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IOT Based Flood Control and Management: Hybrid Sensor Approach

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Abstract

Flooding remains one of the most severe environmental problems in urban drainage systems because water can rise quickly, damage property, interrupt transportation, and create unsafe public conditions. This paper presents a prototype-level Internet of Things (IoT) based flood control and monitoring system that uses a hybrid sensor approach to identify flood risk conditions before the situation becomes critical. The prototype integrates an ultrasonic sensor for live water level measurement, a rain sensor for rainfall detection, a float sensor for high-level confirmation, and a DHT11 sensor for temperature and humidity tracking. An Esp32 is used as the central controller to read sensor values, compare them with threshold limits, and transmit the status to a website dashboard. The monitoring logic classifies the water state into normal, moderate, and danger zones. When the danger threshold is crossed, the buzzer and LED indicators are activated and a controller pump is switched on through a driver or relay stage so that excess water can be removed from the drainage channel. The main contribution of this work is the combination of early detection and active mitigation in one affordable prototype. Instead of reporting only the flood condition, the system can also respond to the danger by starting drainage support automatically. The same concept can be adapted for smart drainage lines, retention tanks, and selected dam-side monitoring points where timely response is important.

Keywords: Flood Monitoring, Internet Of Things, Esp32, Ultrasonic Sensor, Rain Sensor, Float Sensor, DHT11, Smart Drainage System

1. Introduction

Flood control is no longer a problem limited to large river basins. Many cities and semi-urban locations now experience water logging because rainfall intensity is higher, drains are clogged, and water channels are not monitored continuously. In such situations, manual inspection is slow and often begins only after visible overflow has already started. A low-cost IoT system can help by observing the water condition continuously and by reporting warning states before the site is fully flooded.

The present work is based on a prototype model that simulates the behavior of a smart drainage node. The design is intentionally simple so that it can be used in student projects and laboratory demonstrations. At the same time, it reflects the practical logic used in real monitoring systems. The prototype combines multiple sensors because flood formation is usually influenced by more than one factor. Rainfall indicates weather stress, the ultrasonic sensor measures the water surface distance, the float sensor confirms a physical rise, and the DHT11 sensor records surrounding humidity and temperature.

Fig No. 1 Kerala Flood (2011)

Esp32 is selected as the controller because it is inexpensive, widely available, and sufficient for reading multiple sensors in a small embedded system. The controller acts as the data collector, decision maker, and output trigger for alarms and pump control. A website dashboard is added so that the system is not limited to local indicators. The user can inspect the flood status remotely, which is useful in rain conditions, nighttime conditions, and locations that are difficult to reach quickly.

Recent research shows that IoT-based flood systems are becoming increasingly practical because they can combine real-time sensing, web visualization, cloud storage, and automated action [3]. Reviews in this area also report that ultrasonic sensors are frequently used for water-level estimation, while alert mechanisms and pumping systems are being added to improve response time [7]. The proposed prototype follows the same general direction, but keeps the implementation simple enough to be built and tested with common educational hardware.

The main motivation of the project is to demonstrate a complete detection-to-action chain. In many low-cost systems, the device only informs the user that water is high, but no physical response is executed. Here, when the level reaches the danger zone, the system does not stop at warning the user. It also activates a pump so that the extra water can be discharged from the drainage line. This makes the project useful as a practical drainage support model.

2. Literature Review

Flood monitoring research has shifted from simple level sensing to integrated early warning systems. Earlier designs typically used one sensor and a buzzer, but such systems often suffered from false alarms or missed cases because flood development is influenced by rainfall, water level, and environmental context together. Modern designs use sensor fusion, dashboards, and communication modules so that one device can present both local and remote status [4, 6].

