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Viksit Bharat @2047

AI-Enabled, Data Driven and Secure Digital Governance

COMPENDIUM

of e-governance Initiatives

TABLE OF CONTENTS

Chapter- 1……..5

AI-Based Health Governance for All: Leveraging NextGen eHospital HMIS for Viksit Bharat 2047

Author:

- Shri Madhukar Kumar Bhagat, Ministry of Health and Family Welfare
- Shri C.J. Antony, Ministry of Health and Family Welfare
- Shri Ravindra Kumar, Ministry of Health and Family Welfare

Chapter- 2……..12

AI-Driven Governance Transformation in Department of Rural Development

Author:

- Ms. Aditi Singh, Ministry of Rural Development, Government of India
- Shri Ajay More, Ministry of Rural Development, Government of India
- Shri Ashutosh Khanna, Ministry of Rural Development

Chapter- 3……21

Digital Transformation of Indian Power Sector; Challenges & Regulatory Measures

Author:

- Shri L K S Rathore, I.E.S, Chief Engineer (Regulatory Affair), Central Electricity Authority, Ministry of Power
- Shri Arvind Kumar Meena, I.E.S., Deputy Director (Regulatory Affair), Central Electricity Authority, Ministry of Power
- Shri Himanshu Kumar, Deputy Manager, CSIRT-Power, Ministry of Power

Chapter- 4……35

Jal Seva Aankalan: A Data-Driven, Citizen-Centred Digital Framework for Assessing Rural Water Supply Services under Jal Jeevan Mission

Author:

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Chapter- 5……43

Puramithra: AI- Enabled Advisory System A Platform for Data- Driven Urban Governance and Citizen Service Delivery in Andhra Pradesh

Author:

- Shri S. Suresh Kumar IAS, Principal Secretary, MA&UD Department, Govt. of Andhra Pradesh
- Dr. P. Sampath Kumar IAS, Commissioner & Director of Municipal Administration, MA&UD Department, Government of Andhra Pradesh

TABLE OF CONTENTS

Chapter- 6……..……52

Putting Citizens First: How Stakeholder Consultation Shaped Kerala's Strategic AI Governance Initiatives

Author:

- Shri Seeram Sambasiva Rao, IAS - Special Secretary, IT Department, Govt. of Kerala
- Dr. Sabarish K - Head, eGovernance, KSITM
- Shri Sandip Kumar, IAS - Director, Kerala State IT Mission

Chapter- 7……..…62

AI and Digital Infrastructure for Secure Public Services: Learnings from the Enforcement Directorate

Author:

- Shri Manoj Mittal, IRS, Deputy Director, Directorate of Enforcement, Ministry of Finance, Government of India

Chapter- 8……..…69

Cross-Database Revenue Intelligence: A Data-Driven Municipal Revenue Leakage Detection Framework — Evidence from Rajamahendravaram Municipal Corporation

Author:

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Chapter- 9……..…80

Institutionalizing Digital Governance: The Role of OMMAS in the Decentralized Management of Rural Road Assets

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- Shri Abhishek Srivastava, Consultant (IT Division), MoRD (Ministry of Rural Development) & NRIDA (National Rural Infrastructure Development Agency)

Chapter- 10……85

Artificial Intelligence Use-cases for skilling programme in DDU-GKY and RSETI: Strengthening Rural Skilling Governance

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- Shri Raj priy Singh, Director – Rural Skills Division Department of Rural Development, Government of India

TABLE OF CONTENTS

Chapter- 11…… ……..……93

AI-Enabled Grassroots Governance in India: Towards Decentralised, Data-Driven and Citizen-Centric Local Administration for Viksit Bharat 2047

Author:

- Ms. Manjiri Dhawade, Research Associate, School of Government, MIT-WPU, Pune

Chapter- 12……..…99

Rajasthan State Recruitment Portal

Author:

- Shri Rajesh Saini, Group General Manager, Department of Information Technology Communication, Government of Rajasthan
- Ms. Neha Chaudhary, Senior Project Officer, SeMT,
- Ms. Shruti Sharma, Assistant Programmer,

Chapter- 13……..…110

UP-IMRAS (Uttar Pradesh – Integrated Medical Research Application System) An AI-Enabled Sovereign Digital Infrastructure for Clinical Research Governance — The Uttar Pradesh Model

Author:

- Ms. Kritika Sharma (IAS), Managing Director & Chief Executive Officer, Uttar Pradesh Promote Pharma Council

Chapter- 14……..…116

Andhra Pradesh Development Permission Management System (APDPMS): AI Enabled Advisory System

Author:

- Shri S. Suresh Kumar IAS, Principal Secretary, MA&UD Department, Government of Andhra Pradesh
- Smt. R.J.Vidyullatha, Director of Town and Country Planning, MA&UD Department,

Chapter- 15……..……125

AI Tapaal: AI for the Government Workforce and Digital Correspondence Management in Nagpur Zilla Parishad

Author:

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TABLE OF CONTENTS

Chapter- 16……..……132

Towards Intelligent Pilgrimage Mobility Management: A Computer Vision Framework for Crowd and Traffic Flow Analysis

Author:

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CHAPTER 1
AI-Based Health Governance for All: Leveraging NextGen eHospital HMIS for Viksit Bharat 2047

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ABSTRACT

India's journey towards Viksit Bharat 2047 requires a healthcare system that is inclusive, efficient, and resilient. Artificial Intelligence (AI), when integrated with digital public infrastructure, offers a transformative pathway for achieving this vision. NextGen eHospital, a nationwide Hospital Management Information System (HMIS), provides a unified digital backbone that supports healthcare delivery, data integration, and governance. NextGen eHospital fulfils Ayushman Bharat Vision of full digitization of health records, services and interoperability facilitating continuum of care.

This paper examines the role of NextGen eHospital in enabling AI-based health governance through integrated workflows, real-time analytics, and AI-driven clinical and administrative capabilities. It highlights current applications of AI in diagnostics, decision support, and workflow automation, and proposes a phased roadmap for expanding AI adoption through 2047. The study demonstrates that AI-enabled HMIS platforms can significantly improve access, efficiency, transparency, and sustainability, thereby strengthening public health governance and ensuring equitable healthcare for all citizens.

INDEX TERMS

AI Governance, HMIS, Digital Health, ABDM, Healthcare Analytics, Viksit Bharat 2047

1. INTRODUCTION

India's healthcare system has achieved significant progress in expanding infrastructure and service delivery; however, key challenges such as fragmented data ecosystems, disparities in access, and operational inefficiencies continue to affect overall outcomes. Traditional governance approaches remain largely reactive, constraining the system's ability to anticipate, monitor, and respond effectively to emerging public health needs.

To address these challenges, the National Informatics Centre (NIC), with support from the Ministry of Electronics and Information Technology (MeitY), designed and developed the eHospital system, which has been implemented across over 1,000 hospitals nationwide since 2015, including premier institutions such as AIIMS Delhi.

Building upon this foundation, and in line with the broader digital transformation initiatives undertaken across the health sector, the NextGen eHospital platform was conceptualized and redeveloped by NIC under the aegis of the Ministry of Health & Family Welfare (MoHFW). The platform provides a unified Hospital Management Information System (HMIS) that seamlessly integrates clinical, administrative, and governance functions across healthcare facilities. Concurrently, initiatives under the Ayushman Bharat Digital Mission (ABDM) have further strengthened the ecosystem by enabling interoperable and integrated digital health frameworks. Thus, the NextGen eHospital fulfils Ayushman Bharat Vision of full digitization of health records, services and interoperability facilitating continuum of care i.e. right from tertiary care hospitals to Ayushman Aarogya Mandirs.

To address contemporary citizen healthcare needs, the NextGen eHospital platform is actively adopting AI-based solutions. The integration of AI significantly enhances platform capabilities through predictive analytics, process automation, and intelligent decision-support systems. This evolution enables a transition from reactive care delivery to proactive and preventive healthcare models. Consequently, the AI-enabled NextGen eHospital platform holds strong potential to serve as a foundational pillar for scalable, inclusive, and data-driven health governance, fully aligned with national priorities aimed at improving healthcare delivery and outcomes.

2. NEXTGEN eHOSPITAL AS DIGITAL BACKBONE OF HEALTH GOVERNANCE

2.1 Unified Healthcare Platform

NextGen eHospital integrates core hospital operations including outpatient and inpatient services, diagnostics (LIS/RIS), pharmacy, billing, and telemedicine into a single digital platform. This ensures that the entire patient journey is captured and managed seamlessly.

The integration eliminates data silos and enables real-time access to patient information, improving coordination among healthcare providers. Patients benefit from reduced waiting times, continuity of care, and easy access to their medical records. Such integration forms the foundation for efficient service delivery and data-driven governance.

2.2 Overarching Architecture

The platform is built on a microservices-based, API-first architecture deployed on cloud infrastructure. This allows independent scaling of system components and ensures flexibility in handling large volumes of transactions.

Integration with ABDM and national health registries enables standardized, consent-based data exchange. Adoption of interoperability standards such as FHIR and HL7 ensures seamless communication across systems [1]. The platform also supports lab analyser integrations which is supporting direct lab result recordings (eliminating human intervention in between) into the HMIS. This architecture supports scalability across thousands of healthcare facilities while maintaining performance, security, and reliability.

2.3 Citizen-Centric Service Delivery

NextGen eHospital enhances citizen experience through digital access to healthcare services such as online registration, appointments, and electronic health records. Patients can access prescriptions and reports remotely, reducing dependence on physical visits.

The availability of longitudinal health records improves continuity of care and empowers individuals to participate actively in managing their health. This citizen-centric approach strengthens transparency, accessibility, and trust in the healthcare system.

3. AI AS AN ENABLER OF HEALTH GOVERNANCE

3.1 AI-Driven Clinical Decision Support

AI-based Clinical Decision Support Systems (CDSS) assist healthcare providers by analysing patient data and recommending evidence-based treatment pathways. These systems enhance diagnostic accuracy, reduce clinical errors, and standardize care across facilities [2].

By providing real-time alerts and insights, AI augments clinical expertise and improves patient safety.

3.2 AI in Diagnostics and Tele-Radiology

AI-enabled diagnostic tools can detect abnormalities in medical imaging with high accuracy, supporting early disease detection. Integration with tele-radiology allows remote interpretation of diagnostic images, addressing the shortage of specialists in rural areas [3].

These capabilities significantly reduce turnaround time for reports and improve access to quality diagnostics.

3.3 AI in Workflow Automation

AI automates routine tasks such as patient triage, scheduling, and clinical documentation. Voice-to-text tools reduce documentation burden, allowing healthcare professionals to focus more on patient care.

Automation improves efficiency, reduces errors, and enhances resource utilization within healthcare facilities.

3.4 AI for Data-Driven Governance

AI-driven analytics transform healthcare data into actionable insights. Real-time dashboards enable monitoring of key performance indicators such as patient load, resource utilization, and service efficiency.

Predictive analytics supports early detection of disease trends and enables proactive interventions. This shifts governance from reactive decision-making to predictive and evidence-based planning [4].

4. IMPACT OF AI-ENABLED NEXTGEN EHOSPITAL

4.1 Scale and Reach

What makes NextGen e-Hospital truly impactful is the scale and depth of its adoption across the country since 2022. The platform is already operational in over 3,900 healthcare facilities, supporting an extensive volume of healthcare delivery, including more than 59 crore OPD visits and 1.75 crore IPD admissions. This demonstrates that the system is not merely conceptual but is actively delivering measurable outcomes on the ground.

From primary health centres to leading tertiary institutions such as Ayushman Arogya Mandirs in Lakshadweep, Manipur, and Ladakh, as well as major hospitals like Dr. RML Hospital, Safdarjung Hospital, and KGMU Lucknow, the platform brings standardization and consistency in service delivery across diverse geographies and levels of care.

The widespread adoption also enables the generation of real-time, high-quality health data, which plays a critical role in evidence-based planning, monitoring, and decision-making. Most importantly, this scale translates into tangible benefits for millions of citizens, who are already experiencing more efficient, transparent, and accessible healthcare services through the platform.

4.2 Improved Efficiency

For patients, one of the biggest changes is simply saving time. Processes that earlier took hours like registration, diagnostics, or discharge are now much faster and smoother. Doctors and staff also benefit because they no longer have to deal with scattered records or repetitive paperwork. Everything is available in one place, helping them focus more on patient care. Hospitals can manage their resources better, whether it’s beds, staff, or equipment. Overall, the system makes healthcare delivery faster, simpler, and more organized.

4.3 Accessibility and Equity

Perhaps the most meaningful change is how healthcare is reaching people who were earlier left out. Through telemedicine, someone in a remote village can now consult a specialist without travelling long distances. Language is no longer a barrier, thanks to multilingual support that makes services easier to understand. Even basic access through mobile phones helps bring healthcare closer to rural populations. These small but important changes make the system more inclusive and ensure that quality care is not limited to cities.

4.4 Economic and Social Impact

Healthcare is not just about treatment it also affects people's daily lives and income. By reducing travel, waiting time, and repeated visits, the platform helps lower expenses for patients. This is especially important for families that depend on daily wages. Saving time also means people can return to work sooner and maintain their livelihoods. Better health outcomes lead to stronger communities and a more productive society. In this way, the impact goes beyond hospitals and touches everyday life.

4.5 Environmental Sustainability

An often-overlooked benefit is how digital healthcare supports the environment. Moving away from paper-based records has significantly reduced paper usage, saving resources like trees and water. Fewer hospital visits also mean less travel, which helps cut down pollution. Cloud-based systems use resources more efficiently compared to traditional setups. While each change may seem small, together they contribute to a greener and more sustainable healthcare system.

5. AI-BASED HEALTH GOVERNANCE MODEL

The integration of AI with NextGen eHospital creates a connected governance framework where every stakeholder citizens, doctors, administrators, and policymakers plays a meaningful role. Instead of working in silos, these layers are linked through real-time data and digital systems. This ensures that decisions are not only faster but also grounded in actual needs and realities on the ground.

5.1 Citizen Layer

At the heart of this model is the citizen. People can now access healthcare services more easily whether it's booking an appointment, viewing reports, or consulting a doctor online. Having access to their own health records gives them a sense of ownership and control over their health journey. It also reduces dependency on physical documents and repeated hospital visits. For many, especially in rural areas, this means healthcare is no longer distant or complicated. It becomes more personal, accessible, and empowering.

5.2 Provider Layer

For doctors and healthcare staff, AI acts like a supportive assistant rather than a replacement. It helps them make better decisions by providing insights, alerts, and recommendations based on patient data. Routine tasks like documentation and scheduling become easier, reducing their workload. This allows them to spend more time focusing on patient care rather than paperwork. It also helps maintain consistency in treatment across different facilities. Overall, it improves both the efficiency and confidence of healthcare providers.

5.3 Administrative Layer

Hospital administrators benefit from a clear, real-time view of what is happening within their facilities. They can monitor patient flow, bed availability, and service efficiency without relying on delayed reports. This helps them make quick decisions like reallocating staff or managing resources during peak demand. It reduces guesswork and improves planning. As a result, hospitals can run more smoothly and respond better to patient needs. It brings a sense of control and transparency to day-to-day operations.

5.4 Policy Layer

At the highest level, AI helps policymakers see the bigger picture. By analysing data from across the healthcare system, it identifies trends, gaps, and emerging health risks. This allows governments to plan ahead whether it's preparing for disease outbreaks or improving healthcare infrastructure. Policies can be designed based on real evidence rather than assumptions. This leads to more effective and targeted interventions. Ultimately, it ensures that decisions made at the top truly benefit people on the ground.

5.5 Overall Impact

Together, these layers create a system where everyone is connected and informed. From a patient visiting a clinic to policymakers shaping national health strategies, decisions are supported by accurate and timely data. This not only improves efficiency but also builds trust in the healthcare system. It reflects a shift toward governance that is not just digital, but also more responsive, inclusive, and human-centred.

6. ROADMAP TO 2047: INCREASING AI PENETRATION

6.1 Phase 1 (2025–2030): Digital Foundation

This phase is about getting the basics right. The focus is on expanding NextGen eHospital across all public health facilities so that every patient interaction is digitally captured. Standardizing health data ensures that information can be shared and understood across systems. AI begins to assist in areas like diagnostics and routine workflows, helping doctors and staff gradually get comfortable with technology. At its core, this phase builds trust both among healthcare providers and citizens while laying a strong digital foundation for the future.

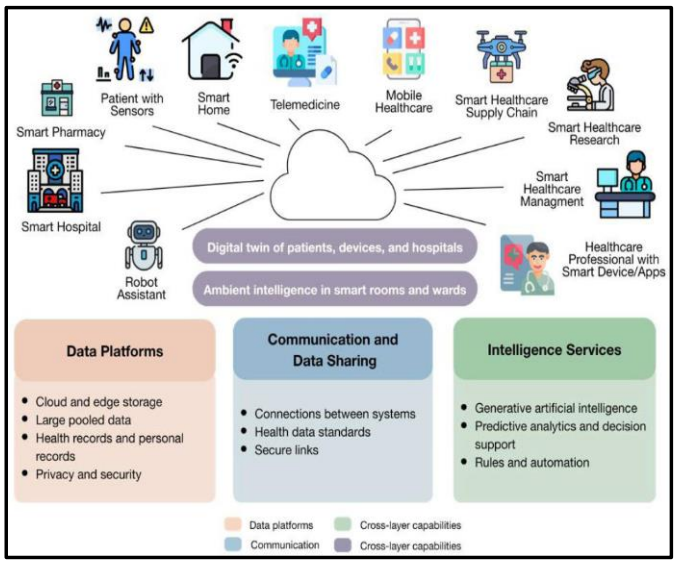
6.2 Phase 2 (2030–2035): Integrated AI Governance

Once the foundation is in place, the next step is connecting everything. Hospitals, labs, and health systems start working as one integrated network. AI begins to play a larger role by helping identify health trends and supporting targeted interventions for specific populations. Wearables and IoT devices bring real-time health data into the system, making monitoring more continuous rather than episodic. Healthcare governance becomes more coordinated, enabling better planning and more responsive services for citizens.

6.3 Phase 3 (2035–2040): Predictive Healthcare Systems

In this phase, healthcare becomes more proactive than reactive. Instead of waiting for people to fall sick, AI helps predict potential health risks and disease outbreaks in advance. Hospitals can plan resources better, and doctors can offer more personalized care based on individual health profiles. Patients benefit from early interventions, reducing complications and improving overall outcomes. This marks a shift toward a system that actively works to keep people healthy, rather than just treating illness.

6.4 Phase 4 (2040–2047): Autonomous Health Governance



By this stage, healthcare systems become highly intelligent and self-improving. AI continuously learns from vast amounts of data to optimize services, predict needs, and guide decisions. Digital twins virtual models of healthcare systems—help simulate scenarios and improve planning before real-world implementation. Preventive and precision healthcare become the norm, with timely interventions happening almost seamlessly. Ultimately, this phase represents a mature system where healthcare is not only efficient and accessible but also anticipates and adapts to the needs of every citizen.

7. CHALLENGES AND MITIGATION STRATEGIES

While AI-based healthcare brings great potential, challenges like limited digital infrastructure in rural areas, data privacy concerns, and hesitation in adopting new technologies cannot be ignored. Addressing these requires practical steps—improving infrastructure, training healthcare staff, and ensuring strong data protection frameworks. When people feel confident and systems are secure, adoption becomes much smoother. A balanced approach that combines technology with human readiness is key to long-term success.

8. WAY FORWARD

Going forward, expanding NextGen eHospital across the country is essential to ensure its benefits reach every citizen. Continued focus on AI innovation, strong cybersecurity, and collaboration between government and private players will accelerate progress. Just as important is listening to users doctors, staff, and patients to keep improving the system. This approach will help build a healthcare ecosystem that is not only advanced but also practical and people-focused.

9. CONCLUSION

NextGen eHospital demonstrates how digital platforms, combined with AI, can transform healthcare delivery and governance in India. By improving efficiency, expanding access, and enabling data-driven decision-making, it provides a strong foundation for inclusive healthcare systems.

As India advances toward Viksit Bharat 2047, AI-enabled health governance will play a pivotal role in ensuring accessible, equitable, and sustainable healthcare for all citizens.

ACRONYM

Acronym	Full Form
ABDM	Ayushman Bharat Digital Mission
AI	Artificial Intelligence
AIIMS	All India Institute of Medical Sciences
API	Application Programming Interface
CDSS	Clinical Decision Support System
FHIR	Fast Healthcare Interoperability Resources
HL7	Health Level Seven
HMIS	Hospital Management Information System
IoT	Internet of Things
IPD	Inpatient Department
KGMU	King George's Medical University
LIS	Laboratory Information System
MeitY	Ministry of Electronics and Information Technology
MoHFW	Ministry of Health & Family Welfare
NIC	National Informatics Centre
OPD	Outpatient Department
RIS	Radiology Information System
RML	Ram Manohar Lohia (Hospital)
WHO	World Health Organization

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CHAPTER 2
AI-Driven Governance Transformation in Department of Rural Development

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ABSTRACT

This paper examines a series of Artificial Intelligence (AI) interventions deployed across India's flagship rural development and skilling programmes, including the Pradhan Mantri Awaas Yojana – Gramin (PMAY-G), the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), and national skilling initiatives such as the Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDUGKY) and the Rural Self Employment Training Institutes (RSETI). These interventions directly address the themes of AI-based Governance for All and AI and Digital Infrastructure for Secure Public Services. Leveraging technologies including Edge-AI biometrics, Computer Vision (CV), Vision-Language Models (VLMs), Object Detection, and Retrieval-Augmented Generation (RAG), the interventions institute a paradigm shift from reactive, sample-based administration to proactive, evidence-based, real-time governance. Over 50 million household surveys with mandatory dual face authentication, more than 150 million photographic records analysed by AI, and an intelligent internal audit platform replicable across 40+ Ministries collectively demonstrate the transformative potential of AI-enabled digital infrastructure for achieving Viksit Bharat 2047.

INDEX TERMS

AI-based Governance, Biometric Authentication, Computer Vision, Secure Digital Infrastructure, Retrieval-Augmented Generation.

1. INTRODUCTION

The governance of large-scale social welfare programmes in India presents one of the most complex public administration challenges in the world. Flagship schemes such as PMAY-G, MGNREGA, and national skilling initiatives collectively encompass tens of millions of beneficiaries, billions of rupees in annual expenditure, and thousands of field-level implementing agencies spread across every district and block in the country. Historically, the integrity, efficiency, and transparency of these programmes have been constrained by heavy dependence on manual processes-attendance registers prone to proxy entries, sample-based field inspections susceptible to human error, and retrospective audit mechanisms unable to keep pace with the volume and velocity of programme transactions [1].

The Government of India's strategic commitment to Viksit Bharat 2047 demands a fundamental reimagining of how public services are governed and delivered. The Digital India initiative and the National Strategy for Artificial Intelligence [2] provide the policy scaffolding within which AI-based tools can be systematically integrated into the governance machinery. The 29th National Conference on e-Governance, themed Viksit Bharat 2047: AI Enabled, Data Driven and Secure Digital Governance, provides the intellectual platform for consolidating these experiences and charting an actionable course forward.

This paper presents a cohesive account of AI interventions implemented across the rural development and skilling ecosystem by the Department of Rural Development (DoRD), Ministry of Rural Development, Government of India. The interventions span four distinct categories of AI technology: (i) Edge-AI biometric identity assurance; (ii) large-scale Computer Vision for photographic evidence analysis; (iii) Object Detection for physical compliance monitoring; and (iv) Retrieval-Augmented Generation (RAG) for intelligent audit assistance. Together, they constitute a replicable, scalable model for AI-driven

transformation of public service delivery-squarely aligned with the sub-themes of AI-based Governance for All and AI and Digital Infrastructure for Secure Public Services.

The paper is structured as follows. Section 2 describes biometric identity interventions. Section 3 details Computer Vision applications. Section 4 covers Object Detection use cases. Section 5 presents the AI-powered audit platform. Section 6 synthesises key learnings and conclusions.

2. BIOMETRIC IDENTITY ASSURANCE AT LAST MILE

The integrity of any public service delivery programme rests on the accuracy of identity verification at the 'last mile'-the final point of interaction between the government and the citizen-beneficiary. Failures at this juncture, including proxy attendance, impersonation, and ghost entries, erode programme credibility, generate financial leakage, and deprive legitimate beneficiaries of entitlements [3]. AI-powered biometric assurance provides a scalable, tamper-resistant solution to this challenge.

2.1. Trusted Service Delivery in PMAY-G

A. Problem Statement

The Pradhan Mantri Awaas Yojana – Gramin (PMAY-G), which aims to provide pucca housing to all rural households in need, faced a compound identity verification challenge at scale. It was critical to confirm that designated government officials had physically visited the beneficiary's site and that the rightful beneficiary was genuinely present-to prevent ghost entries or impersonation. These requirements were complicated by unreliable mobile internet connectivity, variable lighting conditions, and diverse device capabilities among field officials [4].

B. AI-Powered Intervention

An AI-driven Face Authentication system was implemented as the primary identity assurance mechanism. Key design features engineered for rural field operations include:

- **Face-based e-KYC:** A one-time, connected authentication establishes a trusted digital identity baseline, linking biometric profiles to Aadhaar-seeded programme records.
- **On-device and Edge-based Authentication:** Subsequent authentications are performed locally on the mobile device using compressed AI inference models, enabling seamless, zero-latency verification in fully offline scenarios [5].
- **Dual Authentication Protocol:** A programme transaction can only be finalised upon successful face authentication of both the service provider (government official) and the service recipient (beneficiary).
- **Contextual Integrity Checks:** All authentication events are reinforced with geo-fencing and time-stamping, creating an immutable audit trail of each interaction.

C. Technical Architecture

The system is built on an 'Edge-Native Biometric Identity Layer.' The proprietary 'Temporal Fusion Engine' synthesises a composite biometric identity from a short, dynamic sequence of frames-rather than a single static image-significantly improving recognition accuracy under adverse field conditions [6]. A multi-layered anti-spoofing framework employs passive and active liveness detection at the client side and deep learning models trained to detect photo attacks, screen replays, 3D masks, and deepfake-generated synthetic faces on the server side.

D. Impact Created

Over **50 million household surveys** have been conducted using mandatory dual face authentication. This large-scale deployment has effectively eliminated ghost entries and impersonation fraud, substantially improved the trustworthiness and auditability of PMAY-G programme data, and improved compliance without creating undue friction for legitimate users.

2.2. Real-Time Attendance in MGNREGA

A. Problem Statement

The earlier attendance workflow for MGNREGA-the world's largest rural employment guarantee programme-lacked real-time biometric identity validation at the worksite. The NREGS Mobile Monitoring System (NMMS) application relied on photographic evidence susceptible to proxy attendance, identity misuse, and digital manipulation. At national scale, these weaknesses translated into erroneous wage disbursements, delayed payments to genuine workers, and weakened accountability of implementing agencies [7].

B. AI-Powered Intervention

An AI-Based Attendance Verification system integrated into the NMMS application performs on-the-spot face detection and one-to-one recognition, matching each worker's live facial capture against their Aadhaar-linked biometric record on the digital muster roll. Multi-modal anti-spoofing capabilities detect static photographs, video replay attacks, and digitally manipulated images. The solution operates in a low-bandwidth mode, batching authentication events and synchronising with central servers when connectivity is restored [8].

C. Impact Created

The deployment has fundamentally transformed the credibility of MGNREGA programme records. Elimination of proxy entries ensures that wage payments are disbursed exclusively for actual work performed by genuine workers, delivering financial efficiency for the exchequer and improved equity of outcomes for rural households. The tamper-resistant attendance data also strengthens the evidentiary basis for grievance redressal and social audit processes.

2.3. Real-Time Attendance for Skilling Programmes

A. Problem Statement

In government-sponsored skilling programmes conducted across thousands of training centres under schemes such as DDUGKY and RSETI, manual attendance tracking was prone to errors, deliberate manipulation, and significant administrative overhead. Consolidating attendance data from multiple geographically dispersed centres was time-consuming and provided limited real-time visibility to programme managers.

B. AI-Powered Intervention and Impact

A Computer Vision-powered facial recognition system is being deployed across DDUGKY and RSETI training centres. The contactless, real-time system definitively eliminates proxy attendance and makes verified data immediately available to programme stakeholders. Over **4 lakh registered candidates and 8,000+ trainers** across thousands of centres will benefit from enhanced attendance accuracy, strengthening programme monitoring and certification integrity [9].

3. COMPUTER VISION FOR LARGE-SCALE VERIFICATION

Computer Vision (CV) enables machines to extract structured information from visual data at a scale wholly infeasible for human reviewers, while simultaneously improving the objectivity, consistency, and auditability of decisions [10]. The Department of Rural Development has deployed CV at an unprecedented scale, processing hundreds of millions of programme photographs to support eligibility determination, compliance verification, and data integrity assurance.

3.1. Automated Housing Assessment in PMAY-G

A. Problem Statement

PMAY-G's housing assessment process generated over **150 million images from more than 50 million household surveys**. Manually reviewing this volume was operationally impractical, and human reviewers exhibited inherent subjectivity in applying housing condition classification rules-particularly for borderline cases-creating risks of incorrect eligibility determinations and improper fund disbursement [11].

B. AI-Powered Intervention

The Department deployed advanced Computer Vision models fine-tuned on a curated dataset of rural Indian housing imagery. These models analyse structural features visible in survey photographs-roof material, wall material, and overall structural condition-to automatically classify housing status as dilapidated, semi-permanent, pucca (permanent), or under-construction. Confidence-based decisioning routes borderline cases to human reviewers, preserving administrative accountability while reducing the burden of manual review.

The system employs a state-of-the-art Vision-Language Model (VLM) primed with the programme's formal decision matrix, enabling 'Semantic Structural Analysis.' The VLM interprets nuanced rule-based distinctions-such as correctly classifying a structure with permanent brick walls but a temporary thatched roof-producing a structured JSON output object for seamless integration with the PMAY-G Management Information System (MIS) [12].

C. Impact Created

Table 2. PMAY-G Computer Vision Deployment - Impact Metrics

Metric	Result
Household Surveys Verified	Over 50 million
Images Processed	Over 150 million
Houses Validated	More than 30 million (under construction or completed)
Manual Workload Reduction	Significant; faster processing of financial instalments
Governance Outcome	Improved accuracy, reduced subjectivity, enhanced national-level auditability

3.2. Legacy Data Integrity in MGNREGA

A. Problem Statement

Prior to real-time face authentication, the NMMS application relied on photographic evidence for worker attendance. The legacy dataset-numbering in the crores-accumulated images susceptible to duplication,

recycling, and digital manipulation. Manual verification of such a volume was infeasible, creating significant residual risk to programme integrity and financial accuracy.

B. AI-Powered Intervention and Impact

An AI-Based Deduplication and Spoof-Detection system was deployed to analyse the entire legacy attendance photograph repository. The deep learning model computes perceptual hash signatures and feature embeddings to identify near-duplicate or recycled images, detects manipulation artefacts, and generates a risk-ranked list of suspicious records automatically routed to field officials for corrective action [13]. The initiative delivered a substantial improvement in the integrity of historical attendance records, enabling retroactive accountability and correction of erroneous wage calculations.

3.3. Automated Assessment Evaluation for Skilling Programmes

A. Problem Statement and Intervention

In RSETI skilling programmes, the manual evaluation of Optical Mark Recognition (OMR) candidate assessments was labour-intensive and inconsistent, delaying certifications and introducing scoring variability across training centres [9].

Computer Vision techniques automatically scan and grade OMR sheets, applying image pre-processing to correct for skew and lighting variation, and employing trained CV models to detect and classify response bubbles with high accuracy. Approximately **7 lakh candidates trained annually** under the RSETI scheme will benefit from faster, more consistent, and more transparent evaluations, with real-time analytics enabling continuous improvement of training curricula.

4. OBJECT DETECTION FOR COMPLIANCE MONITORING

Object Detection enables AI systems to identify, localise, and count specific objects within images or video frames. In public programme governance, this technology automates physical inspection and compliance verification-replacing infrequent, costly, and subjective human inspections with systematic, scalable, and evidence-based AI-powered assessments [14].

4.1. Infrastructure Verification at Training Centres

A. Problem Statement

Under DDUGKY and RSETI, training centres are required to meet prescribed infrastructure standards as a condition of accreditation. These standards specify mandatory assets including adequate lighting fixtures, ceiling fans, computers, and projectors. Manually verifying compliance across thousands of centres was labour-intensive, prone to inconsistency, and offered limited scalability.

B. AI-Powered Intervention and Impact

Object Detection algorithms deployed through a mobile application automatically identify and enumerate specified asset categories from inspection photographs, producing objective, evidence-backed compliance reports and automatically flagging non-compliant centres for follow-up action [9]. Thousands of training centres and over **4 lakh candidates** will benefit from more systematic and consistent infrastructure monitoring, improving adherence to quality standards and contributing to better learning outcomes.

4.2. Candidate Headcount Verification

A. Problem Statement and Intervention

During physical inspections, manually counting candidates present in a training batch is inefficient and error-prone, undermining compliance reporting on batch size norms and trainer-to-candidate ratios. Object Detection technology applied to inspection photographs delivers an instantaneous, automated headcount recorded alongside a timestamp and geo-tag for programme records. Approximately **1,000+ training centres** are being connected for regular AI-powered inspections, strengthening regulatory compliance verification and providing a more reliable and auditable evidence base for programme reporting [9].

5. ENHANCING AUDIT WITH CONVERSATIONAL AI

The strategic importance of internal audit as a mechanism for financial discipline and systemic accountability within large-scale government programmes cannot be overstated. However, the sheer volume and diversity of data generated by rural development programmes renders comprehensive manual audit coverage impossible [15]. AI-based audit tools offer a transformative solution: automating the preliminary analysis of vast datasets, surfacing high-risk patterns for human review, and converting the audit function from a retrospective, sample-based activity into a continuous, risk-focused governance instrument.

5.1. The Rural Internal Audit Portal Bot

A. Problem Statement

The internal audit framework of DoRD operated primarily through manual, sample-based reviews of programme data and financial records. Audit coverage was necessarily limited by the capacity of the human audit team relative to the enormous scale of programme activity, meaning irregularities in unsampled areas could go undetected for extended periods, reducing the deterrent effect of the audit function [16].

B. AI-Powered Intervention

The Internal Audit Bot is a Retrieval-Augmented Generation (RAG) based AI assistant built on a large language model (LLM) foundation. The system ingests thousands of localised programme reports, financial statements, expenditure records, and administrative returns from across all DoRD schemes. Using RAG architecture, it retrieves semantically relevant document segments in response to auditor queries and synthesises coherent, evidence-linked responses-enabling conversational interrogation of the programme data corpus [17].

The bot systematically scans the ingested data for statistical anomalies, process deviations, inconsistencies with prescribed financial norms, and patterns indicative of compliance risk. It generates a risk-ranked digest of potential audit findings, allowing human auditors to direct their attention and expertise to the most critical issues first.

C. Technical Architecture

The RAG pipeline comprises three principal components:

(i) a document ingestion and embedding module that converts programme reports into dense vector representations indexed in a high-dimensional vector database; (ii) a retrieval module that uses semantic similarity search to identify contextually relevant document segments; and (iii) a generation module that synthesises coherent, evidence-referenced audit narratives from the retrieved context-ensuring responses are grounded in actual programme data [18].

D. Impact Created

In alignment with Controller General of Accounts (CGA) advisories on AI-enabled audit, the Internal Audit platform is designed as a common, reusable framework-not a programme-specific silo. The modular architecture supports replication across more than 40 Ministries and Departments, enabling centralised monitoring of thousands of audit cases annually at minimal marginal cost, representing a significant force multiplication of Government audit capacity.

6. KEY LEARNINGS AND CONCLUSIONS

The interventions described in this paper collectively yield a rich set of learnings relevant to the design, deployment, and scaling of AI-based governance solutions in the Indian public sector context:

- **Edge-AI is a prerequisite for inclusive digital governance:** Deploying AI at the last mile-in remote villages with unreliable internet-demands on-device inference architectures. The PMAY-G and MGNREGA biometric systems demonstrate that Edge-AI is a foundational requirement for inclusive digital governance that genuinely reaches every citizen [5].
- **AI-human collaboration maximises efficiency and accountability:** The confidence-based decisioning architecture in PMAY-G-routing borderline cases to human reviewers-demonstrates the importance of designing AI as a decision support tool. This hybrid model preserves accountability, builds institutional trust, and ensures edge cases receive appropriate human attention [12].
- **Large-scale AI deployment reveals systemic risks invisible to sampling:** The MGNREGA legacy data deduplication initiative showed that AI-powered exhaustive analysis can surface pervasive irregularity patterns that would otherwise remain undetected. Scale is not just an efficiency advantage but a qualitative governance improvement [13].
- **Reusable AI platforms are a public good multiplier:** The Internal Audit Bot's design as a common configurable framework replicable across 40+ Ministries illustrates a critical principle: platforms architected for reuse generate disproportionate public value relative to their development cost [17].
- **Anti-spoofing and security are non-negotiable:** Multi-layered anti-spoofing frameworks-combining edge-side liveness detection with server-side deep learning defences-reflect that AI-based identity systems in high-stakes public service delivery must be adversarially robust from the outset, not retrofitted [6].
- **Programme data quality is a governance asset:** Across all interventions, deploying AI has simultaneously generated higher-quality, more structured, and more auditable programme data enabling better policy analytics, more effective grievance redressal, and evidence-based programme design.

