Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

IoT-Enabled Digital Transformation of State Tubewell Irrigation Systems: A Case Study of an IoT-Based Pump Monitoring System

Anil Garg[1](IAS), Shiv Prasad Maurya[2*], Pankaj Kumar Verma[3], Shashank Kumar[4]
[1]Principal Secretary, Irrigation and Water Resources Department, Government of Uttar Pradesh, India.
[2]Chief Engineer, Tubewell East Zone, Ayodhya, Irrigation and Water Resources Department, Uttar Pradesh, India.
[3]Superintending Engineer, Tubewell Circle, Ayodhya, Irrigation and Water Resources Department, Uttar Pradesh, India.
[4]Executive Engineer, Tubewell Division, Barabanki, Irrigation and Water Resources Department, Uttar Pradesh, India.
***Corresponding Author:** Shiv Prasad Maurya, **Email:** shivpmaurya@yahoo.co.in

ARTICLE INFO

Received: 15 Apr 2026

Revised: 01 June 2026

Accepted:10 June 2026

ABSTRACT

The Tubewell East Zone, Ayodhya manages 9,107 government tubewells covering approximately 7.36 lakh hectares of agricultural land. Before this initiative, pump operations were managed manually with no real-time data, leading to frequent motor burn cases, high downtime and poor irrigation reliability. The system uses cloud-connected sensors with M2M SIM-based connectivity to track nine key parameters and generate pre-failure alerts. After deployment, total running hours increased from 1,37,868 to 1,84,637 hours, irrigation coverage grew from 5,945.08 hectares to 8,354.77 hectares and zero motor burn cases were recorded. The estimated economic benefit is approximately Rs. 1.25 lakh per tubewell per year. This study offers a replicable governance model for digital transformation of public irrigation infrastructure in developing economies.

Keywords: IoT; Tubewell Irrigation; Pump Monitoring; Predictive Maintenance; Digital Transformation; Agricultural Water Management; Uttar Pradesh.

1. INTRODUCTION

The Digital Transformation of State Tubewell Irrigation through IoT-Based Pump Monitoring System in Tubewell East Zone, Ayodhya represents a landmark initiative by the Irrigation Department, Uttar Pradesh. The Tubewell East Zone, Ayodhya has been instrumental in ensuring irrigation to farmers for decades, operating 9,107 government tubewells and covering approximately 7.36 lakh hectares of agricultural land. This large-scale infrastructure forms the backbone of agricultural productivity in the region.

India uses nearly 89 percent of its total freshwater for agriculture, and groundwater-based irrigation through government tubewells remains the primary source of water for millions of smallholder farmers across Uttar Pradesh (Central Water Commission, 2021). When pumps failed without warning, crops dried out and farmers lost income with no quick remedy. The entire maintenance approach was reactive, meaning that corrective actions were taken only after failures had already occurred, often causing irreversible motor damage, delayed restoration and mounting repair costs. This kind of reactive approach is well established in engineering literature as significantly more expensive than condition-based monitoring over time (Short & Twiddle, 2019; Moleda et al., 2020).

The conventional system faced several specific operational problems. There were sudden pump failures with no early warning. Fault detection was always delayed because there was no sensor data to trigger alerts. Operator shortages meant that many tubewells ran unattended for extended periods. Monitoring across geographically dispersed assets was impractical without digital tools. Together, these problems made it nearly impossible to plan maintenance, allocate resources efficiently or hold anyone accountable for pump performance. The case for an IoT-based transition was both technical and administrative (Ministry of Water Resources, 2012; Bureau of Energy Efficiency, 2005).

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

2. LITERATURE REVIEW

IoT applications in agricultural irrigation and industrial pump monitoring have grown substantially in peer-reviewed literature. Kamienski et al. (2019) developed the SWAMP platform across Brazil and Europe, demonstrating that cloud-connected sensor networks can deliver scalable precision irrigation management with real-time data. Their finding that IoT platforms must support multiple sensor types and legacy hardware to be practically deployable is directly relevant to the Ayodhya context. Kashyap et al. (2021) extended this by combining IoT sensor feeds with deep learning models for irrigation scheduling and showed significant improvements in water use efficiency over conventional schedule-based methods (Kamienski et al., 2019; Kashyap et al., 2021).

Predictive maintenance of pumps using sensor data has been validated in comparable settings. Short and Twiddle (2019) deployed an edge IoT device on large-scale pumping equipment in the UK water industry using Modbus protocol and GSM connectivity. Their system used real-time condition monitoring to detect early signs of wear, preventing failures before they occurred. Moleda et al. (2020) applied SCADA-based regression models to boiler feed pump data and showed that deviations from normal operation can be detected weeks before physical failure. Both studies confirm that affordable sensor systems can eliminate most unplanned pump outages (Short & Twiddle, 2019; Moleda et al., 2020).

Three-phase induction motors of the type used in government tubewells have also been studied in IoT health monitoring research. Yousuf et al. (2024) built a system monitoring temperature, vibration, current and voltage with GSM-based remote alerts and confirmed that continuous sensor tracking prevents motor burn events that otherwise go undetected under manual inspection. Ciancetta et al. (2021) showed that indirect current measurement using a single transducer can estimate motor mechanical power with less than 8 percent error, reducing hardware cost considerably for large-scale rollouts. These findings directly informed the sensor and alert design in the Ayodhya system (Yousuf et al., 2024; Ciancetta et al., 2021).

Broader reviews of smart farming and agricultural IoT confirm that connectivity, legacy integration and operator training are the primary barriers to adoption in government settings, all of which were encountered during the Ayodhya pilot. Idoje et al. (2021) reviewed IoT, cloud computing and machine learning across crop and animal production and identified these barriers as consistent across developing-country deployments. Xu et al. (2022) reviewed agricultural IoT architectures and confirmed that standardized communication protocols such as Modbus allow horizontal scaling without redesign. Parvathi Sangeetha et al. (2022) specifically studied IoT irrigation management in India and documented measurable gains in system reliability and farmer satisfaction comparable to those reported here (Idoje et al., 2021; Xu et al., 2022; Parvathi Sangeetha et al., 2022).