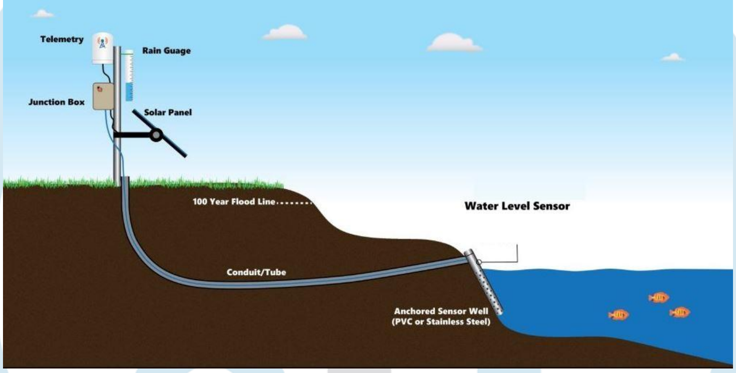


Fig No. 2 Typical System used in the. S. Choosumrong's Research Paper

A systematic review published in 2019 reported that IoT sensors and computer vision methods were increasingly used for flood monitoring and mapping, especially in locations where water spread had to be tracked continuously [4]. The study highlighted the importance of low-cost sensor networks because they can be installed at multiple points and can provide continuous data without requiring permanent human supervision.

More recent publications emphasize the role of real-time dashboards and automatic mitigation. A 2025 smart drainage study presented an IoT-based system that monitored water conditions and used pumps to redirect excess water away from collection points [2]. This shows an important transition from passive reporting to active flood management. The same study also demonstrated that web visualization improves usability because the operator can understand the condition of the drainage network at a glance.

A 2025 flood monitoring device study further confirmed that low-cost IoT designs are still relevant, especially for regions that need affordable and scalable flood awareness tools [1]. The focus on low-cost deployment is important for student and community-level systems because the hardware can be reproduced with minimal cost while still providing useful emergency support.

Review papers published in 2023 and 2024 show that sensor diversity matters. Ultrasonic sensors are commonly chosen for water-level reading, while humidity, rainfall, and communication quality are also considered in modern designs [3, 5, 6]. This supports the idea that a hybrid sensor approach can create more reliable decisions than a single-source input design.

Computer vision and edge computing have also been explored, especially in more advanced monitoring systems [7]. However, such methods can increase complexity, power demand, and implementation cost. For that reason, the present prototype intentionally focuses on widely available hardware and rule-based logic so that it remains easy to understand, easy to assemble, and easy to maintain.

Overall, the literature indicates that effective flood monitoring systems should satisfy three requirements: continuous sensing, timely alert generation, and a meaningful response mechanism. The proposed work is designed around these same requirements and extends them by including a pump-based drainage action that can support early flood control.

3. Problem Statement And Objectives

The core problem addressed in this paper is the delay between flood onset and corrective action. In many drainage environments, water first accumulates slowly and then rises abruptly. By the time a person notices the overflow, the condition has already become dangerous. A hybrid sensing model can reduce this delay by continuously checking the environment and by issuing alerts as soon as threshold values are crossed.

The first objective is to measure the local water state using multiple low-cost sensors. The second objective is to analyze the readings on Esp32 and classify the situation into normal, moderate, and danger categories. The third objective is to show the condition on a website so that the data can be checked remotely. The fourth objective is to trigger an audible alarm, a visual alert, and a pump action when the danger threshold is reached.

A fifth objective is to keep the prototype simple enough for academic demonstration. The model should be understandable without advanced hardware and should rely on commonly available components. This makes the system suitable for workshops, laboratories, and mini project installations. At the same time, the design should remain realistic enough to represent a small-scale drainage support node.

4. Proposed System Architecture

The system is organized into four main layers: sensing, processing, communication, and action. In the sensing layer, the ultrasonic sensor measures the water surface distance, the rain sensor detects rainfall or wetness, the float sensor verifies high water conditions, and the DHT11 sensor provides temperature and humidity values. These readings describe different aspects of the same environment, which makes the final decision more dependable.

The processing layer is handled by the Esp32. It reads sensor values at fixed intervals, performs simple filtering where needed, and compares the results with the threshold values stored in the program. This rule-based design is a good fit for a prototype because it is transparent and easy to debug. If a sensor behaves unexpectedly, the user can isolate the issue without requiring heavy computation or external cloud processing.

