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IoT-Based Flood Monitoring System with LoRa Communication and Automatic Gate Barrier

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Abstract

Flooding remains a major natural disaster in Malaysia, causing extensive property damage and threatening human safety, particularly in flood-prone residential areas. Existing flood mitigation systems are often manually operated, costly, or limited in coverage, leading to delayed responses during sudden flood events. This study presents an IoT-based smart flood monitoring system utilising LoRa communication and an automatic gate barrier for real-time flood mitigation. The architecture employs a decentralised design: a detection unit utilising discrete float-switch sensors, a LoRa-integrated transmitter for long-range data propagation, and a receiver node for real-time actuation and Telegram notification. Managed by an ESP32 microcontroller, the system implements a tri-level threshold logic comprising Normal, Warning, and Danger states. At the Warning level, the gate is partially deployed to 45° and a Telegram alert is issued. Meanwhile, at the Danger level, full deployment to 90° is executed. Experimental results indicate stable indoor LoRa communication up to 10 meters with RSSI values ranging from −53 dBm to −67 dBm and SNR up to 10.50 dB. Under outdoor line-of-sight (LOS) conditions, LoRa communication was successfully maintained up to 50 m, with RSSI decreasing to −90 dBm and SNR between 1.50 dB and 5.75 dB. Although signal degradation increased with distance, alert notifications were still received at 50 m, while communication failed beyond 60 m due to the receiver's sensitivity limits. The findings suggest that this integrated framework offers a scalable and cost-effective solution for autonomous flood management and disaster risk reduction.

1. Introduction

Flooding is categorised as one of the most frequent and destructive natural disasters in Malaysia, leading to substantial economic losses and risking human lives [1]. Factors such as rapid urbanisation, climate change, and inadequate drainage infrastructure have intensified the frequency of flash floods, particularly within low-lying residential and urban sectors [2]. Conventional mitigation strategies, including manually deployed barrier gates, necessitate human intervention and immediate response, which are often unattainable during sudden flood events or in the absence of residents [3]. While various monitoring systems exist, many depend on costly infrastructure or lack location-specific data [4]. Furthermore, most systems focus only on alerts without providing a physical response to prevent water intrusion [5]. There is a clear need for an automated, cost-effective solution that integrates early warning with physical protection. This study proposes an IoT-based flood monitoring system featuring an automatic gate barrier powered by LoRa communication. The system integrates real-time sensing, long-range wireless transmission, and automated mechanical actuation with instant user notifications [6]. The primary contribution is the two-stage automatic barrier mechanism combined with a resilient LoRa framework, providing a practical solution for areas with limited internet connectivity [7].

2. Literature Review

The flood monitoring has significantly evolved through the integration of Internet of Things (IoT) architectures and Low-Power Wide-Area Network (LPWAN) technologies. Among these, LoRa (Long Range) communication has emerged as a preferred solution due to its low power consumption.

Previous research has demonstrated the feasibility of LoRa for sensing and communication reliability and energy efficiency. However, their architecture lacks an integrated automated mitigation mechanism. Similarly, while many existing systems utilise ultrasonic or float sensors to relay alerts to cloud platforms, they function primarily as passive early-warning tools. These systems lack the physical intervention capabilities. A structured comparison of these representative systems is provided in Table 1.

Table 1 C*omparison of related flood monitoring systems*

Study/System	Communication Technology	Detection Method	Alert Mechanism	Automatic Barrier
IoT-Based Flood Monitoring using ESP32	Wi-Fi	TOF10120 laser sensor	Blynk app, LED, buzzer	No
GSM-Based Flood Alert System	GSM	Ultrasonic sensor	SMS	No
Flood Detection using Image Processing	Wi-Fi / Cloud	Camera, rain gauge, float switch, flow meter	Android app, cloud	No
Flood Early Warning System using WSN	XBee (WSN)	Humidity, temperature, rainfall, wind sensors	Database logging	No
LoRa-Based Monitoring	LoRa (RFM95W)	Ultrasonic sensor	Web-based alarm	No
Proposed System	LoRa (SX1278)	Dual float switches	Telegram Bot	Yes

The proposed system lies in the integrated multi-stage framework. It utilizes tri-level threshold logic to drive a servo motor actuation. Employing a two-stage served driven barrier that deploys incrementally relative to flood severity. Unlike conventional passive systems, this design bridges the gap between early warning and automated mitigation, providing a practical solution for localized flood defense.