This paper has presented a comprehensive account of AI interventions demonstrating that AI-enabled, data-driven, and secure digital governance is not a future aspiration-it is an operational reality at massive scale today. The interventions span the full technology spectrum: from Edge-AI biometrics securing last-mile service delivery, to Computer Vision processing hundreds of millions of images, to Object Detection automating physical compliance verification, to RAG-powered AI transforming the audit function across the Government of India.

These experiences validate a replicable model characterised by: a citizen-centric design philosophy that places inclusion at its core; a security-first architecture that treats adversarial robustness as a fundamental design requirement; a hybrid AI-human workflow that preserves accountability while achieving scale; and a platform orientation that maximises public value through reuse and standardisation. As India advances towards Viksit Bharat 2047, these interventions offer a compelling proof-of-concept and practical

implementation roadmap for AI-based Governance for All and AI and Digital Infrastructure for Secure Public Services.

APPENDIX: PROGRAMME-WISE AI DEPLOYMENT SUMMARY

Programme	AI Technology	Key Use Case	Scale of Impact
PMAY-G	Edge-AI Biometrics Computer Vision (VLM)	Dual authenticati on for officials & beneficiaries Automated housing condition classification	50M+ surveys; ghost entries eliminated 30M+ houses validated ; 150M+ images
MGNREGA	Face Recognition + Anti-Spoofing AI Deduplication	Real-time worksite attendance verification Legacy attendance data cleansing	Proxy attendance eliminated; millions of workers Crores of records validated ; fraud detected
DDUGKY/RS ETI	CV Facial Recognition Object Detection	Contactless candidate attendance Infrastructu re & headcount verification	4 lakh+ candidat es; 8,000+ trainers 1,000+ centres; 4 lakh+ candidates
RSETI	OMR-based CV	Automated assessment scoring	7 lakh+ candidat es annually
DoRD (All)	RAG Conversatio nal AI	AI Internal Audit Bot	Replicable across 40+ Ministries

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CHAPTER 3
Digital Transformation of Indian Power Sector; Challenges & Regulatory Measures

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ABSTRACT

The Indian power sector is a critical national infrastructure that plays a vital role in economic growth, public safety, and national security. Digital transformation in power sector refers to the integration of advanced digital technologies, including IoT sensors, cloud platforms, artificial intelligence (AI), and digital twins, into core operations to enhance efficiency, reliability, and customer experience. It extends beyond simple automation, embedding data-driven decision-making across generation, transmission, distribution, and billing. Central to this shift are modern energy management systems, which unify real-time data streams and analytics to oversee grid performance and automate control actions. Digital transformation means replacing manual procedures with connected workflows and predictive tools that anticipate equipment failures, manage peak loads, and adapt to intermittent renewable energy sources. It aligns operational excellence with regulatory compliance and sustainability goals by embedding energy management principles into every process.

Accelerated digitization and automation in the power sector are revolutionizing energy management. Driven by AI, smart grids, and the Internet of Things (IoT), these technologies optimize system operation, generation, transmission distribution, integration of renewable energy sources. At the same time cyber-attacks on power supply systems have emerged as a serious threat, with malicious intent to disrupt grid operations, damage critical equipment, and cause cascading brownouts or large-scale blackouts. Such attacks can directly impact grid reliability and public confidence. Modern cyber-attacks on power systems are attributed to nation-sponsored or state-sponsored threat actors. Past global incidents have shown that cyber-attacks can lead to prolonged power outages and manipulation of grid operations. Additionally, leakage of sensitive operational data can help attackers design more advanced and targeted future attacks, making the threat long-term and strategic in nature.

This paper explores the regulatory initiatives and approaches to safeguard the Power sector's Critical Information Infrastructure.

Recognizing the evolving cyber threats, India has adopted a regulatory-driven approach to strengthen cybersecurity and cyber resilience in the power sector. This paper focuses on the upcoming Central Electricity Authority (CEA) Cybersecurity Regulation 2026, which aims to establish a uniform, mandatory cybersecurity framework across the power sector. The regulation places responsibility not only on power sector utilities but also on service providers, equipment vendors, and consultants to maintain trained and well-sensitized cybersecurity personnel. It mandates implementation of preventive and detective controls, vulnerability management, secure network architecture, and regular cyber security audits.

A key aspect of the regulation is its focus on cyber resilience, defined as the ability of a Responsible Entity to prepare for cyber incidents, respond effectively, and recover quickly while ensuring continuity of critical power operations. Mandatory half-yearly and annual cyber audits, supported by threat intelligence and advisories, are required to continuously improve the security posture. These audit reports are subject to regulatory inspection to identify gaps and ensure compliance.

The growing adoption of Artificial Intelligence (AI) in cybersecurity is playing a dual role by strengthening threat detection, predictive analysis, and automated incident response, while simultaneously enabling adversaries to develop more sophisticated, adaptive, and large-scale cyber-attacks.

The paper also highlights the important role of CSIRT-Power, established by the Ministry of Power, in supporting sector-wide cybersecurity operations. CSIRT-Power operates a 24×7 Security Operations Centre with dedicated incident response and forensic teams. It also coordinates six Sectoral CERTs covering generation, transmission, grid operation, renewable energy, and distribution. Together, the CEA Cybersecurity Regulation 2026 and CSIRT-Power provide a structured and proactive framework to build a cyber-resilient Indian power sector capable of addressing present and future cyber threats.

Keywords: Cyber Resilience, Indian Power Sector, CEA Cybersecurity Regulation 2026, CSIRT-Power, Critical Infrastructure Protection, IT-OT Security, Incident Response.

1. INTRODUCTION

The Indian power sector is undergoing a major transformation with increased use of digital technologies, automation, and interconnected systems across generation, transmission, grid operation, renewable energy, and distribution. While these advancements have improved efficiency and operational visibility, they have also introduced new cybersecurity risks that can directly impact grid reliability and national security. Recognizing the critical nature of these Cyber risks, the Government of India has initiated a structured and regulation-driven approach to cybersecurity in the power sector.

To address cyber security challenges in the power sector, the Ministry of Power (MoP) have issued the CEA Cyber Security Guidelines 2021 and established CSIRT-Power for coordinated incident response. Further, six Sectoral CERTs have been created across power sector to strengthen sector-specific cyber resilience. Capacity-building initiatives are being undertaken with academia and industry, along with this, work is currently in progress for the introduction of cyber security regulations 2026, model contractual clauses, a trusted vendor framework for the power sector etc.

1.1 Cybersecurity Challenges in Power Sector Digitization and Automation

The increasing digitization and automation of the power sector have significantly improved operational efficiency, monitoring, and grid management. However, the growing integration of IT and OT systems, smart grid technologies, remote access, and interconnected communication networks has also expanded the cyber-attack surface, creating new risks to grid reliability and national security.

1.1.1 Internet Exposure and Network Connectivity Risks

Traditionally isolated power systems are now connected through digital communication networks, remote monitoring platforms, and third-party access channels, increasing exposure to cyber threats.

Identified Risks:

- Unencrypted Communication: Legacy OT systems often transmit operational data without proper encryption.
- Weak Authentication: Default credentials, shared accounts, and lack of Multi-Factor Authentication (MFA).
- Legacy Industrial Protocols: Protocols such as IEC 60870-5-104, Modbus TCP, and DNP3 lack built-in security mechanisms.
- Remote Access Vulnerabilities: Insecure VPNs and third-party maintenance access may provide unauthorized entry into OT networks.
- SCADA/HMI Exploitation: Vulnerabilities in SCADA and HMI systems may enable unauthorized operational commands.

Real-World Impact:

The 2015 Ukraine power grid cyberattack exploited compromised remote access systems, causing large-scale power outages and demonstrating the vulnerability of interconnected grid infrastructure.

1.1.2 Supply Chain and Embedded System Vulnerabilities

Modern power infrastructure depends on globally sourced hardware, firmware, and third-party software components, increasing supply-chain cyber risks.

Attack Vectors:

- Firmware-Level Backdoors: Malicious code implanted during manufacturing or software updates.
- Compromised Third-Party Components: Multiple vendors with varying cybersecurity practices increase exposure.
- Counterfeit Equipment: Imported or unverified components may contain insecure or malicious code.
- Software Build Compromise: Attacks targeting software repositories and development pipelines.
- Cryptographic Weaknesses: Hardcoded credentials and insecure encryption mechanisms in OT devices.

1.1.3 False Data Injection (FDI) and Integrity Attacks

Power system operations rely heavily on real-time sensor and SCADA data. Manipulation of this data can result in incorrect operational decisions and grid instability.

Attack Scenarios:

- Manipulation of voltage, frequency, or load measurements.
- False telemetry inputs influencing EMS and SCADA decisions.
- Unauthorized switching or isolation of healthy equipment.
- Grid instability through coordinated data manipulation.
- Power market and scheduling manipulation using false operational data.

1.1.4 Emerging Cyber Threats

- GPS Spoofing: Manipulated timing signals affecting synchro phasor and grid synchronization systems.
- DoS/DDoS Attacks: Flooding communication and SCADA networks to disrupt operations.
- Ransomware in OT Environments: Disruption of operational continuity and recovery processes.
- Insider Threats: Malicious or accidental misuse of privileged access.
- AI-Powered Attacks: AI-enabled phishing, adaptive malware, and predictive cyberattack strategies targeting critical infrastructure.
- Cloud and IoT Risks: Misconfigured cloud platforms and insecure IoT devices increasing exposure.
- Advanced Persistent Threats (APTs): Nation-state actors conducting long-term espionage and infrastructure disruption campaigns.

1.2 Ministry of Power directives to address Cyber Security issues in Power Sector

- As per the Ministry of Power (MoP) order No 25-11/6/2018-PG dated 2 July 2020, all imported equipment and components used in the power supply system must be tested within India. This testing is required to check for embedded malware, trojans, or any cyber security threats. The equipment must also comply with Indian Standards. Such testing will be carried out only in laboratories certified and designated by the Ministry of Power.
- CSIRT-POWER was notified to be set up at Central Electricity Authority (CEA) vide MOP Order No 1/32/2021/IT&CS (258359) Dated 05th April 2023. The notification stated that the CSIRT-Power shall function as an extended arm to Indian CERT-In (Computer Emergency Response Team) and would help the utilities in cyber incident handling and to ensure better cyber security preparedness in the power sector.

1.3 Cyber security Provisions in Indian Electricity Grid Code (IEGC) 2023

The Indian Electricity Grid Code (IEGC), 2023, issued by the Central Electricity Regulatory Commission (CERC), provides a comprehensive regulatory framework for secure, reliable, and coordinated operation of the national power grid, including strong emphasis on cyber security as follows:

- Mandates protection of the national grid against malware, spyware, cyber-attacks, hacking, and other cyber threats, along with regular security audits and system upgrades.
- Requires all grid-related entities (NLDC, RLDCs, SLDCs, CTU, STUs, power exchanges, etc.) to implement a cyber security framework as per IT Act 2000, CEA regulations 2007, and CEA Cyber Security Guidelines 2021.
- Makes cyber security audits compulsory and reporting of cyber incidents to government agencies.
- Establishes a Cyber Security Coordination Forum through the sectoral CERT to enable coordination, information sharing, and resolution of cyber security issues at national and regional levels.

2.0 Ministry of Power initiatives

2.1 CSIRT-Power

CSIRT-Power has been established by MoP and fully functional w.e.f September 2024. This is first sectoral 24*7 SOC of any civil sector in Govt of India. CSIRT-Power is having Security Operation Centre, Data Centre equipped with cutting edge technology and expert manpower, along with a dedicated cyber forensic lab which helps to prevent, detect, handle, and respond to respond to cyber security incidents in Power sector utilities.

Key Activities of CSIRT-Power: -

- Laying down the Cyber Security framework and protocol for the Power Sector
- Laying down Standard Operating Procedures for Cyber Security
- Reviewing the Cyber Security arrangements in the different wings from time to time and strengthening such arrangements
- Implementation of Trusted Vendor system
- Drafting of Model Contractual Clauses for Cyber Security
- Analysis of Cyber Security Incidents

- Cyber Security Testing
- CISO Workshop
- Analysis, follow-up & action on Alert and Advisories, issued by NCIIPC, CERT-In & MHA
- Capacity development for using Vulnerabilities Scanning tools.
- Security Control Selection & Tailoring Process
- Vetting of Cyber Test bed Proposals.

2.2 INITIATIVES/ ACTIVITIES OF CSIRT-POWER

2.2.1 Incident Response & Forensic

CSIRT-Power Team has been 24*7 actively involved in doing the analysis of the cyber security incidents reported to Utilities by Central Agencies like CERT-In/ NCIIPC/ Intelligence Bureau/TSOC/CSK etc.

Incident response team and Forensic team has been established at CSIRT-Power. The CSIRT Power Team collects the logs, does the forensics analysis for the purpose of RCA (Root Cause Analysis) using limited resources available with it. Incident wise report is also prepared with recommendations made for closure of identified gaps. The involvement of CSIRT-Power brings in sector specific insight thus helps in better analysis of incident. Fig. 1 shows the incident response approach and fig. 2 shows Incident Response and Forensic Team workflow of CSIRT-Power.



Fig 1. *Incident Response Approach*

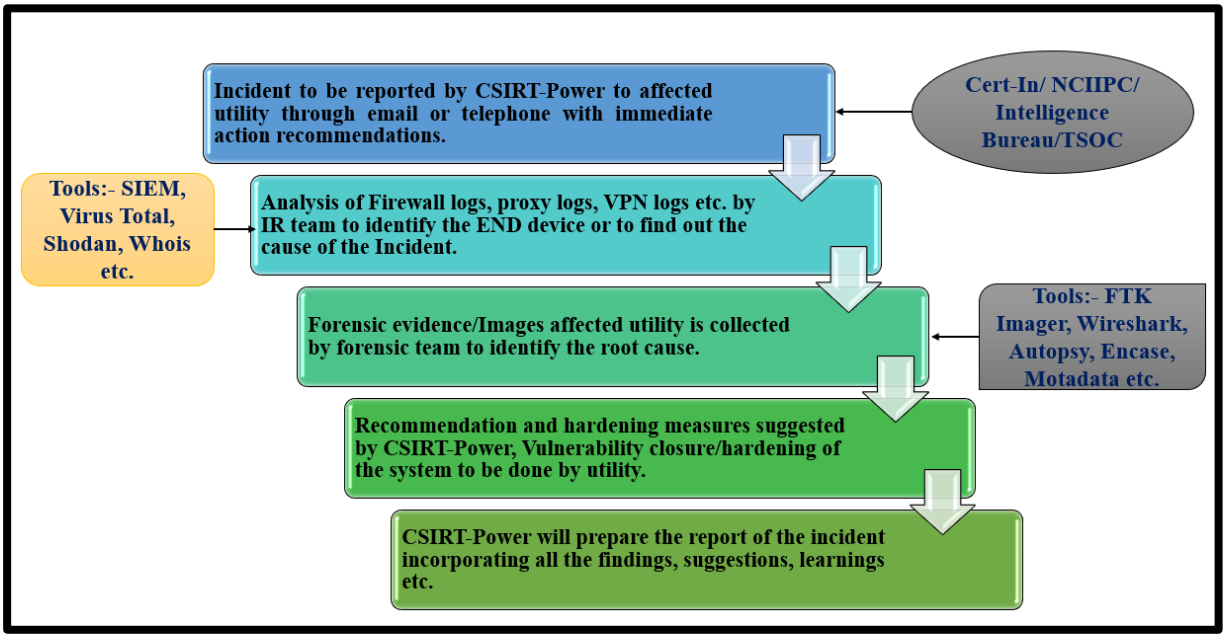


Fig 2. *Incident Response and Forensic Team workflow*

2.2.2 Trusted Vendor System

The CSIRT Power has been vigorously involved in establishing a "Trusted Vendor" System to counter cyber-security supply chain threats in the Indian Power Sector. Here Procurement is envisaged to be done from trusted sources-countries/vendors whose cyber integrity can be relied upon; for supplying equipment to the Power Sector in India. This system is also envisaged as a self-disclosure-based system, on which suppliers would be assessed through an appropriate inter-disciplinary institutional mechanism, based on an established set of criteria.

2.2.3 Cyber Security Framework

For assessment of Cyber security preparedness of Power sector utilities, CSIRT-Power is following below mentioned parameters:

- Appointment of CISO/Alternate CISO
- Setting up of ISD
- CSK on Boarding
- Implementation of C-CMP
- Identification of CIIs & Protected Systems
- Cyber Security Policy
- ISO 27001 Certification
- Cyber Security Audit
- Mandatory Cyber Security Training
- Log Retention

2.2.4 Deployment of SOC at all SLDC

Power System Development Fund (PSDF) has been constituted vide Central Electricity Regulatory Commission (Power System Development Fund) Regulations, 2010 dated 4th June 2010. Regional Power Committees, Generating Companies, Transmission Licensees, Distribution Licensees and Load Dispatch Centres as the case may be, shall submit the schemes to NLDC as Nodal Agency for funding from PSDF.

In compliance of IT Rules 2018, SLDCs are required to deploy a security operation centre for continuous monitoring of cybersecurity events and timely respond thereof.

CSIRT-Power in consultation with Grid India, NCIIPC and concerned SLDCs has formulated Model BOQ, consisting of various components to be deployed at SOC. In this line, CSIRT-Power is reviewing SLDCs architectures for deployment of SOC.

2.3 Guideline on Scope of Cybersecurity Audit in the Power Sector

CSIRT-Power has issued Guideline on Scope of Cybersecurity Audit in the Power Sector. The specific purpose of this guideline is to provide a template for scope of conducting cybersecurity audits in the power sector against a set of requirements/standards/baselines, through CERT-In empaneled auditors. Power sector utilities are mandated to conduct periodic cybersecurity audit of both Information Technology (IT) and Operational Technology (OT) assets, through auditors empaneled by the Computer Emergency Response Team - India (CERT-In). In alignment with the directions provided, these cybersecurity audits go beyond Vulnerability Assessment and Penetration Testing (VA/PT) of applications and systems.

The objective of the cybersecurity audit is to carry out a comprehensive assessment of all cyber assets of the power utility to identify vulnerabilities and improve security. It evaluates the resilience of IT and OT architectures, effectiveness of technical controls, system hardening, and security configurations. The audit also includes a detailed review of OT systems while considering their operational constraints. Additionally, it verifies regulatory compliance and performs gap analysis against recognized frameworks such as ISO 27001 and IEC 62443 to strengthen overall cyber resilience.

Guideline on the Scope of Vulnerability Assessment (VA) & Penetration Testing (PT): -

The scope includes assessing, identifying, analyzing, and assisting in mitigating cybersecurity vulnerabilities and should include following:

- VA/PT Assessment: Conducting a comprehensive Vulnerability Assessment & Penetration Testing of the IT/OT infrastructure and web applications.
- Reporting: Documentation and reporting of identified vulnerabilities, bugs, and other cybersecurity issues.
- Remediation: Providing required support for the closure of identified gaps and vulnerabilities.
- Compliance: Providing support for compliance with VA/PT requirements, ensuring alignment with security standards and best practices.

2.4 Capacity Building

- Regional Workshops: In line with directions issued during the Regional Power Ministers' Conference in June 2025, five workshops were organized across the Eastern, North-Eastern, Southern, Northern, and Western regions. Conducted with host utilities such as DVC, OPTCL, PGCIL, NTPC, and GSECL, these workshops brought together over 700 professionals from state utilities, central PSUs, renewable developers, and private players for awareness and sensitization.
- Capacity building exercises (tailor made) conducted in collaboration with academia (i.e. IIT Kanpur, Rastriya Raksha University, PGCOE IISC Bengaluru, and IIT Kharagpur), industry, premier cyber security organizations of India, more than 850+ power professionals trained through these programs.
- Workshops, trainings, awareness sessions, conferences and cyber security exercises are being organized regularly by various agencies including NCIIPC, CERT-in and CSIRT-power, utilities, industry and academia to spread awareness among the stakeholders.

2.5 AI Use in CSIRT-Power and Measures to Tackle AI-Driven Threats

CSIRT Power has deployed SIEM tool and is planning to integrate AI and Machine Learning tools to:

- Detect risky zones in OT and IT networks — like repeated login failures, unusual traffic, etc.
- Spot patterns of cyberattacks or insider misuse.
- AI tools help build real-time threat maps and identify high-risk assets in the grid.

Anomaly Detection: AI algorithms can be trained on historical network traffic data and system logs to establish a baseline of normal behaviour. Deviations from this baseline, such as unusual communication patterns or unauthorized access attempts, can indicate a potential cyberattack. AI can flag these anomalies for further investigation by security analysts.

Threat Intelligence Analysis: Use of AI to process and analyse large volumes of threat intelligence data from various sources. This helps identify emerging threats, understand attacker tactics and techniques, and proactively implement security measures.

CSIRT-Power is planning to implement below measures to tackle AI driven challenges:

- AI Threat Awareness: Monitoring of new threats like AI malware, data poisoning, model hacking.
- Zero Trust Model: AI-based Zero Trust security for OT systems, only tested devices are implemented.
- Red-Teaming & Simulations: Conducts AI cyberattack simulations to test readiness of the grid.
- Attackers leverage AI to orchestrate large-scale Distributed Denial of Service (DDoS) attacks against critical power grid infrastructure. It is planned to implement a multi-layered approach including traffic monitoring, rate limiting, web application firewalls, content delivery networks.
- Empowering power system officers through Trainings: Providing training programs for officers in power system. These programs cover how to detect and respond to AI-based attacks, including sophisticated social engineering tactics like deepfakes and phishing attempts. By equipping people with the knowledge and skills they need, we strengthen our human firewall and improve our overall security posture.
- Actively collaborating with CERT-In and NCIIPC to share threat intelligence about AI-related attacks.

3.0 Draft Central Electricity Authority (Cyber Security in Power Sector) Regulations, 2026

To address the Cyber Security challenges, a dedicated committee was constituted with clearly defined Terms of Reference. As part of its mandate, the committee was tasked with preparing draft cybersecurity regulations for the power sector in consultation with all concerned stakeholders. This regulation ensures that cybersecurity is addressed not only at the operational stage but also during the design, testing, and certification phases of power sector equipment, thereby reducing systemic risks from the supply chain.

The upcoming cybersecurity regulation adopts a comprehensive regulation-based approach rather than a voluntary guideline model. It directs utilities to establish a formal cybersecurity governance structure and implement business-integrated cybersecurity policies with active involvement of top management. This marks an important shift, as cybersecurity is treated as a strategic business risk rather than a purely technical issue. The regulation also emphasizes coordinated cyber incident and crisis management to ensure effective response during cyber emergencies

Upcoming regulation addresses critical concerns related to data privacy and security, supply chain risks, outsourcing arrangements, and cloud service integration, areas that were largely outside the scope of earlier guidelines. Compared to earlier cybersecurity guidelines 2021, the regulation is significantly more comprehensive. It expands coverage to include additional areas as shown Fig. 3.

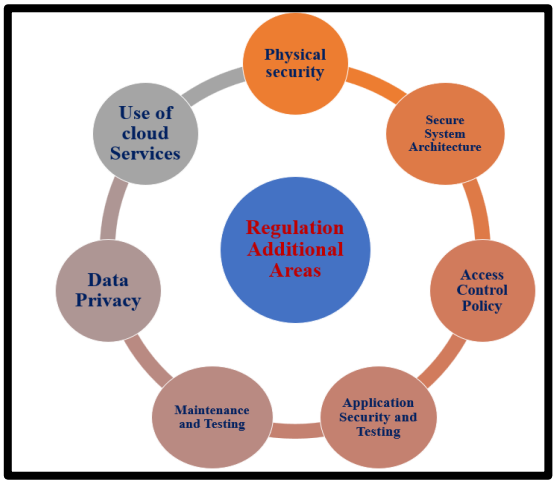


Fig 3. *Regulation Additional Areas*

By making these requirements mandatory, the regulation aims to ensure uniform implementation and consistent cybersecurity posture across the power sector.

3.1 Provision of computer security incident response team (CSIRT) – power through regulation

Draft Central Electricity Authority (Cyber Security in Power Sector) Regulations, 2026 designates CSIRT-Power as the central and authoritative body for managing cybersecurity incidents in the Indian power sector. It acts as the nodal agency for incident coordination, threat analysis, and sector-wide cyber resilience. The regulation significantly strengthens CSIRT-Power's role by granting it operational, advisory, and oversight responsibilities across all power sector entities.

Key responsibilities of CSIRT-Power include, but are not limited to:

- Coordinating response to cyber security incidents and issuing alerts, advisories, and guidelines in collaboration with CERT-In and NCIIPC
- Collecting and analysing incident data, including logs, forensic records, and system information, while ensuring protection of sensitive data
- Guiding, reviewing, and validating Cyber Crisis Management Plans (CCMPs) and overseeing cyber drills and simulations
- Enhancing sector-wide cybersecurity posture through audits, assessments, capacity building, and research collaboration

Draft regulation establishes the foundational framework for the regulation. It defines the scope, applicability, commencement, and key terminologies that are referenced throughout the regulation.

It will be applicable to:

- All entities that own, operate, or manage Operational Technology (OT) infrastructure associated with the power system.
- All Information Technology (IT) systems that are physically or logically connected to OT systems.
- Both existing and upcoming infrastructure, ensuring cybersecurity is addressed not only for new systems but also for legacy installations.
- Power Exchanges and Over-the-Counter (OTC) platforms, with specific exclusions as defined in the regulation.
- Vendors are required to comply with specific cybersecurity provisions, recognizing that supply-chain risks are a major source of cyber threats in the power sector.

3.2 General cyber security requirements

The CEA Cyber Security Regulations, 2026 translates regulatory intent into mandatory, actionable cybersecurity requirements for power sector entities. By covering leadership accountability, technical controls, workforce readiness, vendor risks, audits, and continuous monitoring, this chapter lays the foundation for sustained cyber resilience across the Indian power sector.

Key Requirements

- **Cybersecurity Governance and Leadership:** Entities are required to appoint a senior-level Chief Information Security Officer (CISO) and an Alternate CISO with clearly defined roles, reporting structure, tenure, and ring-fenced cybersecurity responsibilities. The CISO must report to the head of the entity and undergo regular cybersecurity training to maintain competence.

- **Dedicated Cybersecurity Workforce:** A dedicated Information Security Division (ISD), headed by the CISO and operating round-the-clock from within India, must be established with adequate, trained, and certified manpower deployed for a minimum tenure to ensure continuity and accountability.
- **Policies, Plans, and Crisis Management:** Entities must define and maintain a documented Cyber Security Policy (CSP) approved at the board or top management level. A Cyber Crisis Management Plan (CCMP), prepared in consultation with CSIRT-Power and vetted by CERT-In, must be implemented, tested through drills, and activated during actual cyber crises.
- **Network Segregation and Perimeter Security:** Critical Information Infrastructure (CII) networks must be logically and physically segregated from the internet and non-critical networks. Electronic Security Perimeters (ESP) must be protected using firewalls, intrusion detection and prevention systems, deep packet inspection, geo-fencing, signature and behaviour-based controls, and continuous monitoring.
- **Application, Web, and Remote Access Security:** Public-facing web applications, APIs, and services must undergo cybersecurity audit clearance before deployment. Web Application Firewalls (WAFs) are mandatory for critical applications. Remote access to cyber assets is permitted only for emergency or troubleshooting purposes, subject to CISO approval, risk assessment, continuous monitoring, and detailed logging.
- **Awareness, Training, and Cyber Exercises:** Entities must conduct regular cybersecurity awareness programs, mock drills, tabletop exercises, and simulations at least once every six months. All personnel, including vendor staff with access to critical systems, must undergo mandatory sector-specific cybersecurity training.
- **Data Protection, Cloud Security, and Vendor Management:** Sensitive and critical data, including cloud-hosted data, must be encrypted, securely stored within India, and protected through contractual safeguards such as NDAs (Non-Disclosure Agreement) and SLAs (Service Level agreement). Vendors and service providers must undergo risk assessment, comply with cybersecurity requirements, and be held accountable for breaches.
- **Backup, Audit, and Certification Requirements:** Regular online and offline backups of critical systems must be maintained in secure environments. Comprehensive cybersecurity audits, including vulnerability assessment and penetration testing (VAPT), must be conducted annually. Entities must ensure compliance with ISO/IEC 27001 or equivalent Technical Criteria Certification.
- **Asset Management and Risk Mitigation:** Entities must maintain detailed cyber asset registers, including system configurations, network architecture, and data flows. A Cyber Risk Assessment and Mitigation Plan (CRAMP) must be implemented and periodically updated to manage vulnerabilities, threats, and risks across all cyber assets.
- **Monitoring, Compliance, and Legal Alignment:** Continuous surveillance and logging of IT and OT systems is mandatory to detect threats and anomalies. Entities must comply with directions issued under the Information Technology Act, 2000, CERT-In advisories, trusted procurement requirements, and national cybersecurity directives.

3.3 Cyber security requirements for OT systems

The draft CEA Cyber Security Regulations, 2026also focuses on Operational Technology (OT) systems which directly control and monitor power system operations and therefore carry the highest operational risk in case of a cyber-attack. Unlike IT systems, OT systems demand high availability, deterministic communication, and safety assurance. This chapter introduces additional, OT-specific cybersecurity

requirements to address risks arising from IT–OT interconnection, remote operation, real-time data exchange, and supply chain dependencies.

Key OT-Specific Cyber Security Requirements

- **Physical and Logical Isolation of OT Systems:** OT systems must be physically isolated from the internet and IT networks. Where isolation is not feasible due to business requirements, controlled IT–OT interconnection is permitted only after risk assessment, approval of competent authority, and implementation of hardened logical separation with continuous monitoring and logging.
- **Perimeter Security at IT–OT Interconnection Points:** Dedicated perimeter-level cybersecurity devices such as firewalls and intrusion detection systems must be deployed at OT interconnection points. These controls must support OT protocols, deep packet inspection, behaviour-based detection, geo-fencing, and offline update mechanisms.
- **Secure Communication Channels for Power System Operations:** Control, operation, and real-time data exchange of power system elements must be carried over dedicated, secure communication channels isolated from the internet and restricted within national boundaries. Any cross-border data exchange, if required, must follow strict approval, monitoring, and security controls.
- **Controlled Remote Operation and Access:** Remote operation of OT systems is permitted only within India and strictly for business necessity, subject to prior approval of the head or board of the entity. Such access must use dedicated communication channels, be isolated from the internet, and be continuously monitored for anomalies.
- **Compliance with Testing and Operational Standards:** OT equipment, components, and systems used for control and operation of power systems must comply with applicable testing standards and directions issued by the Government of India to ensure safety, reliability, and cybersecurity assurance.
- **Isolation of OT Communication and Data:** Communication channels and operational data of OT systems must remain isolated from IT systems to prevent lateral movement of cyber threats and unauthorised access.
- **Trusted Procurement of OT Equipment and Services:** All OT equipment, components, and services must be procured only from trusted sources, in line with government-issued orders, guidelines, and trusted vendor frameworks.

3.4 Functions & responsibilities of ciso and information security division (ISD)

The draft CEA Cyber Security Regulations, 2026 mentioned about the qualifications, authority, and responsibilities of the Chief Information Security Officer (CISO) and the Information Security Division (ISD). It positions the CISO as the central nodal officer responsible for cybersecurity governance, incident reporting, compliance monitoring, and coordination with CSIRT-Power and national agencies. The chapter mandates timely reporting of cyber incidents, implementation of security controls, management of cyber risks, and maintenance of logs, asset registers, and forensic records. It also assigns responsibility for managing remote access, patching, backups, audits, threat intelligence, and cyber crisis preparedness.

Overall, this chapter ensures clear accountability, leadership continuity, and operational ownership of cybersecurity within power sector entities.

3.5 Cyber security policy (CSP)

The draft CEA Cyber Security Regulations, 2026 mandates the formulation of a comprehensive Cyber Security Policy (CSP) aligned with the entity's Business Continuity Plan and applicable to both IT and OT environments. The CSP must define governance structure, roles and responsibilities, asset classification,

risk assessment mechanisms, incident response and recovery procedures, and access control requirements. It requires guidelines for protected systems and inclusion of processes for vulnerability management, cyber sabotage reporting, and periodic review. The chapter also addresses personnel risk, supply chain risk, remote access controls, data protection, and backup policies.

Through this chapter, cybersecurity policy is institutionalized as a living document supporting continuous risk management and regulatory compliance.

3.6 Cyber crisis management plan (CCMP)

Upcoming regulation also covers the mandate of the development and implementation of a structured Cyber Crisis Management Plan (CCMP) to ensure effective handling of cyber crises in the power sector utility. The CCMP must define standard operating procedures for detection, identification, and classification of cyber incidents, along with clearly documented crisis scenarios. It requires identification of internal and external stakeholders, their roles and responsibilities, and predefined communication mechanisms to enable coordinated response during a cyber crisis. The plan must include mitigation measures to minimise impact and enable early recovery of critical operations.

It also emphasises regular testing and validation of the CCMP through annual exercises and mock drills, covering different crisis scenarios over time. Entities are required to document actual cyber crisis events, capture lessons learnt, and share relevant insights with CSIRT-Power and other stakeholders for sector-wide improvement. The CCMP is to be periodically updated by incorporating feedback, observations, and evolving threat intelligence, ensuring continuous enhancement of cyber resilience in the power sector.

3.7 Cybersecurity requirements for vendors

Upcoming regulation extends cybersecurity accountability to vendors, recognising that supply chain vulnerabilities pose significant risks to power sector. It mandates that vendors supplying hardware, software, or systems must support secure operations throughout the system lifecycle. Vendors are required to provide documented and tested recovery procedures to enable restoration of systems in case of cyber incidents.

This requires vendors to ensure timely availability of security patches and updates for all supplied systems and components until the end of contractual or useful life. Vendors must also provide complete documentation, including installation requirements, security configurations, patch dependencies, and end-of-support or end-of-life details for hardware and software. To improve transparency and trust, vendors are mandated to submit a Software Bill of Materials (SBOM) in line with CERT-In guidelines, covering firmware and software deployed in critical systems.

Vendors must also support verification of trusted sources as required by government directives. Through these provisions, the regulation strengthens supply chain security and reduces cyber risks arising from third-party dependencies in the power sector.

3.8 Cyber security audit

Upcoming regulation establishes cyber security audit as a mandatory mechanism to assess, verify, and continuously improve the cyber security posture of power sector utilities. It ensures that cyber security controls are not only implemented but also periodically evaluated for effectiveness and compliance. The chapter strengthens accountability by defining clear timelines for audit reporting, vulnerability closure, and regulatory oversight.

Key requirements:

- Cyber security audits must be conducted as per guidelines and directions issued by CSIRT-Power and other designated government agencies, covering verification of closure of previous audit findings.

- Critical and high-risk vulnerabilities must be addressed on priority, with defined timelines for remediation and deployment of compensatory controls until full closure.
- The CISO is responsible for reviewing audit outcomes, reporting major non-compliances to top management, and facilitating independent verification or third-party audits as directed by competent authorities.

4.0 Summary

The Indian power sector is a critical national infrastructure and is becoming increasingly vulnerable to cyber threats due to rapid digitalisation, IT-OT integration, remote operations, and dependence on third-party vendors and service providers. Recognizing these growing risks, the Ministry of Power, through the Central Electricity Authority (CEA), has proposed the Cyber Security Regulations, 2026 to create a strong, uniform, and enforceable cybersecurity framework for the entire power sector.

This paper provides an overview of the upcoming regulations and explains their important provisions chapter-wise to help utilities, vendors, and other stakeholders understand their roles, responsibilities, and compliance requirements. Unlike earlier advisory guidelines, the proposed regulation introduces mandatory cybersecurity governance, operational security controls, accountability mechanisms, and regulatory compliance requirements across the power sector.

The regulation gives major importance to cyber resilience by mandating regular risk assessments, cybersecurity audits, incident response planning, cyber crisis management, training programs, and mock drills. It also focuses on securing Operational Technology (OT) systems, managing legacy infrastructure, controlling remote access, and protecting Critical Information Infrastructure (CII). Special attention has been given to vendor and supply-chain cybersecurity, which is emerging as one of the biggest cyber risk areas in the power sector.

The regulations also strengthen the role of CSIRT-Power as the central agency for incident response, coordination, threat intelligence sharing, cybersecurity guidance, and sector-wide situational awareness. CSIRT-Power acts as the cybersecurity coordination and defence hub for the Indian power sector by supporting utilities in incident handling, audits, capacity building, and cyber preparedness activities. The increasing use of Artificial Intelligence (AI) in cybersecurity is helping utilities improve threat detection, predictive analysis, and automated response capabilities, while at the same time enabling attackers to launch more advanced and intelligent cyber-attacks.

