Prasad, R. C., Mahajan, R., & Priyadarshini, R. (2019). Earthquake Early Warning System (EEWS). International Research Journal of Engineering and Technology (IRJET), 09 | Sep 2019, 383–384. https://www.irjet.net

[3] Pandey, N., Rao, K. H. S., Seshank, V., Pokala, S., & Sunil, A. T. (2021). EARTHQUAKE ALERT SYSTEM BASED ON IOT TECHNOLOGY. Journal of Emerging Technologies and Innovative Research (JETIR), 8(5). https://www.jetir.org/papers/JETIR2105384.pdf

[4] Chen, F., Shieh, H., & Tu, J. (2023b). Development of earthquake detection and warning system based on sensors. Sensors and Materials, 35(4), 1211. https://doi.org/10.18494/sam4116

[5] Pierleoni, P., Concetti, R., Marzorati, S., Belli, A., & Palma, L. (2023). Internet of Things for Earthquake Early Warning Systems: A performance comparison between communication protocols. IEEE Access, 11, 43183–43194. https://doi.org/10.1109/access.2023.3271773

[6] Pierleoni, P., Concetti, R., Marzorati, S., Belli, A., & Palma, L. (2023b). Internet of Things for Earthquake Early Warning Systems: A performance comparison between communication protocols. IEEE Access, 11, 43183–43194. https://doi.org/10.1109/access.2023.3271773

[7] Alphonsa A. and Ravi G., "Earthquake early warning system by IOT using Wireless sensor networks," 2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), Chennai, India, 2016, pp. 1201-1205, doi: 10.1109/WiSPNET.2016.7566327.

[8] Abdalzaher, M., Krichen, M., Yiltas-Kaplan, D., Dhaou, I. B., & Adoni, W. (2023). Early detection of earthquakes using IoT and Cloud Infrastructure: A survey. Sustainability, 15(15), 11713. https://doi.org/10.3390/su151511713

[9] Kafadar, Ö., Tunç, S., & Tunç, B. (2024). ESenTRy: an on-site earthquake early warning system based on the instrumental modified Mercalli intensity. Earth Science Informatics, 17(5), 5027–5041. https://doi.org/10.1007/s12145-024-01407-2

[10] Abdalzaher, M. S., Elsayed, H. A., Fouda, M. M., & Salim, M. M. (2023). Employing machine learning and IoT for earthquake early warning system in smart cities. Energies, 16(1), 495. https://doi.org/10.3390/en16010495

[11] Akhavan, M., Rashvand, P., & Razzaghi, M. S. (2024). AN IOT-BASED EARTHQUAKE EARLY WARNING SYSTEM WITH FUZZY LOGIC FOR UTILITY CONTROL IN TEHRAN. Architecture and Engineering, 9(4), 49–64. https://doi.org/10.23968/2500-0055-2024-9-4-49-64

[12] IoT-Based Seismic Sensor Network Design for Early Warning System in Kalimantan: Literature review. (2024). In Journal of Computation Physics and Earth Science (Vols. 4–4, Issue 2, pp. 39–46). https://journal.physan.org/index.php/jocpes/index

[13] Arunkumar A, Shyam Joseph A, Manikandan P S, Jayasudhakar J "Earthquake Early Warning System By IOT Using Wireless Sensor Networks" Iconic Research And Engineering Journals Volume 2 Issue 10 2019 Page 41-44.

[14] Nandy, M., Dubey, A., & Kalinga University. (2024). Innovative earthquake warning system for enhancing public health prevention. In SEEJPH [Journal-article].

[15] Prakash, G., Chandra, M., & Shivanesh. (2025). Earthquake Detection and Autonomous Activation of Safety Systems with Integration of GPS technology. In International Current Journal of Engineering and Science (ICJES), International Current Journal of Engineering and Science (ICJES) (Vol. 4, Issue 1, pp. 26–29). https://doi.org/10.47001/ICJES/2025.401004

[16] Awadallah, S., Moure, D., & Torres-González, P. (2019). An internet of things (IoT) application on volcano monitoring. Sensors, 19(21), 4651. https://doi.org/10.3390/s19214651

[17] Kumar, M. (2023, May 18). Earthquake early warning system by IOT using wireless sensor networks. Aeologic News. https://www.aeologic.com/news/earthquake-early-warning-system-by-iot-using-wireless-sensor-networks/
[18] Earthquake Definition, Causes, Effects, & facts. Encyclopedia Britannica: https://www.britannica.com/science/earthquake-geology.
[19] Tutorials Point. (2025, March 25). ESP32 for IoT Introduction. https://www.tutorialspoint.com/esp32_for_iot/esp32_for_iot_introduction.htm
[20] Shahid, M. (2022, March 3). water level sensor | Water Level Sensor working | Water level detector. Techatronic. https://techatronic.com/what-is-water-level-sensor-working-explanation-of-water-level-sensor/
[21] What is a breadboard? (n.d.). ttps://hibp.ecse.rpi.edu/~connor/education/breadboard.pdf
[22] Soil moisture Sensor: PIN configuration, working and applications. ElProCus - Electronic Projects for Engineering Students. https://www.elprocus.com/soil-moisture-sensor-working-and-applications/
[23] Buzzer: Working, Types, circuit, Advantages & Disadvantages. ElProCus - Electronic Projects for Engineering Students. https://www.elprocus.com/buzzer-working-applications/
[24] Application note of Sharp dust sensor GP2Y1010AU0F. In Attachment-1 (pp. 1–6). https://global.sharp/products/device/lineup/data/pdf/datasheet/gp2y1010au_appl_e.pdf
[25] Wokwi - World's most advanced ESP32 Simulator. (n.d.). https://wokwi.com/
[26] Rosca, C., & Stancu, A. (2024). Earthquake Prediction and alert system using IoT infrastructure and Cloud-Based environmental data analysis. Applied Sciences, 14(22), 10169. https://doi.org/10.3390/app142210169
[27] Abdalzaher, M. S., Elsayed, H. A., Fouda, M. M., & Salim, M. M. (2023). Employing machine learning and IoT for earthquake early warning system in smart cities. Energies, 16(1), 495. https://doi.org/10.3390/en16010495
[28] Abdalzaher, M., Krichen, M., Yiltas-Kaplan, D., Dhaou, I. B., & Adoni, W. (2023). Early detection of earthquakes using IoT and Cloud Infrastructure: A survey. Sustainability, 15(15), 11713. https://doi.org/10.3390/su151511713
[29] Saini, K., & Kalra, S. (2021). IoT-based earthquake prediction using fog and cloud computing. AIJR Proceedings, 201–207. https://doi.org/10.21467/proceedings.114.28

AUTHORS DETAILS

Mr. Subhankar Sarkar, Corresponding Author - B.Tech & M.Tech in CSE, B.ED - Pedagogy of Mathematics. A.D.F.M. & P.G.D.F.S.E – (Fire & Safety). Presently Ph.D. Enrolled at - Dept. of CSE, M.A.K.A.U.T- Simhat, Haringhata, Nadia, W.B. India. and Member, Disaster Management and Civil Defence - Murshidabad, West Bengal, India. Research Interest- Internet of Things, Cloud Computing, Machine learning, Disaster Management. Email- elinksuvankar.sarkar@gmail.com