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DESIGN THINKING LABORATORY REPORT

IS237DL

Submitted by

Name 1: Dhruthi D	**USN1: 1RV23IS046**
Name2: Meghana J L	**USN2: 1RV23IS070**
Name3: Mithra N Gowda	**USN3: 1RV23IS071**
Name4: Poornashree H V	**USN4: RVCE24BIS402**

WATER MONITORING SYSTEM

Under the guidance of

Dr. Ashwini K B
Associate Professor at RVCE
Dept. of ISE
RV College of Engineering®

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RV COLLEGE OF ENGINEERING®, BENGALURU-59

(Autonomous Institution Affiliated to VTU, Belagavi)

DEPARTMENT OF INFORMATION SCIENCE AND ENGINEERING

CERTIFICATE

Certified that the Design thinking Laboratory work titled ***'WATER MONITORING SYSTEM'*** is carried out by **Student name (USN),** in partial fulfilment for the requirement of degree of **Bachelor of Engineering in Information Science and Engineering** of the Visvesvaraya Technological University, Belagavi during the year 2024-2025. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the report.

Dr. Ashwini K B	**Dr. Sagar B M**
Associate Professor at RVCE	**Professor and HoD**
Department of ISE	**Department of ISE**

External Viva

Name of Examiners	**Signature with Date**
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Dhruthi D - 1RV23IS046
Meghana J L – 1RV23IS070
Mithra N Gowda – 1RV23IS071
Poornashree H V - RVCE24BIS402

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ABSTRACT

Water scarcity and inefficiency in water management are critical challenges worldwide, with residential and industrial sectors being significant contributors to water wastage. Recent advancements in the Internet of Things (IoT) and smart technologies have enabled innovative solutions to address these challenges. This project focuses on developing an IoT-based water monitoring system designed to optimize water usage and mitigate wastage. The global water monitoring market, projected to grow significantly due to increasing water scarcity and rising demand for efficient resource management, underscores the relevance of this domain.

Despite the availability of traditional water meters and standalone systems, they often lack real-time monitoring, predictive insights, and automated alerts, limiting their effectiveness. Emerging opportunities in IoT integration and data-driven analytics have opened avenues to enhance water monitoring capabilities. This project leverages existing IoT frameworks, water flow sensor technologies, and real-time communication platforms, addressing their limitations by incorporating advanced data processing and user engagement features. The work was motivated by the need for an affordable, scalable, and user-friendly system that could cater to diverse applications, from households to industries.

The system follows a structured methodology involving the use of Raspberry Pi as the processing unit, integrating water flow sensors to collect real-time data. Twilio's communication API was utilized to send instant notifications and alerts. Python-based data processing and visualization tools were employed for actionable insights. Key assumptions included the accuracy of sensor data under normal environmental conditions and the scalability of the system for larger infrastructures. The development adhered to an iterative design process, focusing on system reliability, scalability, and cost-effectiveness. The outcomes are expected to significantly contribute to sustainable water management practices.

2.

EMPATHY

2.1 Client Details

2.1.1 Stakeholders

1. **Government Authorities**: Local municipalities responsible for ensuring sustainable water supply and addressing water wastage in residential and public spaces.
2. **Environmental Organizations**: Groups advocating for water conservation and supporting community-driven sustainability initiatives.
3. **Housing Societies and Community Leaders**: Representatives managing water resources for residential complexes or neighbourhoods.

2.1.2 Base Users

1. **System Operators**: Technicians or staff responsible for the setup, monitoring, and maintenance of the water monitoring system.
2. **Community Managers**: Individuals overseeing fair distribution and billing of water resources for residential groups or public areas.
3. **Data Analysts**: Professionals analysing water usage patterns and generating actionable insights for conservation planning.

2.1.3 End Users

1. **Residents**: Individuals and families residing in homes or apartments who benefit from water tracking, alerts, and efficient resource use.
2. **Communities**: Neighbourhood groups collectively monitoring and sharing water usage data for informed decision-making.
3. **Public Utility Users**: Users of shared water resources (e.g., parks, public restrooms) benefiting from improved water management.

