AUTOMATED WATER LEAKAGE DETECTION AND CONTROL SYSTEM WITH IOT INTEGRATION

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***Abstract*—The water leakage detection and control system is designed to monitor and manage water flow efficiently, preventing wastage and potential damage. It employs two water flow sensors—one at the inlet to measure the total incoming flow and another at the outlet to track the actual flow. Any discrepancy between these readings indicates a leakage in the pipeline. Upon detecting a leakage, the system automatically activates a solenoid valve to shut off the water supply, stopping further wastage. Simultaneously, the pump motor is turned off to halt water flow, ensuring controlled operation. To enhance responsiveness, a GSM module sends an SMS alert to a designated person, notifying them of the leakage incident in real time. Additionally, the system updates the status on an IoT-enabled webpage, allowing remote monitoring and data analysis. This IoT integration provides users with a continuous log of water flow patterns and leakage incidents, enabling proactive maintenance. The system not only conserves water but also reduces operational costs by minimizing damages caused by unnoticed leaks. The real-time monitoring feature ensures that immediate action can be taken upon detecting a fault, enhancing reliability and efficiency. By automating the detection and control process, this project offers a smart and effective solution for residential, industrial, and agricultural water management applications. The combination of flow sensors, solenoid valves, pump motor control, GSM alerts, and IoT integration creates a comprehensive water conservation system that prevents losses, promotes sustainable water usage, and ensures uninterrupted water distribution. The system's ability to detect, report, and mitigate leakages autonomously makes it a valuable asset in water management infrastructure, providing users with an efficient and cost-effective approach to handling water supply issues. This innovative solution enhances sustainability by preventing excessive water wastage, promoting conservation, and improving overall resource management.**

1.INTRODUCTION

The The water leakage detection and control system is an advanced solution designed to monitor and manage water flow efficiently using sensors and automation. It employs two water flow sensors—one at the inlet and another at the outlet—to continuously track water usage. A mismatch between the readings of these sensors indicates a possible leakage in the pipeline. Upon detecting such discrepancies, the system automatically closes a solenoid valve and turns off the pump motor to prevent further water wastage and potential damage. It integrates a GSM module that sends immediate SMS alerts to notify the user about the leakage. Additionally, the system features IoT integration that updates the water flow status in real-time on a web platform, enabling remote monitoring and data logging for further analysis. automated response ensures quick action, reduces maintenance costs, and promotes water conservation. The pump motor remains off until the issue is resolved and system stability is restored. By combining sensor technology, GSM alerts, and IoT functionality, the system offers a smart, reliable, and efficient method for detecting and controlling water leaks. It is well-suited for use in residential, industrial, and agricultural settings, contributing to sustainable water management. The water leakage detection and control system has a wide scope across various sectors where efficient water management is critical. In residential areas, it helps homeowners prevent water wastage and structural damage caused by undetected leaks. In industrial and agricultural settings, where large volumes of water are used, the system ensures minimal resource loss and enhances operational efficiency. The integration of GSM and IoT technologies allows for real-time alerts and remote monitoring, making the system highly effective for smart city applications and modern infrastructure. Additionally, the project contributes to water conservation efforts by detecting leaks early and automating the control process. Its scalable design makes it adaptable for both small and large-scale water distribution networks, positioning it as a vital tool in sustainable resource management and preventive maintenance.

Existing models :

Manual Monitoring and Detection – Traditional water leakage detection relies on manual inspection, which is time-consuming, inefficient, and prone to human error, leading to delayed responses and increased water wastage.

Lack of Automated Control – Existing systems do not have an automated mechanism to stop water flow upon detecting a leakage, resulting in continuous wastage and potential damage to infrastructure.

Limited Alert and Monitoring System – Conventional setups lack real-time alerting and remote monitoring via IoT, making it difficult to track leaks instantly and take prompt action to prevent excessive water loss.

Disadvantages :

Delayed Detection and Response – Manual inspection methods result in slow leak detection, leading to unnecessary water wastage and potential damage before corrective action is taken.

Continuous Water Loss – In the absence of an automated shutoff mechanism, water continues to leak until manually addressed, increasing water bills and resource wastage.

Higher Maintenance Costs – Frequent unnoticed leaks can cause structural damage, requiring costly repairs and replacements in pipelines and water distribution systems.

