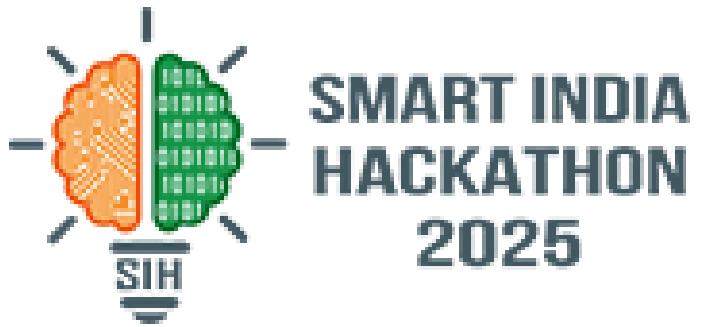


SMART INDIA HACKATHON 2025



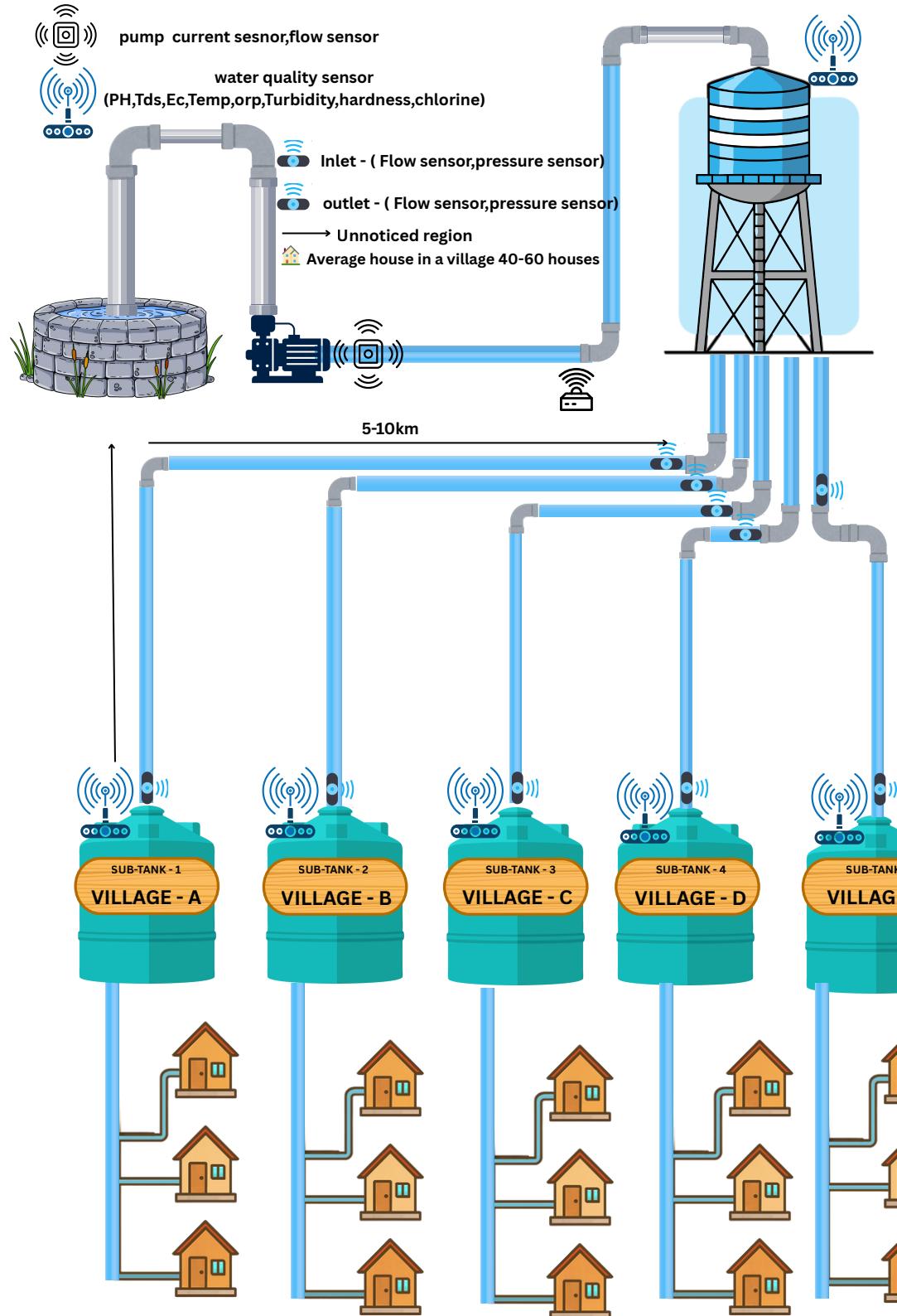
GRAM JAL JEEVAN

- **Problem Statement ID – SIH25241**
- **Problem Statement Title-** Empowering Gram Panchayats to manage daily Operation & Maintenance (O&M) of Rural Piped Water Supply Systems using low-cost digital tools for routine monitoring.
- **Theme-** Clean & Green Technology
- **PS Category-** Software
- **Team ID-** 60195
- **Team Name -**FLUID FUSION

SUSTAINABLE DEVELOPMENT GOALS:



WATER DISTRIBUTION



PROPOSED SOLUTION

- **Real-time IoT monitoring** gives instant visibility of flow, pressure, pump health, tank levels, and water quality.
- Data dashboards show pump hours, valve status, tank levels, leak alerts, and water quality.
- Geo-tagged asset mapping keeps a digital record of pipelines, valves, and tanks.
- Offline-enabled GP mobile app lets operators log tasks, faults, and water quality tests easily
- **ML-based predictions** detect leaks, pump inefficiencies, and abnormal flow/pressure patterns early.

PROBLEMS SOLVED

- **Manual infrastructure checks** → Real-time IoT monitoring of flow, pressure, pump status, and tank levels. (**daily monitoring**)
- Unorganized O&M tasks → Digital logging of routine checks, faults, and maintenance activities.
- Irregular water quality testing → Continuous monitoring with sensors and digital test.
- **Late detection of faults** → ML-based early alerts for leaks, pump issues, and abnormal patterns. (**preventive maintenance**)
- **Limited visibility for officials** → Geo-tagged dashboards for clear, data-driven decision-making.
- **Manual Water quality checks** → Digitalised as per need

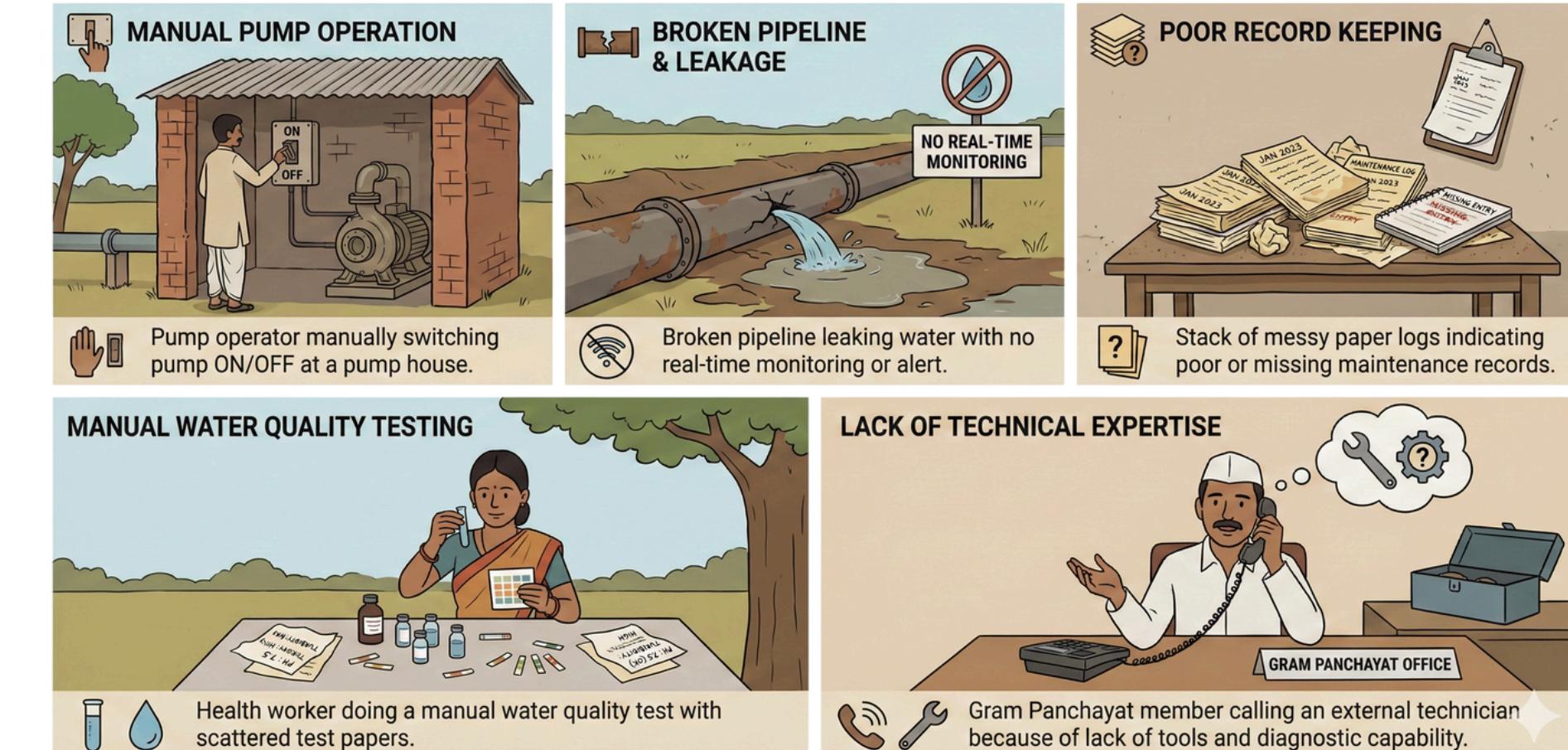
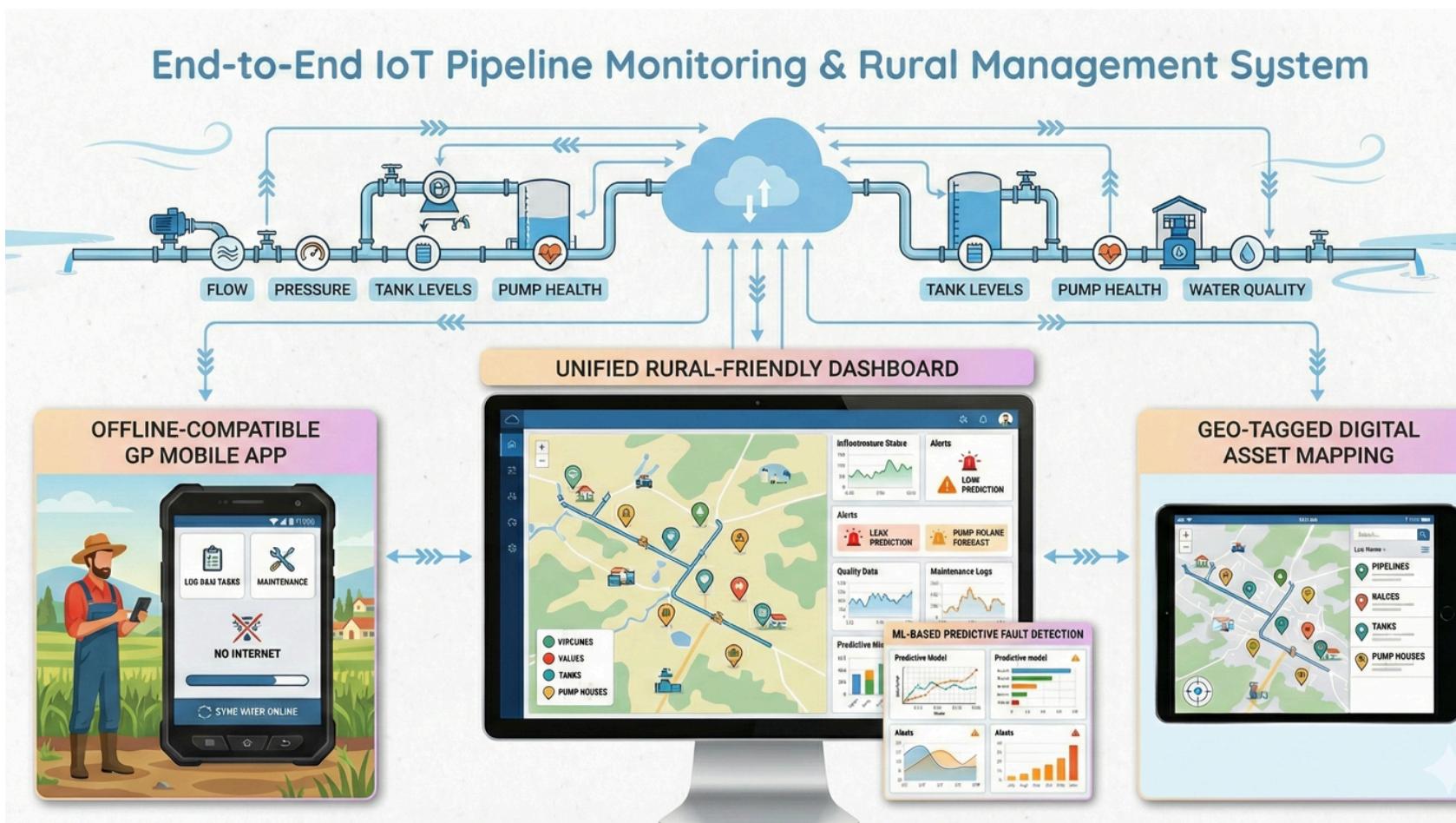
INNOVATION