Energy management and water savings from IoT irrigation systems have also been quantified in recent work. Khan et al. (2022) found that intelligent energy management schemes embedded in IoT irrigation platforms simultaneously reduce power consumption and water waste. Liao et al. (2021) demonstrated in greenhouse trials that real-time soil moisture-based irrigation cut water use without reducing yield. Benyezza et al. (2021) reported 20 to 35 percent reductions in energy and water costs from IoT zoning in field irrigation systems. These findings support the financial case for scaling the Ayodhya model and suggest that energy savings are an additional benefit not fully quantified in this study (Khan et al., 2022; Liao et al., 2021; Benyezza et al., 2021).

3. PROBLEM STATEMENT

Pump failure in government tubewells is not merely a mechanical issue. It carries multi-dimensional consequences across agricultural, financial and administrative domains. Crop damage and reduced output are the most immediate effects felt by farmers. Financial losses ripple through households that depend on irrigated harvests. Increased repair and maintenance costs drain departmental budgets. Inefficient use of government resources reduces the value of the infrastructure investment. And operational stress on engineers grows as they respond to unpredictable breakdowns across a large geographic area. The absence of real-time monitoring was the structural root of these problems. Failures were detected only after occurrence, leaving no room for preventive action. Maintenance was entirely reactive rather than preventive, which is consistently the more expensive approach in engineering asset management (Short & Twiddle, 2019; Pech et al., 2021). High downtime reduced both irrigation service delivery and the

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

operational life of pumps. The shortage of tubewell operators compounded the problem by leaving assets unattended, sometimes for days after a failure had occurred. A secondary but serious governance problem was the complete absence of performance data. Without records of when pumps ran, how long they operated and why they stopped, engineers could not plan maintenance schedules, justify resource allocation or evaluate performance across circles. This lack of accountability made systematic management of the 9,107-tubewell network virtually impossible (Bureau of Energy Efficiency, 2005; Ministry of Water Resources, 2012).

4. OBJECTIVES

The department aimed to transform irrigation management through the following specific objectives:

- Enable real-time monitoring of pump performance
- Early fault detection before system failure
- Improve operational efficiency and reduce downtime
- Provide remote access to pump status for engineers
- Transition from reactive maintenance to predictive maintenance

5. METHODOLOGY AND APPROACH

To address these challenges, the department implemented an IoT-based pump monitoring system beginning with a single pilot site. The pilot was located at Tubewell No. 109 FPG, Village Salempur, Block Fatehpur in Barabanki district. This site was selected because it represented typical field conditions in the zone: standard pump capacity, existing legacy starter systems and no prior digital infrastructure. The photograph in Figure 1 shows the pilot installation. Success at this site provided the validated technical template for the broader rollout.

Figure 1: Pilot Installation - Tubewell No. 109 FPG, Village Salempur, Block Fatehpur, Barabanki; Latitude: 27.246942, Longitude: 81.107197)

The system architecture is shown in Figure 2. Hardware deployed at each tubewell included IoT sensors interfaced with a smart motor protection system. The sensors communicated through the Modbus RS-485 protocol, a standard and reliable industrial protocol suited for field-to-cloud data transfer from legacy equipment (Ciancetta et al., 2021). Data was transmitted using M2M SIM-based GSM connectivity to a cloud-integrated web dashboard. A centralized command center was established to coordinate training, calibration and real-time oversight across all installed sites.