Overall, the CEA Cyber Security Regulations, 2026 represent a major step towards building a secure and cyber-resilient Indian power sector. Successful implementation of these regulations will require strong management commitment, skilled cybersecurity professionals, continuous monitoring, and close coordination among utilities, vendors, regulators, and government agencies.

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CHAPTER 4
Jal Seva Aankalan: A Data-Driven, Citizen-Centred Digital Framework for Assessing Rural Water Supply Services under Jal Jeevan Mission

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ABSTRACT

The Jal Jeevan Mission (JJM) has transformed rural India's drinking water landscape by providing Functional Household Tap Connections (FHTCs) to over 15 crore rural households. As the Mission transitions to long-term service delivery, the governance challenge shifts toward ensuring regularity, adequacy, and quality across six lakh villages. Traditional functionality assessments based on periodic third-party surveys faced limitations in scale, local ownership, and real-time planning. This paper presents Jal Seva Aankalan (JSAn), a Gram Panchayat-led, census-based digital assessment framework launched in December 2025 to institutionalize participatory monitoring.

Covering 1,17,010 Har Ghar Jal reported Gram Panchayats, JSAn integrates Gram Sabha deliberations, digital data entry through JJM-IMIS, District Technical

Unit (DTU) diagnostics, and citizen feedback via the Meri Panchayat App. JSAn is a governance innovation combining decentralized democratic institutions with digital public infrastructure to create a continuous villageto-national evidence pipeline. The framework demonstrates how community-owned assessment and tiered planning can collectively strengthen accountability and sustainability. Finally, the paper highlights the replicability of the JSAn model for broader rural governance sectors including sanitation and solid waste management.

INDEX TERMS

Jal Jeevan Mission, Jal Seva Aankalan, eGovernance, Participatory Governance, Data-Driven Governance.

1. INTRODUCTION

Access to safe and reliable drinking water is a fundamental necessity and a key determinant of public health, socioeconomic development and human dignity. Recognising this, the Government of India launched the Jal Jeevan Mission (JJM) on 15th August 2019 with the ambitious goal of providing a Functional Household Tap Connection (FHTC) to every rural household. As of 2025-26, the Mission has provided tap water connections to over 15 crore rural households across India, transforming the drinking water landscape of rural communities and making it one of the world's largest rural water supply programmes. Yet the very success of this expansion has reshaped the central governance question. The policy frontier has moved beyond verifying the physical presence of a tap connection toward evaluating whether the water flowing through it meets the four-fold test of regularity, adequacy, potability and long-term sustainability.

The constitutional and institutional foundations for this transition are already in place. The 73rd Constitutional Amendment Act, 1992, through Article 243G and the Eleventh Schedule, enabled devolution of drinking water functions to Panchayati Raj Institutions, empowering Gram Panchayats to plan, implement, operate and manage local water supply systems [1]. Building on this, JJM has established a multi-tier institutional architecture: the National Jal Jeevan Mission (NJJM) provides policy direction and strategic oversight at the Centre; State Water and Sanitation Missions (SWSMs) coordinate planning, implementation and monitoring at the state level; District Water and Sanitation Missions (DWSMs), chaired by the District Collector, ensure implementation and supervision at the district level, supported by District Technical Units (DTUs) that provide continuous technical assistance; and at the village level, the Gram Panchayat - through its Village Water and Sanitation Committee (VWSC) functioning as a standing committee - serves as the owner and operator of in-village water supply infrastructure, accountable for service outcomes to households [1].

Monitoring service delivery across more than six lakh villages presents substantial administrative and governance challenges. Until recently, the primary instrument for gauging tap-water performance was the Functionality Assessment (FA) survey, commissioned to independent agencies that employed tablet/mobile-based structured household interviews (CAPI). Although these exercises delivered statistically rigorous and impartial findings, they were inherently periodic, resource-intensive and sample driven, resulting in limited village-level visibility. The 2024 survey, for instance, covered 19,812 villages across 761 districts - a statistical sample that, while representative, could not capture the granular reality of every village [2].

Jal Seva Aankalan (JSAn) was conceptualised to address these limitations. The Operational Guidelines for JJM 2.0 (April 2026) formally institutionalise JSAn as a community-led governance tool, mandating that Gram

Panchayats and VWSCs undertake periodic self-assessment of drinking water service delivery, with findings publicly disclosed and used to prepare Service Improvement Plans at district and state levels (Section 3.6.1) [1]. Formally inaugurated on 30 December 2025 by the Union Minister for Jal Shakti through the JJM-IMIS Panchayat Dashboard, JSAn represents a transition from externally administered, sample-driven evaluation toward an institutionalised, community-owned, census-scale digitally enabled selfassessment framework linked to structured improvement planning. It covers all 1,17,010 HGJ reported Gram Panchayats reported on or before 31.12.2024, making it one of the largest participatory digital governance exercises in rural public service delivery globally.

This paper presents Jal Seva Aankalan as a model of data driven administrative reform and participatory digital governance. It analyses how JSAn integrates democratic local institutions, interoperable digital platforms and structured governance workflows to establish a scalable framework for continuous service delivery assessment and evidence-based decision-making.

2. METHODOLOGICAL APPROACH

This paper adopts a descriptive and institutional governance analysis approach to examine the design, operationalisation and governance architecture of Jal Seva Aankalan under Jal Jeevan Mission. The analysis is based on: official operational guidelines and Standard Operating Procedures (SoPs); Jal Jeevan Mission administrative communications; JJM-IMIS workflow architecture; GP Assessment and DTU Review formats; implementation advisories issued by DDWS; functionality assessment reports; and administrative process mapping of JSAn workflows.

The study focuses on: governance architecture; citizen participation mechanisms; digital platform integration; administrative accountability structure; data governance framework; and date driven evidence-based planning mechanisms. The paper does not attempt statistical evaluation of water supply outcomes but instead analyses JSAn as an institutional and e-governance innovation within the broader framework of decentralised rural service delivery.

3. GOVERNANCE CHALLENGE IN RURAL WATER SUPPLY MONITORING

The transition of Jal Jeevan Mission from infrastructure expansion to sustained service delivery created new governance requirements. Rural water supply systems require continuous monitoring of regularity of supply, adequacy of water quantity, water quality, functionality of schemes, source sustainability, operation and maintenance systems, and citizen satisfaction.

Traditional monitoring approaches were insufficient for continuous service governance at national scale. The major governance challenges included:

- **Scale and Coverage Challenge:** India has more than six lakh villages and lakhs of water supply infrastructure assets distributed across geographically diverse terrains. Periodic sample surveys could not provide universal administrative visibility.
- **Delayed Corrective Planning:** Sample survey findings often became available months after field assessment, limiting timely operational interventions.
- **Weak Local Ownership:** Externally conducted assessments often treated citizens as respondents rather than governance participants, resulting in limited community ownership of outcomes.
- **Fragmented Accountability:** Village-level issues frequently travelled upward administratively without structured root cause analysis or prioritised planning mechanisms.
- **Limited Citizen Verification:** Existing systems lacked institutionalised mechanisms for post-reporting citizen validation and grievance-based correction.

These governance gaps necessitated a new monitoring architecture that was decentralised, digitally integrated, community-owned, administratively actionable and scalable at national level.

4. JAL SEVA AANKALAN: CONCEPT AND GOVERNANCE ARCHITECTURE

Jal Seva Aankalan is conceived as a systematic, village owned evaluation mechanism in which elected Panchayat institutions and community members jointly appraise the performance of rural water supply services using structured digital workflows Unlike conventional audit or inspection mechanisms, JSAn is designed as a participatory governance process where citizens collectively assess the status of water supply services through Gram Sabha deliberations [3].

A) Assessment Framework: Six Pillars

The assessment is anchored in six thematic pillars that together capture the full spectrum of service performance: (i) Regularity - whether supply conforms to its declared schedule throughout the year, including seasonal variation; (ii) Adequacy - whether per-capita availability meets the

Mission's 55 LPCD norm at the habitation level; (iii) Quality - encompassing treatment processes, disinfection practices, and the frequency and coverage of Field Test Kit (FTK) testing; (iv) Source Sustainability - existence of recharge structures and protective measures to safeguard long-term source viability; (v) Skilled Manpower for O&M - whether trained operators are available and have undergone recognised capacity-building programmes; and (vi) Recurring Issues - a structured catalogue of persistent operational problems such as pipeline breakage, pump failure or power-supply disruptions.

B) Four-Tier Digital Architecture

JSAn follows a structured four-tier mechanism that creates a seamless digital pipeline from village-level assessment to national-level planning:

Tier 1 – GP Assessment Form: A village-level service assessment form filled by the Panchayat Secretary on JJMIMIS after Gram Sabha deliberation, capturing ground-level status of water supply services across all six pillars. The form contains over 40 data fields covering coverage, regularity, adequacy, quality, maintenance, source sustainability and institutional participation [3]. Importantly, the data reflects collective community deliberation rather than individual reporting.

Tier 2 – DTU Review Form: A diagnostic root cause analysis form filled by the District Technical Unit (DTU) for each adverse response reported in the GP Assessment Form. Issues are classified into technical, infrastructure, operational and institutional categories, transforming raw assessment data into actionable intelligence.

Tier 3 – District Improvement Plan (DIP): District Water and Sanitation Missions (DWSMs) prepare prioritised District Improvement Plans based on aggregated GP and DTU findings. This enables evidence-based allocation of resources and targeted interventions.

Integration with ABDM and national health registries enables standardized, consent-based data exchange. Adoption of interoperability standards such as FHIR and HL7 ensures seamless communication across systems [1]. The platform also supports lab analyser integrations which is supporting direct lab result recordings (eliminating human intervention in between) into the HMIS. This architecture supports scalability across thousands of healthcare facilities while maintaining performance, security, and reliability.

Tier 4 – State Improvement Plan (SIP): State-level aggregation and planning by the State Water and Sanitation Mission (SWSM), identifying systemic issues, inter-district variations and policy interventions requiring state-level support.

This architecture ensures that data flows upward for planning while accountability remains anchored at the village level. A deliberate design choice is that no tier above the village is empowered to approve, reject or modify the GP's reported data - their role is facilitative and supportive, preserving the community ownership of the assessment process [3].

5. CITIZEN PARTICIPATION AS THE CORE GOVERNANCE PRINCIPLE

The most distinctive feature of Jal Seva Aankalan is that it places citizens and their elected local institutions at the centre of the assessment process. JSAn data originates from community deliberation and is validated through democratic processes.

A) VWSC-led Focused Group Discussion

The assessment process begins with a structured Focused Group Discussion (FGD) convened by the VWSC. Participants include VWSC members, Panchayat Secretary, water users (including women, SC/ST and vulnerable groups), ASHA and Anganwadi workers, FTK-trained women, SHG members, pump operators and O&M contractor representatives [3]. Discussions are conducted in the local language, translating technical parameters into everyday experience - for example, whether each household member can fill enough vessels during a single supply cycle serves as a proxy for adequacy. This ensures that technical service parameters are translated into lived community experience.

B) Gram Sabha Validation and Collective Endorsement

The findings of the VWSC meeting are presented before the Gram Sabha - the constitutionally mandated assembly of all village voters. The Panchayat Secretary explains each assessment question, and discussions focus on collective experience rather than individual opinions.

This process embeds three critical governance principles: (a) informed consent - citizens understand what is being assessed and why; (b) collective validation - the data represents community consensus, not an individual's view; and (c) democratic accountability - the Gram Sabha resolution creates a public record that the community can hold its institutions accountable against.

C) Digital Transparency and Citizen Feedback

Once the digital form is finalised on JJM-IMIS, its contents are automatically published on the Meri Panchayat App, opening a time-bound window during which any resident of the village may raise objections or flag discrepancies. This post-submission disclosure layer introduces four reinforcing governance benefits: transparent public access to official records, citizen-driven scrutiny of self-reported data, participatory validation that extends beyond the Gram Sabha hall, and a digital trail of accountability linking each concern to a responsible administrative tier.

D) Inclusive Participation Design

JSAn deliberately mandates the participation of marginalised community members. The GP Assessment Form records the presence of SC/ST representatives, ASHA workers, Anganwadi workers, and FTK-trained women in the Gram Sabha [3]. This is not merely a formality - the presence of frontline health and nutrition workers ensures that water quality and its impact on vulnerable populations (children, pregnant women, elderly) is factored into the assessment. Women's participation is further strengthened through FTK-trained women who present their water quality test registers to citizens during the Gram Sabha, adding a technical validation layer to community deliberation.

TABLE I: COMPARISON: THIRD-PARTY SURVEY VS. JAL SEVA AANKALAN

Parameter	FHTC Survey 2024	JSAn 2025-26
Approach	Third-party independent survey	GP-led self-assessment
Coverage	Sample-based (19,812 villages)	Census-based (1,17,010 GPs)
Data Source	CAPI household interviews	Gram Sabha deliberation + digital entry
Citizen Role	Respondent (passive)	Validator and feedback provider (active)
Validation	Multi-level survey supervision	Gram Sabha resolution + Meri Panchayat App
Diagnostic Layer	Not applicable	DTU root cause analysis
Improvement Planning	Not directly linked	DIP & SIP modules on JJM-IMIS
Frequency	Periodic (biennial)	Annual (institutionalised)
Cost	Significant (third-party engagement)	Minimal (existing institutional setup)

6. DATA-DRIVEN ADMINISTRATIVE REFORM AND GOVERNANCE INNOVATIONS

JSAn introduces several significant governance innovations within public service monitoring systems.

A) Data Integrity and Finality

A critical design safeguard is the immutability of submitted records: once the Panchayat Secretary finalises the digital form, no higher-level functionary - at the district or state tier - can edit or override the entries. Officials at these levels retain read-only access and that too is enabled once 90% of eligible GPs filled the GP level assessment form. This architectural choice insulates village-level reporting from administrative pressure and preserves the authenticity of community-generated evidence [3].

B) Record Preservation

As per the advisory dated 30th January 2026, Panchayat Secretaries are required to preserve hard copies of Gram Sabha resolutions, signed Jal Seva Aankalan Forms and attendance sheets for a minimum of one year

[5]. This parallel paper archive creates a verifiable audit trail that can be cross-referenced against the digital submission whenever independent scrutiny is warranted.

C) Citizen Verification Layer

Public disclosure through Meri Panchayat App enables participatory verification of official records.

D) Leveraging Existing Digital Infrastructure

A key design principle of JSAn is that it does not create new technology platforms but leverages existing government digital infrastructure. The Panchayat Secretary uses existing eGramSwaraj portal credentials to access the JJM-IMIS Panchayat Dashboard through API sharing. Citizens access data through the already-established Meri Panchayat App. Water quality data connects with the existing Water Quality Management Information System (WQMIS) [4]. This approach minimises technology adoption barriers, reduces costs and ensures interoperability across government platforms.

E) Evidence-Based Planning and Convergence

The structured data generated by JSAn enables evidencebased planning that was previously not possible with sample-based surveys. Districts can now identify specific villages with water quality issues, map source sustainability concerns geographically, prioritise O&M interventions based on actual disruption patterns and plan targeted training programmes based on skill gaps reported by villages. The data also supports convergence with related programmes such as the Gram Panchayat Development Plan (GPDP) under the Ministry of Panchayati Raj, ensuring that water service improvement is integrated into broader village development planning.

TABLE II: GOVERNANCE OUTCOME MATRIX

Governance Challenge	JSAn Intervention	Governance Outcome
Sample-based monitoring	Census-based GP assessment	Full administrative visibility
Weak citizen ownership	Gram Sabha-led validation	Community accountability
Delayed issue identification	Digital IMIS workflow	Faster planning response
Fragmented diagnostics	DTU root cause analysis	Evidence-based interventions
High assessment cost	Existing PRI ecosystem utilisation	Cost optimisation
Limited transparency	Meri Panchayat App disclosure	Public scrutiny
Hierarchical reporting pressure	Immutable GP submissions	Improved data integrity
Silo-based planning	DIP & SIP integration	Structured planning architecture

7. RESULTS AND KEY LEARNINGS

The first cycle of Jal Seva Aankalan was operationalised across all States and Union Territories, covering HGJ reported Gram Panchayats on or before 31.12.2024 through the structured four-stage process. Key learnings from the design and implementation include:

Participatory Governance at Scale: JSAn demonstrates that Gram Sabha-based governance can be operationalised at national scale through interoperable digital systems.

Low-Cost Governance Innovation: By utilising existing institutional structures (VWSC, Gram Sabha, Panchayat Secretary) and digital platforms (eGramSwaraj, JJM-IMIS WQMIS, Meri Panchayat App), JSAn achieves census-level coverage at a fraction of the cost of sample-based thirdparty surveys.

Closing the Accountability Loop: The four-tier architecture ensures that each administrative level does its own work - villages assess, DTUs diagnose, districts plan and states coordinate. This prevents problems from simply being passed upward and creates accountability at every tier. Each tier adds value rather than merely forwarding data.

Democratic Data Generation: Unlike top-down data collection systems, JSAn data is generated through democratic deliberation. The requirement that the Gram Sabha approve the assessment through a formal resolution, combined with the citizen feedback window on the Meri Panchayat App, creates a dual-validation mechanism that enhances data credibility while strengthening democratic governance at the grassroots level.

Replicability Across Sectors: The JSAn model - combining Gram Sabha deliberation, digital data entry, citizen feedback and tiered improvement planning - is replicable across other rural service delivery domains such as sanitation, solid waste management, rural roads and Gram Panchayat service delivery systems. The framework offers a template for any programme seeking to transition from periodic external evaluation to continuous community-owned monitoring.

8. CONCLUSION AND WAY FORWARD

Jal Seva Aankalan represents a fundamental reimagining of how government programmes are monitored and assessed. By placing the Gram Sabha at the centre of the assessment process, it transforms citizens from passive beneficiaries into active evaluators of service delivery. By leveraging existing digital platforms, it creates a cost-effective, scalable and sustainable monitoring ecosystem. By structuring data flow through a four-tier architecture, it enables evidence-based planning from village to national level.

The framework demonstrates that data-driven governance need not be centralised or technology-dominated. When digital systems are designed around democratic local institutions such as the Gram Sabha and VWSC, they can strengthen citizen ownership, transparency and accountability in public service delivery.

JSAn establishes a scalable governance model where: citizens generate and validate service delivery data; digital platforms enable transparency and interoperability; administrative tiers undertake structured diagnostic and planning functions; and evidence flows seamlessly from village to state level.

The framework aligns strongly with the broader national vision of Digital India, Panchayati Raj strengthening, localisation of Sustainable Development Goals (SDGs) and Viksit Bharat 2047.

Going forward, JSAn will be institutionalised as an annual assessment cycle, with the data repository growing richer each year. Integration with AI-based analytics on JJM-IMIS could enable predictive identification of service delivery risks, automated flagging of anomalies and intelligent prioritisation of improvement interventions. The four-tier data pipeline - JSA assessments at the GP level, DTU diagnostics at the district level, District Improvement Plans and State Improvement Plans - constitutes a nationally-scaled, structured dataset spanning approximately 1.17 lakh Gram Panchayats, creating a unique foundation for AI-enabled governance. The citizen feedback mechanism through the Meri Panchayat App can be strengthened to enable real-time, continuous monitoring beyond the 30-day window. Future cycles may also explore integration with IoT-based water quality sensors and smart metering to complement community perceptions with realtime instrumentation data. Jal Seva Aankalan is not merely a monitoring

tool - it is a governance innovation that embodies the principle that the best custodians of public services are the citizens who use them every day.

9. ACKNOWLEDGEMENTS

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CHAPTER 5

Puramithra: AI- Enabled Advisory System A Platform for Data- Driven Urban Governance and Citizen Service Delivery in Andhra Pradesh

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ABSTRACT

India's Urban Local Bodies (ULBs) are mandated to deliver a diverse portfolio of civic services - from property tax collection and water supply billing to trade licences, building permissions and grievance redressal - yet most ULBs continue to operate through fragmented, department- specific portals that citizens with multiple interfaces and deny administrators a unified view of urban performance. [1]. The Government of Andhra Pradesh has addressed this challenge through Puramithra - a blend of 'Pura' (Urban) and 'Mitra' (Friend) - an integrated, AI- enabled municipal governance platform that unifies payments (property tax, water tax, trade licences), municipal services and citizen grievances into a single, accessible digital ecosystem across all 123 ULBs.

Puramithra's AI engine, trained on over one million urban issue images, automates grievance classification, while its GIS- driven spatial analytics identify infrastructure hotspots and generate optimised field visit advisories for Commissioners [2]. With 18,06,466 registered citizens, a 98.45% grievance resolution efficiency and an AI advisory system serving every tier of the municipal hierarchy, Puramithra demonstrates how artificial intelligence can be institutionalised within urban governance to deliver accountable, citizen- centric outcomes [3].

The platform's way forward envisions a single unified AI Advisory Platform - one interface for every citizen need and every administrative decision, irrespective of whether it concerns a payment, service, grievance or entitlement - aligned with the Viksit Bharat 2047 vision.

INDEX TERMS

Integrated Urban Governance, AI- Driven Advisory System, Municipal Payments, Property Tax, Water Tax, Grievance Redressal, GIS Analytics, Smart Cities, Puramithra, e- Governance, SLA Compliance, Unified Digital Platform, Swarna Andhra 2047.

1. INTRODUCTION

The Government of Andhra Pradesh has formalised a progressive paradigm for urban governance through its Swarna Andhra @2047 vision, structurally guided by its strategic pillars known as the "Padi Sutralu" - ten guiding principles designed to transform Andhra Pradesh into a globally competitive, wealthy, healthy and happy state by the centenary of India's independence [4]. A core directive among these principles is the integration of Deep Tech across all walks of governance and public life, positioning Andhra Pradesh as a national innovation leader.

Swarna Andhra's deep tech vision is not confined to research parks and investment summits. It finds practical expression in governance platforms like Puramithra - where AI classifies citizen grievances, GIS analytics guide Commissioner field visits, and predictive intelligence enables pre-emptive infrastructure maintenance across 123 Urban Local Bodies. This is the Padi Sutralu principle in action: deep technology embedded not as a showcase but as the daily operating layer of state administration, delivering the accountable, citizen- centric governance that Swarna Andhra @2047 promises every resident of Andhra Pradesh [5]

Urban Local Bodies are the closest tier of government to the citizen. They collect property taxes and water charges, issue trade licences and building permissions, maintain sanitation infrastructure, respond to civic complaints and administer welfare programmes. Yet the citizen's experience of interacting with a ULB has historically been characterised by fragmentation - a different office for each service, a different portal for each payment, a different complaint channel for each department [6]. This multiplicity imposes a disproportionate burden on citizens with limited digital literacy or time - precisely those whom municipal governance is most obligated to serve.

As Andhra Pradesh moves toward the Swarna Andhra @2047 milestone, sustainable progress relies on digitally empowering existing grassroots institutions - specifically the Swarna Wards - by equipping them with real- time data engines and an AI- based digital ecosystem.

The Government of Andhra Pradesh has advanced this vision through Puramithra - an integrated, AI-enabled urban governance platform that unifies payments (property tax, water tax, trade licences, building permissions), municipal services and citizen grievances into one platform across all 123 Urban Local Bodies.

This paper presents Puramithra's integrated architecture, its AI- driven advisory capabilities, performance outcomes, and its roadmap toward a Universal AI Advisory Platform aligned with Viksit Bharat 2047.

2. OBJECTIVE, NEED AND PROBLEM CONTEXT

2.1 Objective

Puramithra's foundational objective is to make every urban municipal service - payment, application, complaint, entitlement - accessible through a single, AI- powered platform that simultaneously generates real- time governance intelligence for administrators at every tier [2] Specific objectives include:

- Provide citizens a single digital interface for all municipal payments - property tax, water tax, trade licences and building permissions - eliminating the need to navigate multiple portals or offices.
- Enable image- based grievance filing with AI- powered classification and automatic routing to the responsible ward- level officer without manual intervention.
- Generate GIS- driven infrastructure hotspot maps and optimised field visit advisories for ULB Commissioners using aggregated grievance and service data.
- Deliver tiered AI advisories from Ward Secretaries to state administrators, converting raw operational data into actionable governance intelligence. [7] [2].
- Build a unified, language- inclusive platform in English and Telugu, accessible to all citizens irrespective of digital literacy, in line with the Digital India accessibility mandate [8].
- Establish a replicable, AI- governed urban services model for adoption across Indian ULBs under the Viksit Bharat 2047 framework.

2.2 Problem Context and Need

Prior to Puramithra, the urban governance landscape in Andhra Pradesh exhibited structural inefficiencies common across Indian ULBs [1] [6]:

- Citizens had to visit separate municipal counters or navigate multiple portals to pay property tax, utility payments and service requests.
- Grievance filing required physical visits; no unified digital registry existed across departments, creating persistent data silos [9].

- Municipal revenue collection for property tax and water charges suffered from low digital adoption, high default rates and absence of demand- side analytics.
- No accountability mechanism existed at field- officer level; escalation was entirely manual and subject to systemic delays.
- Senior administrators received periodic paper reports rather than real- time dashboards, making timely corrective action impossible.

Municipal Commissioners lacked a unified view of ward- level operations, revenue health, service delivery status and grievance patterns simultaneously. The absence of an integrated data layer prevented the cross-departmental intelligence necessary for responsive urban governance.

3. PURAMITHRA: INTEGRATED PLATFORM ARCHITECTURE

3.1 A Unified Municipal Services Ecosystem

Puramithra's fundamental design principle is integration. Rather than digitising individual services in isolation, the platform aggregates the full spectrum of citizen- facing municipal functions into one application - accessible through a mobile app and web application with a common AI intelligence layer operating across all modules [2]. A citizen paying property tax, checking a water bill, filing a drainage complaint and enquiring about a welfare scheme can complete all these interactions through a single session - in Telugu or English, by voice or by text - without switching platforms, portals or counters.

To prevent confusion and accelerate problem- solving, Puramithra automatically routes citizen inputs into 8 municipal categories comprising 124 sub- categories. This structural grouping ensures that grievances are immediately assigned to the correct department without manual sorting delays, in alignment with the CPGRAMS framework for categorised grievance management at the national level [10].

Table 1. Puramithra Functional Categories

S.No	Name of Category	No. of Sub- categories
1	Administration	6
2	Engineering	18
3	Public Health & Sanitation	56
4	Revenue	12
5	Town Planning	13
6	Urban Poverty Alleviation	12
7	Water Supply	4
8	Street Lighting	3

3.2 Municipal Payments: Property Tax, Water Tax and Licences

Municipal payments represent the financial foundation of ULB operations. Puramithra integrates the primary revenue- generating services directly into the citizen interface, in alignment with the Ministry of Finance's push for digital payment adoption across municipal bodies under the Digital India programme [8]:

Property Tax: Citizens can view tax assessments, check outstanding dues and arrears, make full or partial payments with instant digital receipts, file self- assessment revisions and raise objections - all within the

application. AI- driven demand analytics identify high- default areas and generate targeted notice delivery advisories for revenue officers.

Water Tax and Charges: Water bill viewing, payment, new connection applications, metre reading dispute submissions, disconnection and reconnection requests are managed within Puramithra. Real- time billing status and payment confirmation replaces the previous system of separate utility portal navigation.

Trade Licences and Building Permissions: Business owners and property developers can apply, renew, pay fees, track inspections and receive status notifications - eliminating multiple office visits that were a significant compliance burden on small and micro enterprises, consistent with the Ease of Doing Business reforms under the DPIIT framework [11].

By integrating these payment services, Puramithra transforms the ULB from a series of disconnected counters into a unified digital municipality - where revenue collection, service delivery and civic accountability operate from a common data foundation.

3.3 AI- Based Grievance Detection and Classification

Puramithra's grievance module is powered by an AI vision model trained on over one million urban issue images, sourced from the earlier Puraseva platform, documented environmental blackspots and comprehensive field datasets [2]. The citizen workflow is intentionally minimal: one photograph triggers the entire governance response chain.

- The AI model instantaneously classifies the uploaded image into the correct sub- category from 124 options across 8 municipal departments wings.
- Embedded GPS metadata pins the complaint's precise geographic location automatically.
- The grievance is routed directly to the responsible Swarna Ward Secretary without manual intervention.
- The SLA countdown initiates in real time, and citizens receive live status updates until resolution - consistent with the proactive disclosure norms under the Right to Information Act, 2005 [12]
- English and Telugau voice and text chatbot interfaces ensure accessibility for citizens with limited smartphone proficiency.

This Snap- Submit- Sort architecture eliminates the burden on citizens - who no longer need to identify the correct department - removes manual routing bottlenecks, and places accountability with the Swarna ward level official geographically having jurisdiction to the issue.

3.4 Decentralised Execution: Swarna Ward Architecture

Puramithra's governance model is structured around Andhra Pradesh's Swarna Ward offices - the grassroots administrative unit, operationalising the decentralisation mandate of the 74th Constitutional Amendment, 1992 [13] Each Ward Secretary receives geo- tagged work orders - whether grievances, service requests or payment- related field tasks - directly on their mobile device, building personal accountability into day- to- day administration. This decentralised architecture ensures that AI intelligence generated at the platform level translates into physical ward- level action, rather than remaining confined to dashboard visualisations.

4. AI- DRIVEN ADVISORY SYSTEM: FRAMEWORK AND ANALYSIS

Puramithra's most transformative capability is its AI- Driven Advisory System - an integrated intelligence layer that converts the platform's unified data pool (payments, services, grievances, field operations) into actionable advisories for every tier of municipal administration. This is what distinguishes Puramithra from

a digitisation initiative: it is a governance intelligence platform, consistent with the National e- Governance Plan's vision of integrated service delivery [14].

4.1 SLA- Based Accountability and Automated Escalation

Every grievance and service request on Puramithra carries a pre- determined SLA resolution window, in alignment with the Service Level Agreement norms prescribed under the Andhra Pradesh Municipal Administration Act [15]. The system enforces compliance through two mechanisms. Real- Time Citizen Tracking makes visible to the citizen which official holds their request and how much SLA time remains, creating social accountability alongside institutional accountability. The Automated Escalation Matrix ensures that any SLA breach without a validated technical justification triggers automatic escalation to the supervising municipal officer, bypassing manual reporting chains. This automated loop has delivered a grievance resolution efficiency of 98.45–98.7% - among the highest recorded for any urban governance platform in India, substantially outperforming the national CPGRAMS average [10].

4.2 GIS- Driven Hotspot Detection and Field Visit Advisory

Individual grievances reveal isolated incidents. Puramithra's AI backend aggregates spatial data across all service and complaint records to reveal systemic infrastructure failures, operationalising the GIS- based urban management principles recommended under the Smart Cities Mission [16]:

- 100- Metre Buffer Rule: Five or more same- type complaints within a 100- metre radius automatically trigger a high- priority Hotspot flag, indicating infrastructural breakdown rather than a one- off issue.
- Automated Hotspot Maps: Priority- ranked, colour- coded GIS hotspot maps are pushed to ULB Commissioner dashboards, synthesising grievance volume, severity, SLA breach rates and geographic clustering.
- Optimised Field Visit Routing: The dashboard computes the most efficient inspection route for the Commissioner's daily field visit, maximising public impact per unit of executive time.

This spatial intelligence layer transforms Puramithra's unified data - spanning payments, services and grievances - into a live urban health map unavailable under any fragmented departmental data model.

4.3 Commissioner Field Visit Module

Each day, ULB Commissioners undertake AI- guided field inspections recorded within the APCMMS (Andhra Pradesh Consistent Monitoring of Municipal Services) application, covering: direct verification of AI- identified grievance hotspots; sanitation and public health infrastructure; Anna Canteen food quality audits (the state- run initiative providing affordable ₹5 meals to ensure food security); and civil works and encroachment enforcement. By grounding senior executive decisions in AI- generated spatial intelligence rather than subordinate verbal reporting.

4.4 Tiered Advisory Intelligence Across the Administrative Hierarchy

Puramithra delivers differentiated advisory outputs calibrated to each administrative level, ensuring that AI- generated insights drive actionable guidance at every tier rather than producing undifferentiated data outputs [3]:

- Ward Secretaries receive real- time, geo- tagged work orders with SLA deadlines across grievances, service applications and revenue tasks.
- ULB Commissioners receive GIS hotspot maps, optimised field inspection routes, payment collection dashboards and operational readiness reports.

- State- Level Administrators access aggregated cross- ULB performance data enabling comparative benchmarking, policy design and resource allocation decisions across Andhra Pradesh.

5. PERFORMANCE AND IMPACT

Table 2 presents the key performance indicators of the Puramithra platform as of 2025–26 [2].

Indicator	Value
Urban Households Covered	~47 Lakh
Registered Citizens	18,06,466
Urban Local Bodies Covered	123 ULBs
Total Grievances Registered	1,27,893+
Total Grievances Resolved	1,25,915+
Grievance Resolution Efficiency	98.45–98.7%
SLA- based Timely Resolution	~80%
AI Model Training Dataset	1 Million+ Images
Municipal Categories / Sub- categories	8 / 124
Citizen Interface Languages	English & Telugu (Voice + Text)

The 98.45–98.7% grievance resolution efficiency - achieved through AI classification, automated routing, SLA enforcement and escalation - substantially outperforms national averages for urban grievance platform. Citizen adoption of 18,06,466 registered users across approximately 47 lakh urban households reflects a platform penetration rate of approximately 39% of urban households without mandatory enrolment - a level of voluntary digital adoption that validates the platform's utility- first design approach, consistent with the Digital India user- centric service delivery model [8].

The integration of municipal payments within Puramithra has produced measurable improvements in digital revenue collection, reducing citizen footfall at municipal counters and enabling real- time reconciliation of payment receipts against demand registers. The GIS field visit module has redirected Commissioner inspection priorities from routine patrol patterns toward data- identified high- impact locations, producing demonstrable improvements in SLA compliance rates after executive intervention [2]

Critically, the platform's architecture - unified data across payments, services and grievances - enables cross- domain analytical intelligence that siloed departmental portals cannot generate. A ward with high property tax arrears, elevated water supply complaints and repeated sanitation grievances can now be identified as a compound vulnerability requiring multi- departmental intervention, reflecting the integrated service delivery vision of the National Urban Policy Framework [17].

6. EMPIRICAL SUCCESS OF PURAMITHRA

Puramithra institutionalises AI across the full urban governance cycle - from a citizen photographing a pothole to a commissioner receiving a data- driven field advisory - making AI- enabled governance a daily administrative reality rather than a showcase capability, operationalising NITI Aayog's National Strategy for AI in public service delivery [5].

- Unified payment, service and grievance data drives SLA enforcement, hotspot detection, revenue analytics and tiered executive advisories - representing data- driven administrative reform at demonstrable scale, aligned with sub- theme 2 of the 29th NCeG on Data- Driven Administrative Reforms and Citizen Service Delivery.

- Puramithra operationalises the Smart City vision across 123 ULBs of varying size and capacity - demonstrating that AI- driven urban governance is achievable beyond Smart Cities Mission pilot cities, extending the benefits of intelligent urban management to Tier- 2 and Tier- 3 municipalities [16].
- By routing all functions - payments, services, grievances - to Swarna Ward Secretaries, Puramithra embeds digital accountability at the most decentralised tier of urban administration, fulfilling the spirit and letter of the 74th Constitutional Amendment, 1992 [13].

7. WAY FORWARD: UNIVERSAL AI ADVISORY PLATFORM

Puramithra's integrated architecture and performance record establish the foundation for its next evolutionary phase: a Universal AI Advisory Platform - a single AI- powered interface through which any citizen can meet any municipal need and any administrator can receive AI- generated guidance on any governance function, irrespective of whether it concerns a payment, service, grievance, entitlement or policy decision [3].

7.1 Vision: One Platform, Every Need

The core principle of the Universal AI Advisory Platform is universality of access. A citizen should not need to classify their need as a 'payment', 'service', 'grievance' or 'scheme enquiry' - they should be able to express their need and receive AI- guided resolution through one interface [5]. The platform will serve:

- Citizens seeking to pay property tax, file a complaint, check water supply status, apply for a welfare scheme or obtain a trade licence - through one conversational AI interface in their preferred language.
- Swarna Ward Secretaries and Municipal Officers managing integrated work queues spanning revenue, services and grievances - with AI advisory synthesising priorities across all domains.
- ULB Commissioners overseeing holistic urban performance in a single executive dashboard.
- State Administrators benchmarking ULBs across all dimensions to inform policy and resource allocation.
- Elected Representatives monitoring Swarna ward level performance across all municipal functions with real- time, verified data, supporting the accountability framework under the 74th Amendment [13].

7.2 Technical Roadmap

The Universal AI Advisory Platform will advance across four technical dimensions. A Universal Service Layer will expand Puramithra's framework to encompass every municipal citizen interaction into a single AI- navigated interface.