2.2 Need Analysis

2.2.1 Questionnaire and Analysis

1. Have you ever experienced water shortages in your building due to overconsumption?

2. Do you have any water consumption monitoring system implemented in your residential area?

3. Do you monitor water usage regularly?

4. How often do you monitor your water usage?

5. How useful would it be for you to receive real-time updates on your water usage?

6. Would it be beneficial to receive an alert when your water consumption reaches a certain threshold?

7. At what threshold level would you prefer to receive a water consumption warning?

8. How would you prefer to receive alerts about your water consumption?

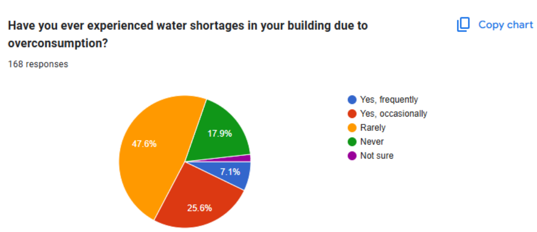
9. What additional information would you like to see in the app related to your water usage?

10. Would you support a tiered water tariff structure based on consumption levels?

11. How fair do you think it is to increase the water tariff with higher usage?

12. Who do you think would be most impacted by this information on water consumption and environmental sustainability?

13. Do you believe this project will have an impact on water consumption and environmental sustainability?



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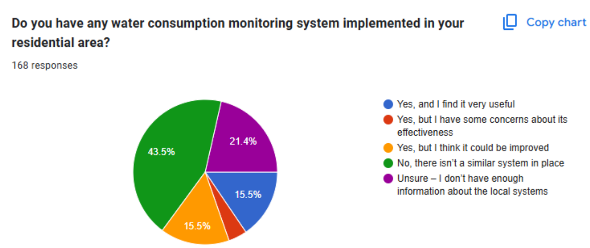

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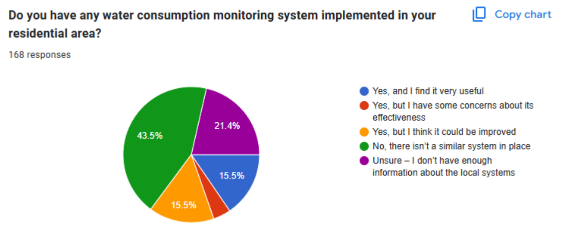

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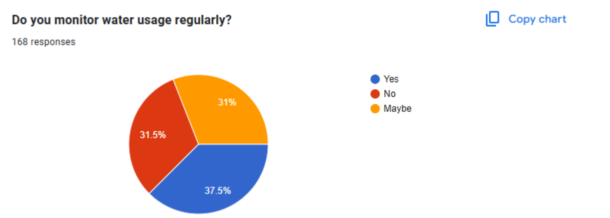

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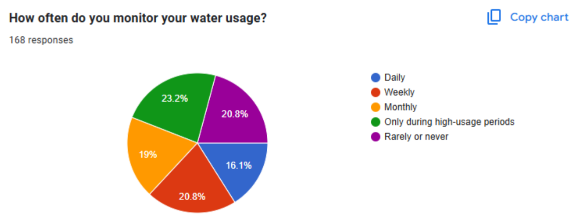

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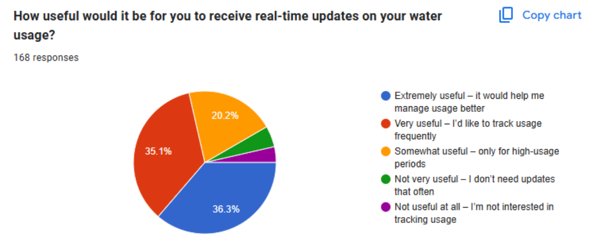