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

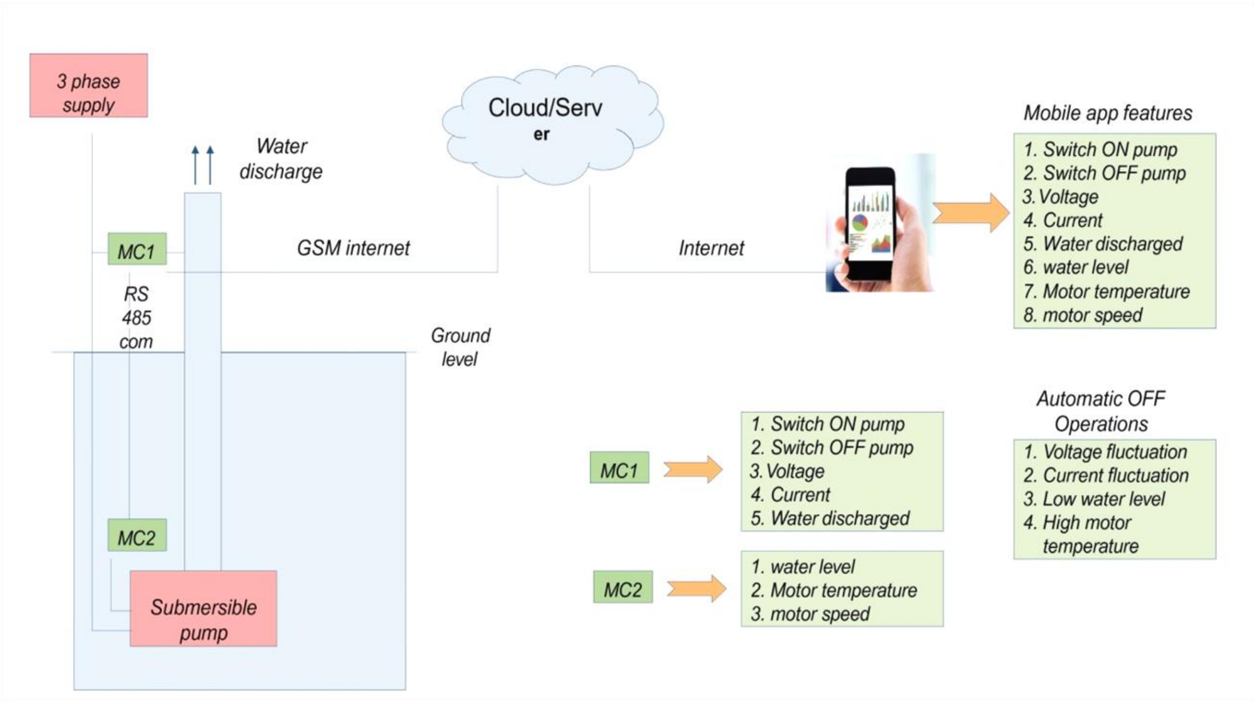


Figure 2: IoT System Architecture: 3-Phase Pump connected via Modbus RS-485 to GSM/Cloud gateway with mobile and web dashboard access

5.1 Key Deployment Components

The deployment at each tubewell included:

- IoT sensors and controllers
- Smart motor protection systems
- M2M SIM-based connectivity
- Cloud-integrated web dashboard

Technical integration involved:

- Modbus RS-485 communication protocols
- Real-time telemetry data acquisition
- Centralized command center with monitoring dashboard

5.2 Challenges and Resolutions

Three principal challenges were encountered during deployment. Network connectivity was inconsistent in remote field locations and was resolved through network optimization and selective placement of communication hardware. Integration with existing legacy starter systems required custom adapters since older equipment did not natively support Modbus communication. Data synchronization issues between field sensors and the cloud platform were resolved through firmware updates and gateway-level buffering. These solutions were standardized and documented to support the phased rollout to 110 sites (Idoje et al., 2021).

6. SYSTEM FEATURES AND TECHNICAL ANALYSIS

The IoT system continuously monitors nine key operational parameters that together cover all major failure modes in submersible agricultural pump motors:

- Voltage fluctuation
- Current imbalance
- Motor temperature

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

- Vibration patterns
- Dry-run condition
- Power factor
- Discharge
- Hydraulic power
- Energy consumption

These nine parameters provide both electrical and hydraulic health coverage. Temperature and vibration are early indicators of bearing wear and winding degradation, which are the leading causes of motor burn in submersible pumps. Current imbalance and voltage fluctuation identify electrical supply problems before they cause winding damage. Dry-run detection prevents motor damage when water levels drop below the pump intake, a common failure mode during dry seasons (Yousuf et al., 2024; Bureau of Energy Efficiency, 2005). Monitoring discharge and hydraulic power adds a hydraulic health layer that is specific to irrigation pump performance and not typically included in standard industrial motor monitoring systems.

6.1 Advanced System Features

Beyond basic parameter monitoring the system includes:

- AI-based predictive analytics that detect degradation trends before readings cross alarm thresholds
- Automated alerts before failure, sent to engineers via dashboard and mobile
- Centralized dashboard monitoring across all 110 installed sites on a live map interface
- Live CCTV integration for remote visual verification of site conditions
- Remote accessibility for engineers from any internet-connected device

Figure 3 shows the live dashboard interface. The system displays real-time operational status, live sensor readings, discharge rates, drawdown levels, RPM and average current values for each connected pump. Engineers can view historical trends, set threshold levels and receive instant alerts when readings deviate from normal ranges (Kashyap et al., 2021; Pech et al., 2021).

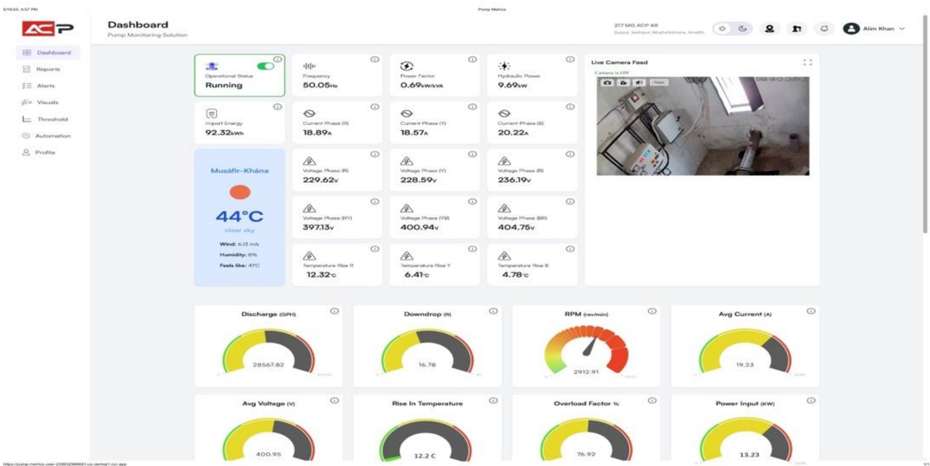


Figure 3: Live Dashboard: ACP Pump Monitoring Solution showing real-time parameters including Frequency (50.05 Hz), Power Factor (0.69), Hydraulic Power (9.69 kW), Voltage (392.32 V), Current (18.89 A), Active Power (18.57 kW), Energy (20.22 kWh), Discharge (2567.82 lpm), Drawdown (16.78 m), RPM (2912.91), Avg Current (10.23 A)

Figure 4 shows the live CCTV feed integrated into the monitoring platform. Remote visual verification allows engineers to confirm actual site conditions without a physical visit, which is a significant practical benefit in a zone where pump sites are spread across multiple districts.