A Conversational AI Interface powered by a large language model will accept voice, text and image inputs in English, Telugu and regional dialects - consistent with India's multilingual accessibility commitments under the National Language Technology Mission [18].

Cross- Departmental Data Integration will connect Puramithra's AI engine across all state department systems, enabling holistic advisory outputs rather than departmental data silos. Finally, a Privacy- Preserving Federated Architecture will enable AI model learning from all 123 ULBs without centralising personally identifiable citizen data, ensuring full compliance with the Digital Personal Data Protection Act, 2023 [19].

8. CONCLUSION

Andhra Pradesh has crossed a significant milestone in its digital governance journey. Through Puramithra, the state has demonstrated that artificial intelligence is no longer a future aspiration for urban administration - it is a present reality, operating daily across every Urban Local Body, serving citizens, guiding field officers and informing executive decisions simultaneously. That achievement, built from the ground up across municipalities of every size and capacity, places Andhra Pradesh firmly among India's leading digital governance states.

Yet the state is not resting on that foundation. The Swarna Andhra @2047 vision and its Padi Sutralu principles signal a government that views Puramithra not as a destination but as a starting point. The planned evolution toward a universal AI Advisory Platform - one intelligent interface for every citizen need and every administrative decision - reflects an ambition that goes well beyond digitising existing services. It is a reimagination of how government and citizen relate to each other in the digital age. With Quantum Valley rising in Amaravati, AI academies being established across higher education institutions, and deep tech embedded as a core governance principle, Andhra Pradesh is assembling the infrastructure, talent and institutional will to become India's digital governance leader [5]. The convergence of citizen- facing platforms like Puramithra, state- level AI ecosystems and a long- term vision anchored in technology for public good positions the state to set the standard that others will follow.

The journey from fragmented municipal counters to an AI- guided urban ecosystem has already begun. The next chapter - a fully integrated, predictive and proactive digital state - is well within reach. Andhra Pradesh is not waiting for the future of governance to arrive. AP is building it.

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CHAPTER 6
Putting Citizens First: How Stakeholder Consultation Shaped Kerala's Strategic AI Governance Initiatives

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ABSTRACT

Before a single line of architecture was written for Kerala's three flagship AI programmes, the state government went out and asked people. Not industry representatives. Not IT consultants. Farmers in Wayanad, teachers in Palakkad, fisherfolk in Kasaragod, homemakers in Alappuzha, and retired government servants in Pathanamthitta — 2,100 respondents across all 14 districts of Kerala, interviewed in Malayalam, about what they actually expected from Artificial Intelligence, what made them uneasy about it, and under what conditions they would trust a government AI system at all. This paper reports those findings and explains how they shaped the Kerala AI Mission (K-AIM), the K-AI Initiative convergence platform, and the VidyAI Programme. What students wanted, most insistently, was an AI tutor for mathematics that explains reasoning rather than dispensing answers, general public wanted a welfare navigation system that stops demanding the same documents from seven different windows, employment preparation tools in a language they actually speak, and healthcare guidance that does not try to replace their doctor. What they feared was plainer still: that their Aadhaar data and health records would be misused, that AI would flood digital channels with convincing misinformation, and that the jobs of people they knew would quietly disappear. Those concerns are now governance requirements built into K-AIM's design, not optional safeguards to be considered later. The paper traces that path from listening to building.

INDEX TERMS

K-AIM, K-AI Initiative, VidyAI, stakeholder consultation, public value, Kerala, Malayalam AI, citizen-centric governance, e-Governance, DPDP Act 2023.

1. INTRODUCTION

"Technology that is not built around people ends up adding another form to fill, another trip to an office, another password to forget." That line came from a planning discussion inside the Government of Kerala, and it stuck. Not because it is particularly original, but because everyone in the room had seen it happen. Kerala's own e-governance record is a study in contrasts: platforms like FRIENDS and Akshaya transformed the experience of paying utility bills or filing a land transaction for millions of citizens, while other systems, deployed with insufficient attention to language and local practice, became elaborate workarounds that educated, urban users navigated with mild inconvenience and everyone else largely gave up on.

So when the question of AI came up, the government made a choice that is less common than it should be. Before committing to platforms, before signing vendor agreements, before any architecture decisions were finalised, it went out and asked citizens what they wanted.

Two thousand one hundred respondents. Fourteen districts. The full occupational range of Kerala society, surveyed in Malayalam. That consultation produced the findings reported here, and those findings directly shaped the Kerala AI Mission (K-AIM), the K-AI Initiative, and the VidyAI Programme. The paper follows that path from listening to building, and makes the case that the path matters as much as the destination. Readers looking for the findings can skip to Section 5; those interested in how those findings changed specific design decisions should read Section 7 alongside it.

2. KERALA'S THREE STRATEGIC AI INITIATIVES

India's IndiaAI Mission, approved with an outlay of Rs. 10,372 crore for AI compute, datasets, skilling, and safe-AI governance infrastructure [1], created real pressure on states to articulate an AI strategy that was more than aspiration. Kerala came into this moment with something useful already in place: KITE had trained roughly 80,000 school teachers in AI-related skills and had introduced robotics and AI into the school curriculum [2]. That was a foundation. What it was not was a plan for how AI would serve ordinary citizens in government services, healthcare, agriculture, and welfare delivery.

2.1 Kerala AI Mission (K-AIM)

K-AIM is the state's institutional mechanism for implementing AI at scale across public administration and public service delivery. The decision to use a mission-mode structure, rather than routing AI work through individual departments, was itself a governance statement: this is a long commitment, not a pilot. K-AIM covers welfare access, public health, school education, agriculture, fisheries, local self-governance, and disaster management. Its founding principles — inclusion, transparency, and democratic accountability — were drawn directly from the consultation findings described in this paper, not from a policy template.

2.2 K-AI Initiative

Every state AI programme eventually runs into the same wall: government cannot build everything itself, especially not in a lower-resource language like Malayalam where specialised AI capabilities require dedicated investment and deep linguistic expertise. The K-AI Initiative is Kerala's answer to that problem. It is a convergence platform, bringing together government agencies, startups, academic institutions, and civil society organisations around specific public-interest AI goals. The working model is co-development: citizen-identified needs are translated into jointly designed products with open governance arrangements. A Malayalam welfare navigator. An AI mathematics tutor for secondary school students. Agricultural advisory tools for coastal fishing communities. These are not procurement tenders; they are collaborative build efforts.

2.3 VidyAI Programme

Of all the things that can go wrong when government deploys AI, one of the least discussed is the simplest: officials who are supposed to oversee AI-assisted decisions have no reliable way to evaluate whether those decisions are any good. VidyAI, operating under the tagline 'Smart Officers, Smarter Governance,' is the Government of Kerala's structured response to that gap. The programme equips public servants across the state administration with Generative AI tools, practical skills for evaluating AI outputs critically, and governance awareness training that covers the conditions under which AI outputs should and should not be acted upon. The premise is straightforward: human oversight only works when the humans doing the overseeing have been properly equipped. VidyAI is that equipment.

All three initiatives share something more important than a shared acronym family: they were designed after the consultation findings came in, not before.

3. GROUNDING IN SCHOLARSHIP

3.1 Why the Sequence Matters

The e-governance literature has documented, with some consistency, that technology projects bypassing structured citizen needs assessment tend to optimise for institutional metrics — processing speed, cost reduction, digitisation counts — while underperforming on the things citizens actually care about, like whether the service works in their language, whether the process is genuinely simpler than the paper-based alternative, and whether the outputs can be trusted [3]. AI amplifies both sides of this equation. A well-grounded AI system can extend government reach dramatically. A poorly grounded one can reproduce and

scale historical inequities at a speed that paper-based bureaucracy never could. Moving from AI ethics principles to institutionalised practice requires real evidence about real needs [4], and that evidence can only come from asking.

Kleizen et al. [5] tested this empirically. Citizens, they found, do not trust government AI simply because the government calls it trustworthy. Trust accrues from specific, observable behaviours: honest disclosure of system limitations, clear escalation paths to human review, and demonstrated consistency between what the system says it will do and what it actually does. Kerala's consultation was partly an audit of which of these conditions citizens rated most urgent.

3.2 Public Value as the Practical Test

Moore's public value framework [6] poses a challenge that is deceptively simple: are the people who most need this service actually better off? Not on average, not in aggregate, but specifically the people who were hardest to reach before. Bannister and Connolly [7] applied this test to digital government and found that e-governance creates genuine public value when it expands equitable access and builds legitimate institutional authority, not simply when it moves a paper process online with a new interface. Kerala's consultation was designed around this test. Rather than asking what AI can deliver efficiently, it asked whether what AI can deliver is what the people who need it most actually want.

Floridi et al.'s five AI ethics principles [8] — beneficence, non-maleficence, autonomy, justice, and explicability — are not abstract in the Kerala context. Explicability, for instance, means a Panchayat-level official in Idukki must be able to understand why an AI system flagged or approved a welfare application. Justice means the system must perform equivalently for a Malayalam-speaking fisherwoman in Kannur and an English-speaking software engineer in Ernakulam. These are design constraints, not aspirations.

3.3 The Language Gap

Here is a practical consequence of training AI predominantly on English-language data: when a public service AI communicates in poor Malayalam, it reproduces in digital form the same exclusion that paper-based English-language government forms imposed on citizens who never learned to read English [9]. The technology changes; the structural disadvantage does not. Naidoo and Chadha [10] found that genuinely responsive AI must preserve administrative context and practical intent alongside semantic content — the difference, in Kerala's terms, between a citizen understanding which documents she needs for a pension application and a citizen misunderstanding the translation and being turned away at the taluk office. Kerala's consultation treated language accessibility as a foundational infrastructure issue requiring budget allocation from the start, not a localisation feature to be added after the core system is built.

4. CONSULTATION METHODOLOGY

The first design question for the consultation was: who counts as a stakeholder? In most technology governance exercises, the answer in practice is IT professionals, industry representatives, and policy specialists. Kerala's consultation was built on a different answer. The stakeholders who matter most for public AI are the citizens who will actually use AI-mediated public services, many of whom have limited formal exposure to AI tools, communicate primarily in Malayalam, and carry considerable accumulated frustration with digital interfaces that were designed for someone else.

An exploratory mixed-method design was used. Structured questions generated data that could be compared across districts and occupational groups. Open-ended questions, which field investigators were trained to pursue patiently and record carefully, produced the texture that statistical summaries obscure. A 68-year-old woman in Idukki wanted to know where her health records would be stored and who could look at them. A Standard X student in Malappuram wanted someone to explain trigonometry the same way ten times over without getting impatient. A widow in Thrissur described spending four months and multiple days of lost

wages navigating a pension application that required her to visit three different offices and submit the same income certificate at each.

The survey covered all 14 revenue districts: Thiruvananthapuram, Kollam, Pathanamthitta, Alappuzha, Kottayam, Idukki, Ernakulam, Thrissur, Palakkad, Malappuram, Kozhikode, Wayanad, Kannur, and Kasaragod. Total respondents: 2,100, averaging 150 per district with a range of 100 to 200. All instruments were in Malayalam. Field investigators were briefed to explain AI through locally familiar examples rather than technical definitions that presuppose prior exposure.

Respondent profile: students and youth 18%, small entrepreneurs and MSMEs 13%, government employees 12%, teachers 11%, IT and professional workers 10%, homemakers 9%, health workers 8%, farmers and fisherfolk 8%, senior citizens 7%, others 4%. Gender split was near-equal. Location: 52% rural, 26% semi-urban, 22% urban. Open-ended responses were thematically coded; closed-ended items were frequency-analysed.

5. WHAT THE CONSULTATION FOUND

5.1 The Pattern of Expectations

Four things came up in district after district, across occupational groups that had almost nothing else in common: learning support in mathematics, relief from the procedural maze of welfare services, employment preparation tools, and basic healthcare navigation. Running through all four was something that field investigators started describing as the fifth finding: every one of these has to work in Malayalam. Not through a translation layer that produces grammatically correct but administratively meaningless text. In real, functional Malayalam, the kind a Panchayat secretary or a school student or a fisherfolk cooperative member would actually use. Table 1 shows the full distribution.

TABLE 1. STAKEHOLDER AI EXPECTATION CATEGORIES

Expectation Category	Count	%
Education, maths & personalised learning	410	20
Public service & welfare access	330	16
Employment, skilling & career support	305	15
Healthcare guidance & elderly care	265	13
Malayalam-language assistance	231	11
Productivity & professional support	206	9.8
Small business & entrepreneurship	166	7.9
Personal life management	101	4.8
Agriculture, fisheries & livelihoods	55	2.6
Creative expression & media	31	1.5
Total	**2,100**	**100**

5.2 Mathematics: The Wall Between Students and Their Futures

Nineteen-point five percent. Education led every other expectation category, and the single most specific and consistent sub-finding within education was demand for AI that can teach mathematics. Respondents across age groups described mathematics as the subject where students most often get stuck and most need

help that is patient, cumulative, and available when they need it, which is frequently 11 p.m. the night before an examination, not during school hours.

What they described wanting was not a calculator, not a solution generator, but something closer to a very patient tutor who can take a problem in algebra or statistics or coordinate geometry and work through it step by step, in Malayalam, identifying exactly where the student's reasoning went wrong and offering a different approach without any indication of frustration at being asked the same question for the fifth time — which, as several respondents pointed out, is precisely what most human teachers, working with classes of fifty students and a packed syllabus, cannot realistically provide.

The stakes are not just pedagogical. Mathematical underconfidence closes doors into data science, AI research, engineering, and finance. Those are the fields Kerala's AI mission is trying to develop. Both VidyAI's teacher-empowerment component and K-AIM's direct student-facing platform were shaped by this finding.

5.3 Welfare Services: What 'Digital' Has Not Yet Fixed

One pattern came through the open-ended responses so consistently that it bordered on verbatim. A widow in Thrissur needs a pension for herself and an educational scholarship for her son. Both schemes exist. She is eligible for both. Getting both required four months, visits to three offices, and submission of the same income certificate at each window, because each department keeps its own records and shares nothing with the others. She is not unusual. This experience, in some variation, was described by respondents across almost every district.

What they wanted from AI was a system that works in the opposite direction from the current one. Rather than requiring citizens to discover which schemes they might be eligible for, navigate separate application processes for each, and repeatedly re-prove the same basic facts about their lives, respondents described wanting AI that would, with their explicit consent, identify what they are likely entitled to, notify them, and walk them through a single guided process. The 'tell me once' principle — provide your information once and have it used across all relevant services — was not a phrase that existed in the consultation instruments. It emerged from the responses. It is now central to K-AIM's service architecture, and the K-AI Initiative is building the Malayalam-language application navigator that makes it real.

5.4 Employment, Healthcare, and Language

Employment expectations carried an internal contradiction that the consultation made visible. Among the 305 respondents who prioritised employment and skilling support, a significant share of the same individuals also expressed concern about AI-driven job displacement [11]. Youth who wanted help writing a CV also worried that the clerical job the CV was targeting might not exist in two years. Returning migrants from the Gulf who wanted interview preparation tools were also asking whether the customer service roles they were trained for would still be available. VidyAI's framing of AI as a tool that augments government roles rather than eliminates them was a considered public communication choice, not just a design principle.

Healthcare expectations (12.6%) were pragmatic and consistent. Respondents across all districts wanted appointment guidance, medication reminders, chronic condition monitoring, and help understanding medical instructions. The phrase 'not instead of a doctor' appeared, unprompted, in responses from Wayanad to Kasaragod.

Malayalam access was not a separate concern from any of the above. It was the condition on which all the above depended. A service that communicates in technically inadequate Malayalam is not a service for the population that most needs public services. Field investigators reported that this point came up in nearly every focus group, from nearly every demographic segment. K-AIM's Malayalam-first infrastructure commitment started here.

5.5 Concerns: What Citizens Need the Government to Guarantee

The concerns data in Table 2 is sometimes read as evidence of public resistance to AI. That is the wrong reading. These are governance requirements. Citizens were not saying they do not want AI. They were specifying the conditions under which they will trust it. A government that responds to this data by planning a public awareness campaign has fundamentally misread it. A government that responds by building consent mechanisms, bias audit requirements, and language quality standards into its AI architecture has understood it.

TABLE 2. STAKEHOLDER CONCERNS ABOUT AI

Concern Category	Count	%
Data privacy and misuse	510	24.3
Misinformation and fake content	410	19.5
Job loss and employment insecurity	385	18.3
Unreliable or wrong AI outputs	330	15.7
Over-dependence & reduced thinking	206	9.8
Bias and unfair decisions	126	6
Digital exclusion	80	3.8
Surveillance and profiling	53	2.5
Total	**2,100**	**100**

Data privacy led at 24.3%, and the specificity of the concern was striking. Respondents did not say they were worried about 'data.' They named: Aadhaar numbers, land records, health histories, bank account details, family photographs. They asked concrete questions: where will this be stored, who can look at it, what happens if there is a breach, how do I get it deleted if I change my mind. Those are exactly the questions India's Digital Personal Data Protection Act, 2023 [12] is designed to answer, and K-AIM has adopted DPDP compliance as a mandatory baseline across all systems.

Teachers and local government officials were particularly vocal about misinformation (19.5%). They were not speaking theoretically. Several described specific incidents: health misinformation during the COVID-19 period that spread through WhatsApp and required active correction through official channels, fabricated welfare scheme announcements that brought crowds to taluk offices on false pretences, politically motivated fake videos that circulated before elections. They saw AI-generated content as a qualitatively different version of the same problem, and they were right to. The concern about unreliable AI outputs (15.7%) concentrated in the domains where errors carry the heaviest consequences: health advice, welfare eligibility determinations, land records, and tax guidance. One phrase came up independently in multiple districts: an AI that says the wrong thing confidently is more dangerous than one that says nothing.

6. KERALA AI PUBLIC VALUE FRAMEWORK

The eight-pillar Kerala AI Public Value Framework was derived from the consultation data and validated against established responsible AI frameworks [13]-[15]. Each pillar addresses a specific cluster in the findings. The pillars are listed below with deliberately varied explanatory depth — some require more unpacking than others.

- **Inclusion by Architecture:** Voice input in Malayalam, low-bandwidth interfaces, and assisted delivery through Akshaya Centres are not accessibility add-ons. They are design requirements from day one, because the citizens with the most to gain from well-designed public AI are precisely those who have been most consistently served last by digital systems designed for urban, English-proficient users.
- **Earned Trust:** Every K-AIM system tells citizens, in plain Malayalam, what it can and cannot do, who is responsible for it, and how to reach a human official when the AI falls short. Simple. Necessary.
- **Malayalam as Public Infrastructure:** Speech recognition, natural language processing, domain-specific conversational AI, and administrative terminology glossaries in Malayalam require sustained investment at a scale comparable to road maintenance or electricity grid management. Without that investment, AI in Kerala's public services is infrastructure for a minority, regardless of what the policy documents say about inclusion. The budget line for Malayalam AI capability was established before K-AIM's application layer was scoped.
- **Human Authority Preserved:** AI supports decisions in welfare eligibility, healthcare triage, legal matters, and educational assessment. It does not make them. This is not a principle that can be stated once in a policy document and then quietly eroded by operational convenience. VidyAI was designed specifically because preserving human authority requires training the humans who are supposed to exercise it.
- **Data Rights, Not Data Extraction:** Purpose limitation. Consent at every data-sharing junction. Citizen access to their own records. Retention controls. Independent audit. These are the operational requirements of DPDP Act compliance [12], and they are the architecture through which the 'tell me once' service model is implemented. Citizen data is an asset held in trust, not a resource to be mined.
- **Open Workings:** Training data documentation, model performance metrics, and bias testing results for all K-AIM public systems are shared with independent academic and civil society reviewers through K-AI Initiative governance structures. This requirement came from the IT professional respondents in the consultation — Kerala's own technical community asking for accountability of systems that will govern them. It would have been easy to ignore. It was not ignored.
- **AI Literacy as a Public Good:** Just as digital literacy was a prerequisite for e-governance adoption, AI literacy is a prerequisite for AI governance that citizens can hold accountable. VidyAI covers officials. K-AIM's citizen-facing programme covers everyone else, in Malayalam, across all districts.
- **Test Before Scale:** Mathematics tutoring AI. Welfare navigation systems. Agricultural advisory tools. These are built and tested in structured K-AI Initiative sandbox environments with privacy review, bias assessment, and public feedback stages before state-wide deployment. The same logic that drove the consultation — learn before committing — applies to every system K-AIM launches.

7. FROM FINDINGS TO DESIGN: THE TRACEABLE PATH

Most stakeholder consultations produce a report. The report is filed. The design team, which has been working in parallel, continues with its earlier assumptions. Kerala's consultation was designed to prevent this. The analysis was formally presented to K-AIM, K-AI Initiative, and VidyAI design teams before any architectural decisions were locked, and specific findings were treated as binding constraints where they conflicted with initial assumptions. Table 3 makes the traceability explicit.

TABLE 3. FROM CONSULTATION FINDING TO INITIATIVE DESIGN DECISION

What Stakeholders Said	Initiative	What Was Designed
Need maths AI tutor — explains reasoning in Malayalam, not just answers	K-AIM Education Pillar	Free Malayalam conceptual maths tutoring platform; not answer-delivery
'Tell me once' — stop asking for same documents across departments	K-AIM / K-AI Initiative	Consented inter-dept. data layer; proactive eligibility notification
Malayalam is a functional prerequisite, not a preference	K-AIM / K-AI Initiative	Malayalam-first infrastructure funded at public-goods level
Officials need to evaluate AI critically, not just use it	VidyAI	GenAI tools + mandatory critical-evaluation and oversight training
Public AI must be independently auditable — not a black box	K-AI Initiative	Open governance structure; external academic and civil society audit access
Aadhaar, health records, land data — specific privacy fears	K-AIM (all pillars)	DPDP Act compliance mandated; privacy impact assessment before deployment
Senior citizens and rural users are not an edge case	K-AIM Inclusion Pillar	Akshaya Centre integration; voice-first interface; no English-only access
AI should augment government roles, not eliminate them	VidyAI / K-AI Initiative	Augmentation framing built into all VidyAI communications and training design

One finding changed a design assumption that the team had considered settled. The initial plan was an English-language interface with a Malayalam translation layer. Consultation responses made clear, repeatedly and across multiple districts, that citizens experience translation layers as systems that were built for someone else. The decision was reversed. Malayalam became the primary language of system design, with English as the secondary interface. That change added cost and timeline. It was still the right call.

8. RECOMMENDATIONS FOR OTHER STATES

Kerala's specific findings will not transfer unchanged to Andhra Pradesh or Assam or Jharkhand. The language communities are different, the e-governance infrastructure maturity differs, the dominant concerns in the consultation will differ by context. What transfers is the logic and the discipline.

- Run the consultation before the design sprint. Before any architecture is specified, before vendor conversations begin. The Government of Kerala ran it first and held the design team back until the findings were available. That requires institutional discipline and political willingness to slow down a process that everyone wants to accelerate. It is worth it.
- Sample the full social spectrum. If the consultation skews toward educated, urban, digitally fluent respondents, the AI that results will serve educated, urban, digitally fluent citizens. The citizens with the most to gain from AI that works are usually not in that group.

- Budget for language before budgeting for the application. A regional language AI capability funded as an afterthought will perform like an afterthought. The failure will show in the outputs, and the communities who were supposed to benefit will notice and stop using the system.
- Train officials before deploying consequential AI. The VidyAI model addresses a failure mode that the governance literature increasingly recognises [5],[13]: human oversight requirements are meaningless when the humans doing the overseeing lack the skills to evaluate what they are overseeing.
- Build convergence structures. Public-interest AI in lower-resource languages requires pooled effort from government, academia, startups, and civil society. The K-AI Initiative provides a replicable model for how to organise that convergence with shared governance.
- Make audit results public. Performance metrics, bias testing outcomes, and privacy impact assessments for government AI systems should be available to citizens in accessible language. The demand for this will come from every state's technical community if asked. Plan for it now rather than retrofitting it after controversy forces the issue.

9. CONCLUSION

There is a version of this story where K-AIM, K-AI Initiative, and VidyAI were designed in a ministry office by a small team of officials and consultants working from national policy frameworks and international best-practice documents. That story is told often enough. It produces systems that are defensible on paper and frustrating in practice, that work well enough for the population segment that was implicitly imagined during design and work poorly for everyone else.

Kerala chose a different version. Two thousand one hundred conversations, across 14 districts, in Malayalam. A widow in Thrissur who spent four months getting a pension she was already entitled to. A student in Malappuram who needs a mathematics tutor that does not run out of patience. A fisherfolk cooperative in Kasaragod where no one reads English government forms. These are not edge cases to be accommodated after the main system is built. They are the point.

The question that K-AIM, K-AI Initiative, and VidyAI will ultimately be judged on is not whether they demonstrate cutting-edge AI capability, or whether they receive recognition at national e-governance conferences, or whether their launch events generate good coverage — the question is whether the homemaker in Wayanad who has never successfully accessed a digital government service can, within the next three years, find out what welfare schemes she is entitled to, complete an application in Malayalam, on a basic smartphone, without making a single trip to a government office.

Kerala thinks the answer will be yes. The consultation told us what is needed. The initiatives provide the institutional mechanism. Whether that mechanism is kept honest, kept funded, and kept focused on the people who most need it depends on choices that have not yet been made. That is the real work ahead.

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CHAPTER 7
AI and Digital Infrastructure for Secure Public Services: Learnings from the Enforcement Directorate

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ABSTRACT

Enforcement Directorate (ED), one of the premier law enforcement agencies of India, is at the forefront of deploying modern technology and robust digital infrastructure to implement the mandate given to the agency i.e. enforcement of anti-money laundering and foreign exchange related law. This paper elaborates three landmark innovations: the introduction of QR-code-enabled summons to counter the proliferation of fraudulent notices, use of technology to fast track the investigation and deployment of AI assisted analytical tools in fast tracking the process of restitution of the attached assets to the victims under the Prevention of Money Laundering Act (PMLA), 2002. The paper demonstrates how these initiatives align with the vision of Viksit Bharat 2047 - an AI-enabled, data-driven, and secure digital governance framework and recommends wider adoption of these initiatives across law enforcement and regulatory agencies in India.

INDEX TERMS

Enforcement Directorate, QR Code Summons, AI in Law Enforcement, PMLA, Digital Governance, Asset Restitution, Viksit Bharat 2047.

1. INTRODUCTION

The Directorate of Enforcement (ED), functioning under the Department of Revenue, Ministry of Finance, Government of India, is entrusted with enforcing three premier economic legislations: the Prevention of Money Laundering Act (PMLA), 2002, the Foreign Exchange Management Act (FEMA), 1999 and the Fugitive Economic Offenders Act, 2018 (FEOA). As India accelerates its journey towards becoming a USD 30 trillion economy and a fully digitised governance ecosystem by 2047, law enforcement agencies must be equipped with cutting-edge tools that not only enhance investigative efficiency but also protect citizens from fraud and ensure swift restitution of proceeds of crime.

The laws being administered by the Directorate address offences that extend far beyond mere laundering of illicit funds to encompass a wide spectrum of threats to financial integrity and national security. The nature of financial crime is constantly evolving.

Money laundering investigations are inherently complex, often involving multijurisdictional and crossborder transactions, layered financial structures, and rapidly evolving technologies. While the ED continues to investigate traditional economic fraud cases, the evolving criminal landscape has led to a notable rise in cases involving cryptocurrency fraud, cyber-enabled financial crimes, terrorism, anti-national activities, and narcotics trafficking.

The Directorate has also adopted a forwardlooking and focused approach to emerging threats, ensuring that its enforcement strategies remain adaptive, technology-driven, and responsive to the evolving dynamics of financial crime.

A review of enforcement trends highlights the increasing emphasis on attachment of proceeds of crime. During the initial decade of the enactment of the Act (2005-2014), total attachments amounted to ₹5,171.32 crore, averaging approximately ₹574.6 crore annually. In the subsequent decade (2014-2024), total attachments rose sharply to ₹1,19,386.25 crore. In FY 2024-25 alone, attachments stood at ₹30,036.41 crore, and in FY 202526, the Directorate of Enforcement recorded attachments of properties amounting to ₹81,422.63 crore. To place this in perspective, attachments in a single financial year now exceed the cumulative total of the Act's first decade by more than fifteen times. These figures reflect a clear and sustained focus on depriving offenders of the benefits derived from criminal activities.

The Directorate has significantly enhanced its enforcement outcomes, having filed 657 main prosecution complaints under the PMLA during the financial year 2025-26, almost double the 333 filed in FY 2024-25. Additionally, the Directorate also filed 155 supplementary prosecution complaints during FY.202526. Out of the total 2,396 main prosecution complaints filed by the ED to date, over 41% have been filed in the last two years, reflecting a marked acceleration in investigative and prosecutorial efforts.

In cases involving banks, investors, and homebuyers, the objective of the PMLA extends beyond attachment and confiscation to facilitating restitution to victims and rightful owners. This commitment is reflected in the sharp rise in restitution: from negligible levels till FY 2022-23 to ₹71.16 crore in FY 2023-24, increasing significantly to ₹15,263.03 crore in FY 202425, and further to ₹32,678.12 crore in FY 2025-26. Cumulatively, over ₹63,142 crore has been restored to rightful claimants. Notably, in a landmark real estate case in Udaipur, the Directorate facilitated the release of attached properties to over 200 homebuyers. The Hon'ble Supreme Court recorded its appreciation of these efforts. Similarly, in the case of PACL Ltd., assets amounting to approximately ₹15,581 crore have been restituted to the Justice R. M. Lodha Committee for distribution to hundreds of thousands of investors [1].

Critical challenges confronted by the ED in recent years include the complexity and time-intensity of identifying, attaching, and restoring assets in large-scale money laundering cases involving multi-layered corporate structures and cross-border transactions resulting into stretched investigation time lines. The cause of concern also includes the widespread digital frauds and impersonation scams by using fabricated summons purportedly issued by the ED to extort money from citizens. ED is also mandated to restitute the proceeds of crime to the genuine victims who have lost their money to the hands of fraudsters and in this process, speedy and correct identification of large number of victims is a time taking and cumbersome process. These challenges have been effectively addressed through the strategic deployment of AI and digital infrastructure, making ED a model for technology enabled governance in law enforcement.

This paper presents these innovations as a blueprint for Sub-theme 5 of the 29th National Conference on e-Governance: AI and Digital Infrastructure for Secure Public Services.

2. QR-Coded Summons: Securing Citizens Against Fraud

2.1 The Problem: Proliferation of Fake Summons and impersonation

In recent time, a sharp rise has been seen in the digital frauds and impersonation frauds including digital arrests of common citizen for extorting money from them in the name of Law Enforcement Agencies. In impersonation and digital arrest scams, fake summonses purportedly issued by the Law Enforcement Agencies including ED are widely used to pressurise the victim for extortion of the money in the name of agencies. Many such instances have been reported and many of them remain unreported due to fear and unawareness. Sharp escalation in complaints from citizens, businesspersons, and public figures who received fraudulent summons bearing the ED's letterhead, seal, and forged signatures of officers, shows the gravity of the issue at hand. Perpetrators exploited the ED's institutional standing and the fear of legal proceedings to coerce victims into paying bribes or surrendering sensitive financial information. These fake summonses were indistinguishable from genuine notices, as they replicated official formatting with high fidelity. The resultant erosion of institutional trust and the victimisation of innocent citizens necessitated an urgent technological intervention.

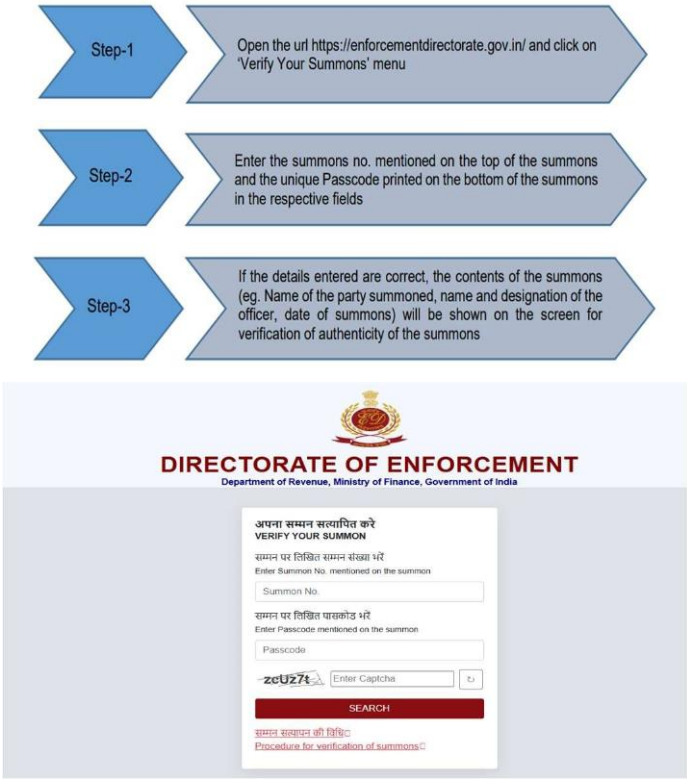
2.2 The Solution: QR Code-Enabled Summons Verification

In order to allow the individuals to verify the authenticity of the summons received by them, the Directorate of Enforcement has implemented a mechanism of generating summons through the system which bears QR code and a unique Passcode at the bottom of the summons. The summons generated from the system is duly signed and stamped by the official issuing the summons and also contains his/her official email id and

the phone number for correspondence purpose. The receiver of the summons can verify the authenticity of the summons by following any of the two procedures mentioned below-

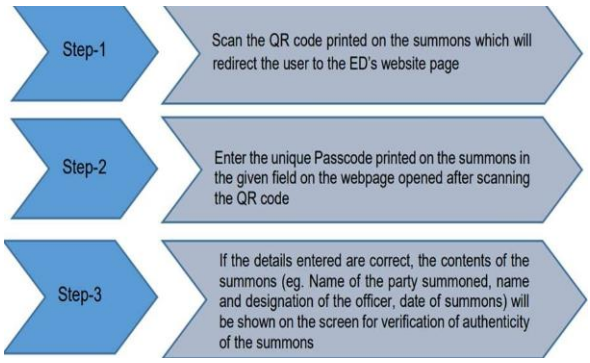
(i) Verification by scanning QR code: The following steps are required to be followed for verification of the authenticity of the system generated summons by scanning the QR code-

generated summons by entering the details of summons on the official website of ED-



2.3. Impact and Outcome

Each summons now contains a unique QR code linked to a centralized database accessible through the ED website's homepage. By simply scanning the code, recipients can instantly verify the authenticity of the summons. This measure has effectively curbed the problem of impersonation and the circulation of fake summons by unscrupulous individuals. This initiative directly embodies the principles of Viksit Bharat 2047: it leverages digital infrastructure to deliver a secure, trust-based interface between ED and the





(ii) Verification by entering details of summons: The following steps are required to be followed for verification of the authenticity of the system

citizens. In this regard, advisory has also been issued and widely publicised through the newspapers, ED website and Official X handle of ED etc. for awareness of the common public [2].

3. USE OF AI-ASSISTED AUTOMATION OF THE CLAIMS AND THE DISBURSEMENT MECHANISM FOR RESTITUTION OF ATTACHED PROPERTIES

3.1 Introduction:

ED has adopted a more proactive and "victim-centric" approach to the restoration of crime property under the PMLA which has further been validated through various judicial pronouncements. Restitution of properties to victims and legitimate claimants is an essential part of the cycle of justice in money laundering investigations. ED under provisions of PMLA is tasked with conducting the Money Laundering investigation wherein the investigation involves cases related to Bank Fraud, Cyber Fraud Cases, Ponzi Scheme Cases etc., wherein either Financial Institutions (FIs) or general public is cheated of its hard-earned money. Hence, to complete the cycle of justice in the Money Laundering investigation it is essential that the accused is punished for criminal offences and the illegally amassed wealth of the accused by cheating the FIs/People is returned to the rightful claimant(s).

3.2 The Challenge: Identification and verification of real victims

The cases of Ponzi scams, Multilevel marketing schemes, Real estate frauds involve lakhs of investors who invest their hard-earned money in the hope of higher returns or homes. However, these innocent investors are duped of their money through fake promises by the fraudsters and scamsters. Quite often, the number of victims in such frauds are quite large and it becomes a difficult task to identify and verify the real victims. This becomes a challenging task for the Law Enforcement Agencies in order to rightfully restitute the money to the real victims.

3.3 The Solution: AI-assisted automation of the claims and the disbursement mechanism

The Rose Valley Group scam is one of the largest financial frauds in India, involving thousands of investors being defrauded. The scam revolved around the Rose Valley Group floating a web of companies to collect public funds illegally. These companies issued secured debentures without complying with the Companies Act. Investors were promised high returns, but instead of being invested in legitimate ventures, the money was funnelled into various group and shell companies. During ED investigation, assets worth thousands of crores (including both movable and immovable) have been attached by ED and subsequently confirmed by the Adjudicating Authority. Subsequently, defrauded investors of the fraud approached High Court of Calcutta to claim their right over the assets attached by ED. Considering the plight of the aggrieved investors and request of ED, the Hon’ble High Court of Calcutta constituted an Asset Disposal Committee (ADC) for redressal of the fraud. More than 31 lakh investors have submitted their claims with respect to the fraud to the ADC.