3. Methodology

The proposed flood monitoring system was implemented using a dual-node architecture consisting of a transmitter node for water level detection and a receiver node for gate actuation and user notification. The system integrates float switch sensors, ESP32 microcontrollers, LoRa SX1278 modules, and an MG996R servo motor. Subsequent subsections detail the hardware configuration, software design, and the control algorithms governing the autonomous response to rising water levels.

3.1 System Overview

The proposed system employs a two-node architecture consisting of a transmitter and a receiver node. The transmitter node monitors water level conditions, while the receiver node processes incoming data, controls the flood barrier gate, and sends alert notifications. LoRa communication is used to transmit flood status data between the nodes, ensuring reliable long-range connectivity. Internet connectivity is only required at the receiver node for Telegram notification delivery. The system is illustrated in Fig. 1.

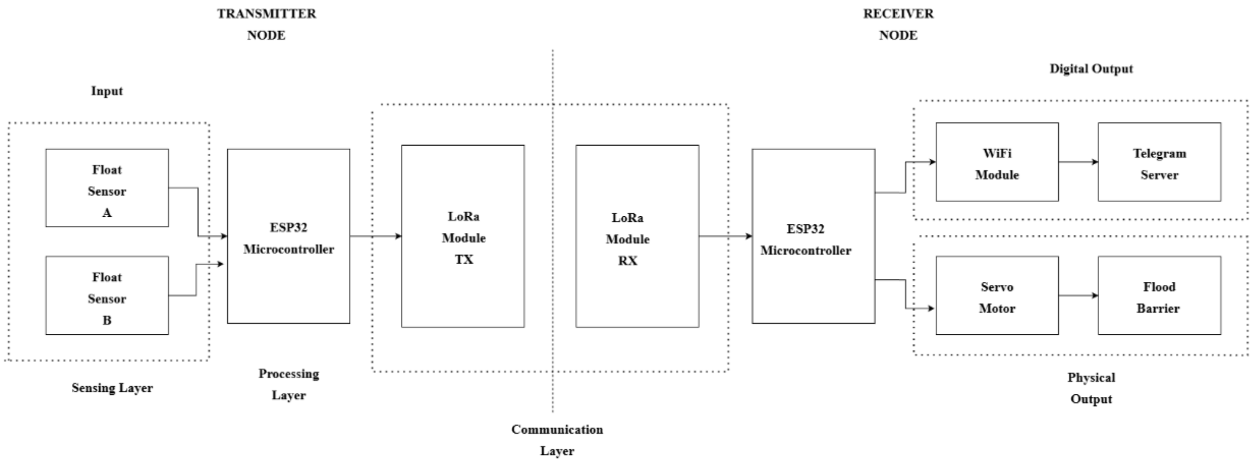


Fig. 1 *Block diagram of the overall system*

3.2 Hardware Configuration

The hardware design includes an ESP32 microcontroller, float-switch water-level sensors, a LoRa transmitter module, a servo motor (MG996R), and a lithium-ion battery. The ESP32 is selected for its low power consumption and integrated Wi-Fi capability. Two float switch sensors are installed at different heights to detect incremental changes in water level. The LoRa module enables long-range wireless communication, while the servo motor actuates the flood barrier gate. Power is supplied using a rechargeable 18650 lithium-ion battery. LoRa communication is implemented using the LoRa library through the SPI interface. Telegram Bot API is integrated to send real-time alerts to users. The system operates based on predefined threshold logic to determine flood severity levels.

3.3 Schematic Diagram

Fig. 2 and Fig. 3 show the schematic diagram of transmitter and receiver nodes.

