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Implementation of an IoT-Based System for River Water Level Measurement and Water Quality Monitoring

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Abstract: *Monitoring river water levels and water quality is a critical requirement for effective flood management and sustainable water resource planning, particularly in remote regions with unpredictable rainfall patterns. Conventional manual monitoring methods are labor-intensive, delayed, and unsuitable for real-time decision-making. To overcome these limitations, this paper presents the design and development of an IoT-based river monitoring system named AquaRead, which enables continuous, autonomous, and real-time monitoring of river conditions. The AquaRead system integrates an ultrasonic water level sensor (DYP-A16NY4W-V1.0) along with multiple water quality sensors, including pH, turbidity, total dissolved solids (TDS), and dissolved oxygen (DO) sensors. These sensors are interfaced with an ESP32 controller for data acquisition, signal conditioning, and packet generation. The collected data is transmitted using a GSM A7670C communication module via the MQTT protocol to a cloud-based platform for storage, processing, and visualization. The system provides real-time monitoring through a web-based dashboard, displaying river water level, water quality parameters, battery status, station location, and flood condition indicators such as Safe, Warning, and Danger levels. In critical situations, automated SMS alerts are sent to authorized personnel to enable rapid response. To ensure reliability during network failures, local data storage using an SD card is incorporated, allowing data synchronization once connectivity is restored. The device is designed for outdoor deployment with a vandal-resistant enclosure and supports solar-powered battery backup for uninterrupted operation. Field validation results demonstrate that the AquaRead system offers a reliable, scalable, and cost-effective solution for continuous river level and water quality monitoring. By enabling timely alerts, real-time data access, and historical trend analysis, the proposed system significantly enhances flood preparedness, early warning capabilities, and informed decision-making for sustainable river basin management*

Keywords: *Monitoring river water*

I. INTRODUCTION

Rivers are vital lifelines for agriculture, drinking water supply, hydroelectric power generation, and maintaining ecological balance. Continuous monitoring of river water levels and water quality is essential for effective water resource management, flood prediction, and ensuring the safety of downstream communities. In India, the Central Water Commission (CWC) is responsible for collecting hydrological data such as river water levels, reservoir inflows, and flood-related information. Traditionally, monitoring at CWC stations is carried out manually using gauge posts, where personnel record hourly observations. This approach is labor-intensive, time-consuming, and susceptible to delays and human errors, particularly in remote or difficult-to-access river locations. Manual monitoring also restricts

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rapid response to sudden changes in river conditions, increasing the risk of flood-related damage to infrastructure and human settlements. The growing impact of climate change has resulted in more frequent extreme weather events, including intense rainfall and flash floods, emphasizing the need for real-time river monitoring systems. Accurate, timely, and continuous data is crucial for early warning mechanisms, flood forecasting, and sustainable water management. Recent advancements in Internet of Things (IoT) technology, GSM-based communication, and cloud computing enable automated and real-time monitoring of river conditions, effectively addressing the limitations of conventional methods.

The sensing unit includes an ultrasonic water level sensor (DYP-A16NY4W-V1.0) along with water quality sensors such as pH, turbidity, total dissolved solids (TDS), and dissolved oxygen (DO) sensors. These sensors are interfaced with an ESP32 microcontroller, which serves as the core control unit responsible for sensor data acquisition, signal processing, and packet formation. The processed data is transmitted using a GSM A7670C module via the MQTT protocol, ensuring reliable and efficient data communication even in areas with limited network connectivity.

The AquaRead system is designed for autonomous and low-maintenance operation, requiring minimal human involvement. It supports periodic data transmission, typically on an hourly basis, and generates emergency alerts when critical water level thresholds are exceeded. To ensure data reliability during network disruptions, the system incorporates local data storage using an SD card, preventing data loss during GSM outages. Once network connectivity is restored, the stored data is automatically synchronized with the cloud platform. This feature is especially important for deployment in remote river basins where communication networks may be unstable.

