# Design and Implementation of a Smart Multi Tank Water Filling and Monitoring System with Android APP Integration for Sustainable Water Resource Management

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## ABSTRACT

*Water scarcity and inefficient domestic/institutional water management remain major problems in many urban and peri-urban communities. This paper presents the design, implementation, and evaluation of a low-cost smart multi-tank water filling and monitoring system using an ESP32 microcontroller, ultrasonic and float sensors, flow measurement, relayed pump control, and an Android mobile application. The system supports prioritized tank filling, automatic pump control with anti-dry-run protection, remote monitoring via Wi-Fi/GSM, and historical consumption logs on a cloud backend. A prototype was built and tested in a campus environment. Results show accurate tank level detection (±2 cm), reliable automatic switching between tanks, reduced overflow incidents, and pump run-time through optimized control logic. The system contributes to sustainable water-resource management by reducing wastage and enabling data-driven conservation measures. Key contributions are: (1) a modular hardware and software architecture for multi-tank control; (2) practical algorithms for prioritized and demand-driven filling; and (3) an Android UI for real-time control and historical analytics. Relevant sensor choices, energy budgeting, and cybersecurity considerations are discussed.*

***Keywords:*** *Smart Water System, Multi-tank Control, Electronic Valves, ESP32, Internet of things, Android App and Sustainable Water Management*

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## INTRODUCTION

Water is an essential natural resource required for domestic, agricultural, industrial, and environmental activities. As global populations continue to increase and urbanization expands, the demand for clean and reliable water supply has risen significantly. According to United Nations Educational, Scientific and Cultural Organization (UNESCO), global water demand is projected to increase considerably in the coming decades due to population growth, industrial development, and the impacts of climate change (UNESCO, 2023). These challenges have intensified the need for efficient and sustainable water management systems that can optimize water utilization while minimizing wastage (WWAP, 2023;

Mekonnen & Hoekstra, 2016). In many developing countries, including Nigeria, irregular municipal water supply has forced households, institutions, and industries to rely heavily on private water storage systems such as overhead tanks and ground reservoirs (Adelodun et al., 2020; Oladipo, 2019). These tanks are commonly filled using electrically powered pumps that transfer water from boreholes or underground storage facilities. While this method helps ensure water availability, the monitoring and control of such systems are often performed manually (Akinola & Olorunfemi, 2021).

Manual monitoring of water tanks presents several operational challenges. Facility managers or household users must frequently inspect tank levels and manually switch pumps on or off to regulate water supply. In many cases, this manual approach results in tank overflow, water wastage, and excessive electricity consumption (Kumar et al., 2019). Additionally, pumps may continue to operate even when the water source is depleted, leading to dry-run conditions that can damage pumping equipment and increase maintenance costs (Gopalakrishnan & Ramachandran, 2020).

Recent advancements in embedded systems, wireless communication technologies, and mobile computing have made it possible to develop automated water management systems capable of monitoring water levels in real time and controlling pumps automatically (Al-Fuqaha et al., 2015; Ray, 2018). The integration of Internet of Things (IoT) technologies further enhances these systems by enabling remote monitoring, data acquisition, and intelligent control through mobile applications and cloud-based platforms. Furthermore, the widespread availability of Android smartphones across developing countries has created opportunities for Android-based monitoring applications to be used in remote water management systems (Statista, 2023). By integrating embedded control units with mobile applications, users can monitor tank levels, pump status, and system performance from any location, thereby improving operational efficiency and convenience.

This study therefore proposes the design and implementation of a smart multi-tank water filling and monitoring system integrated with an Android mobile application. The system automates the monitoring of water levels and the control of pumps and valves, thereby improving water distribution efficiency, reducing water wastage, and enhancing system reliability. Many institutions such as universities, residential estates, and industrial facilities rely on multiple interconnected water storage tanks to ensure a steady water supply. These tanks are typically filled using electrically driven pumps. However, the management of these systems is still largely manual. Manual monitoring and control present several challenges. First, tank overflow frequently occurs when operators forget to switch off pumps after tanks become full. This results in water wastage and increased operational costs. Secondly, pumps may operate even when the water source is empty, leading to dry-run conditions that can cause mechanical damage and reduce pump lifespan. Another limitation of conventional systems is the absence of centralized monitoring and data collection. Without historical water usage records, facility managers cannot accurately analyze water consumption patterns or detect leakages within the distribution system. As the size of institutions grows and water demand increases, manual management of multiple tanks becomes inefficient and prone to human error. Therefore, there is a need for an automated system capable of monitoring water levels, controlling pumps and valves automatically, and providing real-time monitoring through a mobile interface. The main objective of this research therefore, is to design and implement a smart multi-tank water filling and monitoring system integrated with an Android mobile application and the specific objectives include to design an automated water level monitoring system capable of detecting water levels in multiple storage tanks, implement an intelligent pump and valve control mechanism that prevents tank overflow and pump dry-run conditions. Integrate a microcontroller-based control unit with wireless communication capability. Develop an Android mobile application for remote monitoring of water levels and pump status and to implement a data logging mechanism for recording water usage information. The major contributions of this research include the development of a modular IoT architecture for multi-tank water management, automated pump and valve control based on tank priority logic, integration of an Android mobile application for remote monitoring and control and implementation of water usage data logging for improved water management.

## Literature Review

### Water Tank Monitoring Systems

Recent studies have introduced sensor-based monitoring systems capable of measuring water levels in real time. For example, Borankulova et al. (2025) developed a real-time water monitoring system using sensor technologies to improve water resource management. Their system demonstrated improved monitoring accuracy but focused mainly on data collection rather than automated water distribution. Similarly, Pane et al. (2024) developed an IoT-based water tank monitoring system that transmits sensor data to a remote platform. Although the system provided remote monitoring capabilities, it lacked automated pump control and multi-tank management features.