The communication layer publishes the values to a website dashboard. The dashboard can show real-time status, threshold category, and warning state. This is useful because the flood condition can be checked from a browser instead of being observed only on the local prototype. In future versions, the same communication layer can be connected to Wi-Fi, GSM, or cloud services, but the current prototype keeps the focus on local decision making and basic web reporting.

The action layer contains the LED indicators, buzzer, and controller pump. The LEDs give a quick visual indication of the current state. The buzzer provides immediate audio warning near the installation site. The pump is the most important action device because it helps reduce the excess water level. This combination of alarm and mitigation ensures that the system is not limited to passive monitoring.

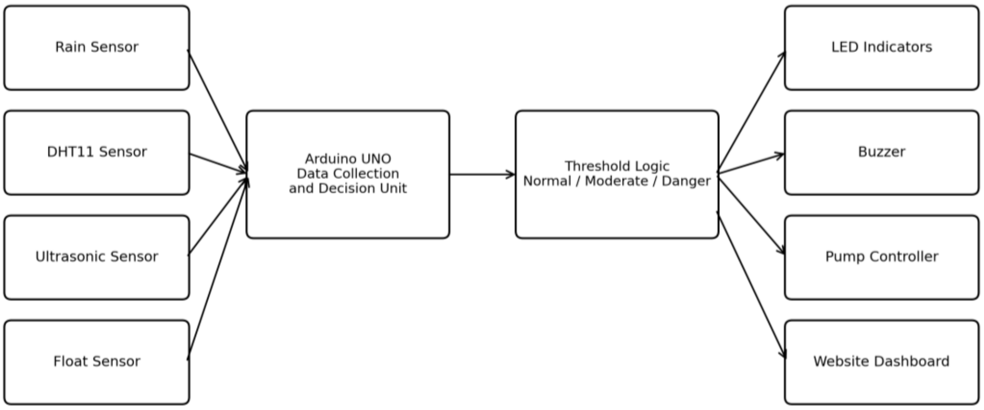


Figure 3. Proposed System Architecture

5. Sensor Placement And Threshold Calibration

Correct sensor placement is essential for reliable flood monitoring. The ultrasonic sensor should be mounted at a fixed height above the water path so that the reflected distance can be measured consistently. The float sensor should be positioned near the critical level, where direct physical confirmation becomes useful. The rain sensor should be exposed to rainfall or water droplets so that the system can detect weather-triggered risk conditions. The DHT11 sensor should be placed away from direct splashes but close enough to represent the local environment.

Calibration is carried out by observing the physical installation and deciding the numerical limits for normal, moderate, and danger states. The values used in this paper are prototype values rather than universal values. In one installation the warning threshold may appear at a small distance from the sensor, while in another site the same numbers may indicate a different water depth. For this reason, calibration should always be done at the deployment site.

The purpose of the threshold logic is not only to detect the flood but also to reduce false alarms. Short spikes in sensor output may occur due to vibration, splash, or temporary obstruction. The system therefore benefits from stable threshold bands instead of a single trigger point. By defining separate bands, the controller can first warn the user and only later activate the pump when the condition becomes severe.

A practical calibration sequence can be followed before final deployment. First, the empty-channel reading is recorded. Second, water is slowly added and the sensor response is observed. Third, the moderate and danger distances are selected based on the container geometry. Fourth, the float sensor activation point is checked and adjusted. This method ensures that the system responds correctly for the actual installation environment.

For the prototype, the threshold values are selected so that the danger state is reached only when the water has clearly exceeded the safe limit. That approach allows the moderate state to act as a preparatory warning. In a real drainage system, a similar design helps operators react early without starting the pump too soon.

