Crowd-Sourced Water-Related Problem

Daripineni Teja
Dept of Computer Science
Engineering Presidency University
Bengaluru, India
daripineniteja@gmail.com

Achanta Hima Chandu
Dept of Computer Science
Engineering Presidency University
Bengaluru, India
chanduygm@gmail.com

Ms. Radhika Sreedharan
Dept of Computer Science
Assistant Professor
School of CSE&IS Presidency University
Bengaluru, India

Abstract— **Water pollution and scarcity are the most pressing issues in rural India, fueled by resource overexploitation, inadequate systems, and poor monitoring. Existing water data collection systems are sluggish, decentralized, and non-localized, leading to delayed action and poor governance. This paper presents a new, scalable crowd-sourced digital platform to democratize water monitoring to facilitate real-time, community-led data submission using web and mobile interfaces. The platform is based on role-based design, with it dividing the users into contributors, verifiers, or administrators, and therefore any data collected is highly validated. Geotagging, media upload, and metadata such as water level and quality status give more tangible, context-rich data sets. Backend is written in Kotlin and Gradle with modular, secure, and API-centric design for best deployment in low-bandwidth and low-resource environments. By incorporating easy reporting, multi-level authentication, and storage extension features, the system addresses key shortcomings of existing citizen science models—i.e., lack of authentication, accessibility to rural areas, and sustainable longevity.**

Keywords*— *Crowd-sourced data, Water resource monitoring, Participatory sensing, Role-based access control, Rural water management, Kotlin backend, Geotagged reporting, Citizen science platform, Environmental data validation, Mobile water monitoring, Decentralized data collection, Community engagement, RESTful APIs, Smart governance, Water quality reporting.

I. INTRODUCTION

India's water crisis is as much a crisis of mismanagement, unbridled exploitation, and de-centralized data systems as a crisis of scarcity. Rural peoples, who are largely reliant on groundwater and monsoon water bodies, are frequently excluded from national monitoring due to logistical, economic, and technological limitations. Therefore, localized data on water quality, availability, and consumption are sparse or outdated, which constrains meaningful intervention.

Government-initiated monitoring systems are likely to depend on periodic manual surveys and infrastructure-intensive installations, which are not scalable and maintainable. Additionally, community members—who are most directly affected by water problems—are seldom empowered to provide data or participate in resource management choices.

Over the past few years, advances in mobile connectivity and digital literacy have opened up new possibilities for participatory governance. Crowd-sourced data collection platforms, particularly in the health and environmental sectors, have proven that local communities can offer rich, real-time information if provided with the appropriate tools and support.

But most current crowd-based water monitoring systems have technical and operational limitations. These are inadequate verification processes, weak backend security, inability to scale to other regions, and weak offline or low-bandwidth support. Additionally, very few systems cater to the requirement of differentiated roles and levels of access to data quality and accountability.

This paper illustrates a novel solution that combines a role-based digital platform for water monitoring with Kotlin-based backend services. The system enables real-time submission of geotagged water data by citizens, with verifiers and administrators ensuring the integrity and utility of the submitted data. With modular architecture and light-weight APIs, the platform is made deployable locally, cost-effective, and scalable geographically. By integrating community participation into the very fabric of its design, this platform not only encourages improved data collection but also heightened awareness, transparency, and co-management of water resources. The ultimate aim is to offer a model replicable by NGOs, academic communities, or governments seeking to democratize water resource management.

II. LITERATURE REVIEW

Recent research emphasizes the increasing role of citizen engagement in water monitoring using mobile and digital tools. A mobile app for groundwater census in South

Africa facilitated community-based data collection, prioritizing geolocation and mobile convenience. It did not have integrated data validation mechanisms and real-time feedback.[1]

In the Indian context, the National Water Development Agency has implemented a number of digital water governance initiatives that emphasize automation, data integration, and centralized command systems. These kinds of models are more relevant to policy-level interventions and do not relate to community-level participatory data schemes. [2]

A study in Europe investigated the application of citizen science in monitoring the environment's water. Such systems incorporate IoT sensors and mobile devices for public engagement at large scale. Though effective, they consume a lot of resources and perhaps may not find use in remote or economically underprivileged regions like in India. [3]

Another Indian research suggested a GIS-supported participatory model for water resource management. The system supported rural users in submitting data via mobile phones but did not include role-based authentication and secure verification levels, which confined its scalability and governance uses. A sensor-based review of water monitoring frameworks compared the advantages of real-time environmental information using embedded devices. Although promising, these models are challenging in terms of deployment expense, technical know-how, and maintenance, particularly in low-resource contexts [10].

