AI & IoT Based Flood Monitoring and System

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Keywords: Internet of Things (IoT), Artificial Intelligence, Time Series Analysis (ARIMA) Algorithm, LID Performance, Flood Early Warning System.

Abstract: Floods are a global hazard to both life and property, in addition to the infrastructure in place, which are enhanced by issues like urbanization, inadequate drainage, and climate change. Proper flood management and warning systems can minimize such losses. Latest solutions that use Internet of Things, and machine learning, make it possible to monitor risk assessment, and alerts, in real time. Some of the techniques used in flood prediction, especially in high-risk urban areas, include the use of AI models and smart sensors. IoT-enabled systems that are equipped with sensors to measure water levels, rainfall, and weather parameters feed into cloud platforms for the precise prediction of flood risks and efficient communication of warnings to stakeholders. The decision-support algorithms in predictive models like the Time Series Analysis ARIMA improve the accuracy of the prediction of floods and enhance the efficient response to emergencies through data analysis on meteorological as well as hydrological entities. These systems, in combination with Low-Impact Development (LID) practices, resilient network connectivity can provide early flood warning capacities, enable rapid decision making, and reduce the effect of floods on vulnerable groups of people. Testing and applications within real-life environments establish significant potential for its acceptance widely to enhance the effectiveness in managing urban flooding as a whole and disaster readiness on a global scale.

1 INTRODUCTION

Floods are one of the most common natural disasters around the world, affecting millions of people's lives, infrastructure, agricultural systems, and economies with far-reaching and devastating effects. Thus, the rise in frequency and intensity of floods has also brought along apprehensions of their impact as the population of the world and urbanization continue to grow. Although urbanization acts as an impetus for economic growth, it is also known to increase the flood risk associated with the region when coupled with poor infrastructure. Water absorption into the ground decreases with impervious surfaces created by roads, buildings, and pavements. This increased vulnerability, combined with that of climate change, causes unpredictable weather patterns and increasingly intense rainfalls, placing the urban area at high risks of extreme flooding. The techniques of flood management call for approaches toward managing flood risks across cities and communities worldwide and are motivated to advance. Traditionally, the application of flood management techniques largely depends on historical records regarding floods. These records could be invaluable but hardly ever satisfy the actual demand for in real-time risk mitigation, as observed today. It is because of these very limitations of the traditional systems that researchers and policymakers have used the opportunities presented by these new technologies, such as IoT and ML, for developing dynamic, responsive, and data-driven flood management systems. For example, this type of IoT technology can track and connect millions of sensors, which allows for real-time monitoring of key flood indicators in the environment, such as water levels, rainfall, and weather conditions. At the same time, ML algorithms can go through this data to find patterns and make predictions for early flood warning and informed decision-making to mitigate damage to lives, property, and infrastructure.

Flood prediction models, especially machine learning and AI-based ones, are revolutionizing the approach to flood management and rely on massive datasets and computational power. Such models make highly accurate forecasts of rainfall, river discharge, and flood levels using predictive algorithms such as Time Series Analysis and Auto-Regressive Integrated

Goel, V., Shukla, A., Pandey, V. K. and Kumari, M.
AI & IoT Based Flood Monitoring and System.
DOI: 10.5220/0013874200004919

In *Proceedings of the 1st International Conference on Research and Development in Information, Communication, and Computing Technologies (ICRDICCT'25 2025) - Volume 1*, pages 834-841
ISBN: 978-989-758-777-1

Moving Average (ARIMA). Such predictions allow for earlier warnings, which give local governments and disaster response agencies crucial time to activate the response plan, alert communities, and deploy necessary resources. Improvements in cloud computing allow for data centralisation and processing in near real time from sensors placed around the globe, easy to scale and integrate across and between regions and even perhaps nationally.