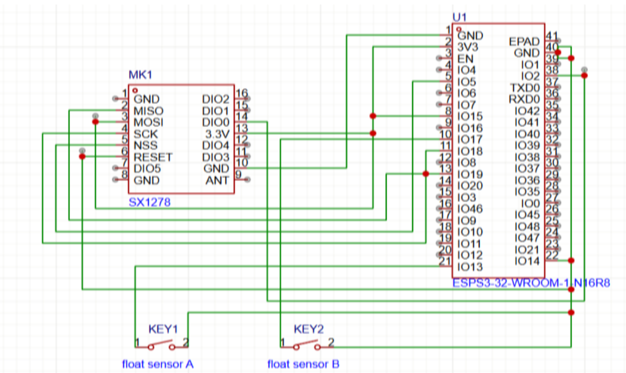


Fig. 2 *Schematic diagram for transmitter node*

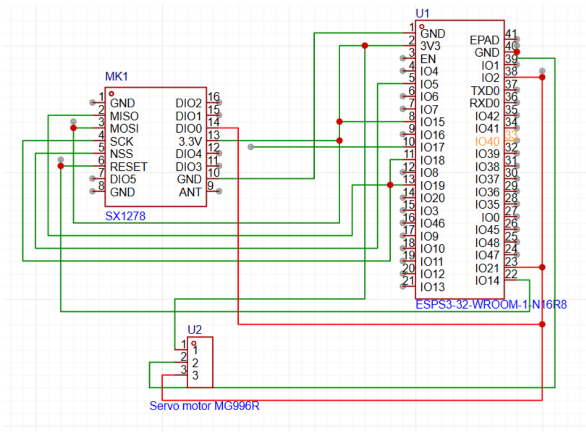


Fig. 3 *Schematic diagram for receiver node*

3.4 ESP32 Pin Configuration

Both nodes are powered using 3.7V 18650 lithium-ion batteries with a voltage boost module providing a regulated 5V output for the servo motor. The ESP32 operates at a 3.3V logic level. Proper grounding was implemented to minimise signal instability. The ESP32 microcontroller serves as the central processing unit for both nodes. The detailed pin configuration is summarised in Tables 2 and 3 to ensure reproducibility.

Table 2 *Transmitter node pin configuration*

Component	ESP32 Pin
Float Switch A (Lower Level)	GPIO13
Float Switch B (Upper Level)	GPIO17
LoRa NSS	GPIO05
LoRa SCK	GPIO18
LoRa MISO	GPIO19
LoRa MOSI	GPIO15
LoRa RST	GPIO14
LoRa DIO0	GPIO2
GND	GND
VCC	3.3V

Table 3 *Receiver node pin configuration*

Component	ESP32 Pin
LoRa NSS	GPIO05
LoRa SCK	GPIO18
LoRa MISO	GPIO19
LoRa MOSI	GPIO15
LoRa RST	GPIO14
LoRa DIO0	GPIO02
GND	GND
VCC	3.3V
Servo Motor Signal	GPIO21

3.4.1 LoRa Communication Configuration

The LoRa SX1278 module was configured to operate in the 433 MHz Industrial, Scientific, and Medical (ISM) band. The communication parameters were defined as follows: carrier frequency of 433 MHz, bandwidth of 125 kHz, spreading factor (SF) of 7, coding rate (CR) of 4/5, and transmit power of 17 dBm. These parameters were configured to achieve a trade-off between communication range, spectral efficiency, and power consumption. A spreading factor of 7 was chosen to maintain a moderate data rate while preserving link robustness, whereas a bandwidth of 125 kHz provides improved sensitivity suitable for short- to medium-range deployment. The selected coding rate enhances forward error correction capability, thereby improving resistance to environmental interference and packet loss.

4. Results and Discussion

This section provides an analysis of an IoT-Based Smart Flood Monitoring System with LoRa Communication and an Automatic Gate Barrier. The operational performance of the integrated system, through tests designed to verify sensing reliability, communication performance for the LoRa module, alert delivery, and mechanical response, is illustrated by the servo motor gate.