Table 1. Main Components And Their Roles In The Proposed System

Component	**Function**	**Reason For Use**
Esp32	Central controller that reads sensors and applies threshold logic	Simple and affordable for prototype use
Ultrasonic Sensor	Measures distance to the water surface	Useful for live water-level estimation
Rain Sensor	Detects rainfall and wet surface condition	Provides early indication of storm conditions
Float Sensor	Confirms critical rise through physical float action	Adds direct confirmation at high water
DHT11 Sensor	Measures temperature and humidity	Adds environmental context to the data log
LED Indicators	Show current state visually	Helps with fast local interpretation
Buzzer	Produces audible alarm in danger state	Warns nearby people immediately
Controller Pump	Removes excess water from drainage line	Provides active mitigation instead of only warning

6. Decision Logic And Control Sequence

The decision logic uses the combined output of the sensors to determine the operating state. The ultrasonic sensor is treated as the main water-level source, while the rain sensor and float sensor act as supporting confirmation inputs. If rainfall is detected and the water level begins to rise, the controller moves from the normal condition toward the moderate condition. If the float sensor also becomes active or the measured distance crosses the danger limit, the system immediately enters the danger state.

A simple rule-based algorithm is suitable for the prototype because the system must be easy to explain and test. The controller does not need a complex model to understand whether the water is low, rising, or overflowing. Instead, it compares the live readings with the selected thresholds and then chooses an output action. This makes the behavior predictable and easy to validate during testing.

The normal state indicates that the water path is safe. The moderate state indicates that water has started to accumulate and the system should alert the user. The danger state means that active intervention is required. In the danger state, the buzzer turns on, the warning LED becomes active, and the pump starts removing water from the channel. In this way, the system performs both notification and response.

The control sequence can be summarized as a repeating loop. Read the sensors, compare the values, determine the state, update the dashboard, and execute the required output. Then repeat the same cycle after a short delay. This loop-based design is well suited to Arduino platforms and allows the flood condition to be tracked continuously.

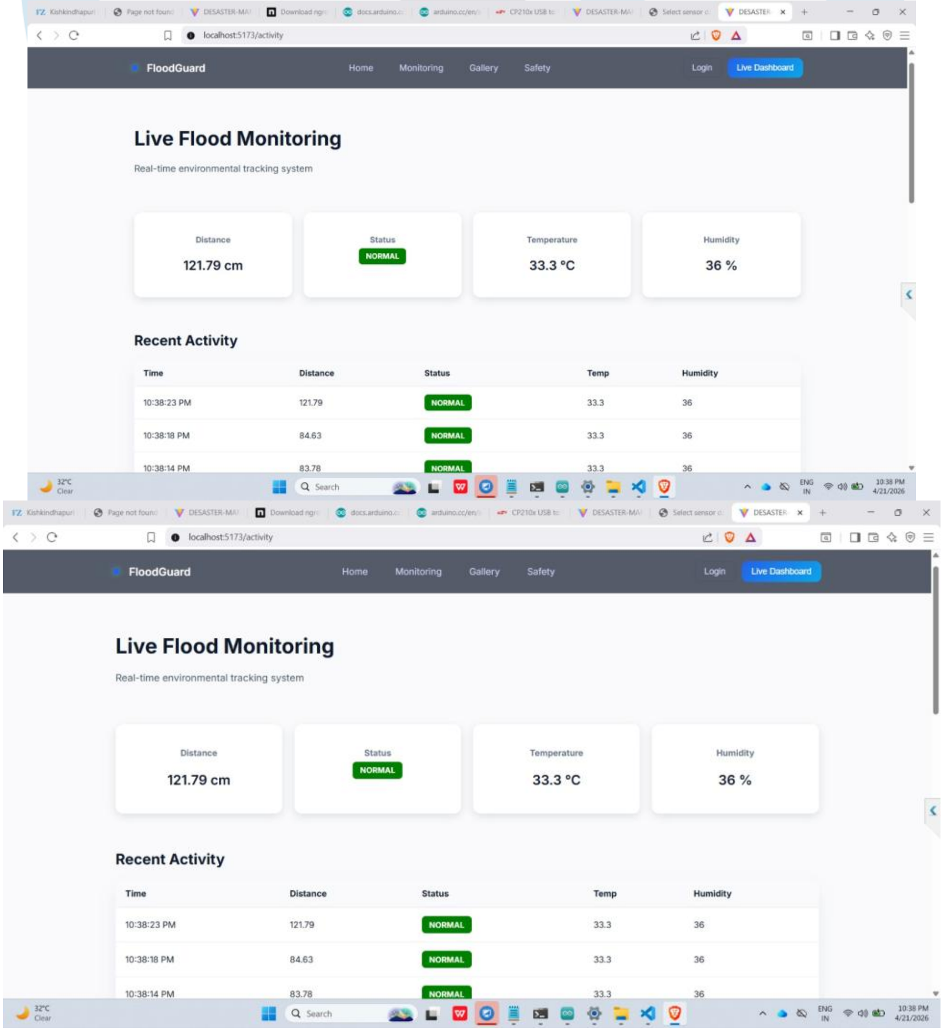
To avoid unstable behavior, the control program may include a short averaging or confirmation step. For example, a single noisy reading can be checked against the next reading before the state is changed. This kind of basic filtering helps reduce unnecessary alarm activation and improves the reliability of the prototype.

