INTERNATIONAL RESEARCH JOURNAL OF
MULTIDISCIPLINARY TECHNOVATION

Asian Research Association

DOI: 10.54392/irjmt24311

IoT-Enabled Flood Monitoring System for Enhanced Dam Surveillance and Risk Mitigation

C. Thirumarai Selvi [a,*], R.S. Sankara Subramanian [b], M. Muthu Krishnan [c], P. Gnana Priya [d]

[a] Department of Electronics and Communication Engineering, Sri Krishna College of Engineering and Technology, Coimbatore-641008, Tamil Nadu, India

[b] Department of Mathematics, PSG Institute of Technology and, Applied Research, Coimbatore-641062, Tamil Nadu, India

[c] Department of Mechanical Engineering, Christ The King Engineering College, Coimbatore-641104, Tamil Nadu, India

[d] Department of Electrical Communication Engineering, Kalaignarkarunanidhi Institute of Technology, Coimbatore- 641114, Tamil Nadu, India

* Corresponding Author Email: thirumaraiselvi@skcet.ac.in

DOI: https://doi.org/10.54392/irjmt24311

Received: 11-03-2024; Revised: 28-04-2024; Accepted: 05-05-2024; Published: 13-05-2024

Check for updates

Abstract: According to the Indian scenario, the majority of reservoirs for holding water are operated independently, which is problematic when there are crises (abnormal inflow, cloudy conditions), which causes the surrounding communities and agricultural areas to be submerged those aquifers. Due to the vast geographic region and depth, it is challenging to manually measure the essential reservoir life metrics. Therefore, this research work suggests a cutting-edge system of reservoir management that includes sensors that are appropriate for measuring variables such as pressure, water level, outflow velocity, inflow velocity, tilt, vibration, etc. The Arduino Uno integrates all of the sensors, and Microsoft Power BI receives the data in real time, where each parameter is shown in an appropriate format for visualization. In case of an emergency water level rise, the alarm is set off. The procedure begins with the collection of data from sensors and concludes with the presentation of that data on a dashboard in a control room situated in a distant place that links to a website where the relevant information can be seen by visitors.

Keywords: Flood monitoring, Internet of Things, Risk mitigation, Arduino, Thing Speak.

1. Introduction

A dam is a physical obstruction that limits water movement. Dams can be used for a variety of purposes, including storing water, distributing it evenly among different areas, generating electricity through hydropower, preventing floods, and modifying water flow. The dam's water is clear utilised for aquaculture, industrial use, human consumption, and irrigation. The oldest known dam dates back to 3000 BC. Dams can be classified according to their size, use, structure, and material. A dam's failure might be disastrous. Gujarat was the scene of India's biggest dam failure, which claimed 2000 lives. Bad maintenance, earthquakes, heavy rains, poor design, insufficient capacity, and instability brought on by water level variations are some of the potential reasons of dam failure.

The majority of Dams are managed manually, which requires extensive work and occasionally produces inaccurate statistics. Therefore, a cutting-edge dam management system is suggested in accordance with the Indian context and illustrates many crucial dam factors in order to overcome these. The information on the website, which includes details such Status of the dam gate, sensor, water level, and gate control, causes the alert sensor to activate when the control system of floodgates and emergency volume of water rises is used. Following data gathering, the data is shown within the dashboard in the nearby control room using the appropriate visualisations. Residents of the adjacent locations will receive a warning message in the event of alarming conditions.

Together, sensor, network, and computer technologies are developing as demand for integrating information systems with the physical world rises. By connecting sensors to the Internet, a technology known as "Internet of Things" enables sensors to develop intelligence. This makes it possible for sensors to talk to one another. All technologies generate a large amount of data, which need enormous data storage. Large volumes of data could be stored online thanks to the cloud, a technology that is gaining popularity as part of the Internet of Things. The sensors collect information by way of the dam and surrounds.

All information is provided to adaptive controller. The use of microcontroller automatically operates the entire system aids in lowering the complexity of the system's design and control. The system's back end gathers parameter data from the relevant sensors, then uploads the data to the database. In order to host web portals and make other decisions, the leaked data is examined. The suggested method utilizes the Internet of Things (IoT), making data exchange over an online database possible. Signals generated by the analysis of the database of sensor information are delivered to the dam control station.