### IoT-

### Based Water Management Systems

The emergence of IoT technologies has significantly improved the capabilities of water monitoring systems.

IoT platforms allow sensors, microcontrollers, and communication networks to exchange data in real time. Al-Shareeda et al. (2025) developed a secure IoT-based water monitoring system using an ESP32 microcontroller and ultrasonic sensors. Their system provided real-time monitoring capabilities and secure communication protocols. Similarly, Muliadi and Isminarti (2023) proposed an IoT-based water monitoring system that transmits sensor data to cloud platforms for remote access. Although these systems demonstrate the benefits of IoT integration, many of them focus primarily on monitoring rather than automated water distribution and pump management.

## Automated Pump Control Systems

Automated pump control systems have also been widely studied as a way to reduce human intervention in water distribution systems. Tubburee et al. (2025) designed an automatic water pump control system using an ESP32 microcontroller and water level sensors. The system automatically activated or deactivated pumps based on water levels. Similarly, Rahman et al. (2025) developed an IoT-based tank monitoring and pump control system that enables remote monitoring and automated pump operation. However, many existing systems are designed primarily for single-tank environments and do not support intelligent distribution of water among multiple storage tanks (Table 1).

## Research Contribution of the Proposed System

The proposed system offers several improvements over existing water monitoring and pump control systems. It supports multi-tank water management by efficiently handling multiple interconnected tanks, unlike conventional systems that focus on a single tank. The system integrates automated control of both the water pump and electronic valves, thereby preventing tank overflow and protecting the pump from dry-run conditions. It also incorporates an Android mobile application that enables users to monitor water levels, pump status, and overall system performance in real time. Through Wi-Fi communication, the system allows for remote monitoring and control, enhancing user convenience and operational efficiency. In addition, it features water usage data logging, which supports analysis, planning, and sustainable water resource management. Furthermore, the system is designed using low-cost microcontrollers such as ESP8266 and Arduino, making it scalable and suitable for deployment in residential, educational, and industrial settings. Comparison of Existing Systems vs Proposed System(Research Contribution Table). To clearly highlight the novelty and contribution of the proposed smart multi-tank water filling and monitoring system, a comparison is made between existing systems reported in the literature and the proposed system developed in this study. Most previous systems focus mainly on single-tank monitoring or simple pump automation, while the proposed system integrates multi-tank management, Android-based monitoring, automated pump and valve control, and water consumption data logging. Table 2 presents a comparison of selected existing systems with the proposed system based on important system features such as IoT monitoring, pump automation, mobile application integration, multi-tank capability, and data logging.

## Research Gap

Despite the significant progress in IoT-based water monitoring systems, several limitations remain. Many existing systems focus only on single-tank monitoring and lack intelligent multi-tank water distribution capabilities. Additionally, some systems lack mobile application interfaces for user interaction, while others do not provide historical data logging for water consumption analysis. To address these limitations, this study proposes a smart multi-tank water filling and monitoring system integrated with an Android mobile application. The proposed system combines automated pump and valve control with real-time monitoring and water usage data logging.

## Conceptual Framework and System Architecture

The conceptual framework of the proposed system illustrates the interaction between sensing devices, the microcontroller-based control unit, communication interfaces, and the user monitoring platform (Figure 1).

**The system architecture consists of four major layers:**

### Input Layer

This layer consists of sensors installed in each water tank. Ultrasonic sensors measure water levels continuously, while float switches provide redundant safety detection for minimum and maximum water levels.

### Processing Layer

The processing layer consists of the ESP32 microcontroller, which receives signals from sensors and executes control algorithms to determine when to activate pumps or open valves.

### Communication Layer

The communication layer enables interaction between the hardware system and the Android mobile application using Wi-Fi connectivity.

**Table 1:** Summary of Reviewed Literature.

| Author | Year | System Type | Technology Used | Key Contribution | Limitation |
|---|---|---|---|---|---|
| Borankulova et al. | 2025 | Water Level Monitoring | Sensors, IoT | Real-time water level monitoring | Limited automation |
| Pane et al. | 2024 | IoT Tank Monitoring | IoT sensors | Remote monitoring of water levels | No multi-tank management |
| Al-Shareeda et al. | 2025 | IoT Monitoring System | ESP32, ultrasonic sensor | Secure real-time monitoring | Focus on monitoring only |
| Wister et al. | 2024 | Smart Water Monitoring | IoT sensors | Monitoring of tank water levels | No pump automation |
| Muliadi & Isminarti | 2023 | IoT Water Control | IoT platform | Remote monitoring and control | Limited scalability |
| Rafi et al. | 2019 | IoT Pump Control | IoT sensors and cloud | Automated pump control | No mobile app integration |
| Silva et al. | 2025 | Smart Water Platform | IoT monitoring system | Sustainable water management platform | Limited focus on tank distribution |
| Tubburee et al. | 2025 | Automatic Pump Control | ESP32, sensors | Automated pump control system | No historical data logging |
| Mbonu et al. | 2024 | Smart Pumping System | IoT monitoring | Remote monitoring of pump operation | No multi-tank system |
| Rahman et al. | 2025 | Tank Monitoring System | IoT sensors | Real-time monitoring and pump control | Limited data analytics |
| Forhad et al. | 2024 | Water Monitoring | IoT sensors | Real-time water monitoring | Focus on water quality |
| Morchid et al. | 2024 | Smart Irrigation | IoT sensors and cloud | Efficient water resource management | Focus on irrigation systems |

