

**A LORAWAN-BASED IOT ARCHITECTURE FOR REAL-TIME FLOOD SENSING  
AND SAFETY NOTIFICATION VIA SMS****Hidear Talirongan**Professor, School of Graduate Studies, Northwestern Mindanao State College of Science and  
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**ABSTRACT**

Flooding continues to threaten many communities, particularly where water level monitoring and warning processes remain manual and slow. This study aims to design and simulate a smart flood management system that automates water level detection, long range data transmission, and SMS based alert notification. The purpose of the research is to address delays in information flow during flood events and to provide an efficient mechanism that supports timely disaster preparedness and response. A design and simulation approach was employed to develop the system architecture, integrating LoRaWAN for remote data communication and an SMS gateway for the automated dissemination of alerts.

Results from the simulation show that the system achieved stable long-range transmission, low power consumption, and a very acceptable success rate in sending SMS alerts once threshold levels were reached. Dashboard components, message formats, and monitoring functions performed according to the expected design requirements. These findings indicate that the system is feasible, reliable, and suitable for enhancing early warning capabilities in flood prone communities. Further field testing and eventual deployment are recommended to validate the system's performance in real environmental conditions and expand its features for greater disaster resilience.

**Keywords:**

Wireless Communication, Flood Monitoring, Disaster Preparedness, Community, Ultrasonic Sensor

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**INTRODUCTION**

Floods are major threats to lives and property in many parts of the [7], [12] and remain responsible for a significant portion of disaster related fatalities and affected populations [14]. As these events continue to occur in various regions, they highlight the increasing vulnerability of communities to natural hazards. Since flooding is inevitable resulting from the natural rainfall runoff process [18] this means that there is a need for an early warning system for floods to reduce potential casualties, enhance the efficacy of disaster risk reduction efforts, and play an essential part in boosting adaptability to floods. This emphasizes the importance of preparedness and the necessity for systems that can respond promptly to flood related conditions.

The worldwide damage caused by flooding has been extremely severe in recent decades [9], showing the widespread impact of this natural phenomenon. Flood has the costliest damaged properties and affects most people among all natural disasters [20]. It may cause erosion or land slippage [21] and cause many damages to agricultural lands and residential areas which demonstrates how flooding continues to disrupt both the environment and human settlements [23]. These effects contribute to long term challenges for communities and require more effective strategies to minimize losses.

A flood management study was started by researchers such as Uma, Hassan, Sung, and Loong. Concerning the well-defined procedures for flood management and risk reduction, Uma adapted the stages of operational risk management in his research on flood risk and flood management [23], Hassan mentioned key factors for future flood risk management in their study on the dilemmas and pathways to dealing with flood problems [12], Sung has stated preference choice models in his study on mountainous areas choices for relocation to flood free areas [21], and Loong stated the importance of IoT devices for flood forecasting models. According to Sung et al., prolonged flooding and rain have caused devastation and problems in low-lying areas [21]. In their findings, Desta et al., summarized basic key points from authors, including highland and lowland interaction processes and how the activities of highland areas may contribute in terms of flooding in low-lying areas.

According to the article “IOT System: Water Level Monitoring for Flood Management” by Hassan et al. 2020, floods are a common natural disaster around the world. It endangers people and causes death, injury, damage, and significant property loss. Floods are regarded as a common calamity in Malaysia, more specifically the weather during the end of the year. With the advancement of technology, warning systems for flood management have progressed quickly. The Short Message Service (SMS) of the Global System for Mobile Communications is used by these devices to let people know ahead of time. For the implementation, it uses the Arduino board to manage the entire system and GSM shields for transmitting data. These serve as a foundation for these early warning systems. The model assesses the water level using sensors such as a float switch sensor. Data collection follows analyzing the level of emergency based on the threshold level set. When a threshold value is triggered, a warning message is then sent to the community. SMS is used to connect the various system components over the GSM network.

Based on Ragnoli et al., “Flooding is a common phenomenon in both types of environment in rural and urban areas. Due to certain geographical features, the severity of flooding differs, such as the presence of rivers or lakes near a residential area” [16]. The design, implementation, and test results are presented in this paper of a LoRa based flood monitoring system tested in a real world scenario. Using a modular approach, the system is capable of being linked to various peripherals or sensors without changing too much on the hardware and the whole system’s architecture. A device linked to sensors and a microcontroller that is attached to a LoRa wireless module for sending data. The information is subsequently handled and kept in a web format, where a notification feature is established in case of flooding.