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II LITERATURE SURVEY

Ramratan and Vinayak (2016) proposed a smart water management system utilizing Internet of Things (IoT) technology to efficiently monitor and control water usage, specifically designed for easy installation in residential societies. The system integrates sensors placed within a water tank that continuously detect and transmit real-time water level data. This information is automatically updated on a cloud platform, enabling users to access and visualize the current water levels remotely via an Android application on smartphones connected to the Internet. The system also incorporates intelligent motor control based on the water level: the motor is automatically activated when the water level falls below a predefined threshold and deactivated when the tank approaches full capacity. This automation ensures optimal water usage, prevents overflow, minimizes wastage, and promotes sustainable water management practices through real-time monitoring and control.

Chellaswamy C and Nisha J (2018) proposed an Internet of Things (IoT) based Dam Water Management System (IoT-DWM) aimed at addressing water-related challenges, particularly in agricultural applications. Recognizing that water plays a vital role in various sectors of daily life, the authors introduced new methods such as adaptive management and remote sensing, integrated with emerging concepts like water security and global information integration. The proposed IoT-DWM framework is structured into multiple components, including a field sensing section, an IoT network section, and a dam control section. Real-time data is collected through various sensors deployed in agricultural fields and is continuously updated to the cloud. The dam controller accesses this real-time data from specific areas and estimates the corresponding.

Carlos Kamienski and Juha-Pekka Soininen (2020) introduced SWAMP, an Internet of Things (IoT)-based Smart Water Management Platform designed for precision irrigation in agriculture. Recognizing that agricultural irrigation is the largest consumer of freshwater globally, the authors emphasized the urgent need for the intensive use of advanced technologies to optimize water usage, reduce energy consumption, and improve crop quality. Although IoT and related technologies are considered ideal candidates for smart water management applications, their effectiveness still requires validation through real-world

Kaushik Gupta and Mandar Kulkarni (2018) discussed the application of Internet of Things (IoT) technology for smart water management in housing societies, emphasizing the role of automation as a critical attribute in the modern era. The authors highlighted how automation significantly enhances comfort and convenience in people's daily lives, proposing its integration into water management systems to promote sustainability. The primary objective of their work is to raise awareness about the importance of using water judiciously and to provide readers with comprehensive . knowledge regarding the operational mechanisms of IoT-based water management systems. They further elaborate on how the integration of IoT can revolutionize residentialwater management by offering real-time monitoring, intelligent decision-making, and resource optimization. The study also emphasizes that such systems represent the future of sustainable water management in residential settings, ensuring efficient usage and conservation of water resources through technological advancements.

Vaishnavi Jeurkar (2020) presented an IoT-based Water Management System designed to address the complexities of water usage monitoring in industrial environments. Recognizing that industries utilize water in diverse ways and that water scarcity is increasingly aggravated by droughts and overuse, the author identified a critical gap in industries' awareness of their own water consumption patterns. To tackle this issue, the proposed system offers real-time measurement of vital water parameters such as temperature, water level, and overall consumption. Leveraging the Internet of Things (IoT), the system enables remote monitoring and control through smartphones, thereby enhancing accessibility and operational efficiency. A key innovation highlighted in the system is the use of a capacitive level sensor that operates based on changes in capacitance corresponding to variations in the area between sensor plates. This design effectively overcomes the limitations associated with conventional capacitive level sensors, providing a more reliable and accurate method for industrial water management.

III Methodology

The water leakage detection and control system operates using two water flow sensors, a solenoid valve, a pump motor, a GSM module, and IoT integration. One water flow sensor is installed at the inlet to measure the total water flow entering the system, while the second sensor is placed downstream to monitor the actual flow at the output. If the readings of both sensors do not match, it indicates a leakage in the pipeline. When a leakage is detected, the system immediately triggers the solenoid valve to close the water supply, preventing further wastage. Simultaneously, the pump motor is deactivated to stop the water flow, ensuring minimal loss and damage. The GSM module plays a crucial role in alerting the concerned individual by sending an SMS notification about the leakage incident. Additionally, the system updates the status on an IoT webpage in real-time, allowing remote monitoring and management. This IoT-based feature provides continuous water flow monitoring and logs data for analysis. The project enhances water conservation by preventing leaks from causing excessive wastage and potential structural damage. It also ensures a prompt response to leaks, reducing maintenance costs and increasing the efficiency of the water distribution system. The integration of GSM and IoT makes the system highly reliable, as users can take immediate action upon receiving alerts. The pump motor resumes operation only after the leakage is fixed and system stability is restored. This automated approach ensures a smart and efficient way of detecting and addressing water leaks, making it an ideal solution for residential, industrial, and agricultural water management applications.