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

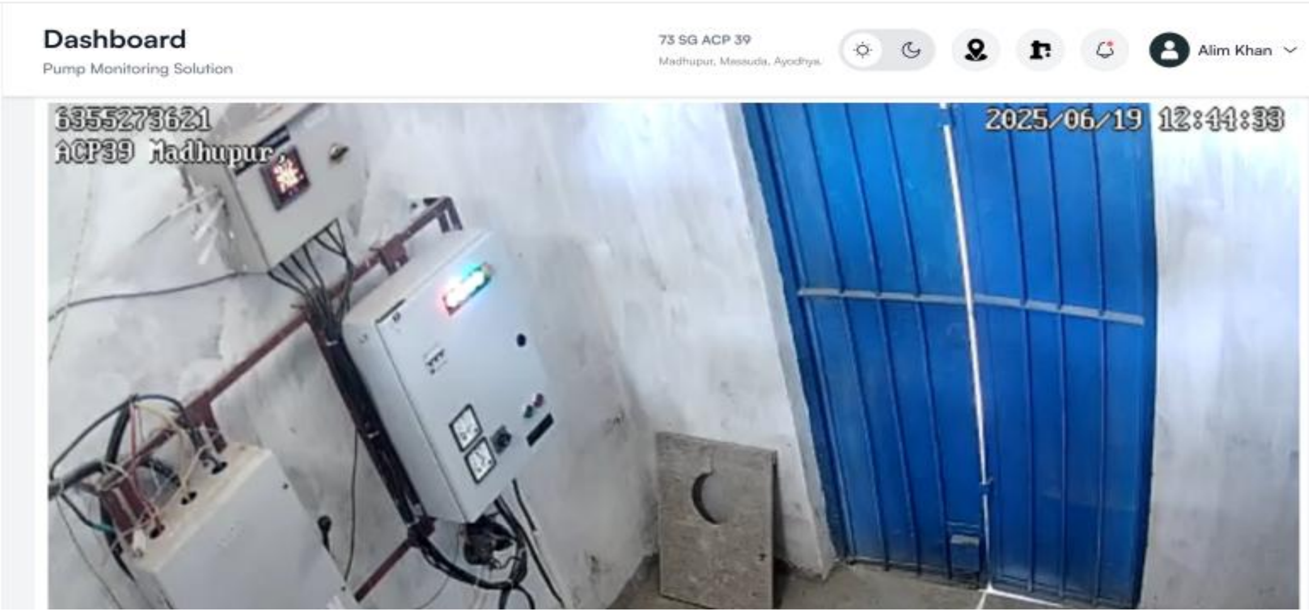


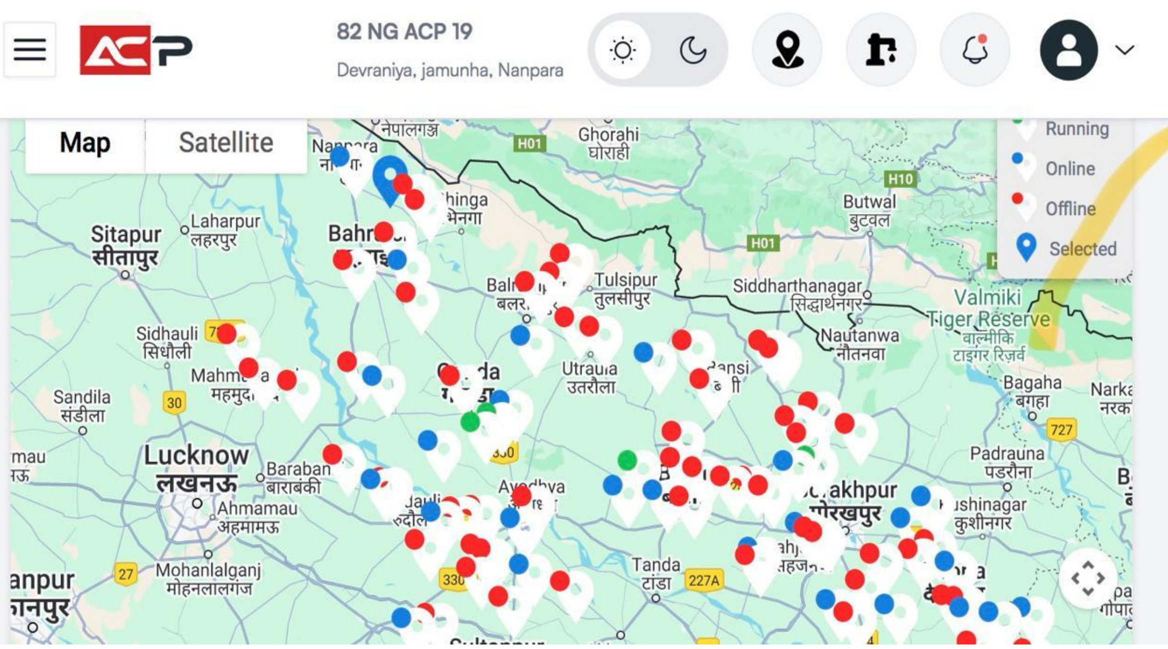
Figure 4: Live CCTV Integration within the ACP Dashboard: Remote visual monitoring of tubewell pump site

IoT-enabled irrigation systems significantly improve efficiency, automation and resource optimization while enabling predictive maintenance and reducing manual dependency. This system represents a genuine transition toward Preventive Intelligence in government irrigation management.

7. Implementation Scale

The circle-wise distribution is given in Table 1.

Figure 5 shows the geographic distribution of all 110 IoT-enabled tubewells across the Tubewell East Zone. The map view allows engineers to track operational status, connectivity and alerts for each site from a single interface.



Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

Figure 5: Geographic Map View: IoT-Enabled Tubewell Network across Tubewell East Zone, Ayodhya (110 Tubewells shown with Running, Online, Offline and Selected status indicators)

A centralized command centre was established to coordinate all aspects of the rollout including IoT installation, sensor calibration, dashboard integration and engineer training. This created a scalable digital infrastructure for irrigation management. The standardized Modbus and cloud architecture allows new tubewells to be added by installing sensor hardware at the new site without requiring any new software development (Xu et al., 2022).