**Table 2:** Comparison of Existing Systems and Proposed System.

| Author / System | IoT Monitoring | Automatic Pump Control | Mobile App Integration | Multi-Tank Management | Data Logging | Key Limitation |
|---|---|---|---|---|---|---|
| Rafi et al. (2019) | ✓ | ✓ | ✕ | ✕ | ✕ | Focus on pump control for a single tank |
| Muliadi & Isminarti (2023) | ✓ | ✓ | ✕ | ✕ | ✕ | Limited remote interface |
| Pane et al. (2024) | ✓ | ✕ | ✓ | ✕ | ✕ | Monitoring only without pump automation |
| Wister et al. (2024) | ✓ | ✕ | ✓ | ✕ | ✕ | Designed mainly for water level monitoring |
| Mbonu et al. (2024) | ✓ | ✓ | ✕ | ✕ | ✕ | No user-friendly mobile interface |
| Tubburee et al. (2025) | ✓ | ✓ | ✕ | ✕ | ✕ | Focus on automatic pump control only |
| Rahman et al. (2025) | ✓ | ✓ | ✓ | ✕ | ✕ | Does not support multiple tank distribution |
| Silva et al. (2025) | ✓ | ✕ | ✓ | ✕ | ✓ | Focus on monitoring and data collection |
| **Proposed System** | ✓ | ✓ | ✓ | ✓ | ✓ | Designed for intelligent multi-tank water management |

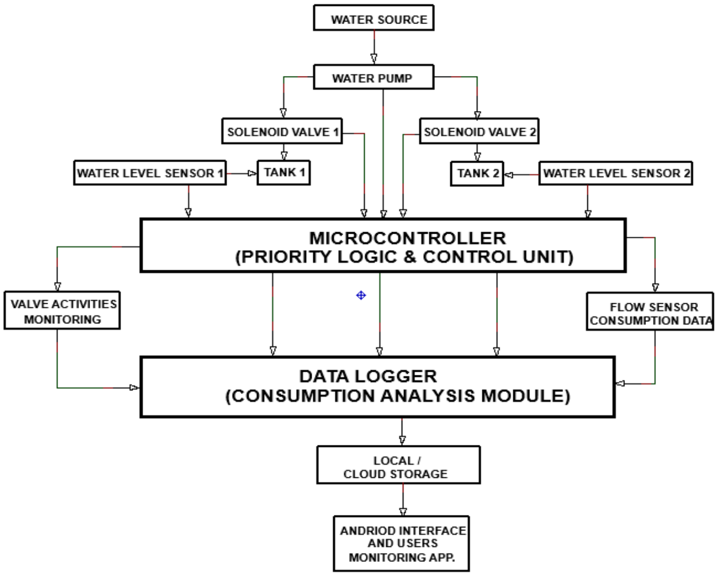


**Figure 1:** Block diagram of the Smart Multi Tank Water Filling and Monitoring System with Android App Integration

### Output Layer

The output layer includes pump control, solenoid valve control, real-time monitoring on the Android application, and historical data logging.

## MATERIALS AND METHODS

### Materials

The design of the proposed System integrates hardware and software components to achieve automated water level control with Wi-Fi-enabled monitoring via an Android mobile application. The system consists of two tanks, an AC water pump, electronic water valves, flow sensor, ultrasonic water level sensors, and an ESP32 microcontroller.

The design methodology is categorized into two sections, which includes;

a. Software design
b. Hardware design

The hardware design uses block diagrams and circuit diagrams to describe and implement the hardware functionality whereas the software design and implementation methodology uses a program flowchart to describe the software in relationship to the hardware.

### Hardware Design

### Microcontroller Unit (ESP32)

The ESP32 microcontroller serves as the central control unit of the system. It was selected due to its integrated Wi-Fi and Bluetooth capabilities, high processing power, and low energy consumption.
Key specifications include:

i. Dual-core 32-bit processor
ii. 2.4 GHz Wi-Fi connectivity
iii. Clock speed up to 240 MHz
iv. Up to 34 GPIO pins
v. 520 KB SRAM

### Ultrasonic Water Level Sensor

Ultrasonic sensors measure the distance between the sensor and the water surface by emitting ultrasonic pulses and measuring the time required for the echo to return (Figure 2).

The distance to the water surface is calculated using the equation: $d = \frac{vt}{2}$

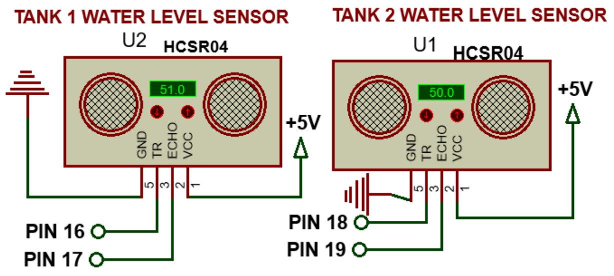


**Figure 2:** The Ultrasonic Sensors Configuration (Proteus) for Tank 1&2

Where: d = distance to water surface v = speed of sound (343 m/s), t = echo time

### AC Water Pump

A 1 HP single-phase AC centrifugal pump was used to transfer water from the reservoir to the storage tanks. The pump operates at 220–240 V and provides a flow rate of approximately 40–60 L/min.

### Water Level Sensors

The sensors were installed at the minimum and maximum levels in each tank. These sensors provide additional safety by ensuring reliable detection of critical water levels.

$Distance = \frac{Time\ x\ Speed\ of\ sound}{2} = \frac{t\ x\ 343m/s}{2}$ d(m) = 171.5t(μs)
Where: Time = pulse duration in seconds Speed of sound ≈ 343 m/s at room temperature
The division by 2 accounts for the round trip (coming and going) of the signal.

### Method / Design Consideration

The Echo pin outputs 5V, which exceeds the ESP32's GPIO tolerance of 3.3 V. A voltage divider is used to protect the microcontroller. The Trig pin can be directly triggered by the ESP32 using a digital output pin.