It includes three modules

A. Water Flow Monitoring Module

This module is responsible for detecting discrepancies in water flow, indicating possible leakage. It uses two Water Flow Sensors—one installed at the inlet and another at the outlet. These sensors continuously measure the flow rate and send data to the Microcontroller (such as an Arduino or ESP32). If the values from the sensors differ significantly, it suggests a leak in the pipeline. This real-time comparison enables accurate detection of anomalies in the system. The collected data is also forwarded for logging and monitoring, making this module the core of the system's leak detection mechanism.

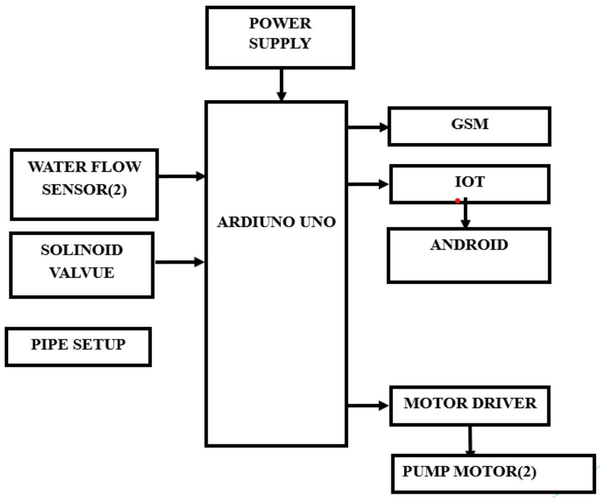

Figure 1: Block Diagram

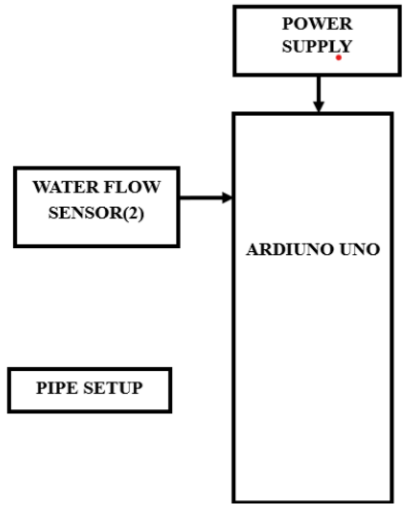

Figure 2: Water Flow Monitoring Module

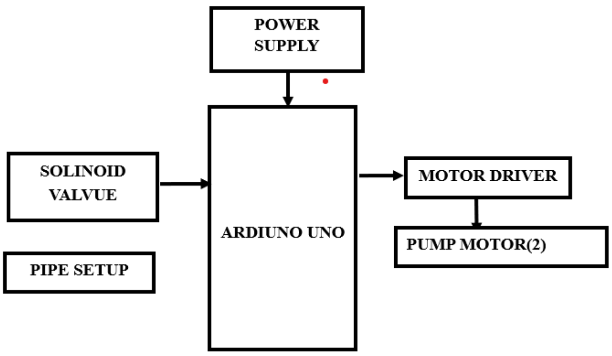

Figure 3: Leakage Control and Prevention Module

B. Leakage Control and Prevention Module

Upon detecting a leakage, this module takes immediate action to minimize water wastage. It uses a Solenoid Valve to automatically cut off the water supply, preventing further leakage. Simultaneously, the Pump Motor is turned off via a Relay Module, ensuring that water does not continue flowing. This automated response is managed by the Microcontroller, which receives signals from the sensors and executes the control logic. The system remains inactive until the issue is fixed, making it efficient and safe. This module ensures prompt containment of leaks, reducing damage and maintenance costs.