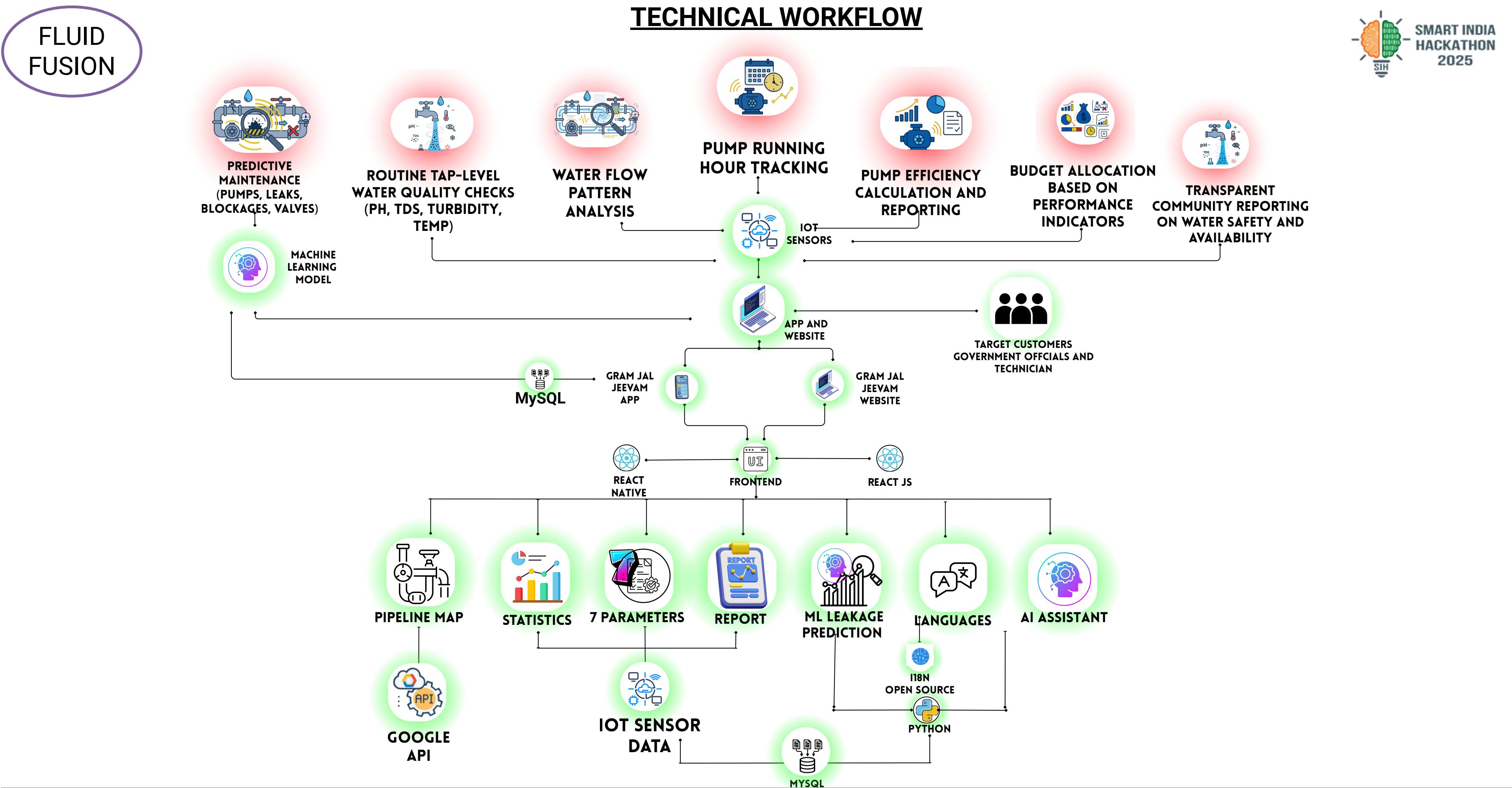
- End-to-end IoT pipeline monitoring** covering flow, pressure, tank levels, pump health, and water quality in real time.
- ML-based predictive fault detection** that predicts leaks, pump failures, and anomalies before they occur.
- Offline-compatible GP mobile app** enabling rural operators to log O&M tasks without internet.
- Geo-tagged digital asset mapping** for pipelines, valves, tanks, and pump houses to simplify field maintenance.
- Unified rural-friendly dashboard** combining infrastructure status, alerts, quality data, and maintenance logs in one place

GRAM JAL JEEVAN

EXISTING METHODS IN RURAL INDIA

- Pump and valve operations** are fully manual, requiring physical visits for every action.
- There is **no real-time monitoring** of flow, pressure, or leaks, so issues are noticed only after failures.
- Maintenance logs** are paper-based or missing, leaving no reliable history of system performance.
- Water quality tests are **irregular and manually recorded**, with results often lost or ignored.
- Gram Panchayats **depend heavily on external technicians** due to limited tools and diagnostic capability