8. RESULTS AND OUTCOMES

The IoT system delivered measurable and impactful outcomes across all four administrative circles. Table 2 presents the complete before-and-after comparison by circle for running hours and irrigation coverage.

***Table 2**: Circle-wise Operational Outcomes Before and After IoT Installation*

Sr.	Circle	IoT	Run Hrs Before IoT	Irrig. Ha Before IoT	Run Hrs After IoT	Irrig. Ha After IoT	Increase Hrs	Increase Ha
1	Ayodhya	35	38,793	1,845	59,234	2,949	20,441	1,104
2	Gonda	21	26,378	1,167	32,065	1,441	5,687	274
3	Gorakhpur	33	47,129	1,917	59,697	2,352	12,568	435
4	Basti	21	25,568	1,016	33,641	1,613	8,073	597
	Total	**110**	**1,37,868**	**5,945**	**1,84,637**	**8,355**	**46,769**	**2,410**

8.1 Quantitative Impact

At the zone level, total running hours increased from 1,37,868 to 1,84,637 hours, adding 46,769 hours of operational time. Total irrigation coverage grew from 5,945.08 hectares to 8,354.77 hectares, a gain of 2,409.69 hectares. Approximately 49,426 metres of rewinding wire was also saved as a direct consequence of zero motor burn cases during the monitoring period. All four circles showed consistent improvement, confirming that the results were not isolated to one area or set of conditions.

8.2 Operational Achievements

The qualitative shift in operational performance is captured in Table 3 and the performance comparison chart in Figure 6.

***Table 3:** Operational Parameter Comparison Before and After IoT*

Sr. No.	Parameter	Before IoT	After IoT
1	Motor Burn Cases	High	Zero
2	Monitoring Type	Manual	Real-time
3	Maintenance	Reactive	Predictive
4	Downtime	High	Minimal

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

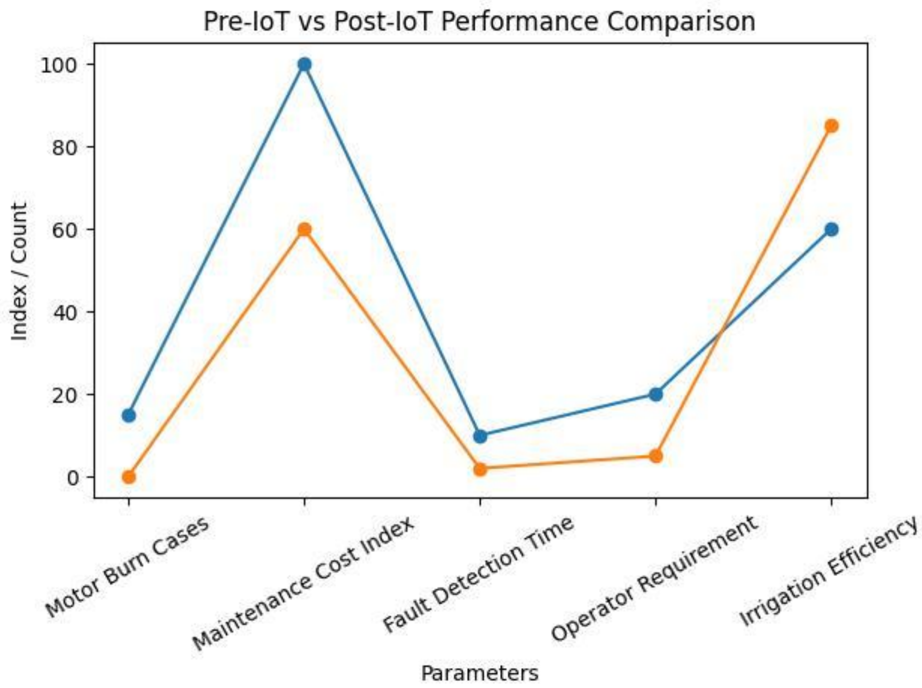


Figure 6: Pre-IoT vs Post-IoT Performance Comparison across five key parameters: Motor Burn Cases, Maintenance Cost Index, Fault Detection Time, Operator Requirement and Irrigation Efficiency

Zero motor burning cases across 110 tubewells in a single year is the most significant operational outcome. Studies in comparable settings confirm that continuous monitoring of motor winding temperature and current imbalance reliably prevents burn events that would otherwise go undetected under manual inspection regimes (Pech et al., 2021; Short & Twiddle, 2019). Zero major technical failures and continuous uninterrupted irrigation across all four circles confirm that the system functioned reliably under diverse field conditions throughout the monitoring period.

8.3 Efficiency Gains

Beyond the headline numbers the system produced tangible operational improvements. Reduced maintenance costs resulted from the elimination of unplanned failures. Improved planning and response became possible because engineers could now monitor pump status remotely and prioritize site visits based on actual sensor data rather than scheduled rounds. Increased transparency and accountability were achieved because historical performance records became available for the first time, enabling data-driven management decisions at the circle and zone level (Parvathi Sangeetha et al., 2022).

9. FINANCIAL IMPACT AND COST REDUCTION ANALYSIS

The implementation of the IoT-based pump monitoring system has resulted in significant financial savings in maintenance costs along with enhanced agricultural productivity due to increased irrigation availability. A comprehensive techno-economic assessment is presented below.