For long-term outdoor deployment, the system is housed in a rugged, weatherproof, and vandal-resistant enclosure to withstand harsh environmental conditions and unauthorized interference. The inclusion of battery backup with solar charging capability ensures uninterrupted operation during power failures, making the system suitable for continuous field deployment. AquaRead supports monitoring of multiple river stations simultaneously, providing real-time information on water level, water quality parameters, battery status, signal strength,

Flood conditions are categorized into Safe, Warning, and Danger levels based on predefined thresholds, enabling timely and effective response by authorities. Automated SMS alerts are sent to authorized personnel when critical conditions are detected, ensuring rapid intervention.

In addition to water level monitoring, the system estimates river discharge using a power-law relationship based on measured water levels. Discharge estimation, combined with water quality analysis and historical trends, offers deeper insight into river behavior, supporting flood prediction, flow assessment, and preventive planning. All collected data is visualized on the AquaRead web-based dashboard, which provides real-time updates, historical data analysis, interactive graphs, and station-wise comparisons. The dashboard allows authorities to monitor multiple locations efficiently and assess flood risks with greater accuracy.

In conclusion, the AquaRead system overcomes the limitations of traditional river monitoring by offering a reliable, real-time, and autonomous IoT-based solution. By integrating multi-parameter sensing, GSM communication, cloud-based storage, and intelligent data visualization, the system enhances flood management and water resource planning. Designed for challenging environmental conditions and scalable deployment, AquaRead ensures uninterrupted monitoring through local data storage and renewable power support. The system enables timely alerts, accurate measurements, and continuous observation, strengthening the ability of authorities to protect communities and manage river ecosystems sustainably. Its implementation represents a significant step toward modernizing hydrological monitoring in India and provides a scalable framework for adoption in other regions facing similar water management challenges.

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II. METHODOLOGY

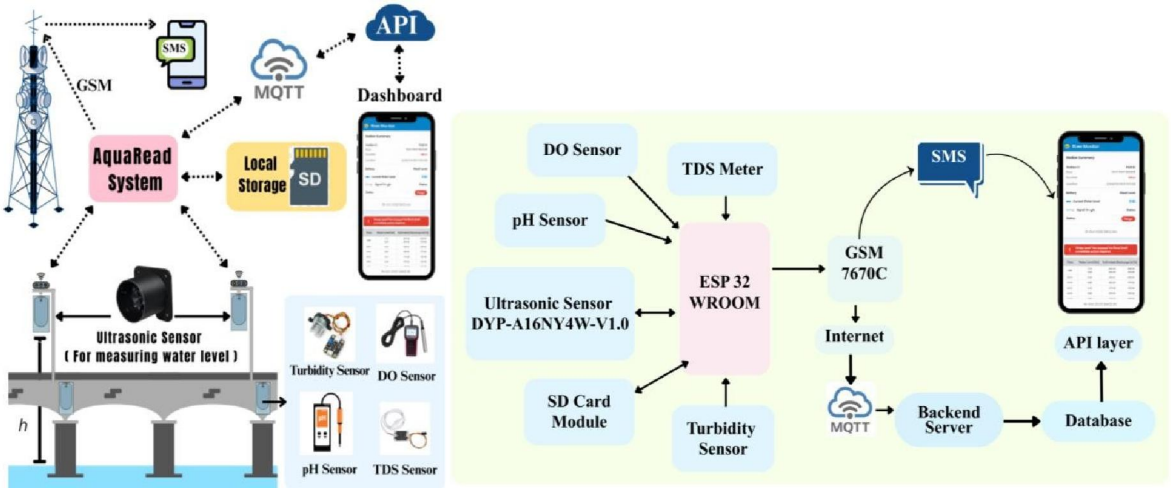

Fig 2 : Hardware , IOT and Communication Flow

The AquaRead system forms the core of the methodology, ensuring accurate and continuous river water level monitoring using IoT technology. The system is designed to measure, store, and transmit hydrological data automatically while operating reliably in outdoor and remote environments.

2.1 Sensor Deployment and Data Acquisition

The AquaRead system deploys a waterproof ultrasonic sensor (DYP-A16NY4W-V1.0) above the river surface to measure water level accurately in real time. Along with this, water quality sensors for pH, turbidity, TDS, and dissolved oxygen continuously capture river health parameters. All readings are timestamped, tagged with GPS coordinates, and supported by a solar-powered battery system that ensures uninterrupted 24×7 operation with efficient power monitoring.