Floods are among the most common natural disasters in the globe. Flood management is an integral component of governance in flood-prone areas and countries. The need to continuously assess and analyze adverse or ambient environmental conditions in real time necessitates the development of a monitoring system capable of detecting floods in advance. Mohammed *et al.*,[1] discusses various Internet of Things (IoT)-based techniques and applications used for efficient flood monitoring and an early warning system. It is observed that in the future, combining IoT and Synthetic Aperture Radar (SAR) data may be useful in developing robust and secure flood monitoring and early warning systems that provide effective and efficient mapping during natural disasters. Various sensors collect the vital sign of flood, then machine learning techniques are applied over the datas and forecast floods by analyzing fluctuating trends in climate variables, such as temperature, moisture, and rainfall. Water reservoir or dam damages limits the following victims: water management, water resource allocation, flood alert and forecasting. An divine flood forecasting model was developed by Hayder *et a*l.,[2] based on exponential smoothing and long short term memory based deep learning structure supports all the above victims. One SMS gateway-based flood warning prototype was designed by Ramadhani *et al.*, [3] through ultrasonic sensor for measuring water level together with an alarm buzzer on the Arduino core. The primary goal of this systems sends SMS alert to the pre-configured mobile devices.

In the following areas where, heavy water flow regions, strong barriers could be constructed, flood warnings are exclusively essential for identifying and predicting flood hazards. Prathaban *et al*.,[4] proposed a system with GSM modules and essential sensors to inform flood related data and also keep track of the nearby dam regions. For continuous monitoring and alerting the people who stays in the river banks and reduce the damage, an image processing based flood alerting prototype was designed by Priantama *et al*.,[5] using Android mobile phones. Climate and weather forecasting steps are essential in urban areas for its sustainable development. Multifractal detrended fluctuation analysis (MDFA) was applied over the space-borne sensors data sets. This method addresses anthropogenic heat, surfac heat flux transportation and to work for non-linear climatic changes to achieve environment sustainability. Climate and weather forecasting steps are essential in urban areas for its sustainable development promoted by Kimothi, *et al*., [6]. Multifractal detrended fluctuation analysis (MDFA) was applied over the space-borne sensors data sets. This method addresses anthropogenic heat, surface heat flux transportation and to work for non-linear climatic changes to achieve environment sustainability. The country Malaysia is located proximity to the equator region. This causes more flood and create more loss of life and vast property damages. Lam [7] has suggested a system to identify the depth of flood and sends through short message services. This system also works for real time process to reduce the risks.

2. Related Work

Akshay Bajirao and Shankareppagol suggest using an ultrasonic sensor to measure water level. Rotating shaft's angular position is determined using a rotary encoder (state of the dam gate) [8]. Use a float sensor to verify the level of the spillages. Model B of the Raspberry Pi 3 is connected to all of the sensors. The information is displayed in places like the location of the dam control and the dam authority office, as well as on a website, via SMS notifications sent to important parties, and during catastrophe management. Kavitha and Jayalakshmi suggest that an ultrasonic sensor be utilized to gauge water level in order to operate the dam gate [9]. Development board for Node MCU microcontrollers with sensor integration. the Wi-Fi module is utilized (ESP8266), data is transferred via thing talk. The general public receives the principal water level alertvia GSM. Singh Rajawat and Prashant Bhardwaj make the suggestion that the servomotor used to position the dam gate is a rotary curator [10]. The copper probes' continuity allows them to measure the water level. According to the instructions the user provides through a programmer, the microcontroller creates the intended output from the input. Jiang Peng *et al.,* recommend water environment monitoring based on wireless sensor network, which can measure things like temperature, humidity, pH, turbidity, electric conductivity, dissolved oxygen and so on [11]. This system includes data monitoring nodes, video station and remote center.

Feng *et al*., investigated and sensitized the flood flow in urban areas [12]. They have simulated the flood flow in two different sites: sub-watershed at Toronto and Canada. They have used six land use maps at various years. The experimentation was done over six simulated conditions. Their simplified model took 4 hours as in the cased of flash flood mapping and 20 min for flood plain mapping. Hong *et al*., suggested a solution for urban flooding, which minimizes the risk of flood structure [13]. Their idea mainly concentrated on water logging risk and correlates the structural indicators with urban flooding. They improved their proposed design by installing drainage pump which is mounted over the vehicle. Chen *et al.*, performed a hierarchical investigation on waterlogging accidents [14]. They have analyzed interconnection among various factors through the increase in accident. Also, they student the various countermeasures and government policies during the flood accidents. From the historical records, interannual flood disasters are analysed by Joaquin *et al*., [15]. They developed a dynamically modifying data driven model for adapting the climatical variations. Experimentations are carried out over the NFIP data with ML regresssors. Regressor's performance are enhanced using bias correction. Janizadeh *et al*., examined the flood disaster regions using various machine learning algorithms known as Random forest, Naïve Bayes and Bayesian additive regression method [16]. Lin *et al* mapped the flood prone areas by employing geographically weighted regression method [17]. Sixteen morphometric parameters applied here enhances the performance of the work. Variation inflation factor reduces the multi co-linearity. This method outperforms the non-Spatial logistic regression method. Deep learning methods convolutional is applied by Abdalla *et al.*, to improve the captured features and spatial information [18]. Long short-term memory method also applied to predict the rainfall-runoff in the regions. Precipitation and temperature inputs are used to predict the flow rate of the water flow. Combination of LSTM with CNN provides the fine tuning of this work studied.