9.1 Baseline Maintenance Costs Per Tubewell Per Year

- **Average annual maintenance budget (Mechanical + Civil):** Rs. 45,000
- **Motor rewinding and repair (per burn case):** ~Rs. 25,000
- **Starter / TP switch damage:** ~Rs. 4,000 to Rs. 5,000

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

9.2 Typical Pre-IoT Scenario

Under conventional operating conditions each tubewell experienced at least one motor burn case and one starter/TP switch failure annually. Approximate annual corrective expenditure: Rs. 25,000 + Rs. 5,000 = **Rs. 30,000 per tubewell.**

9.3 Post-IoT Scenario

- **Motor burn cases:** Zero
- **Electrical damage incidents:** Minimal to negligible

9.4 Estimated Maintenance Savings

- **Savings per tubewell:** Rs. 25,000 to Rs. 30,000 annually
- **Reduction in maintenance cost:** Approximately 55 to 65 percent

This demonstrates a substantial reduction in maintenance expenditure along with improved system reliability and reduced downtime. IoT base systems have demonstrated significant operational efficiency improvements, reinforcing the effectiveness of such digital interventions.

9.5 Irrigation and Crop Productivity Impact

The IoT-based system resulted in an average increase of approximately 22 hectares of irrigation per tubewell annually. Table 4 presents the crop-wise distribution and income estimates.

Table 4: *Crop-wise Irrigation Area and Incremental Income per Tubewell*

Crop Season	Area / Tubewell (Ha)	Avg. Gross Value (Rs./Ha)	Benefit @ 10% Gain
Paddy (Kharif)	~9	~90,000	Rs. 81,000
Wheat (Rabi)	~13	~90,000	Rs. 1,17,000
Total	**~22**		**Rs. 1,98,000**

9.6 Total Incremental Crop Benefit

Total incremental crop benefit: Rs. 81,000 + Rs. 1,17,000 = **Rs. 1,98,000 (~Rs. 2.0 lakh per tubewell per year).**

9.7 Conservative Adjustment (Field Realism Factor)

A 50 percent effectiveness factor is applied considering partial irrigation contribution of tubewells, distribution losses and field variability, and dependence on rainfall and other inputs.

Adjusted Crop Benefit: Rs. 2.0 lakh x 0.5 = **Rs. 1,00,000 per tubewell per year.**

9.8 Total Economic Benefit Per Tubewell

Table 5: *Total Economic Benefit Per Tubewell Per Year*

Sr. No.	Component	Benefit (Rs./Tubewell/Year)
1	Crop productivity increase	~Rs. 1,00,000
2	Maintenance cost savings	~Rs. 25,000
	Total Benefit	**~Rs. 1.25 lakh / year**

The IoT-based pump monitoring system delivers dual benefits. The engineering benefit is a significant reduction in maintenance costs and system failures. The agricultural benefit is increased irrigation availability leading to improved crop productivity. The total estimated economic benefit of approximately **Rs. 1.25 lakh per tubewell annually** is a conservative estimate. It does not include indirect benefits such as reduced engineer travel, avoided crop losses from downtime or improvements in farmer income stability. These would further strengthen the case for scaling (Liao et al., 2021; Benyezza et al., 2021).

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

10. SOCIO-ECONOMIC IMPACT

10.1 Improved Agricultural Productivity

At the farm level, increased running hours meant that irrigation reached crops on time during critical growth stages. Farmers in all four circles received more reliable water supply, contributing to higher crop yields and more stable incomes. This benefit is particularly significant for smallholder farmers who have little financial buffer against crop loss from irrigation failure (Parvathi Sangeetha et al., 2022; Khan et al., 2022).

10.2 Addressing Manpower Constraints

With remote monitoring, one engineer can now track dozens of pump sites simultaneously from a computer or mobile device. The need for physical site visits drops to cases where the dashboard actually flags a problem. This is a major operational change in a department that chronically lacks enough operators relative to the number of assets it manages. Reduced dependency on manual monitoring and efficient handling of tubewell operator shortages together mean that the department can deliver better service with its existing workforce (Idoje et al., 2021).

10.3 Governance Improvements

Enhanced transparency and data-driven decision-making emerged as governance benefits. Circle-level engineers now have objective performance data to support planning and budget requests. Division-level oversight became more systematic because pump performance could be tracked and compared across sites in real time. Better accountability at every level of the department became possible because historical records were available for review (Ministry of Water Resources, 2012; Central Water Commission, 2021).

11. FUTURE SCOPE

The most immediate opportunity is replication of this model across other regions of Uttar Pradesh. The standardized architecture means that new zones can be onboarded using the same hardware, software and cloud platform. The training materials and installation protocols from the Ayodhya rollout provide a ready deployment template that does not require rebuilding from scratch.

The next technical step is integration with advanced analytics and AI-based automation. The sensor data accumulated from 110 tubewells over two operational years provides a substantial dataset for training models that can predict failure events further in advance than simple threshold alerts. Scaling up to cover all 9,107 government tubewells in the zone is the long-term goal, and at that scale the water security, governance and economic benefits would be transformational (Kashyap et al., 2021; Xu et al., 2022).

12. VISION

- From Reactive Repairs to Predictive Protection
- From Manual Monitoring to Intelligent Control
- From Traditional Irrigation to Digital Transformation
- Every Pump Secured. Every Farmer Empowered.

13. CONCLUSION

The IoT-based Smart Pump Monitoring System represents a transformative shift in irrigation management in the Tubewell East Zone, Ayodhya. It successfully demonstrates a transition from reactive maintenance to predictive protection, a significant reduction of approximately 50 percent in maintenance costs in monetary terms, an increase in irrigation coverage and operational efficiency, enhanced farmer productivity due to improved water availability and effective management of operator shortages through automation. This initiative is not only a technological advancement but also a scalable governance model aligned with Digital India, delivering measurable economic and social benefits. The zero motor burn result across 110 tubewells in a single year and the Rs. 1.25 lakh per tubewell annual benefit make a strong evidence-based case for policy-level adoption across the state. Outcomes are consistent with comparable international studies on IoT-enabled pump monitoring and smart irrigation. The model is directly replicable. Hardware costs are modest, the architecture is standardized and the implementation process is

Journal of Information Systems Engineering and Management
2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

documented. Scaling to all 9,107 tubewells in the East Zone and ultimately across Uttar Pradesh requires policy commitment and budget allocation but the technical foundation is already in place and validated.