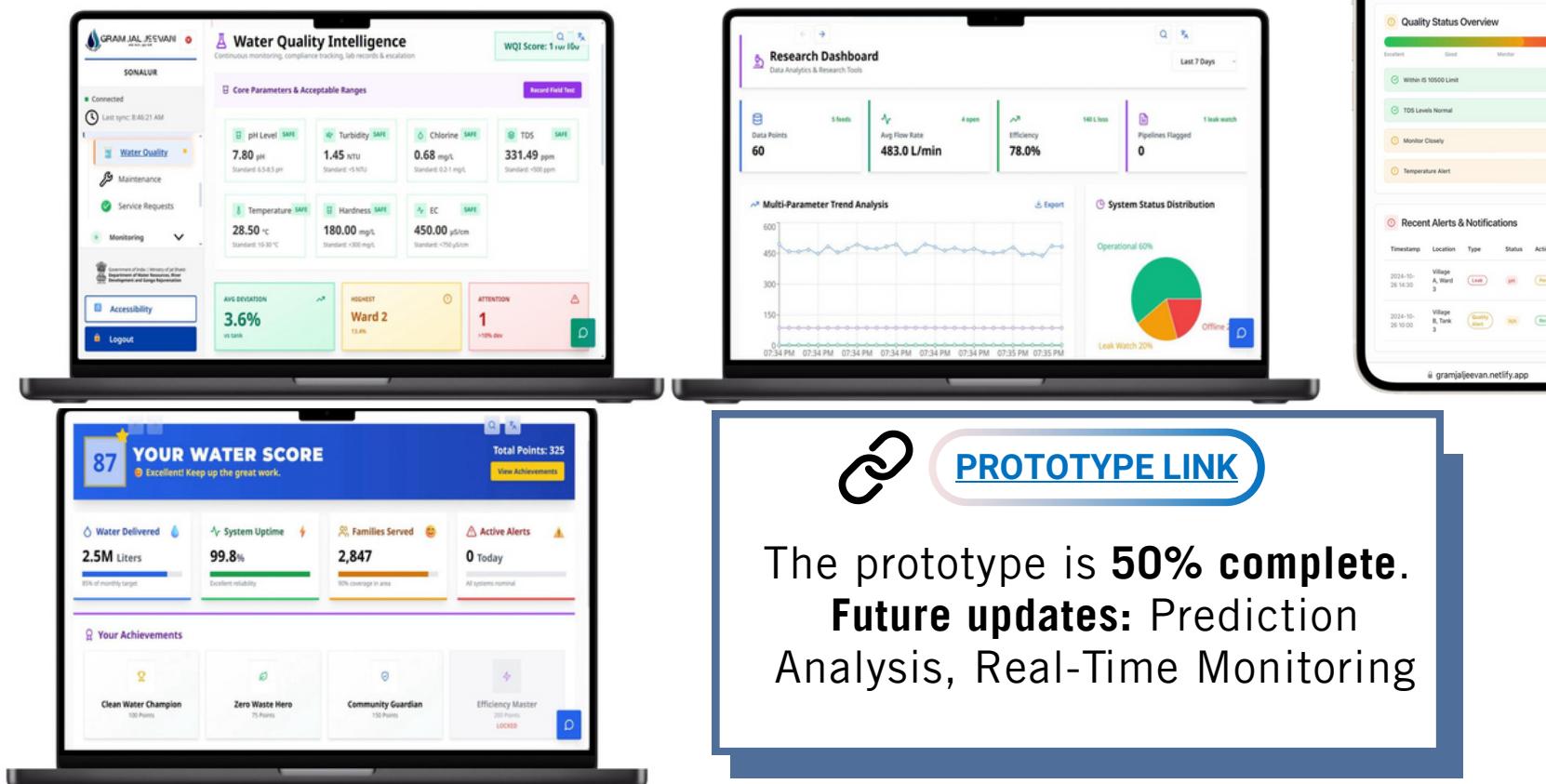


TECHNICAL APPROACH

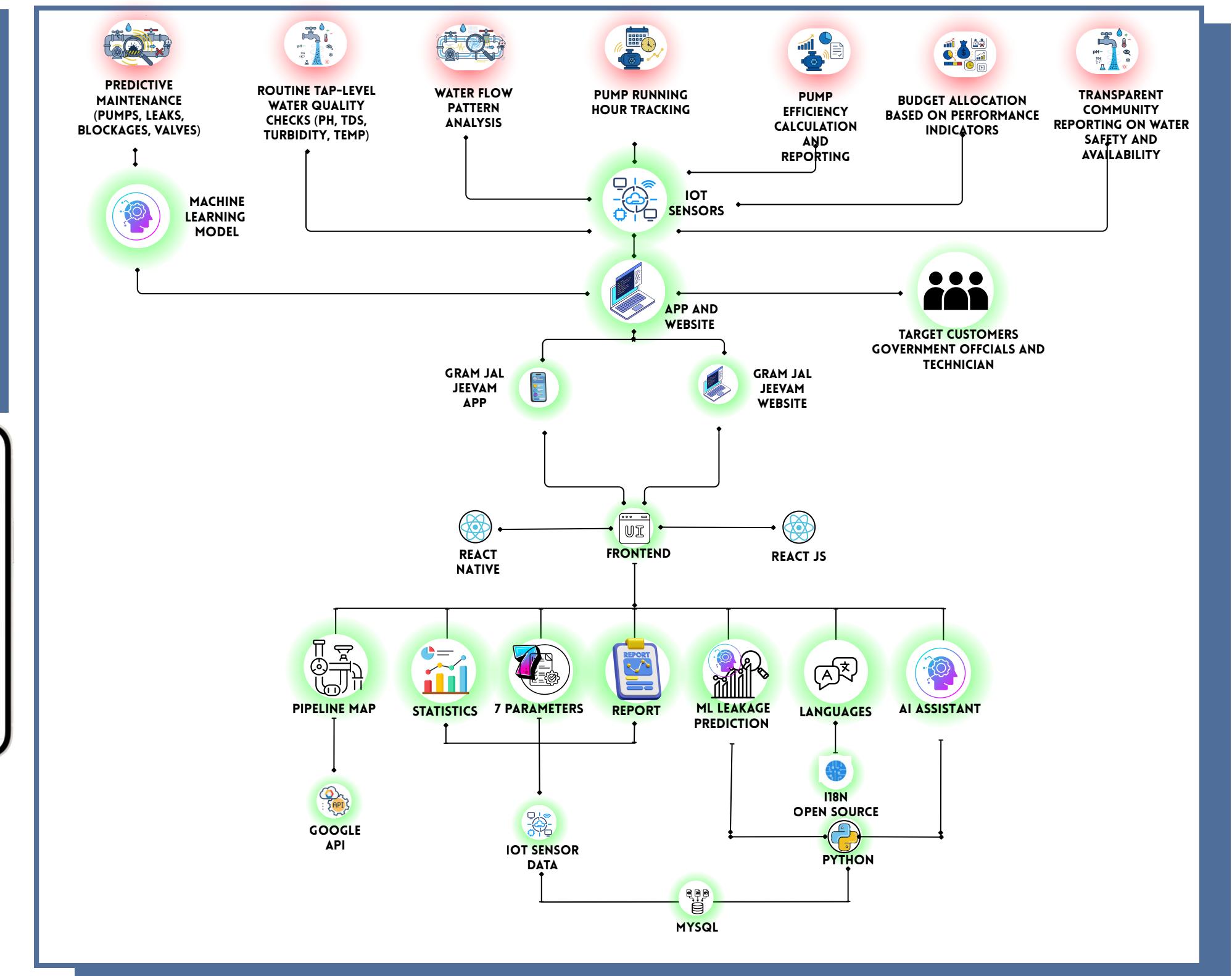
TECH STACK

- COMMUNICATION**
LORAWAN (AS PER RURAL NETWORK AVAILABILITY)
- BACKEND**
NODE.JS, SQL, THE THINGS NETWORK, PYTHON
- FRONTEND**
REACT.JS (WEB DASHBOARD), MOBILE APP (REACT NATIVE)
- ANALYTICS**
PYTHON
- CLOUD**
AWS
- INTEGRATION**
REST API + MQTT + GEO-TAGGING SERVICES

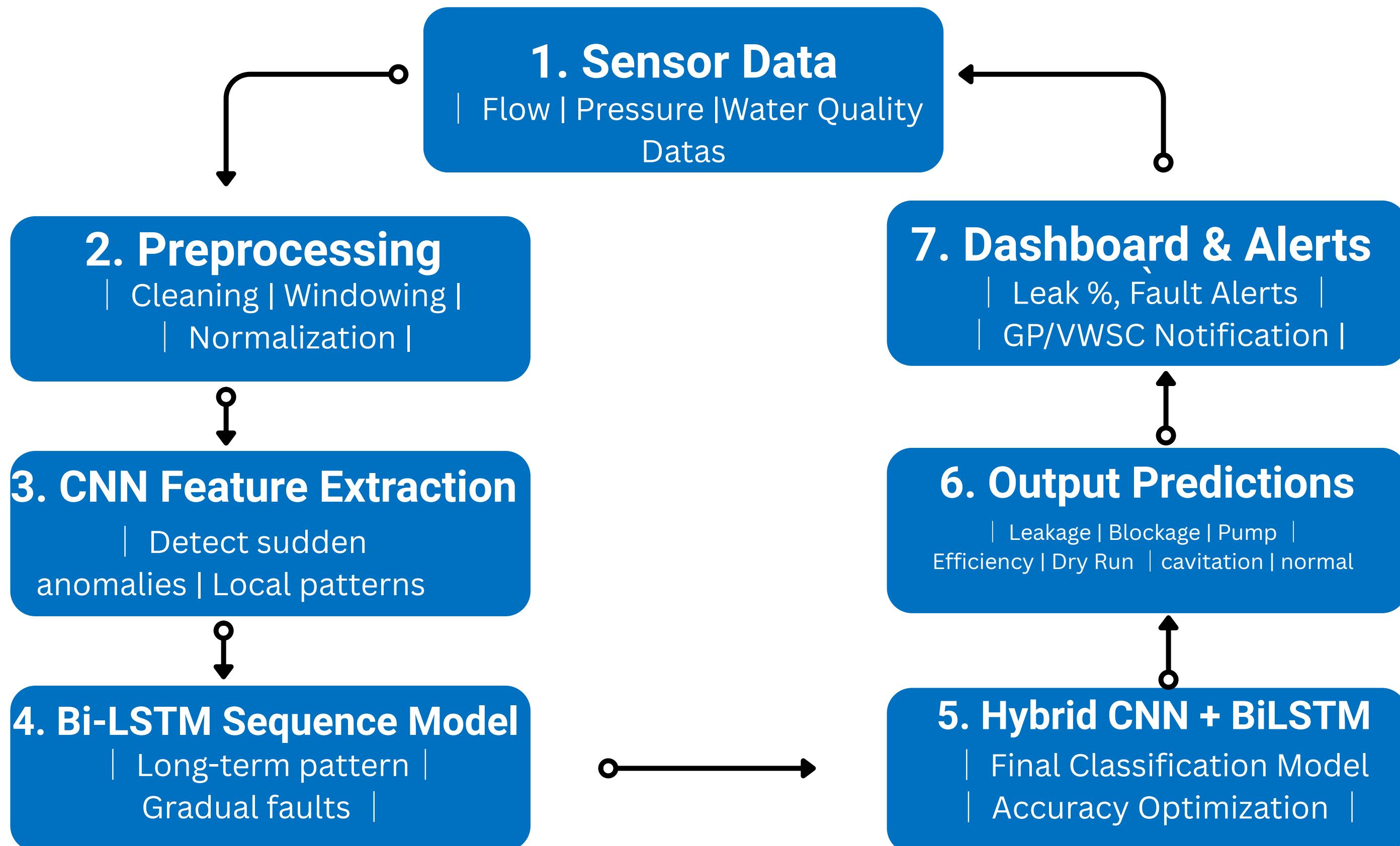
PROTOTYPE



TECHNICAL WORKFLOW



GRAM JAL JEEVAN DATA FLOW



STAKE HOLDERS

- **Gram Panchayat** - responsible for governing the village
- **Nal Jal Mitras (operators and plumbers)** - keDep the system running every day.

BENEFICIARIES

- **Village households receiving piped water**- consistent, safe, and uninterrupted drinking water
- **Local farmers using stored/tank water**- stable water availability for irrigation
- **School & Anganwadi facilities**- drinking, cooking, sanitation, and children's hygiene.
- **Entire rural community relying on safe drinking water**- improved water quality, fewer failures, and reliable supply

SOLUTION APPROACH

EXPECTED OUTCOME 1: DIGITAL TOOLS

Digital Tool 1 : **Gram Jal Jeevan Web Application - Smart IoT and AI-ML Enabled Solution- LOW COST & USER FRIENDLY**

Digital Tool 2 : **Gram Jal Jeevan Mobile Application**

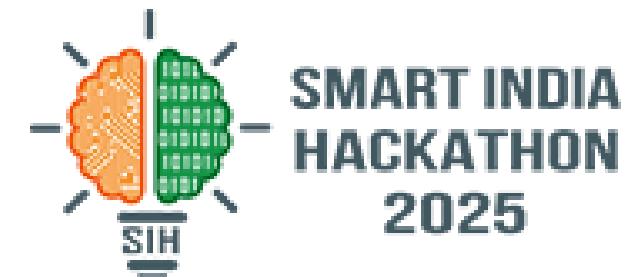


- **Easy Tracking of Infrastructure's Performance**
Pump Efficiency, Tank Storage, Pipe Line Leak Detection, Water Quality Checking
- **Help in Early Detection of Issues**
Predictive Analysis has made to prevent the issues - Alerts
- **Support Data-based Local Decision Making**
AI-ML used to predict the performance of the infrastructures in the system
- **Promote Community Ownership and Accountability of Water Assets.**
A centralized, user-friendly dashboard