ED in coordination with the ADC has continued to play a pivotal role in the restitution process for victims of the Rose Valley Group scam, resulting in completion of 16 phases of fund disbursement and release of Rs. 127.69 Crore to 1,73,350 victims as of April 2026.

A major milestone in the restitution process was achieved on 22 April 2025, when ED handed over a demand draft of Rs. 517.54 Crore to the ADC pursuant to orders obtained from the Hon'ble Special Court at Bhubaneswar, enabling restitution of attached Proceeds of Crime for the benefit of victims.

In a major development for the above cause, the ED and ADC have initiated automation of the claims and disbursement mechanism through Artificial Intelligence-based technology, for which approval of the Hon'ble High Court has been obtained on 31.03.2026. The ADC has entered into an arrangement with Stock Holding Document Management Services Limited, a government company for revamping the refund portal so that KYC extraction and multistage matching of claims can be carried out in a time bound and efficient manner. With the revamped system, the disbursement timeline is expected to reduce significantly. Scope of using AI in the process of identification, verification and restitution to the real victims include Extraction of Personally Identifiable Information from a list of valid documents using AI engine for cross verification with the depositor data in the company's portal, Data matching process (Three step process) to speed up back office processing which are Rose Valley Data versus Depositor Data, Depositor Data versus Extracted Data and Depositor Data versus Check leaf Data, Deduplication using Aadhaar number, Revamping the payment process, bucketing of the investors based on the amount invested and integration with banks [3].

This AI assisted automation of the claims and the disbursement mechanism for Restitution of attached properties would not only speed up the restitution process but also eliminate the risk of human error. In the scam like Rose valley where more than 30 lakh investors have already raised their claims, identification, verification and restitution to rightful claimants is a challenge which can be addressed by the use of AI.

4. SPEEDING UP THE INVESTIGATION

4.1 Challenges

Modern money laundering operations are characterised by extreme structural complexity: layered shell companies, nominee directors, benami property chains, cryptocurrency wallets, use of thousands of mule accounts, offshore entities and interlinked trusts. The typology of cases investigated by ED has significantly evolved over the years. Initially, cases of Bank Fraud constituted the majority of the cases taken up for investigation under the category of fraud. However, in the last few years, there has been a sharp rise in technology-driven and cross-border typologies, including crypto-cyber frauds, online betting apps, and digital arrest scams. ED has also seen growing involvement in NDPS-linked financial networks, where drug trafficking proceeds are laundered through real estate, trade-based laundering, and crypto assets. Whereas the bank fraud cases have seen a declining trend, cases involving money laundering through Cyberenabled Frauds, Real Estate Scams, investment scams and Ponzi scheme cases have increased over the last few years. In these cases, the proceeds of crime are routed through hundreds of entities across multiple jurisdictions before being invested in attachable assets. Manual investigation of such networks required years of effort, enormous manpower, and was susceptible to human error and delay. Identifying money trail of the proceeds of crime routed through thousands of bank accounts, crypto wallets and shell entities (both domestic and foreign) is a herculean task and requires a lot of time and effort. In response to increasingly sophisticated financial crimes, ED has adopted proactive approach in leveraging modern forensic technology and data analytics that has enhanced the precision and speed of its diverse range of investigations.

4.2 Solution

Use of technology and forensic tools in investigation:

In recent years, there has been renewed shift in focus from Person/summon centric approach to Technology centric approach in gathering of intelligence and investigation by ED. Use of tools such as data analysis software, OSINT techniques, advanced cyber forensic tools, bank statement analysis tools and integrated access to domestic intelligence platforms such as National Information Grid (NATGRID), FINNET 2.0, Corporate Data Management (CDM) of Ministry of Corporate Affairs and Inter-Operable Criminal Justice System (ICJS), etc. have materially shortened the time required to establish money trails, identify beneficial ownership, and build legally sustainable evidence. Where investigations previously stalled for want of proof or relied entirely on physical searches, officers now triangulate financial intelligence from multiple databases simultaneously, trace cryptocurrency flows through blockchain analytics, and access corporate and property records in real time. The result is faster investigations, stronger prosecution complaints, and a growing pipeline of matters moving from investigation to trial.

Impact: Reduced life cycle of investigation and faster disposal of cases

In the past few years especially during last two years, the Directorate has successfully implemented a systemic shift toward expedited investigative timelines and enhanced technological integration. Last two financial years i.e. 2024-25 & 2025-26 are characterized by peak performance across almost all critical enforcement metrics mainly towards disposal of cases recorded by way of filing of Prosecution Complaints, thus reducing the life cycle of cases from earlier 3-4 years to 1.5-2 years.

Case Study: In the Bit Connect case, victims across the world were induced to invest in digital currency through a fraudulent trading platform that promised unusually high returns. The accused persons misrepresented investment opportunities and utilized complex digital transaction mechanisms to conceal the movement of funds. BitConnect falsely claimed to use a proprietary “volatility trading bot” that could generate returns of up to 40 per cent per month. The platform allegedly displayed fictitious daily returns of about 1 per cent, amounting to nearly 3,700 per cent annually. Investigations by ED revealed that no such trading system or bot existed and that investor funds were misappropriated through a network of cryptocurrency wallets. Subsequently after gathering data/intelligence regarding the perpetrators of the scam and thorough analysis of cryptocurrency wallets through blockchain analysis, significant quantities of cryptocurrency were identified and seized valuing Rs. 2170 crores along with other valuable assets. These digital assets were subsequently secured in designated cold wallets under the control of the Enforcement Directorate to prevent further dissipation of proceeds of crime. Two key accused have been arrested and a prosecution complaint was filed before the Special PMLA Court.

The ED's enhanced use of technology and innovative measures such as QR-coded summons and AI-powered restitution are not isolated technological experiments but are deeply aligned with the overarching vision of Viksit Bharat 2047. They demonstrate that AI and digital infrastructure can simultaneously enhance the investigating capabilities of the law enforcement agencies as well as the protective obligations of the state (through anti-fraud safeguards and victim restitution). These innovations are also scalable, replicable, and interoperable. The QR verification framework can be adopted by any regulatory or law enforcement agency issuing statutory notices, while the AI Assisted restitution mechanism can be implemented in other cases where large number of victims/applicants are involved.

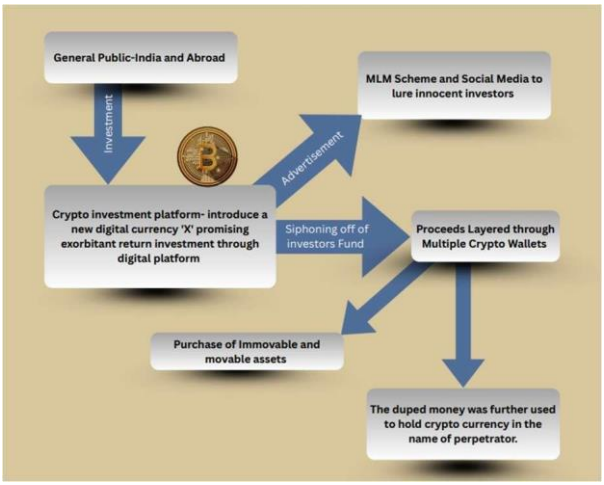
Critically, these tools do not merely digitise existing processes; they reimagine them. The restitution module, for instance, compresses a process that once took years into weeks, restoring economic justice to victims at a pace commensurate with the speed of modern financial crime.

ALIGNMENT WITH VIKSIT BHARAT 2047

The ED's enhanced use of technology and innovative measures such as QR-coded summons and AI-powered restitution are not isolated technological experiments but are deeply aligned with the overarching vision of Viksit Bharat 2047. They demonstrate that AI and digital infrastructure can simultaneously enhance the investigating capabilities of the law enforcement agencies as well as the protective obligations of the state (through anti-fraud safeguards and victim restitution). These innovations are also scalable, replicable, and interoperable. The QR verification framework can be adopted by any regulatory or law enforcement agency issuing statutory notices, while the AI Assisted restitution mechanism can be implemented in other cases where large number of victims/applicants are involved.

CONCLUSION

The Enforcement Directorate's deployment of QRcoded summons, use of technology in fast tracking the investigation and AI assisted asset restitution tools represents a paradigm shift in Indian law enforcement that harmonises investigative rigour with citizen protection, and speed with fairness. These innovations demonstrate that secure digital governance is not merely a technological aspiration but an operational reality, achievable within existing constitutional and legal frameworks. As India advances towards 2047, the ED's model offers a replicable blueprint for use of AI and digital infrastructure to make the law enforcement agencies more just, more transparent, and more trustworthy in the eyes of every citizen they serve.



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CHAPTER 8

Cross-Database Revenue Intelligence: A Data-Driven Municipal Revenue Leakage Detection Framework — Evidence from Rajamahendravaram Municipal Corporation

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ABSTRACT

Municipal financial self-sufficiency remains India's most critical urban governance challenge. Urban Local Bodies (ULBs) collectively mobilise barely 20–30% of their theoretical own-source revenue potential — a structural fiscal deficit that constrains service delivery, infrastructure investment, and administrative capacity. This paper presents the Cross-Database Revenue Intelligence (CDRI) framework operationalised by Rajamahendravaram Municipal Corporation (RMC) through its Smart Governance Operations Centre (SGOC), which systematically identifies revenue leakage through algorithmic cross-referencing of four municipal database pairs: commercial electricity connections vs. trade licence registries; building permissions vs. property tax assessments; vacant land registrations vs. tax coverage; and water consumption data vs. billing records. Deployed as a data-driven intervention, the framework identified 14% of businesses without trade licences, 18% additional unassessed properties, 3.9% of registered vacant land escaping tax assessment, and 11% underbilled water connections. The outcomes are measurable and independently validated: in 2025-26, RMC achieved total revenue collections of ₹87.86 crore (house tax ₹65.53 Cr, vacant land ₹11.56 Cr, water charges ₹10.77 Cr) — a 5.57% year-on-year increase over ₹83.23 crore in 2024-25, with house tax collection efficiency improving from 74.17% to 81.84%. RMC ranked 2nd among all Andhra Pradesh Municipal Corporations in property tax achievement (82.41%) for 2025-26. This paper establishes CDRI as a replicable, low-cost, AI-augmentable methodology that transforms municipal revenue management from a compliance-dependent exercise into a proactive, data-intelligence-driven fiscal governance system.

KEYWORDS

Cross-Database Revenue Intelligence; Municipal Revenue Leakage; Property Tax Reform; Trade Licence Audit; Water Billing Efficiency; Data-Driven Governance; SGOC; Urban Fiscal Reform; Viksit Bharat 2047.

ABBREVIATIONS

AI – Artificial Intelligence; AMRUT – Atal Mission for Rejuvenation and Urban Transformation; AP – Andhra Pradesh; APEPDCL – Andhra Pradesh Eastern Power Distribution Company Limited; CDMA – Commissioner & Director of Municipal Administration; CDRI – Cross-Database Revenue Intelligence; Cr – Crore; DCB – Demand, Collection and Balance; DARPG – Department of Administrative Reforms and Public Grievances; GIS – Geographic Information System; IAS – Indian Administrative Service; IVRS – Interactive Voice Response System; MA&UD – Municipal Administration and Urban Development; MeitY – Ministry of Electronics and Information Technology;

MoHUA – Ministry of Housing and Urban Affairs; MoU – Memorandum of Understanding;

NCeG – National Conference on e-Governance; NIUA – National Institute of Urban Affairs; NITI – National Institution for Transforming India; PUB – Public Utilities Board; RMC – Rajamahendravaram Municipal Corporation; SGOC – Smart Governance Operations Centre; SLA – Service Level Agreement; SQL – Structured Query Language; ULB – Urban Local Body; USD – United States Dollar; YoY – Year-on-Year.

1. INTRODUCTION

The fiscal architecture of Indian Urban Local Bodies (ULBs) is characterised by a persistent paradox: municipalities administer extensive asset bases — properties, businesses, water infrastructure, and public lands — but collect a fraction of the revenue those assets theoretically generate. The 15th Finance Commission (2021) [1] estimated India's urban local bodies' aggregate own-source revenue at approximately ₹1.2 lakh crore annually, while academic estimates suggest this figure should be 3–4 times higher. The gap represents the scale of municipal revenue leakage at the national level.

Critically, this leakage does not arise primarily from evasion or corruption. It arises from analytical blindness: municipal systems collect data in departmental silos but never cross-reference them to identify the gap between what is registered in one system and what appears — or fails to appear — in another. A business receiving a commercial electricity connection is almost certainly operating commercially; the question is whether it has a trade licence. A building that received a construction permission generates a tax liability; the question is whether it appears in the property tax database. These are structurally obvious questions that go systematically unanswered in most Indian ULBs because no mechanism exists to make the databases speak to each other.

This paper documents how Rajamahendravaram Municipal Corporation operationalised exactly this cross-database intelligence through its CDRI framework within the Smart Governance Operations Centre — and presents the quantified fiscal outcomes for 2024-25 and 2025-26, independently validated through the Andhra Pradesh Municipal Administration Revenue Dashboard [2].

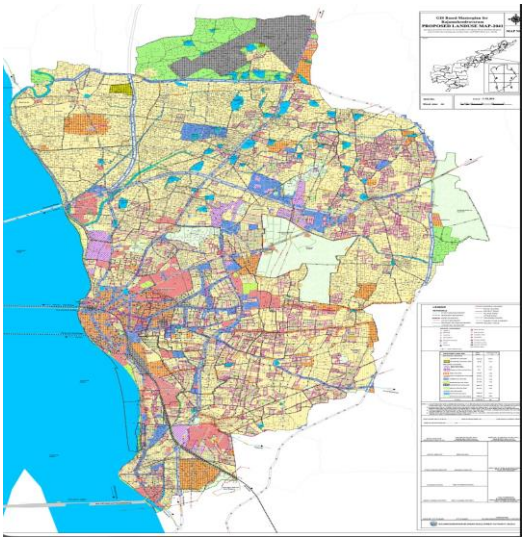


Figure 1: *Rajamahendravaram Master Plan, Land use Map*

1.1 Research Objectives

- To document the CDRI methodology as a replicable analytical framework for Indian ULBs.
- To present RMC's two-year quantified revenue performance (2024-25 and 2025-26) across three revenue streams, with AP state-ranking context. To establish data-driven cross-database analysis as the primary tool for bridging India's municipal revenue gap.To project the national-scale fiscal impact of CDRI deployment and propose policy recommendations.

2. LITERATURE REVIEW AND CONTEXTUAL FRAMEWORK

Property tax reform in India has been extensively studied but inadequately implemented. The National Institute of Urban Affairs (NIUA, 2019) [3] documented that India's property tax-to-GDP ratio stands at approximately 0.15% — compared to 0.45–0.80% in other emerging economies and 1.1–1.5% in developed

nations. The McKinsey Global Institute [4] estimated that Indian cities could generate $1.1 trillion in additional revenue over 20 years through improved property tax administration alone. The World Bank (2021) [5] found that only 60% of eligible properties in sample Indian cities were actually assessed, and of those assessed, 40% were significantly undervalued.

Cross-database analytics for revenue recovery has international precedent demonstrating both feasibility and scale. Colombia's PREDIO system cross-references land registry, electricity connections, and satellite imagery to identify unregistered properties, recovering approximately USD 300 million annually in property tax [6]. Brazil's Geosampa GIS platform in São Paulo cross-references seven data sources to maintain real-time property tax assessment coverage. South Africa's municipal analytics platforms use similar mismatch detection. In each case, the methodology is identical to what RMC's CDRI implements: intelligent cross-referencing of data systems that already exist — requiring no new data collection, only new analytical connections.

Within India, the DARPG Annual Report on e-Governance (2025) [7] identified revenue analytics integration as a key gap in municipal digital transformation. The NITI Aayog (2023) [8] noted that ULBs with data-driven revenue management outperform peers by 15–25% in own-source revenue collection. RMC's CDRI provides the first fully documented operational evidence of this framework in a Tier-2 Indian city.

3. PROBLEM STATEMENT: THE REVENUE BLINDNESS CHALLENGE

Prior to the CDRI framework, RMC's revenue management exhibited four structural gaps that collectively resulted in significant uncollected own-source revenue:

Table 1: Pre-CDRI Revenue Management Gaps at RMC

Revenue Stream	Existing System	Gap / Blind Spot	Revenue Consequence
Trade Licence	Trade licence registry maintained by Revenue dept.	Never cross-referenced with electricity board commercial connections	14% of businesses operating without licence
Property Tax	Building permissions issued by Town Planning; tax assessed by Revenue	No automatic trigger from building completion → tax registration	18% of permitted properties not assessed
Vacant Land Tax	Registration Dept. maintains land ownership records	Registered parcels never systematically matched to tax database	3.9% of registered land un-assessed for tax
Water Charges	Meter readings and billing records in separate systems	Consumption-billing mismatch not flagged automatically	11% of connections underbilled — meter errors/admin gaps

The aggregate impact of these four gaps — across a city with 1,35,338 assessments and a total revenue demand of ₹153.29 crore in 2025-26 — represents a substantial and quantifiable fiscal deficit that CDRI was designed to systematically close.

4. METHODOLOGY: THE CDRI FRAMEWORK

4.1 Framework Design

The CDRI framework operates through a four-step analytical pipeline applied simultaneously across four database pairs (Figure 2). The pipeline is embedded within the SGOC's daily governance intelligence engine, producing automated exception reports to responsible departments and generating escalation alerts for high-priority recovery cases.

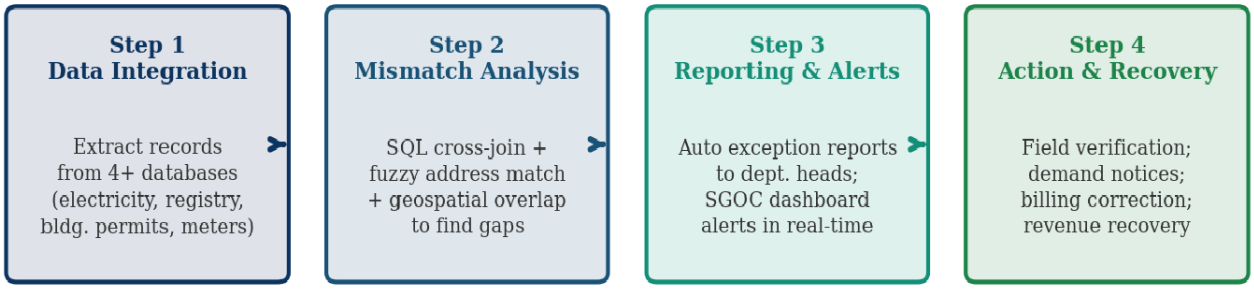


Figure 2: *Cross-Database Revenue Intelligence (CDRI) — four-step analytical pipeline embedded in SGOC [RMC SGOC Revenue Intelligence Framework, 2025-26]*

4.2 Four Database Pairs — Analytical Methodology

Table 2: CDRI Four Database Pairs — Methodology, Findings, and recovery actions with international analogues

Database Pair	Cross-Reference Method	Leakage Found	Revenue Action	International Analogue
Commercial Electricity Connections vs. Trade Licence Registry	electricity board connection IDs against trade licence database by address/pin	**14% of commercial connections have no trade licence**	Licence notices issued; enforcement drive initiated; recurring annual fee recovery	Colombia PREDIO system [6]
Building Permissions vs. Property Tax Assessment	Building completion certificates matched to property tax database by survey/parcel number	**18% of permissions not in tax database**	Assessment orders issued; demand notices generated; perpetual tax stream activated	Brazil Geosampa São Paulo [6]
Vacant Land Registrations vs. Tax Assessment	Registration dept. parcel records geo-matched against RMC tax assessment coverage polygons	**3.9% of registered parcels not in tax roll**	Vacant land tax assessment orders; one-time and recurring recovery	South Africa ULB analytics [6]
Water Consumption (Meter) vs. Billing Records	Meter readings cross-referenced with billing ledger; statistical outlier detection for high consumption/low-billing mismatches	**11% of metered connections underbilled**	Technical inspection; meter replacement; billing correction; arrear recovery	Singapore PUB metering [9]

4.3 Applicable Standards

The CDRI framework benchmarks RMC's revenue performance against: (i) NIUA property tax efficiency norms [3]; (ii) 15th Finance Commission devolution criteria for own-source revenue performance [1]; (iii) AMRUT 2.0 guidelines on municipal financial sustainability [10]; and (iv) World Bank municipal finance benchmarks [5]. Collection efficiency is calculated as: Collections ÷ Total Demand × 100, consistent with AP Municipal Administration Revenue Dashboard methodology [2].

5. INITIATIVE AND CASE STUDY: RMC REVENUE PERFORMANCE 2024-25 & 2025-26

5.1 Two-Year Revenue Performance — All Streams

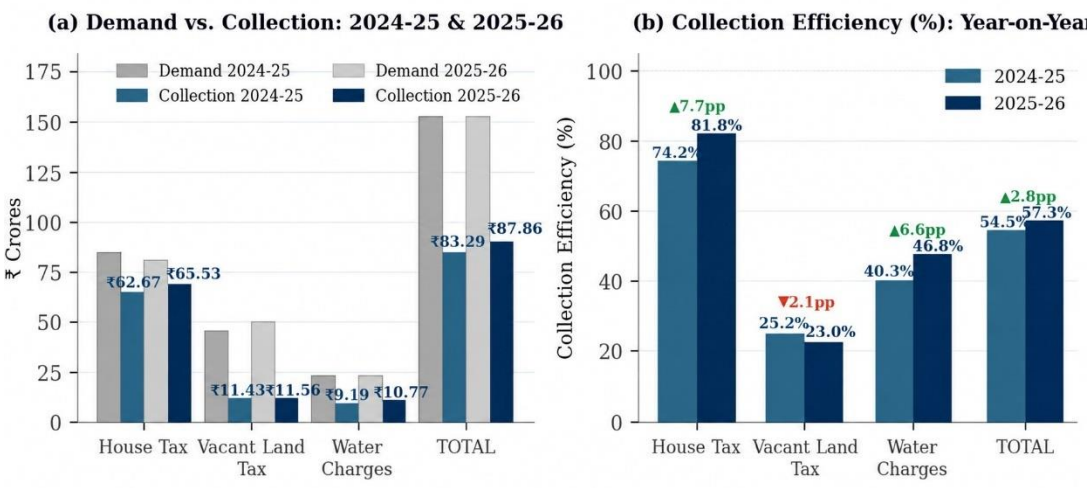


Figure 3: *RMC revenue performance — demand vs. collection across all three streams, 2024-25 and 2025-26 (₹ Crore). Source: AP Municipal Administration Revenue Dashboard & RMC Tax Records, 31 March 2026 [2].*

Figure 3 presents a comprehensive two-year comparative analysis across all three revenue streams. Total collections rose from ₹83.23 crore (2024-25) to ₹87.86 crore (2025-26) — a net increase of ₹4.63 crore (+5.57% YoY). House tax remains the dominant stream, contributing 74.6% of total collections in 2025-26.

Table 3: RMC Revenue Performance — Two-Year Summary (₹ Crores)

Revenue Stream	Assessments 2024-25	Demand 2024-25	Collection 2024-25	Efficiency 2024-25	Demand 2025-26	Collection 2025-26	Efficiency 2025-26	YoY Growth(Collection)
House Tax	81,595 / 82,339	₹ 84.41	₹ 62.61	74.17%	₹ 79.56	₹ 65.57	**82.41%**	**+4.67% (+₹2.92 Cr)**
Vacant Land Tax	5,614 / 5,768	₹ 45.43	₹ 11.43	25.16%	₹ 50.22	₹ 11.56	23.02%	**+1.14% (+₹0.13 Cr)**
Water Charges	47,044 / 47,231	₹ 22.82	₹ 9.19	40.27%	₹ 23.00	₹ 10.77	**46.83%**	**+17.19% (+₹1.58 Cr)**
TOTAL	**1,34,253 / 1,35,338**	**₹ 152.66**	**₹ 83.23**	**54.52%**	**₹ 153.29**	**₹ 87.86**	**57.32%**	**+5.57% (+₹4.63 Cr)**

5.2 Property Tax Performance and AP State Ranking

Figure 4 presents RMC's property tax achievement (82.41%) in the context of all Andhra Pradesh municipal corporations for 2025-26, as recorded on the AP Municipal Administration Revenue Dashboard [2]. RMC ranked 2nd among all AP corporations — achieving ₹65.57 crore in property tax collections against a total demand of ₹79.56 crore — a 13.6% increase over the previous year's collections. This performance was recognised with a state-level award from the Principal Secretary and Commissioner & Director of Municipal Administration (CDMA), Andhra Pradesh.

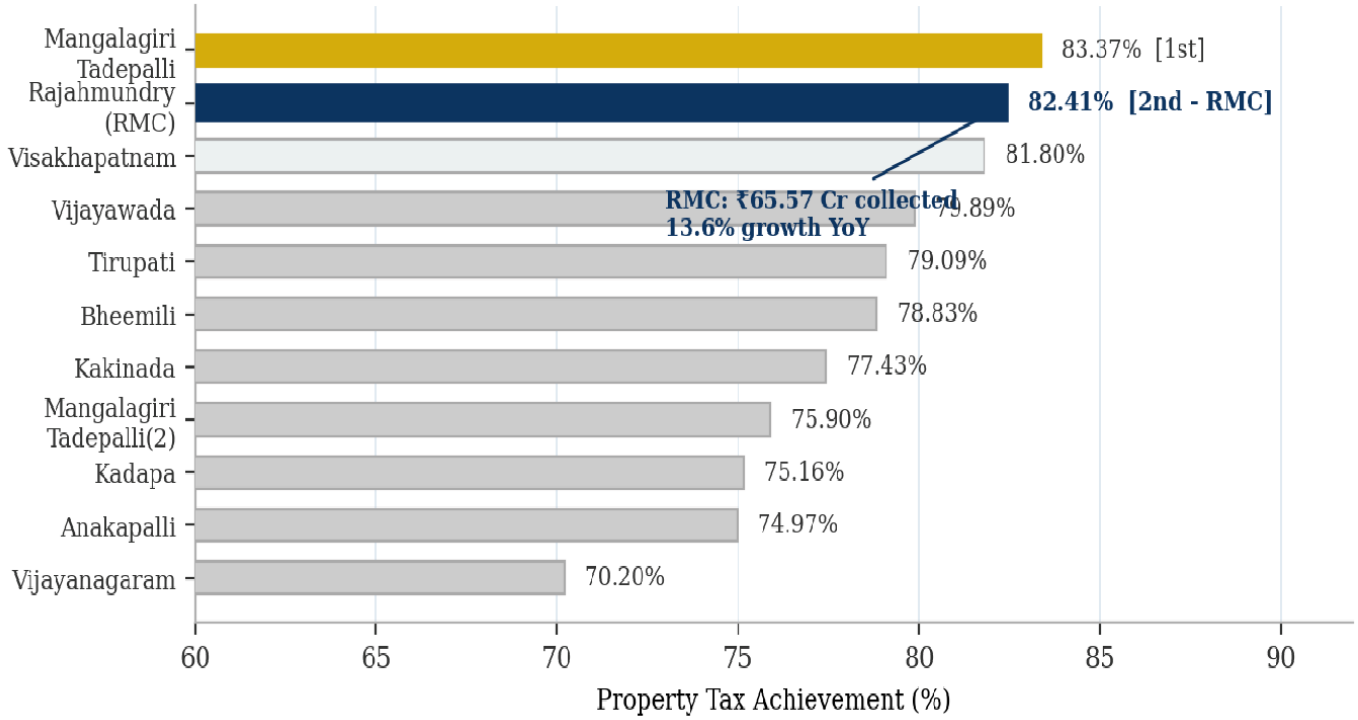


Figure 4: *AP Municipal Corporations property tax achievement ranking, 2025-26 (01-Apr-2025 to 31-Mar-2026). RMC ranked 2nd at 82.41% achievement. Source: AP Municipal Administration Revenue Dashboard [2].*

Recognition: RMC received the State Revenue Achievement Award with 13.6% year-on-year growth — the result of

systematic CDRI-driven revenue intelligence and team-wide performance accountability.

5.3 Revenue Leakage Detection Findings and House Tax Balance Reduction

Figure 5 presents CDRI leakage findings across four database pairs alongside the measurable reduction in house tax outstanding balance — the most direct indicator of CDRI effectiveness. Outstanding house tax balance declined from ₹21.80 crore (2024-25) to ₹14.54 crore (2025-26) — a reduction of ₹7.26 crore (33.3% balance reduction in a single year). This directly reflects CDRI-driven identification and recovery from previously undetected assessments.

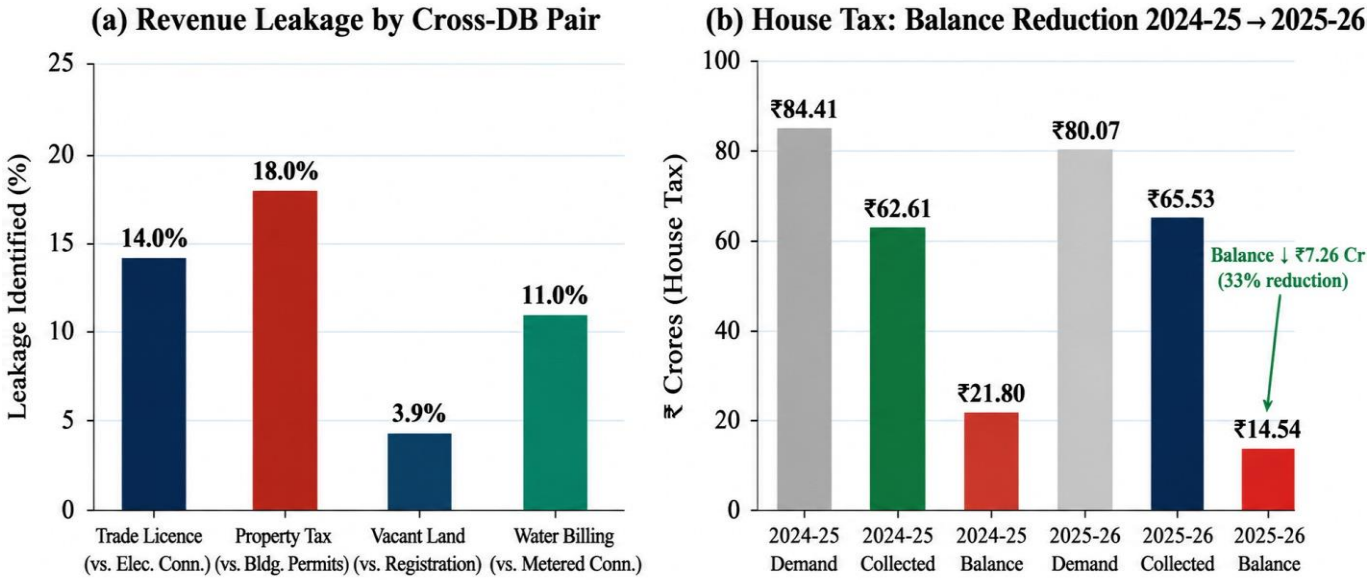


Figure 5: *(a) CDRI revenue leakage by database pair; (b) House tax outstanding balance reduction 2024-25 → 2025-26. Sources: RMC CDRI Analytics; AP Revenue Dashboard [2]; RMC Tax Ledger, 31 Mar 2026.*

5.4 Assessment Base Growth and International Benchmarking

Figure 6 presents assessment base growth across all three streams alongside an international benchmark comparison of overall revenue collection efficiency. RMC's overall efficiency improved from 54.52% (2024-25) to 57.32% (2025-26) — a 2.8 percentage point improvement — with a trajectory towards national best practices (60–65%) and international benchmarks (78–92%). The assessment base grew by 744 additional house tax assessments and 154 new vacant land assessments, reflecting CDRI-driven new property identification.

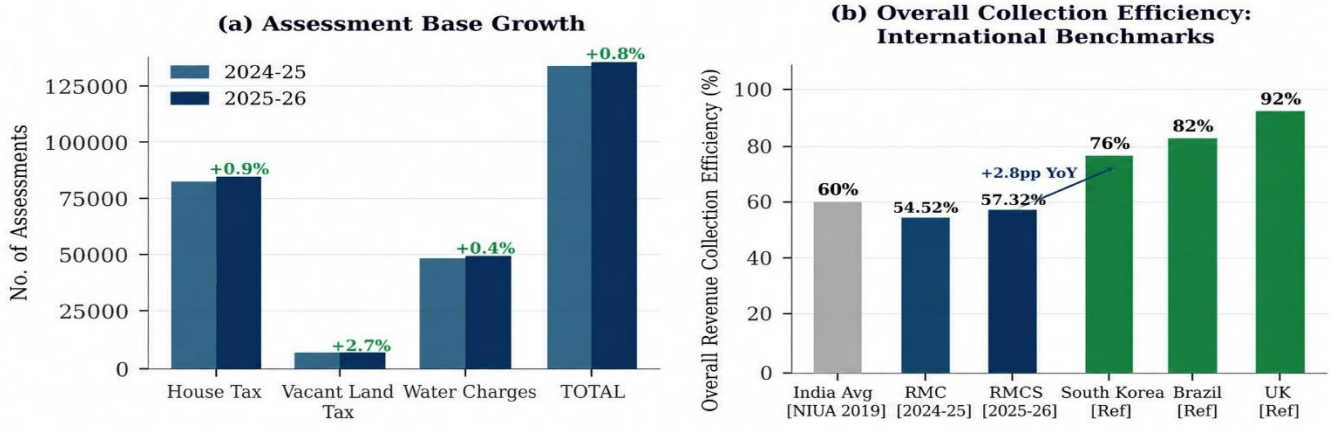


Figure 6: *(a) Assessment base growth 2024-25 → 2025-26; (b) Overall revenue collection efficiency benchmarked internationally. Sources: RMC Tax Records; NIUA 2019 [3]; World Bank 2021 [5].*

5.5 Revenue Mix and Growth Trajectory

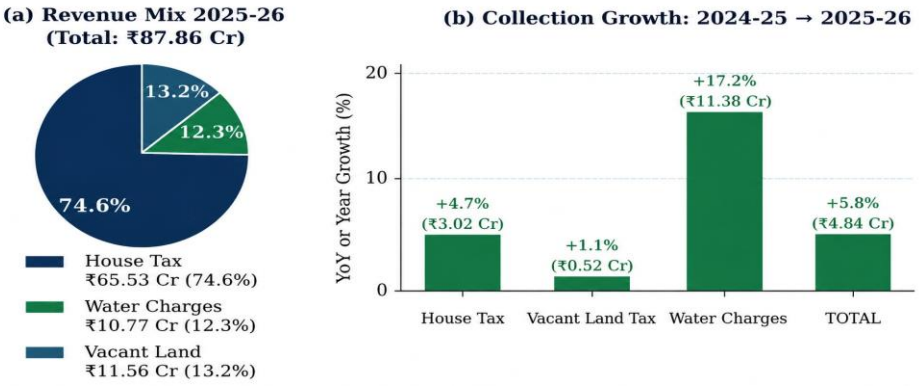


Figure 7: *(a) Revenue mix by stream, 2025-26; (b) Year-on-year collection growth rates. Source: RMC Tax Ledger; AP Municipal Administration Revenue Dashboard [2], 31 March 2026 (revised).*

Figure 7 presents the revenue mix across streams and year-on-year growth rates. Water charges showed the highest growth rate (+17.19%), reflecting CDRI-identified underbilling correction. House tax showed the largest absolute growth (+₹2.92 crore). Together, these figures demonstrate that systematic cross-database analysis converts previously invisible revenue gaps into measurable fiscal gains without new tax imposition.