Those works together illustrate a key omission: although there are digital solutions for monitoring water, most lack role-based workflows, cannot be used in rural settings, or need extensive hardware infrastructure. This project bridges those gaps through the provision of a role-driven, mobile-accessible, and extensible backend solution for participatory water governance.

III. SYSTEM ARCHITECTURE

1. Frontend Layer: The frontend is built with mobile-first design to be able to support Android smartphones, prevalent even in rural areas. It can be later extended to a responsive web interface for admin or dashboard views. Key features are: User Authentication and Role-based Navigation: The app dynamically loads different functionalities based on login credentials for Users, Verifiers, or Admins.

Report Submission Interface:

- Geolocation Capture: Utilizes GPS modules to automatically assign the user's location.
- Media Uploads: Images (e.g., of contaminated sources, tank overflows) to add visual context.
- Custom Metadata Forms: Input of water quality (e.g., color, smell), availability status, source type (well, tap, canal), and comments.

Offline Caching: Data cached locally in areas with poor network and synchronized upon reconnection.

2. Backend Layer: The backend is developed in Kotlin with the Gradle build system for performance, flexibility, and seamless integration with JVM-based ecosystems. It adheres to the Model-View-Controller (MVC) pattern, providing clean separation of data, logic, and interfaces.

Important Features:

- Authentication Module:
- Provides secure login (session-based or JWT).
- Role mapping: Admin, Verifier, User.
- Secure password hashing and session management.

API Controllers:

- Written based on RESTful principles.
- Endpoints encompass user management (/register, /login, /update-role), report submission (/submit-report, /fetch-reports), and verification workflows (/verify-report, /flag-report).

Validation and Workflow Engine:

- Regular user submissions go into a pending queue.
- Verifiers view a dashboard with batch and map views to accept, flag, or comment on submissions.
- Verified data is tagged with a confidence level or reviewer comments for admin monitoring.

Notification Service:

- Optional module that notifies verifiers/admins of new reports within their locality or role scope.

Admin Dashboard APIs:

- Facilitate user analytics, data trends, and system monitoring overall.

3. Database Layer: The persistence layer of the system is capable of supporting scalable storage of structured and unstructured data.

- Preferred Engines: PostgreSQL (to support complex relational queries and GIS functionality) or Firebase Realtime DB (to support light installations and real-time synchronization).

Stored Data Includes:

- Users: Role, contact information, login credentials (hashed securely).

- Reports: Text information (e.g., metadata), location, timestamps, verification status.

- Media Files: Image URLs or blobs (depending on storage backend—Firebase Storage or local/cloud S3).

- Verification Logs: Inspect timestamps, reviewer, status history, comments.

IV. METHODOLOGY

Crowd Resource system presents a robust and well-defined digital solution to address the inefficiencies of the traditional complaint reporting systems—especially for water or municipal-related issues. It has been designed to give transparency, efficiency, accountability, and community participation in the complaint process. The approach is a multi-role step-by-step process that complements modern digital process and public service needs:

Step 1: User Authentication and Registration

- Citizens register and sign in to the system by entering secure credentials.

- The authentication module safeguards authorized users from unauthorized access to complaint submission and tracking capabilities.

- safeguards user-specific dashboards and personal complaint histories.

Step 2: Submitting Complaints

- Authenticated users are able to file complaints through completing a preformatted form

- The complaint entry on each enables the users.

- Add a title and description of the issue.

- Include an image as graphical proof.

- Provide location information (e.g., address or coordinates).

- The backend keeps all the entries in an SQLite database and attributes them with timestamp and status tags (e.g., "Pending", "In Progress", "Resolved").

Step 3: Admin Validation and Task Distribution

- Admins use a different portal/dashboard for login.

- All complaints are listed in an organized list with filters (e.g., date, location, status).

- Admins examine new complaints and assign them to assigned workers by area or availability.

- Role-based assignment prevents improper delegation and lack of accountability Admins use a different portal/dashboard for login.

- All complaints are listed in an organized list with filters (e.g., date, location, status).