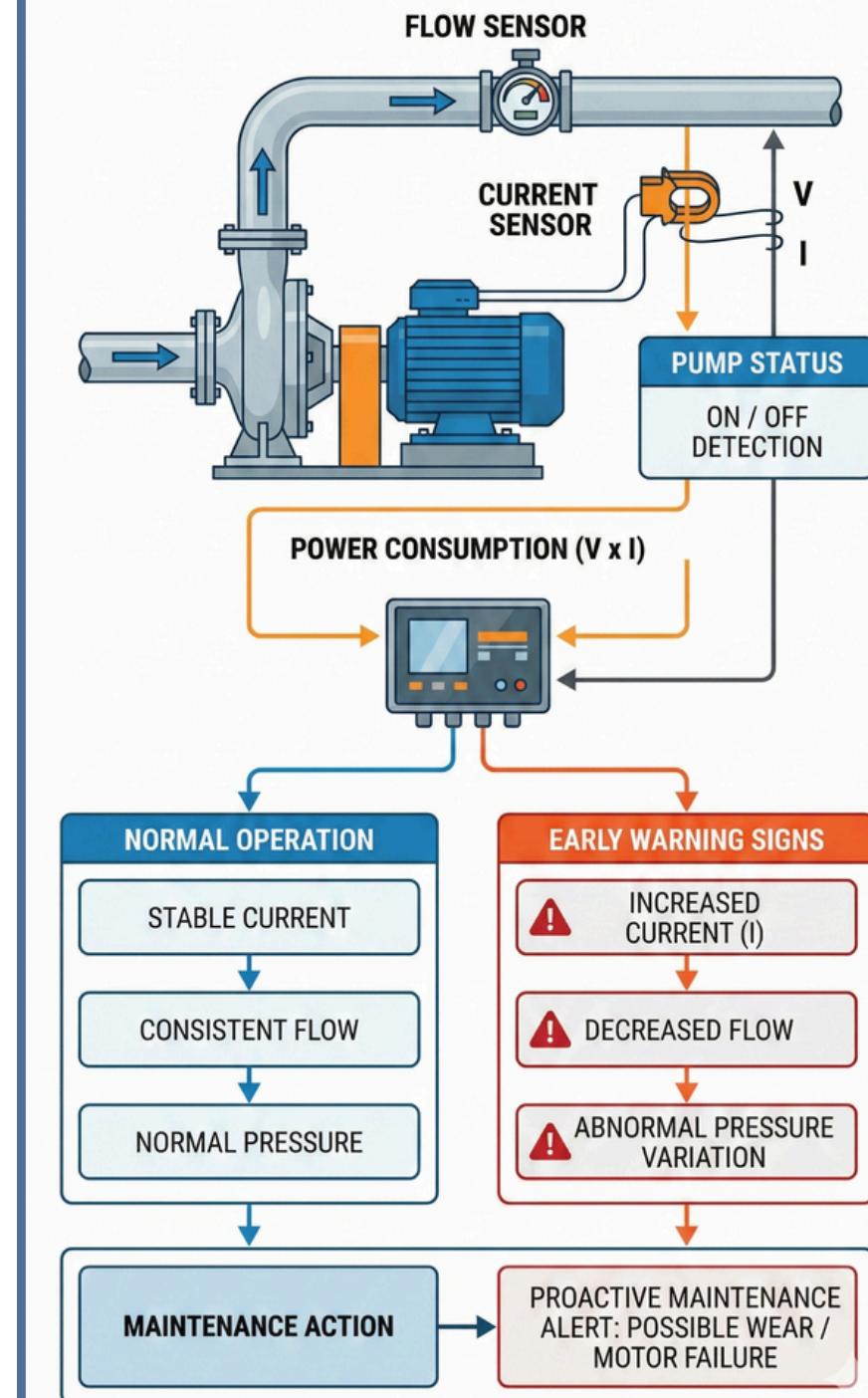
EXPECTED OUTCOME 2 : EASY ROUTINE CHECKS FOR VILLAGE LEVEL ADEQUACY

- Flow sensors and current sensors are installed in the pump
- Detect whether the pump is turned on/off in the site.
- **Power Consumption ($V \times I$)** - When current consumption increases while flow decreases, or when pressure varies abnormally, it indicates early signs of pump wear possible motor failure before major pump breakdown occurs..

Power Consumption	Loss /Imbalance Features	Description	Category
5HP: 3-4.5kw, 7.5HP: 4.5-6.5kw, 10HP: 6-8.8kw, 15HP: 9-13.5kw	0 – 5 %	Normal Electrical Variation	Acceptable
	5 – 10 %	Overload or Inefficiency Trend	Warning
	> 10 %	Overcurrent, Bearing Friction, Pump Overload	Critical
Pump Efficiency	Loss /Imbalance Features	Description	Category
Range:55-75	0 – 15 %	Minor Mechanical Loss (Normal Wear)	Acceptable
	15 – 25 %	Impeller Wear, Minor Cavitation	Warning
	> 25 %	Major Hydraulic Degradation	Critical



PUMP MAINTENANCE MONITORING SYSTEM

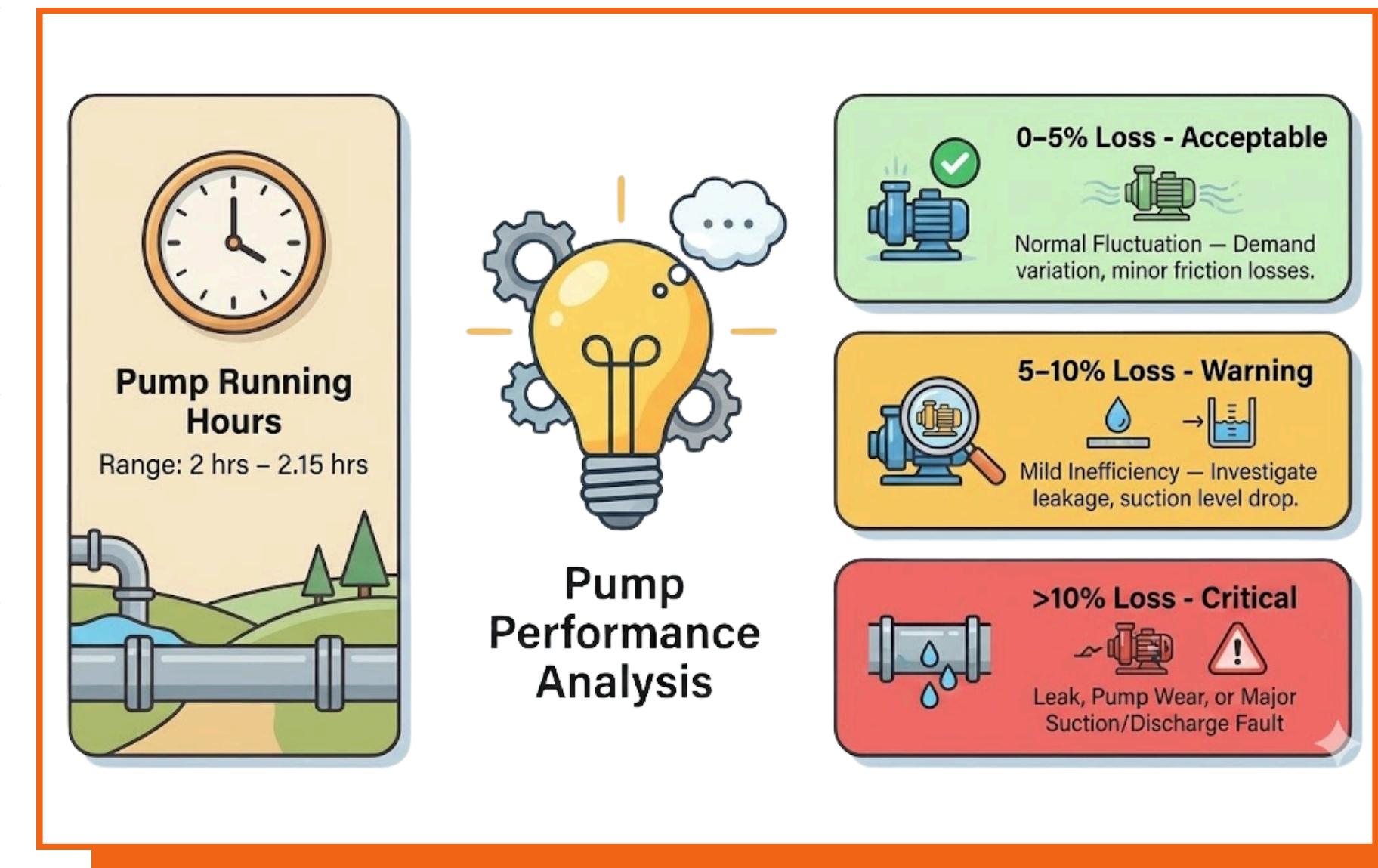


SOLUTION APPROACH

EXPECTED OUTCOME 2: EASY ROUTINE CHECKS FOR VILLAGE LEVEL ADEQUACY

Pump Running Hours : Stop Time – Start Time :

Pump Running Hours	Loss /Imbalance Features	Description	Category
Range: 2 hrs-2.15 hrs	0 – 5 %	Normal Fluctuation (Demand Variation, Minor Friction Losses)	Acceptable
	5 – 10 %	Mild Inefficiency — Investigate Leakage, Suction Level Drop	Warning
	> 10 %	Leak, Pump Wear, or Major Suction/Discharge Fault	Critical

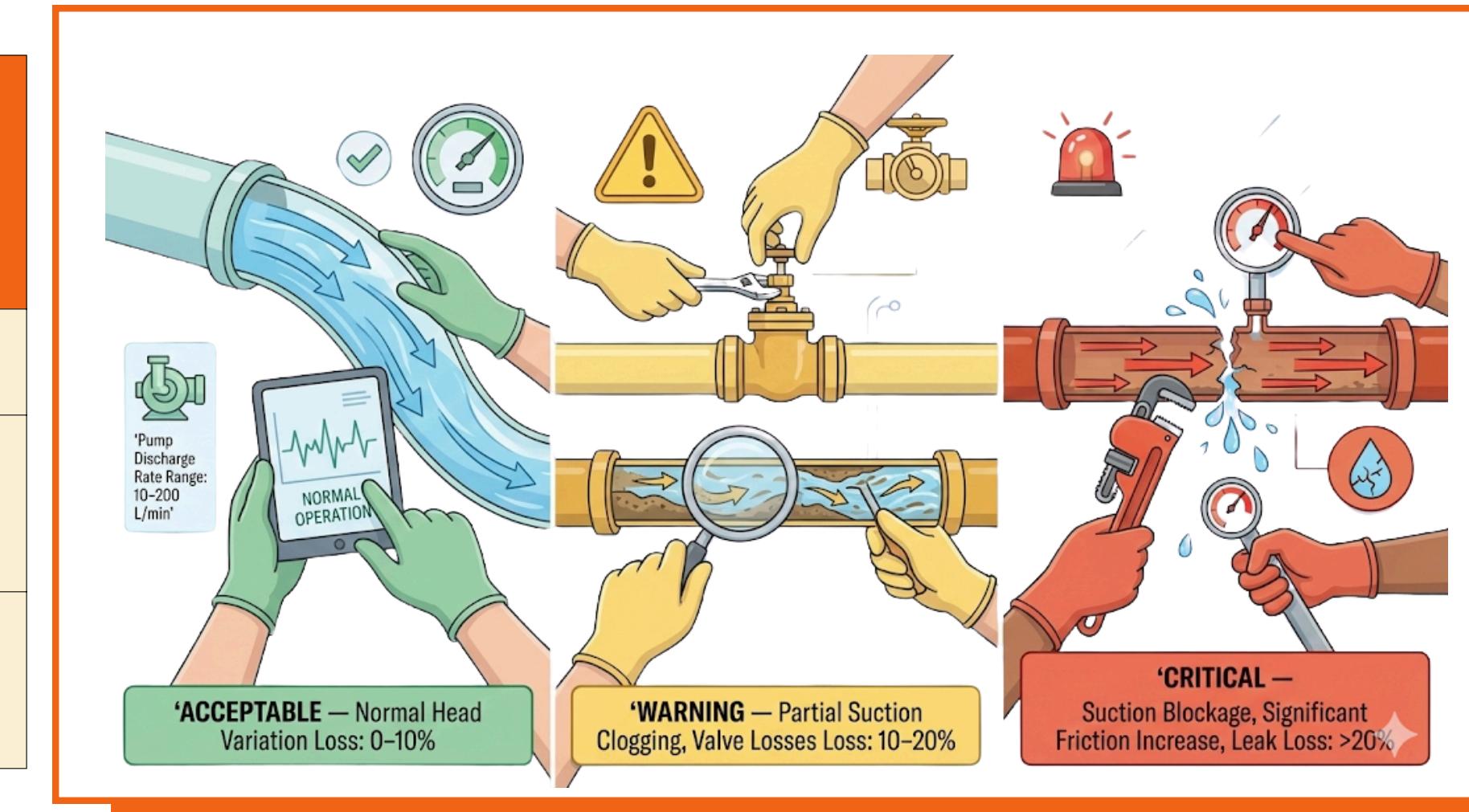


SOLUTION APPROACH

EXPECTED OUTCOME 2: EASY ROUTINE CHECKS FOR VILLAGE LEVEL ADEQUACY

Pump Discharge Rate: Flow rate at end point

Pump Discharge Rate	Loss /Imbalance Features	Description	Category
Range: 10- 200L/min	0 – 10 %	Normal Head Variation	Acceptable
	10 – 20 %	Partial Suction Clogging, Valve Losses	Warning
	> 20 %	Suction Blockage, Significant Friction Increase, Leak	Critical

