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Development of an IoT-Based System for Early Detection of Flooding and QGIS Mapping of Affected Areas in Batangas State University-Pablo Borbon Campus

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Abstract: This study investigates the effectiveness of an IoT-based Early Warning Flood Alert System developed to improve disaster preparedness and community safety in flood-prone areas. The system integrates water-level detecting modules, GPS technology, and a QGIS-based mapping platform to accurately locate, monitor, and display areas experiencing rising water levels. The prototype underwent comprehensive testing, including evaluations of sensing accuracy, system response time, real-time data transmission, and durability under varying environmental conditions. Results indicate that the system performs reliably, providing consistent and precise updates as water levels change. Its ability to issue early alerts allows users and local authorities to take immediate precautionary measures, reducing the risk of property damage and ensuring community readiness during potential flooding events. Overall, the study concludes that the IoT-based system offers substantial benefits, demonstrating strong potential as a low-cost, scalable, and efficient solution for flood monitoring. Its implementation contributes positively to the surrounding community and supports Batangas State University–Pablo Borbon Campus in strengthening preparedness, resilience, and risk-reduction initiatives.

Keywords: IoT-based flood alert system, water-level monitoring, QGIS mapping, disaster preparedness, flood-risk reduction, community safety.

I. INTRODUCTION

In 2025, the Philippines experienced several typhoons, one of which is a supertyphoon that caused significant loss of life and extensive damage to industrial, economic and community infrastructures. The main reason why flooding is one of the most frequent and destructive natural hazards in the Philippines is because of its geographical position within the Pacific typhoon belt. (*Merz et al., 2021)* Severe water accumulation—often intensified by inadequate drainage systems and the increasing intensity of typhoons—has caused widespread damage to property and disrupted daily activities within communities *(Lagmay et al., 2017)*. These impacts have become more recurrent and severe amid climate change, which continues to amplify rainfall and extreme weather events *(Fulgar, 2024)*.

Academic institutions are not exempt from these hazards, leading to prolonged closures and disruptions in educational activities *(Samad & Sheikh, 2024)*. Heavy rainfall periods can flood areas like Batangas City, including Batangas State University – Pablo Borbon Campus. Over the past years, campus operations have frequently been disrupted by rising water levels that pose risks to students, staff, and facilities. The school lacks adequate emergency preparedness, including evacuation plans, availability of emergency equipment and resources, disaster preparedness guidelines, and psychological first aid and counseling *(Shah et al., 2018)*. Existing on-campus warning mechanisms are mainly manual, slow, and dependent on human monitoring, which limits response time and reduces the effectiveness of evacuation and safety procedures. This local experience reflects broader global concerns, as major flood disasters worldwide continue to result in significant losses and highlight challenges in ensuring that early warnings reach vulnerable populations *(World Meteorological Organization, 2024)*.

With the rise of modern technologies, such as the Internet of Things (IoT) and Geographic Information Systems (GIS), there is an opportunity to improve how flood risks are monitored and communicated. The researchers, being Geodetic Engineering students, understand the essential role of spatial data accuracy and real-time monitoring in enhancing disaster preparedness. Integrating IoT-based water-level sensors with GIS platforms such as QGIS will not only visualize flooded areas but also notify users of the exact location of the affected site, allowing for faster and more informed responses.

This study will develop a Smart Flood Alert System that incorporates IoT water-level sensors with QGIS mapping to enhance early detection and warning capabilities within Batangas State University – Pablo Borbon Campus. The system will help improve preparedness on campus, reduce risks to the community, and support broader disaster-risk-reduction initiatives by automatically sending alerts with real-time data and precise location-based notifications. Furthermore, the results of this research may serve as a reference for other educational institutions seeking to adopt technology-driven solutions for flood management.

