 ***DOI:** 10.5281/zenodo.17795962*

Title

# SMART WATER LEVER REMOTE MONITORING SYSTEM


Author

**INNOCENT CHADZANDIANI**

Co-Author

**MS FUNNY CHATOLA**



Issue October 2025

Certificate AR2025 A19MTQ


publications

**ABSTRACT**

Accurate and real-time water level monitoring is essential for effective management of water resources across households, agriculture, and industrial applications. Traditional monitoring approaches, such as manual gauge readings and float-based sensors, are often labor-intensive, prone to error, and unsuitable for large-scale or high-rise building deployments. This study presents the design and implementation of a real-time water level monitoring system using Internet of Things (IoT) technology integrated with the Django web framework. The system employs an ultrasonic sensor interfaced with an Arduino microcontroller to capture precise distance measurements from the water surface. A Python-based script running on a connected computer reads serial data from the Arduino, processes the raw measurements into percentage-based water levels, and transmits the data to a backend server. The backend stores the information in a relational database and provides RESTful endpoints for a web-based frontend. The frontend offers live water level visualization, historical trend analysis, and automatic alert notifications when water levels surpass or fall below predefined thresholds. Experimental evaluation indicates that the system delivers reliable measurements with an average accuracy of ±1 cm, while alerts are triggered within seconds of threshold violations. The web interface allows remote monitoring from any internet-enabled device, significantly reducing reliance on manual inspections and minimizing risks associated with overflow or dry-run conditions. By combining IoT sensing, real-time data processing, and web-based visualization, the proposed system enhances operational efficiency, improves water resource management, and provides a scalable solution adaptable to residential, commercial, and industrial environments. The results demonstrate the potential of IoT-enabled monitoring for transforming traditional water management practices into intelligent, automated systems capable of timely decision-making.

**KEYWORDS:** Water level monitoring, Internet of Things (IoT), Ultrasonic sensor, Arduino, Real-time data, Django web framework

## INTRODUCTION

### Background

Water is one of the most vital resources for human survival and economic development. Its efficient management is critical across households, agriculture, and industrial operations. With increasing population growth and urbanization, the demand for water has risen sharply, putting pressure on existing infrastructure. Traditional water level monitoring methods, such as manual gauge readings, float-based sensors, or mechanical indicators, have been widely used for decades. However, these methods are often labor-intensive, prone to human error, and limited in their ability to provide continuous, real-time data. In high-rise buildings, industrial facilities, and agricultural systems, where water tanks and reservoirs can be large and distributed over multiple locations, conventional monitoring becomes impractical.

DOI: 10.5281/zenodo.17795962

Furthermore, reliance on manual inspections can lead to delayed detection of overflow or dry-run conditions, which may cause significant operational disruptions, water wastage, and safety hazards. Therefore, there is a growing need for automated and reliable monitoring systems that can provide accurate and timely information about water levels to prevent losses and improve resource management.

**Context**

The rapid advancement of Internet of Things (IoT) technologies has transformed the way monitoring systems are designed and deployed. IoT combines sensors, microcontrollers, data processing units, and communication protocols to enable real-time data acquisition, remote monitoring, and automated control. In the context of water management, IoT-enabled systems offer several advantages over traditional methods. Ultrasonic sensors, for example, can measure water levels without physical contact, reducing maintenance requirements and increasing reliability. Microcontrollers such as Arduino allow seamless integration of multiple sensors and support data transmission to cloud servers or local databases. Web-based platforms, built using frameworks like Django, enable visualization of water levels, historical trend analysis, and instant notifications when thresholds are exceeded. In high-rise residential buildings, remote monitoring can reduce dependency on manual inspections and provide stakeholders with immediate information about water availability. Similarly, industrial facilities can prevent equipment damage and operational delays by detecting abnormal water levels early. These developments make IoT- based water monitoring systems scalable, cost-effective, and adaptable to various settings.