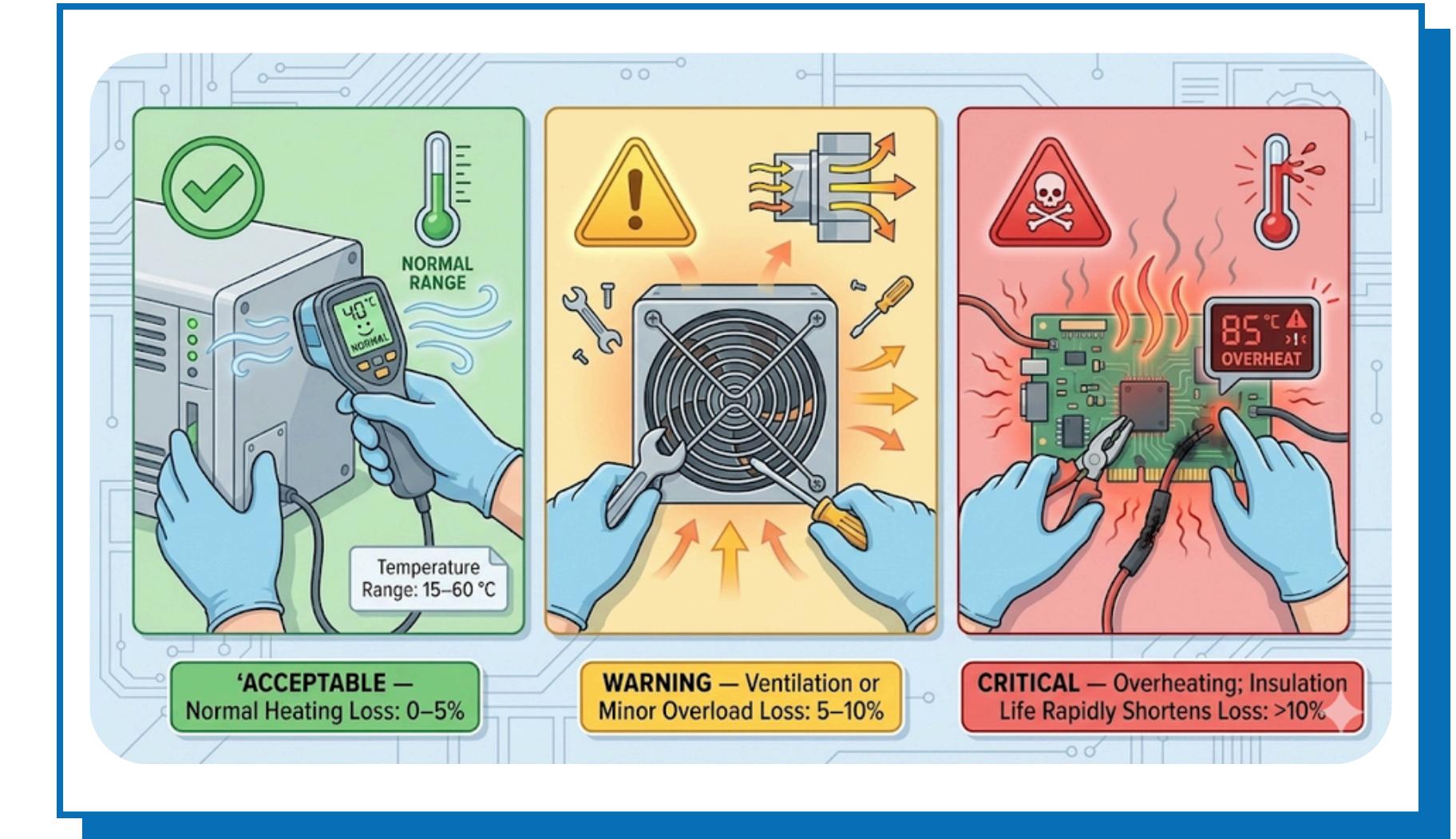


SOLUTION APPROACH

EXPECTED OUTCOME 2:EASY ROUTINE CHECKS FOR VILLAGE LEVEL ADEQUACY

Pump Temperature : Temperature Sensor

Temperature	Loss /Imbalance Features	Description	Category
Range: 15-60 °C	0 – 5 %	Normal Heating	Acceptable
	5 – 10 %	Ventilation Or Minor Overload	Warning
	> 10 %	Overheating — Insulation Life Rapidly Shortens	Critical

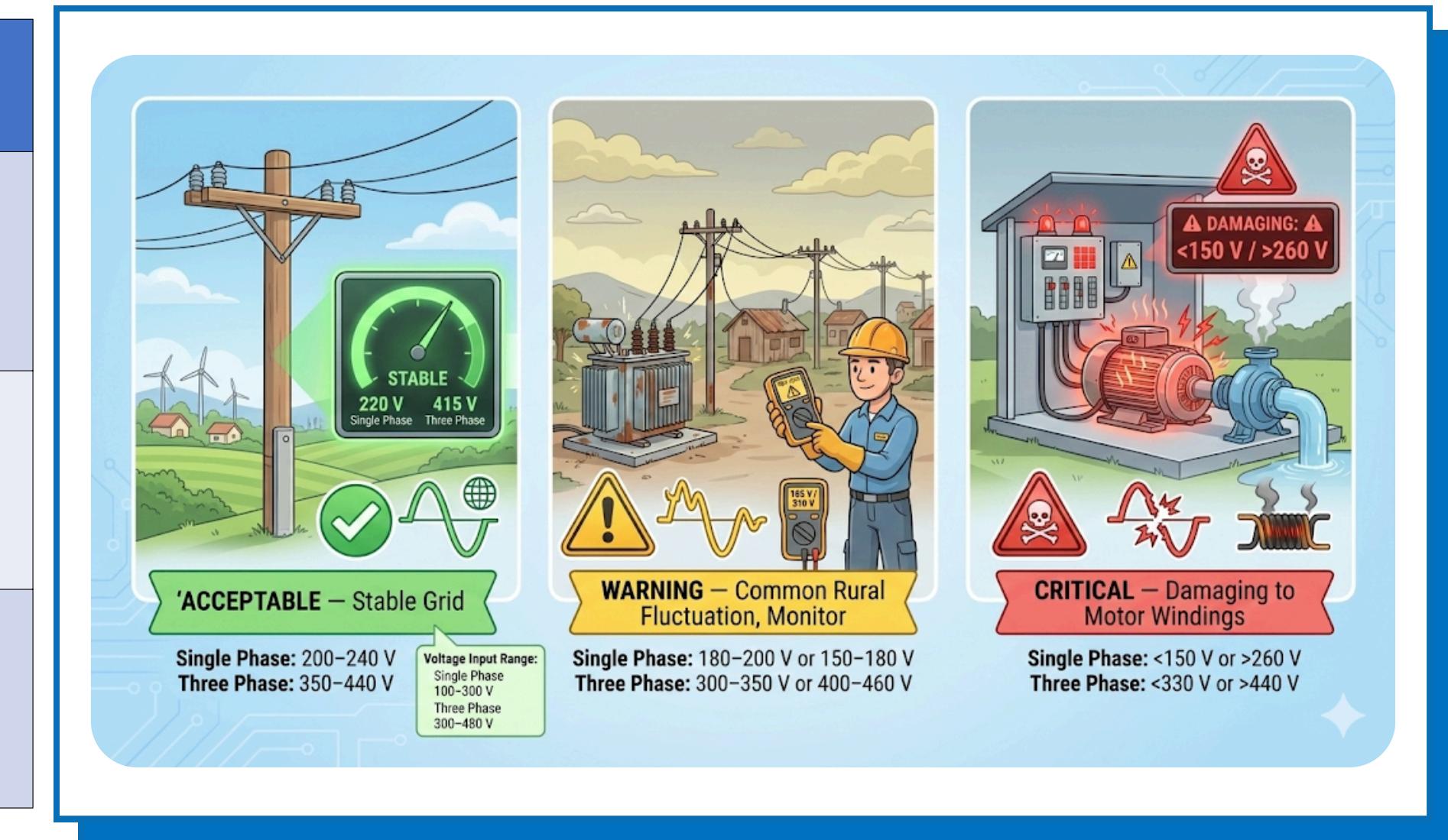


SOLUTION APPROACH

EXPECTED OUTCOME 2:EASY ROUTINE CHECKS FOR VILLAGE LEVEL ADEQUACY

Voltage Fluctuations: From Voltage Data

Voltage	Loss /Imbalance Features	Description	Category
Range: Single Phase: 100-300V 3 Phase: 300-480V	200-240V (Single Phase) 350-440V (Three Phase)	Stable Grid	Acceptable
	180-200 V or 150-180V (Single Phase) 300-350V or 400-460V (Three Phase)	Common Rural Fluctuation — Monitor	Warning
	< 150V or > 260V (Single Phase) < 330V OR > 440V (Three Phase)	Damaging To Motor Windings	Critical



SOLUTION APPROACH

EXPECTED OUTCOME 2: PIPELINE LEAKAGE DETECTION

Features	Range	Description
Flow Features		
Hour of Day	0 – 180 L/min	0 When No Supply; 80–150 L/Min During Distribution
Night_Flag	0 – 80 L/min each	10–60 L/Min Depending On Village Size And Valve Status
Flow Main Out	0 – 180 L/min	Should Be Close To Flow_Main_Out When No Leak
Flow in Village A,B,C,D,E	0 – 80 L/min each	10–60 L/Min Depending On Village Size And Valve Status
Pressure Features		
Pressure Main Out	1.0 – 2.0 bar	0 when no supply; 80–150 L/min during distribution
Pressure in Last Node	0.3 – 1.5 bar	Lowest at far village (5 km away)
Press Drop per Kilometer	0.03 – 0.15 bar/km (normal)	With 5 km: ~0.15–0.75 bar drop in normal condition

- **Flow and pressure sensors** are installed in the pipe line.
- These readings help us identify **leakages or blockages** in real time
- **Monitor flow patterns** by comparing inlet and outlet values and observing flow curve behavior over time.
- If there is a **sudden drop** in outlet flow or an abnormal difference between inlet and outlet, then there is leakage, pipe blockage, or any illegal pipeline connection on the pipeline strea
- In the **household zones**, **flow meters are deployed** to detect illegal connections or abnormal consumption patterns

