OPTIMISING NON REVENUE WATER DISTRIBUTION NETWORK USING DATA DRIVEN APPROACH FOR WATER LOSS REDUCTION

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Keywords:

Non-Revenue Water (NRW), Water Distribution Systems, Leak Detection, Pressure Management, Smart Metering, Water Conservation.

Introduction:

Non-revenue water,the water produced but unbilled due to system inefficiencies, losses, or unauthorized use, poses significant economic and environmental challenges to water utilities globally. Globally, NRW levels can vary dramatically, with developing countries experiencing losses as high as 70%, while developed nations typically manage to keep NRW below 30%. The economic implications are profound, with utilities worldwide losing billions of dollars annually due to NRW moreover contributing to environmental degradation by wasting precious water resources and increasing the energy required for water treatment and distribution.

Objectives:

- Determine the percentage of Non- Revenue Water in the selected water distribution area Nitte Meenakshi Institute of Technology.
- Identify key factors contributing to Non-Revenue Water, such as leaks, inaccurate metering, damaged pipes at the selected study area.
- Recommend practical measures to reduce water loss based on analysis for the selected study area.

- Assess the impact of the proposed measures using simple simulations for the selected study area.

Methodology:

- Data Analytics and Predictive Maintenance: To use collected data for forecasting issues using Python and optimizing operations. Real-Time Data Analytics technique is utilized for processes incoming data from meters and sensors to detect anomalies and identifying consumption patterns
- Leak Detection**:** Acoustic Leak Detection technique is used by utilizing sensors that detect sound waves produced by water escaping from pipes. Acoustic signals vary depending on pipe material, pressure, and leak size. Helps in pinpointing leak locations without excavation. Real-Time Pressure Monitoring uses pressure sensors installed throughout the network sudden drops in pressure can indicate leaks or bursts.
- Smart Metering: Advanced Metering Infrastructure (AMI) technique is enabled where two-way communication between water meters and utility is done by transmitting real-time consumption data. Detects anomalies such as continuous flow, which may indicate a leak. IoT-enabled water meters ,Data analytics dashboards and Cloud-based management systems tools are used.
- Geographic Information Systems (GIS): QGIS mapping software for Leak Pattern Mapping and Infrastructure Layering technique is utilized to identify areas with recurring leaks and Integrating data about pipe age, material, diameter, and installation date. Helps identify weak points in the system enabling prioritization of maintenance based on risk levels.
- Pressure Management: Automated Pressure Control Valves (PCVs) are used which automatically adjust pressure based on flow conditions and time of day (demand patterns

Result and Conclusion:

The project, *"Optimizing Non-Revenue Water Distribution Network Using Data-Driven Approaches for Water Loss Reduction,"* highlights the vital role of technologies like GIS and IoT in tackling Non-Revenue Water (NRW). Our analysis identified major contributors to NRW, including pipe leaks, meter inaccuracies, aging infrastructure, and inadequate funding. Despite these challenges, integrating data analytics into

existing water networks offers an effective path to enhance efficiency. Addressing NRW is essential not only to reduce economic losses for utilities but also to combat water scarcity and environmental degradation. Solutions such as infrastructure replacement, smart metering, and pressure management are practical outcomes of a data-driven strategy.

Future Scope:

The future scope of this project includes:

- Minimizing financial losses for utilities and
- Conserving precious water resources
- Importance of integrating modern technologies and data analytics into water management systems to achieve sustainable urban water distribution,
- Ultimately serving as a scalable model for other regions facing similar challenges.

Project Outcome & Industry Relevance:

Improved Financial Performance by minimizing losses, utilities can bill more accurately for the water supplied and enhances revenue without increasing water production, which reduces operational costs. Infrastructure Longevity by pressure management reducing pipe stress, thereby extending the lifespan of the water distribution network. Customer satisfaction and trust on accurate billing through smart metering increases customer trust. Implementing Advanced Metering systems, smart valves, and leak detection technologies to reduce NRW in cities are useful in cities like Bangalore where water supply is under stress. Advancing Smart Water Management promotes integration of IoT, AI, and GIS instead of traditional water utility operations by setting a foundation for digital transformation in water utilities.

Primary Simulation Model:

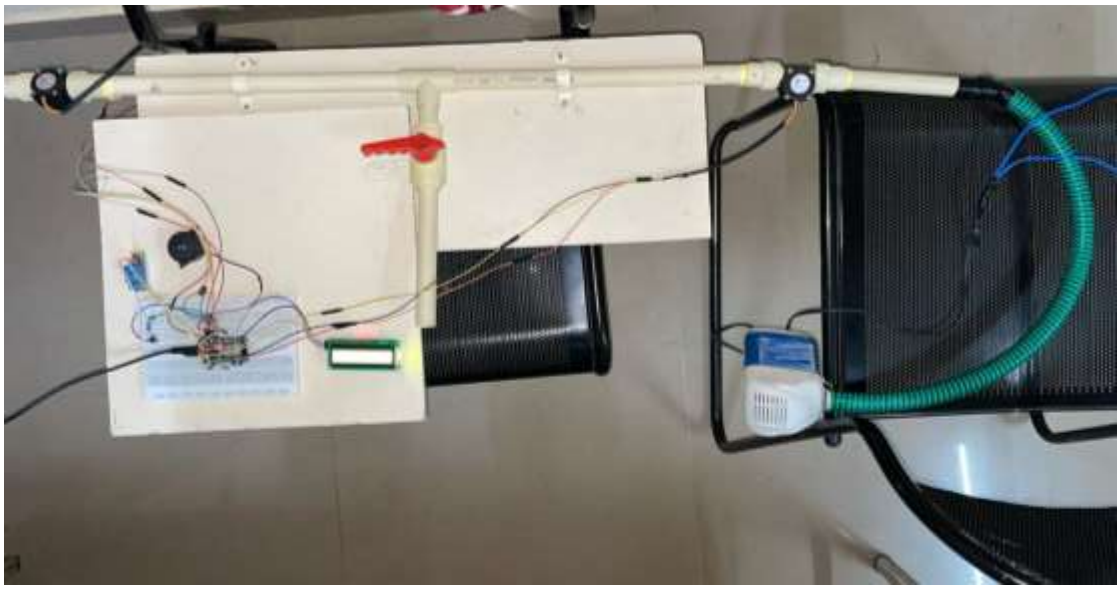

Figure 1 Primary Simulation Model

Project Outcomes and Learnings:

- The project estimates water loss in the distribution system at Nitte Meenakshi Institute of Technology, identifying key causes such as pipe leaks and meter inaccuracies.
- It bridges technology and infrastructure gaps by applying data-driven strategies for scalable and efficient utility management.
- Highlights the critical role of civil engineers in designing durable water distribution systems and ensuring long-term functionality.
- Emphasizes ethical responsibility in addressing water scarcity by reducing non-revenue water (NRW), promoting sustainability, and encouraging continuous technical skill development.