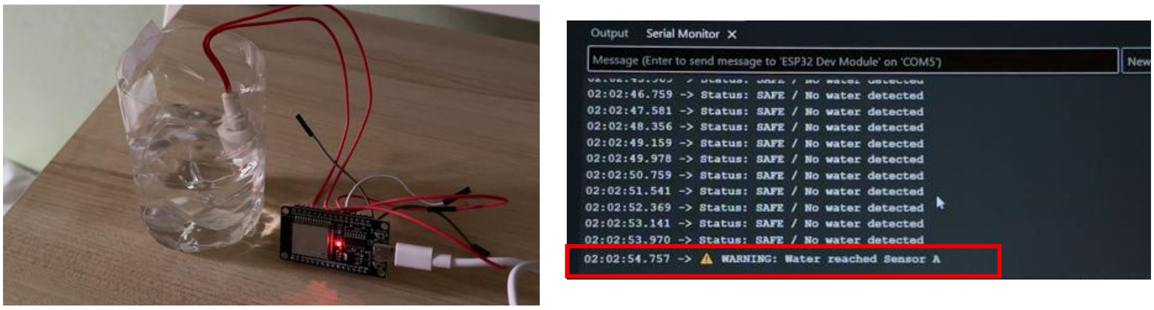
4.1 Water Level Detection and Classification

The float switch sensors exhibited high precision in detecting water transitions, accurately classifying flood conditions into the predefined 'Normal,' 'Warning,' and 'Danger' states. Throughout the experimental phase, the detection mechanism maintained consistent operational stability, with zero false-trigger events recorded during repeated immersion cycles. Table 4 summarises level classifications based on the severity of rising water levels.

Table 4 *Functional test results for level classification*

Water Level Condition	Sensor A (Lower)	Sensor B (Upper)	System State
Normal	Low	Low	Safe
Warning Level	High	Low	Warning
Danger Level	High	High	Danger

As illustrated in Fig. 4(a), activation of Sensor A resulted in a HIGH logic state, triggering the Warning condition. The corresponding serial monitor output in Fig. 4(b) verifies successful sensor acquisition and logic execution. These results validate the reliability of discrete float-switch sensing for multi-level flood detection in residential-scale applications.



(a) **(b)**

Fig. 4 *Warning severity state (a) Sensor A in HIGH logic state; (b) Serial monitor output*

4.2 LoRa Communication Performance and Link Reliability

To evaluate the communication performance and link budget of the system, testing was conducted by measuring the Received Signal Strength Indicator (RSSI), Signal-to-Noise Ratio (SNR), and Packet Delivery Ratio (PDR) across varying indoor and outdoor distances. For each test distance, multiple packet transmissions were conducted to assess link stability. The PDR was calculated as:

$$PDR\ (\%) = \frac{Packet\ Received}{Packet\ Transmitted} \times 100\% \quad (1)$$

The reliability of the LoRa link was verified by triggering the sensors at increasing intervals from the receiver node to observe signal degradation. Table 5 summarises the resulting signal attenuation, illustrating the relationship between physical distance and signal integrity. These measurements are critical for determining the maximum effective range of the flood monitoring system in real-world deployment scenarios.

Table 5 *Typical LoRa values*

SNR (dB)	Quality	Notes
>10 dB	Excellent	Very reliable communication
5-10 dB	Good	Communication works reliably, with a slight chance of delay
0-5 dB	Fair	Some packet loss possible
< 0 dB	Poor	Likely to fail

4.2.1 Indoor Environment

To evaluate communication performance, Table 6 shows the performance of the LoRa testing communication in an indoor environment and transmission distances. The evaluation focuses on signal quality in terms of RSSI and SNR, and PDR, as well as the system's ability to successfully deliver Telegram flood alerts.

Table 6 *LoRa communication distance test indoor*

Distance (meters)	SNR (dB)	RSSI (dBm)	Distance Status	Packet Sent	Packet Received	PDR (%)
0.7	10.25	-53	Close	50	50	100
3.0	9.25	-60	Close	50	50	100
7.0	9.50	-67	Close	50	50	100
10	10.50	-67	Moderate	50	50	100
20	5.50	-89	Moderate	50	50	100

Under indoor LOS and wall-obstructed conditions, RSSI values ranged from −53 dBm to −89 dBm, while SNR varied between 5.50 dB and 10.50 dB. Despite attenuation caused by wall obstruction, communication remained stable with an estimated PDR ≈ 100%, as all transmitted alerts were successfully received and delivered via Telegram. The SNR values remained within the "Good" to "Excellent" range (>5 dB), indicating strong signal integrity in short-range indoor deployment scenarios. Fig. 5 shows an example of how LoRa was tested under an indoor environment.