- Admins examine new complaints and assign them to assigned workers by area or availability.

- Role-based assignment prevents improper delegation and lack of accountability.

Step 4: Worker Task Management and Updates

- Workers who have been assigned receive complaint information, including location and image data.

➢ Once the issue has been resolved, workers can:

- Mark the complaint status as "Resolved".
- Provide remarks or feedback on the resolution process.
- This complaint status update is displayed live within the system.

Step 5: Complaint Tracking and Notifying in Real-Time

- Any time, from their dashboard, users can check the status of the complaints that they have lodged

- Status change notifications (e.g., assigned, in process, resolved).

- This makes life more transparent and less frustrating to users.

V. CONCLUSION

This project offers an effective platform for water complaint management, simplifying issue reporting and resolution. By allowing users to report location-based complaints, offering structured worker assignments, and providing a complaint-tracking dashboard, it enhances efficiency and accountability. Authorities can track trends, workers can resolve issues systematically, and users get timely updates. The structured approach facilitates quicker resolution and reduces delays, making water issue management more dependable and organized. This system greatly increases public involvement in water issue solving. To enhance efficiency even further, subsequent upgrades could involve an AI-driven complaint classification system for auto-prioritization. There could be a notification system to keep the users informed about complaint status. Even a chatbot integration for real-time query resolution would boost user interaction.

Incorporating predictive analytics would assist authorities in identifying high-risk zones based on complaint patterns. These upgrades will further make the system more responsive, data-driven, and efficient in dealing with water related matters.

VI. FUTURE WORK

Adoption of Blockchain Technology:
For greater transparency and trust in data verification processes, future versions of the platform can incorporate blockchain-based report submission verification. This unalterable ledger can ensure secure tracking of water data—from field submission to verification and final use in decision-making. Validation processes can be made automatic through the use of smart contracts, and token-based incentives can be given for reliable contributors [1][2].

Sophisticated AI and Machine Learning Models:
It can be augmented with deep learning models to enable intelligent processing of uploaded videos and images for automatic detection of water source problems (e.g., leakage, contamination, overflow). Large annotated data sets can be used to train models in order to enhance classification accuracy and detect water degradation patterns, abuse, or seasonality patterns [3].

Scalability to Urban and Rural Markets:
Though originally conceived for rural deployment, the platform is scalable to urban slums with high population density and far-flung villages. In the urban setting, the system can be blended with smart city infrastructure; in the rural setting, light-weighted deployment with low-hardware (e.g., SMS- or USSD-based modules) can provide reach and functionality in low-connectivity conditions [4].

Predictive Water Resource Monitoring:
Through the utilization of historical as well as live data, the platform can use forecasting models for predicting water shortages, pollution hazard, and replenishment based on rainfall. All these predictions would help local authorities in advance water conservation planning, particularly during months of drought or monsoon season [5].

Circular Resource Management Linkages:
Expansion in the future can also include the integration of the platform with water recycling and reuse infrastructure, including greywater recycling plants, groundwater recharge plants, and rainwater harvesting systems. This allows for an end-to-end water lifecycle strategy, merging data capture with water circularity practice sustainably [6].

Sole Mobile Application for Community Engagement:
A richer mobile app can be developed to provide personalized dashboards, reminder for submission, gamified rewards for active users, multilingual capabilities, and a learning center on water quality, conservation measures, and source protection. The status update in real-time will facilitate maintaining community engagement [7].

Energy-Efficient Sensing Integration:
To additionally automate reporting of water quality and quantity, low-power IoT sensors can be integrated with the platform. They can be solar-powered and installed on tanks, wells, or streams to automatically send turbidity, pH, or flow rate data, reducing the workload of manual reporting [8].

Monitoring Industrial Wastewater and Contaminants:
A sophisticated extension would be capable of monitoring industrial wastewaters and agricultural runoff for the detection of chemical pollutants in water supplies. Chemical sensors and special modules could be employed for the detection of toxic levels of nitrates, fluorides, heavy metals, or pathogens [9].

Policy Integration and Government Compliance:
The platform can be synchronized with national and regional water management policies (e.g., Jal Jeevan Mission, Swachh Bharat Abhiyan). The integration of real-time monitoring data with municipal dashboards facilitates regulatory compliance, transparency, and policy-making [10].