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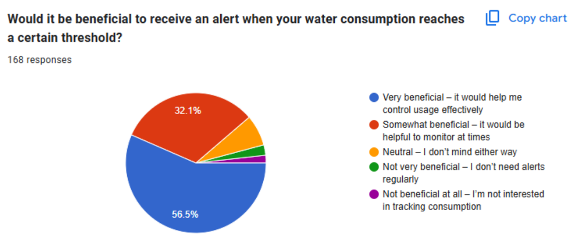

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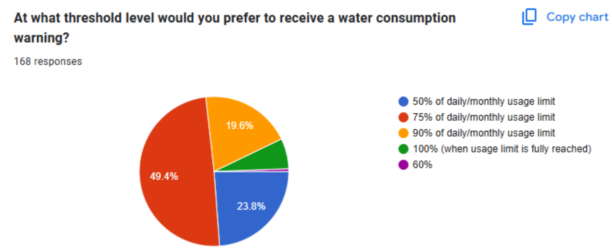

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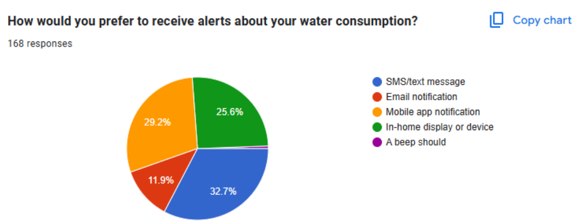

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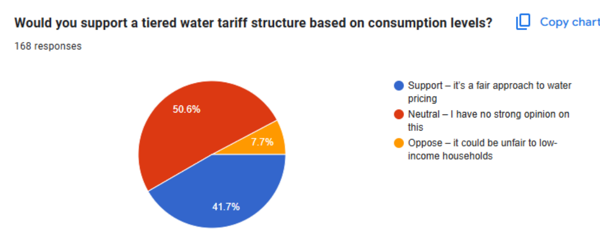

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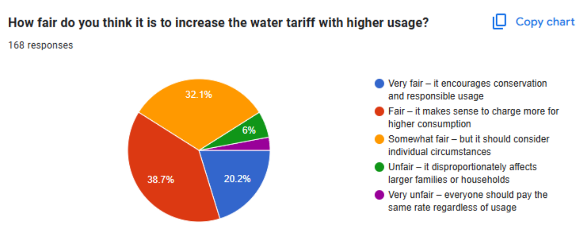

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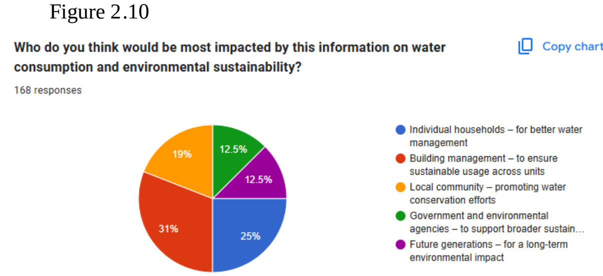

Figure 2.12

3.

DEFINE

3.1 Problem Statement

Water management in residential and community settings faces significant challenges due to the lack of real-time monitoring systems and effective conservation tools. Without immediate insights, users are unaware of their consumption patterns, leading to excessive usage and wastage. Traditional water meters and static billing systems fail to incentivize responsible usage or detect anomalies like leaks, resulting in inefficient distribution and missed opportunities for timely intervention, especially in water-scarce regions.

The absence of alerts and dynamic tariff models further discourages sustainable practices, as static tariffs fail to reflect varying consumption levels. Communities also lack collaborative platforms to monitor and manage shared resources effectively. These challenges underscore the need for a real-time water monitoring solution that provides data-driven insights, alerts, and incentives to promote sustainable practices and conserve resources.