Soh et al. in “Riverbank Monitoring using Image Processing for Early Flood Warning System via IoT” describe a system that observes river water levels using image processing by analyzing the difference between the water height as well as the water level on the riverbank. The assessed flood intensity is transmitted to an IoT platform that alerts individuals when a critical threshold is met.

In the study “Development of a smart sensing unit for LoRaWAN-based IoT flood monitoring and warning system in catchment areas” by Zakaria et al, they have developed a new way using a model for detecting early flood warning signs considering that their system is user friendly and provide real time data. In sensing water level data, they took advantage of ultrasonic sensing devices, which help in alerting in in-charge offices and possible affected individuals of a probable flooding. The system also integrates features that allow the community to inquire on the current or actual water level, specifically its status on the selected area for monitoring through the dashboard of a mobile application. The aim of their study is to give knowledge for the preparation of citizens whenever a flood is coming. Their work utilizes Arduino as the brain of the system connected with peripherals such as ultrasonic sensors monitored through web-based dashboard.

Based on the project of Hashemi-Beni et al., which is “A low cost IoT based deep learning method of water gauge measurement for flood monitoring”, they analyzed the technical challenges of flood monitoring devices. As its flood detection method, their system used image processing and used several sensors which are ground based camera/ CCTV Cameras, water level sensors, rainfall sensors and camera based gauge systems for different purposes to increase the reliability. Quantifying key parameters in flood detection, specifically precipitation rate, image based information, and algorithmic performance, the gathered data is promptly transmitted to the public in real-time.

According to a literature by Desta et al., 2024, natural phenomena such as floods and heavy rainfall are inevitable and sometimes unexpected that can cause minimal to major casualties and destruction of many homes and infrastructures. To avoid major effects of these naturally occurring phenomena, Flood Monitoring Systems (FMS) are built for this reason. Many agencies, most commonly the civil protection agencies uses various types of system designed to monitor flood levels. However, most of these systems are very expensive and difficult to use and maintain. Most conventional channel lock gates are manually operated and lack real-time monitoring of

water levels, which can lead to channel overflows and flash floods. Electronic devices, especially automated electronic devices, play an important role in our modern life. The advancement of electronic devices to nanoscale dimensions has led to improvements in microcontroller architectures and their data processing capabilities. Climate change stands as a significant challenge that has confounded global leaders, resulting in the thinning of the ozone. Few countries in the world have been hit by a devastating hurricane that caused billions of dollars in property damage and thousands of deaths.

Based on the article “Design of Information Monitoring System Flood Based Internet of Things (IoT)” research has been done by earlier researchers to help create catastrophe information and communication systems. Analog technology, web based digital technology, mobile applications, and other advancements have all been made in system research and development [1]. There have been gradual changes in technology, such as the introduction of early detection and warning system for flood that communicate precipitation height information in real-time [14]. One ultrasonic sensor is used in the study as both the input and output components, with the web server acting as the output component. In addition to using web based output on these kind of systems, there are information systems that utilizes GSM for communication, such as the prototype fire monitoring information system, Building Based GSM Module [18].

In the rural area of Mozambique, LoRaWAN is evaluated in terms of its connectivity and reliability on both distance and terrain elevation. LoRaWAN has improved the coverage even in the use of only basic hardware [8], [24], making it a good pair or integration for early flood warning systems. Also, LoRaWAN is a low powered connectivity making it good for battery powered sensors and actuators [15], [19]. Related to these findings many researches have also used LoraWAN along with other sensors and modules for flood warning [17] such as high-performance pressure sensor [22].

In the paper "Development and Implementation of an IoT Based Early Flood Detection and Monitoring System Utilizing Time Series Forecasting for Real-Time Alerts in Resource Constrained Environments" [13], flooding is one of the natural calamities that cannot be prevented. It occurred too quickly and impacted a large number of houses and lives. Before this, the majority of the systems that have been created have only been targeted at a few areas. In addition, because they lack any information or statistics regarding the weather, the bulk of the population is unaware of when the flood will occur. All the problems with the current method can be fixed with a smart IoT flood monitoring system [11]. The suggested technique works well in urban and rural settings. In Malaysia, a mix of natural and human elements leads to flooding. Historically, Malaysians are a riverine community, as early inhabitants established themselves along the banks of the peninsula's major rivers. Combined with natural elements like heavy monsoon rains, severe convective storms, inadequate drainage, and various local influences, floods have become a frequent occurrence in the lives of many Malaysians. Based on this article, the web-based IoT platform is utilized, and it offers an open API service that stores and retrieves sensor data, displaying the live sensed data on dashboards. The suggested system will offer an uncomplicated and fundamental monitoring interface, adequate information on flood levels, and upcoming short term water level forecasts.