$Vout = Vin \left(\frac{R2}{R1+R2}\right)$ Where Vout = 3.3v and Vin = 5v

Assuming R2 to be 2kΩ $3.3 = 5\left(\frac{2000}{R1+2000}\right)$

$R1 = 3400/3.3 R1 = 1030\Omega$ (Approximately 1kΩ)

### Solenoid Valves

Normally closed solenoid valves were used to regulate water flow between the pump and the tanks. The valves

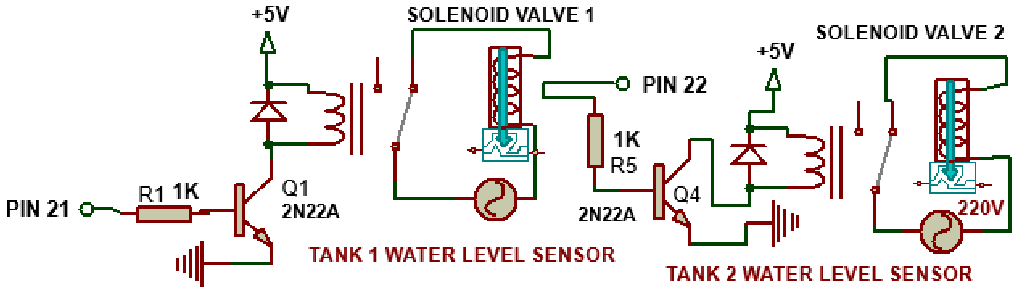


**Figure 3:** Solenoid Valves Interfacing with Microcontroller

open when activated by the microcontroller and close automatically when power is removed (Figure 3).

### Design Considerations for the YF-S201 Water Flow Sensor

When integrating the YF-S201 water flow sensor into a smart multi-tank water filling and monitoring system, several design factors must be considered to ensure accurate measurement, reliability, and safe operation (Figure 4).

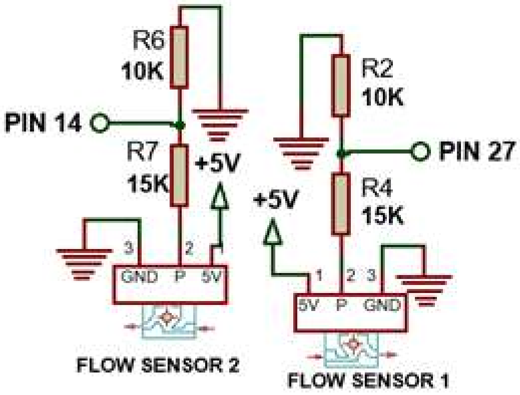


**Figure 4:** Flow Sensor Interfacing with Esp 32 Pins

### Operating Voltage Compatibility

The YF-S201 typically operates at 5 V DC

**Design considerations:** This provides a stable 5 V supply to power the sensor and uses a voltage divider or logic level shifter on the signal line to prevent over-voltage on ESP32 GPIO pins. It also ensures that the microcontroller and sensor share a common ground (Table 3).

### Flow Rate Measurement Range

### Pulse Signal Processing

**Table 3:** The sensor operates within a specific range.

| Parameter | Typical Value |
|---|---|
| Minimum flow rate | ~1 L/min |
| Maximum flow rate | ~30 L/min |
| Output type | Pulse signal |
| Pulse frequency | ≈ 7.5 × Flow rate |

The YF-S201 produces a digital pulse output generated by a Hall-effect sensor detecting rotor movement.
Design considerations

i. Connect the signal to an interrupt-capable GPIO pin 14 & 27.

ii. Use hardware interrupts instead of polling to avoid missing pulses.

### Flow Calculation Formula

The YF-S201 produces pulses proportional to water flow:

Flow Rate (L/min) $= \frac{frequency}{7.5}$

Where: Pulse frequency = pulses per second 7.5 = sensor calibration constant

If the ESP32 measures 75 pulses per second: $\frac{frequency}{7.5} = \frac{75}{7.5} =$ 10 L/min

### Water Consumption Measurement

To monitor total water usage, the system integrates the flow rate over time.

Total Volume Formula: $Volume\ (Litres) = \frac{Total\ Pulses}{450}$

YF-S201 produces ≈450 pulses per litre. If the ESP32 detects 4500 pulses when the water flows, therefore, 10 litres of water is been measured. Thus, the controller continuously counts pulses and converts them to litres.

### Relay Driver Circuit for AC water pump

A relay module was used to interface the ESP32 microcontroller with high-voltage devices such as the pump and solenoid valves. The relay provides electrical isolation between the control circuit and the power circuit (Figure 5).

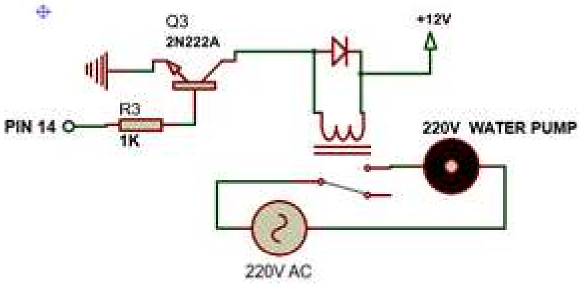


**Figure 5:** Water Pump Interfacing via Relay

## Software Design

The software design and implementation methodology use a program flowchart to describe the software in relationship to the hardware. The figure below describes the flow charts diagram that shows the logic with which the program code was written (Figure 6).

