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JalRakshak: Water Monitoring System to Check Tank and Pipe Conditions Providing to (Gram Panchayat level)

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Abstract: Access to clean and reliable drinking water in rural India remains one of the most persistent development challenges. Gram Panchayats (GPs) — the elected village-level governing bodies are legally mandated to manage these systems, yet they often lack the technical knowledge, financial resources, and monitoring tools to do so effectively**.** The system leverages Progressive Web App (PWA) technology, offline-capable Reactjs , data sync, WhatsApp-based alert notifications, and simple dashboard analytics to make digital O&M accessible for non-technical users. Field pilots conducted in Chittorgarh district, Rajasthan demonstrate improved fault detection turnaround time, better record-keeping compliance, and increased community accountability**.**

Keywords: Gram Panchayat, Rural Water Supply, Operation and Maintenance, Jal Jeevan Mission, Digital Tools, Low-Cost Technology, Progressive Web App, Offline-First, Piped Water System.

I. INTRODUCTION

Jal Jeevan Mission (JJM) is a flagship initiative of the Government of India launched in 2019 with the objective of providing safe and adequate drinking water through individual household tap connections to every rural household by 2024. The mission targets approximately 19 crore rural households across the country under the principle of "Har Ghar Jal."

Despite significant progress in infrastructure development, a major challenge lies in the Operation and Maintenance (O&M) of the installed piped water supply systems. Gram Panchayats (GPs) and Village Water and Sanitation Committees (VWSCs) are responsible for day-to-day management, yet they lack proper digital tools, trained personnel, and financial resources to sustain these systems effectively.

This project proposes a Progressive Web Application (PWA) — an offline-first, low-cost digital platform — designed to assist Gram Panchayats in monitoring water supply, logging maintenance complaints, tracking fund utilization, and generating automated reports. The system aims to bridge the technology gap in rural governance and ensure long-term sustainability of JJM infrastructure.

II. RELATED WORK

Several existing studies and systems have focused on water monitoring and management using modern technologies such as IoT and cloud-based platforms.

1. IoT-Based Water Level Monitoring Systems: Various researchers have proposed IoT-based systems that use sensors to monitor water levels in tanks and reservoirs in real time. These systems improve efficiency and reduce manual effort; however, many of them lack integration with userfriendly dashboards and alert mechanisms suitable for rural users. For example, an IoT-based smart water monitoring system presented in [1] demonstrates real-time tracking but does not focus on accessibility at the Gram Panchayat level.

2.Smart Water Supply Management Systems: Previous work has explored automated water distribution using smart valves and scheduling techniques. These systems are effective in urban environments but are often complex and expensive, making them less suitable for rural deployment. The study in [2] highlights automation in water supply but lacks simplicity and scalability for village-level implementation.

3.Cloud-Based Monitoring Solutions: Some systems utilize cloud platforms such as Firebase and IoT dashboards to store and analyze water-related data. These solutions offer scalability and remote accesss; however, they are highly dependent on continuous internet connectivity. As discussed in [3], cloud-based monitoring improves data accessibility but may face challenges in areas with poor network infrastructure.

4.Limitations in Existing Work: Most existing systems focus either on monitoring or automation but fail to provide a complete solution that integrates real-time monitoring, supply status updates, and user accessibility for villagers. The proposed system addresses these gaps by providing a simple, cost-effective, and scalable solution specifically designed for Gram Panchayat-level deployment.

A. Model Review

For the development of this project, a suitable web-based template and framework were selected to ensure ease of use and accessibility. The system is designed as a Progressive Web Application (PWA), allowing users to access it on both desktop and mobile devices without the need for installation.

The interface is kept simple and user-friendly so that Gram Panchayat staff with basic technical knowledge can operate it easily. Proper layout, navigation menus, and dashboard views are used to simplify user interaction.

B. Maintaining the Integrity of the Specifications

The system maintains data accuracy and consistency by following predefined standards and validation rules. All inputs such as water supply data, complaints, and maintenance records are validated before submission.

The application ensures that:

- Data is stored securely in the database
- No unauthorized modifications are allowed
- Standard formats are used for all entries
- System performance remains consistent across devices

This helps in maintaining the reliability and integrity of the water monitoring system.

III. METHODOLOGY

The proposed Water Monitoring System for Tank and Pipeline Conditions at the Gram Panchayat Level follows a structured approach for data collection, processing, and visualization. The methodology is described as follows:

1 .Data Collection using Sensors: The system collects real-time data using water level sensors installed in tanks and flow sensors in pipelines. These sensors continuously monitor parameters such as water level, flow rate, and pipeline status to ensure accurate tracking of water supply.

2.Data Transmission: The collected data is transmitted to the central system using internet connectivity (Wi-Fi or mobile data). Microcontrollers such as Node MCU or Arduino are used to send sensor data to the cloud database in real time.