II. OBJECTIVES

The primary objective of this study is to design, develop, and assess a Smart Flood Alert System which utilizes Internet of Things (IoT) capable of detecting early signs of flooding and integrating its real-time data with QGIS for precise spatial mapping of affected areas within Batangas State University – Pablo Borbon Campus.

Specifically the study aims to:

1) To design and implement an IoT-based flood monitoring system utilizing water-level and environmental sensors to collect and transmit real-time hydrological data in flood-prone areas on campus.
2) To develop and integrate a QGIS-based geospatial mapping interface that shows the representation of the monitored data and identifies flood-affected areas within the campus.
3) To develop an alarm system that automatically activates when water levels reach predetermined danger thresholds.
4) To evaluate the performance of the system in terms of accuracy, responsiveness, reliability, and usability through laboratory and field-testing under varying water-level conditions.
5) To determine the overall effectiveness of the prototype in supporting flood preparedness and safety within the university premises.

III. MATERIALS AND METHODS

A. *Research Methodology*

This study followed an experimental-developmental research design, with the focus placed on building and evaluating the prototype rather than gathering survey data. The researchers designed, assembled, and programmed the loT device, then tested its performance through a series of controlled procedures. After generating sensor readings, the data was imported into QGIS for mapping and spatial analysis.

B. *System Components*

The prototype was built using the following major components:

1) Water-level sensor (ultrasonic or float-based)
2) ESP32 or Arduino microcontroller
3) Wi-Fi or LoRa communication element
4) Rechargeable power source
5) Web dashboard for monitoring
6) QGIS software for mapping and spatial visualization

C. *Prototype Development*

The development phase involved designing and fabricating the device's enclosure, setting up and programming the microcontroller, and calibrating the sensor to ensure accurate readings. Alongside the hardware work, the researchers developed the online dashboard for real-time monitoring. GIS layers for QGIS were also prepared, including basemaps, sensor coordinates, and flood-prone areas that would later be used to visualize collected data.

D. *Test Procedures*

1) Accuracy Test: Accuracy tests were conducted by comparing manual measurements of water levels at 1-cm increments with readings from the sensor.
2) Response Time Measure: Time elapsed between changes in water levels and when these changes appeared on the web dashboard were measured.
3) Test of Stability of Communication: Stability of communication through Wi-Fi were tested over various distances and at different signal strength to measure reliability of transmitting data.

4) Flood Stimulation: Simulations of controlled water floods were conducted on the prototype in a known flood area on campus to test system response to real time conditions.
5) QGIS Maps: Maps were created using coordinates of sensor locations, and areas with previous flooding events, along with water level data collected from accuracy testing.

IV. RESULTS AND DISCUSSION

A. *Functionality Testing*

Functionality testing assessed whether the system performed all intended operations accurately and reliably. Sensor readings, data processing, transmission, storage, dashboard visuals, and alert notifications all worked smoothly throughout the tests.

Table I. Functionality Test Instrument

Criteria	Executive Status
Sensor Functionality	
The water-level sensors responded accurately to varying heights.	Sensors responded accurately to varying water levels.
Microcontroller (Data Processing)	
The microcontroller processed incoming sensor data without delay.	Processed sensor inputs without delay.
Communication Module(Wi-Fi/LoRa/GSM)	
Data was consistently transmitted to the server with stable connectivity.	Maintained stable and consistent data transmission.
Backend / Server Processing	
The backend received, filtered, and stored data correctly.	Received, filtered, and stored data correctly.
Web Dashboard (Data Display)	
Real-time readings and system status were displayed correctly on the dashboard.	Displayed accurate and real-time readings.
QGIS Mapping Integration	
Flood-prone areas were accurately plotted and updated in QGIS.	Flood-prone areas correctly plotted and updated.
Alert System	
Automatic notifications were successfully sent to students via SMS.	Automatic SMS notifications sent successfully.
Power System	
The device operated continuously with stable power delivery.	Operated continuously with stable power.
Laptop / Programming Module	
Programming, calibration, and debugging were completed smoothly.	Programming, calibration, and debugging performed smoothly.