**Research Objectives**

The primary aim of this research is to design and implement a real-time water level monitoring system that is accurate, reliable, and remotely accessible. Specific objectives include:

- Sensor Development: Design and deploy a sensing module using an ultrasonic sensor interfaced with an Arduino microcontroller to capture precise water level measurements.
- Data Processing: Implement a data acquisition system that converts raw sensor readings into percentage-based water levels for meaningful interpretation.
- Web-Based Platform: Develop a Django-based platform to visualize live water levels, monitor historical trends, and generate alerts when levels fall outside predefined thresholds.
- System Evaluation: Conduct experimental testing to evaluate the system's accuracy, responsiveness, reliability, and suitability for various operational conditions, including high-rise buildings, household tanks, and industrial reservoirs.

By achieving these objectives, the proposed system addresses the limitations of traditional water monitoring methods, reduces manual intervention, and ensures timely decision-making. The study contributes to the development of scalable IoT solutions that can enhance water resource management, minimize operational risks, and support sustainable usage in both residential and industrial environments.

**LITERATURE REVIEW**

Year of publication “2021” Authors” *Pahuja & Kumar*.” Title “Importance of water level monitoring” Discussion: The absence of reliable monitoring systems can lead to several issues, such as water leakage, overflow, or complete depletion, all of which have economic and environmental implications. In larger contexts like dam reservoirs or urban water distribution, ineffective monitoring may even result in catastrophic flooding or shortages. Thus, implementing robust monitoring systems is essential for resource optimization, cost control, and safety. Since water is a finite natural resource that is increasingly under stress due to urbanization, industrial use, population growth, and climate change.

Year of publication “2022” Authors” *Wang et al*.” Title “Traditional water level monitoring methods” Discussion: Traditional monitoring systems lack the sophistication needed to support data logging, historical analysis, or remote access, making them unsuitable for modern applications. Moreover, they do not offer any form of predictive analytics or cloud-based data storage, limiting their value in long-term water management strategies. These techniques are often manual and mechanical, involving physical inspection or simple float-based mechanisms. These methods are typically used in residential water tanks or small-scale agricultural setups. Operators visually inspect calibrated level markers or mechanical floats and log values manually. Although these methods are inexpensive, they suffer from several limitations:

Year of publication “2020” Authors*” Goyal & Arora.”* Title “Internet of Things in water level monitoring” Discussion: IoT implementations offer numerous advantages such as 24/7 remote monitoring, energy efficiency, and real-time alerting. In agricultural settings, such systems can be combined with soil moisture sensors and automated valves to create smart irrigation solutions. In industrial applications, they ensure constant surveillance and help in predictive maintenance of water storage systems. The emergence of the Internet of Things (IoT) has revolutionized water monitoring by enabling the automation of data collection, transmission, and response. IoT-based systems utilize smart sensors and microcontrollers to detect and transmit data to cloud platforms or local servers in real time. These systems allow stakeholders to access water level information from any internet-enabled device, often with additional features like mobile notifications or trend analysis.

Year of publication “2022” Authors” *Holovaty & Kaplan-Moss*.” Title “Django framework in Web based applications” Discussion: Django's strength in rapid development, code reusability, and deployment readiness has made it ideal for time-sensitive monitoring applications. The key component of any IoT monitoring system is the backend infrastructure that collects, processes, and presents sensor data. Django, a high-level Python web framework, is widely used for building robust and scalable web applications for

IoT projects. Its modular design, security features, and powerful administrative interface make it ideal for managing water monitoring data. In water level monitoring systems. With Django's built-in features like form validation, error handling, and session management, developers can build secure, maintainable, and interactive interfaces for end- users.

Year of publication "2020" Authors "*Sharma & Das."* Title "Sensor technologies used in water monitoring" Discussion: ultrasonic sensors, when integrated with microcontrollers and wireless modules such as GSM or Wi-Fi, demonstrate superior performance for remote and real-time monitoring applications thereby combining accuracy, reliability, and flexibility. A wide range of sensor technologies has been explored in academic and industrial research for effective water level monitoring. These sensors differ in terms of accuracy, cost, contact type, and suitability for different environments. Among the most commonly used are ultrasonic, capacitive and float-based sensors. Each of these has its own advantages and constraints.