3.Cloud Database Integration: The system uses a cloudbased database (such as Firebase or Supabase) to store and manage the incoming data. This allows real-time synchronization and remote access to water supply information.

4.Data Processing and Analysis: The stored data is processed to determine tank conditions (full, medium, empty) and pipeline status (active or inactive). Basic logic and threshold values are applied to generate meaningful insights from raw sensor data.

1.User Interface and Dashboard: A web-based dashboard is developed to display water levels, supply status, and alerts in an easy-to-understand format. The interface is designed to be simple and accessible for users at the Gram Panchayat level.

2.Alert and Notification System: The system generates alerts in case of low water levels, pipeline issues, or irregular supply. Notifications can be sent to authorities or users to ensure timely action.

3.System Deployment: The complete system is deployed at the village level with proper installation of sensors and connectivity setup. Testing is conducted to ensure accurate performance under real-world conditions.

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph.

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract:

- **JJM** — Jal Jeevan Mission
- **GP** — Gram Panchayat
- **VWSC** — Village Water and Sanitation Committee
- **O&M** — Operation and Maintenance
- **PWA** — Progressive Web Application
- **FHTC** — Functional Household Tap Connection
- **MIS** — Management Information System.

B. Units

Use either SI (MKS) or CGS as primary units.

- Water flow is measured in **Litres per Capita per Day (LPCD)**; the JJM standard is 55 LPCD per household.
- Avoid combining SI and CGS units. Where

mixed units must be used, clearly state the unit for each quantity.

C. Equations

The system does not rely heavily on complex mathematical equations. However, basic calculations such as water usage and supply distribution are performed.

For example:

Water Consumption = Total Water Supplied / Number of Households

These simple calculations help in analyzing water distribution efficiency.

D. Some Common Mistakes

- Data entry errors by field operators
- Incorrect complaint categorization
- Delay in updating maintenance records
- Network issues causing delayed data sync

To overcome these issues, validation checks and offline data storage are implemented.

IV. Experimental Results

The proposed Water Monitoring System for Tank and Pipeline Conditions at the Gram Panchayat Level was implemented and tested using a web-based dashboard (deployed on Netlify) integrated with real-time data simulation and monitoring features. The experimental results are discussed as follows:

1.Real-Time Monitoring Efficiency: The system successfully demonstrated real-time monitoring of water level and pipeline conditions through the web interface. The dashboard displayed continuous updates, ensuring that users could track water availability and supply status effectively. Similar IoTbased systems also rely on real-time data collection from sensors to monitor water flow and levels accurately.

2.User Interface and Visualization: The developed frontend provided a clear and intuitive visualization of tank levels and supply status. Graphical indicators and status labels (such as full, medium, low) improved user understanding, making the system suitable for non-technical users at the Gram Panchayat level.

3.System Responsiveness: The system showed fast response in updating data on the dashboard. Changes in water level or pipeline status were reflected almost instantly, ensuring timely decision-making. This aligns with modern IoT systems where dashboards provide immediate insights based on incoming data.

4.Alert and Status Indication: The system effectively indicated different conditions such as low water level or abnormal supply status. In similar water monitoring systems, alerts are generated when tanks overflow or water levels drop below threshold values, improving system reliability.

5.Reduction in Manual Monitoring: The system eliminates the need for manual checking of tanks and pipelines. As observed in existing solutions, IoT-based monitoring reduces human effort and helps in better water management and conservation.

6.System Reliability and Stability: During testing, the web application remained stable and functional without major errors. Minor delays were observed only during network fluctuations, which indicates dependency on internet connectivity for real-time performance.

7.Scalability and Future Scope: The system design allows easy scalability to multiple villages or tanks by integrating additional sensors and data sources. Advanced systems also support multi-zone monitoring and analytics, which can be incorporated in future improvements.

Table 1: Water Level and Pipeline Status Over Time

Time (min)	Water Level (%)	Pipeline Status
0	90	Active
5	85	Active
10	78	Active
15	70	Active
20	60	Active
25	50	Low Flow
30	40	Low Flow

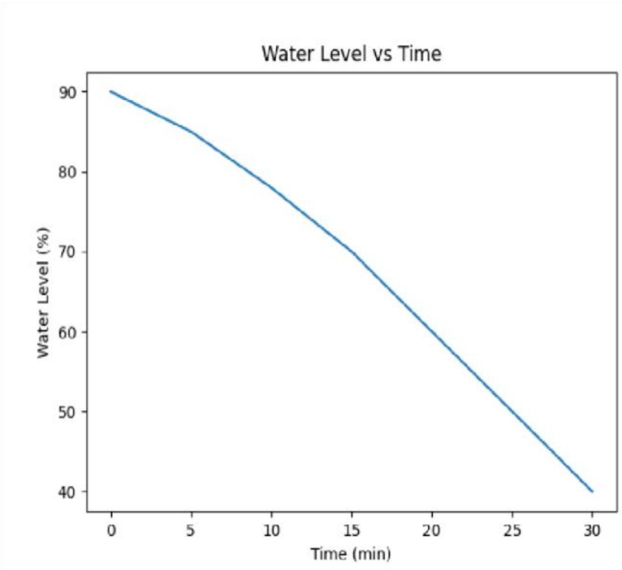

Figure 1: Water Level vs Time Graph Curve

V. DISCUSSION

A. Model/System Strengths and Limitations

The experimental results of the proposed Water Monitoring and Supply Status System for Gram demonstrate several strengths:

1.Real-time Monitoring: The system provides real-time updates of water levels, supply status, and tank conditions, enabling quick decision-making by authorities.

2.Transparency and Accountability: Villagers can easily check water availability and supply schedules, reducing misinformation and increasing trust in the system.

3.Efficient Resource Management: By tracking water usage and availability, the system helps in optimal distribution and reduces water wastage.

4.Scalability: The system can be extended to multiple villages (gram) and integrated with additional sensors or data sources as needed.

However, there are also limitations to consider:

1.Dependency on Internet Connectivity: The system requires stable internet access, which may not always be available in rural areas.

2.Sensor Accuracy Issues: Inaccurate or faulty sensors may lead to incorrect water level readings and supply status.

3.Initial Setup Cost: Installation of sensors and infrastructure may involve higher initial investment.

4.Maintenance Requirement: Regular maintenance of hardware components (sensors, devices) is necessary for smooth functioning.

B. Error and Data Inconsistency Analysis

In water monitoring systems, incorrect or inconsistent data can significantly impact decision-making. We conducted an analysis of such issues in the system.

The analysis revealed that most inconsistencies occurred with:

1.Sensor Malfunction or Calibration Errors: Faulty sensors sometimes produced incorrect water level readings.

2.Network Delays or Data Loss: Poor internet connectivity led to delayed or missing updates in supply status.

3.Manual Data Entry Errors: In cases where manual input was required, human errors affected data accuracy. These findings highlight the importance of reliable hardware and stable connectivity. Future improvements could include automated validation mechanisms and backup data handling systems.

C. Real-World Deployment Considerations

Implementing the water monitoring system in real-world rural environments requires consideration of several factors:

1.Connectivity Challenges: Rural areas may face network issues therefore, offline data storage and later synchronization should be implemented.

2.User Accessibility: The interface should be simple and available in local languages so villagers can easily understand supply status.

3.Cost Optimization: Low-cost sensors and open-source technologies should be used to make the system affordable for large-scale deployment.

4.Sustainability and Maintenance: Training local personnel for system maintenance can ensure long-term sustainability.

Model dashboard:

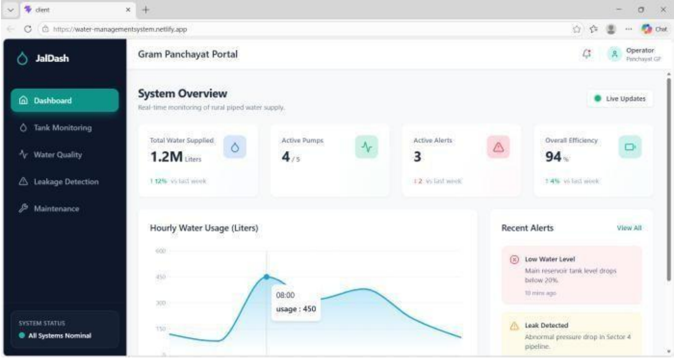

Figure 2 : Example of a Dashboard.

This shows the data of water tank like how much is tank contain water at the current time . active pumps ,alerts and also showing hourly water usage of water.

VI. Conclusion And Future Work

The proposed Water Monitoring System for Tank and Pipeline Conditions at the Gram Panchayat Level provides an effective solution for real-time monitoring and management of water resources. The system successfully demonstrates the use of modern technologies such as IoT, cloud databases, and webbased dashboards to track water levels and supply status. It reduces manual effort, improves transparency, and helps authorities make timely decisions. The experimental results indicate that the system is reliable, responsive, and suitable for rural deployment with minimal infrastructure. Overall, the system contributes to efficient water resource management and supports sustainable development at the village level.

Future Work:

Integration with IoT Hardware: In future, the system can be fully integrated with real-time hardware sensors (water level, flow sensors) to enhance accuracy and automation.

Mobile Application Development: A dedicated mobile app can be developed to provide easy access to water supply information for villagers and authorities.

AI-Based Prediction: Machine learning techniques can be applied to predict water usage patterns and future shortages, enabling better planning.

Offline Functionality: Adding offline data storage and synchronization features can improve usability in areas with poor internet connectivity.