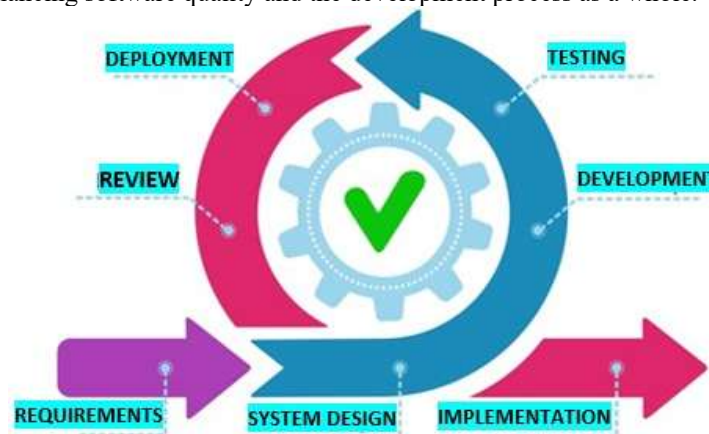
Through the use of published articles, gathered ideas that are similar to the methods, such as the study of Siddique et al. about the use of Wireless sensor networks (WSNs) [4] and the need for a reliable warning system that gives an early detection feature for flood disasters in the study of Soh et al. are considered as a help in developing the said automated system. The gathered data can be considered beneficial for the system and should be included, such as Flood Hazard Mapping, the study of Basnyat et al., which has a vital component for appropriate planning in flood prone areas. Unlike other studies, like Hassan et al. that have a flood monitoring system through the use of Short Message Service (SMS) via Global System for Mobile Communications (GSM) [6] for sending alert notifications, the project will use LoRaWAN to avoid interruption in case of a power outage and signal interference.

### OBJECTIVES

Disaster risk reduction and management offices have staff to monitor water levels in the highlands and manually alert their office through radio when an emergency level is observed. The said system is said to be implemented for flood alerts. The office then alarms the community through a siren warning. However, problems still surface with their existing system due to some delays with their manual system. To provide a major change and solution to the existing problem, this project aims to design and simulate a (1) Water Level Sensor device (a prototype) and a software of Flood Safety Notification Broadcast System, and (2) perform a simulation of the device and the software to present its significance to address the real world situation of flood incidents.

### METHODOLOGY

**Research Design.** The Agile method will be used to specify which tasks will be completed at each stage of the web system development process. It is a detailed plan for managing a project by breaking it down into phases. It entails constant client collaboration and continuous improvement at every stage. The life cycle is a methodology for enhancing software quality and the development process as a whole.



*Figure 1 Agile Model*

The following are the phases of the model:

**Plan:** Set up the first and equipment necessary for production optimization. To establish the beginning point and condition

**Design:** The client is involved in the project from the beginning, and their feedback is essential. We selected technologies like Arduino and LoRa and reviewed options with the client.

**Development:** frequently delivered using sprints. Testing feedback and any adjustments must be made immediately.

**Test:** To ensure that the process is operating as intended, these GV reports

**Deployment:** Through regular feedback, the client contributes to the system improvement

**Review:** This is to guarantee that essential metrics are successfully reviewed and tracked

**Launch:** The staged release of the complete system project is being prepared for the whole.

**Analysis.** Weighted mean and thematic analysis were applied as statistical techniques to examine the data received from survey questionnaires distributed to the participants of this study to determine the degree of system approval. The 3 point Likert scale was used to tabulate and analyze the data.

**Rating Scale:**

The end user will be given a survey form to complete for the collection of data and information(s). It is a three item survey questionnaire where responses are rated in 3-1-point scores with respective verbal interpretations.