Table 2. Threshold Zones And System Response

Zone	**Typical Water Level**	**System Interpretation**	**System Response**
Normal	Below the warning limit	Drainage is stable	Only safe indicator shown
Moderate	Near the warning limit	Water is rising and must be watched	Warning LED and dashboard alert
Danger	Crosses the critical limit	Flood risk is high	Buzzer on, red LED on, pump activated

7. Data Flow, Website Dashboard And Alerting

The dashboard is the main visual interface of the system. It receives the current sensor values from the controller and displays them in a form that can be understood by the user at a glance. In a flood-related application, fast interpretation is important. A user should be able to see whether the site is safe, under observation, or in danger without reading complicated logs.



Live Flood Monitoring

Real-time environmental tracking system

Distance: 121.79 cm
Status: NORMAL
Temperature: 33.3 °C
Humidity: 36 %

Recent Activity

Time	Distance	Status	Temp	Humidity
10:38:23 PM	121.79	NORMAL	33.3	36
10:38:18 PM	84.63	NORMAL	33.3	36
10:38:14 PM	83.78	NORMAL	33.3	36

Fig No.4 Live Dashboard

Besides live status, the dashboard can also support time-based recording. This is useful because the history of sensor values helps explain how the flood condition changed over time. For example, the recorded data can show when rain started, how quickly the water level rose, and at what point the pump was triggered. Such records are useful for later calibration, maintenance, and report preparation.

The alerting part is intentionally multi-channel. Local alerting is done through the buzzer and LEDs so that nearby people receive immediate warning. Remote alerting is done through the web interface so that the user can check the system from another location. In a more advanced deployment, the same data stream can be connected to SMS, email, or cloud notifications.The data flow itself is straightforward. Sensors generate readings, the Arduino processes them, the status is published to the website, and the control outputs are activated if the danger threshold is reached. Because the processing is local, the response delay remains low. That low delay is important for flood control, where each minute can matter during heavy rainfall.

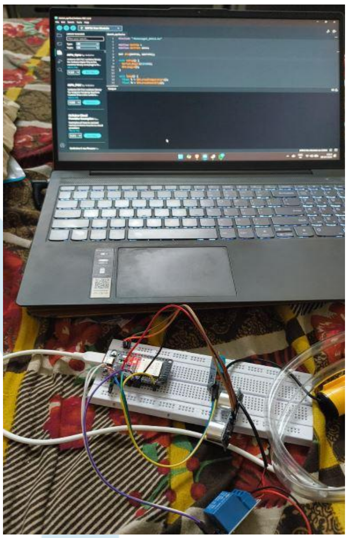


Fig No. 5 Prototype

8. Prototype Implementation, Test Cases And Expected Results

The prototype can be assembled on a small test platform that includes a water container or drainage model, a pump outlet, an indicator panel, and a browser-based dashboard. The ultrasonic sensor is placed above the water surface, the float sensor is installed at the critical level, and the rain sensor is used to simulate rainfall or wetness. The DHT11 sensor can run continuously as part of the environmental log.

During testing, water is added gradually to verify whether the system changes state correctly. In the first stage, the system should remain in the normal condition. In the second stage, the moderate warning should appear when the water approaches the selected threshold. In the third stage, the danger warning should start the buzzer and the pump. This staged behavior shows whether the threshold bands are working as intended.