There are numerous methods available to measure the impact of flood over the road transportation. Some gap is identified between the characteristics of flood and the road nature for better prediction of flood flow disasters. Haque *et al*., filled this gap by taking the flood features like velocity and its depth together with the road characteristics like surface material, width and height of the road [19]. Multiple regression method used here determines the significant damage effectively. Monsoon floods and vulnerable areas are detected using a random forest method combined with three more algorithms [20]. Slime mould algorithm, Invasive weed optimization and Satin bower bird optimization algorithms are utilized here and achieved high accuracy. Integrated satellite and optical images were used to predict the flood. In the recent days, urban floods usually increase the loss. Urbanization and poor drainage are the main causes for flood. Himanshu *et al.,* [21] integrated the artificial intelligence with smart IOT devices. This post-flood management system measures the urban flood prediction. Flood management system is essential in the flood prone area. have developed a flood management system by combining synthetic aperture radar and IoT technologies. Rain and ultrasonic sensors collect the data and sent to cloud. Then machine learning techniques are employed for early prediction of occurrence of flood.

Panahi *et al*., uses SAR satellite images extracted data for flood prediction [22]. Support vector machine (SVM) based machine algorithm was applied for the prediction with meta heuristic features. Differential evolution and grey-wolf optimization algorithms are combined applied over the data set and achieved high accuracy. Global warming signs the authorities about the severity of flood occurrence in different parts of the country. The study made by the Wesley *et al.,* discussed about the flood risk management process and highlights the issues caused by the same [23]. By observing the causes and effects the mitigation of flood risk management can be taken care in advance. Observations on hydrology form satellite images are the main resources for constructing the early warning systems. The system designed by Tuyen *et al.,* applies the deep learning UNT architecture with particle swarm optimization algorithm to clearly send the warning alarm [24].

Wrapper partial decision tree algorithm is utilized for early drought and crop prediction in different agricultural land to improve the productivity and minimizes the loss. This system is tested over five data sets and observed with proper F-score [25]. Drought and weather monitoring of 18 meterological parameters were constantly observed for three months and utilized for proper early flood prediction. Extreme gradient boost algorithm and SVM algorithm were applied over the deep learning architecture for the proper prediction of flood [26]. Unmanned aerial vehicle based captured images are applied for flood detection by Munawar *et al*., [27]. Haar cascade classifier and convolutional neural network algorithm employed here predicts the flood flow with maximum efficacy. This system performance can be enhanced using Lidar. From the above study, it is clear that conventional methods use the micro controller for analyzing the vital signs of flood monitoring. While the measure sensors data exceeded the threshold, it will warn/inform the residents and authorities through GSM. Recently, machine learning methods are helpful for predicting the rainfall rate. The main gap we found here is the sensors data can be incorporated with internet of things. And the collected sensors data can be interpreted using Thing Speak visualization tool as a vibrant community of developer to provide solution for flood monitoring and mitigation.

3. Methodology

Early detection of abnormal water level, water pressure, temperature and other parameters are collected from multiple sensors in the Internet of Things platform is essential for the flood monitoring. This inter vent measures to prevent dam failures as a proactive maintenance can prevent dam failures and mitigate the risk of catastrophic flooding. Figure 1 presents the working module of the proposed work.

Block Diagram

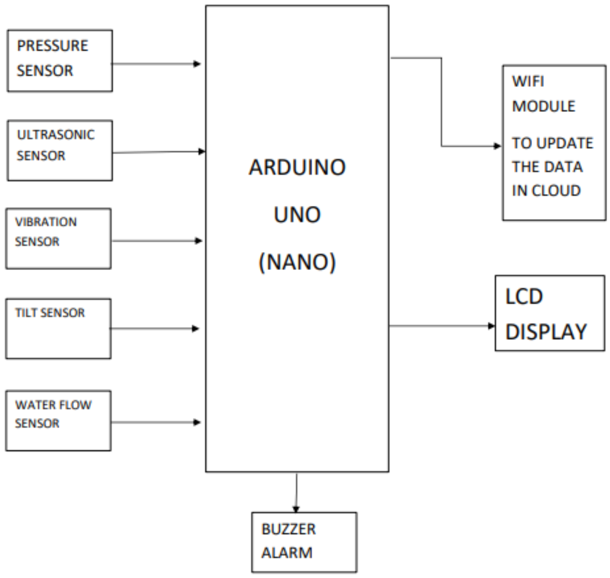

Figure 1. Workflow of the System

3.1 Components Required

A. Hardware Requirements

- Arduino UNO.
- Ultrasonic sensor
- Water flow sensor
- Vibration sensor
- Tilt sensor
- Pressure sensor
- WIFI module
- LCD display
- Buzzer

B. Software Requirements

- *Arduino IDE*

Arduino UNO

Arduino is a freely available electronics platform with straightforward software and hardware. Using an Arduino board to collect inputs such as sunlight on a detector, a finger on a button, or a tweet, you may start a machine, turn on an LED, and upload stuff online.