Behavioral Analysis and Community Motivation:
With behavior models and gamification, subsequent releases can observe how feedback, rewards, and peer comparison affect communities. Point systems, recognition incentives, and leaderboards can motivate sustainable behavior and enhance submission consistency [11].

Dynamic Resource Routing and Allocation:
Depending on intensity and frequency of water complaints received from a specific location, AI-based dynamic routing systems can help NGOs and local authorities in decision-making about resource allocation—technical support, maintenance personnel, or provision of clean water [1][2].

Climate-Specific Tailoring:
These can be tailored to accommodate region-specific climatic conditions—e.g., dust-proofing hardware components for dry regions or waterproofing and corrosion-proofing for coastal and flood-prone areas. UI designs can also be tailored to accommodate cultural contexts and language preferences [3].

Integration with Renewable Energy Systems:
The use of solar-powered edge nodes and mobile devices can reduce energy usage and make deployments more sustainable. In areas with poor electricity availability, such integration of renewables will ensure constant service and reduced maintenance costs [4].

Hazardous and Emergency Event Reporting:
Other modules can help citizens report immediate emergency water incidents—like chemical spills, contamination of floods, or unexpected dry wells. Authorities can be informed through SMS or push

notification modules, allowing more rapid intervention [5].

Real-Time Feedback Mechanism for Users: The inclusion of bi-directional communication channels will allow users to flag data inaccuracies, suggest improvements, or flag unresolved issues. This user feedback loop will enhance platform reliability, build trust, and allow users to take ownership of their local water resources [6].

Internationalization and Localization: For worldwide deployment, the system may be designed to accommodate different languages, units of measurement, water quality codes, and communal structures. Customer-specific APIs and config modules would enable the platform to be deployed in other geographies with a certain amount of adaptation [7].

Intelligent Integration with GIS Mapping Tools: The integration of heatmaps and geospatial dashboards will provide graphical displays of reporting density, water scarcity trends, and high-risk zones. This will facilitate graphical planning and resource allocation by NGOs and administrators [8].

Citizen Science and Education Outreach: A follow-up publication would provide educational modules and toolkits to facilitate water quality monitoring for school and college levels. Participation by citizen science can provide more integrated, broader dataset while increasing water literacy [9].

Collaborations with Research and Environmental Agencies: The system can be brought into alignment with databases maintained by research institutions, water boards, and meteorological offices. Collaborative modeling, long-term research, and larger-scale water planning efforts can be enabled by data-sharing partnerships [10].

VII. REFERENCE

[1] S. Adamala, "An overview of big data applications in water resources engineering," Mach. Learn. Res., vol. 2, no. 1, pp. 10–18, 2017.

[2] T. H. Assumpcao, A. A. Popescu, J. R. O'Hara, and A. D. Chapman, "Citizens' campaigns for environmental water monitoring: Lessons from field experiments," IEEE Access, vol. 7, pp. 134601–134620, 2019.

[3] X. Cai, K. Wallington, M. Shafiee-Jood, and L. Marston, "Advances in Water Resources," ScienceDirect, 2018. [Online]. Available: https://www.sciencedirect.com

[4] S. R. Dennis, I. Dennis, and T. Mongala, "Mobile App for Hydrocensus and Groundwater Monitoring," 2022.

[5] A. Kliskey, P. Williams, D. L. Griffith, V. H. Dale, C. Schelly, A. M. Marshall, and V. S., "Sustainability," 2021. [Online]. Available: https://www.mdpi.com

[6] S. Manfreda et al., "Advancing river monitoring using image-based techniques: challenges and opportunities," Hydrological Sciences Journal, vol. 69, no. 6, pp. 657–677, 2024.

[7] C. Pahl-Wostl, P. Gorris, N. Jager, L. Koch, L. Lebel, C. Stein, and S. Venghaus, "Sustainability Science," 2021. [Online]. Available: https://link.springer.com

[8] A. Seth, "Digital Participatory Tools for Water Resource Management in Rural Communities in India."

[9] B. Strobl, Quality of crowdsourced water level observations, Ph.D. dissertation, Univ. of Zurich, 2020.

[10] N. E. Thomas, Information and awareness as a means to develop water supply systems in rural and peri-urban Bangladesh, M.S. thesis, Delft Univ. of Technology, 2020.