A good prototype should also demonstrate that the sensor combination improves confidence. The ultrasonic reading alone may detect distance, but the float sensor confirms actual rise. The rain sensor shows that external weather conditions are active, and the DHT11 sensor adds a general environmental record. Together, these inputs produce a more complete picture than a single sensor could provide.

The expected result of the prototype is not only a displayed warning but also a visible water-removal response. If the water level remains high after the danger threshold, the pump should continue until the level returns toward the safe band. This creates a practical feedback loop and demonstrates why the project is suitable for drainage assistance.

Table 3. Sample Test Scenarios And Expected Behavior

Test Scenario	**Expected System State**	**Expected Output**
No rainfall and low water level	Normal	Safe LED only, no buzzer, pump off
Rainfall begins but water remains low	Normal or Moderate	Weather status shown, no urgent action
Water rises near the threshold	Moderate	Warning LED and dashboard alert
Water crosses the danger threshold	Danger	Buzzer on, red LED on, pump activated

9. Discussion

The prototype shows that a flood control system does not always need advanced machine learning to be useful. When the environment is well understood and the installation site is small, a carefully calibrated threshold model can work effectively. The advantage of this approach is its clarity. The user can see why the system moved from normal to moderate and then to danger.

The design also demonstrates the value of combining monitoring with control. In many low-cost systems, the user receives a warning and then must act manually. Here, the pump provides automatic help at the danger stage. That is especially useful in drainage applications because it can reduce the accumulation of water while the user is still responding to the alert.

Although the system is not a full hydrological prediction model, it provides a strong educational and practical foundation. A future version may include cloud analytics, GSM alerts, better waterproof enclosures, and battery backup. Those additions would allow the same concept to be used in harsher conditions and for larger-scale monitoring.

The project is therefore best understood as a prototype smart drainage controller. It is small enough to be built in a laboratory, but it also reflects the logic required in real flood management: sense early, warn quickly, and act immediately.

10. Advantages, Limitations And Future Scope

The main advantage of the system is affordability. The selected components are common and can be used without expensive infrastructure. Another advantage is redundancy. Because several sensors are used together, the system becomes less dependent on a single reading. This improves reliability in practical conditions where splashing, moisture, or noise may affect one sensor.

A further advantage is that the system is not only an alarm but also a control device. The ability to switch on a pump when danger is detected makes the design more valuable for drainage support. The website interface also increases usefulness because it allows remote checking and can be expanded into a larger monitoring application.

The main limitation is that the threshold values must be adjusted manually for each site. A value that is suitable for one drainage channel may not be suitable for another. The DHT11 sensor is also basic and mainly provides background conditions rather than detailed flood prediction. For that reason, future versions can include more advanced sensors and smarter analytics.

In future work, the system can be upgraded with Wi-Fi or GSM modules for stronger connectivity, cloud storage for historical analysis, solar power for backup operation, and machine learning for early trend prediction. The same concept can also be extended to larger drainage networks, retention tanks, and dam-support monitoring where automated discharge and early warning are important.

11. Field Deployment And Maintenance

A practical flood control node must operate in conditions that are not as clean or stable as a laboratory setup. Drainage channels may contain mud, floating debris, leaves, and splashing water. For that reason, the sensor mounting points should be checked carefully so that the ultrasonic sensor remains above the water surface and the float sensor is free to move without obstruction. Stable mounting improves both measurement accuracy and long-term reliability.

The enclosure for the controller and wiring should be placed above the highest expected splash line. Even in a prototype, keeping the electronics away from direct water contact is important because moisture can disturb readings and damage the board. Cable routing should also be neat and short, with sufficient insulation around exposed terminals. A simple waterproof box can greatly improve the practical value of the system during testing.

Power planning is another important part of deployment. The Esp32 and sensors consume low power, but the pump may require a separate supply with a proper driver stage. This separation prevents pump load from affecting the controller voltage. In real field use, a battery backup or solar source can be added so that the system continues to work during unstable power conditions. Reliable power is essential because flood events often occur during storms when the supply network itself may be weak.

