INTELLIGENT DISASTER MANAGEMENT SYSTEM USING IOT AND CLOUD-CONNECTED MOBILE APPLICATIONS

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Abstract: Natural disasters such as floods, earthquakes, landslides, and cyclones pose significant threats to human life and infrastructure. Traditional disaster management systems often lack real-time responsiveness and efficient communication, which are critical during emergencies. To address these limitations, this project proposes an Intelligent Disaster Management System that leverages Internet of Things (IoT) technologies and cloud-connected mobile applications to detect, monitor, and communicate disaster-related information in real time. The system integrates a variety of environmental sensors including ultrasonic sensors for flood level detection, vibration sensors for seismic activity, accelerometers for landslide monitoring, and anemometers for measuring wind speed. These sensors are interfaced with microcontrollers (e.g., Arduino Mega 2560 and ESP8266) that collect and transmit data via Wi-Fi and GSM networks to a centralized cloud platform. This enables continuous monitoring of affected areas, even in remote or low-infrastructure locations. The cloud platform processes and stores the sensor data, which is then visualized and made accessible through a mobile application. The app provides early warnings, live alerts, and critical instructions to both users and rescue authorities. SMS alerts are automatically triggered in high-risk zones using the GSM module to ensure communication is maintained even when internet access is unavailable. The system also supports a broadcast feature to inform nearby populations via radio or loudspeakers. By combining real-time sensor data, automated alerts, and mobile connectivity, the proposed solution enhances situational awareness and response efficiency. This project demonstrates a scalable, low-cost, and intelligent approach to disaster preparedness, capable of saving lives by reducing response time and improving coordination between agencies and civilians during emergencies.

IndexTerms - IoT, Real-time Monitoring, Arduino Embedded System, Remote data Acquisition.

I. INTRODUCTION

Disasters—whether natural, such as earthquakes, floods, and wildfires, or man-made, including industrial accidents and terrorist attacks—pose significant threats to human lives, infrastructure, and economic stability. Traditional disaster management systems often rely on manual reporting, delayed data analysis, and fragmented communication channels, leading to inefficient response efforts. In many cases, critical decisions are made based on incomplete or outdated information, exacerbating the impact of disasters. The increasing frequency and severity of such events, compounded by climate change and urbanization, demand a paradigm shift toward smarter, faster, and more reliable disaster management solutions. Emerging technologies such as the Internet of Things (IoT), cloud computing, and mobile applications offer unprecedented opportunities to revolutionize how disasters are predicted, monitored, and managed.

The integration of IoT-based sensor networks enables real-time data collection from diverse environmental parameters, including seismic activity, water levels, temperature, and air quality. These sensors, deployed in high-risk zones, continuously transmit data to a cloud based analytics platform, where machine learning algorithms process and interpret the information to generate early warnings, predict disaster trajectories, and assess potential damage. Unlike conventional systems that react to disasters after they occur, this intelligent framework adopts a proactive approach, identifying risks before they escalate into full-blown crises. Additionally, cloud computing ensures scalability, allowing the system to handle massive data streams from thousands of sensors while maintaining high availability even during peak disaster scenarios.

To bridge the gap between data and actionable response, cloud-connected mobile applications play a pivotal role in disseminating critical information to both emergency responders and the general public. First responders receive real-time situational updates, optimized resource allocation recommendations, and coordination tools through dedicated applications. Meanwhile, civilians can access personalized emergency alerts, evacuation routes, and crowd sourced incident reports, fostering a collaborative disaster response ecosystem. By unifying IoT, cloud intelligence, and mobile technology, this system enhances disaster resilience, reduces response times, and minimizes casualties and economic losses. The ultimate goal is to create an adaptive, intelligent disaster management infrastructure that not only reacts to emergencies but also anticipates and mitigates them, safeguarding communities in an increasingly unpredictable world.

II. Literature Review

Sharma et al [1] article describes the advanced technology Internet of things (IOT) visualizes a worldwide, that is, internally connected, networks of smart physical entities. IOT is a promising technology used in several applications including disaster management. In disaster management, the role of IOT is so important and ubiquitous and could be life-saving. Is article describes the role of IoT in disaster management. More precisely, it presents IOT- based disaster management for different kind of disasters with a comparison between some solutions that are available in the market.