Points	Verbal Interpretation
3 points	Very Acceptable
2 points	Acceptable
1 point	Not Acceptable

The Likert scale is structured and weighted as follows: very acceptable = 3, acceptable = 2, and not acceptable = 1. The following decision rule was used:

Range of the Weighted Mean	Range of the Weighted Mean	Range of the Weighted Mean
2.8 – 3.0	3	Very Acceptable (Functionalities are well understood by the user)

1.9 – 2.7	2	Acceptable (Functionalities of the system are somewhat understood by the user or accepted with a minor condition)
1.0 – 1.8	1	Not Acceptable (The functionalities of the system are not understood and are not clear to the user)
1.9 – 2.7	2	Acceptable (Functionalities of the system are somewhat understood by the user or accepted with a minor condition)

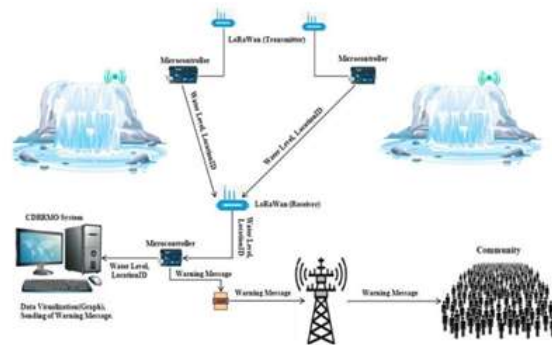
*(Table 1, Likert Scale)*

**Current Technical Situations.** Currently, the staff manually monitors the water level in a dam and reports to the office whenever a certain level is noticed through radio.



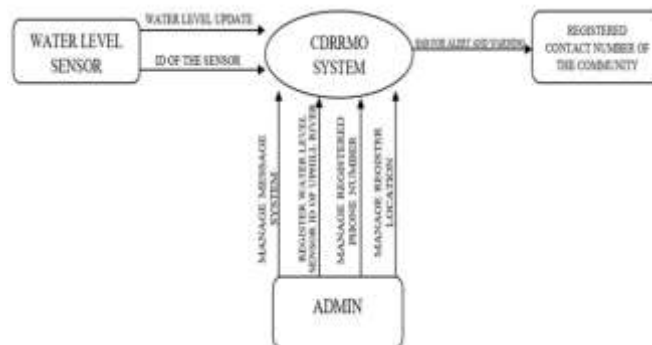
*Figure 2 Current Technical Situation*

**Design of Software, System, and Processes.** Continuous data generation by the sensors (according to the set time interval) will be sent through a solar-powered LoRaWan (transmitter) to the receiving LoRaWan. The received data will then be shown as a graph to display historical data. When certain warning levels are reached, the system sends the alert message to the registered phone numbers in the system’s database through SMS, which will be transmitted to the nearest cell tower. From the cell tower, the emergency message is passed to an SMS center (SMSC). From the center, the message is forwarded to the nearest cell tower of the community phone numbers that are registered in the system.



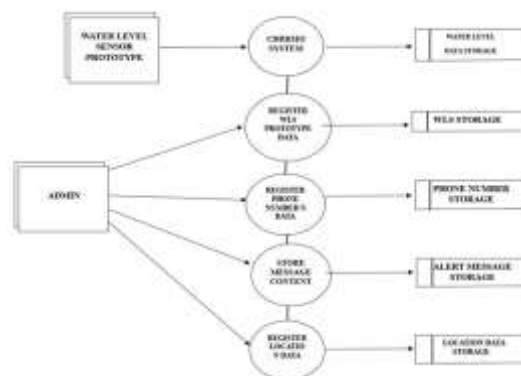
**Figure 3 System Architecture**

**Context Diagram.** Figure 4 presents a visual summary of the entities that are part of and included in the system. The diagram depicts the core functionalities of a system along with the participants that engage with it. The diagram features three primary participants: the administrator, the registered contact number of the community, and the water level sensor that gains value from the system. The functions on the front end are primarily managed by the user, while the admin takes care of the back end or adding information.



**Figure 4 Context Diagram**

**Data Flow Diagram.** The Flood Safety Notification Broadcast System’s DFD Figure 5 presents a summary of the system's comprehensive data management. One node signifies the primary process, outside entities (users), and information (inputs and outputs). This level illustrates the complete structure as one bubble, featuring incoming and outgoing indicators that show data input and output.