3.1 Empathy Map

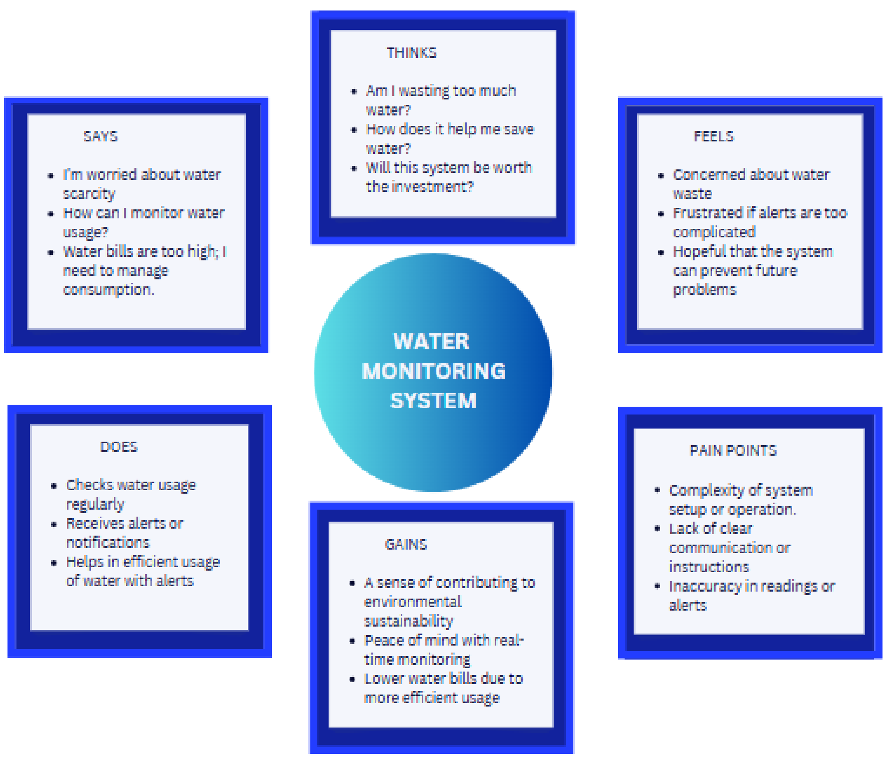

Figure 3.1 . Empathy map

4.