Sinha et al [2] article describe the disaster management aims to mitigate the potential damage from the disasters, ensure immediate and suitable assistance to the victims, and attain effective and rapid recovery. These objectives require a planned and effective rescue operation post such disasters. Different types of information about the impact of the disaster are, hence, required for planning an effective and immediate relief operation. The IoT technology available today is quite mature and has the potential to be very useful in disaster situations. This paper analyses the requirements for planning rescue operation for such natural disasters and proposes an IoT based solution to cater the identified requirements.

Ray et al [3] article describe the occurrence of disasters has the potential to impede the progress of sustainable urban development. For instance, it has the potential to result in significant human casualties and substantial economic repercussions. Sustainable cities, as outlined in the United Nations Sustainable Development Goal 12, prioritize the objective of disaster risk reduction. According to the Gesi Smarter 2030, the Internet of Things (IoT) assumes a pivotal.

Zeng et al [4] article describe the natural disasters are becoming more frequent and more severe as a result of global warming. It is critical to take precautions before disasters, to gather and analyze information simultaneously while they are happening, and to make accurate assessments after them given that the deaths and injuries brought on by such disasters both leave lasting traumas in the life of society and damage the economy. Internet of Things (IoT) technology is a young field that can assist intelligent safety-critical systems with data collection, processing in cloud edge data centers, and application of prediction methodologies for discovering key points and unexpected patterns using 5G technology.

Ozen et al [5] article describe the disasters are the most vulnerable factors which are affecting the human life and environment. Smart cities are mainly affected by disasters. This shows the requirement of an efficient disaster management system in smart cities. This paper deals with disaster management technique used in smart cities to detect disasters like building fire, pollution in atmosphere, route blockage using Big Data Analysis and Internet of Things (IoT).

Ali et al [6] article describe the disasters are uncertain occasions that can impose a drastic impact on human life and building infrastructures. Information and Communication Technology (ICT) plays a vital role in coping with such situations by enabling and integrating multiple technological resources to develop Disaster Management Systems (DMSs). In this context, a majority of

the existing DMSs use networking architectures based upon the Internet Protocol (IP) focusing on location-dependent communications. However, IP-based communications face the limitations of inefficient bandwidth utilization, high processing, data security, and excessive memory intake.

Abkenar et al [7] article describe the advancements in IoT technology have been instrumental in the design and implementation of various ubiquitous services. One such design activity was carried out by the authors of this paper, who proposed a novel cloud-centric IoT-based disaster management framework and developed a multimedia-based prototype that employed real-time geographical maps. The multimedia-based system can provide vital information on maps that can improve the planning and execution of evacuation tasks. This study was intended to explore the acceptance of the proposed technology by the specific set of users that could potentially lead to its adoption by rescue agencies for carrying out indoor rescue and evacuation operations.

Yun et al [8] article describe the disaster management systems require accurate disaster monitoring and prediction services to reduce damages caused by natural disasters. Digital twins of natural environments can provide the services for the systems with physics-based and data driven disaster models. However, the digital twins might generate erroneous disaster prediction due to the impracticability of defining high-fidelity physics-based models for complex natural disaster behaviour and the dependency of datadriven models on the training dataset.