Fig. 5 *LoRa testing for indoor environment at 0.7 m*

4.2.2 Outdoor Line-of-Sight (LOS) Environment

Table 7 illustrates the communication performance of the LoRa under an outdoor environment and different transmission distances.

Table 7 *LoRa communication distance test outdoor*

Distance (meters)	SNR (dB)	RSSI (dBm)	Distance Status	Packet Sent	Packet Received	PDR (%)
10	4.00	-89	Moderate	50	50	100
20	3.00	-88	Moderate	50	50	100
30	1.50	-88	Moderate	50	50	100
40	5.75	-84	Moderate	50	50	100
50	1.75	-90	Far	50	45	90
60	-	-	Far	50	0	0

Outdoor LOS testing demonstrated successful communication up to 50 m. RSSI decreased progressively from −84 dBm to −90 dBm as distance increased, while SNR varied between 1.50 dB and 5.75 dB. At 50 m, although RSSI reached -90 dBm and SNR reduced to 1.75 dB, Telegram alerts were still delivered with minor noise interference, corresponding to an estimated PDR above 90%. Beyond 60 m, communication failure occurred due to receiver sensitivity limitations, resulting in complete packet loss (PDR = 0%). The observed degradation trend follows standard logarithmic path-loss behaviour in radio frequency propagation models. Fig. 6 illustrates how testing of LoRa communication was conducted under an outdoor environment.

Fig. 6 *LoRa testing for the outdoor environment at 50 m*

4.2.3 Comparison with Typical LoRa Benchmarks

The current system utilizes a Spreading Factor of 7 (SF7) and a 125 kHz bandwidth to prioritize data rate and latency over maximum propagation range. While higher SF values (e.g., SF10–SF12) can achieve multi-kilometer coverage in rural settings, the achieved 50 m stable range remains optimal for localized residential flood barrier deployment. Table 8 indicates the comparison of LoRa configuration.

Table 8 *Comparison of LoRa configuration*

Parameter	Current Configuration (SF7)	Extended Range (SF10-12)
Data Rate	Higher	Lower
Latency	Low (Fast response)	High (Slower response)
Range	Moderate (Local)	High (kilometers)

4.3 Alert System Analysis

Following the comparison of LoRa and Wi-Fi links, the efficiency of the dual interface alerting framework was evaluated. Reliability tests confirmed that the Telegram Bot effectively provides real-time mobile notifications with minimal latency, bridging the gap between field sensing and remote awareness. As illustrated in Fig. 7, the

'Warning' state trigger transmits telemetry data, including system status and live RSSI/SNR metrics, to verify LoRa link stability during delivery.

Fig. 7 *Telegram Bot notification when warning state triggers*

4.4 Servo Angle Accuracy Analysis

The operational efficacy of the gate barrier mechanism is dependent on the angular precision of the MG996R servo motor. To quantify the mechanical reliability of the system, a controlled positioning characterisation was performed. The actuator was subjected to five discrete command setpoints: 0°, 45°, 90, 135°, and 180°. The physical displacement was verified using a protractor to detect any deviations between the digital control signal and the mechanical output. To ensure statistical significance and evaluate the repeatability of the actuation, two independent trials were conducted for each reference angle. The angular error (Δ) was calculated using the following relation:

$$\Delta = \theta_{commanded} - \theta_{measured} \quad (1)$$

To verify the mechanical precision of the flood barrier, a controlled angular accuracy test was conducted. As illustrated in the experimental setup in Fig. 8, the servo motor was mounted to a fixed axis with an indicator needle to measure physical displacement against commanded setpoints.