The IoT allows for continuous monitoring and automatic data collection, integral aspects of providing timely and accurately provided flood risk assessments. IoT technology permits a converged network of strategically located sensors in flood-prone areas to collect data in real time, thereby affording the possibility of comprehensive understanding of local environmental changes. Thus, sensors might send real-time data to the cloud platforms regarding a multiplicity of parameters including precipitation rates, the moisture content in the soil, levels of river water, and atmospheric pressure. The final approach in data management comprises a core of designing and developing reliable flood prediction models together with making actionable information delivery to the stakeholders.

Cloud infrastructures are rustic by strengthening these systems, whereby easy integration of data comes along with analytics at scale. They have made data from vast sensor devices possibly available for storage and processing. This ensures that local authorities and emergency responders are kept informed in order to respond quickly to such events. Cloud computing bridged the gap of collecting data and the actual action of decision-making within a centralized data ecosystem. That is how flood warnings through various channels, for example, mobile applications, public alert systems, and even direct notification to emergency teams, may be delivered. Also, such systems are designed to work under tough conditions with resilient network connectivity ensuring constant monitoring even in adverse weather events.

DSS forms a very important component of effective flood management. It uses predictive models and algorithms to evaluate the risk of flooding in real-time and provides recommendations for action. Decision-support algorithms incorporate not only meteorological and hydrological data but also contextual information, including land use patterns, population density, and drainage system capacity, to present an accurate risk profile. Contextual integration allows for adaptive responses, with DSS able to suggest preemptive actions such as activating flood gates, issuing evacuation alerts, or mobilizing emergency services in high-risk scenarios. Such systems are more effective in terms of increasing precision and response velocity of the strategies to boost community resilience against flood disaster.

A new emerging concept of Low-Impact Development in flood management practice that seeks to combine a natural landscape feature and good sustainable urban planning practice against risk through flooding. LID approaches utilize the application of permeable pavements, rain gardens, and green roofs as measures to enhance the infiltration rate of water while minimizing the runoff and thereby intensifying the natural capacity for urban areas to absorb. With LID coupled with IoT and ML-based flood prediction systems, mitigation of immediate risks associated with flooding also fosters a long-term aspect of the resilience of the city at large, thereby relieving pressure on the drainage systems so that cities may face even extreme weather conditions with a sense of security.

Advancement in IoT, ML, and cloud computing improves multiple aspects of flood prediction, but challenges in widespread usage are immense. These high-tech systems have technical, financial, and operational constraints that may not be achieved in low- and middle-income regions. The extensive sensor networks may be very expensive to deploy and maintain resilient connectivity, especially in remote or under-resourced areas. Moreover, issues of data privacy and cybersecurity also need to be taken into account because sensitive information gathered from smart cities can easily be accessed by unauthorized individuals. International cooperation, public-private partnerships, and policy support are essential factors in developing sustainable, accessible, and inclusive flood management solutions against these challenges.

Case studies and pilot projects worldwide have demonstrated the effective implementation of IoT and ML-based flood management systems in spite of these challenges. For instance, Japan and the Netherlands have developed very large-scale, IoT-enabled networks for flood monitoring that decrease flood-related losses and strengthen community preparedness. Working with technology vendors, cities in flood-risk regions have created effective alerting systems that combine real-time sensor information, machine-learning-based forecasts, and decision-support algorithms to inform the authorities and citizens about a potential risk. Such examples will transform the future of flood management and set a precedent for other cities to become flood-resilient.

Instead, the confluence of IoT, ML, and cloud computing technologies is helping open a new era in flood management defined more by proactive risk reduction and improved disaster preparedness. Real-time monitoring, predictive analytics, and decision support systems allow communities to better anticipate and respond to floods. LID-based practices in urban planning could make cities less prone to flooding over time and bring sustainable and resilient development. As research continues, new technologies are developed and policy frameworks support this transition, the global adaptation of IoT and ML-enabled flood management systems will provide an opportunity for a safer, more resilient future against the challenges of climate change.