2.2 IoT Hardware and Control

An ESP32 microcontroller serves as the central unit, acquiring data from water level and water quality sensors and preparing structured data packets. The GSM A7670C module transmits data to the cloud using the MQTT protocol at defined intervals. During network outages, sensor data is securely stored on an SD card and automatically synchronized once connectivity is restored, ensuring data reliability.

2.3 Software and Dashboard

The system firmware is developed using the Arduino IDE to manage sensor interfacing, data processing, GSM communication, and local storage. The AquaRead backend is implemented using the Flask framework with a PostgreSQL database for data storage and analysis. A web-based dashboard provides real-time visualization of water level, water quality parameters, battery status, location, and flood condition indicators across multiple monitoring stations.

2.4 Communication and Alert Logic

MQTT over GSM is used for lightweight and reliable data transmission between field units and the cloud server, while UART and SPI interfaces manage internal module communication. The ESP32 evaluates real-time readings against predefined thresholds to classify conditions as Safe, Warning, or Danger. In critical situations, automated SMS alerts are sent to authorized authorities, and the dashboard highlights alerts for immediate response.

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III. RESULT DISCUSSIONS

3.1 Hardware Prototype

A working hardware model of the AquaRead system was developed using ESP32, HC SR-04 ultrasonic sensor for testing , SIM900A GSM module, and SD card interface. The setup successfully measured real-time river levels, transmitted data to the cloud via MQTT, and operated continuously using solar power and battery backup.

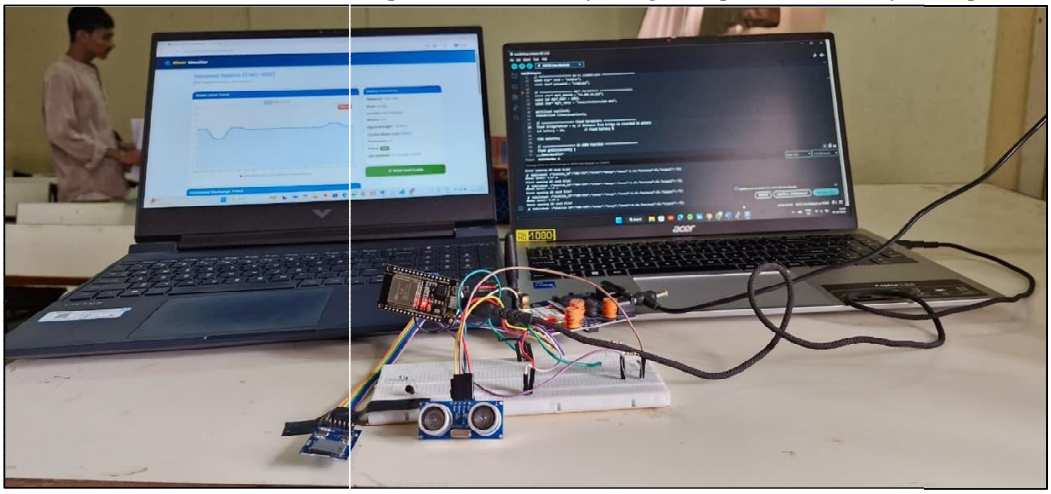

Fig 3: IOT Hardware Setup

3.2 Web App Prototype

The AquaRead web application was implemented using Flask and PostgreSQL, featuring a real-time dashboard that displays water level, battery status, station location, and flood alerts. The system supports live monitoring, automatic data updates, and SMS notifications during critical flood conditions.