Ultrasonic Sensor

An sensor module is an item of equipment that measures an object's range using ultrasound waves and then converts the sound that is rebounded into an electric signal. Thresholds can be set based on historical flood data and when water level approach or exceed these thresholds, automated alerts ca be triggered to warn authorities, and residents downstream of potential flood risks.

Waterflow sensor

A water flow sensor is composed of a hall-effect sensor, a water impeller, and a copper shell. Water moves through the rotor at different rates, changing the rotor's speed as a process. Measurement of water level in rivers, streams and water bodies to monitor rising water level, which are indicative of potential flooding.

Vibration sensor

Machine vibration levels are measured using a vibration sensor, also known as a vibration detector, for screening and analysis in dam Gates. This sensor detects vibrations in infrastructure such as bridges/dams. Unusual vibration could indicate structures damage or erosion signaling potential flood risks.

Tilt sensor

Inclinometers are another name for tilt sensors. They are a particular class of position sensor used to calculate an object's slope or angle. Monitoring the tilt of flood barriers retaining walls or flood gates to ensure they remain in optimal positions to mitigate flood rises.

Pressure sensor

A pressure gauge is a kind of electronic device that monitors, or keeps track of water pressure while transforming the physical information it senses into an electronic signal. Measuring the water pressure in rivers/streams to monitor the changes in water levels.

Sudden increase in pressure could indicate rising water levels, potentially signaling and impending flood.

WIFI Module

Data transmission and reception over Wi-Fi are handled by wifi modules or wifi microcontrollers. They can also respond to commands transmitted via Wi-Fi. Wi-Fi modules are utilised for inter-device communication.

LCD Display

A liquid-crystal display is a horizontal monitor or other electrically assisted optical device that uses polarizers and the ability of liquid crystals to modulate light (LCD) (Figure 2). Particles don't generate light directly; instead, they use a backlighting or reflector to produce coloured or monochromatic images.

Buzzer

A mechanical, electromechanical, or piezo audio signalling device is a buzzer or beeper. Buzzers are widely employed as timers, alarm clocks, and to confirm user input such mouse clicks and keystrokes.

Arduino IDE

The Arduino Software (IDE), also referred to as the Arduino Integrated Development Environment (IDE), has menus, a message area, a text console, a toolbar with buttons for essential operations, and a text editor for creating code. It connects to the Arduino hardware to upload programmers and communicate with them.

3.2 Prototype

3.2.1 Working Description

Water flow, ultrasonic, pressure, and tilt sensors are included in IOT flood monitoring. With the aid of the right sensors, it is utilized to measure all the various dam parameters, such as water level and deformation. and provide the necessary analytics. The sensors are connected to an Arduino UNO microcontroller, which is connected via WiFi to a cloud database in Azure through IoT hub. Necessary analytics are then performed on the collected raw data with the assistance of the Azure stream Analytics API, and the data is then sent to Microsoft PowerBI. You require a WiFi connection to run the IOT-based dam monitoring system project.

Using a Wi-Fi module, the microcontroller or Arduino board connects 28 to the wireless network. Without a functioning WiFi network, this project cannot be completed. Using a WiFi module or even the Hotspot feature on your smartphone, you may establish a WiFi zone. These sensors continuously provide input to the Arduino UNO board. The data is then sent to a specific URL/IP address and sent to the cloud. Then, after a specific amount of time, the data sending to IP activity is repeated. The developed prototype model and prototype initialized information displayed on the LCD is depicted on Figure 3 and 4