C. Notification and IOT Monitoring

This module focuses on alerting the user and enabling remote access. When leakage is detected, the GSM Module sends an SMS Alert to the user's phone, providing immediate notification. At the same time, the system updates real-time status on an IoT Webpage using a Wi-Fi Module (e.g., built-in on ESP32). This allows users to monitor water flow data, system status, and leakage history remotely. The module ensures that users stay informed and can take action even when away, enhancing the reliability and usability of the system in smart home and industrial environments .IoT-based application development platforms must possess the flexibility to adapt to various crops, climates, and geographical regions. The SWAMP project specifically develops IoT-based methods and strategies for smart water management within the precision irrigation sector and conducts pilot implementations across different countries, including Italy, Spain, and Brazil. This paper presents the SWAMP project's vision, detailed architecture, pilot studies, and the scenario-based development approach adopted to ensure that the platform is versatile and effective across diverse agricultural

IV Experimental and Results:

The Automated Water Leakage Detection and Control System with IoT Integration represents a significant advancement in modern water management, engineered to precisely monitor and control water flow to mitigate wastage and avert potential damage. The system employs a dual-sensor approach, utilizing water flow sensors at both the inlet and outlet of the pipeline, to continuously measure water flow dynamics and detect any inconsistencies that signify a leakage. Upon identifying a discrepancy, the system is programmed to trigger an automated response, activating a solenoid valve to promptly terminate the water supply and deactivating the pump motor to halt water flow. This immediate action is crucial in minimizing water loss and preventing structural damage. To enhance user awareness and system responsiveness, a GSM module is integrated to deliver real-time SMS alerts, notifying users of leakage events. Furthermore, the system incorporates IoT capabilities, providing continuous updates on water flow status and leakage incidents via a dedicated web platform, thereby enabling remote monitoring and data analysis. This comprehensive integration of automated control, real-time alerts, and remote monitoring not only conserves water resources but also contributes to reducing operational costs and improving the overall efficiency and reliability of water management across residential, industrial, and agricultural sectors.

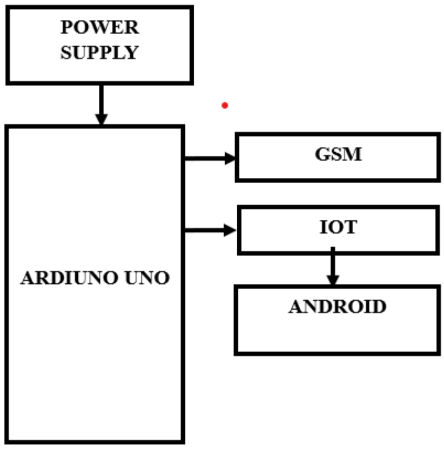

Figure 4: Notification and IOT Monitoring

The following series of figures illustrates key aspects of the user interface and system functionalities of the Automated Water Leakage Detection and Control System with IoT Integration. These interfaces are designed to provide both users and administrators with the necessary tools for effective monitoring, reporting, and management of water leakage events. The figures highlight the system's capacity for real-time data presentation, user interaction, and detailed event logging, demonstrating its comprehensive approach to water conservation and damage prevention