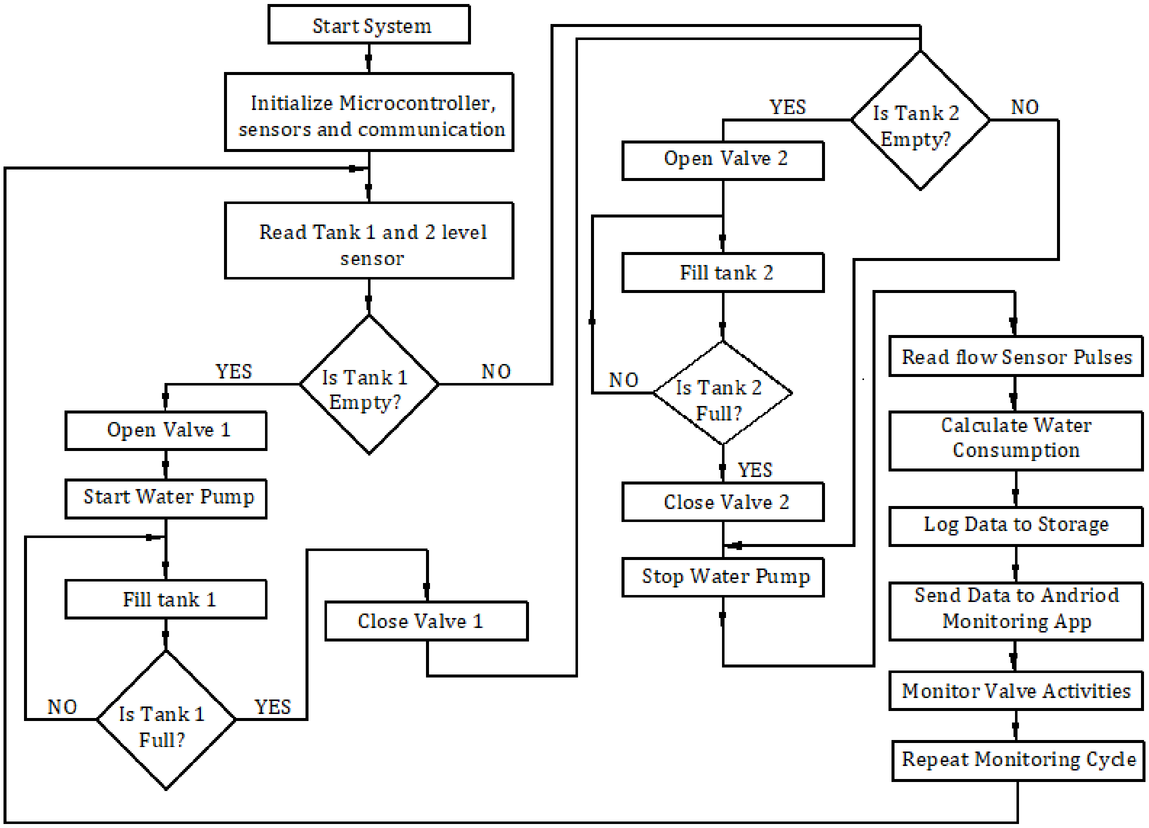


**Figure 6:** Flow Chart for the Multi-Tank Water Filling System Integrated with an Android Mobile Application

## Android Mobile Application

The Android application provides a user interface for monitoring and controlling the system. Features include:

- real-time tank level display
- pump status monitoring
- manual control override
- push notifications for system alerts
- historical water usage graphs

## Android Mobile Application Interface Design

The Android mobile application provides a user-friendly interface that enables users to monitor, control, and analyze the water management system in real time. The app communicates with the microcontroller through a Wi-Fi connection and displays system status, tank levels, and water usage data.

### Main Features of the Mobile Application

### Real-Time Water Tank Level Display

The application continuously displays the water level of Tank 1 and Tank 2 using graphical indicators such as progress bars or percentage meters.
Functions include:

a. Real-time monitoring of water levels
b. Visual indicators showing Empty, Low, Medium, and Full
c. Separate display panels for Tank 1 and Tank 2
d. Automatic refresh of tank level data from sensors

Example display format: Tank 1 Level: 75% Tank 2 Level: 40%
This feature allows users to quickly determine the current water storage status.

### Water Pump Status Monitoring

The application displays the operational status of the AC water pump.
Displayed information:

i.Pump ON/OFF state
ii.Pump running duration
iii.System operation indicator
Example: Pump Status: ON Pump Runtime: 12 minutes

This helps users verify whether the pump is currently filling the tanks.

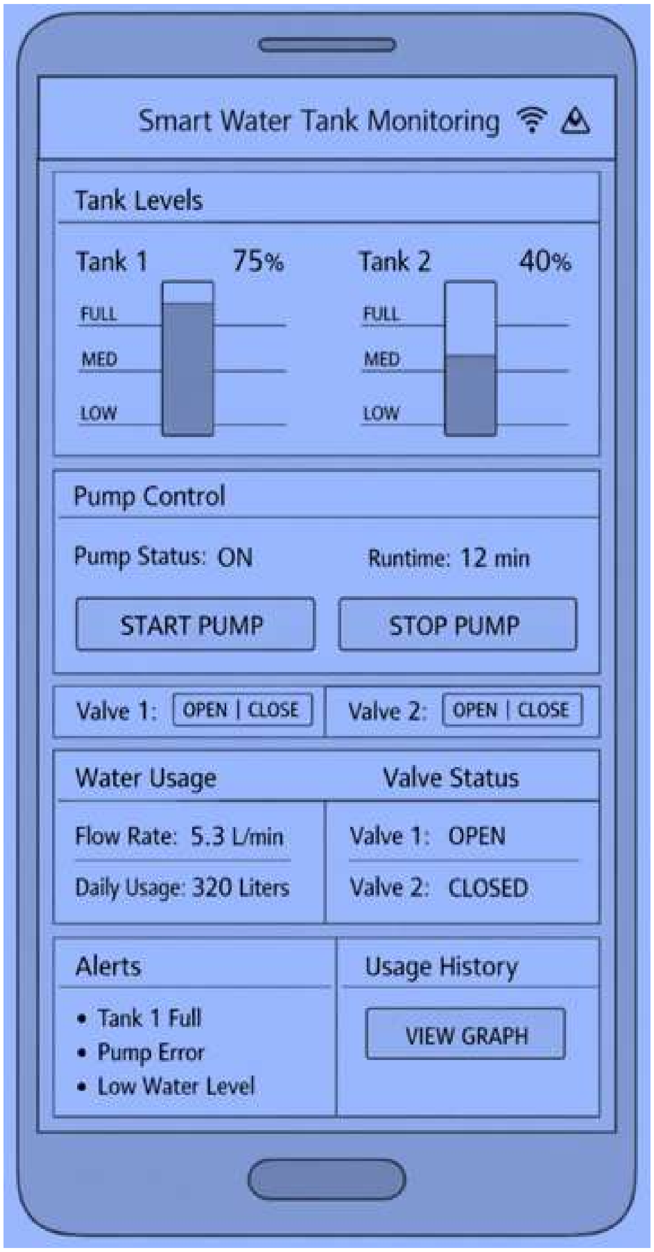
### Manual Control Override

The application allows users to manually override the automatic control system (Figure 7). Manual control options include:
This feature is useful when manual intervention is required during maintenance or unusual system conditions.