1.1 Motivation

This paper synthesizes recent developments in AI and IoT-based flood monitoring and rescue systems aiming at pinpointing existing research gaps, showcasing real-life applications, and offering interdisciplinary insights. Focusing on floods as a global challenge, it emphasizes the necessity of a collaborative effort in order to resolve the issue. Concerning the potential of AI and IoT technologies to increase flood resilience and mitigate disaster impacts, it speculates on future directions that provide valuable perspectives for both academic discourse and practical deployment in order to contribute to enhancing global flood management strategies.

1.2 Objective

This is an advanced proactive system for monitoring floods supported by AI and IoT technologies. The system brings about mitigation of impacts from floods. Sensors deployed to establish the water level and early detection of danger, with support from AI models, will help prepare for proper planning on how to evacuate in time. Strong alert mechanisms with SMS, mobile applications, and social media notifications will ensure that warnings are brought widely.

With location tracking and real-time communication tools for emergency response teams, rescue operations flow efficiently. Community involvement is enabled through education and resource availability. This system is scalable and adaptable using open-source technologies and resource optimization, which makes it affordable to deploy in most geographical areas and flood scenarios. The ultimate goal of this particular system is to reduce loss of life and property and help develop community resilience and disaster management capacity.

2 LITERATURE SURVEY

Anisha Daniel P J et.al, 2021 proposed a model Internet of Things (IoT) Based Monitoring of Floods and Alerting System: Causes and implications of flooding, the importance of flood monitoring, and alert mechanisms are explained by the writer. He recommends an Arduino Mega with water and rain sensors, which would help predict flooding and hence alert the authorities and other neighboring areas using IoT technology. Real-time information and prediction of the number of days before a given region gets flooded will ensure prompt alarming to affected regions. The IoT-based flood detection system for early warning will provide timely alerts on level of water and hence timely evacuations, preserving lives and properties.

The project utilizes Raspberry Pi, LED, Buzzer, ultrasonic sensor, and an Android Application for monitoring floods and prediction. The model also employs historical data and machine learning algorithms for precise prediction of the flooding. This means that users and authorities can conveniently respond and manage a disaster. Himanshu Rai Goyal et.al, 2021 proposed a post-management system with the help of IoT devices and an AI approach. This system uses the ANN algorithms to process data from drainage condition sensors, rainfall sensors, and network monitoring sensors. Although efficient, it has limited scalability for extensive urban areas, integration of various data sources, and validation against real-time, large-scale floods. Other comparisons with some other advanced AI models remain unexplored, such as DNN and reinforcement learning. Muhammad Izzat Zakaria el.al, 2023 reported a LoRaWAN-based IoT system using LoRa Shield and ultrasonic sensors to monitor and alert of floods in catchment areas. The system adopted ARIMA for time series forecasting; however, it does not attempt any adaptive spreading factors for different scenarios, alternative communication technologies, mesh networking towards the expansion of coverage, and advanced data analysis methods such as machine learning that enhance the precision of flood prediction.

Kavitha Chaduvula et.al, 2021 presented an IoT-based flood alert monitoring system using microcontroller 8051 with pressure, water level, temperature, and rainfall sensors. The proposed system comprised the use of ARIMA and ANN models for predictive analysis. Long-term reliability and performance, integration with existing systems, scalability for broad deployment, or energy optimization strategies for remote use were not addressed in the study.

Saeed Javanmaedi et.al, 2024 proposed an M-RL: A Mobility and Impersonation Aware IDS for DDoS UDP Flooding Attacks in IoT-Fog Networks, in which they tackled the challenges of detecting and mitigating DDoS attacks in IoT-fog environments. The authors proposed a hybrid model, M-RL, which fuses an RL technique with the RSS method for the improvement of security in networks. The research study finds out the lacunae present in today's anomaly detection techniques and discusses the requirement of comprehensive, energy-efficient solutions for power nodes using fuzzy logic and operating with energy-harvesting devices. In this study, Ismail Essamlali el.al, 2024 has proposed a new architecture of Low Impact Development (LID) stormwater management using IoT and machine learning. By sensing rainfall, soil moisture, water level, flow rate, and water quality, the system enhances predictability and develops decision-making capabilities. They point out that no dedicated monitoring facilities and policy framework exist for LID, and future work is in place to overcome regulatory challenges and encourage stakeholder collaborations.