SOLUTION APPROACH - EXPECTED OUTCOME 2 PIPELINE LEAKAGE DETECTION

Features	Range	Description
Tank Level Features		
Level in Main Tank	0 – 100 %	Usually Operated Between 40–90 %
Level in Tank A, B, C, D, E	0 – 100 %	Often 20–90 % During Normal Cycles
Loss / Imbalance Features		
Loss Fraction Global	0 – 0.05 (0–5%)	Normal Friction / Meter Error
	0.05 – 0.20	Suspicious → Small Leak / Calibration Issue
	> 0.20	Strong Indication of Leak or Illegal Draw-Off
Segment Loss Fraction AB,BC,CD,DE	0 – 0.05 (0–5%)	Normal
	0.05 – 0.20	Possible Small Leak in that Segment
	> 0.20	High Chance of Leak in that Segment
Behaviour / Mismatch Features		
Main Tank Discharge Mismatch	0 – 0.05 (0–5%)	System Behaving as Expected
Village A Fill Mismatch	> 0.05 (5–30%)	Level Falling Faster or Slower than Flow Reading → Leak or Sensor Issue
Village A,B,C,D,E Fill Mismatch	0 – 0.05	Tank Level Change Consistent with Inlet Flow
Leak Detection		
Leak Segment Label	0	No leak
	1	Leak in AB
	2	Leak in BC
	3	Leak in CD
	4	Leak in DE

SOLUTION APPROACH

EXPECTED OUTCOME 2: TANK AND VALVE STATUS

Storage Tank

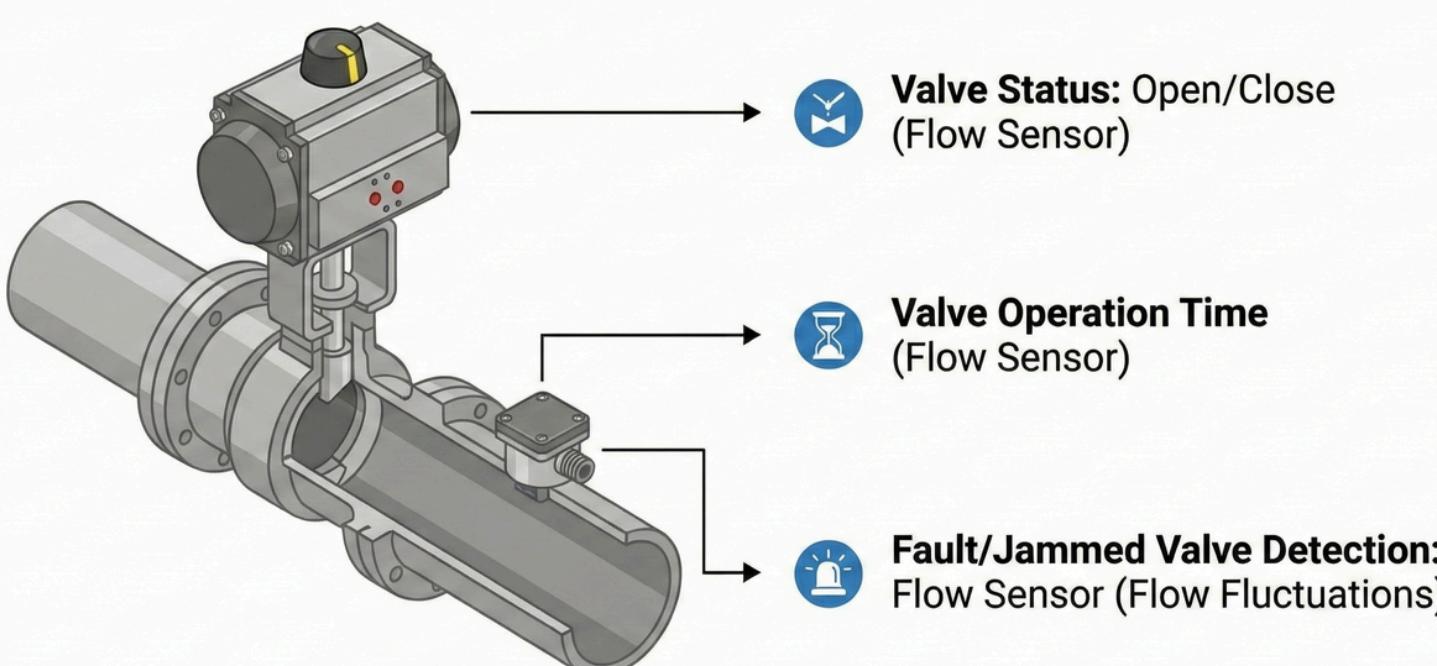
- Tank Water Level : Numeric Percentage (%) or Liters
- Tank Filling Time : Ultrasonic Sensor
- Tank Emptiness Duration : Ultrasonic Sensor and Flow Sensor
- Overflow Alerts : Ultrasonic Sensor
- Supply Duration from Tank : Water Volume and Flow Sensor Valve
- Valve Status : Open/Close - Flow Sensor
- Valve Operation Time : Flow Sensor
- Fault/Jammed Valve Detection : Flow Sensor - (Flow Fluctuations)



Valve:

- Valve Status : Open/Close - Flow Sensor
- Valve Operation Time : Flow Sensor

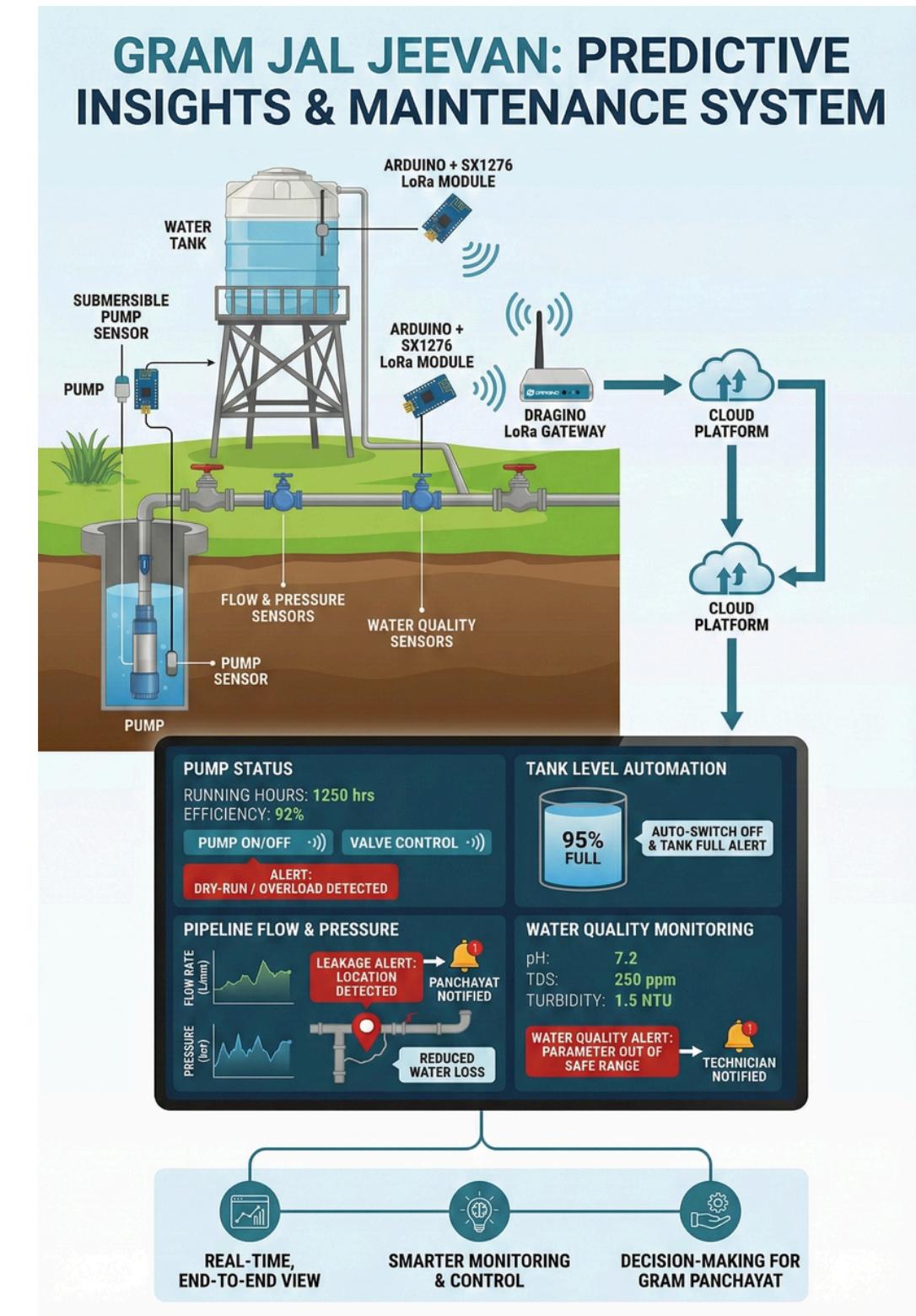
Fault/Jammed Valve Detection : Flow Sensor -
(Flow Fluctuations)



SOLUTION APPROACH

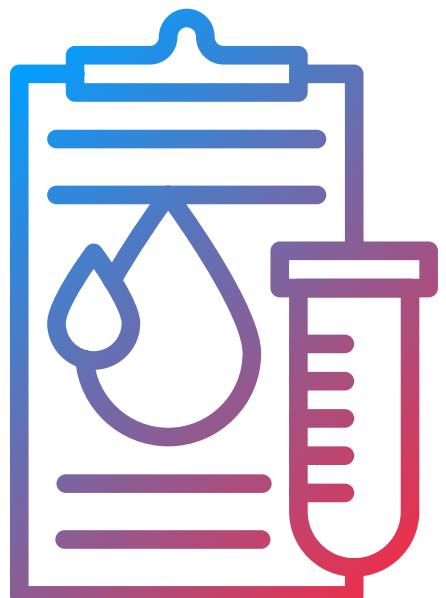
EXPECTED OUTCOME 3: PREDICTIVE INSIGHTS AND MAINTANENCE

- All sensor data is transmitted through **LoRa communication** using **Arduino + SX1276 LoRa modules**, and received at a **Dragino gateway**
- Data reaches our cloud platform and appears on our **Gram Jal Jeevan Dashboard**.
- **Pump ON/OFF**, valve control and tank level automation can be done in remote way..
- **Pump running hours** and efficiency are automatically tracked
- If the pump goes into dry-run or overload, the system immediately pushes an **alert**
- When the tank becomes full, the **dashboard auto-switches off the pump** and generates a **Tank Full Alert** for the operator
- **Water leak and contamination alerts** reach the Panchayat instantly
- Water **loss** is reduced
- The platform also shows the **flow and pressure** in each pipeline.
- Any abnormal drop is instantly marked as a **Leakage Alert** with the exact location
- If any water quality parameter goes out of the safe range, **Gram Jal Jeevan** automatically issues a **Water Quality Alert** and notifies the **technician**
- A **real-time, end-to-end view of the entire water distribution system**, monitoring, control, and decision-making in smarter way is possible for Gram Panchayat