### Push Notifications for System Alerts

The application sends instant notifications to inform the user about important system events.
Examples of alerts:

a Tank 1 Full
b Tank Level Low
c Pump Fault or Error
d Tank 2 Full



Tank 1 75%
Tank 2 40%
Pump Status: ON
Runtime: 12 min
Valve 1:
Valve 2:
Flow Rate: 5.3 L/min
Daily Usage: 320 Liters
Valve 1: OPEN
Valve 2: CLOSED
- Tank 1 Full
- Pump Error
- Low Water Level

**Figure 7:** A View of the Android Interface

| | | |
|---|---|---|
| Start Pump | Open Valve 2 | Open Valve 1 |
| Stop Pump | Close Valve 2 | Close Valve 1 |

e Pump Activated
f Abnormal Water Flow Detection

Notifications ensure that users remain informed even when the app is not actively open.

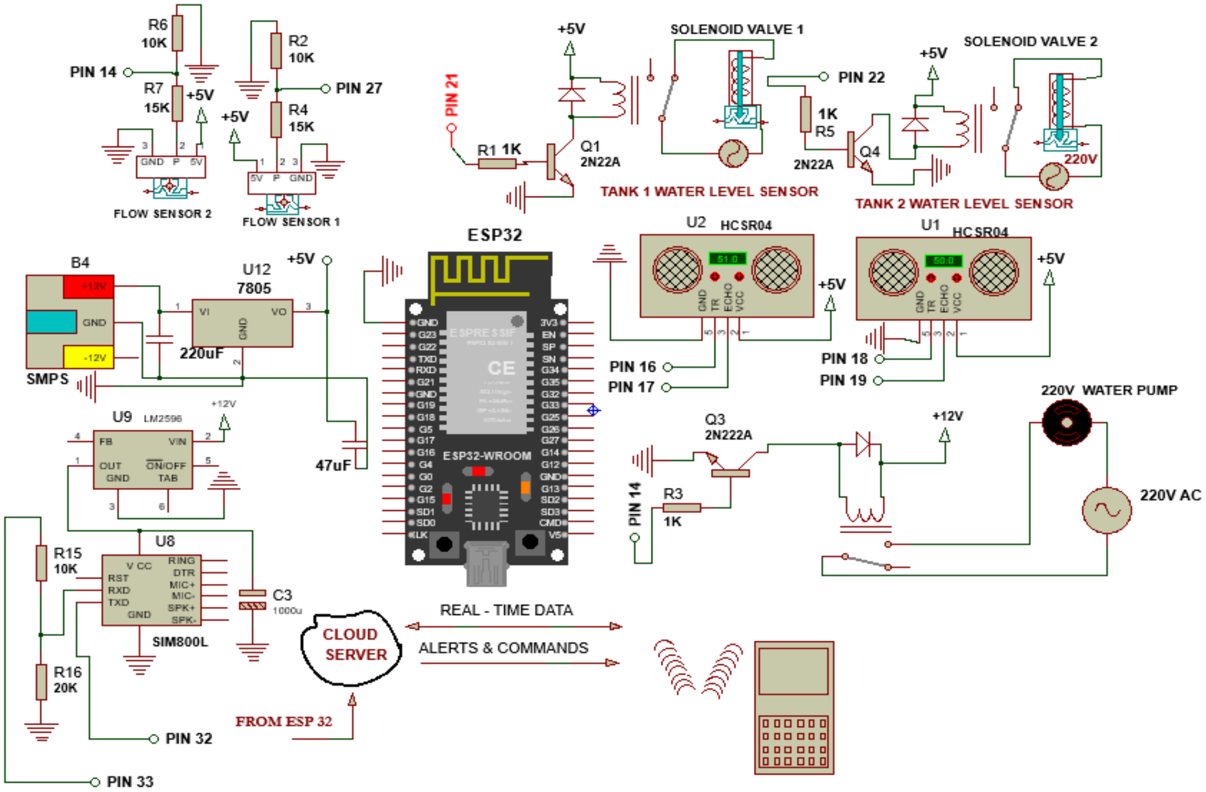


**Figure 8:** Circuit diagram A Smart Multi-Tank Water Filling and Monitoring System with Android App

### Water Consumption Rate Monitoring

The application displays the rate of water consumption measured by the flow sensor (YF-S201).
Displayed parameters includes instantaneous flow rate (liters/min) and total water consumption.
Flow Rate: 5.3 L/min and Daily Consumption: 320 Liters
This feature helps users monitor water usage and detect excessive consumption.

### Valve 1 and Valve 2 Status Display

The application displays the real-time operational status of both electronic valves controlling the tanks.
Displayed information:

Valve 1 Status: OPEN / CLOSED
Valve 2 Status: OPEN / CLOSED

This allows the user to confirm which tank is currently receiving water.

### Historical Water Usage Graphs

The application records water usage data and presents it in graphical form for analysis. Graph types include Daily water usage, Weekly consumption. Monthly consumption and Pump operation time vs water volume (Figure 8). Examples of graphical analysis includes water consumption vs time  tank level vs time and pump runtime vs water delivered. These graphs help users understand water usage patterns and improve water management efficiency.