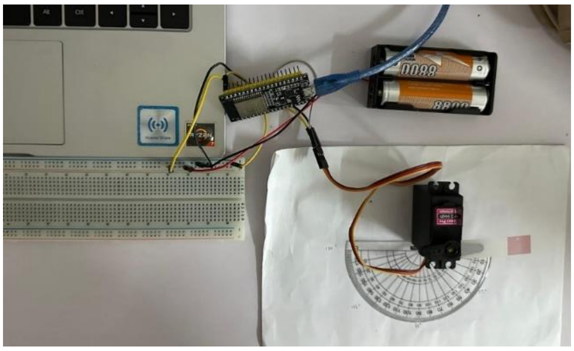


Fig. 8 *Experimental setup for servo motor angle*

Table 9 *Servo motor accuracy test*

Commanded Angle (°)	Actual Angle Trial 1 (°)	Actual Angle Trial 2 (°)	Avg. Actual (°)	Angle Error (Δ)
0	0	0	0	0
45	46	45	45.5	-0.5°
90	90	89	89.5	+0.5°
135	134	134	134.0	+1.0°
180	178	179	178.5	+1.5°

The quantitative results, summarised in Table 9, evaluate the actuator's deviation and operational accuracy across the specified range of motion. Although a peak variance of +1.5° was observed, this magnitude of error is functionally negligible. These findings validate that the control algorithm successfully translates sensory thresholds into reliable physical actuation.

5. Conclusion

This research successfully validated an IoT-based flood monitoring system with LoRa communication and an automatic gate barrier, fulfilling all primary design objectives. The system effectively integrates real-time sensing, long-range communication, automated mechanical response, and instant alert notification. The system demonstrated high operational reliability through a LoRa-based monitoring link that maintained a robust Signal-to-Noise Ratio (SNR) above 8 dB in obstructed environments, ensuring data integrity across extended ranges. Furthermore, the mechanical characterisation of the automated barrier revealed superior precision. By seamlessly integrating real-time hydrological sensing with precise mechanical actuation, this system provides a reliable, autonomous solution for flood mitigation that significantly minimises the requirement for human intervention during critical surge events.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Irdina Nur Nadhirah Roshamzani, Siti Hajar Aminah Ali;* ***data collection:*** *Irdina Nur Nadhirah Roshamzani;* ***analysis and interpretation of results:*** *Irdina Nur Nadhirah Roshamzani;* ***draft manuscript preparation:*** *Irdina Nur Nadhirah Roshamzani. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] IRFC, “Malaysia: Floods - Dec 2024.” Accessed Dec. 02, 2024. [Online]. Available: https://reliefweb.int/report/malaysia/malaysia-flood-2024-dref-operational-update-mdrmy011

[2] Department of Statistics Malaysia (DOSM), “Special Release on Impact of Floods in Malaysia,” Accessed 2024. [Online]. Available: https://www.dosm.gov.my/uploads/release-content/file_20250319122430.pdf

[3] Krishnan, A. Mugesh, S. P. Kumar, and R. Manivanna, “Analytical study on Self Closing Flood Barrier using ANSYS,” *International Journal of Engineering Research and Technology*, vol. 3, no. 16, Jul. 2018.

[4] M. Chan, Dec. 27, 2023, “Malaysia’s RM145 million flood warning system labelled a failure – accuracy rate of just 5.6%,” *Paul Tan’s Automotive News*. [Online]. Available: https://paultan.org/2023/11/24/malaysias-rm145-million-flood-warning-system-labelled-a-failure-accuracy-rate-of-just-5-6/

[5] L. K. S. Tolentino, “Real time flood detection, alarm and monitoring system using image processing and multiple linear regression,” *Journal of Computational Innovations and Engineering Applications*, Jan. 2023, doi: 10.2139/ssrn.4319789.

[6] W. Faturochman, P. Dauni, E. Teguh Arujisaputra, A. Husain, and I. Abdurrohim, “Design of Flood Early Warning Monitoring System Using a Microcontroller Ultrasonic Sensor Based on Website and Telegram Chat Bot”, *JESII: Journal of Elektronik Sistem Informasi*, 1(2), pp. 101–110, Dec. 2023, doi: 10.31848/jesii.v1i2.3358.

[7] M. Ragnoli, G. Barile, A. Leoni, G. Ferri, and V. Stornelli, “An autonomous Low-Power LORA-Based Flood-Monitoring system,” *Journal of Low Power Electronics and Applications*, vol. 10, no. 2, p. 15, May 2020, doi: 10.3390/jlpea10020015.