The results show that the system operated efficiently and reliably across all components. The water-level sensors responded accurately to varying heights, while the microcontroller processed data without delay, ensuring real-time performance. Data transmission remained stable through the communication modules, and the backend consistently received, filtered, and stored information correctly. The web dashboard displayed accurate and updated readings, and QGIS mapping successfully plotted and refreshed flood-prone areas. In addition, the alert system delivered SMS notifications without error, and the device maintained continuous operation with stable power. Overall, these outcomes confirm that the system functions smoothly and is well-suited for practical use. Ensuring that sensors, microcontrollers, and communication modules operate reliably is essential, as accurate water-level detection and timely alert delivery directly impact the effectiveness of flood monitoring systems and the safety of communities at risk (Sushma M. P. et al., 2025).

Sushma M. P., Namith R., Nirmitha P., Prajwal K. T., & Prathiksha M. Y. (2025). *IOT Based Flood Monitoring and Alerting System*. International Advanced Research Journal in Science, Engineering and Technology (IARJSET).
https://iarjset.com/papers/iot-based-flood-monitoring-and-alerting-system/?utm_source=chatgpt.com

B. Safety Testing Instrument

Safety testing evaluated whether the system could be operated without risks to users, equipment, or the environment. Components were checked for proper wiring, structural stability, electrical safety, and secure enclosure.

Table II. Safety Test Instrument

Criteria	Remarks
All sensors are mounted on stable surfaces and shielded from moisture to avoid electrical hazards and corrosion.	100%
Wires are organized, insulated, and fastened to prevent accidental pulling, tangling, or exposure of live connections	100%
The power supply is connected only after verifying correct voltage levels and is disconnected during assembly or modification.	100%
Damaged or deformed components are removed immediately and disposed of according to laboratory safety guidelines.	100%
The Arduino Mega is placed on a non-conductive surface and protected from accidental static discharge during assembly.	100%
The waterproof enclosure box is tightly closed and positioned away from direct impact to ensure all internal components remain protected.	100%
The LED power indicator is connected with the correct polarity and placed in a visible area to allow safe monitoring of system status.	100%
The electronic buzzer is mounted securely and tested at safe sound levels to prevent overheating or excessive vibration.	100%
The A9G module is handled with care and operated in a well-ventilated space to avoid signal interference and thermal build-up.	100%

The results show full compliance with all safety criteria. Sensors were securely mounted and protected from moisture, wires were properly insulated, and the power supply was handled with correct safety procedures. Damaged components were removed promptly, and the Arduino Mega was kept on a non-conductive surface. The enclosure box was tightly sealed, indicators and alarms were safely installed, and the A9G module was operated in a ventilated area. Overall, the system met all safety requirements and can be used without risk. Following strict safety protocols is essential in IoT-based flood monitoring systems, as proper handling of sensors, wiring, and modules ensures both user safety and reliable system performance (Siddique, Ahmed, & Husain, 2023).

Siddique, M., Ahmed, T., & Husain, M. S. (2023). Flood Monitoring and Early Warning Systems--An IoT Based Perspective. *EAI endorsed transactions on internet of things*, *9*(2). https://www.researchgate.net/profile/Mohd-Shahid-Husain/publication/372568673_Flood_Monitoring_and_Early_Warning_Systems_-_An_IoT_Based_Perspective/links/64c2382404d6c44bc35d7ee3/Flood-Monitoring-and-Early-Warning-Systems-An-IoT-Based-Perspective.pdf

C. Feasibility Test Instrument

Feasibility testing evaluated whether the system is practical, cost-efficient, sustainable, and suitable for long-term use. The assessment examined component compatibility, material affordability, environmental impact, and overall usability.