Waheb A. Jabbar et al., 2023 presented an IoT-based system using LoRaWAN for rural water quality monitoring where pH, turbidity, temperature, and TDS sensors have been integrated along with solar cell power. Deep learning models enhance the data handling process; however, the calibration process of the system in a remote location is not perfect. Energy consumption in idle and active states along with integration of AI/ML for proactive monitoring and more research work is required for effective deployment.

Tae Sung Cheong et.al., 2024 proposed a flood early warning system for small streams based on real-time hydrodynamic information. Their approach employs CCTV-based automatic discharge measurement, water surface elevation gauges, and surface imaging velocimetry, enhanced by the Robust Constrained Nonlinear Optimization Algorithm (RCNOA). Future work will delve into diverse runoff forecasting within numerical models for rainfall prediction, evaluating the effects of urbanization, climate change, and land use on flood risk. Briefly, Jinping Liu et al., 2022 reviewed the current state of technologies for monitoring and forecasting urban floods in the TC region through various types of sensors, including satellite, radar, crowdsourced, and IoT-based mobile sensors. Their finding brings out the seriousness of the need to integrate advanced sensor data into high-performance big data techniques together with AI algorithms to be capable of improving complex ones in urban flood forecasting with intricate land and sewage systems. Martin Pies et.al., 2024 elaborate advanced applications of IoT-based wireless sensors for remote geotechnical monitoring and structural diagnostics. Integration of data accuracy along with outdoor antennas is the primary aspect of their research, essentially using geotechnical water-resistance sensors. Optimization algorithms and signal prediction models have been deployed; however, there is further scope for higher sensor power efficiency, better water resistance, and improved wireless signal transmission conditions, mainly when underwater in different conditions.

2.1 Used Sensors

Table 1 shows the various sensors used and their specifications.

Table 1: Sensor Specifications: Range and Accuracy.

Sensor	Range	Accuracy
Rainfall Sensor	0 to 500 mm/h	Typically ±1% to ±5% of reading
Air Quality Sensor	CO_2 Levels: 0 to 5000 ppm VOC (Volatile Organic Compounds): 0 to 1000 ppm	±(5-10)% of the reading depending on the pollutant type
Flow Rate Sensor	0.1 to 2500 L/min	±1% to ±3% of reading
Temperature & Humidity Sensor	Temperature Range: -40°C to 125°C Humidity Range: 0% to 100% RH	Temperature: ±0.1°C to ±2°C Humidity: ±2% to ±5% RH

2.2 Used Machine Learning Algorithm

Table 2: Algorithm Used.

Algorithm	Range	Accuracy
Time Series Analysis (ARIMA)	Short to Medium-Term Forecasting Single-Variable Forecasting	Dependence on Historical Data Quality Trend and Seasonality Handling Real-Time Data Integration

Table 2 gives the range and accuracy of the algorithm used.

3 PROBLEM STATEMENT

Worldwide, the frequency and intensity of flooding events continue to rise as a result of climate change, greater urbanization and changing weather patterns. The outcomes of such flooding are severe, leading to the loss of life and property in communities, destruction or inundation of economic assets, disruptions of port operations which facilitate efficient trading activities amongst nations precipitating into regional economies collapse as well affecting biomes stability for example coral reef susceptibility due sea temperature rise. Conventional flood monitoring systems exist, but that requires data to be gathered manually and they depend on localized sensors which do not provide immediate assessment of an extensive area due to the fact areas are so varied. These limitations lead to slower response times, insufficient early warnings and a greater dependency on reactive rather than proactive disaster management approaches.

In existing monitoring systems often only few parts of the data are monitored which can make it impossible to produce full, as fresh, insights that would have been required for successful flood prediction/migration. However, these systems frequently lack the ability to offer forecasts on time and at a high level of resolution while other implementations that are based in resource-deprived locations (such as remote rural regions) do not have sufficient resources from sensor deployment and maintenance. It is a deficiency that leaves wide open the possibility of avoidable losses in affected areas.