6. OUTCOMES AND IMPACT

Table 4: CDRI Outcomes — RMC 2025-26 vs. Benchmarks

Outcome Indicator	RMC 2024-25	RMC 2025-26	National / Benchmark
House Tax collection efficiency	74.17%	**81.84% ▲**	~60–70% national avg [3]
Overall collection efficiency (3 streams)	54.52%	**57.32% ▲**	~50–60% typical ULB [5]
Total revenue collected	₹83.23 Cr	**₹87.86 Cr ▲**	+5.57% YoY growth
Property tax YoY growth (AP Dashboard)	₹60.24 Cr (2024-25)	**₹65.57 Cr (+13.6%) ▲**	AP Corp avg: ~6–8% [2]
AP State Ranking (Property Tax in % Achievement)	-	**2nd Rank — 82.41%**	1st: Mangalagiri 83.37% [2]
House Tax outstanding balance	₹21.80 Cr	**₹14.54 Cr ▼ (–33.3%)**	Balance reduction — key CDRI outcome
Businesses identified without trade licence	Not quantified	**14% of commercial connections**	Comparable: Colombia PREDIO [6]
Additional unassessed properties identified	Not quantified	**18% of building permissions**	Brazil Geosampa: ~15% [6]
Underbilled water connections	Not quantified	**11% of metered connections**	Water charges growth: +17.19% YoY
State recognition	—	**Award: 2nd highest % revenue collection**	Government of Andhra Pradesh, 2026

7. CHALLENGES, LESSONS LEARNED, AND MITIGATIONS

Table 5: CDRI Implementation Challenges and Lessons

Challenge	Description	Mitigation	Lesson for Replication
Data access from external agencies	Electricity board and Registration Dept. data not automatically available to municipal bodies	State-level bilateral MoU with APEPDCL and Registration Dept.; AP MA&UD facilitated access	State must enable data-sharing MoUs before CDRI deployment begins
Address standardisation	Legacy databases use inconsistent address formats, preventing direct SQL joins	Fuzzy address matching algorithm; geo-coordinate overlay for parcel-level cross-referencing	30-day data quality audit essential before integration; invest in geo-tagging
Departmental resistance	Revenue, Town Planning, and Engineering departments initially reluctant to share real-time data	Transparent framing as decision-support tool; Commissioner-led inter-department review meetings; demonstrated early wins	Start with willing departments; show outcomes to bring in others
Vacant land low efficiency (23.02%)	Vacant land tax collection efficiency declined from 25.16% to 23.02% despite identification of 3.9% additional parcels	Demand increased faster than collection capacity; field verification and legal dispute resolution workflow initiated	Identification and collection are separate phases; plan field capacity alongside analytics
Water charges arrear complexity	Underbilled connections involved both metering errors and consumer disputes	Tiered resolution: technical inspection for meter faults; IVRS-based consumer awareness for billing disputes; structured instalment plans	Billing correction requires both technical and consumer engagement protocols

8. REPLICABILITY AND SCALABILITY

The CDRI framework requires no new data collection — only intelligent cross-analysis of systems already in operation. Its replication across Indian ULBs depends on four enabling conditions: (i) bilateral data-sharing MoUs between electricity distribution companies, registration departments, and municipal bodies; (ii) a standardised address/property ID system enabling cross-database joins; (iii) an in-house or shared analytics cadre capable of running SQL cross-referencing scripts; and (iv) a governance accountability mechanism (such as SGOC) that routes exception reports to department heads with SLA-based closure tracking.

Table 6: National Scale Projection — CDRI Revenue Recovery Potential

Revenue Category	Leakage Foundation RMC	Projected Recovery per City (₹ Crore / year, indicative)
Trade Licence Fees	14% unlicensed	₹2–8 Cr
Property Tax (Unassessed)	18% unassessed	₹5–20 Cr
Vacant Land Tax	3.9% unassessed	₹1–3 Cr
Water Billing Efficiency	11% underbilled	₹2–6 Cr
TOTAL (Conservative Estimate)	—	**₹10–37 Cr / city**

Conservative national projection: deployment of CDRI across India's 500+ major ULBs could recover ₹10,000–15,000 crore annually — without new taxes, without rate changes, and using data systems already in operation. This represents a transformational fiscal opportunity for Indian municipal finance [1,5].

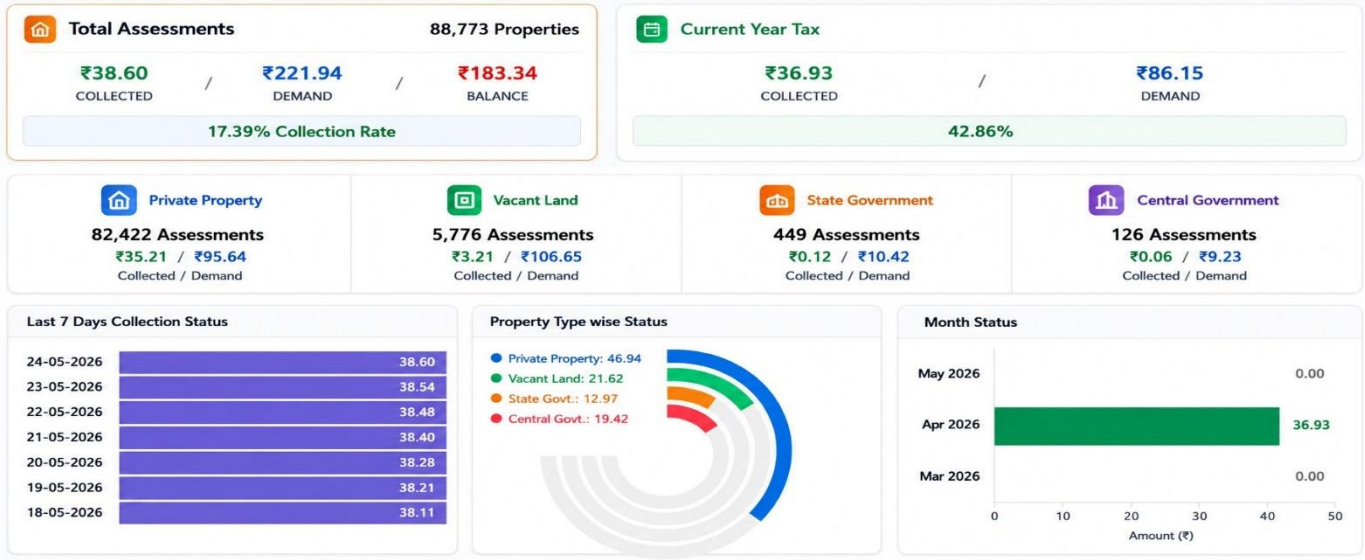


Figure 8: *Property Tax Dashboard: Real time details of Assessments, Demand, Collected, Balance. (April 2026 data as on 24.05.26)*

9. CONCLUSION AND POLICY RECOMMENDATIONS

RMC's CDRI framework demonstrates, through independently verified and state corroborated data, that data-driven revenue intelligence can deliver measurable fiscal improvement in a Tier-2 ULB without new taxation, external funding, or proprietary technology. The results — 2nd AP state ranking, 13.6% property tax growth, 33.3% reduction in outstanding balance, and 5.57% overall revenue growth — are achieved through a replicable analytical methodology that requires only the will to make existing databases speak to each other.

- Mandate cross-database revenue audit annually for all ULBs above 3 lakh population as a State Finance Commission devolution condition (MoHUA/State MA&UD Departments).
- Establish a national data-sharing MoU framework (DARPG) enabling electricity boards, registration departments, and water utilities to share data with municipal bodies — the single largest enabler for CDRI deployment at scale.

- Develop an open-source CDRI platform (MeitY + MoHUA) — standardised, configurable, zero-licensing-cost software for all Indian ULBs, eliminating the technology procurement barrier for smaller cities.
- Incorporate Revenue Mobilisation Efficiency as a criterion in the next Finance Commission devolution formula, creating fiscal incentives for CDRI adoption.
- Replicate RMC's Civic Data Cadre model — a 5–10 member in-house analytics team trained in cross-database revenue intelligence — in all ULBs above 3 lakh, under a DARPG national training programme.
- Address vacant land tax low collection efficiency (23.02%) through dedicated legal-clearance and field-verification protocols alongside analytics — recognising that identification and collection require separate operational pipelines.

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CHAPTER 9
Institutionalizing Digital Governance: The Role of OMMAS in the Decentralized Management of Rural Road Assets

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ABSTRACT

The **Pradhan Mantri Gram Sadak Yojana (PMGSY)**, launched in December 2000, has grown into one of the world's largest rural road infrastructure programmes. Over two decades it has evolved from a conventional connectivity initiative into a digitally enabled governance ecosystem spanning planning, execution, monitoring, and long-term asset maintenance.

Central to this transformation is the **Online Management, Monitoring and Accounting System (OMMAS 2.0)**, the core digital platform governing the full project lifecycle under PMGSY. Through real-time monitoring, financial oversight, quality assurance, and structured workflow management across a decentralised multi-tier framework, OMMAS has materially strengthened transparency and administrative accountability.

Strategic expansion under PMGSY-IV, the **Vibrant Village Programme (VVP)**, and **PM-JANMAN** has extended the programme's reach to border villages and Particularly Vulnerable Tribal Groups (PVTGs). The integration of Artificial Intelligence into the **eMARG** platform represents the next stage of digital maturation, enabling objective road-condition assessment and more efficient maintenance oversight. This paper argues that digital governance—combining decentralised execution with centralised digital oversight—has become indispensable to effective, accountable, and inclusive rural infrastructure delivery at scale.

KEYWORDS

Digital Governance; PMGSY; OMMAS; Public Digital Infrastructure; Rural Roads; AI Governance; e-Governance; Infrastructure Monitoring

1. INTRODUCTION: THE EVOLUTION OF RURAL CONNECTIVITY IN INDIA

Since its launch in December 2000, the Pradhan Mantri Gram Sadak Yojana (PMGSY) has emerged as one of the world's largest rural road programmes. As of 2024, it has sanctioned over

8.49 lakh kilometres of roads, connected more than 1.62 lakh habitations, and recorded cumulative expenditure exceeding ₹3.53 lakh crore [1]. The scale of implementation raises a fundamental governance question: how can such a geographically dispersed and financially intensive programme maintain transparency, accountability, and quality assurance simultaneously?

PMGSY has evolved markedly across its implementation phases. PMGSY-I concentrated on providing basic connectivity to unserved habitations, while subsequent phases broadened scope to include road upgradation and consolidation of rural transport networks. PMGSY-IV reflects a more strategic approach, incorporating the Vibrant Village Programme (VVP) for border villages and PM-JANMAN, which targets infrastructure access for Particularly Vulnerable Tribal Groups (PVTGs) across identified geographies [1].

The programme's inclusion framework—based on habitation population thresholds with differentiated criteria for plains, hill, tribal, and special-category areas—requires accurate and continuously updated spatial and demographic data. Managing this complexity through conventional administrative processes

alone would be impracticable. Digital systems such as OMMAS, supported by GIS-based planning, habitation mapping, geo-tagging, and real-time population records, have therefore become critical enablers of programme delivery [2].

2. OMMAS 2.0: THE ARCHITECTURAL FRAMEWORK OF E-GOVERNANCE

OMMAS 2.0 functions as an enterprise e-governance platform designed to support the full lifecycle of rural roads under PMGSY—from planning and implementation to maintenance—within a centralised digital framework that enables decentralised execution [2].

2.1 Core Functional Module

- **TR/MRL (Target Road / Major Rural Links):** Identifies proposed road links for providing connectivity to unconnected habitations.
- **Proposal Management:** Supports district-level annual proposals, state-level consolidation, and project approval workflows.
- **Agreement Management:** Maintains contract award records and contractor engagement details.
- **Physical Progress Monitoring (PMIS):** Tracks construction progress against approved milestones, including digital measurement and reporting mechanisms.
- **Quality Monitoring:** Supports the multi-tier quality assurance framework for inspection and compliance during construction.
- **Receipts and Payments:** Enables financial tracking, fund-release monitoring, and expenditure management.
- **Maintenance Management:** Maintains records of completed road assets to support upkeep and lifecycle monitoring.

2.2 Interoperability and Integration

The effectiveness of PMGSY depends on strong digital coordination across multiple institutions and implementation layers. OMMAS achieves this through interoperability with key government platforms:

- **GePNIC:** e-procurement integration for transparent contractor selection.
- **PFMS / SNA-based financial platforms:** Real-time fund tracking and payment management.
- **GIS-based planning systems:** Spatial oversight and route verification.
- **Citizen grievance mechanisms:** Structured channels for public feedback and redress.

This integration architecture ensures that operational, financial, and monitoring functions are coordinated within a unified system, reducing data silos and administrative duplication [2].

3. GRASSROOTS DATA COLLECTION: THE GRAM SADAK SURVEY APP & PMGSY-IV

The Gram Sadak Survey (GSS) mobile application serves as the primary field-level data collection tool for planning and verification under PMGSY-IV, which focuses on connecting currently unserved habitations through targeted rural road development. The application enables standardised digital surveying, improving the reliability of field-level data [1, 2].

3.1 Maker–Checker Validation Framework

A central governance feature of the application is its Maker–Checker validation framework, under which field surveys conducted by designated officials are reviewed and approved by supervisory authorities before final acceptance. This layered validation improves data quality and reduces the risk of inaccurate reporting—a common challenge in large-scale field data collection programmes.

3.2 Technical Survey Protocols

Survey teams capture geo-coordinates and waypoints along proposed alignments, including critical points such as curves, slopes, and junctions at prescribed intervals to ensure route accuracy. GPS-enabled, geo-tagged image capture provides verifiable visual evidence. Beyond route mapping, the platform documents associated infrastructure access points—schools, primary health centres, markets, and banking facilities—offering a broader view of connectivity requirements [2].

The inclusion of offline functionality makes the application particularly valuable in remote geographies, including border and tribal regions where network connectivity is limited. Integration with Local Government Directory (LGD) codes and updated habitation data ensures administrative consistency and interoperability with other government systems.

4. AI INTEGRATION: ADVANCING MAINTENANCE GOVERNANCE THROUGH EMARG

A significant advancement in PMGSY's digital governance framework is the integration of Artificial Intelligence (AI) into the eMARG (Electronic Maintenance of Rural Roads) platform to strengthen maintenance monitoring and objective performance assessment [3].

4.1 System Functionality

The AI-enabled system analyses geo-tagged road inspection images to support objective assessment of road conditions and identify inconsistencies between field observations and submitted performance evaluation scores. Importantly, the system functions as a decision-support tool rather than an autonomous decision-maker: it generates alerts for reviewing officials during the approval process, preserving administrative accountability while augmenting analytical capacity.

4.2 Operational Impact

The integration of AI into eMARG has produced measurable improvements in maintenance oversight efficiency, including reported reductions in manual review time for performance evaluation reports. By enabling early identification of poorly maintained or high-risk road assets, the system supports more informed prioritisation of maintenance activities and resource allocation [3].

This intervention reflects the broader evolution of PMGSY: from a digitally monitored infrastructure programme toward a more data-driven governance model for asset management and service delivery—consistent with the Indian government's wider push toward AI-enabled public administration.

5. SOCIO-ECONOMIC IMPACT AND QUALITY PERFORMANCE

The effectiveness of PMGSY's digital governance framework is ultimately validated by its outcomes—both in the quality of physical assets delivered and in the socio-economic changes experienced by connected communities. The evidence below, drawn from independent evaluations and OMMAS quality data, demonstrates the programme's impact across multiple dimensions [4, 5].

Table 1: Socio-Economic and Quality Outcomes of PMGSY

Impact Dimension	Metric / Outcome	Source
Agricultural Efficiency	8% increase in crops transported to markets	World Bank (2018)
Rural Employment	13% rise in non-farm primary employment	World Bank (2018)
Maternal Health	30% reduction in home births due to improved facility access	PMGSY Impact Evaluation
Girls' Education	Secondary enrolment rose from 56% to 65%	MoRD Evaluation Division
Construction Quality	96% of completed roads rated Satisfactory	OMMAS Quality Module
Maintenance Quality	84% of maintenance works rated Satisfactory	OMMAS Quality Module
Multidimensional Poverty	MRDI: 32.3 (connected) vs. 43.7 (unconnected habitations)	PMGSY Impact Evaluation

Sources: *World Bank (2018) [5]; MoRD Evaluation Division [4]; OMMAS Quality Module [2].*

5.1 Quality Assurance and Digital Accountability

The high satisfactory ratings for construction (96%) and maintenance (84%) are directly attributable to the transparency enforced by OMMAS, wherein every project phase is subject to geo-tagged verification and multi-tier quality inspection. When data is systematically captured and publicly accessible, the incentive for sub-standard work is substantially reduced.

5.2 Connectivity and Multidimensional Poverty Reduction

The relationship between reliable road connectivity and poverty reduction is evident in programme data. In habitations connected under PMGSY, the Multidimensional Rural Deprivation Index (MRDI) stands at 32.3, compared to 43.7 in unconnected habitations [4]. This gap underscores that physical connectivity, when delivered through an accountable governance system, serves as a primary driver of rural poverty reduction.

6. CONCLUSION: TOWARD A DATA-DRIVEN RURAL GOVERNANCE MODEL

OMMAS has evolved from a programme monitoring system into a comprehensive digital governance platform, integrating planning, execution, quality assurance, financial supervision, and maintenance management within a unified architecture. The AI-enabled capabilities introduced through eMARG represent the next phase of this evolution, strengthening maintenance evaluation and enabling earlier identification of quality risks [2, 3].

Looking ahead, emerging capabilities—satellite-based infrastructure monitoring, advanced geospatial analytics, and technology-enabled grievance redressal—offer further opportunities to improve rural infrastructure administration and enhance public responsiveness.

The broader significance of PMGSY's digital transformation, however, lies beyond administrative efficiency. By establishing a unified digital governance framework with standardised data, transparent workflows, and strengthened oversight, PMGSY has meaningfully raised accountability in infrastructure delivery. This digital foundation supports more effective rural connectivity planning and implementation, contributing to social inclusion, improved access to essential services, and sustained rural economic

development—demonstrating that effective governance and physical infrastructure are mutually reinforcing pillars of rural development policy.

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All references follow the APA 7th edition citation style. In-text citations throughout this paper use the corresponding reference numbers in square brackets (e.g., [1]).

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CHAPTER 10
Artificial Intelligence Use-cases for skilling programme in DDU-GKY and RSETI: Strengthening Rural Skilling Governance

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ABSTRACT

Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY) and Rural Self Employment Training Institutes (RSETIs) are among the flagship rural skilling and livelihood initiatives of the Ministry of Rural Development aimed at enhancing employability, promoting self-employment, and strengthening economic participation among rural youth and aspiring entrepreneurs across the country. These programmes operate through an extensive network of training centres and institutions spread across diverse geographical regions, including remote and connectivity-challenged rural areas. Given the scale and complexity of programme implementation, ensuring transparency, accountability, attendance authenticity, assessment integrity, infrastructure compliance, and effective monitoring have emerged as a major governance and operational challenge.

To address these challenges, a comprehensive Unified IT Platform has been developed for DDU-GKY 2.0 and RSETI 2.0, integrating advanced Artificial Intelligence (AI) and Computer Vision technologies into critical operational and monitoring processes. The integrated approach adopted through the Unified IT Platform establishes a scalable, transparent, and technology-driven framework capable of supporting efficient programme implementation across geographically dispersed and resource-constrained environments. This paper presents a structured overview of four key AI-enabled interventions implemented through the platform, namely facial recognition-based attendance management, AI-driven infrastructure verification, AI-enabled automated candidate assessment, and AI-based real-time headcount monitoring using IP camera systems.

INDEX TERMS

DDU-GKY, RSETI, Artificial Intelligence, Computer Vision, Facial Recognition, Liveness Detection, Geo-tagging, Candidate Assessment, Infrastructure Verification, Remote Monitoring, Digital Governance, Rural Skilling.

1. INTRODUCTION

India stands at a unique demographic crossroads. With more than sixty-five percent of its population below the age of thirty- five, the nation possesses an extraordinary human resource potential that, if adequately skilled and employed, could drive sustained economic growth for decades. However, realizing this demographic dividend requires systematic investment in skill development, particularly among rural populations who have historically faced barriers to quality vocational training and meaningful employment opportunities.

Recognizing this imperative, the Ministry of Rural Development has established two flagship programmes designed to address the skilling needs of rural India. The Deen Dayal Upadhyaya Grameen Kaushalya Yojana, commonly known as DDUGKY, is a placement-linked skill development initiative targeting rural youth between fifteen and thirty-five years of age. The programme operates through a network of Project Implementing Agencies who establish and manage training centres offering courses aligned with industry requirements, with mandatory placement support for successfully trained candidates. Complementing this wage employment focus, the Rural Self Employment Training Institutes, or RSETIs, provide short-term

residential training programmes designed to equip rural youth with entrepreneurial skills necessary for establishing self- employment ventures. These institutes operate across all districts of India under the management of participating banks, offering intensive training programmes ranging from one to six weeks in duration.

The following table summaries key programme parameters that define the scale of the programmes:

Parameter	DDUGKY	RSETI
Programme Objective	Wage Employment	Self-Employment
Candidate Registration	9+ lakh candidates	
Training Centres	835	644
Trainings Completed	1+ lakh candidates	2+ lakh candidates
Project Implementing Agencies	3000+	Bank-managed (25 banks)
Training Duration	12 - 48 weeks	1 – 24 weeks

2. UNIFIED IT PLATFORM FOR DDU-GKY AND RSETI

A comprehensive unified digital platform has been developed for the end-to-end operationalization and monitoring of both DDU-GKY and RSETI programmes. Prior to this initiative, nearly 25 independent applications and modules were functioning in silos for activities such as candidate registration, training management, attendance monitoring, assessment tracking, placement management, inspection, and reporting. Many of the critical processes such as candidate mobilization, attendance, assessment, payment processing and accounting were manual.

The newly developed unified IT platform consolidates these disparate applications into a single integrated ecosystem, enabling seamless coordination among stakeholders including the Ministry, State Rural Livelihood Missions (SRLMs), Project Implementing Agencies (PIAs), RSETIs, training centres, assessors, inspectors, and beneficiaries.

Further, advanced technologies based on Artificial Intelligence (AI) are being integrated into various critical operational processes such as training centre infrastructure verifications, candidate attendance tracking, candidate assessments and inspections of training centers, to enhance transparency, monitoring, and compliance across training centers.

3. AI INTERVENTIONS IMPLEMENTED IN THE UNIFIED IT PLATFORM

3.1 AI Intervention 1: Facial Recognition-Based Attendance

3.1.1 Use Case Description

Attendance is one of the most critical processes in any skilling programme. It determines whether candidates are participating in training and also supports downstream processes such as assessment eligibility, stipend calculation, compliance monitoring, and payment processing.

In the Unified IT Platform, all users undergo Aadhaar-based eKYC and are approved by the competent authority during registration. Candidate registration is carried out through the candidate mobile application using Aadhaar-based face recognition service. Attendance in the platform is primarily marked through Aadhaar Enabled Biometric Attendance System. To avoid dependency on only one method and to support field conditions, Aadhaar-based face recognition through the mobile application has also been introduced.

However, many rural training centres operate in areas where internet connectivity is weak or intermittent. In such cases, real- time Aadhaar-based authentication may not always be feasible. To address this challenge, the platform provides an AI-based facial recognition attendance mechanism that supports both online and offline modes.

The system allows attendance to be captured locally on authorized devices even when network connectivity is unavailable. Once connectivity is restored, attendance records are securely synchronized with the central server. This ensures continuity of training operations without compromising the integrity of attendance data.

3.1.2 Technical Design

The facial recognition attendance system uses computer vision techniques to verify the identity of candidates and trainers. During registration, the face template of the user is securely mapped with the beneficiary profile after Aadhaar eKYC. During attendance marking, the captured face is matched against the stored template.

The system includes the following technical safeguards:

- **Face matching:** Candidate face images are converted into digital facial templates and compared with registered templates.
- **Liveness detection:** The system validates whether the captured image belongs to a live person and not a photograph, video, or screen replay.
- **Device authorization:** Attendance can be captured only through authorized devices mapped to the training centre.
- **Geo-location validation:** Attendance records are tagged with location information to ensure that attendance is marked from the authorized centre.
- **Timestamp validation:** Each attendance event carries a timestamp to support audit and compliance.
- **Offline sync:** Attendance captured offline is stored securely and synchronized with the central system once internet connectivity is restored.
- **Duplicate prevention:** The system checks for repeated or duplicate attendance entries for the same session.

3.1.3 Key Benefits

For candidates, the system provides a transparent and contactless attendance mechanism. It reduces dependency on manual registers and supports attendance capture even in low- connectivity regions.

For government and implementing agencies, the intervention improves the reliability of attendance data. It helps reduce impersonation, proxy attendance, duplicate attendance, and ghost beneficiaries. It also enables centralized monitoring through dashboards and strengthens audit readiness through geo-tagged and time-stamped records.

3.2 AI Intervention 2: Infrastructure Verification at Training Centres

3.2.1 Use Case Description

Training centre infrastructure has a direct impact on the quality of training. Classrooms, furniture, equipment, lighting, computers, safety facilities, and other basic amenities must be available as per scheme norms. Traditionally, infrastructure verification depended heavily on physical inspections and manual reports. This created scope for subjectivity, delays, and mismatch between declared and actual assets.

The Unified IT Platform introduces an AI-enabled infrastructure verification system. Under this system, authorized inspectors capture geo-tagged and time-stamped photographs of training centre facilities through the platform. The AI engine then analyzes these images to identify infrastructure assets and compare them with the declared information submitted by the training centre.

3.2.2 Technical Design

The infrastructure verification module uses computer vision and object detection. Captured images are processed to detect and classify objects such as chairs, tables, fans, lights, computers, projectors, whiteboards, and other training-related assets.

The technical workflow includes:

- Inspector logs into the platform using authorized credentials.
- Geo-tagged and time-stamped photographs are captured from the training centre.
- The AI model processes the images and detects relevant infrastructure objects.
- Detected objects are counted and compared against the declared infrastructure inventory.
- Mismatches, missing assets, duplicate claims, or anomalies are flagged.
- The output is stored in the system and made available through dashboards and reports.

The system can be further strengthened by using image quality checks, object confidence scores, duplicate image detection, and metadata validation to prevent misuse.

3.2.3 Key Features

- Automated detection of training centre assets from images
- Real-time comparison of declared and detected infrastructure
- Geo-tagged and time-stamped inspection evidence
- Standardized inspection workflow across centres
- Automated anomaly reports and alerts
- Dashboard-based compliance monitoring

3.2.4 Key Benefits

For beneficiaries, the intervention helps ensure that training is conducted in better-equipped and compliant centres. This improves the learning environment and contributes to better training outcomes.

For government and implementing agencies, AI-based infrastructure verification reduces dependency on subjective manual inspection reports. It enables scalable monitoring across thousands of centres and supports evidence-based decision- making. It also strengthens transparency in fund utilization and compliance management.

3.3 AI Intervention 3: AI-Enabled Candidate Assessment

3.3.1 Use Case Description

Assessment is a critical stage in skilling programmes because it validates whether candidates have acquired the required competencies. Manual assessment processes, especially manual checking of OMR sheets or paper-based answer sheets, can be slow and prone to errors. In large-scale programmes, delays in assessment and certification can also affect placement and livelihood outcomes.

The Unified IT Platform introduces an AI-enabled assessment automation framework. The system supports assessment scheduling, generation of examination plans, preparation of randomized question sets, and generation of QR-coded OMR sheets, automated evaluation, and result processing.

3.3.2 Technical Design

The assessment module uses computer vision and Optical Mark Recognition technologies. OMR sheets are scanned or captured digitally, and the AI-enabled system interprets the marked responses. The responses are then evaluated against the answer key.

The system includes the following technical components:

- **QR-coded OMR sheets:** Each OMR sheet carries a unique QR code for candidate mapping, traceability, and prevention of duplicate sheets.
- **Randomized question sets:** Question papers or question sequences can be randomized to reduce copying and coordinated malpractice.
- **OMR scanning and interpretation:** Computer vision algorithms identify marked bubbles and interpret candidate responses.
- **Automated scoring:** The system validates responses against the answer key and generates scores automatically.
- **Anomaly detection:** Suspicious patterns, duplicate entries, unusual score distributions, or possible malpractice indicators are flagged.
- **Digital audit trail:** Every stage of assessment processing is recorded for review and audit.

3.3.3 Key Features

- AI and computer vision-based OMR evaluation
- Secure QR-coded answer sheets
- Randomized question sets to prevent malpractice
- Automated scoring and faster result generation
- Real-time dashboards for assessment monitoring
- Anomaly detection and fraud prevention

3.3.4 Key Benefits

For candidates, the system ensures fair, transparent, and faster assessment. It reduces delays in certification and improves trust in the assessment process.

For programme administrators, automated assessment reduces manual effort, minimizes human error, and supports standardized evaluation across centres. It also improves monitoring of assessment agencies and provides better visibility into candidate performance.

3.4 AI Intervention 4: AI-Enabled Monitoring of Candidates through IP Cameras

3.4.1 Use Case Description

Attendance records show whether candidates have been marked present, but they may not always confirm the actual number of candidates physically present in the classroom at a given time. For stronger

monitoring, the Unified IT Platform uses IP camera snapshots and computer vision to support remote candidate monitoring.

Under this intervention, an inspection officer or authorized user captures a live snapshot from the training canter's IP camera. The AI system analyzes the image to count candidates, compares the detected headcount with the batch attendance records of that day, and highlight discrepancies.

This creates an independent layer of verification and allows programme officers to conduct virtual inspections without always visiting the center physically.

3.4.2 Technical Design

The AI-enabled monitoring system uses computer vision models for person or face detection in classroom images. The system processes IP camera snapshots and generates structured outputs such as detected headcount, discrepancy status, timestamp, camera ID, and inspection reference.

The technical workflow includes:

- Authorized officer initiates remote inspection.
- Live snapshot is captured from the training centre IP camera.
- AI model detects and counts candidates visible in the classroom.
- Detected headcount is compared with batch roster or recorded attendance.
- Any mismatch is flagged for review.
- Snapshot and metadata are stored as tamper-resistant evidence.
- Results are displayed on dashboards for monitoring authorities.

3.4.3 Key Features

- Candidate counting using computer vision
- Prevention of double counting through identity or object tracking techniques
- Cross-verification against batch strength or attendance records
- Metadata integration including timestamp and camera ID
- Secure storage of inspection evidence
- Real-time dashboards for monitoring officers
- Automated alerts for ghost attendance or batch padding

3.4.4 Key Benefits

For candidates, the system supports fair attendance verification and improves transparency. It also reduces the need for frequent disruptive physical inspections.

For government and implementing agencies, the intervention improves monitoring coverage. It helps detect inflated attendance, batch padding, and mismatch between reported and actual classroom presence. It also enables data-driven planning for retention, batch scheduling, and inspection prioritization.

4. TECHNOLOGICAL ARCHITECTURE AND PROCESS DESIGN

The four interventions are unified by a common design philosophy: use AI to capture field evidence, validate it automatically, and convert it into auditable administrative intelligence. Across attendance, infrastructure checks, assessments, and headcount monitoring, the system relies on computer vision, structured data outputs, geo-tagging, timestamps, anomaly detection, and dashboard integration.

A notable architectural feature is support for field realities such as low-connectivity conditions and remote locations. Offline- capable attendance capture, later synchronization, and remote inspection through IP camera analysis indicate that the platform is built not only for technological sophistication but also for operational practicality in rural deployment contexts.

Taken together, these benefits illustrate a transition from reactive compliance to proactive governance. AI does not replace programme administration, but augments it with more reliable signals, standardized evidence, and faster decision support.

5. AI INTERVENTIONS: CONSOLIDATED CHALLENGE-SOLUTION MATRIX

Challenge	AI-Based Solution	Technology	Outcome
Ghost candidates	Face recognition eKYC	Computer Vision	Fraudulent enrolments eliminated
Proxy attendance	Real-time biometric matching	Computer Vision	Authentic presence verified
Infrastructure non-compliance	Automated quality check	Object Detection	Objective compliance assessment
Limited inspection coverage	Virtual inspections via IP camera	Object Detection	Expanded monitoring reach
Partial-day attendance	Continuous headcount	Object Detection	Full-day presence validation
Assessment bias	Automated scoring	OCR	Fair, consistent evaluation
Delayed certification	Accelerated processing	OCR	Rapid results declaration
Monitoring at scale	Predictive analytics dashboards	AI/ML	Real-time governance insight

6. FUTURE SCOPE: AI'S EXPANDING ROLE IN SKILLING GOVERNANCE

Several frontier applications present potential for future integration:

- **AI-Powered Candidate Mobilization and Counselling:** Help candidate identify their area of interest and recommend suitable courses. The system would use conversational AI in regional languages, simple aptitude assessments, candidate profile analysis, and local labour market information. Based on this, the platform can suggest training programmes that are more aligned with the candidate's strengths and employment prospects. This can improve candidate-course fitment, reduce dropouts, and support better placement or self-employment outcomes.
- **AI-Based Skill Gap Analysis:** Analyzing labour market trends and candidate profiles to recommend optimal training programmes and predict employment outcomes.
- **Predictive Dropout Intervention:** Early identification of at-risk candidates through behavioural pattern analysis, enabling proactive retention interventions.

- **Natural Language Processing for Candidate Support:** AI-powered chatbots providing programme information, grievance registration, and query resolution in regional languages.
- **Automated Content Quality Assessment:** AI evaluation of training content and delivery quality through video analysis of classroom sessions.
- **Blockchain Integration for Credential Verification:** Tamper-proof digital credentials with AI-verified authenticity for employer verification.

7. POLICY AND IMPLEMENTATION SIGNIFICANCE

The AI interventions in DDU-GKY and RSETI are significant because they show how digital governance systems can be tailored for large public programmes operating under field constraints. Rather than limiting AI to analytics after the fact, the platform embeds intelligence directly into operational processes such as attendance capture, inspections, and assessments. This makes compliance verification continuous rather than occasional.

The formatted reference paper also presents these interventions as evidence of cross-programme learning within the Ministry of Rural Development, where a unified technology platform supports reusable AI capabilities across schemes. Such an approach has broader policy value because interoperable digital building blocks can reduce duplication, improve administrative consistency, and speed future innovation in rural development systems.

8. CONCLUSION

The integration of artificial intelligence into DDU-GKY and RSETI through the Unified IT Platform represents a practical governance innovation for rural skilling programmes. By combining facial recognition-based attendance, object detection for infrastructure verification, AI-enabled assessments, and IP camera-based classroom monitoring, the platform addresses core challenges of authenticity, transparency, and scale.

These interventions demonstrate that AI can strengthen public programme delivery when it is embedded in real workflows, adapted to low-connectivity conditions, and linked to auditable evidence systems. In this respect, DDU-GKY and RSETI offer a meaningful model for applying AI in development administration where trust, reach, and implementation efficiency are equally important.

CHAPTER 11
AI-Enabled Grassroots Governance in India: Towards Decentralised, Data-Driven and Citizen-Centric Local Administration for Viksit Bharat 2047

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ABSTRACT

India's transition towards Viksit Bharat 2047 necessitates the transformation of grassroots governance through Artificial Intelligence (AI), data-driven administration, and citizen-centric digital service delivery. The growing integration of AI within Panchayati Raj Institutions (PRIs), urban local bodies, and public service platforms has opened new possibilities for transparent, efficient, and participatory governance. This paper examines the emerging role of AI-enabled governance systems in strengthening decentralized administration, improving public service delivery, and enhancing administrative responsiveness at the local level. It analyses how technologies such as AI-powered grievance redressal systems, multilingual digital platforms, predictive analytics, and data dashboards can improve governance outcomes and bridge rural-urban digital divides. The paper further explores key initiatives including eGramSwaraj, SabhaSaar, BHASHINI, AI-enabled citizen assistance platforms, and international digital governance models such as Estonia's data-driven governance architecture. Through comparative case studies and policy analysis, the study identifies major opportunities and challenges relating to digital inclusion, data privacy, institutional capacity, algorithmic accountability, and local administrative preparedness. The paper argues that effective AI-enabled grassroots governance requires a participatory, ethical, and decentralized governance framework that balances technological innovation with democratic accountability. It concludes by proposing a governance roadmap for building inclusive, secure, and citizen-centric local administrative systems aligned with the vision of Digital India and Viksit Bharat 2047.

KEYWORDS

Local governance, Data-driven, Democratic, Public-administration, public service.

1. INTRODUCTION

The emergence of digital governance has fundamentally transformed public administration across the world. In India, the vision of "Viksit Bharat 2047" places strong emphasis on technology-enabled governance, inclusive development, and efficient public service delivery. The rapid adoption of Artificial Intelligence (AI), digital public infrastructure, and data-driven governance systems has created new opportunities for strengthening grassroots democracy and decentralized administration.

Grassroots governance institutions such as Gram Panchayats and Urban Local Bodies (ULBs) constitute the foundation of India's democratic governance structure. However, these institutions often face challenges including limited administrative capacity, delays in service delivery, lack of transparency, and weak citizen engagement. AI-enabled governance systems can significantly improve administrative responsiveness, planning, financial transparency, and participatory governance at the local level. (National Conference on e-Governance [NCeG], n.d.)

Recent initiatives such as eGramSwaraj, SabhaSaar, BHASHINI, and AI-based grievance management systems demonstrate India's transition towards digital and intelligent governance. These initiatives indicate that AI is increasingly being used not only for automation but also for enhancing democratic participation and inclusive governance. (Press Information Bureau [PIB], 2026a) This paper analyses the emerging role of AI-enabled grassroots governance in India and examines how data-driven governance systems can strengthen local administration and citizen-centric service delivery.