## METHODOLOGIES

The Agile research methodology provides a flexible and iterative approach to developing a water level monitoring system using an ultrasonic sensor. Unlike traditional linear models, Agile promotes continuous improvement through short, incremental development cycles known as sprints. The process begins with identifying high-level requirements such as real-time monitoring, data accuracy, alert systems, and remote access. The system is then developed in iterations, starting with a basic prototype that includes the ultrasonic sensor and Arduino microcontroller for capturing water levels. Each sprint involves designing, implementing, and testing small modules such as sensor calibration, data transmission, web display, and alert notifications. Feedback is collected after every sprint from users or stakeholders to refine features and improve performance. This adaptive approach allows for rapid changes, early detection of issues, and continuous user involvement. By applying Agile, the development team can create a robust, user-centered, and scalable water level monitoring system that evolves with changing requirements and environmental conditions.

## ALGORITHM

Algorithm is defined as a process or set of rules to be followed in calculations or other problem solving operations, especially by a computer. Algorithms act as exact list of instructions that conduct specified actions step by step in either hardware- or software-based routines. Algorithms are widely used throughout all areas of the Information Technology. Algorithms power search engines, manage databases, optimize network traffic, secure communications through encryption, and even enable artificial intelligence and machine learning. Additionally, algorithms can vary in complexity from simple arithmetic operations to advanced heuristics or recursive procedures for solving complex problems. In the smart water level monitoring system, there are three main types of algorithms that were used.

 DOI: 10.5281/zenodo.17795962

**Threshold-based algorithm**

The water level monitoring system uses an ultrasonic sensor typically follows a threshold-based algorithm combined with distance-to-level conversion logic. The algorithm begins by continuously triggering the ultrasonic sensor to emit sound waves and measure the time taken for the echo to return. This time is then converted into a distance using the speed of sound formula.

The measured distance is subtracted from the total height of the tank to determine the actual water level. The system then compares the calculated level against predefined threshold values such as low, medium, and high. Based on these thresholds, the algorithm can trigger specific actions, such as sending alerts, logging data, or turning a water pump on or off. In more advanced systems, the algorithm may include averaging filters to smooth out sensor noise and timing logic to prevent false readings due to ripples or disturbances. This simple yet effective approach ensures accurate, real-time monitoring and decision-making.

**Time based data logging algorithm**

This is used to automatically collect and store water level data at regular intervals, making it essential for trend analysis, reporting, and real-time monitoring in a water level monitoring system using ultrasonic sensors. It has a purpose of periodically record water level data (distance or volume) along with a timestamp, storing it in a database or file for later use. It works by setting a time interval like 10 seconds, reading the sensor data, converting the data to water level in cm, generating a time stamp to feature the real time and then store it in the cloud.

**Communication algorithm**

This is the set of instructions and logic that manages how the Arduino-based water level monitoring system shares its data with other devices, services. It is essential for making the system smart thereby monitoring the water level remotely. Its purpose is to transmit the measured water level data from the Arduino to the external destinations like the remote servers and the mobile applications. The key function is Formatting the water level reading into a suitable message (e.g., JSON string or plain text).

**RESULTS**

The major findings obtained from the design, implementation, and evaluation of the IoT-based real-time water level monitoring system. The results focus on sensor performance, accuracy of data transmission, response time for alerts, system scalability, and usability of the web interface. **System Deployment and Operation**

The prototype was deployed using an ultrasonic sensor mounted above a household water tank. An Arduino Uno captured real-time distance measurements which were transmitted via a Python serial listener to the Django backend over HTTP. The backend stored the readings in a PostgreSQL database and provided live visualization via a web dashboard.

The system successfully operated continuously for 14 days during evaluation, recording water- level changes with a sampling interval rate of 5 seconds. No system crashes or communication failures were observed during normal operation

 DOI: 10.5281/zenodo.17795962

**Sensor Measurement Accuracy**

The ultrasonic sensor readings were compared against manually measured values using a meter stick for validation. The average deviation observed between the prototype and manual reference measurements was ±1 cm. The accuracy remained consistent under different tank fill levels, demonstrating the reliability of ultrasonic-based sensing for non-contact measurement.

Experiments were conducted by manually measuring water levels at multiple points and comparing them to system readings.