Author Contributions

Shri Anil Garg (IAS) is presently posted as Principal Secretary, Irrigation and Water Resources Department, Government of Uttar Pradesh, India. He belongs to the 1996 batch of the Indian Administrative Service. He holds a B.Tech. in Electronics and Communication from Thapar University, Patiala. He began his administrative career as Joint Magistrate in Deoria, Haridwar, and Roorkee, and later served as Chief Development Officer, Bareilly. He has extensive experience in district administration, having served as District Magistrate in thirteen districts of Uttar Pradesh, including Bareilly, Ayodhya, Meerut, Jhansi, Ambedkar Nagar, Kaushambi, Pilibhit, Badaun, Shahjahanpur, Basti, Siddharth Nagar, Mainpuri, and Aligarh. He has also served as Divisional Commissioner of the Lucknow, Bareilly, and Aligarh Divisions. In the field of industrial and infrastructure development, Shri Garg has held key leadership positions as Managing Director, Uttar Pradesh State Industrial Development Authority (UPSIDA); Chief Executive Officer, Yamuna Expressway Industrial Development Authority; and Additional Chief Executive Officer, Greater Noida Industrial Development Authority. His service portfolio includes important roles such as Secretary, Higher Education; Special Secretary in the Power and Revenue Departments; Rural Development Commissioner; Excise Commissioner; Director of Land Acquisition; and Judicial Member of the Board of Revenue. He also served as Additional Chief Electoral Officer during the 2017 Uttar Pradesh State Assembly Elections. He is presently heading the Irrigation and Water Resources Department in Uttar Pradesh as Principal Secretary. His present role entails overseeing the country's longest canal network and managing the state's vital water infrastructure, including dams, reservoirs, and flood control schemes. His role is crucial to the state's agricultural productivity, ensuring the operation of major and minor lift irrigation canals and tubewells to provide essential water resources for the farming sector.

Shiv Prasad Maurya is a distinguished Chief Engineer with more than 25 years of strong technical and managerial experience in the Irrigation and Water Resources Department, Uttar Pradesh, India. He holds a B.E. in Mechanical Engineering from Madan Mohan Malviya Engineering College, Gorakhpur. Joining the department in October 2000 as an Assistant Engineer, he has built deep technical expertise over the last 25 years. His diverse experience includes the construction and maintenance of state tubewells, the procurement of heavy electrical and mechanical machinery, and the structural maintenance of barrages and dams. Additionally, he has successfully managed complex river engineering works, including large-scale dredging operations for flood control and water management. After moving up through key leadership roles, he now manages over 9,000 state tubewells and 10 major pump canals. Mr. Maurya introduced the department's first software for control and monitoring with tracking rewinding wire distribution, developed UP Irrigation's first solar-powered lift canal, and added smart IoT systems to eco-friendly state tubewells. His exceptional work in both field of administration and technical engineering has brought him high recognition within the department. For his outstanding performance, he was honoured with an Excellence Award and Certificate by the Chief Engineer, Varanasi, during his tenure as an Executive Engineer. Later, during his service as a Superintending Engineer, he received another prestigious Excellence Award from the Engineer-in-Chief (the highest engineering authority in the department).

Moving forward, his professional work and academic research focus heavily on modernizing irrigation and water infrastructure. His key areas of interest include developing smart irrigation and water resource management systems, deploying Internet of Things (IoT) technologies in state tubewells and lift canals for farmer utilities to monitor operations in real-time, and building eco-friendly, sustainable irrigation systems to support agricultural growth.

Pankaj Kumar Verma is a distinguished Superintending Engineer with more than 25 years of extensive technical and managerial experience in the Irrigation and Water Resources Department, Uttar Pradesh, India. He holds a B.Tech degree in Mechanical Engineering from the prestigious Indian Institute of Technology Roorkee. Joining the department as an Assistant Engineer in 2000, he has developed deep expertise in irrigation engineering and hydraulic infrastructure throughout his distinguished career. He possesses vast experience in the operation and maintenance of major dams, barrages, and associated hydraulic structures across Uttar Pradesh and has played a significant role in the planning and execution of large-scale dredging operations aimed at improving river flow and mitigating flood risks. He is widely recognized as one of the key officers who initiated and promoted dredging projects within the department to the modernization of river management practices in the state. In addition to his departmental responsibilities, he gained extensive experience in infrastructure development while serving on deputation as a Project Manager in the Uttar Pradesh Projects Corporation, where he successfully managed several large-scale infrastructure projects. Currently serving as the Superintending Engineer, Tubewell Circle, Ayodhya, he oversees the operation and maintenance of more than 2,588 state tubewells and 8 major pump canals. He successfully initiated and implemented IOT based pump monitoring system a pilot project at the field level within his circle and subsequently led its expansion across five districts, demonstrating its operational viability and effectiveness. Throughout his career, Mr. Verma has earned a reputation for technical excellence and innovative problem-solving. His professional interests focus on the modernization of irrigation infrastructure, river training works and the integration of advanced technologies to enhance the performance of irrigation systems to improve irrigation services for farmers.