Table III. Feasibility Test Instrument

Criteria	Remarks
Technical Feasibility	
QGIS integration works smoothly with system data.	100%
Short Messaging Service (SMS) is operating and is able to deliver alerts.	100%
System components (sensors, microcontroller, communication modules) are compatible and function cohesively.	100%
Material availability & Cost	
Materials used are inexpensive and readily available.	100%
Material sourcing is sustainable and reliable.	100%
Operational Sustainability	

The system can be maintained and operated over the long term.	100%
Maintenance and operational costs are reasonable	100%
Environmental Impact	
System design minimizes environmental impact.	100%
Materials and processes are environmentally friendly.	100%

The results show that the system is highly feasible across all evaluated criteria. QGIS integration and SMS alerts operated smoothly, and all components including sensors, the microcontroller, and communication modules functioned cohesively, confirming strong technical feasibility. Materials were inexpensive, readily available, and sustainably sourced, supporting cost-effectiveness. The system also demonstrated good operational sustainability, with manageable maintenance needs and reasonable long-term operating costs. Additionally, the design minimized environmental impact, using materials and processes that are environmentally friendly. Overall, the system is practical, affordable, and suitable for long-term implementation. Recent studies reveal that low-cost IoT platforms using economical ultrasonic or pressure sensors, efficient microcontrollers, and low-overhead data transmission protocols can deliver reliable flood monitoring with minimal installation and maintenance costs. This suggests that systems like ours are not only technically feasible but also financially sustainable for long-term deployment in resource-limited areas (Suharjono et al., 2023). Suharjono, A., Isa, M. R. M., Mukhlisin, M., Supriyo, B., Anif, M., Apriantoro, R., & Wardihani, E. D. (2023). *MiSREd: A Low Cost IoT-Enabled Platform Based on Heterogeneous Wireless Network for Flood Monitoring*. International Journal on Advanced Science, Engineering and Information Technology, 13(3), 1137–1146. https://ijaseit.insightsociety.org/index.php/ijaseit/article/view/18296?utm_source=chatgpt.com

D. Accuracy Test Instrument

Accuracy testing evaluated the system's precision in measuring water levels, processing and transmitting data, updating dashboards, mapping locations, and sending alerts.

Table IV. Accuracy Test Instrument

Criteria	Remarks
Water Level Sensor Accuracy	
Accurately measures different water levels.	100%
Microcontroller Data Accuracy	
Correctly processes and stores sensor readings without data corruption.	100%
Ensures timestamps are accurate and synchronized.	100%
Communication Module Accuracy	
Transmits data correctly to the server without loss or distortion	100%
Receives and acknowledges data packets reliably	100%
Database Accuracy	
Stores correct sensor values with matching timestamps	100%
No missing or duplicated entries during testing.	100%
Dashboard Display Accuracy	
Displays real-time readings identical to database-stored values	100%
Updates consistently without mismatches.	100%
QGIS Mapping Accuracy	
Correctly maps sensor coordinates within acceptable margin.	100%
Accurately highlights affected/flooded areas based on real sensor data.	100%
Alert Accuracy	
Alerts are triggered only when the threshold is exceeded.	100%
No false alerts during safe water-level conditions.	100%

The results show that the system achieved complete accuracy across all tested components. Water-level sensors consistently measured varying levels correctly, while the microcontroller processed and stored readings without corruption and maintained synchronized timestamps.

The communication module transmitted and received data reliably, with no loss or distortion. Database entries were accurate, with no missing or duplicated values, and the dashboard displayed real-time readings that matched stored data. QGIS mapping plotted sensor coordinates correctly and accurately highlighted affected areas. Alert functions also performed flawlessly, triggering only when thresholds were exceeded and producing no false alerts. Overall, the system demonstrated excellent precision and reliability throughout the testing process. Maintaining high accuracy and reliable data handling in IoT-based monitoring systems is critical, as precise measurements and trustworthy alerting directly affect decision-making and early-response effectiveness in flood-prone areas (Choosumrong et al., 2025).