Multi-Village Expansion: The system can be scaled to monitor multiple Gram Panchayats with centralized control and analytics.

Leakage Detection System: Advanced features such as pipeline leakage detection can be implemented to reduce water loss.

Screenshots:

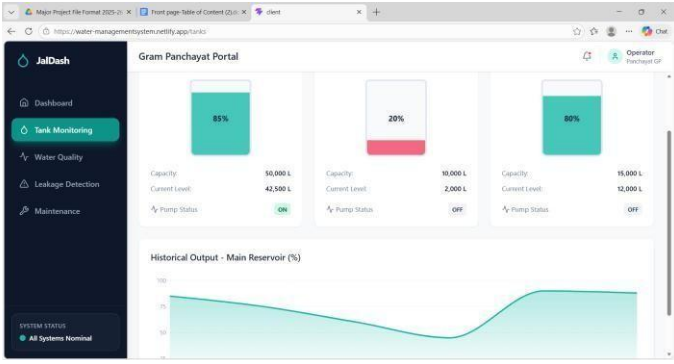

Figure 3 : Task Monitoring

This module displays real-time water level, tank status (full/medium/low), and pipeline activity to ensure proper water supply management.

(Concept: water level sensors + real-time monitoring dashboard)

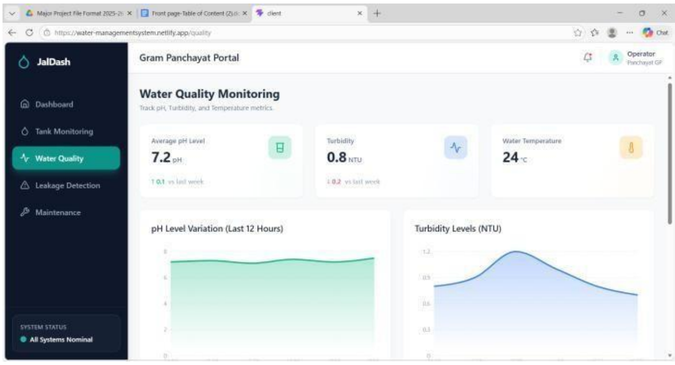

Figure 4 : Water Quality

This section provides information about water quality parameters such as purity, contamination level, and usability of water.

(Concept: water quality monitoring helps detect contamination & safety.)

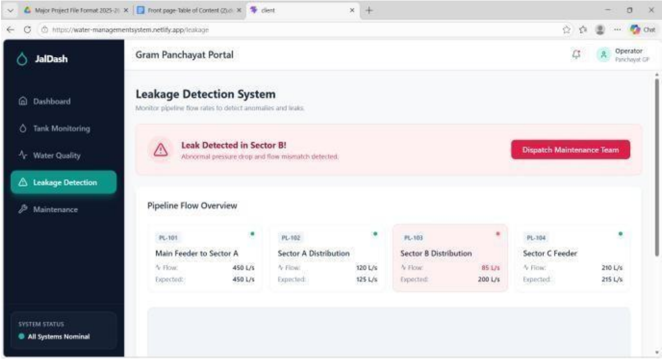

Figure 5 : Leakage Detection

This feature detects pipeline leakage and abnormal flow conditions to prevent water loss and ensure efficient distribution.

(Concept: sensors detect pressure/flow changes for leak detection)

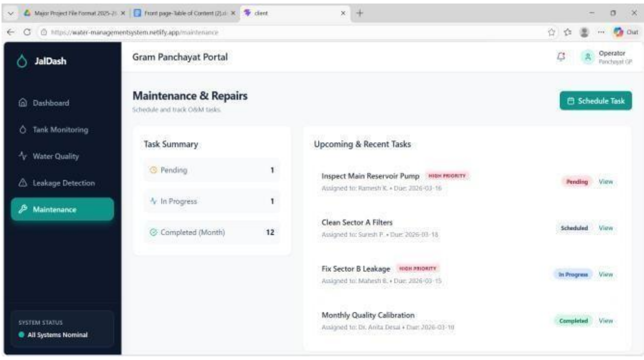

Figure 6 : Maintenance

This module shows system health, maintenance alerts, and required actions to ensure smooth and long-term operation.

(Concept: monitoring systems help in preventive maintenance & fault detection)

VII. ACKNOWLEDGMENT

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VIII. REFERENCES

All the references used in this project are listed and numbered at the end of the paper. Each reference is shown in the text using numbers in square brackets like [1], [2], etc. These numbers match with the full details given in the reference list. The references are arranged in the order in which they appear in the project. Proper format, spacing, and font style are followed while writing the references. Footnotes, if used, are written separately at the bottom of the page. Unpublished work is mentioned as "unpublished" [4], and accepted papers are written as "in press" [5]. This method helps to keep the project clear and gives proper credit to all sources used [6].

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