Damasevicius et al. [9] article describe this paper aims to analyse how emerging technologies (ETs) impact on improving performance in disaster management (DM) processes and, concretely, their impact on the performance according to the different phases of the DM cycle (preparedness, response, recovery and mitigation). Design/methodology/approach – The methodology is based on a systematic review of the literature. Scopus, ProQuest, EBSCO and Web of Science were used as data sources, and an initial sample of 373 scientific articles was collected.
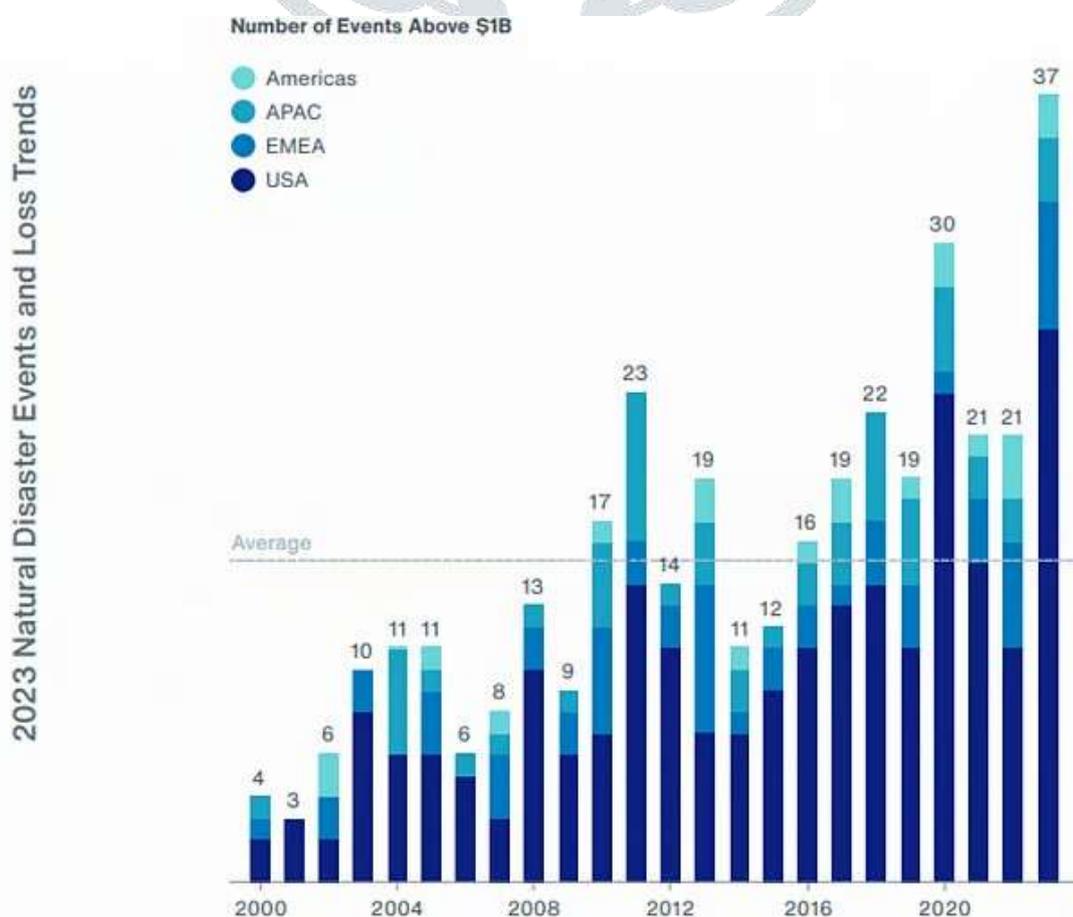

Fig.2.1: Natural Disaster Events and Loss Trends for the year 2023(https://www.downtoearth.org.in)

The gap in insurance coverage for losses due to natural disasters demands attention in view of the number of large-loss natural hazard events, popularly termed as "billion dollar events" that reached record levels in 2023.

According to the report, in 2023 insurance only covered 40 per cent of losses caused by weather and climate change.

Earthquakes caused the most economic losses, but the SCS were most costly to insurers. In the US, there were at least 47 SCS, with insurance covering over 67 per cent of the total economic damage. For the first time ever, insured losses from the SCS surpassed $50 billion, and the preliminary figure is expected at $58 billion, up from the previous high of $44 billion set in 2020.

Severe convective storms are convective systems that are associated with extreme phenomena such as tornadoes, hail, heavy precipitation (rain or snow), strong winds, and lightning. As SCS-related economic and insured losses continue to increase, understanding the drivers behind this is crucial for insurers suggested.

The intensity of tropical cyclones is increasing more quickly, staying at their peak over extended periods of time, and intensifying closest to the landfall point. This is a concerning pattern that points to greater losses for the risk in the future, said the report.