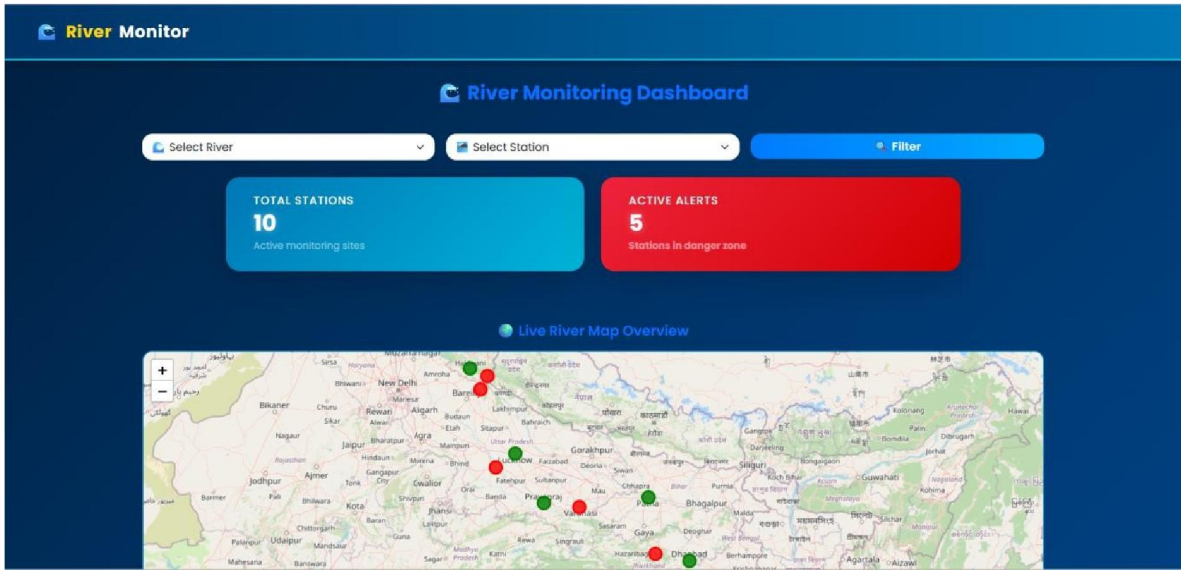

Fig 4 : Map overview of All River Stations

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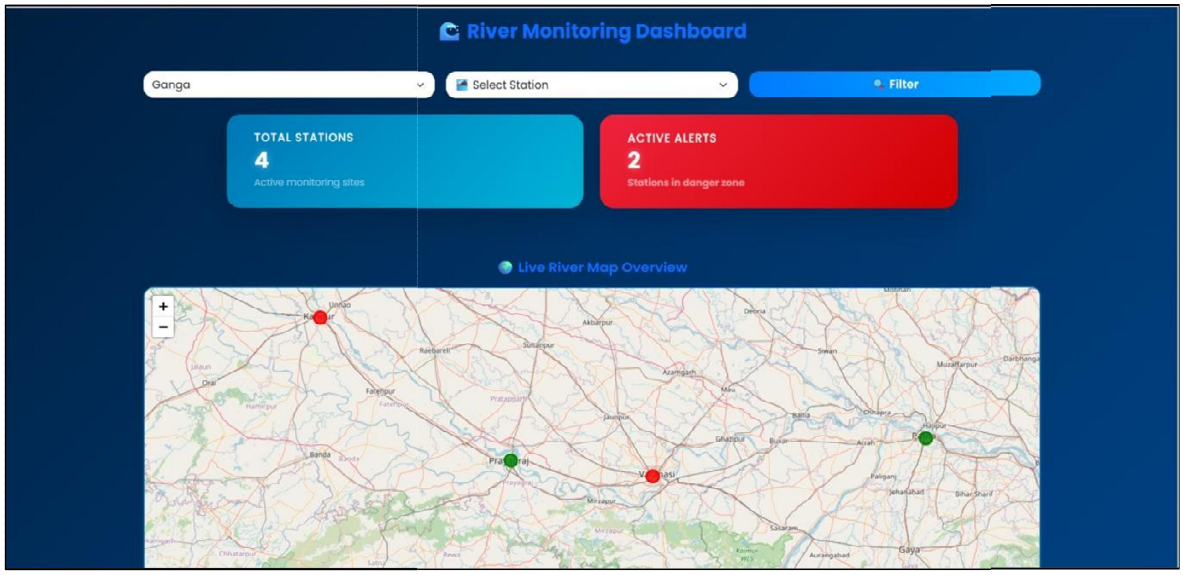