Figure 5 User Interface for Manual Leakage Reporting

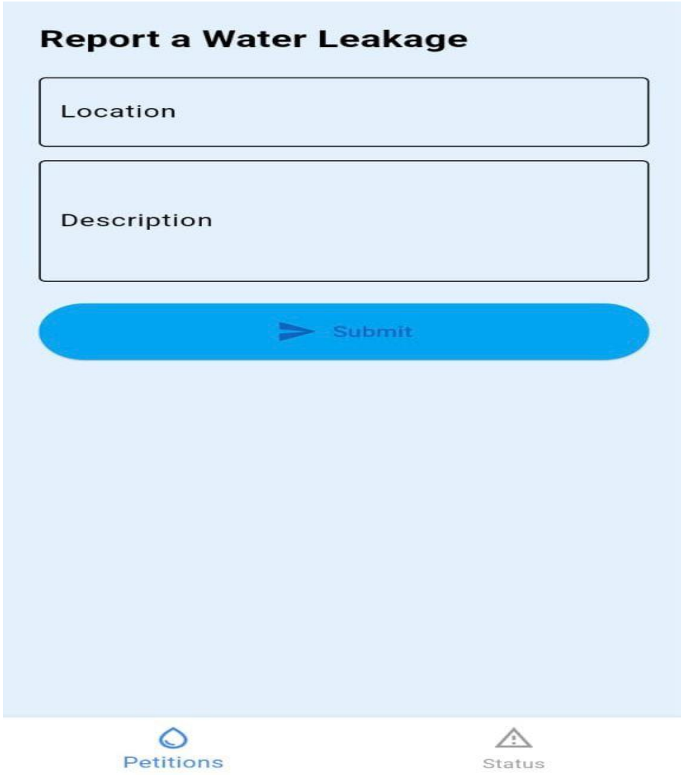

Figure 6 User Interface for Manual Leakage Reporting

Evaluation 1

Figure 5 illustrates the system's dual-interface design, providing segregated access for users and administrators. The 'People' module is tailored for end-users, delivering essential information such as leak alerts and reports, thereby facilitating timely intervention and informed decision-making. This user-centric module is critical for disseminating real-time information and ensuring that stakeholders are promptly notified of any detected anomalies within the water distribution network. Complementarily, the 'Admin' module offers a comprehensive suite of tools for system management, encompassing device oversight and analytical functions. This administrative interface empowers operators to maintain system integrity, monitor device status, and derive actionable insights from aggregated data, ultimately enhancing the system's operational efficiency and enabling proactive maintenance strategies. The clear delineation between user and administrative functions underscores the system's robustness and adaptability to diverse operational requirements."

Evaluation 2

Figure 6 presents the user interface designed to facilitate manual reporting of water leakages within the Automated Water Leakage Detection and Control System. This interface features intuitive fields for users to input the 'Location' and 'Description' of a perceived leak, enabling them to contribute valuable contextual information that might supplement the automated detection mechanisms. The prominent 'Submit' button underscores the simplicity of the reporting process, encouraging users to actively participate in identifying and communicating potential issues.

Figure 7: Detailed Leakage Event Notification with Location Mapping

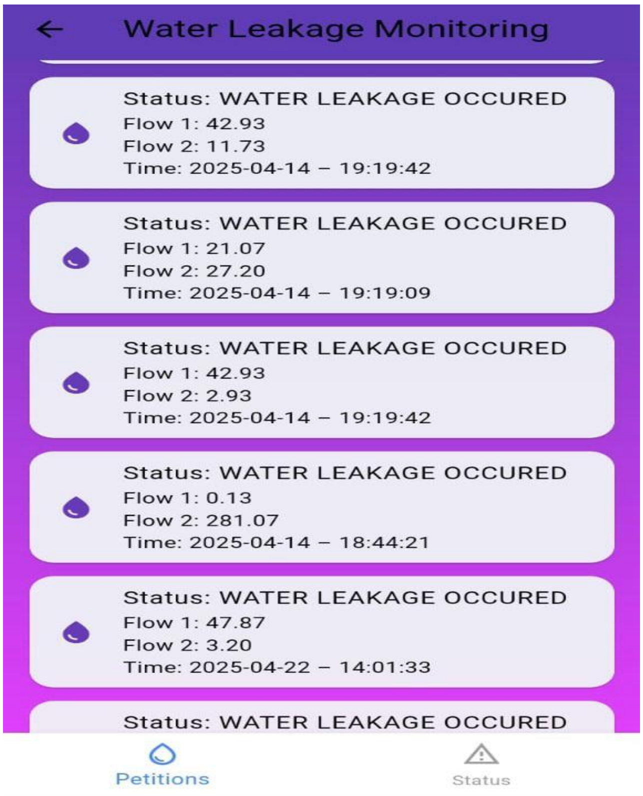

Figure 8: Real-time Water Leakage Monitoring Interface

Evaluation 3

Figure 7 illustrates a detailed notification screen within the Automated Water Leakage Detection and Control System, triggered upon the detection of a significant leakage. The prominent 'Leakage Detected!' alert, accompanied by a warning symbol, immediately draws the user's attention to the critical event. The display provides specific flow rate data, indicating a substantial difference between the inlet flow ('Flow 1: 47.87') and the outlet flow ('Flow 2: 3.20'), thereby quantifying the extent of the water loss. The status is clearly indicated as 'WATER LEAKAGE OCCURRED.' A key feature of this notification is the integration of location services, indicated by the 'View Location on Map' button. This functionality is crucial for pinpointing the precise location of the detected leak, enabling swift and targeted intervention by maintenance personnel. Below the immediate alert, a 'Leakage History' section provides a chronological record of past leakage events, including the status, flow rates, and timestamps. This historical data is invaluable for identifying recurring issues and understanding leakage patterns over time. The combination of immediate, detailed alerts with location mapping and historical data significantly enhances the system's utility in effectively managing and responding to water leakage incidents.