SOLUTION APPROACH - EXPECTED OUTCOME 4: PIPELINE WATER QUALITY

- **Water quality sensors** are placed in main tank and sub-tanks
- **TDS & EC** show the level of minerals dissolved and overall chemical load in water
- **Turbidity** helps identify contamination from suspended particles, mud, or bacterial presence.
- **pH** indicates whether water is acidic or alkaline, affecting corrosion and taste.
- **Temperature** influences disinfectant effectiveness and microbial activity.
- Hardness is strongly correlated with **TDS and EC**
- **Chlorine Prediction - ORP (Oxidation-Reduction Potential)**
- Continuously analyzing these parameters and checking with **IS 10500 -Indian Standard for Drinking Water Quality**, published by the **Bureau of Indian Standards (BIS)**

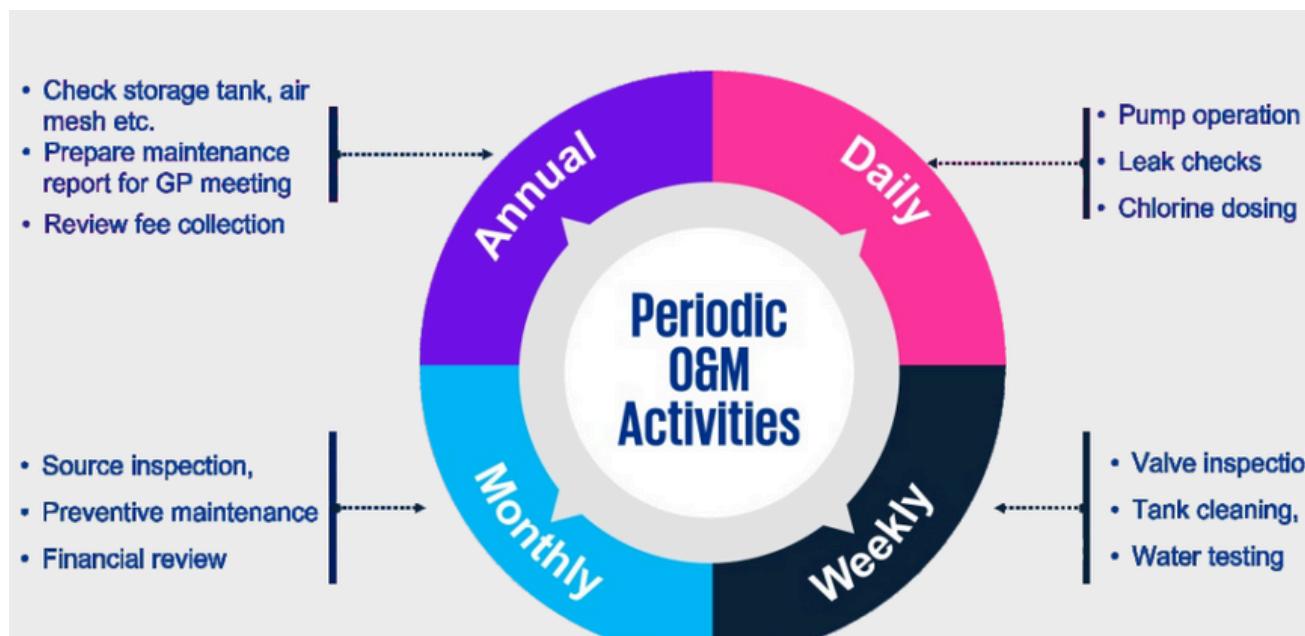


Features	Range	Description
Total Dissolved Solids (TDS)	500	2000
Electrical Conductivity (EC)	200	800
pH	6.5 to 8.5	No relaxation
Turbidity	1	5
Temperature	20	30
Free residual chlorine	0.2	1
Total hardness	200	600
Total Coliform	0 to 100	No relaxation

SOLUTION APPRAOCH - EXPECTED OUTCOME 5: GRAM PANCHAYATS OPERATION

Stake Holders

- **Gram Panchayat** - responsible for governing the village
- **VWSC / Pani Samiti** - ensuring operation and maintenance
- **Nal Jal Mitras (operators and plumbers)** - keep the system running every day.



Monsoon Prep

- Clean sources
- Protect electicals

Summer Prep

- Desilt ponds
- Fix leaks
- Plan supply

**Har Ghar Jal :
Aaj aur Kal**



All Seasons

- Paint metal parts
- Record maintenance

Winter Prep

- Clean tanks
- Lubricate pumps

GRAM JAL JEEVAN

EXECUTION TIMELINE FOR HACKATHON

ROUND 1- 12 Hours

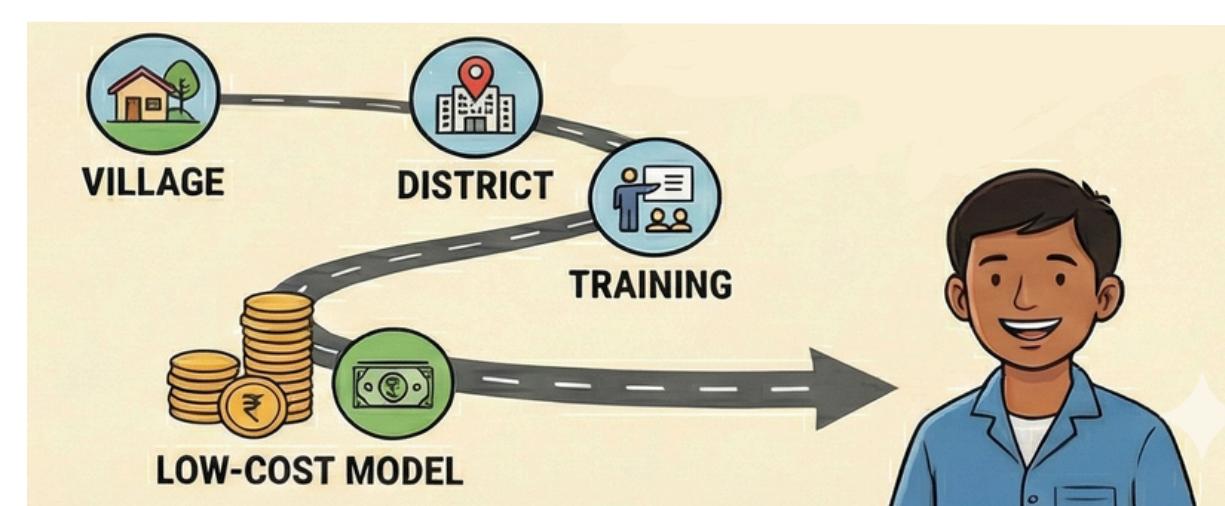
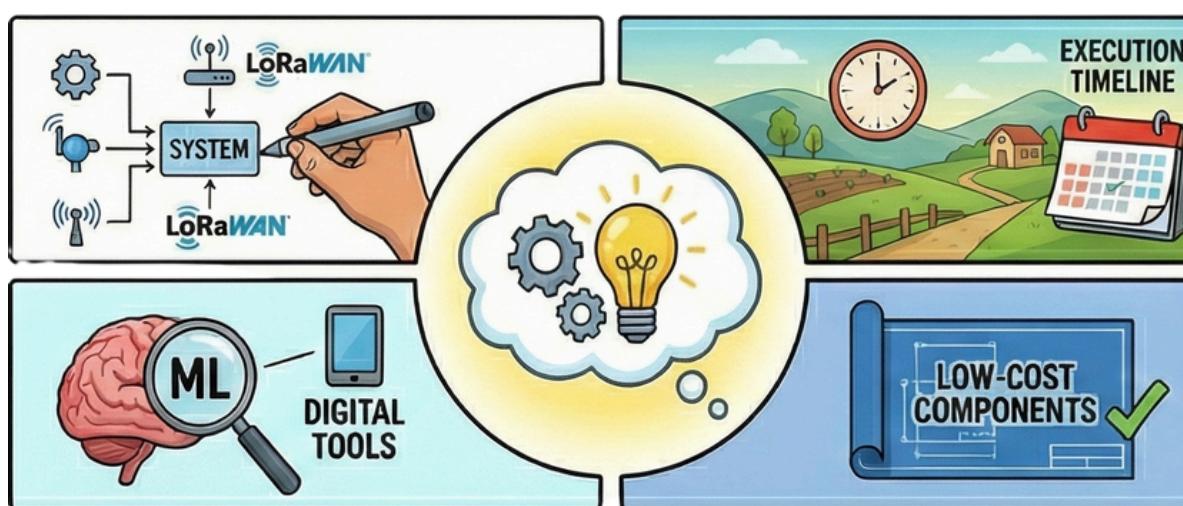
- Identified **key rural water management gaps.**
- Planned system architecture and components.
- Finalized low-cost, scalable tech choices.
- Planned execution **timeline and workflow.**
- Identified **IoT + ML-based monitoring solution.**

ROUND 2- 12 Hours

- Develop **dashboard and offline GP app.**
- Built **hardware prototype** with core sensors..
- Integrate **hardware, backend, and ML.**
- Improved accuracy through **testing**
- Coordinate **team roles for development.**

ROUND 3- 12 Hours

- Demonstrat key functions aligned with JJM.**
- Deliverer **smooth, user-friendly system demo.**
- Design **scalable, low-cost deployment model.**
- Training** for the stakeholders
- Define **future scope and enhancement**



ROUND 3

FUNCTIONALITY

Real-Time Monitoring:

Tracks flow, pressure, pump status, tank levels, and water quality continuously.

Leak & Anomaly Detection:

Identifies leaks, bursts, and pressure drops instantly using sensors and ML

Pump Health Analysis:

Monitors current temperature & running hours to detect pump issues early.

Water Quality Monitoring:

Measures pH, TDS, turbidity, chlorine, and logs results digitally for safety.

Village-Level Insights:

Shows water supply status for each sub-tank with exact flow and pressure data.

Digital O&M Logging:

Enables recording of routine checks, fault maintenance through the GP app.

Predictive ML Alerts:

Provides leak probability, pump failure prediction, and abnormal pattern alerts.

Offline Operation:

Works in rural areas using LoRaWAN with intermittent or no internet.