Fig 5: River Stations of a particular River

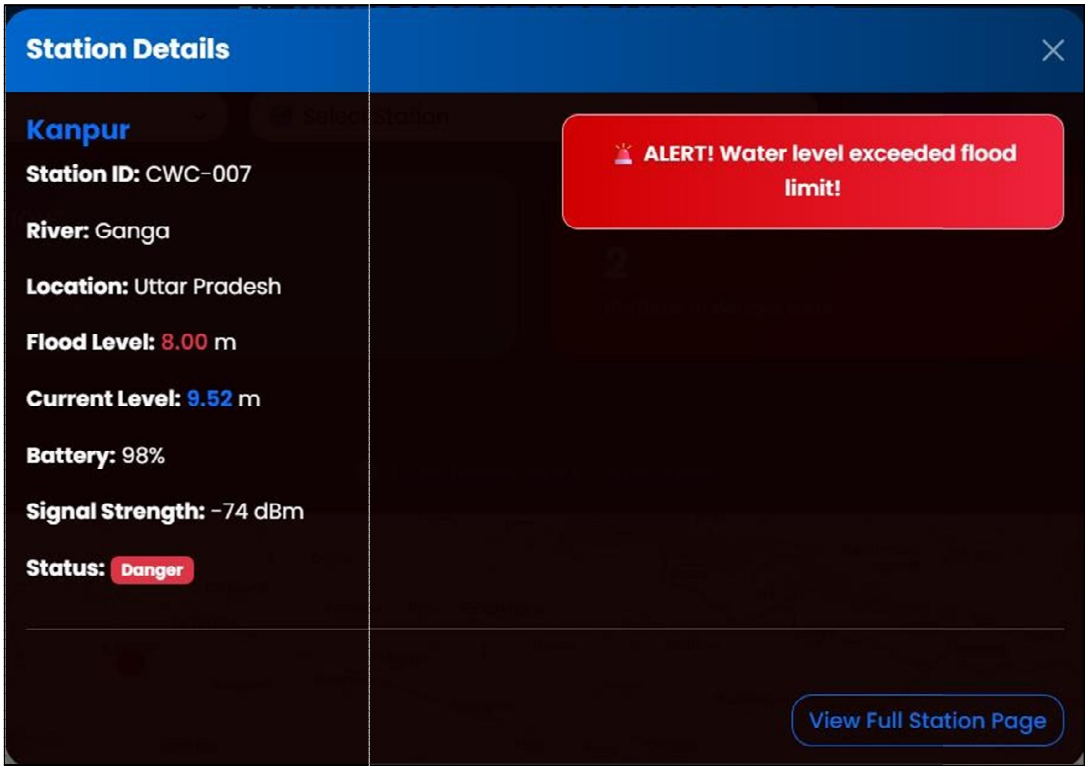

Fig 6 :River water level details

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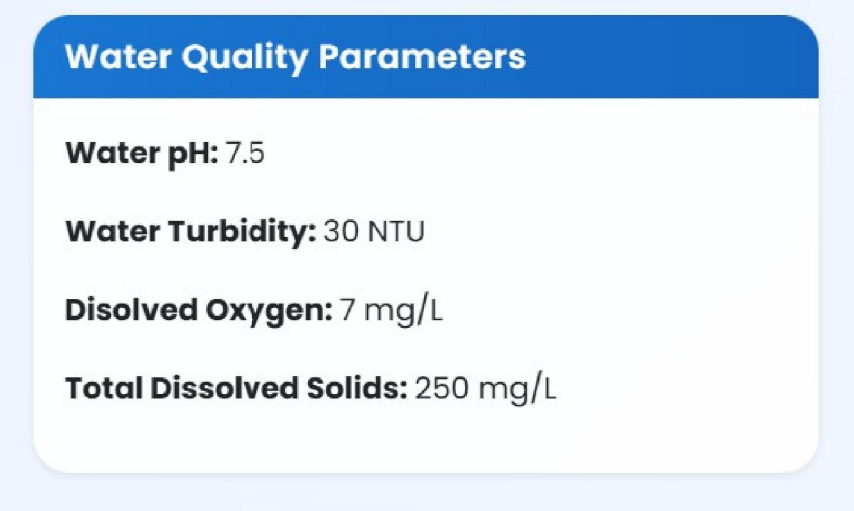