IDEATE

4.1 Mindmaps

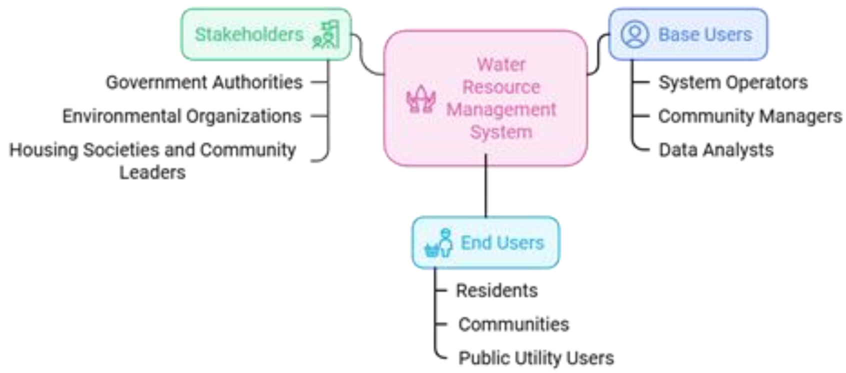

Figure 4.1. Mindmap showing clients for the project

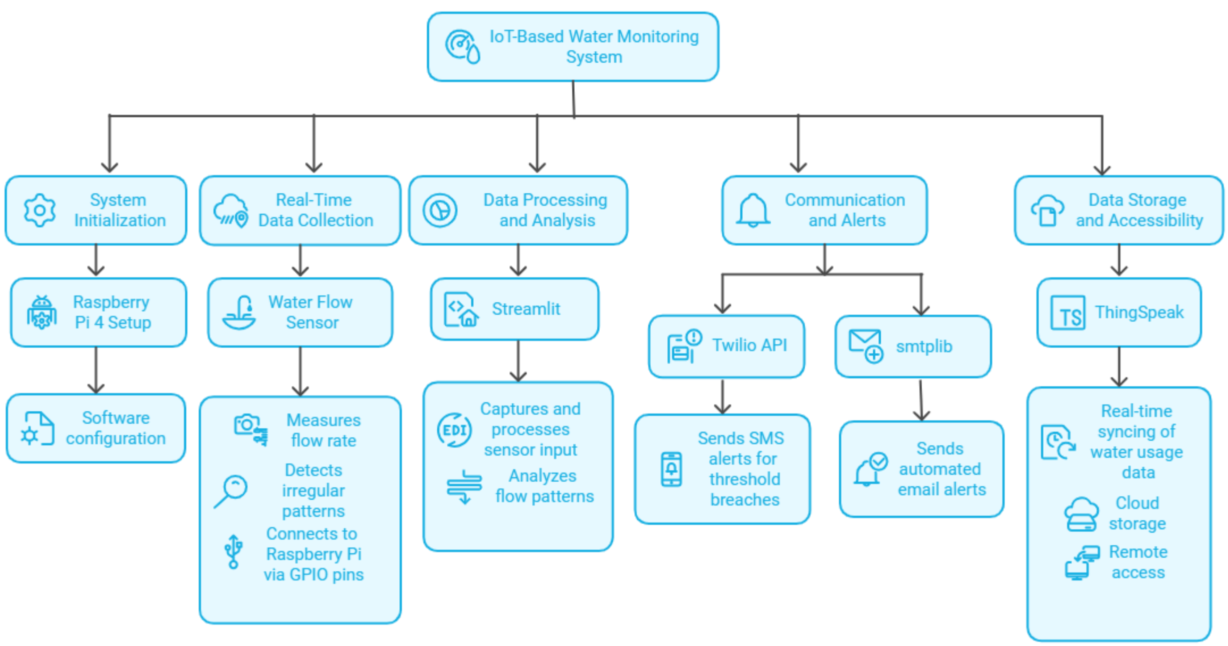

Figure 4.2 Mindmap showing methodology technologies

4.2 Prime challenges identification

1. **Accuracy of Data Collection**: Ensuring the data collected about water usage was consistent and reliable was a major challenge, as even small errors could lead to incorrect insights.
2. **Timely Alerts**: Setting up a system to send alerts quickly when water usage crossed a threshold was tricky, as delays could reduce the effectiveness of warnings.
3. **System Coordination**: Making sure all parts of the system worked well together, from tracking water usage to storing and analysing the data, required a lot of effort and fine-tuning.
4. **User Accessibility**: Designing the system in a way that would be easy for everyone to understand, and use was challenging, especially for non-technical users.
5. **Reliability Under Real Conditions**: Testing the system in real-world conditions, like power outages or poor internet connectivity, highlighted gaps that needed to be fixed to ensure smooth functioning

5.

PROTOTYPE

5.1 Technologies used for prototyping

1. **Raspberry Pi:** Serves as the main control hub, processing sensor data and enabling internet-based remote monitoring
2. **Water Flow Sensor**: Measures real-time water flow to track consumption and detect leaks through irregular patterns.
3. **Twilio:** Delivers SMS alerts for abnormal water usage and customizable real-time notifications.
4. **Smtplib**: Enables secure email alerts, automated updates, and password recovery via reset links.
5. **Streamlit:** A Python-based framework for building interactive and user-friendly web applications, particularly suited for data visualization and analysis.
6. **ThingSpeak:** A cloud platform for IoT applications that enables real-time data collection, storage, analysis, and visualization