Although, since 2000, severe convective storms and tropical cyclones have been the two most expensive occurrences for insurers overall, it is expected that SCS will overtake in the years to come.

These findings may worry insurers in the US who are already planning to cut out damage caused by hurricanes, wind and hail from policies underwriting property along coastlines and in wildfire country.

List of major natural disasters that have occurred over the last 20 years in India

Table 2.1:Statistical Comparison of Disaster Management[https://www.atlas-mag.net/en]

| Date	Place	Nature of the event	Economic losses	Insured losses	Number of fatalities	Number of affected persons
			(in billion USD)			
May 2020	West Bengal	Hurricane Amphan	13.5	ND	103	500 000 homeless
August 2018	Kerala	Floods	3.52	0.37	504	223 139 homeless
November 2015	Chennai (Tamil Nadu)	Floods	2.37	0.98	289	-
April 2015	Himalaya	Storm	-	-	78	20 000 injured
October 2014	Andhra Pradesh	Storm	7.56	0.68	68	43 injured
September 2014	Jammu and Kashmir	Floods	6.45	0.26	665	-
June 2013	Uttarranchal	Floods	1.21	0.55	5 748	4 473 injured 271 931 homeless
September 2009	Andhra Pradesh	Floods	5.63	0.06	300	2 000 000 homeless
August 2006	Gujarat	Floods	4.3	0.52	350	4 000 000 homeless
July 2005	Maharashtra	Floods	4.36	0.93	1 150	15 000 homeless
January 2001	Gujarat	Earthquake	6.13	0.14	19 737	166 850 injured 1 790 000 homeless

III. Methodology
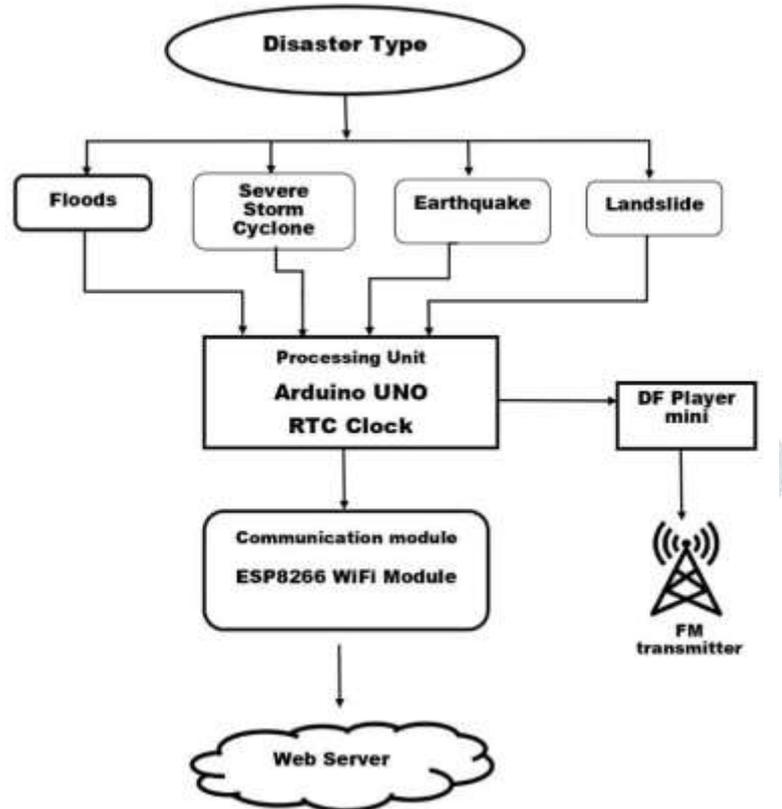
Fig.3.1: Detection of Disaster and Public Notification

The proposed disaster management system is designed to intelligently monitor environmental changes using a network of IoT sensors connected to an Arduino Mega microcontroller. The system includes a combination of ultrasonic sensors for water level detection, vibration sensors for seismic activity, anemometers for wind speed, and accelerometers for movement and tilting, which can be indicative of landslides or earthquakes. These sensors continuously collect environmental data and feed it into the Arduino Mega for processing.