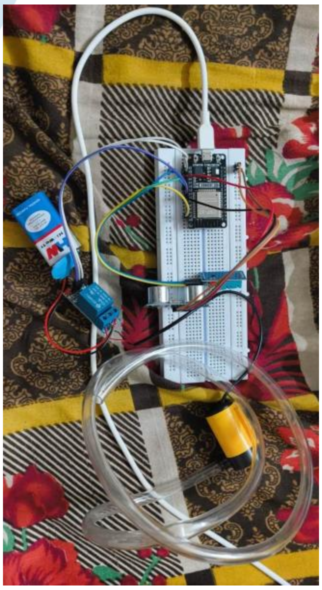


Fig No.6 Final Deployment

Maintenance should include regular inspection of the sensors and the pipe path. The ultrasonic sensor window should be cleaned if dust or moisture accumulates on it. The rain sensor should be checked for corrosion or buildup, and the float sensor should be tested manually to make sure it still moves freely. The pump line should also be inspected for blockage because a blocked outlet can reduce the effectiveness of the entire mitigation process.

From an operational perspective, the system works best when the alarm rules are tested before the rainy season begins. During a controlled test, the operator can raise the water level slowly and confirm that the transition from normal to moderate and then to danger occurs at the right points. This practice allows the user to trust the warning states and prevents confusion when the system is used in an actual emergency.

The dashboard should also be treated as a maintenance tool rather than only a display screen. If readings remain constant for a long period, the user may suspect a sensor fault. If the rain sensor shows activity but the ultrasonic sensor remains unchanged, the operator can verify whether the sensor is correctly mounted. Thus, the dashboard helps not only with flood awareness but also with troubleshooting and system health monitoring.

In larger deployments, several such nodes can be placed at different points in a drainage network. One node may monitor the inlet, another may monitor a low-lying section, and a third may monitor the outlet to the pump chamber. Data from multiple points can then be combined by a central web application. This is how the same small prototype can evolve into a broader monitoring system without changing the core logic too much.

The same architecture can also support future dam-related applications. In that case, the threshold values would be stricter, the casing would need to be stronger, and the pump or valve control would need to follow official safety rules. Even though the prototype is not a replacement for professional hydraulic control systems, it shows the essential idea: observe the water level, identify risk early, and trigger a response immediately.

The control sequence used in the prototype can be summarized in a simple algorithm. First, initialize the sensors, display components, and pump control pin. Second, read the ultrasonic, rain, float, and DHT11 values. Third, compare the water level with the selected threshold limits. Fourth, update the dashboard and the local indicators. Fifth, activate the buzzer and pump if the danger zone is detected. Sixth, repeat the process continuously at short intervals so that the site remains under observation.

If the water returns below the danger zone after pumping, the controller can switch back to moderate or normal state. This return path is important because it prevents the system from staying in alarm mode longer than necessary. A balanced design should both detect risk and recognize when the condition has improved. That makes the prototype more practical for real drainage management.

During user demonstration, it is helpful to explain each sensor separately and then show how the combined decision is made. This improves understanding for students and reviewers because they can see why the hybrid approach is more trustworthy than a single-sensor alarm. The system therefore serves not only as a monitoring model but also as a teaching model for IoT, sensing, and automatic control.

Overall, field deployment is successful when the physical installation, power arrangement, sensor calibration, and maintenance routine are all treated as part of the system design. The flood control prototype is small, but the same engineering principles apply at larger scale. Careful deployment is what turns a classroom demonstration into a useful monitoring solution.

11. Conclusion

This paper presented an IoT based flood control and monitoring prototype that uses an ultrasonic sensor, rain sensor, float sensor, and DHT11 sensor with an Esp32 controller, a website dashboard, LED indicators, a buzzer, and a controller pump. The hybrid sensor approach improves reliability because it combines level sensing, rainfall awareness, and physical high-level confirmation. The system classifies the condition into normal, moderate, and danger zones, which makes the decision logic simple and understandable. When the danger zone is reached, the system does not only alert the user; it also activates the pump to remove excess water from the drainage line. The result is a compact and practical model for early warning and automated drainage assistance. With further development, the same design can be scaled for real drainage infrastructure and can support future smart water management applications.

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