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) presents a transformative solution to these challenges. By deploying IoT-enabled sensors across critical flood-prone zones, data on rainfall, river levels, soil moisture, and other key variables can be continuously gathered in real time. AI algorithms can then analyze this data to produce predictive models, providing advanced flood alerts and actionable insights for communities and first responders. These systems allow for enhanced situational awareness, early warning signals, and automated response mechanisms, empowering communities to take preventive action, optimize resource allocation, and reduce potential damages. By addressing the limitations of traditional monitoring, an AI- and IoT-based flood monitoring system can play a crucial role in adapting to the evolving climate landscape and improving resilience against flood-related disasters.

4 PROPOSED METHODOLOGY

The goal of this flood detection and alerting system is to enable real-time monitoring, prediction, and alert distribution through a centralized web portal. The system integrates IoT sensors with a cloud-based platform to collect, analyze, and disseminate information, allowing users from various sectors such as emergency response, healthcare, and the general public to receive timely alerts and make informed decisions. Figure 1 shows the block diagram of the proposed system.

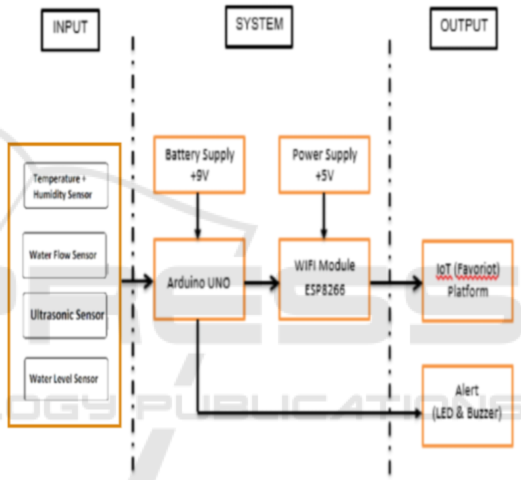

Figure 1: Block Diagram.

1. **IoT Devices and Data Collection**: The IoT setup uses multiple sensors connected to an Arduino Uno, which serves as the control unit. The sensors continuously monitor environmental parameters relevant to flooding. Data collected by these sensors are transmitted to a web server over the cloud using a Wi-Fi module, allowing real-time access and storage of information.

2. **Data Storage and Cloud Integration**: The cloud serves as a centralized storage system, holding both real-time and historical flood data in CSV format. This data is accessible for predictive analysis, enabling the detection of potential flooding trends and making it available for use in future machine learning models.

3. **Real-Time Alerts and User Access**: Based on real-time data, alerts are triggered using visual

(LEDs), auditory (buzzers), and mobile app notifications. Alerts are prioritized to notify users according to the urgency, ensuring that stakeholders can respond effectively to mitigate flood damage.

4. **Web Portal and Inter-User Communication**: The web portal connects users, allowing them to access a range of services such as blood banks, ambulance services, and hospitals that are essential during flood emergencies. The portal fosters communication and coordination among users, enhancing emergency response efficiency.

4.1 Role of Sensors

1. **Ultrasonic Sensor**: This sensor (figure 2) measures the distance between the water surface and a fixed point. In this project, it monitors water level rise in real-time. By emitting ultrasonic waves and calculating the time it takes for the waves to bounce back, the sensor estimates the water level, which helps detect rising water before a flood occurs.

Figure 2: Ultrasonic Sensor.

2. **Water Flow Sensor**: A water flow sensor (figure 3) detects the movement and rate of water flow. This information helps identify potential blockages or changes in water flow, which can contribute to flooding. Monitoring water flow rates enables the system to respond proactively if flow patterns indicate flood risks.

Figure 3: Water Flow Sensor.

3. **Water Level Sensor**: The water level sensor (figure 4) directly measures the water level in reservoirs, rivers, or other bodies of water. The data helps determine if the water level is reaching critical points. This sensor is essential for confirming that the water has exceeded safe thresholds, signaling the need for immediate alerts.