Each sensor is connected and powered according to its requirements. The ultrasonic sensor determines the water level in rivers or tanks to detect possible floods, while the vibration sensor identifies sudden ground tremors, signaling potential earthquakes. The accelerometer tracks movement or shifting of the installation area, and the anemometer monitors wind speeds that may indicate storms or cyclones. Additionally, the system integrates a Real-Time Clock (RTC) module to accurately timestamp each data reading, ensuring the records are time-sensitive and useful for historical analysis.

The Arduino Mega serves as the central controller that collects and processes all sensor data. It checks whether any sensor reading exceeds predefined safety thresholds that indicate the onset of a disaster. If such conditions are met, the Arduino initiates local alerts using a DF Player Mini to play warning audio messages via a speaker. Simultaneously, the GPS module fetches the current location of the device, which is crucial for alerting specific regional authorities or residents [10].

For communication with the cloud or a mobile application, the system utilizes an ESP8266 Wi Fi module. The ESP8266 is responsible for transmitting the sensor data, along with the timestamp and GPS location, to a remote server or cloud database. This data is then analyzed and displayed on a dashboard or mobile application, and real-time alerts (such as SMS or push notifications) are sent to users in the affected area. This ensures both on-site and remote awareness of potentially hazardous conditions.

This integrated approach allows for fast, automated, and localized disaster detection and alerting, making the system highly effective for early warning and response. By combining sensor data with cloud-based processing and mobile connectivity, the system offers a scalable and cost-effective solution for disaster-prone regions. It not only aids in saving lives through timely alerts but also builds a foundation for data-driven disaster preparedness in the long run.

The intelligent disaster management system is designed to detect and respond to a variety of natural disasters including floods, severe storms, cyclones, earthquakes, and landslides. The system architecture is structured in a modular format that begins with

identifying the type of disaster using appropriate sensors connected to a central processing unit. Each disaster type— such as rising water levels for floods, high wind speeds for storms, ground vibrations for earthquakes, and land shifts for landslides—is monitored using dedicated sensors interfaced with a microcontroller.

At the heart of the system is the processing unit, which consists of an Arduino UNO microcontroller paired with an RTC (Real-Time Clock) module. The RTC ensures that all sensor readings are accurately timestamped, which is critical for analyzing the timing and progression of disaster events. The Arduino receives inputs from the various disaster-detecting sensors and evaluates the conditions against predefined thresholds. If the sensor data crosses these thresholds, the Arduino classifies the type and severity of the disaster in real time.

Once a disaster is detected, the system triggers two forms of alert mechanisms. The first is a local audio alert through a DF Player Mini that plays pre-recorded safety messages or sirens via a speaker. The second mechanism is the FM transmitter antenna, which can broadcast emergency alerts over FM radio to reach a wider audience in areas with poor internet connectivity. This dual-alert system ensures that affected individuals are informed quickly and effectively.

In addition to local alerts, the system is equipped with a communication module—the ESP8266 Wi-Fi module—that transmits the disaster data, including type, timestamp, and possibly location, to a remote web server. This enables real-time monitoring of disaster events through an online dashboard, which can be accessed by emergency response teams, government officials, or the general public through a mobile app or browser. This cloud-based communication enhances the scalability and responsiveness of the system.