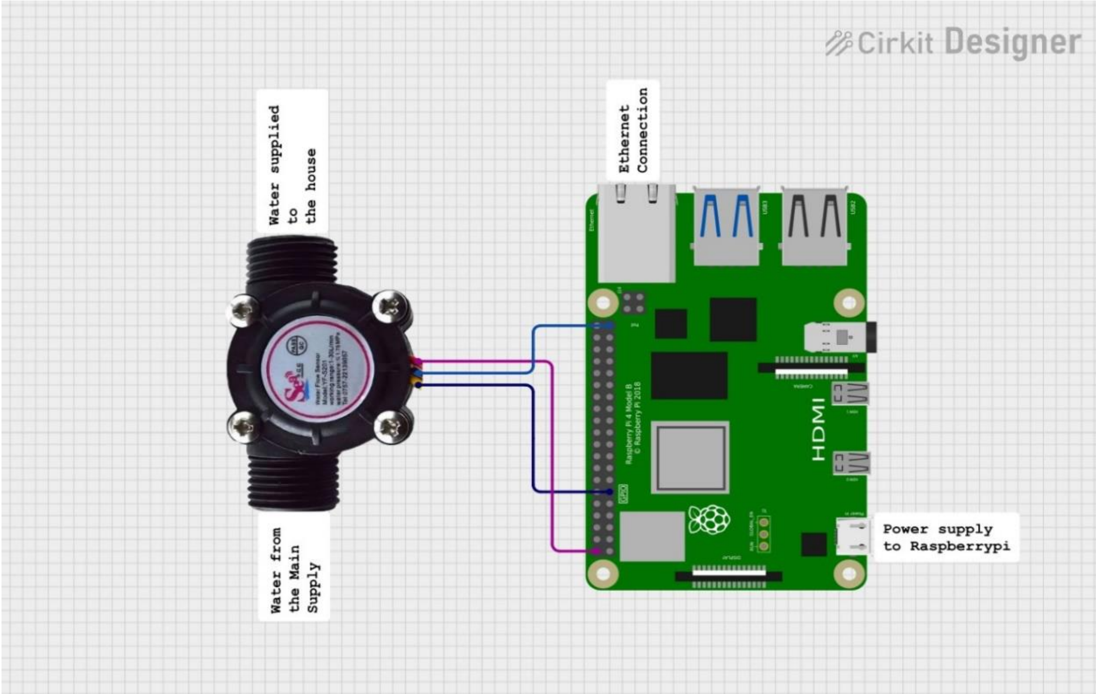

Figure 5.0 Circuit Diagram

5.2 Solution developed

- **Data Collection:**
  The YF-G1 water flow sensor continuously monitors water usage and sends the readings to the Raspberry Pi 4 for processing.
- **Data Storage and Transfer:**
  - In the presence of an active internet connection, the Raspberry Pi transfers the collected data directly to ThingSpeak for real-time storage and visualization.
  - If the internet connection is unavailable, the data is temporarily stored locally on the Raspberry Pi. Once the connection is restored, the locally stored data is uploaded to ThingSpeak, ensuring no information is lost.
- **Integration with Streamlit Web Application:**
  The data stored in ThingSpeak is accessed by the Streamlit web application, which serves as an interactive platform for real-time monitoring and analysis.
- **Data Analysis:**
  The Streamlit web app analyses the collected data, identifying usage patterns, trends, and any anomalies, such as excessive consumption or irregular flow rates.
- **Alert System**:
  Based on the analysis, alerts are triggered when water usage exceeds predefined thresholds. Notifications are sent to users via SMS (using Twilio) and email (using smtplib) to enable prompt action and water conservation.