2. CONCEPTUAL FRAMEWORK: AI AND DATA-DRIVEN GOVERNANCE

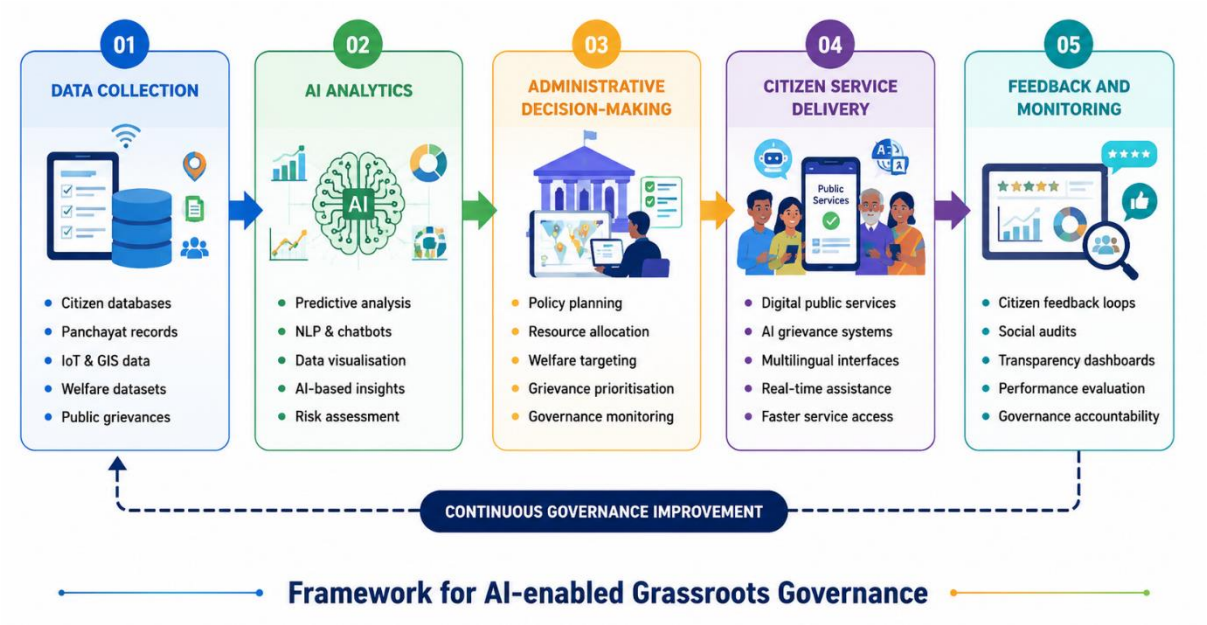
AI-enabled governance refers to the use of machine learning, predictive analytics, natural language processing, and intelligent digital systems in public administration and decision-making processes. AI

technologies can improve governance efficiency by automating administrative functions, enabling real-time monitoring, and enhancing citizen interaction with government institutions.

Data-driven governance focuses on evidence-based policymaking through the systematic collection, analysis, and utilisation of public data. In the context of grassroots governance, data-driven systems can support local planning, welfare targeting, grievance redressal, and resource allocation. AI further strengthens these processes by enabling predictive governance and automated administrative support. (Press Information Bureau [PIB], 2026a)

The integration of AI with Digital Public Infrastructure (DPI) has become central to India's governance strategy. Platforms such as Aadhaar, Unified Payments Interface (UPI), DigiLocker, and BHASHINI represent the expansion of interoperable digital governance ecosystems capable of supporting population-scale governance delivery. (ETGovernment, 2026)

A simplified governance framework for AI-enabled grassroots governance can be understood as:



Framework for AI-enabled Grassroots Governance

The framework illustrates the process of AI-enabled grassroots governance through an integrated and data-driven administrative model. The governance cycle begins with data collection from citizen databases, Panchayat records, welfare datasets, and public grievances, which are then processed using AI analytics such as predictive analysis, chatbots, and data visualisation tools. These insights support administrative decision-making related to policy planning, resource allocation, and grievance prioritisation. The next stage focuses on citizen service delivery through multilingual digital platforms, AI-enabled grievance systems, and real-time public assistance mechanisms. Finally, feedback and monitoring systems ensure transparency, accountability, social audits, and continuous governance improvement. The framework highlights how AI can strengthen decentralised governance by making public administration more efficient, participatory, responsive, and citizen-centric in alignment with the vision of Viksit Bharat 2047.

3. AI-ENABLED GRASSROOTS GOVERNANCE IN INDIA

3.1 eGramSwaraj Platform

The eGramSwaraj platform represents one of India's most significant digital governance initiatives for Panchayati Raj Institutions. Developed under the e-Panchayat Mission Mode Project, the platform integrates planning, accounting, monitoring, asset management, and financial transactions into a unified digital system. (Press Information Bureau [PIB], 2026b)

The platform has enabled real-time financial transparency by integrating with the Public Financial Management System (PFMS). According to government reports, over ₹3 lakh crore in cumulative payments have been processed through eGramSwaraj, significantly reducing manual paperwork and increasing accountability. (Press Information Bureau [PIB], 2026a)

The system also supports evidence-based local planning by enabling Gram Panchayats to upload development plans digitally. This strengthens decentralized governance by improving coordination between local bodies and higher administrative institutions.

3.2 SabhaSaar: AI for Participatory Governance

SabhaSaar is an AI-enabled governance platform designed for automated transcription and summarisation of Gram Sabha meetings. The platform converts audio and video recordings into structured meeting minutes, resolutions, and action points. (Press Information Bureau [PIB], 2026b) Integrated with BHASHINI, SabhaSaar supports multiple Indian languages and improves accessibility for citizens from diverse linguistic backgrounds. This initiative strengthens democratic participation by ensuring transparent documentation of local decision-making processes. (Press Information Bureau [PIB], 2026a) SabhaSaar demonstrates how AI can institutionalize participatory democracy by making local governance proceedings more transparent, searchable, and publicly accessible.

3.3 BHASHINI and Multilingual Governance

India's linguistic diversity presents a major challenge for inclusive digital governance. The BHASHINI initiative addresses this challenge through AI-powered multilingual translation and speech technologies. BHASHINI enables citizens to interact with governance systems in local languages through voice-based interfaces, translation tools, and conversational AI systems. This is particularly important in rural areas where digital literacy and English proficiency remain limited. (ETGovernment, 2026) Voice-first governance systems supported by BHASHINI can significantly improve citizen access to welfare schemes, grievance redressal systems, and public information services.

4. CASE STUDIES AND BEST PRACTICES

4.1 eGramSwaraj: Digital Financial Governance in Rural India

The eGramSwaraj platform demonstrates how digital systems can improve financial governance at the local level. The integration of Panchayat-level transactions with PFMS has increased transparency, reduced delays, and enabled real-time expenditure tracking. (Press Information Bureau [PIB], 2026b)

The platform's large-scale adoption across over 2.5 lakh Gram Panchayats reflects its institutional relevance and scalability. It also demonstrates how digital governance can reduce corruption risks and strengthen public accountability.

4.2 SabhaSaar and AI-Driven Democratic Participation

SabhaSaar is among the most innovative examples of AI-enabled participatory governance in India. By automating the documentation of Gram Sabha meetings, the platform improves institutional memory, transparency, and administrative efficiency. (Policy Edge, n.d.)

Its multilingual capabilities make governance processes more inclusive and accessible for marginalized communities. The initiative highlights how AI can support democratic decentralization rather than merely administrative automation.

4.3 Estonia's Digital Governance Model

Estonia is widely recognized as a global leader in digital governance. Its governance model is based on interoperable digital identity systems, open government data, and integrated public service platforms. Estonia's "X-Road" digital infrastructure enables secure information exchange across government departments while maintaining citizen data security. (Tallberg et al., 2023)

- The Estonian experience offers important lessons for India, particularly regarding:
- Interoperability between governance platforms,
- Secure data-sharing frame works,
- Digital trust mechanisms,
- Integrated citizen service delivery.

India can adapt similar interoperable governance architectures to strengthen local governance systems while maintaining data sovereignty and privacy protections.

5. CHALLENGES IN AI-ENABLED GRASSROOTS GOVERNANCE

Despite significant progress, AI-enabled governance faces multiple structural and ethical challenges.

- **Digital Divide and Administrative Capacity:** Rural India continues to face infrastructural limitations including internet connectivity gaps, low digital literacy, and inadequate administrative training. Many local institutions lack the technical capacity to effectively implement AI-enabled systems. (Press Information Bureau [PIB], 2026)
- **Data Privacy and Ethical Concerns:** AI governance systems involve large-scale collection and processing of citizen data, raising concerns regarding surveillance, privacy, and algorithmic bias. Without appropriate safeguards, AI systems may reinforce exclusion or discriminatory governance outcomes. (Samarawickrama, 2022)
- **Institutional Fragmentation:** AI governance in India is often characterized by fragmented institutional frameworks and lack of interoperability between departments. Effective AI governance requires coordinated national and local governance mechanisms. (Agarwal & Nene, 2026)
- **Citizen Trust and Accountability:** The increasing use of AI in governance raises questions regarding explainability and accountability. Citizens may lose trust in governance systems if AI-based decisions remain opaque or inaccessible. Human oversight therefore remains essential in governance decision-making processes.

6. POLICY RECOMMENDATIONS FOR STRENGTHENING AI-ENABLED GRASSROOTS GOVERNANCE IN INDIA

- **Institutional Reforms:** Effective AI-enabled governance requires strong institutional mechanisms at the local level. Panchayati Raj Institutions (PRIs) should establish dedicated AI governance cells to coordinate digital governance initiatives, monitor implementation, and ensure data-driven decision-making. These cells can function as nodal agencies for integrating AI technologies into rural administration. Additionally, the government should formulate standardized AI governance guidelines for local bodies to ensure uniformity, transparency, and accountability across states and districts. Such institutional reforms will create an enabling ecosystem for sustainable AI adoption in grassroots governance.
- **Capacity Building and Digital Readiness:** The successful implementation of AI in local governance depends on the digital capacity of officials and citizens. Training programmes should be organized to

enhance AI literacy, digital governance skills, and data management capabilities among Panchayat officials, local administrators, and frontline workers. Simultaneously, rural digital infrastructure must be strengthened through improved internet connectivity, digital service centers, cloud-based governance systems, and reliable electricity access. Bridging the rural digital divide is essential for inclusive and efficient AI-driven governance.

- **Ethical and Accountable Governance:** AI systems used in governance must operate within ethical and democratic frameworks. Transparent accountability mechanisms should be introduced to ensure that AI-assisted decisions remain explainable, auditable, and free from bias. Clear grievance redressal systems should also be developed to address errors or misuse of automated systems. Furthermore, citizen consent, privacy protection, and data security must remain central to AI governance frameworks. Strong safeguards are necessary to prevent data misuse and maintain public trust in digital governance systems.
- **Citizen-Centric AI Governance:** AI technologies should be designed to improve citizen participation and accessibility in governance processes. Since India is linguistically diverse, multilingual and voice-based AI interfaces can help rural citizens access public services more easily, particularly those with low literacy levels. AI-assisted citizen feedback systems can also strengthen participatory governance by enabling real-time grievance collection, public consultation, and service evaluation. Such citizen-centric approaches can make governance more responsive, inclusive, and transparent.
- **Interoperable and Integrated Governance Systems:** Fragmented governance platforms often reduce administrative efficiency. Therefore, governance databases and digital platforms across departments should be integrated to enable seamless coordination and information sharing. Developing secure and interoperable Digital Public Infrastructure (DPI) for local governance can improve service delivery, reduce duplication, and support evidence-based policymaking. Integrated digital ecosystems will help local governments respond more effectively to developmental challenges and citizen needs.

The integration of AI into grassroots governance has the potential to transform rural administration by improving efficiency, transparency, and citizen participation. However, achieving this transformation requires institutional reforms, ethical safeguards, digital infrastructure, and inclusive governance frameworks. By adopting these policy measures, India can build an accountable and citizen-centric governance ecosystem aligned with the vision of Viksit Bharat 2047.

7. CONCLUSION

AI-enabled governance has the potential to transform India's grassroots administrative systems through data-driven decision-making, transparency, and citizen-centric service delivery. Initiatives such as eGramSwaraj, SabhaSaar, and BHASHINI demonstrate that AI can strengthen democratic decentralization and improve governance accessibility at the local level. (Press Information Bureau [PIB], 2026b).

However, technological innovation alone cannot guarantee effective governance outcomes. AI systems must remain ethical, inclusive, transparent, and accountable. Human oversight, institutional capacity, and citizen participation remain critical for ensuring that AI strengthens democracy rather than undermining it. (Samarawickrama, 2022).

India has the opportunity to develop a globally relevant model of AI-enabled grassroots governance that combines technological innovation with democratic accountability. Such a model can significantly contribute to the vision of Viksit Bharat 2047 by creating responsive, transparent, and citizen-centric governance systems.

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CHAPTER 12
Rajasthan State Recruitment Portal

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ABSTRACT

The State Recruitment Portal is a centralized digital platform developed to automate and manage the complete recruitment lifecycle for government departments and recruitment agencies in Rajasthan. Earlier, recruitment processes were managed independently by different departments, resulting in lack of coordination, repetitive verification processes, communication gaps, and operational inefficiencies. Information related to debarred or blacklisted candidates was not centrally available, due to which such candidates could participate in recruitments conducted by other departments. Candidates were also required to upload the same documents repeatedly for different recruitments, while departments had to verify the same certificates and records multiple times, causing delays and increasing manual workload.

Traditional recruitment systems also faced issues such as manual scrutiny, fragmented communication, non-uniform verification standards, delayed processing, and difficulties in detecting fake documents, duplicate applications, impersonation, and fraudulent activities. Separate departmental workflows further created inconsistencies in recruitment management, monitoring, and reporting.

The State Recruitment Portal addresses these challenges through a centralized and integrated recruitment ecosystem with One Time Registration (OTR), centralized candidate profiles, digital scrutiny, automated workflows, AI-based fraud detection, OCR-based document verification, biometric authentication, and face recognition technologies. The portal enables secure information sharing between departments, reduces repetitive document uploads and verification processes, improves transparency, strengthens recruitment security, and provides faster, paperless, and technology-driven recruitment governance across the State.

INDEX TERMS

OTR (One Time Registration), ODV (One Time Document Verification), Application Stack 1(RPSC, RSSB, Other Government Department), Application Stack 2(Police, Home Guard Department), Admit Card, Scrutiny, Question Objection.

INTRODUCTION

The State Recruitment Portal is a centralized workflow-based software application developed for digital management of recruitment activities conducted by government departments and recruitment agencies in Rajasthan. The portal acts as a single-window platform where candidates, departments, recruitment boards, scrutiny teams, verification authorities, and administrators can perform all recruitment-related operations digitally. The initiative supports transparent, accountable, secure, and paperless recruitment governance across the State.

NEED OF STATE RECRUITMENT PORTAL

Traditional recruitment processes involve manual applications, physical document verification, delayed communication, and operational challenges in conducting large-scale examinations. Departments often face difficulties in managing candidate records, examination workflows, scrutiny activities, and result preparation efficiently. The State Recruitment Portal addresses these challenges by providing a centralized

digital ecosystem with automated workflows, real-time communication, secure verification mechanisms, and transparent recruitment processing. Before implementation of the State Recruitment Portal, recruitment processes were managed independently by different departments and recruitment agencies, resulting in several operational and coordination challenges. There was no centralized communication mechanism between departments, due to which information related to debarred, blacklisted, or fraudulent candidates was not shared effectively among recruitment agencies. As a result, candidates debarred in one recruitment could participate in recruitments conducted by other departments. Candidates were required to upload the same educational, identity, caste, and eligibility documents repeatedly for different recruitments, while departments had to verify the same documents multiple times, causing delays, duplication of effort, and increased manual workload. Manual scrutiny and physical verification processes also increased the chances of human errors, fake document submission, impersonation, and fraudulent activities. Different departments followed separate recruitment workflows and verification standards, leading to inconsistency in recruitment processing, communication gaps, delayed updates, and lack of centralized candidate history, attendance, penalties, and verification records. Large-scale recruitment management, including scrutiny, roll number generation, admit card distribution, attendance verification, and result preparation, required significant manual effort and operational resources. The State Recruitment Portal addresses these challenges through centralized candidate management, One Time Registration (OTR), automated workflows, digital scrutiny, AI-based fraud detection, OCR-based document verification, biometric authentication, face recognition, and real-time communication systems. The integrated platform improves transparency, reduces repetitive verification processes, enhances coordination among departments, strengthens recruitment security, and enables faster, efficient, and technology-driven recruitment management across the State.

About Rajasthan State Recruitment Portal

The State Recruitment Portal is a centralized digital platform developed by the Government of Rajasthan for managing the complete recruitment lifecycle through a single integrated system. The portal enables transparent, secure, paperless, and technology-driven recruitment management for various departments and recruitment agencies. It provides centralized dashboards, automated workflows, digital verification, and real-time communication facilities for candidates and departments. The portal addresses major challenges of traditional recruitment systems such as lack of coordination between departments, repeated document verification, multiple document uploads by candidates, manual scrutiny, delayed communication, and absence of centralized records of debarred candidates. Through OTR, OCR, AI-based fraud detection, biometric authentication, and face recognition technologies, the system improves transparency, efficiency, and recruitment security. The portal also supports fraud prevention and monitoring mechanisms for enforcement agencies such as the Special Operations Group (SOG) Rajasthan. Using AI-based photo matching and face recognition features, SOG can identify suspicious, duplicate, fake, or impersonated candidates involved in recruitment examinations. Through the One Time Registration (OTR) system, each candidate is restricted to maintaining only one unique profile linked with verified identity details. This helps genuine candidates by eliminating the need to create multiple profiles and repeatedly upload the same documents and information for different recruitments. The centralized OTR mechanism also prevents fraudulent candidates from creating multiple IDs or submitting multiple application forms for the same vacancy, thereby helping the Government reduce dummy candidate issues, impersonation, and recruitment-related fraud activities.

Application Workflow Cycle



Figure 1: Application Work Flow

STAKEHOLDERS

The major stakeholders of the State Recruitment Portal include Government Departments, Recruitment Boards and Commissions such as Rajasthan Public Service Commission (RPSC) and Rajasthan Staff Selection Board (RSSB), candidates, scrutiny teams, examination agencies, verification authorities, administrators, and technical support teams. The portal provides role-based access and centralized dashboards for secure and efficient management of recruitment activities.

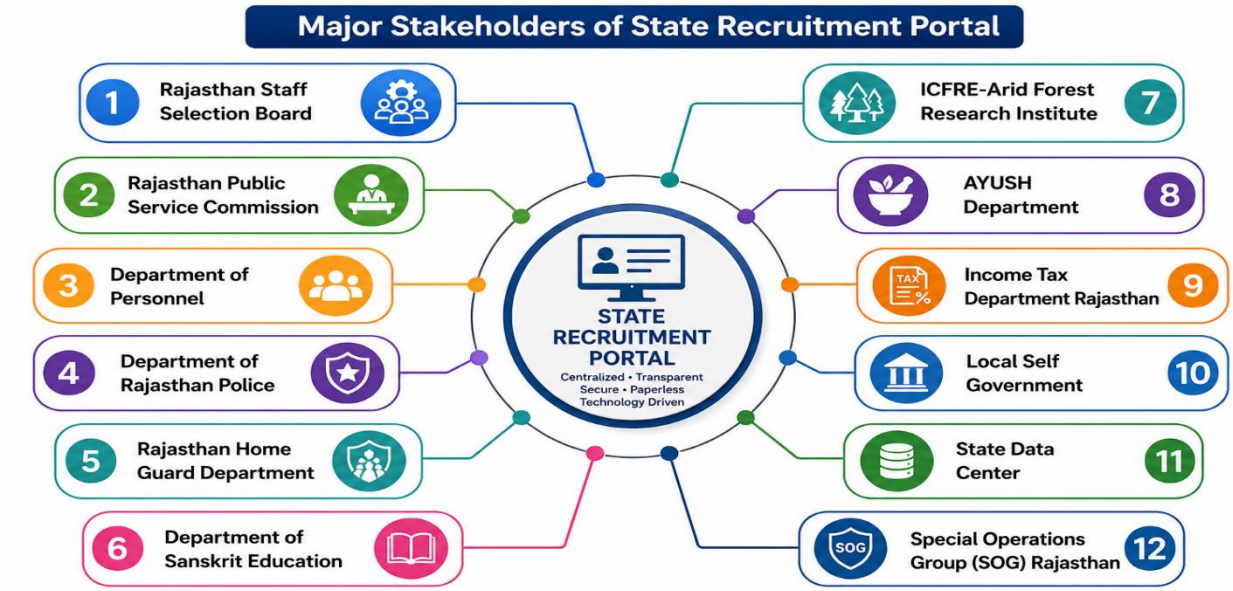


Figure 2: Major Stakeholders of State Recruitment Portal

Stakeholder / User Type	Advantages of State Recruitment Portal
Candidates / Citizens	Single OTR profile for multiple recruitments, one-time document upload, faster application process, online correction facility, real-time notifications, transparent recruitment process, easy access to admit cards and results, grievance and chatbot support
Recruitment Boards (RPSC/RSSB)	Easy recruitment configuration, standardized recruitment process, reduced paperwork, digital verification, centralized candidate records, faster communication and reporting Centralized recruitment management, automated workflows, faster scrutiny and result processing, reduced manual work, AI-based fraud detection, centralized monitoring dashboards.
Administrator	Centralized control over recruitment modules, role management, workflow monitoring, dynamic configuration without development dependency, audit and dashboard monitoring
Moderator	Simplified management of recruitment lifecycle including application edit, withdrawal, scrutiny, admit card, objection handling, and result publication
Scrutiny Moderator	Faster online document verification, OCR-based verification support, audit logs, reduced manual scrutiny effort, improved transparency
SOG / Investigation Agencies	AI-based photo matching, fraud detection, duplicate candidate identification, biometric verification support, centralized investigation records
Verification Interview User	Aadhaar-based biometric verification, face recognition support, secure candidate identity verification during interviews
Report Operator	Easy access to centralized reports, MIS dashboards, recruitment statistics, and real-time monitoring reports
Government of Rajasthan	Transparent and paperless recruitment governance, reduction in dummy candidates and fraud, centralized monitoring, improved operational efficiency, secure data management, and better citizen service delivery. The portal also enables the Government to collect centralized recruitment metadata and analytics, helping departments analyze recruitment trends, number of recruitments conducted during a specific period, region-wise and recruitment-wise application statistics, and candidate participation patterns. This data can further support policy planning, educational improvements, manpower analysis, skill development planning, survey activities, and informed decision-making for future governance and employment strategies.

KEY FUNCTIONAL

State Recruitment Portal has a user-friendly public interface, which is accessible through https://recruitment.rajasthan.gov.in under SSO Portal (Rajasthan Single Sign On). All the feature of the interface are also dynamic and do not have any dependency on the development team. The project also has a complete back end where role-based access is given to stack holder- government officials and candidate (citizen).

Role/User Type	Modules Accessible / Managed
Administrator	• Online Application Form Configuration • OTR Integration Management • Auto Roll Number Generation • Admit Card Management • Result Processing and Auto Preparation • Dashboard and Audit Monitoring • Blockchain-Based OTR Storage Management • AI Chatbot and Notification Management • User Role and Workflow Management
Moderator	• Recruitment Configuration • Application Form Edit Module • Withdrawal Module • Question Objection Module • Scrutiny and Online Document Verification • Interview Verification Module • Penalty Module for Candidate Absence • OCR of Marksheet and Scanned Documents • Result Processing Module • Admit Card and Roll Number Management
Candidate	• Online Application Form Submission • OTR Registration and Profile Management • Application Form Edit Facility • Withdrawal of Application • Admit Card Download • Question Objection Submission • Document Upload and Verification • AI Chatbot and Helpdesk Support • Biometric / Aadhaar Verification • Notification and Communication Services
SOG User	• Photo Verification Module • AI-Based Fraud Detection Module • Document Verification and Investigation Module • Candidate Record Monitoring • Duplicate / Dummy Candidate Detection • Face Recognition and Biometric Verification Monitoring • Investigation and Vigilance Support System
Scrutiny Moderator	• Scrutiny and Online Document Verification • OCR-Based Marksheet Verification • Reservation and Eligibility Verification • Audit Logs and Reviewer Remarks Management • Fraudulent Document Detection
Verification Interview User	• Interview Verification Module • Aadhaar-Based Biometric Verification • Face Recognition Verification • Candidate Attendance and Identity Verification
Report Operator	• Dashboard and MIS Reports • Recruitment Reports Access • Result and Candidate Data Reports • Examination and Verification Reports

MEASURE MODULES OF STATE RECRUITMENT PORTAL

1. Online Application Form Module

Enables candidates to apply digitally through a secure and user-friendly interface with facilities for registration, document upload, fee payment, and real-time verification. Departments can configure recruitment-specific forms dynamically based on eligibility criteria and reservation policies.

2. Application Form Edit Module

Allows candidates to modify submitted applications during a configurable correction period. The system maintains audit logs of all modifications and supports OTP-based verification for secure correction management.

3. OTR Integration Module

Provides centralized One Time Registration facilities where candidates can use a single profile for multiple recruitments. Aadhaar, mobile, and email verification can be integrated for authentication and profile validation.

4. Withdrawal Module

Enables candidates to voluntarily withdraw applications before the specified deadline. The system automatically updates candidate status and supports configurable refund and notification mechanisms.

5. Auto Roll Number Generation Module
Automatically generates unique and randomized roll numbers based on configurable recruitment patterns. Roll numbers can also be integrated with examination centers and attendance systems.

6. Admit Card Module
Supports automatic generation and distribution of admit cards containing candidate details, QR codes, reporting instructions, and examination center information. Candidates can receive admit cards through portal, SMS, email, and WhatsApp integration.

7. Question Objection Module
Allows candidates to raise objections against provisional answer keys within a specified timeline. Subject experts can review objections digitally and finalize answer keys through approval workflows.

8. Scrutiny and Online Document Verification Module
Supports digital scrutiny of candidate eligibility, educational qualifications, reservation claims, and uploaded documents. The module maintains audit logs, reviewer remarks, rejection reasons, and communication records for transparency and accountability.

9. Result Processing and Auto Preparation Module
Automates preparation of merit lists, cut-offs, selection lists, and examination results according to recruitment rules and reservation policies. The module reduces human errors and improves speed in result declaration.

10. Interview Verification Module
Manages interview scheduling, attendance tracking, document verification, panel allocation, and digital interview mark entry. Departments can monitor interview activities through centralized dashboards.

11. Penalty Module for Candidate Absence
Manages penalties and restrictions for candidates remaining absent in examinations after successful application submission. The module automatically identifies absentee candidates using attendance data.

12. OCR of Marksheet and Scanned Documents Module
Uses OCR and Artificial Intelligence technologies to automatically extract data from marksheets, certificates, and scanned documents. This feature minimizes manual data entry and improves verification efficiency.

13. Document Verification and Fraud Detection Module
Uses AI-based technologies to identify fake, manipulated, duplicate, or forged documents uploaded by candidates. Fraud detection mechanisms strengthen security and prevent unauthorized participation.

14. AI Powered Conversational Chat Bot
Provides 24×7 automated assistance to candidates and departments through web portals and mobile platforms. The chatbot supports multilingual communication and recruitment-related guidance.

15. Blockchain Based OTR Information Storage
Stores candidate OTR information securely using blockchain technology to ensure tamper-proof and transparent record management throughout the recruitment lifecycle.

16. Photo Verification Module
Uses AI-powered face recognition technologies to validate candidate photographs and identify duplicate, edited, or suspicious images uploaded during application submission.

17. Biometric Verification / Face Recognition Using Aadhaar

Supports Aadhaar-based biometric authentication, thumb verification, and face recognition during examinations, interviews, and document verification activities to prevent impersonation and proxy attendance.

SYSTEM WORKFLOW

The State Recruitment Portal operates through a centralized workflow-based architecture where recruitment advertisements, applications, examinations, scrutiny, document verification, result preparation, and final selection processes are managed digitally. Candidates register and apply online, departments verify applications through scrutiny workflows, and automated systems handle roll number generation, admit card distribution, attendance verification, and result processing. Notifications are sent to users at each stage through SMS, email, and portal alerts.

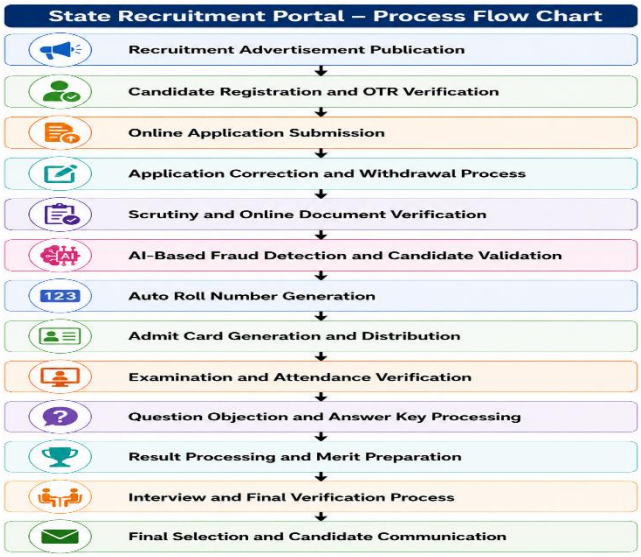


Figure 3: Process Flow Chart

KEY BENEFITS

The portal provides significant benefits including paperless recruitment management, faster processing, transparency, centralized monitoring, improved candidate communication, reduced manual effort, secure verification mechanisms, and efficient examination management. AI-based validation, biometric verification, OCR, and fraud detection technologies strengthen recruitment security and improve operational efficiency for departments and recruitment agencies.

- Paperless Recruitment Management
- Faster Application and Examination Processing
- Improved Transparency and Accountability
- Centralized Monitoring and Dashboard Management
- Real-Time Candidate Communication
- Reduced Manual Work and Operational Effort
- Secure Document and Identity Verification
- AI-Based Fraud Detection Mechanism
- OCR-Based Automated Data Extraction
- Biometric and Face Recognition Verification
- Improved Accuracy in Result Processing
- Efficient Examination and Attendance Management
- Enhanced Data Security and Integrity
- Better Candidate Experience and Accessibility
- Scalable and Technology-Driven Recruitment Governance

TECHNOLOGY PLATFORM

The State Recruitment Portal can be developed using modern web technologies and scalable infrastructure for handling large-scale recruitment operations. The platform supports secure databases, cloud or data center hosting, AI-based integrations, biometric devices, OCR engines, mobile applications, and centralized dashboard monitoring systems for real-time governance and operational control

- App Server: Oracle WebLogic 14.1.1
- Operating System (OS): Linux 8.0 (RHEL / OEL)
- Frontend Technology: Angular SPA
- Authentication System: Rajasthan SSO (OTP / eSign)
- Aadhaar Integration: UIDAI AUA / SubAUA Integration
- Document Integration: DigiLocker API
- Payment Gateway: SBI / HDFC / UPI Gateway
- Notification Services: Bulk SMS + WhatsApp API
- Accessibility Support: WCAG 2.0 + Bilingual Hindi/English Support

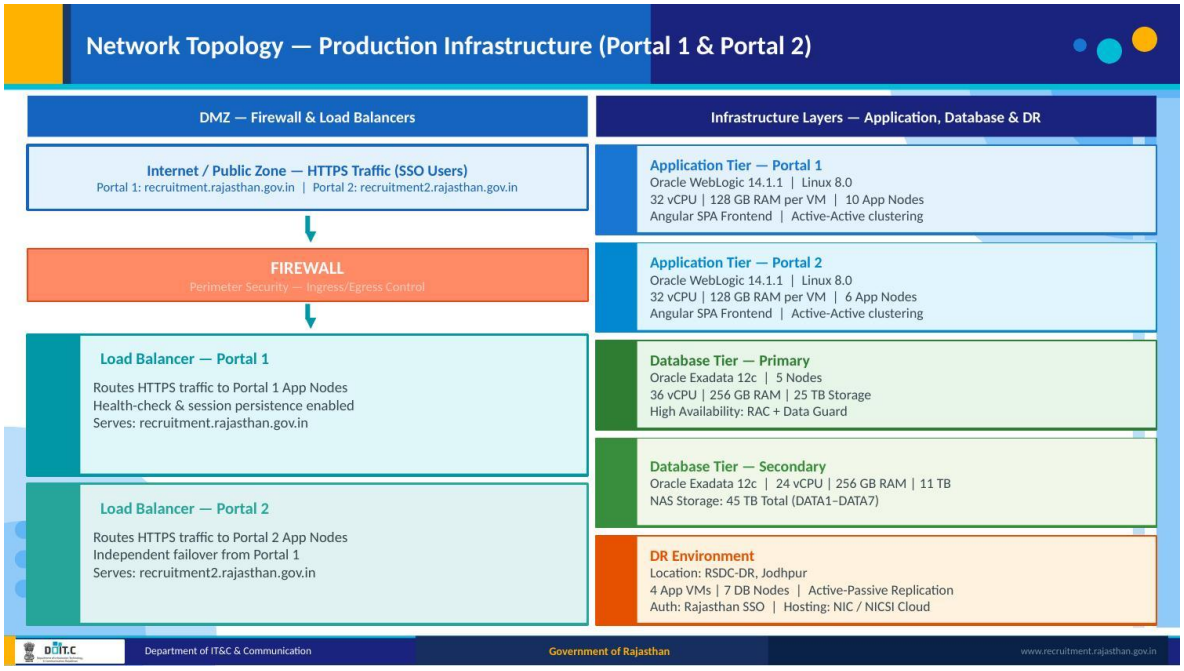


Figure 4: Network Infrastructure of Recruitment Portal on Product Server

IMPLEMENTATION METHODOLOGY

The State Recruitment Portal has been implemented as a centralized recruitment management system for various departments, recruitment boards, and government agencies of Rajasthan. The portal supports end-to-end digital recruitment processes including Department Configuration, Recruitment Configuration, Post Creation, and Application Form Live processes through configurable workflow-based modules. For smooth implementation and standardization of recruitment processes, the State Recruitment Portal provides predefined templates and configurable formats to departments as per recruitment requirements and process modules. Departments provide recruitment-related details such as post information, eligibility criteria, reservation rules, examination schemes, fee structure, and application configuration in these templates. After departmental verification and approval, the finalized details are entered and configured on the Recruitment Portal by authorized Data Entry Operators and recruitment administrators. This process ensures uniformity, accuracy, faster recruitment configuration, and reduced dependency on

technical development teams for regular recruitment activities. The portal also provides an integrated Grievance Management Module for both department users and candidates (citizens) to raise technical issues, recruitment-related problems, and service requests. The grievance system enables tracking and timely resolution of issues through centralized monitoring mechanisms. In addition, a dedicated Help Desk facility is available for candidates to assist them with recruitment-related queries, application issues, technical support, and portal guidance throughout the recruitment lifecycle. The portal enables centralized monitoring, role-based access, workflow approvals, and real-time communication for all stakeholders involved in the recruitment lifecycle, thereby improving transparency, operational efficiency, and digital governance in State recruitment management.

Key Impact of Digital Communication

- Real-time communication with candidates through SMS, email, portal notifications, and WhatsApp integration.
- Faster dissemination of recruitment updates such as admit cards, correction notices, examination schedules, objections, and results.
- Improved transparency and reduced communication gaps between departments, recruitment agencies, and candidates.
- Reduced dependency on physical notices and manual communication processes.
- Instant alerts and notifications help candidates stay
- updated throughout the recruitment lifecycle.
- Centralized communication system improves coordination among stakeholders and recruitment authorities.
- Faster grievance handling and candidate support through digital platforms and AI-powered chatbot services.
- Better accessibility and user experience for candidates across the State.
- Reduction in manual workload, paperwork, and operational delays.
- Improved efficiency, accountability, and paperless governance in recruitment management.

The Road Ahead

The State Recruitment Portal marks a significant step towards technology-driven and citizen-centric recruitment governance in Rajasthan. The platform has vast potential for future enhancements and integration of advanced digital services to further strengthen transparency, operational efficiency, and secure recruitment management across the State. Some of the proposed future developments are as follows:

- Integration with Third Party Payment Modules for seamless online fee collection and automated reconciliation processes.
- Development of a centralized Payment and Finance Management System for recruitment fee accounting, refund management, and financial reporting.
- Implementation of Document Storage and Retrieval Management System (DMS) for secure digital storage of OMR, reuse, and quick retrieval of candidate documents and recruitment records.
- Advanced Result Preparation Module for automated merit generation, reservation management, cut-off preparation, and rule-based result processing.
- Investigation and Vigilance Module for monitoring suspicious activities, malpractice cases.

- Development of Question Bank Development System (QBDS) for secure question paper management, moderation, and examination preparation processes.
- Expansion of AI-based Photo Matching and Biometric Verification systems for stronger candidate authentication and impersonation prevention.
- Centralized Helpdesk Management System for grievance handling, candidate support, and technical assistance.
- Advanced Dashboard and MIS Reporting Systems using Data Analytics for better decision-making, recruitment monitoring, and policy improvements.
- Social Media Integration such as WhatsApp feedback systems,
- automated questionnaires, and communication platforms for enhanced citizen engagement.
- Dynamic Screen and Dynamic Report generation systems for configurable recruitment workflows and customized reporting without dependency on development teams.
- Centralized Messaging and Notification Systems for real-time alerts related to recruitment advertisements, admit cards, objections, scrutiny, interviews, and results.
- The scalable architecture of the State Recruitment Portal also provides opportunities for replication and adoption by other States and government organizations for standardized digital recruitment governance.