Fig. 7: River water quality details



Fig 8: Dashboard (Live Monitoring) River Water level vs Time

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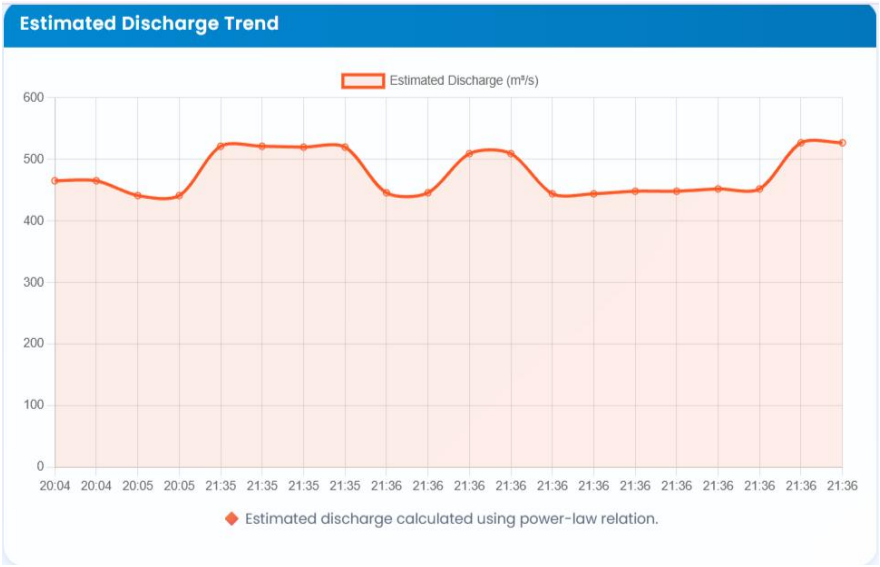

Fig 9: Discharge Trend

Recent Readings

Time	Water Level (m)	Estimated Discharge (m³/s)
20:04	7.09	465.34
20:04	7.09	465.34
20:05	6.31	441.30
20:05	6.31	441.30
21:35	9.27	521.38
21:35	9.27	521.38
21:35	9.21	520.00
21:35	9.21	520.00
21:36	6.45	445.82
21:36	6.45	445.82
21:36	8.76	509.42
21:36	8.76	509.42
21:36	6.40	444.22
21:36	6.40	444.22
21:36	6.53	448.36
21:36	6.53	448.36

Fig 10 : Recent Readings of River Water level & Discharge flow rate

IV. CONCLUSION

The AquaRead system successfully demonstrates an integrated IoT-based solution for continuous river water level and water quality monitoring aimed at improving flood management and sustainable water resource planning. By combining an ultrasonic water level sensor (DYP-A16NY4W-V1.0) with key water quality sensors such as pH, turbidity, total dissolved solids (TDS), and dissolved oxygen (DO), the system provides a comprehensive view of river

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health in real time.The ESP32 controller efficiently handled multi-sensor data acquisition, processing, and packet formation, while the GSM A7670C module enabled reliable data transmission to the cloud using the MQTT protocol. The cloud-based dashboard proved effective in displaying live water level data, water quality parameters, historical trends, battery status, station location, and flood condition indicators (Safe, Warning, and Danger), supporting data-driven decision-making for authorities.

The inclusion of SD card-based offline data storage ensured zero data loss during network outages, and automated SMS alerts enabled rapid response during critical flood or abnormal water quality conditions. The solar-powered system with battery backup ensured uninterrupted 24×7 operation, making AquaRead suitable for remote and outdoor deployments.Overall, the AquaRead system offers a reliable, scalable, low-cost, and low-maintenance solution for real-time river monitoring. The project highlights strong potential for large-scale deployment across river basins, contributing to early flood warning systems, water quality assessment, disaster preparedness, and sustainable river basin management.

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