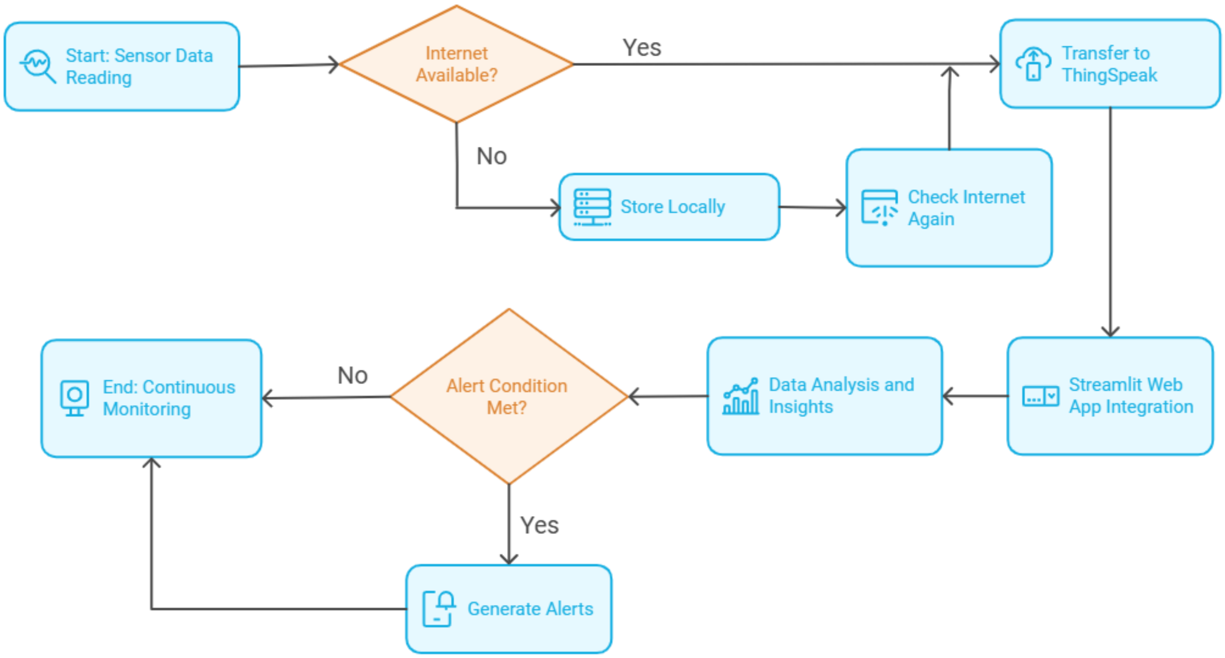

Figure 5.1. Methodology

Domestic water tariff

DOMESTIC	MINIMUM Rs.56/-
a) 0 to 8,000 Liters	Rs. 7.00 per KL
b) 8,001 to 25,000 Liters	Rs. 11.00 per KL
c) 25,001 to 50,000 Liters	Rs. 26.00 per KL
d) Above 50,000 Liters	Rs. 45.00 per KL

Figure 5.2 Water Tariff Table

The charges are based on the quantity of water consumed, with a minimum billing amount of ₹56 for domestic usage. This tiered pricing model encourages water conservation by increasing the rate as consumption increases.

5.3 Outputs

- **Real-Time Water Usage Display**:
  The system provides a live view of water consumption data on the Streamlit web application, allowing users to monitor usage instantly.
- **Historical Data Visualization**:
  Users can access historical water usage trends and patterns through graphs and charts, stored and visualized via ThingSpeak.
- **Threshold Alerts**:
  Notifications are sent via SMS and email when water usage exceeds set thresholds, ensuring timely intervention.
- **Offline Data Syncing**:
  Data collected during offline periods is seamlessly uploaded to ThingSpeak once the internet connection is restored, maintaining data integrity.
- **Actionable Insights**:
  The analysed data provides actionable insights for users to optimize water usage and adopt sustainable practices.
- **User-Friendly Interface**:
  The Streamlit web app offers an intuitive and interactive platform for users to view, analyse, and manage water usage data effectively.

6.

TEST

6.1 Testing Details

1. **Sensor Accuracy Testing**:
   The water flow sensor underwent rigorous trials to measure both high and low flow rates. Repeated tests ensured precise readings, and necessary calibration adjustments were made to maintain accuracy.
2. **Threshold and Alert Validation**:
   Simulated scenarios, such as excessive water usage, were used to test alert mechanisms. SMS and email notifications were assessed for promptness and reliability under various conditions, including network fluctuations.
3. **System Component Testing:**
   All components—Raspberry Pi, the YF-G1 water flow sensor, ThingSpeak, and communication modules—were tested individually and collectively to ensure proper functionality.