## RESULTS AND DISCUSSION

This section presents the experimental results obtained from the Smart Multi-Tank Water Filling and Monitoring System with Android App Integration. The system was tested to evaluate its ability to monitor tank levels, control the pump and valves, measure water flow rate, and provide historical water usage data through the Android application.

### Working Principle / Operation of the Smart Multi-Tank Water Filling and Monitoring System

The smart multi-tank water filling and monitoring system operates by automatically controlling the distribution of water from a source to multiple storage tanks while providing real-time monitoring through an Android mobile application. A microcontroller such as the ESP32 serves

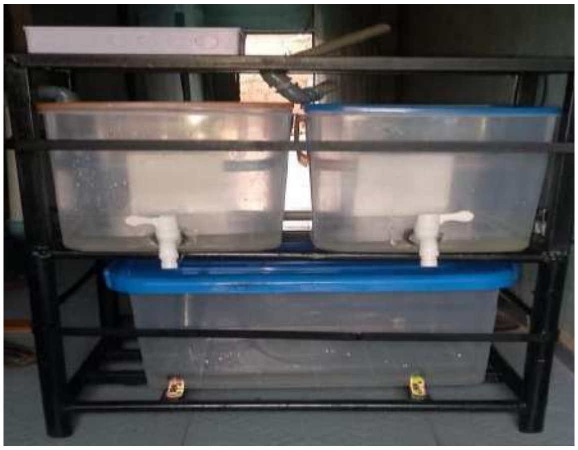
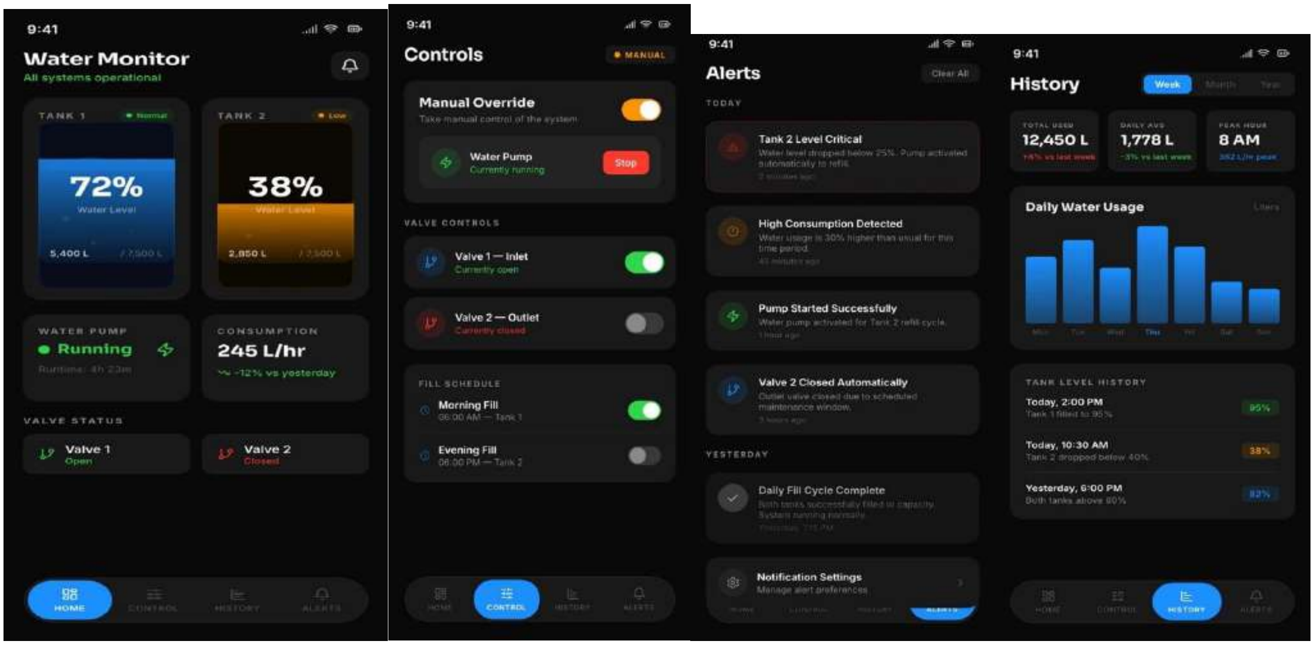


**Figure 9:** Prototype of the Hardware Setup



Water level dropped below 25%. Pump activated automatically to refill.

Water usage is 30% higher than usual for this time period.

Water pump activated for Tank 2 refill cycle.

Outlet valve closed due to scheduled maintenance window.

Both tanks successfully filled to capacity. System running normally.

**Figure 10:** Android Application Implementation GUI Interface Display

as the central control unit of the system. Water level sensors installed in each tank continuously monitor the water levels and send signals to the microcontroller. When the water level in a tank fall below a predefined threshold, the controller activates the water pump and opens the corresponding solenoid valve to allow water to flow into that tank. As water flows through the pipeline, a flow sensor such as the YF-S201 Water Flow Sensor generates pulse signals proportional to the water flow rate. The microcontroller counts these pulses to calculate the flow rate and the total volume of water supplied, which enables monitoring of water consumption. Once the tank reaches its maximum level, the level sensor signals the microcontroller to stop the filling process by closing the valve and switching off the pump if no other tank requires water. The system continuously repeats this monitoring and control process. Operational data such as tank levels, pump status, valve activities, and water consumption are recorded by the data logging module and transmitted to an Android mobile application, where users can monitor the system in real time, receive alerts, and perform manual control if necessary.