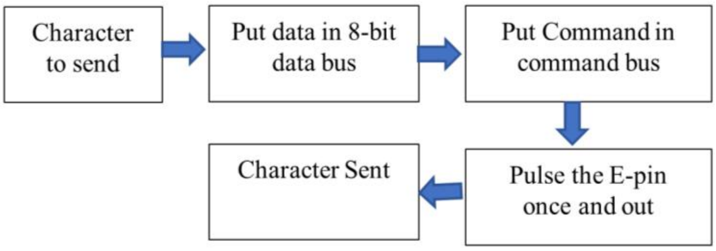

Figure 2. Flow chart of interfacing LCD display

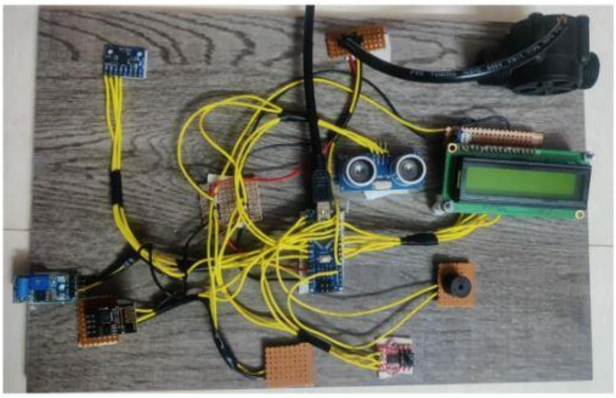

Figure 3. Prototype model

Figure 4. Output in LCD display

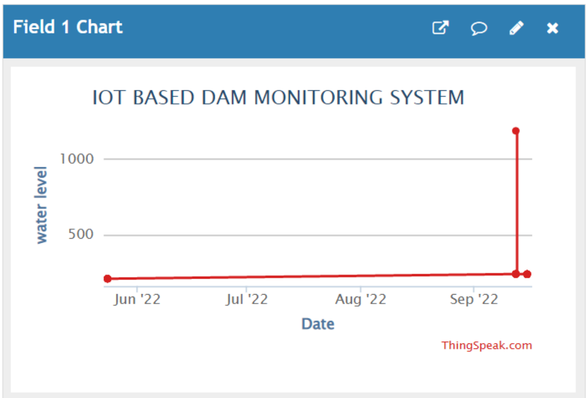

Figure 5. Output screen 1 of water level

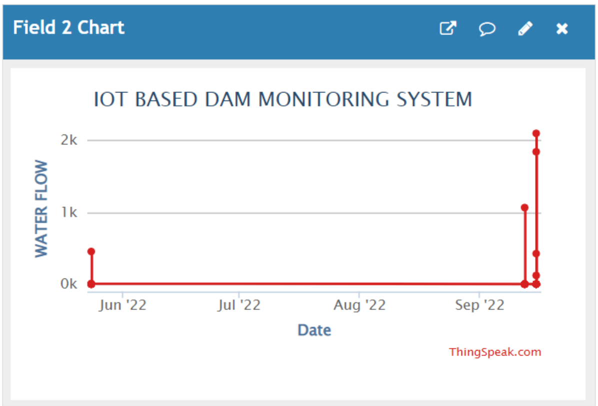

Figure 6. Output screen 2 of waterflow

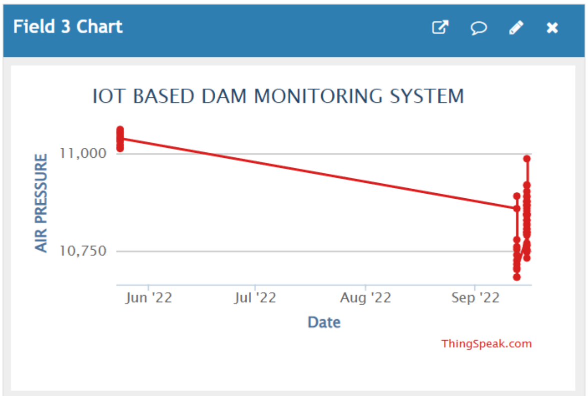

Figure 7. Output screen 3 of air presssure

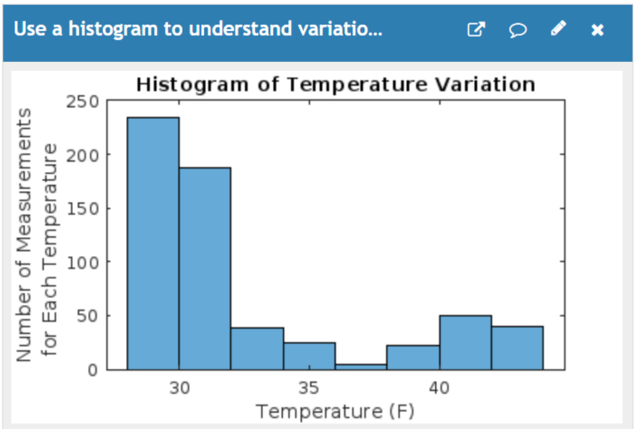

Figure 8. Output screen 4 of temperature

Table 1. Observation of Temperature from the sensor

Time	DHT 11 Temperature sensor output (in Celsius)	Thermometer measurement (in Celsius)
6.00 A.M	22	23
7.00 A.M	22	23
8.00 A.M	22	23
9.00 A.M	23	24
10.00 A.M	25	26
11.00 A.M	25	26
2.00 P.M	27	27
3.00 P.M	28	27
8.00 P.M	21	21
10.00 P.M	20	20

Table 2. Output from Humidity sensor

Time	Humidity measurement
9.25 A.M	64%
9.30 A.M	65%
9.35 A.M	65%
9.40 A.M	60%
10.00 A.M	61%
11.00 P.M	60%

The observed temperature depicted in Table 1. explains there is no much variation among the DHT-11 sensor in the prototype model with the regular thermometer measurement. Also, Table 2. presents the relative humidity at various time periods on a single day. Because of the observed day is the normal day and no signs for possibility of flood/rain the humidity monitored in the range of 61-64%.