4. **Integration Testing**:
   The system's ability to handle real-time data collection, processing, and synchronization was evaluated. Integration tests verified seamless interaction between hardware and software components during high data loads.

6.2 Client feedback

A few of the feedbacks received were-

- "The real-time monitoring and alert system help in conserving water effectively. It's a practical solution for our residential needs."
- "With this system, managing water usage and addressing overconsumption will become much easier."
- "During extended outages, the delay in uploading data to ThingSpeak can be inconvenient."

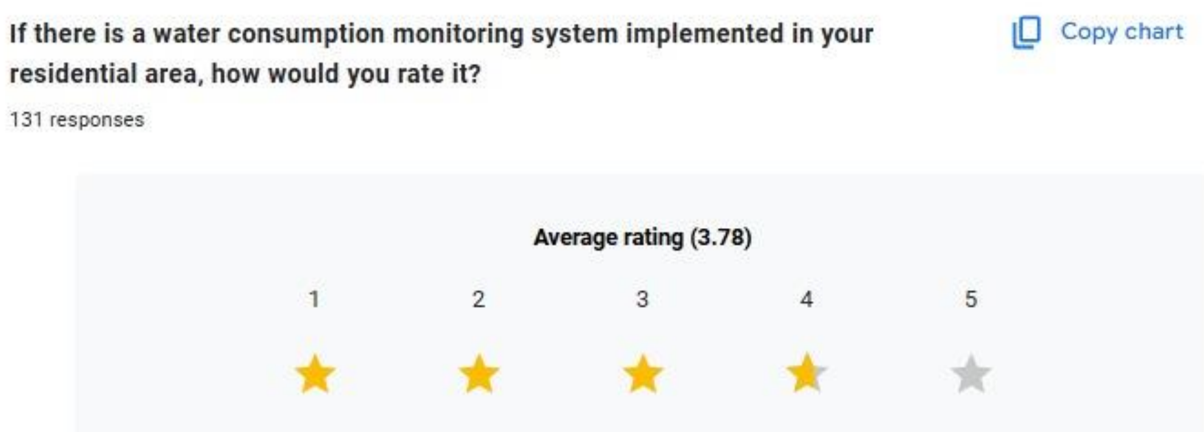

Figure 6.1. Analysis of feedback

The survey conducted before the project highlights the demand and potential impact of implementing a water monitoring system in residential areas. With an average rating of 3.78 out of 5, the ratings suggest a strong interest in adopting technology to improve water management.

7. CONCLUSIONS AND FUTURE SCOPE

7.1 Conclusion

The IoT-based water monitoring system effectively tackles the pressing challenges of water management by offering real-time tracking, alert mechanisms, and actionable insights. It enables users to monitor their consumption patterns, identify anomalies such as leaks or excessive usage, and adopt sustainable practices. The incorporation of threshold-based warnings ensures prompt alerts to minimize wastage, promoting efficient water usage in both residential and community settings. By addressing these critical issues, the system contributes significantly to the responsible management of a vital resource.

Furthermore, the integration of advanced features like real-time data syncing and cloud-based storage ensures the system's accessibility and reliability, even in varied environments. Its scalable design allows for adaptability to diverse user needs, making it a robust solution for water conservation. This project not only provides immediate benefits to users but also establishes a strong framework for future innovations in sustainable water management, paving the way for smarter and more efficient resource utilization.

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7.2 Future Scope

- Integration with Renewable Energy: The system can be enhanced by integrating solar-powered setups to ensure uninterrupted operation in regions with inconsistent power supply.
- Smart AI Predictions: Incorporating AI and machine learning can provide predictive insights for water demand and suggest conservation strategies.
- Mobile App Development: Expanding the system with a user-friendly mobile app for remote monitoring and management of water resources.
- Scalability to Larger Communities: Adapting the system to handle the needs of larger communities or industrial settings with advanced analytics features.
- Expanded Sensor Integration: Adding sensors for additional parameters like water quality or temperature to make the system more comprehensive.

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