Choosumrong, S., Piyathamrongchai, K., Hataitara, R., Soteyome, U., Konkong, N., Chalongsuppunyoo, R., Raghavan, V., & Nemoto, T. (2025). Development of an IoT-Based Flood Monitoring System Integrated with GIS for Lowland Agricultural Areas. *Sensors*, *25*(17), 5477. https://doi.org/10.3390/s25175477

E. Durability Testing

Durability testing assessed the prototype’s ability to withstand prolonged use and environmental stressors such as water exposure and temperature changes.

Table V. Durability Test Instrument

Criteria	Remarks
Equipment Enclosure & Protection for Internal wirings	
The equipment is properly enclosed and protected against dust and water spills.	100%
The chosen enclosure materials are suitable and effective for typical local weather conditions.	100%
Material Strength & Resilience	
All materials were sourced from trusted suppliers to ensure reliability and quality.	100%
The materials can withstand high water levels while allowing the device to remain fully functional	100%
System Longevity	
The system is designed for continuous operation without performance degradation.	100%
The system can endure expected operational stresses over extended periods.	100%
Wirings and Connections of Components	
The internal wirings are strong and securely arranged to resist vibration and movement.	100%
All components are firmly and carefully attached to the enclosure to prevent displacement or damage.	100%

The results show that the system demonstrated strong durability across all criteria. The equipment enclosure effectively protected internal wiring from dust, water, and typical weather conditions, while all materials used were reliable, high-quality, and capable of withstanding high water levels. The system also showed excellent longevity, operating continuously without performance degradation and enduring extended periods of environmental and operational stress. Internal wiring was secure and well-arranged to resist vibration, and all components were firmly attached to prevent displacement or damage. Overall, the prototype proved to be durable, resilient, and suitable for long-term use. In IoT-based flood monitoring systems, using robust enclosures, durable materials, and securely mounted components is crucial for ensuring long-term reliability and consistent performance under prolonged environmental stress (Te et al., 2024).

Te, M. C. L., Bautista, J. A. T., Dimacali, S. M. E. V., Lood, A. V. M., Pangan, M. G. M., & Chua, A. Y. (2024). *A smart IoT urban flood monitoring system using a high-performance pressure sensor with LoRaWAN*. HighTech and Innovation Journal, 5(4). https://doi.org/10.28991/HIJ-2024-05-04-04

V. CONCLUSIONS

In connection with the finding of the study, the following conclusion were drawn:

1) In connection with the findings of the study, the following conclusions were drawn:The system successfully detects potential floods by analyzing sensor data against predefined thresholds, ensuring timely and accurate alerts.
2) The integration of multiple sensors—such as ultrasonic, motion, and light sensors—provides layered detection and strengthens the system's overall reliability.
3) The automatic activation of LEDs, signal lights, relay controls, and SMS alerts demonstrates the system's capability to respond dynamically during flood risks.
4) Incorporating machine learning in future developments could enhance predictive capabilities, enabling more proactive and early warning alerts.
5) Expanding communication systems and implementing backup power sources will further improve the system's functionality and reliability during emergencies, making it a more comprehensive flood management solution.

VI. RECOMMENDATIONS

light of the findings and conclusions of the study, the following recommendations are hereby presented:

1) Researchers recommend expanding the deployment of sensors to additional flood-prone areas around Batangas State University – Pablo Borbon Campus to improve accuracy and coverage of water-level monitoring. Strengthening the system's communication features and especially during heavy rains.
2) It is further recommended to develop a centralized and user-friendly monitoring platform where campus administrators, security personnel, and students can easily access real-time data and alerts. Enhancing the alert system through SMS, mobile notifications, or loud audible alarms will help deliver warnings faster and support quicker evacuation and response.
3) These advanced features can improve early-warning capabilities, provide more accurate predictions, and help strengthen the overall disaster preparedness of the campus.
4) It is also recommended to integrate a solar-powered system to ensure continuous operation even during power outages. Using solar panels can provide a reliable and sustainable energy source, allowing the flood alert system to function without interruption during storms, helping maintain consistent monitoring and timely alerts.