4. Results and Discussion

IoT based dam monitoring constructed system yields the results for water level, air pressure and temperature variation. Figure 5 represents the water level of the model observed for a period of June to September month. It explicitly presents during September month has more water level due to rainfall and in the June month lesser rainfall.

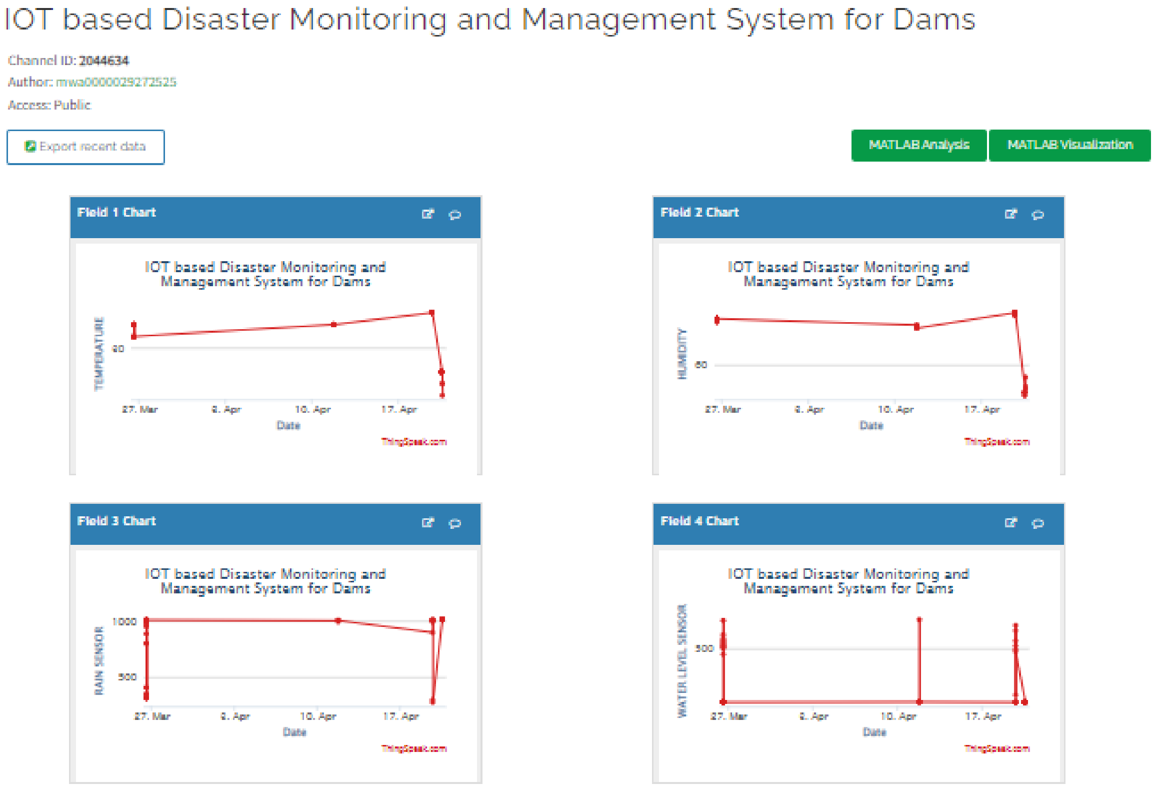

Figure 9. Result screen of the model in cloud

With parallel to the water-level the waterflow for the same period is plotted using Thing Speak visualization tool is depicted in Figure 6. Dam pressure is monitored and presented on Figure 7. Storm or cyclones as the low-pressure system can cause water levels to rise because of increased atmospheric pressure and pushing down the water surface. On the contrary, to the right of this figure represents the high-pressure systems can lead to lower water levels as the pressure on water surface get decreases. Figure 8 represents the histogram of variation in temperature level. Temperature sensors monitors the real-time ambient temperature. This temperature can influence waterflow through melting and evaporation mechanism. High temperature decreases the water-level. Figure 9 represents the measured water level, air pressure and temperature variation updated to the cloud which can be propagated to society through Web Pages. If the water level of the dam or storage reservoirs reaches >80% of the volume of storage places(dam) is identified for heavy warning and found to be cause for flood. People has to move from the river banks. If the storage water level measured from ultrasonic sensor is greater than 55 and less than 80 it is warned to the people to start vacating from those places and water level is less than 55% of the storage it is the safer zone and there is no sign for flood

The suggested technology would make it possible to administer and monitor the dam much more quickly and easily. Over time, data can be logged to offer information. Pertaining to ageing, earthquakes, erosive processes, storms, and other Through data analysis, factors on the overall condition of the dam are revealed. Warning and Engineers can be designed to receive callouts to alert them to potential faults and the When the water level suddenly rises, the automated dam gate opens. Other developments of this concept, including gate status displays, are also conceivable.