The average measurement error was ±1 cm, demonstrating high reliability for practical applications.

**Alert Response**

Threshold-based alerts were tested for both high and low water levels. Alerts were triggered within seconds of threshold violations, enabling timely interventions.

The implemented system successfully monitored water levels in real time across different tank heights and environmental conditions. Experimental evaluation showed that the ultrasonic sensor, coupled with Arduino processing, achieved an average measurement accuracy of ±1 cm when compared to manual readings. Water levels were recorded continuously over a 48-hour period, and the system reliably captured both gradual and sudden changes in tank levels. Threshold-based alerts were triggered immediately when water levels exceeded 90% or dropped below 10%, demonstrating the system's responsiveness. The web interface provided clear visualizations of live data and historical trends, with minimal latency (<2 seconds) between sensor measurement and dashboard update. These results indicate that the system can effectively replace manual monitoring, reduce human error, and provide timely decision-making support for households, agricultural setups, and industrial water storage applications.

## DISCUSSION

The results of the real-time water level monitoring system demonstrate both the feasibility and effectiveness of integrating IoT technologies with web-based visualization platforms. The ultrasonic sensor, interfaced with the Arduino microcontroller, consistently produced accurate distance measurements with an average error of ±1 cm. This level of precision is comparable to other studies in the literature, which report typical ultrasonic sensor accuracies ranging from ±0.5 cm to ±2 cm under controlled conditions (Patel et al., 2020; Singh & Sharma, 2019). The system's responsiveness to sudden water level changes, with alerts triggered within seconds, highlights its potential for proactive water resource management in domestic, agricultural, and industrial settings.

The real-time monitoring capability addresses a significant limitation of traditional methods. Manual gauge readings and float-based sensors, as noted by Kumar et al. (2018), are labor-intensive, prone to human error, and unsuitable for continuous monitoring in high-rise or large-scale installations. In contrast, the proposed system minimizes human intervention, enabling automated data collection and analysis. Furthermore, the integration with the Django web framework provides a scalable and flexible backend, capable of handling multiple tanks or storage sites simultaneously—a feature not commonly addressed in prior IoT-based monitoring systems.

Historical trend visualization revealed valuable insights into water consumption patterns. For example, sudden drops in water levels were accurately recorded and aligned with observed usage events. This aligns with findings by Li et al. (2021), who highlighted the importance of continuous monitoring for predictive maintenance and early detection of anomalies in water distribution networks. Additionally, the system's web interface, which allows remote access from any internet- enabled device, addresses the modern demand for mobile and cloud-based monitoring solutions, expanding the utility beyond localized deployments.

Despite its strengths, the system faces several challenges that align with previous studies. Wi-Fi dependency, as discussed by Ahmad et al. (2020), can limit deployment in remote or infrastructure- poor regions. Similarly, turbulent water surfaces or the presence of foam may occasionally affect ultrasonic readings, a phenomenon noted in studies on sensor reliability in industrial water tanks (Zhang & Wang, 2019). Addressing these limitations may involve the integration of alternative communication protocols, such as LoRaWAN for remote areas, or hybrid sensing methods that combine ultrasonic and pressure-based measurements.

The results also suggest potential applications beyond simple level monitoring. For example, predictive analytics could be integrated to forecast water depletion or overflow events based on historical trends. Machine learning algorithms could identify abnormal consumption patterns, offering additional value for resource management. Such advanced functionalities have been explored in recent IoT water management systems (Hossain et al., 2022), highlighting the potential to transition from passive monitoring to intelligent decision-support systems.

In conclusion, the discussion of results underscores that the proposed system not only meets the practical requirements of accurate, real-time water monitoring but also aligns with contemporary research trends emphasizing automation, scalability, and data-driven management. By combining reliable sensing, web-based visualization, and proactive alerting, the system provides a significant advancement over traditional methods and presents a foundation for future smart water management solutions.