Simple Dashboard:

Displays system health, alerts, trends, supply patterns in one visual interface

COST ESTIMATION

S.No	Particulars	Cost Per Unit (Rs)	Quantity	Total Cost (Rs.)
Software Cost				
1.	AWS, Postgre SQL	5000		5000
Hardware Cost				
5	TDS Sensor	600	1	600
6	pH Sensor	1200	1	1200
7	Temperature Sensor (DS18B20 / Waterproof)	120	1	120
8	Turbidity Sensor	350	1	350
9	ORP Sensor	2000	1	2000
	Ultra Sonis Sensor	120	1	120
10	Adrino + LoRa Shield (SX1276)	800	1	800
11	Dragino LoRa Gateway (Out door gateway)	15000	1	15000
12	Solenoid Valve (½ inch)	650	1	650
13	Flow Sensor (YF-S201 or equivalent)	600	3	1800
14	Pressure Sensor (Water line model 0-1.2MPa)	800	3	2400
Total				33,040

Market Readiness - Cost Estimation – Tamil Nadu

Number of Village Panchayats	:	12,525
Cost Estimation to deploy Gram Jal Jeevan	:	33040 x 12525
Total Cost is for Approximately	:	Rs. 4 Crores

Average Water Supply Quantity - **2,299 MLD** will be distributed in less cost

Market Readiness

- ❖ Gram Jal Jeevan is a unique digital tool
- ❖ There is no such product available in Panchayat
- ❖ Scada is functioning to monitor the large schemes of water distributed system.
- ❖ Scada cost is very high – Starts from 7.5 Lakhs

IMPLEMENTATION PLAN

- Ready for practical deployment in rural water supply systems over nation wide under the Jal Jeevan Mission
- Stakeholders Validation
 - Ms. Vasanthi - Superintendent Engineer (Rtd) – TWAD , Thanjavur
 - Ms. Bindu - Junior Engineer – Walajabad Panchayat Board,Kanchipuram
 - Mr. Levin - Junior Engineer – Walajabad Panchayat Board,Kanchipuram
 - Panchayt Board President - Walajabad Panchayat - Keel Ottivakkam
 - Panchayt Board President - Walajabad Panchayat – Poosivakkam
- Tamil Nadu was awarded First Prize in recognition of outstanding work under Jal Jeevan Mission for providing adequate and potable tap water supply on regular basis to rural households by the Hon'ble President of India.
- **Walajabad Panchayat – Poosivakkam receives this award – The place where we done our pilot run of our Gram Jal Jeevan**
- Achieved Unique Value Proposition (UVP) identified
- Planned to Meet Kanchipuram Collector very soon
- Planned to make our solution as a patent

IMPLEMENTATION

Pilot Run of Gram Jal Jeevan - Walajabad -Panchayat - Keel Ottivakkam



Pilot Run of Gram Jal Jeevan – “Smart Rural Water Operation & Monitoring System”

This is to certify that the Village Panchayat of Walajabad Union, Kanchipuram District “KEEL OTTIVAKKAM” Village, reviewed the performance of the “Gram Jal Jeevan” system. The digital application demonstrates real time village level functionaries such as pump operations, pump efficiency, water level in the tank, flow and leak in the pipe line and quality of the water. The Panchayat confirms that the pilot deployment has been carried out in the field and the system is functioning successfully. The Panchayat recognizes that this project will directly support the objectives of Jal Jeevan Mission (JJM) by strengthening daily Operations & Maintenance (O&M) of our rural piped water supply system.

E.S.M.
தலைவர்
முடிடுவாக்கம் இயாடி

IMPLEMENTATION

Pilot Run of Gram Jal Jeevan - Walajabad -Panchayat - Poosivikkai



GRAM JAL JEEVAN

Pilot Run of Gram Jal Jeevan – “Smart Rural Water Operation & Monitoring System”

This is to certify that the Village Panchayat of Walajabad Union, Kanchipuram District “**POOSIVAKKAM**” Village, reviewed the performance of the “**Gram Jal Jeevan**” system. The digital application demonstrates real time village level functionaries such as pump operations, pump efficiency, water level in the tank, flow and leak in the pipe line and quality of the water. The Panchayat confirms that the pilot deployment has been carried out in the field and the system is functioning successfully. The Panchayat recognizes that this project will directly support the objectives of Jal Jeevan Mission (JJM) by strengthening daily Operations & Maintenance (O&M) of our rural piped water supply system.

செயல் அனுபவாளர்களில் வர்
பூசிவாக்கம் உயராட்சி
வாலாஜாபாத் உயராட்சி ஒன்றியம்
[Signature]
10/10/25

FUTURE SCOPE

- ❖ Edge AI Technologies can be used
- ❖ Acoustic Vibration Sensors
- ❖ The system can also scale to industries, water treatment plants and smart city water infrastructure

- **Easily accessible** through mobile
- Easily accessible through **desktop**
- Clean, **Optimized Design** and Visualization
- **Easy alerts** for all operations
- **Color indicators** (Green–Safe, Yellow–Warning, Red–Critical).
- Visual navigation is **easy for the technician**
- The hardware unit is **compact and waterproof**
- Ensuring a **smooth user experience** even for non-technical operators.



MARKET READINESS

- Ready for practical deployment in rural and urban water supply systems over nation wide under the Jal Jeevan Mission
- Proper solution for the government in **low cost**
- Provided **secure authentication**
- **Real-time data integration**
- Achieved **Transparency**
- **Reduces water loss**
- **Minimize manual monitoring**
- Manual **effort reduced**
- Improved **community trust**
- **Easily Deployable** for Gram Panchayats
- **Low cost system**



Implementation : Phase-wise Deployment

Phase-1: Sensor node installation, leakage detection and live monitoring.

Phase-2: Integration of AI/ML (prediction of COD, BOD, DO, turbidity & chemical dosing optimization).

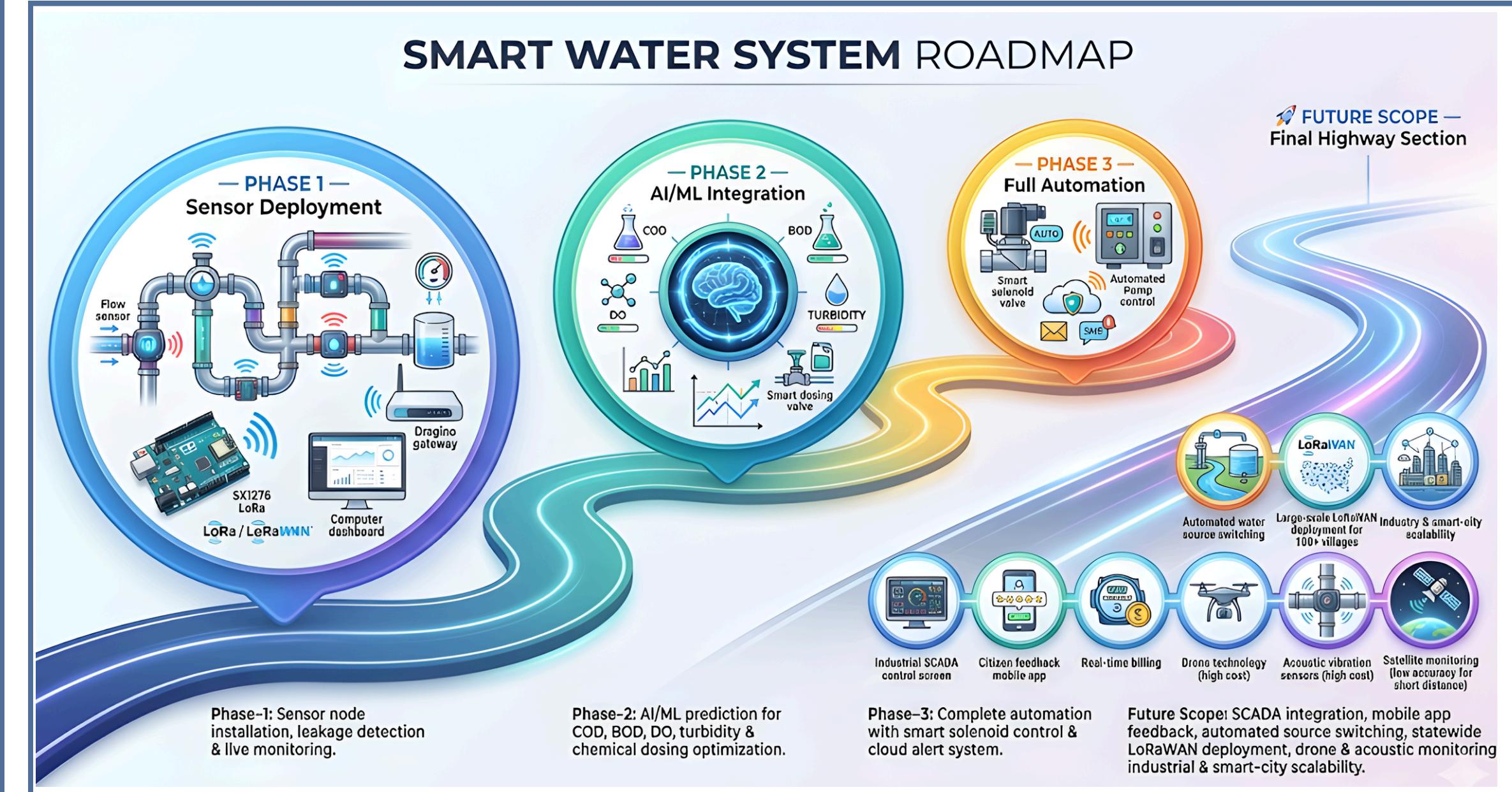
Phase-3: Full automation with smart solenoid control and cloud-based alert system.

Future Scope

- SCADA integration
- Mobile app for citizen feedback
- Real-time billing based on consumption
- Automated source switching (borewell/river/tank), and state wide deployment via LoRaWAN for hundreds of villages.

The system can also scale to industries, water treatment plants and smart city water infrastructure

- Drone Technology – More Cost
- Acoustic Vibration Sensors - More Cost
- Satellite - Not Accurate for short distance



CONCLUSION

- **Gram Jal Jeevan successfully transforms rural water supply management** using real-time IoT monitoring, digital tools, and smart analytics.
- **The system ensures early detection** of leaks, pump issues, and water quality problems, enabling faster action and reducing water wastage.
- **Village-level decision-making becomes data-driven**, with clear dashboards, geo-tagged assets, and routine digital O&M logs.
- Gram Panchayats gain **full ownership and operational control**, reducing dependency on external technicians and improving service reliability.
- The solution is **scalable, low-cost, and ready for multi-village deployment**, aligning perfectly with the goals of Jal Jeevan Mission and sustainable rural development.

RESEARCH AND REFERENCES

REFERENCES

- Guezouli, L. et al., 2024 – IoT and AI for Real-Time Water Monitoring and Leak Detection [click Here](#)
- Abd Jabbar, W.A. et al., 2024 – LoRaWAN-based IoT System for Rural Water Quality Monitoring [click Here](#)
- Cheng, J., Jiang, Z., Wu, H. & Zhang, X., 2025 – Water Pipeline Leak Detection Method Based on Transformer and Transfer Learning [click Here](#)
- X / Author(s), 2024 – AIoT-Driven Leak Detection in Real Water Networks Using Hydroacoustic Data [click Here](#)
- Homaei, M. et al., 2025 – Smart Water Security with AI and Blockchain-Enhanced Digital Twins [click Here](#)

COMPARISON TABLE

Feature	GramJalJeevan (Our Solution)	Existing Systems
Leak Detection	✓ AI-based real-time flow & pressure anomaly detection with auto-valve shutoff	⚠ Manual inspection; delayed fault identification
Water Quality Monitoring	✓ Multi-parameter sensors (pH, TDS, Turbidity, EC, Temp) integrated with IS-10500 compliance	⚠ Periodic lab testing; no continuous monitoring
IoT Integration	✓ Low-cost, solar-powered IoT nodes with LoRa/MQTT connectivity	✗ Limited or no sensor network integration
AI & Predictive Analytics	✓ ML algorithms predict leaks, contamination, and pipe wear before failure	⚠ Static analysis; only reactive maintenance
Dashboard & Visualization	✓ Interactive web dashboard with live maps, analytics, and trend graphs	⚠ Basic spreadsheet or static map reports
Alert & Notification System	✓ Instant geo-tagged alerts via SMS, app, and email	⚠ Manual logbooks; delayed issue communication
Scalability & JJM Integration	✓ Modular, API-ready for Jal Jeevan Mission and state dashboards	⚠ Region-specific tools; not interoperable