By integrating local detection, audio/FM alerting, and cloud-based communication, the system ensures a comprehensive and intelligent disaster management solution. It not only helps in minimizing the impact of natural disasters through timely warnings but also creates a digital record of events for future preparedness and analysis. This methodology demonstrates a low cost, scalable, and community-oriented approach to disaster resilience using IoT and wireless technologies.
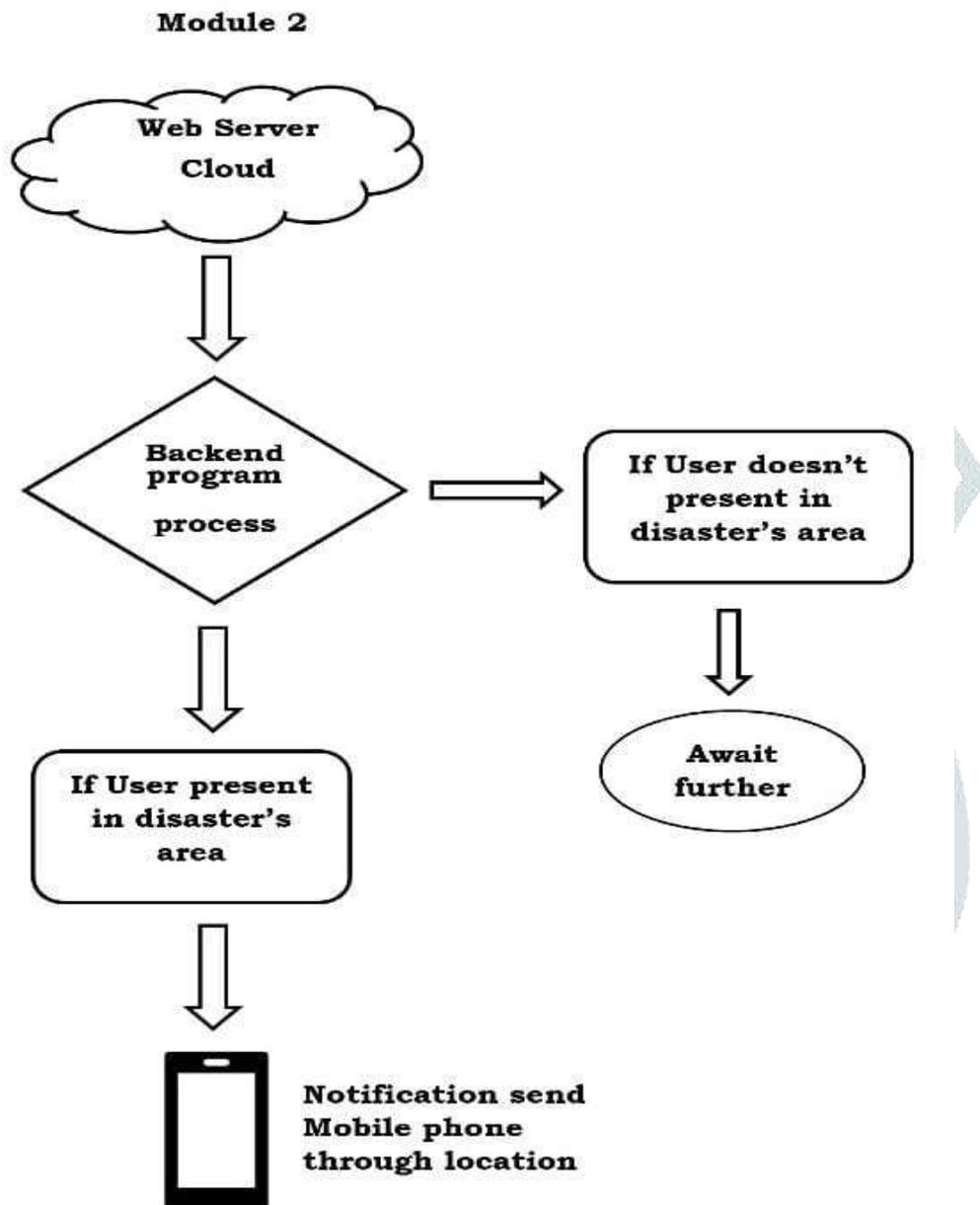
Fig.3.2: Server Side Work Flow

Module 2 of the disaster management system focuses on cloud-based user alerting using real time location analysis and automated notification mechanisms. After sensor data is collected and processed by the Arduino-based hardware in Module 1, the information is sent to a Web Server or Cloud platform via the ESP8266 Wi-Fi module. The cloud acts as a central repository for all incoming disaster data, storing and managing it for analysis and action.

Once the data reaches the cloud, a backend program (typically written in a server-side language such as Node.js, Python, or PHP) processes it. This program performs a critical function: it cross-references the disaster event's GPS coordinates with a user database that contains registered users' locations. Each user's location, provided during registration or updated periodically via a mobile app, is used to check whether they fall within the affected disaster zone.