## System Implementation and Testing

A prototype system was installed consisting of two water tanks. Sensors were installed in each tank and connected to the ESP32 control unit. The Android application was used to monitor system performance. Calibration tests were conducted to evaluate sensor accuracy and system reliability. Various operating conditions were simulated, including tank overflow and pump dry-run scenarios (Figures 9 and 16).

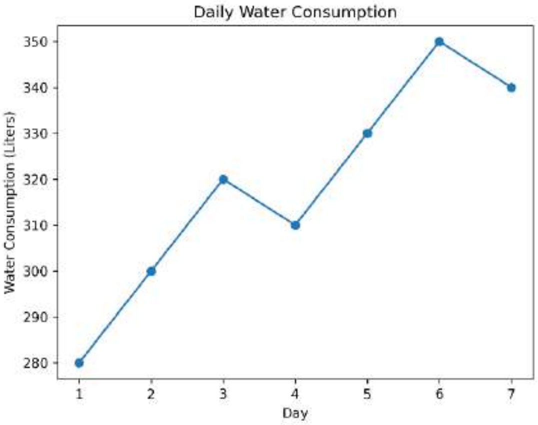


**Figure 11:** Water Usage Pattern Daily.

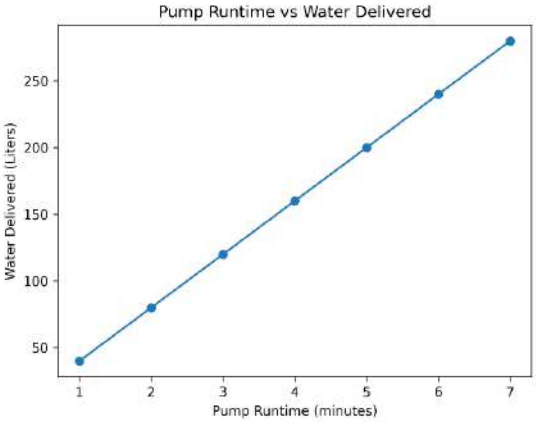
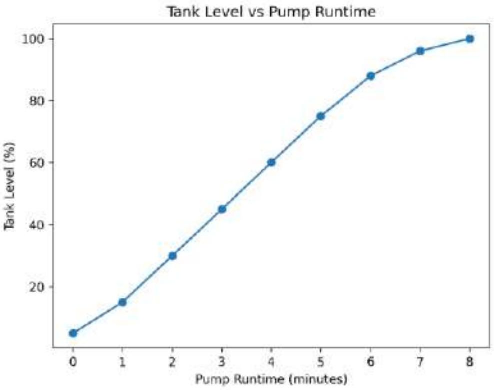


**Figure 12:** Relationship Between Pump Running Time and Water Volume Supplied.



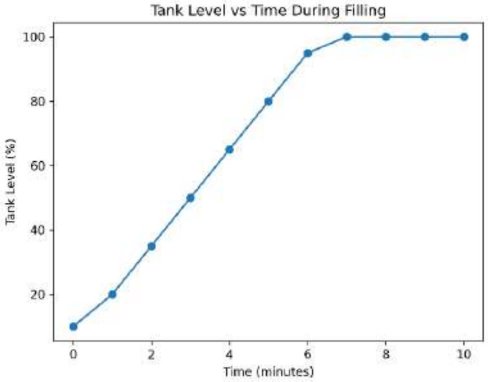
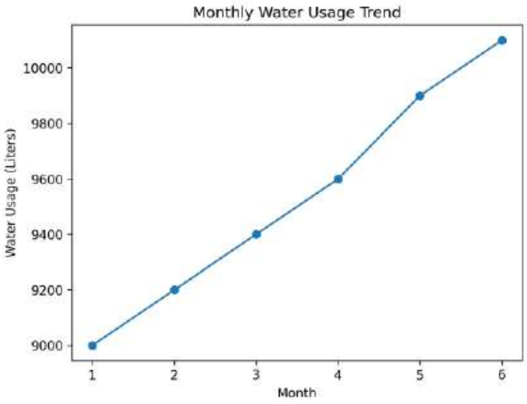


**Figure 13:** Tank Levels over Time during Pump Operation. **Figure 14:** Level of Water in the Tank versus Time



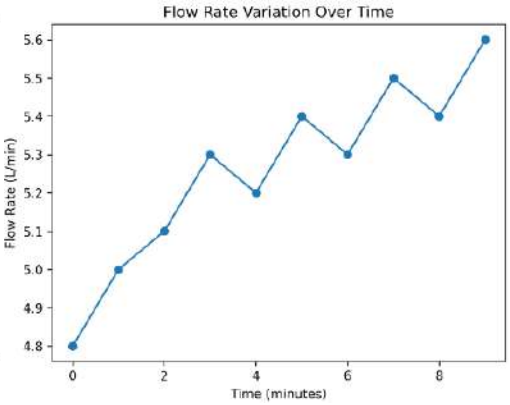


**Figure 15:** Long Term Water Usage Management Analysis.

**Figure 16:** Displays Flow Rate Changes Measured by the YF S201 Flow Sensor.

## System Performance

The results demonstrate that the developed system successfully performs the following functions:

a. Real-time monitoring of water tank levels
b. Automatic control of the water pump
c. Remote monitoring using an Android mobile application
d. Accurate measurement of water consumption using a flow sensor
e. Historical analysis of water usage through graphical visualization

The integration of the ESP8266 microcontroller with the Android mobile application provides an efficient and reliable solution for smart water management.

## Conclusion and Recommendations

This paper presented the design and implementation of a smart multi-tank water filling and monitoring system integrated with an Android mobile application. The system successfully automated water distribution across multiple tanks, prevented overflow conditions, and enabled real-time monitoring through a mobile interface. The results demonstrate that IoT-based automation systems can significantly improve water management efficiency and reduce wastage in institutional and residential environments. Future work may include the integration of machine learning algorithms for predictive water demand analysis, the addition of water quality sensors, and large-scale deployment across multiple facilities.

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