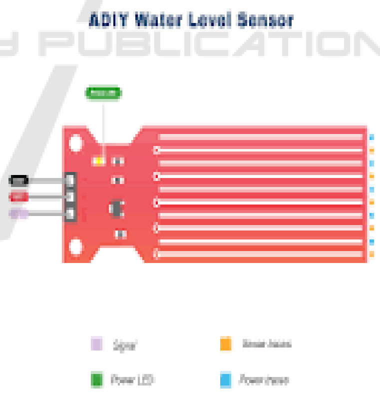

Figure 4: Water Level Sensor.

4. **Temperature and Humidity Sensor**: Temperature and humidity sensors (figure 5) monitor environmental factors that could impact flooding conditions. High humidity and significant temperature variations often correlate with heavy rainfall, which can lead to floods. Tracking these parameters enables better

prediction of weather patterns that may result in flooding.

Figure 5: Temperature and Humidity Sensor.

4.2 Predictive Analysis with the ARIMA Algorithm

The AutoRegressive Integrated Moving Average (ARIMA) algorithm is a statistical model used for forecasting based on historical time-series data. In this project, ARIMA analyzes historical flood data (stored in CSV format) to predict future flood events. The model processes trends and seasonal patterns in the data, enabling it to forecast rising water levels or other flood indicators. By integrating ARIMA predictions with real-time sensor data, the system can provide advanced alerts and help authorities take preventive actions before flooding reaches critical levels.

5 RESULT

All the proposed distributed flood detection and alerting systems use a single centralized web portal to monitor floods in real time, predict them, and, consequently, warn the people. A cloud platform integrates IoT sensors for the real-time collection and analysis of environmental parameters. The stakeholders who should receive an alert in time before any flooding occurs in the area in which they operate are the emergency responders, health-care providers, and the public. The IoT setup has sensors connected to an Arduino Uno that do level, flow rate, and temp and humidity monitoring. Data is transmitted in real time with a Glowlink Wi-Fi module to a cloud server hence available and stored continuously. If the data which are stored in the Cloud in CSV format is helpful in business forecast analysis, let's leave it as it is for later machine learning use cases.

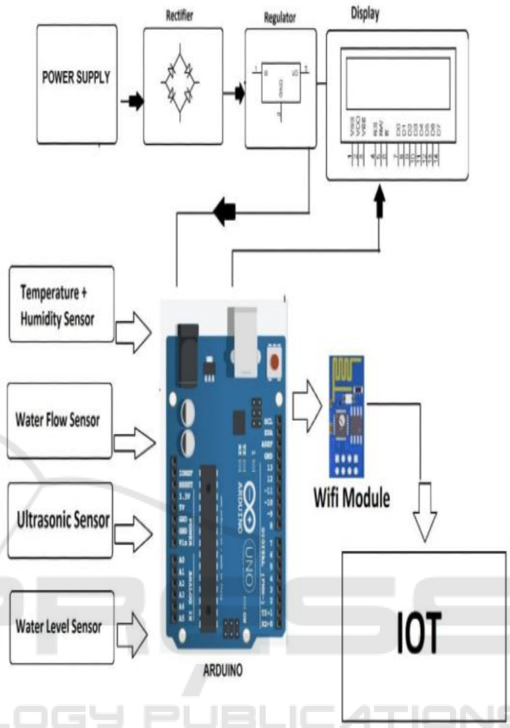

Figure 6: Circuit Diagram.

The urgency of the potential flood threats that arrive is notified as push LEDs and buzzers and mobile through alerts in a semi-automated synchronized process, thus enabling people to take any action on them quite early. The web portal will offer access to needed services and facilitate a medium for the communication between users which could eventually come in handy as an emergent response.

While the ARIMA algorithm processes historical data for predictive analysis, it identifies changing trends patterns including those in flood events. The system augments predictions of ARIMA with live sensor inputs to allow for proactive alerting that equips the authorities with the information required in order to take preventive actions before the flood conditions aggravate. Figure 6 depicts the circuit diagram of the proposed method.