Most significantly, these technologies provide round-the-clock monitoring and change detection for a number of things that could otherwise go unnoticed, while simultaneously accurate information that engineers may use right now to make better judgements.

5. Conclusion

In conclusion, the implementation of IoT technology for flood monitoring offers significant advantages in terms of early detection, rapid response, and efficient resource allocation. Through the integration of sensors, data analytics, and communication systems, real-time monitoring of water levels, weather conditions, and flood risks becomes feasible. This proactive approach enables authorities to issue timely warnings, evacuate vulnerable areas, and deploy emergency services effectively, thereby minimizing the loss of life and property during flood events. More dams that might be built in the near future can be incorporated into the system. With the assistance of Google maps, a new application may be created in the future that allows users to quickly access and locate places that are risk of floods or locations where flooding Could happen. This makes it easier for people to stay away from areas that are about to flood. By incorporating all significant natural catastrophes, such as landslides and earthquakes, this program might be developed into an all-inclusive disaster planning system.

References

[1] M. Siddique, T. Ahmed, M.S. Husain, Flood Monitoring and Early Warning Systems–An IoT Based Perspective. EAI Endorsed Transactions on Internet of Things, 9(2), (2023) https://doi.org/10.4108/eetiot.v9i2.2968

[2] I.M. Hayder, T.A. Al-Amiedy, W.Ghaban, W.F. Saeed, M. Nasser, G. Al-Ali, H.A Younis. An Intelligent Early Flood Forecasting and Prediction Leveraging Machine and Deep Learning Algorithms with Advanced Alert System. Processes, 11, (2023) 481. https://doi.org/10.3390/pr11020481

[3] S. Ramadhani, N. Putri, I. Sulistianingsih, E. Hariyanto, SMS Gateway-Based Early Flood Detection Warning System Design. International Journal of Economic, Technology and Social Sciences (Injects), 2(1), (2021) 62-69. https://doi.org/10.53695/injects.v2i1.223

[4] B.P. Prathaban, R.S. Kumar, M. Jenath, (2023) IoT Based Early Flood Detection and Avoidance System. In Intelligent Systems Design and Applications, Springer, Germany. https://doi.org/10.1007/978-3-031-35501-1_55

[5] R. Priantama, N. Nugraha, E. Darmawan, The Innovation Development of Early Flash Flood Warning System Based on Digital Image Processing through Android Smartphone. In Journal of Physic Conference Series, IOP Publishing, 1477(3), (2020) 032015. https://doi.org/10.1088/1742-6596/1477/3/032015

[6] S. Kimothi, A. Thapliyal, A. Gehlot, A.N. Aledaily, A. Gupta, N. Bilandi, R. Singh, P. Kumar Malik, S. Vaseem Akram. Spatio-temporal fluctuations analysis of land surface temperature (LST) using Remote Sensing data (LANDSAT TM5/8) and multifractal technique to characterize the urban heat Islands (UHIs). Sustainable Energy Technologies and Assessments, 55, (2023) 102956. https://doi.org/10.1016/j.seta.2022.102956

[7] H.Y. Lam, Development of Early flood detection and warning system. Progress in Engineering Application and Technology, 4(2), (2023) 108-120.

[8] L.M. Shankareppagol, C. Akshay Bajirao, J. Yuvraj Praksh, P. Radhika Ramesh, S. Samruddhi Suryawanshi, H. Suhas Shankarrao, Review on IoT Based Dam Parameters Monitoring System. Journal of Information Technology & Software Engineering, 8(5), (2018).

[9] R. Kavitha, R. Kavitha, C. Jayalakshmi, K. Senthil Kumar, Dam Water Level Monitoring and Alerting System using IOT. International Journal of Electronics and Communication Engineering, 5(6), (2018) 19-22. https://doi.org/10.14445/23488549/IJECE-V5I6P105

[10] P. Bhardwaj, Y.S. Rajawat, S. Rajput, S.S. Narvariya, L. Narayan, (2014) Automatic dam shutter senses the water level and control the dam door using servo motor. In Proceedings of 4th SARC-IRF International Conference, New Delhi, India.