Evaluation 4

Figure 8 displays the real-time water leakage monitoring interface of the Automated Water Leakage Detection and Control System. This interface provides a chronological log of detected leakage events, presenting key parameters for each occurrence. Notably, it displays the 'Status' as 'WATER LEAKAGE OCCURRED,' along with the measured flow rates from Sensor 1 ('Flow 1') at the inlet and Sensor 2 ('Flow 2') at the outlet. The significant discrepancies between 'Flow 1' and 'Flow 2' in each entry clearly indicate the presence and magnitude of water loss at specific timestamps. The inclusion of the date and time ('Time') for each event is crucial for temporal analysis of leakage patterns and system response times. This monitoring interface serves as a vital tool for users and administrators to gain immediate insights into leakage incidents, assess the severity of the leaks based on the flow rate differences, and review the historical log for trend analysis. The data presented here underscores the system's capability to not only detect but also log and present critical information about water leakage events in real-time.

The presented figures collectively illustrate the Automated Water Leakage Detection and Control System's robust and user-centric design. From the intuitive interface for manual reporting to the detailed real-time monitoring displays and the comprehensive leakage event notifications, these visual representations underscore the system's capacity to provide timely information, facilitate effective user interaction, and ensure comprehensive management of water resources. These interfaces are critical components that showcase the system's ability to minimize water wastage, enhance operational efficiency, and provide stakeholders with the necessary tools to respond effectively to leakage incidents.

V . RESULT

The Automated Water Leakage Detection and Control System with IoT Integration demonstrates a robust and multifaceted approach to water resource management, with the overarching purpose of minimizing water wastage, preventing associated damage, and enhancing overall water usage efficiency. The system achieves this purpose through the effective integration of real-time monitoring, automated response mechanisms, and user-centric interface design. The core functionality, as detailed in the report, relies on the precise measurement of water flow using dual sensors strategically positioned at the inlet and outlet of the pipeline. This dual-sensor configuration enables the system to detect discrepancies in water flow, which serve as a reliable indicator of leakage events. Upon detection of such a discrepancy, the system initiates an automated response, activating a solenoid valve to promptly cease the water supply and deactivating the pump motor to halt water flow. This automated intervention is a critical outcome, showcasing the system's capacity to react swiftly and efficiently to anomalies, thereby fulfilling its purpose of immediate leakage control. Furthermore, the system's effectiveness is greatly enhanced by its intuitive user interface, as illustrated in Figures 1 through 4. Figure 1 highlights the manual leakage reporting interface, allowing users to actively contribute to the system's purpose of comprehensive leak detection by providing essential location and description details. Figure 2 demonstrates the real-time water leakage monitoring interface, which presents a chronological log of leakage events with precise flow rate data, enabling users to assess the severity and trends of water loss, thus supporting the system's purpose of informed decision-making. Figure 3 showcases the detailed leakage notification screen, providing immediate alerts and location mapping for rapid response, directly serving the system's purpose of timely intervention. These interfaces, combined with the GSM module's SMS alerts, ensure that both users and administrators are promptly informed and equipped to take appropriate action. The integration of IoT capabilities, as reflected in the web-based monitoring and data logging, further enhances the system's utility by providing remote access and analytical tools, contributing to the system's purpose of long-term optimization of water usage. conclusion, the successful implementation of the Automated Water Leakage Detection and Control System results in a significant reduction in water wastage, improved operational efficiency, enhanced system reliability, and ultimately, the realization of its core purpose to promote sustainable and effective water resource management

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VI.CONCLUSION

The development and implementation of the Automated Water Leakage Detection and Control System with IoT Integration represent a significant stride towards more efficient and sustainable water resource management. By employing a dual-sensor system to accurately monitor water flow and automating the response to leakage events through solenoid valve and pump motor control, the system effectively minimizes water wastage and mitigates potential damage.

The integration of user-centric interfaces, as depicted in Figures 5-8, further enhances the system's practicality and effectiveness. These interfaces provide essential functionalities such as manual leak reporting, real-time monitoring of flow rates, and detailed leakage alerts with location mapping, ensuring that users and administrators are well-informed and capable of prompt intervention. The utilization of GSM modules for immediate notifications and IoT connectivity for remote monitoring and data analysis adds another layer of sophistication, enabling comprehensive oversight and long-term optimization of water usage. Ultimately, this system addresses the critical need for proactive water management in various sectors, offering a robust solution to conserve water, reduce operational costs, and promote environmental sustainability. The successful integration of hardware components, software capabilities, and user-focused design culminates in a system that not only detects and controls water leakage but also empowers stakeholders with the tools and information necessary for responsible water stewardship.

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