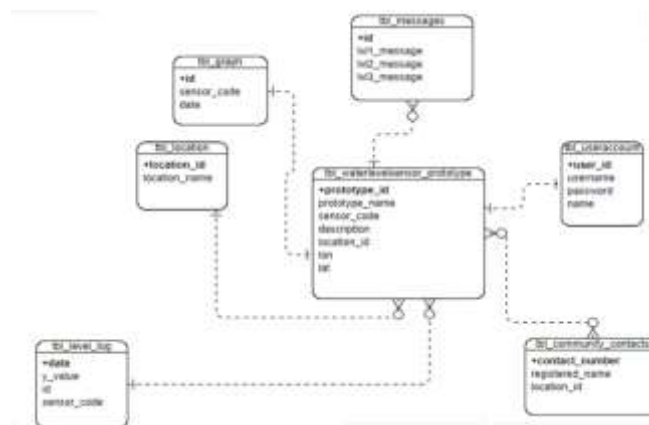
**Figure 5 Data Flow Diagram**

**Functional Decomposition Diagram.** The Functional Decomposition Diagram represents the whole function and all the necessary sub-tasks needed to complete the system. The system has the admin along with its task to control the system. This breaks down the large process of the system to show the overall processes.



*Figure 6 Functional Decomposition Diagram*

**Entity Relationship Diagram.** The Entity Relationship Diagram represents the relationship between two entities where the database that will be created is denoted. Each class will keep track of and save information. The river and community data are used to run the system. Each class has attributes that describe the object's properties and state. Some of the classes also have actions or functions available to them.



*Figure 7 Entity Relationship Diagram*

## RESULTS AND DISCUSSION

**Overview of Simulation and Findings.** The designed and simulated LoRaWAN–SMS Flood Safety Notification Broadcast System demonstrated an effective capability to support early warning efforts in disaster prone areas. The simulation results show that the system successfully collected water level data from sensor nodes, transmitted the information through LoRaWAN, and disseminated warning messages via SMS when

threshold levels were reached. These findings align with previous studies confirming the reliability of LoRaWAN networks for long range, low power flood monitoring applications [3], [5], [25].

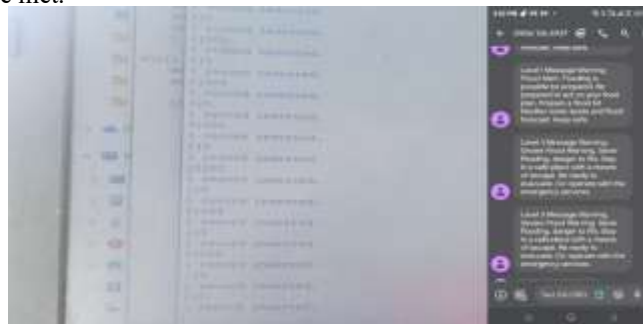
The overall performance indicates that the system can enhance disaster preparedness by enabling timely alerts and reducing dependence on manual monitoring. The dashboard developed for the simulation also provided real time visualization of water level conditions, supporting faster interpretation and decision making, an indicator consistent with earlier IoT-based monitoring research (Te et al., 2024; [2]).

**Hardware Devices.** The figure shows that on the right side are the two arduino and LoRa shields (transmitter) with antenna and ultrasonic sensors used to sense water level from the river. The left side is the LoRa shield (receiver) with antenna, which will be connected to a computer and used to receive data from the two LoRa transmitters. In the top left corner is the GSM module connected to the Arduino. The GSM sends messages automatically when the system receives water level data that is considered as Level 1, 2 or 3.



**Figure 8 Entity Relationship Diagram**

Arduino scripts must be uploaded first to the Arduino microcontroller board for the built prototype to work properly. To see if the script produces the desired results, it was evaluated with the use of the Arduino IDE in a test environment. The python scripts must run for the GSM and LoRa shield to start receiving and sending messages if conditions are met.



**Figure 9 Receiving Data**

**Functionality Testing.** Table 2 displays the responses from the office in-charge to the provided questionnaire, which consists of 15 entries. The questionnaire contains, for the first column, the performance evaluation for its key attributes. For the second column, the weighted mean for each item and for the last column is the rating which is the interpretation of the weighted average. These items are answered by five (5) admin participants from the office in-charge for disaster and risk preparedness. From these results, the findings showed that all the items for performance evaluation for the key attributes are very acceptable. Thus, making the system viable for its intended purpose.