Finally, the scalability of the proposed system presents a notable advantage over many existing solutions. Multiple tanks across residential complexes, industrial plants, or agricultural sites can be monitored simultaneously using the same backend infrastructure. This contrasts with many conventional IoT water monitoring systems, which are limited to single-site deployments (Singh & Sharma, 2019). The combination of reliable sensing, web-based visualization,

 DOI: 10.5281/zenodo.17795962

automated alerts, and remote accessibility positions this system as a practical and versatile solution for modern water redo The discussion of alerts also highlights an opportunity for further system enhancement. While the current implementation triggers notifications upon threshold violations, future systems could incorporate predictive analytics to forecast water level changes. Machine learning models could analyze historical trends to predict abnormal consumption, potential overflow events, or risks of depletion. Hossain et al. (2022) demonstrated that IoT-based water monitoring systems with predictive capabilities significantly improve operational efficiency and reduce resource wastage. Incorporating such intelligent features would transform the system from a passive monitoring tool to an active decision-support platform. urce management. In summary, the discussion underscores that the proposed IoT-enabled water level monitoring system not only meets the practical requirements for accuracy, responsiveness, and usability but also aligns with contemporary research trends emphasizing automation, scalability, and intelligent data-driven management. While challenges remain, particularly regarding connectivity and environmental interference, the system provides a strong foundation for future developments in smart water infrastructure.

## CONCLUSION

The design and implementation of a real-time water level monitoring system using IoT technology integrated with the Django web framework. Experimental evaluation confirmed that the system achieves high measurement accuracy (±1 cm) and provides immediate alert notifications for threshold violations. The web-based interface facilitates remote monitoring, historical trend analysis, and proactive management of water resources. Compared to traditional methods, the proposed system reduces human labor, minimizes errors, and enhances operational efficiency.

The system is highly scalable, adaptable to residential, commercial, and industrial environments, and capable of handling multiple water storage sites simultaneously. Its integration of IoT sensing, Python-based data processing, and Django-based visualization represents a comprehensive solution that transforms conventional water monitoring into an intelligent, automated system. The results and discussion highlight both the practical applicability and alignment with current research in IoT-enabled water management, demonstrating the potential for broader adoption and further enhancement through predictive analytics and hybrid sensing approaches.

Future work may focus on improving connectivity in remote areas, integrating renewable energy sources for autonomous operation, and implementing machine learning algorithms to provide predictive insights and anomaly detection. Overall, the proposed system contributes to sustainable water resource management and represents a meaningful step toward fully automated, smart water infrastructure.

**REFERENCES**

**Ahmad, N., Rahman, M., & Yusof, Y. (2020).** Wireless sensor networks for water quality and level monitoring using IoT technologies. International Journal of Advanced Computer Science and Applications, 11(5), 156–163. https://doi.org/10.14569/IJACSA.2020.0110521

**Arduino. (2024).** Arduino Uno Rev3 technical specifications. Arduino. https://www.arduino.cc

**Django Software Foundation. (2024).** Django documentation (Version 5.0). Django Project. https://docs.djangoproject.com

**Hossain, M. A., Rahman, M. S., & Al Mamun, A. (2022).** IoT-enabled predictive analytics for intelligent water resource management systems. IEEE Access, 10, 115230–115243. https://doi.org/10.1109/ACCESS.2022.3220456

**Kumar, P., Gupta, R., & Sharma, N. (2018).** Automated water level monitoring and management system using IoT. International Journal of Innovative Research in Computer and communication Engineering, 6(4), 4121–4128.

**Li, Y., Zhang, X., & Liu, J. (2021).** Smart water management system based on IoT and cloud computing. Sensors, 21(17), 5747. https://doi.org/10.3390/s21175747

**Patel, A., Desai, P., & Chauhan, K. (2020).** Design and performance evaluation of ultrasonic water level measurement systems for IoT-based monitoring. Journal of Sensor and Actuator Networks, 9(3), 40. https://doi.org/10.3390/jsan9030040

**Singh, R., & Sharma, V. (2019).** Real-time water tank monitoring and control using IoT. International Journal of Engineering and Advanced Technology, 9(1), 163–169. https://doi.org/10.35940/ijeat.A1212.109119

**Zhang, T., & Wang, L. (2019).** Reliability analysis of ultrasonic sensors for industrial water level monitoring. Measurement, 145, 317–325. https://doi.org/10.1016/j.measurement.2019.05.056