If a user is not located in the disaster-prone area, the system awaits further events and refrains from taking any unnecessary action. This filtering avoids spamming unaffected users and ensures system efficiency. On the other hand, if a user is found to be within the radius of danger, the backend logic flags the event for immediate notification. The location-based filtering ensures that only users who are at risk receive alerts.

The system then automatically sends notifications to the mobile devices of users within the disaster area. These alerts may include the type of disaster detected, its severity, location details, and safety instructions. The notification system may use SMS, push notifications, or voice alerts, depending on the setup and integration with communication APIs or services like Twilio or Firebase Cloud Messaging.

This module ensures a targeted, real-time disaster response system that prioritizes user safety through intelligent backend processing and precise geo-location-based notification delivery. It significantly enhances the responsiveness of disaster management efforts by minimizing delay between detection and alert, while also reducing false alarms for users outside the risk zone.

IV. RESULTS AND DISCUSSIONS

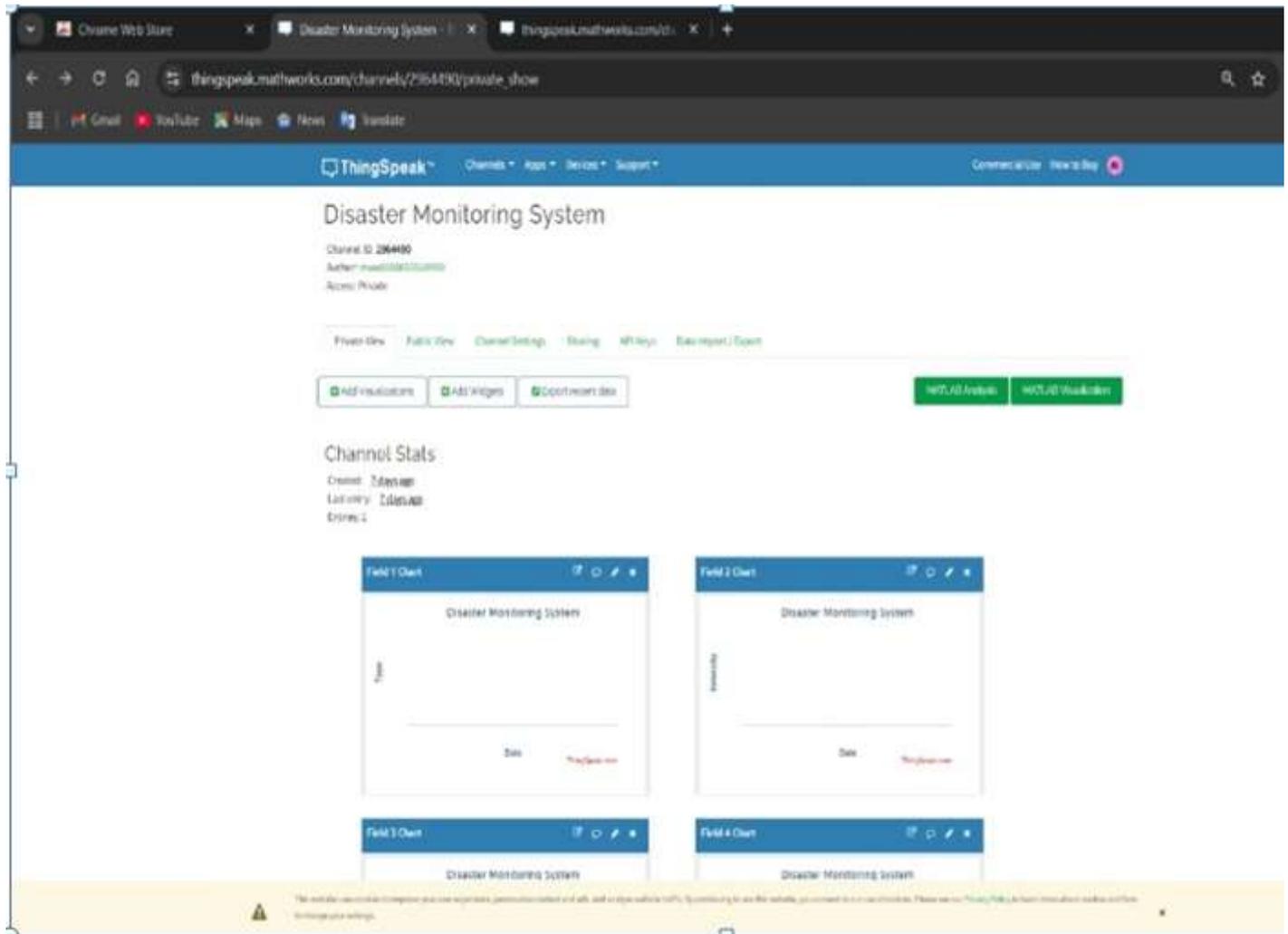**Fig.4.1: Working Model of Disaster Detection**