6 CONCLUSION AND FUTURE SCOPE

This project will show the possibility of creating an alert system that would mitigate the risks of flooding. By this, it could monitor what data the sensors have held, and there is a possibility of the incorporation of sensors within the system for an accurate and efficient system of flood detection. It may prove to benefit other government agencies or authorities, whereby this benefits society in the management and mitigation of flooding, a hazard natural disaster. It gives wide monitoring of all factors that could cause flooding. When water rises and its speed increases, it gives an alert immediately. In simple words, this system gives improved access within the management and response to this catastrophic occurrence. It aids the community to take informed decisions and plan how to overcome this natural catastrophe effectively.

This innovation shall decrease flooding which essentially encompasses an ultrasonic sensor measuring the flood levels on the road, a live streaming camera to monitor live for the occurrence of flooding, and Serial Communication that sends text messages with warnings whereby date, time, water level, and accessibility status are listed. There are three modules under the system: Users, Logs, and Contact Numbers. These can be edited by the admin. For precision, the sensor unit is suggested to be installed in front of the system, perpendicular to the floodwater, and attached with a pole, 3 to 3.5 meters long. For continuous operation, the flood sensors and microcontrollers are all powered with an 80,000 Ampere-Hour (mAh) Solar Power Bank that ensures uninterrupted, round-the-clock water level detection and network data transmission.

REFERENCES

Anisha Daniel P J, Abhishek M L, Frelbin Nazeer3 and Ann Johny "Internet of Things (IoT) Flood Monitoring and Alerting System", International Journal of Innovative Research in Technology, Vol.8, Dec.2021.

Himanshu Rai Goyal, Kamal Kumar Ghanshala, Sachin Sharma "Post flood management system based on smart IoT devices using AI approach", Materials Today: Proceedings, Jan.2021.

Ismail Essamlali, Hasna Nhaila, Mohamed El Khaili "A new architecture of Low Impact Development (LID)-based stormwater management system through Internet of Things (IoT) and Machine Learning integration", Case Studies in Chemical and Environmental Engineering, Vol.10, Sep.2024.

Jinping Liu, Hyo-Seob Cho, Sazali Osman, Hyeon-Gyo Jeong, Kwonmin Lee "Review of the status of urban flood monitoring and forecasting in TC region", Tropical Cyclone Research and Review, Vol.11, July 2022.

Kavitha Chaduvula, Kranthi kumar k., Babu Rao Markapudi, Rathna Jyothi Ch. "Design and Implementation of IoT based flood monitoring system using microcontroller 8051", Materials Today: Proceedings, 2021.

Martin Pies, Jan Velicka, Radovan Hajovsky "Advanced IoT-Based Wireless Sensors for Remote Geotechnical Monitoring and structural Diagnostics", IFAC-PapersOnLine, Vol.58, 2024.

Muhammad Izzat Zakaria, Waheb A, Jabbar, Noorazliza Sulaiman "Development of a smart sensing unit for LoRaWAN-based IoT flood monitoring and warning system in catchment areas", Internet of Things and Cyber-Physical Systems, Vol.3, May 2023.

Saeed Javanmardi, Meysam Ghahramani, Mohammad Shojafar, Mamoun Alazab, Antonio M. Caruso "M-RL: A mobility and impersonation-aware IDS for DDos UDP flooding attacks in IoT-Fog Network", Computers & Security, Vol.140, Feb.2024

Tae Sung Cheong, Seojun Kim, Kang Min Koo "Development of measured hydrodynamic information-based flood early warning system for small streams" , Water Research, Vol.263, Aug 2024.

Waheb A. Jabbar, Tan Mei Ting, M. Fikri I. Hamidun, Ajwad H. Che Kamarudin, Wenyan Wu, Jamil Sultan, AbdulRehman A. Alsewari, Mohammed A.H. Ali "Development of LoRaWAN-based IoT system for water quality monitoring in rural areas ", Expert Systems With Applications, Vol.242, Dec.2023.