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REFERENCES

[1] Choosumrong, S., Piyathamrongchai, K., Hataitara, R., Soteyome, U., Konkong, N., Chalongsuppunyoo, R., Raghavan, V., & Nemoto, T. (2025). Development of an IoT-Based Flood Monitoring System Integrated with GIS for Lowland Agricultural Areas. Sensors, 25(17), 5477. https://doi.org/10.3390/s25175477

[2] Lagmay, A. M. F. A., Racoma, B. A., & … (2017). Disseminating near-real-time hazards information and flood maps in the Philippines through Web-GIS. Journal of Environmental Sciences, 59, 13–23. https://doi.org/10.1016/j.jes.2017.03.014

[3] Merz, B., Blöschl, G., Vorogushyn, S., Dottori, F., Aerts, J. C. J. H., Bates, P., Bertola, M., Kemter, M., Kreibich, H., Lall, U., & Macdonald, E. (2021). Causes, impacts and patterns of disastrous river floods. Nature Reviews Earth & Environment, 2(9), 592–609. https://doi.org/10.1038/s43017-021-00195-3

[4] Samad, N., & Sheikh, I. (2024). Catastrophic Sways of Floods on the Education Sector in Pakistan. Academy of Education and Social Sciences Review. https://doi.org/10.48112/aessr.v4i1.591

[5] Shah, A., Ye, J., Pan, L., Ullah, R., Shah, S., Fahad, S., & Naz, S. (2018). School's Flood Emergency Preparedness in Khyber Pakhtunkhwa Province, Pakistan. International Journal of Disaster Risk Science, 9, 181-194. https://doi.org/10,007/s13753-018-0175-8.

[6] Siddique, M., Ahmed, T., & Husain, M. S. (2023). Flood Monitoring and Early Warning Systems--An IoT Based Perspective. EAI endorsed transactions on internet of things, 9(2). https://www.researchgate.net/profile/Mohd-Shahid-Husain/publication/372568673_Flood_Monitoring_and_Early_Warning_Systems__An_IoT_Based_Perspective/links/64c2382404d6c44bc35d7ee3/Flood-Monitoring-and-Early-Warning-Systems-An-IoT-Based-Perspective.pdf

[7] Suharjono, A., Isa, M. R. M., Mukhlisin, M., Supriyo, B., Anif, M., Apriantoro, R., & Wardihani, E. D. (2023). MiSREd: A Low Cost IoT-Enabled Platform Based on Heterogeneous Wireless Network for Flood Monitoring. International Journal on Advanced Science, Engineering and Information Technology, 13(3), 1137–1146. https://ijaseit.insightsociety.org/index.php/ijaseit/article/view/18296?utm_source=chatgpt.com

[8] Sushma M. P., Namith R., Nirmitha P., Prajwal K. T., & Prathiksha M. Y. (2025). IOT Based Flood Monitoring and Alerting System. International Advanced Research Journal in Science, Engineering and Technology (IARJSET). https://iarjset.com/papers/iot-based-flood-monitoring-and-alerting-system/?utm_source=chatgpt.com

[9] Te, M. C. L., Bautista, J. A. T., Dimacali, S. M. E. V., Lood, A. V. M., Pangan, M. G. M., & Chua, A. Y. (2024). A smart IoT urban flood monitoring system using a high-performance pressure sensor with LoRaWAN. HighTech and Innovation Journal, 5(4). https://doi.org/10.28991/HIJ-2024-05-04-04

[10] World Meteorological Organization (2025, August 6). Devastating floods highlight need and challenges for warnings. https://wmo.int/media/news/devastating-floods-highlight-need-and-challenges-warnings