Fig.4.2:Real-Time Data Logging via Serial Monitor

The development of the Intelligent Disaster Management System using IoT and cloud connected mobile applications has demonstrated significant advancements in disaster detection, response, and preparedness. By integrating various IoT sensors, such as accelerometers for earthquake detection, vibration sensors, and environmental sensors for floods and landslides, the system can monitor real-time data across multiple disaster-prone areas. These sensors continuously gather critical data, which is then sent to a cloud-based server for storage and analysis. This allows for accurate tracking of ongoing and past disaster events, as well as predictive modeling for future risks [11].

The cloud infrastructure plays a crucial role in the system's scalability, enabling the storage of vast amounts of data from IoT sensors and supporting a growing number of users. This centralized data management ensures that historical records and real-time disaster data are easily accessible for decision-makers, authorities, and emergency responders. The system's cloud connectivity also facilitates the synchronization of all connected devices, ensuring seamless data flow between the sensors, server, and mobile application [12][13].

The mobile application, connected to the cloud, serves as the interface for end-users, providing them with real-time alerts, disaster notifications, and location-specific information. Users can register, log in, and receive instant updates about disasters occurring in their vicinity. The app is designed to improve situational awareness, helping users make informed decisions during emergencies. Furthermore, the mobile platform enhances public safety by enabling individuals to quickly share their locations and receive assistance when needed.

Overall, this intelligent disaster management system has the potential to save lives and reduce damage during natural disasters by providing timely alerts, historical data, and actionable insights. Its integration of IoT technology for real-time monitoring, cloud computing for data management, and mobile applications for user interaction creates a powerful tool for disaster response and preparedness; ensuring communities are better equipped to handle emergencies.

V. CONCLUSION AND FUTURE WORK

5.1. CONCLUSION

The development of an Intelligent Disaster Management System using IoT and cloud connected mobile applications represents a major step forward in modernizing how we detect, respond to, and recover from natural disasters. By integrating real-time monitoring through IoT sensors with the scalability and accessibility of cloud computing and mobile platforms, this system provides a fast, accurate, and efficient method of managing emergencies. It enables authorities to collect and analyse disaster-related data as events unfold, and issue timely alerts to potentially affected individuals, helping to minimize loss of life and damage to property.

In conclusion, the Intelligent Disaster Management System offers a comprehensive, innovative solution to the challenges posed by natural disasters. It combines the strengths of IoT, cloud computing, and mobile technology to create a real-time, scalable, and user-centric platform for disaster detection, alerting, and response. As climate change and urbanization continue to increase the frequency and impact of disasters, such systems will become essential tools for safeguarding lives and building resilient communities.

5.2. FUTURE WORK

The Intelligent Disaster Management System, while already effective, presents numerous opportunities for future enhancement and expansion. One promising area is the integration of artificial intelligence (AI) and machine learning (ML) algorithms to analyse sensor data and predict disasters with higher accuracy. These technologies can help identify patterns in historical data, enabling predictive modelling that forecasts disasters before they occur, thus improving early warning systems and proactive response strategies.

Lastly, future work should explore government and community integration, allowing authorities to coordinate better with citizens and emergency services through a unified platform. Establishing partnerships with local disaster management agencies and global humanitarian organizations will help scale the system for regional, national, or even international disaster preparedness and response. These future improvements will strengthen the system's ability to save lives and reduce the impact of disasters globally.

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