[11] Y. Kong, P. Jiang, (2008) Development of data video base station in water environment monitor oriented wireless sensor networks. In Proceedings of the International Conference on Embedded Software and Systems Symposia, IEEE, China. https://doi.org/10.1109/ICESS.Symposia.2008.68

[12] B. Feng, Y. Zhang, R. Bourke, Urbanization impacts on flood risks based on urban growth data and coupled flood models. Nat Hazards, 106, (2021) 613–627. https://doi.org/10.1007/s11069-020-04480-0

[13] H. Lv, Y. Meng, Z. Wu, X. Guan, Y. Liu, Construction of flood loss function for cities lacking disaster data based on three-dimensional (object-function-array) data processing. Science of the total environment, 773, (2021) 145649. https://doi.org/10.1016/j.scitotenv.2021.145649

[14] C. Junfeng, W. Le, Z. Yiqi, H. Fucai, Z. Maohua, Lessons and improvements: Subway waterlogging catastrophe in Zhengzhou, China. Tunnelling and Underground Space Technology, 144, (2024) 105541. https://doi.org/10.1016/j.tust.2023.105541

[15] J. Salas, A. Saha, S. Ravela, Learning inter-annual flood loss risk models from historical flood insurance claims, Journal of Environmental Management, 347, (2023) 118862. https://doi.org/10.1016/j.jenvman.2023.118862

[16] S. Janizadeh, M. Vafakhah, Z. Kapelan, N.M. Dinan, Novel Bayesian additive regression tree methodology for flood susceptibility modeling Water Resource Management. Water Resources Management, 35(13), (2021) 4621-4646. https://doi.org/10.1007/s11269-021-02972-7

[17] J.M. Lin, L. Billa, Spatial prediction of flood-prone areas using geographically weighted regression. Environmental Advances, 6, (2021) 100118. https://doi.org/10.1016/j.envadv.2021.100118

[18] A. Mohammed, G. Corzo, Spatiotemporal convolutional long short-term memory for regional streamflow predictions. Journal of Environmental Management, 350, (2024) 119585. https://doi.org/10.1016/j.jenvman.2023.119585

[19] S. Haque, K. Ikeuchi, B.B. Shrestha, A. Kawasaki, M. Minamide, Establishment of flood damage function model for rural roads: A case study in the Teesta River basin, Bangladesh. Progress in disaster science, 17, (2023) 100269. https://doi.org/10.1016/j.pdisas.2022.100269

[20] S.V. Razavi-Termeh, A. Sadeghi-Niaraki, S.M. Choi, A new approach based on biology-inspired metaheuristic algorithms in combination with random forest to enhance the flood susceptibility mapping. Journal of Environmental Management, 345, (2023)118790. https://doi.org/10.1016/j.jenvman.2023.118790

[21] H.R. Goyal, K.K. Ghanshala, S. Sharma, Post flood management system based on smart IoT devices using AI approach. Materials today: proceedings, 46, (2021) 10411-10417. https://doi.org/10.1016/j.matpr.2020.12.947

[22] M. Panahi, O. Rahmati, Z. Kalantari, H. Darabi, F. Rezaie, D.D. Moghaddam, C.S.S. Ferreira, G. Foody, R. Aliramaee, S.M. Bateni, C.W. Lee, S. Lee, Large-scale dynamic flood monitoring in an arid-zone floodplain using SAR data and hybrid machine-learning models. Journal of Hydrology. 611, (2022) 128001. https://doi.org/10.1016/j.jhydrol.2022.128001

[23] W. Mendes-Da-Silva, E. Flores, D.L. Eckles, Informed decisions regarding flood events induces propensity for insurances. Environmental Science & Policy, 136, (2022) 738-750. https://doi.org/10.1016/j.envsci.2022.07.032

[24] D.N. Tuyen, T.M. Tuan, L.H Son, T.T. Ngan, N.L. Giang, P.H.Thong, V.V. Hieu, V.C. Gerogiannis, D. Tzimos, A. Kanavos, A novel approach combining particle swarm optimization and deep learning for flash flood detection from satellite images. Mathematics, 9(22), (2021) 2846. https://doi.org/10.3390/math9222846

[25] N.G. Rezk, E.E.D. Hemdan, A.F. Attia, A. El-Sayed, M.A. El-Rashidy, An efficient IoT based smart farming system using machine learning algorithms. Multimedia Tools and Applications, 80(1), (2021) 773–797. https://doi.org/10.1007/s11042-020-09740-6

[26] W. Jiang, J. Luo, An evaluation of machine learning and deep learning models for drought prediction using weather data. Journal of Intelligent & Fuzzy Systems, 43(3), (2022) 3611-3626. https://doi.org/10.3233/JIFS-212748

[27] H.S. Munawar, F. Ullah, S. Qayyum, A. Heravi, Application of Deep Learning on UAV-Based Aerial Images for Flood Detection. Smart Cities, 4(3), (2021) 1220–1243. https://doi.org/10.3390/smartcities4030065

Authors Contribution Statement

C. Thirumarai Selvi -Conceptualization, Methodology, Formal analysis, Validation, Writing - Original Draft, **R.S**. **Sankara Subramanian** - Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Writing - Review & Editing, **M. Muthu Krishnan** - Formal Analysis, Writing - Original Draft, Writing - Review & Editing, **P. Gnana Priya** - Formal Analysis, Writing - Original Draft, Writing - Review & Editing. All the authors read and approved the final version of the manuscript.

Competing Interests

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Data Availability

Data will be provided upon request

Has this article screened for similarity?

Yes

About the License