Range of the Weighted Mean	Weighted Mean	Rating
1. The system allows the administrator to view the water level in every date.	3.0	Very Acceptable
2. The system allows the administrator	3.0	Very Acceptable

to edit and update their account.		
3. The system allows the administrator to view the details of the system.	3.0	Very Acceptable
4. The system allows the administrator to add warning messages.	3.0	Very Acceptable
5. The system allows the administrator to edit, delete and update the warning messages.	3.0	Very Acceptable
6. The system allows the administrator to view the messages.	3.0	Very Acceptable
7. The system allows the administrator to add new contacts.	3.0	Very Acceptable
8. The system allows the administrator to show entries of contacts.	3.0	Very Acceptable
9. The system allows the administrator to edit, delete and update the contacts.	3.0	Very Acceptable
10. The system allows the administrator to view the details of the contacts.	3.0	Very Acceptable
11. The system allows the administrator to search the registered contacts.	3.0	Very Acceptable
12. The system allows the administrator to add a new sensor.	3.0	Very Acceptable
13. The system allows the administrator to edit, delete and update the sensor.	3.0	Very Acceptable
14. The system allows the administrator to view the details of the sensor.	3.0	Very Acceptable
15. The system allows the administrator to view the map.	3.0	Very Acceptable

*(Table 2, Overview and Key Performance Attributes)*

**Message Delivery and Alert Performance.** Table 3 displays the responses from the office in-charge to the provided questionnaire, which consists of 15 entries. The questionnaire contains, for the first column, the performance evaluation for the message delivery. For the second column, the weighted average for each question and for the last column is the rating which is the interpretation of the weighted average. These items are answered by five (5) admin participants from the office in-charge for disaster and risk preparedness. From these results, the findings showed that all the items for performance evaluation for message delivery, are very acceptable. Thus, making the system viable in terms of warning message delivery.

Performance	Yes	No
1. Did you receive the message?	3.0	Very Acceptable
2. Did the message arrive completely or is it broken?	3.0	Very Acceptable
3. Can you read the message clearly?	3.0	Very Acceptable
4. Is the message easy to understand?	3.0	Very Acceptable
5. Do you think this message can help you as an alarming message when there is a flood?	3.0	Very Acceptable

*(Table 3, Message Delivery Evaluation Results)***ACKNOWLEDGEMENT**

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**CONCLUSION**

This research aimed to design and simulate a LoRaWAN-based IoT architecture for real-time flood sensing using SMS for the early warning flood alert. The said system is able to promote disaster preparation by monitoring water levels and delivering prompt warning messages to the areas detected to expect flood events. Through the results, the system shows that its intended purpose are correctly designed thus fulfilling its intended purpose. With LoRaWAN integration for the long range communication for the sensed data and SMS for early warning messages, the simulated system shows its reliability for data transmission, real-time monitoring, and timely delivery of warning messages.

Key system functions including water level tracking, sensor management, contact registration, and alert broadcasting performed effectively during simulation testing. The evaluation of message dissemination showed that alerts were received clearly, completely, and in a format that users found understandable and useful for flood response. These results shows that the system's design is reliable technically and will improve disaster information awareness to the common affected areas.

While the study focused on the system's design and simulation, the results provide a strong foundation for future deployment. The system's modularity, scalability, and low-power communication design indicate its potential for practical use in community-based early warning networks.

Despite promising simulation outcomes, the study is limited in several ways. First, the system was not deployed in a real world setting; therefore, environmental factors such as physical obstructions, atmospheric conditions, and real LoRaWAN interference were not fully assessed. Second, SMS delivery performance was evaluated only within a simulated environment, which does not capture potential delays caused by varying telecom network conditions. In addition, the system's simplicity in terms of water level monitoring may limit its capability to detect rapidly changing flood events. Since the research only aimed for design and simulation, the value of its actual performance needs field validation.

For future studies, an implementation of a full prototype is encouraged to evaluate and confirm the system's actual performance on flood prone areas. This will test the system's reliability for prompt response and accuracy given the actual environmental conditions. To improve more, integrating more sensors or environmental parameters is vital for additional function. Environmental parameters may include measuring rainfall intensity, river flow rate, or soil moisture that will provide improvements for risk assessments and enhance flood

prediction. In the area of power management and utilization, future researches may implement device sleep cycles to support longevity of device operation. Also, advanced analytics can be considered for improved data visualization and flood forecasting, providing ease to users for data analyzation especially for local authorities. For the overall protection of the systems data, future systems may include message security and data integrity for practical management of early flood warning systems.

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