Shashank Kumar is a dedicated Executive Engineer with more than 11 years of technical and managerial experience in the Irrigation and Water Resources Department, Uttar Pradesh, India. He joined the department as an Assistant Engineer in December 2014 and has since developed extensive expertise in the operation, maintenance, and management of irrigation infrastructure. Throughout his career, he has gained valuable experience in the operation and maintenance of state tubewells, dams, and associated hydraulic structures. In addition, he possesses specialized industrial workshop experience in the manufacturing of submersible pumpset parts, small canal gates, m.s. barges and pipes of various dimensions used in different pump canal projects. He has also contributed to execution of river training works through dredging operations aimed at improving river flow and reducing flood risks. Currently serving as the Executive Engineer, Tubewell Division, Barabanki, he is responsible for the operation of 487 state tubewells and the construction of pump houses for flood protection works. Mr. Kumar successfully implemented a pilot IoT-based pump monitoring system within his division and played a pivotal role in resolving early-stage technical and operational challenges. Following the successful completion of the pilot project, he made significant contributions to the development of the project dashboard and the integration of multiple IoT devices into a unified web-based monitoring platform. His professional interests focus on the modernization of irrigation infrastructure, deployment of Internet of Things (IoT) technologies and the adoption of innovative engineering solutions to improve the reliability, efficiency, and overall performance of irrigation services for farmers.

REFERENCES

[1] Benyezza, H., Bouhedda, M., & Rebouh, S. (2021). Zoning irrigation smart system based on fuzzy control technology and IoT for water and energy saving. *Journal of Cleaner Production*, *302*, 127001. https://doi.org/10.1016/j.jclepro.2021.127001

[2] Bureau of Energy Efficiency. (2005). *Pumps and pumping systems (Guide Book 3, Chapter 6, 2nd ed.)*. Ministry of Power, Government of India. https://beeindia.gov.in/sites/default/files/3Ch6.pdf

[3] Central Water Commission. (2021). *Water and related statistics*. Ministry of Jal Shakti, Government of India. https://cwc.gov.in/sites/default/files/water-and-related-statistics-2021compressed-2.pdf

2026, 11(3s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

[4] Ciancetta, F., Fiorucci, E., Ometto, A., Fioravanti, A., Mari, S., & Segreto, M.-A. (2021). A low-cost IoT sensors network for monitoring three-phase induction motor mechanical power adopting an indirect measuring method. *Sensors*, *21*(3), 754. https://doi.org/10.3390/s21030754

[5] Elkateb, S., Metwalli, A., Shendy, A., & Abu-Elanien, A. E. B. (2024). Machine learning and IoT-based predictive maintenance approach for industrial applications. *Alexandria Engineering Journal*, *88*, 298-309. https://doi.org/10.1016/j.aej.2023.12.065

[6] Idoje, G., Dagiuklas, T., & Iqbal, M. (2021). Survey for smart farming technologies: Challenges and issues. *Computers & Electrical Engineering*, *92*, 107104. https://doi.org/10.1016/j.compeleceng.2021.107104

[7] Kamienski, C., Soininen, J.-P., Taumberger, M., Dantas, R., Toscano, A., Salmon Cinotti, T., Filev Maia, R., & Torre Neto, A. (2019). Smart water management platform: IoT-based precision irrigation for agriculture. *Sensors*, *19*(2), 276. https://doi.org/10.3390/s19020276

[8] Kashyap, P. K., Kumar, S., Jaiswal, A., Prasad, M., & Gandomi, A. H. (2021). Towards precision agriculture: IoT-enabled intelligent irrigation systems using deep learning neural network. *IEEE Sensors Journal*, *21*(16), 17479-17491. https://doi.org/10.1109/JSEN.2021.3069266

[9] Khan, A. I., Alsolami, F., Alqurashi, F., Abushark, Y. B., & Sarker, I. H. (2022). Novel energy management scheme in IoT enabled smart irrigation system using optimized intelligence methods. *Engineering Applications of Artificial Intelligence*, *114*, 104996. https://doi.org/10.1016/j.engappai.2022.104996

[10] Liao, R., Zhang, S., Zhang, X., Wang, M., Wu, H., & Zhangzhong, L. (2021). Development of smart irrigation systems based on real-time soil moisture data in a greenhouse: Proof of concept. *Agricultural Water Management*, *245*, 106632. https://doi.org/10.1016/j.agwat.2020.106632

[11] Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India. (2012). *National water policy 2012*. Ministry of Jal Shakti. https://jalshakti-dowr.gov.in/sites/default/files/NWP2012Eng6495132651_1.pdf

[12] Moleda, M., Momot, A., & Mrozek, D. (2020). Predictive maintenance of boiler feed water pumps using SCADA data. *Sensors*, *20*(2), 571. https://doi.org/10.3390/s20020571

[13] Parvathi Sangeetha, N., Kumar, N., Ambalgi, A. P., Abdul Haleem, S. L., Thilagam, K., & Vijayakumar, P. (2022). IoT based smart irrigation management system for environmental sustainability in India. *Sustainable Energy Technologies and Assessments*, *52*, 101973. https://doi.org/10.1016/j.seta.2022.101973

[14] Pech, M., Vrchota, J., & Bednar, J. (2021). Predictive maintenance and intelligent sensors in smart factory: Review. *Sensors*, *21*(4), 1470. https://doi.org/10.3390/s21041470

[15] Short, M., & Twiddle, J. (2019). An industrial digitalization platform for condition monitoring and predictive maintenance of pumping equipment. *Sensors*, *19*(17), 3781. https://doi.org/10.3390/s19173781

[16] Xu, J., Gu, B., & Tian, G. (2022). Review of agricultural IoT technology. *Artificial Intelligence in Agriculture*, *6*, 10-22. https://doi.org/10.1016/j.aiia.2022.01.001

[17] Yousuf, M., Alsuwian, T., Amin, A. A., Fareed, S., & Hamza, M. (2024). IoT-based health monitoring and fault detection of industrial AC induction motor for efficient predictive maintenance. *Measurement and Control*, *57*(3-4), 178-195. https://doi.org/10.1177/00202940241231473