Features

The Roadmap for Rajasthan State Recruitment Portal is very long. Some of the features are made live and some are under development phase.

- AI-based photo matching and face recognition help Special Operations Group (SOG) Rajasthan identify fake, duplicate, suspicious, and dummy candidates during recruitment and examination processes.
- Mobile application support enables candidates, departments, and recruitment agencies to access recruitment services, notifications, admit cards, grievance support, and application status anytime and anywhere.
- One Time Document Verification (ODV) facility allows candidates to upload and verify documents only once, which can be reused for multiple recruitments, reducing repetitive verification and document uploads.
- API-based integration with Digi Locker, Pehchaan, and other government portals enables direct fetching of authentic and verified documents from source systems, improving verification accuracy and reducing fake document submissions.
- OCR (Optical Character Recognition) technology automatically scans marksheets and extracts candidate marks and academic details, which are stored as metadata for future recruitment use, reducing manual data entry and improving scrutiny efficiency.
- Blockchain technology is used for secure storage of candidate OTR details, verified documents, verification history, and recruitment records. The tamper-proof system improves data security, transparency, audit tracking, and prevents unauthorized modification or duplicate candidate profiles.
- AI-powered chatbot and centralized helpdesk facilities provide technical support, recruitment guidance, grievance handling, and query resolution for both department users and candidates through automated communication systems.

- AI-based investigation and fraud detection mechanisms identify fake, manipulated, duplicate, or forged documents uploaded by candidates, helping prevent impersonation, dummy candidates, multiple applications, and recruitment-related fraud activities.

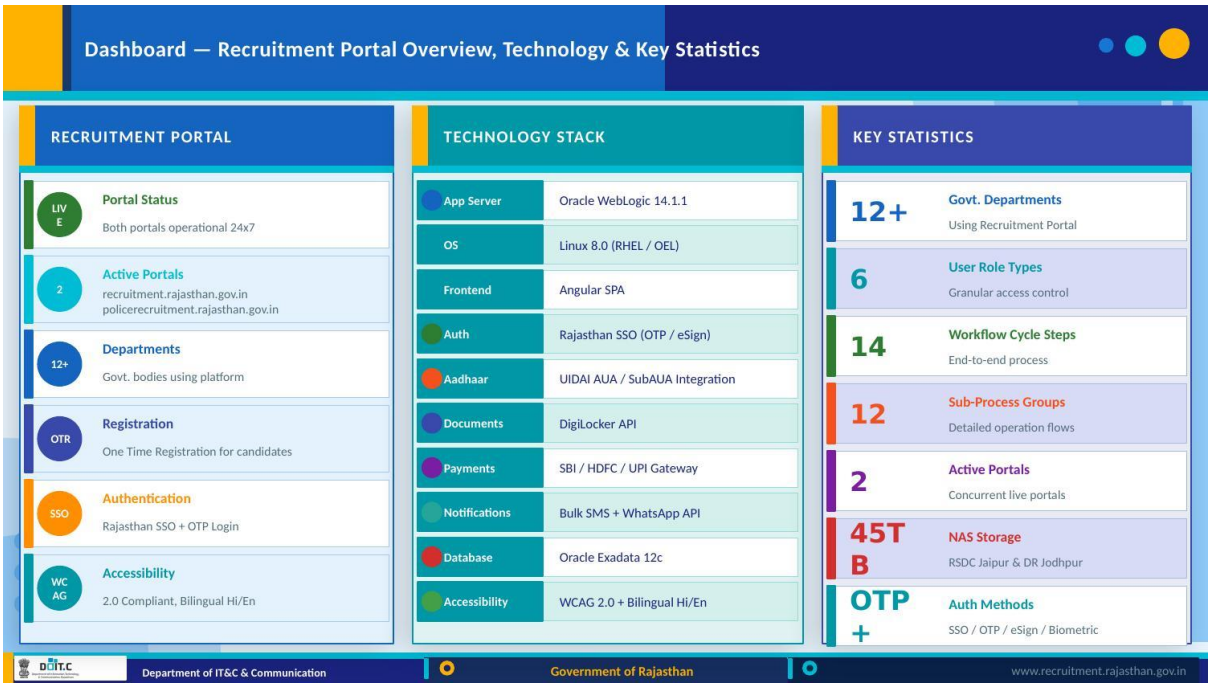


Figure 4: Network Infrastructure of Recruitment Portal on Product Server

CONCLUSION

The State Recruitment Portal is a major step toward digital governance and technology-driven recruitment management in Rajasthan. The platform enables transparent, secure, efficient, and citizen-centric recruitment processes through centralized digital workflows and advanced verification technologies. The integrated ecosystem strengthens accountability, improves operational efficiency, and enhances the overall experience for candidates, departments, and recruitment agencies.

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CHAPTER 13

UP-IMRAS (Uttar Pradesh – Integrated Medical Research Application System) An AI-Enabled Sovereign Digital Infrastructure for Clinical Research Governance —The Uttar Pradesh Model

AUTHORS

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ABSTRACT

India's clinical research governance suffers not from a lack of regulation but from a lack of digital infrastructure to enforce it. Between 2007 and 2010, 1,725 trial participants died, and only 22 families received compensation. Between 2005 and July 2025, 8,205 deaths and 37,711 serious adverse events were recorded with minimal redress, a matter before the Supreme Court of India. The Uttar Pradesh' Integrated Medical Research Application System (UP-IMRAS), commissioned by the UP Promote Pharma Council, Department of Medical Education, Government of Uttar Pradesh, and live since April 2026, is India's first state-level, sovereign, AI-enabled platform for end-to-end clinical research governance. Built at INR 2.5 crore on indigenous infrastructure, it covers 75 districts, over 80 medical institutions, and over 40 Ethics Committees statewide. It operationalizes a 22-SOP regulatory framework issued in January 2026, two of which formally name the UP-IMRAS portal as the mandatory submission and communication channel. This article presents the platform architecture, six live AI interventions, governance outcomes, key learnings, and the UP-IMRAS 2.0 roadmap.

INDEX TERMS

Clinical Research Governance, Artificial Intelligence, Sovereign Digital Infrastructure, e-Governance, NDCT 2019, Ethics Committee.

1. INTRODUCTION

India participates in over 50% of all oncology randomized controlled trials (RCTs) led by high-income countries, the highest proportion among lower-middle-income countries [1]. However, this scale of trial activity has not been matched by a corresponding strengthening of governance infrastructure. The Health Minister reported to Parliament that 1,725 participants died during clinical trials between 2007 and 2010, of whom only 22 received compensation [2]. Between 2005 and July 2025, Swasthya Adhikar Manch compiled 8,205 deaths and 37,711 serious adverse events from government RTI responses [3].

The root cause is not the failure of regulatory intent. India's New Drugs and Clinical Trials Rules (NDCT), 2019 [4], and ICMR Ethical Guidelines 2017 [5] are comprehensive. The failure is one of enforcement infrastructure: without a system that captures consent events with immutable timestamps, records adverse events in real time, tracks compensation obligations, and provides regulators with live operational visibility, even the well-designed regulations remain unenforceable at scale.

The Uttar Pradesh Integrated Medical Research Application System (UP-IMRAS) is the Government of Uttar Pradesh's answer to this infrastructure gap. Commissioned by the UP Promote Pharma Council and live since April 2026, UP-IMRAS is India's first state-level, sovereign, AI-enabled clinical research governance platform. This paper presents the architecture, AI interventions, regulatory integration, and governance outcomes of the proposed system.

2. THE GOVERNANCE INFRASTRUCTURE GAP

India's clinical research regulatory framework is administered through the CDSCO at the national level and Institutional Ethics Committees (IECs) at the institutional level. In practice, this administration has been fragmented and paper-based: protocol submissions in physical files, adverse event reports logged manually and retrospectively, compensation decisions dependent on incomplete paper trails, and EC records

maintained in institutional registers without centralized visibility. This fragmentation creates three compounding governance failures: verification, accountability, and intelligence gaps.

2.1 The 22-SOP Regulatory Framework

In 2026, the UP Promote Pharma Council formally issued a 22-Standard Operating Procedure (SOP) framework (UPCT-SOP 01 through UPCT-SOP 22, Ver 1.0, effective January 1, 2026) for IEC governance across all medical colleges and institutions in Uttar Pradesh, as explicitly stated in SOP 02 [6]. Aligned with the NDCT 2019 [4], ICMR 2017 [5], ICH-GCP E6 (R2), CIOMS 2016, and WHO 2011, this is one of the most comprehensive state-level IEC governance frameworks in India. It contains 47 distinct statutory timelines, nine categories of financial transactions, 18 categories of vulnerable populations requiring additional protection, and five document categories requiring formal archiving.

Critically, two SOPs formally embed the UP-IMRAS within the regulatory framework. SOP 20 (Academic Clinical Trials) mandates that all submissions use a "digitalized form on the UP-IMRAS portal/website" [7]. SOP 22 (Communication Policy) specifies that inward reference numbers are "automatically generated by IEC website" and that outward mail is "generated automatically through the IEC website" for all principal investigators, sponsors, and institutional communications [8]. UP-IMRAS is not a tool alongside the regulatory process; it is the mechanism through which the process is conducted.

3. UP-IMRAS: PLATFORM ARCHITECTURE

3.1 Institutional Coverage

UP-IMRAS is live across 75 districts of Uttar Pradesh, 80+ medical institutions, including KGMU and SGPGI, and soon to be rolled out in IMS BHU; 40+ individually configured Ethics Committee workspaces, and 2,500+ registered investigators.

3.2 Core Functional Modules

UP-IMRAS operationalizes 18 governance workflows, each aligned to a specific SOP: protocol registration and routing (SOP 03); full board and expedited review (SOP 04, SOP 05); exemption review (SOP 06); meeting agenda, quorum, and minutes (SOP 07); resubmission and amendment management (SOP 08); continuing review and automated reminders (SOP 09); deviation and violation detection (SOP 10); SAE review and compensation tracking (SOP 11); document archival and block chain retention (SOP 12); study completion review (SOP 13); premature termination management (SOP 14); vulnerable population protocol enforcement (SOP 15); site monitoring candidate identification (SOP 16); conflict of interest structural enforcement (SOP 17); independent consultant registry (SOP 18); participant complaint management (SOP 19); academic trial review (SOP 20); financial management (SOP 21); and stakeholder communication automation (SOP 22).

3.3 Security and Sovereignty Architecture

The platform is built on an ISO-aligned, Digital Personal Data Protection (DPDP) Act 2023-compliant security architecture with role-based access controls and end-to-end encryption. A secured database layer anchors all critical governance events, including consent timestamps, SAE records, approval decisions, and termination documentation, providing tamper-proof, non-repudiable audit trails. The secured architecture ensures data privacy and maintains all information on sovereign Indian infrastructure, meeting the data sovereignty requirements.

4. AI INTERVENTIONS IN UP-IMRAS

Six Artificial Intelligence interventions are currently live in UP-IMRAS. Collectively, they shift the platform from static digital record-keeping to intelligent, proactive governance support, operationalizing the 47 statutory timelines and multi-stage review workflows of the 22-SOP framework.

4.1 Automated Protocol Screening and Classification

When a protocol is submitted, an AI classification engine analyses the document, extracts key study parameters (therapeutic area, phase, design, investigational product category, and participant population), and auto-populates the Common Application Form (CAF) mandated by SOP 03. The study type is automatically classified, and the UPCT project code is assigned. The engine also routes submissions to the appropriate review track (full board, expedited, or exemption) based on the criteria of SOP 04, 05, and 06, respectively. In the first quarter of operation, the CAF completion time was reduced by an estimated 60–70%, with form accuracy exceeding 90% on structured fields.

4.2 Smart Form Logic and Validation

UP-IMRAS employs dynamic form intelligence across all the data entry interfaces. Form fields activate, deactivate, or change validation rules in real time, based on prior entries. When a protocol declares vulnerable populations — children, pregnant women, prisoners, tribal communities — the additional mandatory fields, specialist reviewer assignments are automatically triggered. When an SAE is classified as life-threatening, the system enforces the 24-hour initial reporting window and 14-day report deadline of SOP 11, dispatching escalation alerts before breaches occur. The 4-day agenda cutoff of SOP 07 is automatically enforced. This layer has materially reduced incomplete submissions and statutory timeline breaches across platforms.

4.3 Document Intelligence: Conversational Query Engine

The most novel AI capability in UP-IMRAS is a document intelligence layer enabling any authorized stakeholder (EC reviewer, regulatory officer, or principal investigator) to have a natural language conversation with the full set of documents submitted for a trial. Rather than manually searching hundreds of pages of protocols, investigator brochures, informed consent forms, and annexures, a reviewer types a question in plain English and receives a synthesized, source-cited answer extracted from the actual submitted documents.

The architecture is Retrieval-Augmented Generation (RAG): documents are indexed into a vector database; a large language model generates answers grounded in retrieved content with citations to source pages; the system never extrapolates beyond what the documents actually contain. This directly addresses the review burden created by SOP 04's nine-criterion full board review requirement across potentially hundreds of pages per protocol per year. No equivalent capability is available in any known Clinical Research System.

4.4 Dashboard Analytics and Pattern Detection

The UP-IMRAS analytics engine provides the UP Promote Pharma Council with a live governance intelligence dashboard across the entire platform. It surfaces submission volume trends by institution and therapeutic area; EC review turnaround distributions against SOP 07's 15-day advance preparation requirement; SAE reporting compliance against SOP 11's 24-hour and 14-day windows; conflict of interest declaration compliance per SOP 17; continuing review due dates per SOP 09; and site monitoring candidate identification using SOP 16's 'for cause' criteria. Pattern detection algorithms flag ECs with anomalously high approval rates, investigators with disproportionate SAE-to-enrolment ratios, and sites with unusual recruitment velocities, enabling data-driven supervisory targeting.

4.5 Anomaly Detection in Submission Workflows

A dedicated anomaly detection layer monitors all workflow events for deviations from established norms, such as consent records created after the date of the first study procedure, approval sequences skipping mandatory intermediate steps, documents submitted with backdated event claims, SAE reports filed outside the 24-hour window without documented justification, and multiple submissions from the same credentials within anomalous time intervals. These anomalies, surfaced as real-time regulatory alerts, add a proactive,

automated detection channel to the reactive pathways defined in SOP 10, applying continuous monitoring across all 2,500+ investigators rather than periodic sampling.

4.6 AI-Powered Meeting Transcription and Minutes Generation

When a study is accepted for EC review and members convene an online meeting through the UP-IMRAS platform, a purpose-built AI meeting assistant — trained on Indian English, Hindi, and clinical research governance vocabulary

— joins the session and performs three functions in real time. First, it captures a complete verbatim record of proceedings. Second, it generates a structured transcript segmented by speaker and agenda item, aligned to the meeting structure mandated by SOP 07: quorum confirmation, prior minutes, new protocol reviews, resubmissions, SAE reports, and policy matters. Third, at the close of the meeting, it automatically generates a draft minutes document in the prescribed format, pre-populated with discussion summaries, decisions reached, queries raised, and actions assigned to named responsible officers.

For EC members, who are typically practicing clinicians with demanding schedules, manual minutes preparation has historically been one of the most significant administrative burdens of IEC work. SOP 07 requires that minutes accurately record deliberations, reasons for decisions, and conflict disclosures for every agenda item. The AI assistant reduces this to a review-and-approve workflow: EC members receive the draft minutes within minutes of the meeting's conclusion, review for accuracy, and the Member Secretary finalizes under Chairperson approval. The language model is currently optimized for Indian English and standard Hindi; active development is underway to extend coverage to Awadhi, Bhojpuri, and other regional language variants used across Uttar Pradesh's 75 districts, reflecting the linguistic diversity of the state's institutional research community.

5. GOVERNANCE OUTCOMES AND KEY LEARNINGS

5.1 From Paper to Platform: Institutional Transformation

UP-IMRAS has moved the entire clinical research governance process in Uttar Pradesh — submission, review, approval, and monitoring — from physical files and institutional registers to a unified digital environment. Every event is time stamped, every document is version-controlled, and every approval is traceable to a named responsible officer. The institutional onboarding process — configuring 40+ EC workspaces, registering 2,500+ investigators, and establishing SOP-aligned workflows — was completed within six months of the platform launch across all major institutions in the state.

5.2 UP-IMRAS as Regulatory Infrastructure

The most significant governance outcome is structural: UP-IMRAS has been formally incorporated into the state regulatory compliance framework. SOP 20 mandates the use of the UP-IMRAS portal as the submission channel for academic clinical trials [7]. SOP 22 designates the UP-IMRAS website as the automated reference number generation and outward communication system [8]. UP-IMRAS is accordingly not a pilot or proof-of-concept; it is an operationally mandated regulatory infrastructure, embedded within the government's own SOPs.

5.3 Key Learnings

Four learnings from the UP-IMRAS deployment are nationally relevant.

- Sovereign infrastructure is achievable at the state scale. The assumption that international vendors are necessary for comparable functionality is incorrect.

- AI interventions succeed when they reduce the burden of existing tasks. Each of the six UP-IMRAS AI features was designed to save time on a workflow that already existed, not to introduce new interface complexity.
- Auditable trails of records deliver governance value precisely at events where accountability disputes arise — consent, SAE timestamps, and compensation decisions. Evidentiary integrity at these moments converts unenforceable regulations into enforceable accountability.
- When a digital platform is formally named in government SOPs as a mandatory submission and communication channel, it transitions from an administrative tool to a regulatory infrastructure. This is the standard to which future digital governance platforms must be held.

6. FORWARD ROADMAP: UP-IMRAS 2.0

UP-IMRAS 1.0 established a sovereign digital infrastructure foundation. UP-IMRAS 2.0, designed and planned for phased delivery over 24–36 months, will build participant protection and ecosystem development layers on top of this foundation, each grounded in the existing 22-SOP framework.

Additional 2.0 modules address gaps surfaced by 1.0: an automated participant compensation enforcement engine with a statutory 30-day clock and District Collector escalation, grounded in the financial accountability architecture of SOP 21 [9]; India's first government-operated block chain-sealed (Hyperledger fabric for creating immutable data records) research misconduct registry; a post-trial access and compassionate use gateway implementing NDCT 2019 and Declaration of Helsinki Article 34; and a continuous EC performance quality assurance module operationalizing SOP 16's monitoring criteria.

7. CONCLUSION

India's clinical research governance crisis is an infrastructure crisis, not a regulatory intent crisis. UP-IMRAS 1.0 demonstrates that a sovereign, AI-enabled regulatory infrastructure can be built at the state scale, at a fraction of commercial costs, and formally embedded within a government's own regulatory framework — not as a parallel system but as the operational mechanism through which regulation is enforced. The platform's formal naming in two of the 22 SOPs, its six live AI interventions operationalizing 47 statutory timelines, and its 75-district deployment make the case that digital governance infrastructure for clinical research is achievable, replicable, and urgently needed on a national scale.

The 29th National Conference on e-Governance convenes at a moment when AI capability, sovereign digital infrastructure ambition, and urgent participant protection needs converge. A national framework for clinical research governance digitization anchored by platforms such as UP-IMRAS is both necessary and achievable.

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CHAPTER 14

Andhra Pradesh Development Permission Management System (APDPMS): AI Enabled Advisory System A Platform for Data- Driven Urban Governance and Citizen Service Delivery in Andhra Pradesh

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ABSTRACT

Under the vision of Viksit Bharat 2047, Andhra Pradesh has undertaken a landmark transformation in development and building permission governance by migrating from fragmented, paper-laden, multi-office processes to a unified, cloud-based, AI-enabled digital platform — the Andhra Pradesh Development Permission Management System (APDPMS) — administered by the Directorate of Town and Country Planning (DT&CP). Deployed across 123 Urban Local Bodies (ULBs) and 21 Urban Development Authorities (UDAs) state-wide, APDPMS has fundamentally redefined how Andhra Pradesh issues building permissions, layout approvals, and occupancy certificates for residential, commercial, and industrial construction.

Built on the AutoDCR® intelligent plan-scrutiny engine, APDPMS introduces automated, rule-based plan checking that eliminates manual subjectivity and drastically compresses approval timelines. The system's 'deemed approval' mechanism — which automatically grants permission if an application remains unprocessed beyond the mandated timeline — embeds institutional accountability directly into the workflow. Deep integrations with the Centralized Finance Management System (CFMS) for online fee collection, the Fire NOC portal, Airport Authority of India (AAI) clearances, RERA, the Single Desk Portal for industries, and the Pura Seva mobile application transform APDPMS into a true whole-of-government service window.

By anchoring every application to a digital property record and GIS-verified parcel, and by empowering Licensed Technical Persons (LTPs) as regulated intermediaries, APDPMS exemplifies the proactive, citizen-first governance model envisaged by Viksit Bharat 2047 — offering a scalable, replicable blueprint for development-permission reform across India.

1. INTRODUCTION

The Vision of Viksit Bharat 2047: Reforming Development Permissions

Achieving the national aspiration of Viksit Bharat 2047 demands that urban governance transcend legacy workflows and embrace integrated, technology-driven administrative systems. Nowhere is this imperative more acutely felt than in the domain of development permissions — the gateway through which every home, commercial complex, and industrial facility enters a city's built environment.

Traditionally, building permission processes in Urban Local Bodies (ULBs) and Urban Development Authorities (UDAs) across India have been characterised by physical plan submissions, multi-level manual scrutiny, in-person fee payment across different counters, and opaque timelines that leave citizens and developers without clarity or recourse. A citizen or developer seeking a building permit in this legacy framework navigates a labyrinthine sequence of visits, each department operating in isolation, often demanding documents already submitted elsewhere. The outcome is predictable: delays measured in months, informal facilitation costs, revenue leakages, and a persistent trust deficit between the public and local government.

Shifting from Manual to Automated Development Governance

Andhra Pradesh's digital governance strategy, anchored in the Viksit Bharat 2047 framework, responds to this systemic failure by deploying APDPMS as the single, authoritative, cloud-based channel for all development permissions. The platform operationalises three foundational principles:

- Automation over Discretion: Replacing manual plan-scrutiny with rule-based AutoDCR® algorithmic checking that validates designs against the Andhra Pradesh Building Rules, 2017 objectively and instantaneously.
- Accountability over Ambiguity: Embedding statutory timelines, SLA-driven escalation, and deemed-approval provisions so that every application has a guaranteed resolution pathway, eliminating indefinite pendency.
- Integration over Isolation: Connecting previously siloed departmental clearances — Fire NOC, AAI height clearance, RERA registration, property tax, industrial single-desk — into one end-to-end digital journey.

This paper evaluates the systemic transformation delivered by APDPMS within Andhra Pradesh's urban local governance ecosystem, drawing upon its operational architecture, performance metrics, and future evolution under the AI-enabled digital governance vision.

2. CURRENT FRAMEWORK ANALYSIS: THE APDPMS PARADIGM

2.1 Operational Scale and Coverage

The APDPMS platform is deployed across all 123 Urban Local Bodies and 21 Urban Development Authorities of Andhra Pradesh, providing a geographically unified and procedurally standardised permission ecosystem regardless of whether an applicant is in a large Municipal Corporation or a smaller Nagar Panchayat. The platform makes permissions accessible on a true 'anytime, anywhere' basis through a cloud-hosted architecture, eliminating the physical geography barrier that previously forced applicants to appear before specific offices during fixed hours.

Every application on APDPMS is initiated through a registered Licensed Technical Person (LTP) — an architect, engineer, or town planner licensed by the concerned authority — who serves as the regulated professional intermediary. This framework assigns clear professional accountability for the accuracy of submitted drawings and documents, while providing applicants a single point of contact for navigating the permission process.

Metric	Value / Outcome
Platform Type	**Cloud-based, Anytime/Anywhere SaaS**
ULBs & UDAs Covered	**123ULB/21UDA across Andhra Pradesh**
Applicant Interface	**Licensed Technical Person (LTP) Registered Portal**
Plan Scrutiny Engine	**AutoDCR® — Automated rule-based AI checking**
Statutory Framework	**Andhra Pradesh Building Rules, 2017**
Deemed Approval Trigger	**Applications pending beyond prescribed SLA timeline**
Post-Approval Verification	**Mandatory within 15 days; auto-deemed if overdue**

2.2 Permission Categories and Application Scope

APDPMS handles the full spectrum of development permissions required for planned urban growth in Andhra Pradesh. Applications are processed across three primary construction categories:

- Residential Buildings: Individual houses, apartment complexes, group housing layouts, and gated community developments across all ULBs and planning areas.
- Commercial Buildings: Retail establishments, office complexes, hotels, multiplexes, and mixed-use developments subject to applicable zoning regulations and AP building Rules.
- Industrial Buildings: Factory and warehouse facilities processed through the platform's integration with the state's Single Desk Portal for industrial clearances.

Beyond primary building permissions, the platform manages layout development approvals, occupancy certificate issuance upon project completion, and mortgage release letters for registered property — covering the complete lifecycle of a development project from inception to occupancy.

2.3 Year-Wise Performance: A Decade of Digital Governance in Numbers

Since its statewide rollout in 2016, APDPMS has processed a cumulative total of 3,49,937 building permissions covering 32,045 acres of site area and 135.44 crore sq. ft. of built-up area, alongside 4,676 layout permissions spanning 41,000 acres and 12,248 occupancy certificates. The year-wise data below captures the platform's sustained scale of operations and its consistent growth across all three permission categories, reflecting growing citizen adoption, increasing investor confidence, and expanding urban development activity across Andhra Pradesh's 123 ULBs and 21 UDAs.

Year	Building Permission			Layout		Occupancy
	Approved (No.)	Site Area (Acres)	BUA (Sq.ft Cr)	Approved (No.)	Site Area (Acres)	Approved (No.)
2015	16	0.46	0.00	-	-	-
2016	17,409	886.29	4.88	-	-	-
2017	33,574	1,557.38	9.02	3	3.94	87
2018	37,542	2,000.27	12.10	121	753.91	916
2019	29,889	2,662.06	12.17	381	3,240.62	976
2020	29,428	2,478.30	10.58	364	2,804.11	1,059
2021	41,841	4,297.65	15.12	642	5,825.77	1,398
2022	44,252	3,283.41	15.61	468	3,819.17	1,614
2023	38,777	3,597.14	15.85	727	6,485.10	1,680
2024	34,763	4,103.17	15.01	547	6,950.53	2,019
2025	27,909	4,996.64	16.48	904	7,138.13	1,864
2026*	14,537	2,182.90	8.61	519	3,979.18	635

** 2026 data is partial (January–May 2026).*

Over a decade of operation, APDPMS has approved more than 3.49 lakh building permissions covering 135.44 crore sq. ft. of built-up area — the digital backbone of Andhra Pradesh's entire formal urban built environment. Layout permissions have grown from 3 in 2017 to 904 in 2025, while occupancy certificates have scaled from 87 in 2017 to over 2,000 in 2024, reflecting deepening compliance and post-construction governance across the state.

3. THE AUTODCR® INTELLIGENT PLAN SCRUTINY ENGINE

3.1 From Manual Checking to Algorithmic Validation

The foundational technology of APDPMS is the AutoDCR® platform — a sophisticated Computer-Aided Design (CAD) rule-checking engine that automatically scrutinises uploaded building plans against the relevant AP Building Rules, 2017 bye-laws, zoning regulations, and site-specific constraints. This automation represents the most transformative departure from legacy building permission systems.

Under the old system, a town planning official would manually examine paper or digital drawings to verify compliance with dozens of parameters: setback distances, plot coverage ratios, floor space index, building height limits, parking provisions, open space requirements, and fire safety specifications. This manual process was time-consuming, susceptible to human error, and introduced subjectivity that created scope for inconsistency.

AutoDCR® reads an architect's CAD drawing and algorithmically checks it against all applicable rules. If every dimension and ratio is compliant, the system generates approval automatically — without any officer having to review or sign off on a routine file.

3.2 How the AutoDCR® Engine Works

When an LTP submits a building plan through the APDPMS portal, the AutoDCR® engine processes the CAD file through a structured multi-parameter validation sequence:

Step 1	Plan Upload: LTP logs in, selects the appropriate ULB/UDA, and uploads the CAD drawing along with mandatory primary and additional documents via the APDPMS portal.
Step 2	Automated Rule Check: AutoDCR® reads the CAD geometry and extracts dimensional data — setbacks, road width, plot area, building height, parking, open spaces — and checks each parameter against the AP Building Rules, 2017 applicable to the specific zone.
Step 3	NOC Trigger Identification: The engine identifies whether the proposal's parameters — particularly building height and activity type — attract statutory NOCs from external agencies (Fire Department, Airport Authority of India). If required, the system automatically redirects the LTP to apply for these clearances from within the APDPMS interface.
Step 4	Fee Calculation and Online Payment: Based on the plot area, building use, and approval type, the system computes the applicable permission fee schedule. Payment is completed through CFMS-integrated channels including net banking and credit/debit cards, with automatic fund transfer to the respective department.

Step 5	Digital Approval Generation: For fully compliant plans with all clearances in place, permission is generated digitally. The approval letter and plan are downloadable directly from the LTP's dashboard without any counter visit.
Step 6	Post-Approval Site Verification: A mandatory physical inspection within 15 days validates that on-ground construction matches the approved plan. If the officer does not complete the inspection within this window, the system automatically treats it as a deemed confirmation.

3.3 Automated NOC Integration: Eliminating Multi-Agency Queues

One of the most consequential integrations within APDPMS is the automated detection and routing of multi-agency NOC requirements. Previously, an applicant had to independently identify which external clearances applied to their building, visit those departments separately, obtain physical NOC documents, and then return to the ULB counter. APDPMS eliminates each of these friction points:

- Fire Department NOC: If AutoDCR® determines that the building height or proposed use (hotel, cinema, hospital, etc.) triggers the mandatory Fire NOC requirement under the National Building Code, it surfaces an in-application prompt for the LTP. A single click redirects to the Fire Department's online portal, pre-populating available project data. Once the Fire NOC is issued, its status automatically appears in the APDPMS console.
- Airport Authority of India (AAI) Clearance: For sites within the funnel zone or obstacle limitation surface of any airport in Andhra Pradesh, APDPMS prompts an AAI height clearance application. The integration allows the LTP to initiate the AAI NOC process directly from within the same portal.
- RERA Integration: Once a building permission is granted for a project qualifying under RERA (Real Estate Regulatory Authority), APDPMS shares the permission details with the RERA system automatically, streamlining project registration for builders and reducing duplicate documentation submissions.
- Property Tax and VLT Linkage: New construction approvals are automatically flagged to the Property Tax and Vacant Land Tax (VLT) modules, closing a significant revenue leakage pathway where newly constructed properties were previously added to the tax roll only after considerable delays.

4. THE SLA FRAMEWORK AND DEEMED APPROVAL: INSTITUTIONAL ACCOUNTABILITY

4.1 SLA-Driven Accountability

APDPMS embeds a rigorous Service Level Agreement framework that assigns mandatory processing timelines to every stage of the permission workflow. Every application in the system is visible to the responsible officer's login dashboard with a countdown clock indicating remaining SLA time. Unlike legacy systems where files could remain in one officer's tray indefinitely, APDPMS creates a transparent, time-stamped audit trail that prevents administrative inaction from escaping scrutiny.

The consequence of SLA breach is not merely a flag or a reminder — it is an automatic institutional sanction: the deemed approval mechanism.

4.2 The Deemed Approval Mechanism: A Structural Reform

A critical governance innovation: if a building permission application remains in an officer's login for more than the prescribed number of days without an approval, rejection, or justified technical deferral, the Government of Andhra Pradesh treats the application as deemed approved. The officer in whose login the file lapsed is personally accountable for any post-construction discrepancies discovered.

This mechanism fundamentally restructures the power balance between citizens and local government. An applicant is no longer at the mercy of an official's willingness to act — the system guarantees that inaction is not a viable outcome. The deemed approval provision serves dual purposes:

- It provides citizens and developers with a guaranteed resolution timeline, enabling project financing, contractor engagement, and construction planning without uncertainty.
- It creates a powerful institutional incentive for officers to process applications within SLA, since a deemed approval on their login record carries personal accountability for subsequent verification of compliance.

Post-approval verification is similarly time-bound: mandatory site inspection must be completed within 15 days of permission issuance. If the officer does not record the inspection within this period, the post-verification is automatically deemed complete — and any future discrepancy found during construction becomes the concerned officer's direct responsibility.

5. CITIZEN-FACING INTERFACE AND ACCESSIBILITY

5.1 The LTP-Led Application Model

APDPMS operates on a professional intermediary model in which every building permission application must be submitted by a Licensed Technical Person registered with the relevant ULB or UDA. This model ensures technical quality of submitted drawings and provides citizens a single professional point of contact for navigating the regulatory framework. An LTP's dashboard provides:

- Submission of new applications across any ULB or UDA in the state through a unified interface.
- Real-time application status tracking, showing exactly which processing stage the file is at, which officer's login currently holds it, and the remaining SLA time.
- Online fee payment via CFMS-integrated gateways without any counter visit.
- Download of digitally signed approval letters and stamped building plans upon permission grant.
- Access to occupancy certificates and mortgage release letters for completed projects.

6. THE WHOLE-OF-GOVERNMENT INTEGRATION ECOSYSTEM

6.1 Financial Integration: CFMS and Transparent Revenue Management

Every fee transaction on APDPMS flows through the Centralised Finance Management System (CFMS), Andhra Pradesh's integrated government treasury platform. This integration delivers multiple governance dividends:

- Cash handling at ULB counters is eliminated, removing a historically significant corruption vulnerability in building permission offices.
- Fee receipts are system-generated and automatically credited to the relevant departmental account without human handling of funds.

- Real-time revenue dashboards give administrators visibility into permission fee collection patterns across all 123 ULBs, supporting evidence-based resource planning.
- Automatic reconciliation with treasury accounts removes billing errors and disputed payment records.

6.2 Industrial Single Desk Integration

For industrial buildings, APDPMS integrates with Andhra Pradesh's Single Desk Portal managed by the Department of Industries. This integration enables industrial project developers to obtain building permissions as part of a consolidated, time-bound industrial clearance process, reducing the total regulatory timeline for setting up manufacturing and warehousing facilities — directly supporting the state's investment promotion objectives under Viksit Bharat 2047.

6.3 RERA Integration

The APDPMS–RERA integration creates a seamless flow between building permission and real estate regulatory compliance. When a developer obtains permission for a project covered under RERA, the permission details are automatically shared with RERA's system, allowing the developer to initiate their RERA registration without resubmitting project documents already captured in APDPMS.

Integrated System	Integration Benefit
CFMS (Centralised Finance Management)	Online fee payment, automatic treasury credit, no cash handling, real-time revenue dashboard
Fire Department NOC Portal	In-platform NOC application; auto-status update on NOC issuance
Airport Authority of India (AAI)	Height clearance application initiated directly from APDPMS
RERA Portal	Building permission data shared automatically for project registration
Single Desk Portal (Industries)	Industrial building permissions part of consolidated investment clearance
Property Tax / VLT System	New constructions auto-flagged to tax roll, preventing revenue leakage

6.4 Secure Digital Governance and Data Integrity

APDPMS incorporates multiple digital governance safeguards to ensure secure, transparent, and accountable service delivery across all Urban Local Bodies and Urban Development Authorities in Andhra Pradesh. The platform operates through role-based access controls, digitally authenticated workflows, audit trails for every transaction, and secure online payment integration through CFMS. Emerging technologies such as Blockchain can further strengthen tamper-proof approval records, transparent transaction history, and secure document verification across the development permission lifecycle. The integration of eSign implementation enables digitally signed approvals, faster authentication, paperless processing, and legally valid electronic service delivery. Every application movement, approval, rejection, and inspection activity is time-stamped and traceable, significantly reducing the scope for unauthorised intervention and ensuring institutional accountability. The cloud-based architecture further enables secure data management, system scalability, and uninterrupted statewide access for citizens, Licensed Technical Persons (LTPs), and government officials.

6.5 Future Roadmap: Towards APDPMS 2.0

APDPMS incorporates multiple digital governance safeguards to ensure secure, transparent, and accountable service delivery across all Urban Local Bodies and Urban Development Authorities in Andhra Pradesh. The platform operates through role-based access controls, digitally authenticated workflows, audit trails for every transaction, and secure online payment integration through CFMS. Every application movement, approval, rejection, and inspection activity is time-stamped and traceable, significantly reducing the scope for unauthorised intervention and ensuring institutional accountability. The cloud-based architecture further enables secure data management, system scalability, and uninterrupted statewide access for citizens, Licensed Technical Persons (LTPs), and government officials.

7. WORKFLOW RATIONALISATION: REDUCING ADMINISTRATIVE LAYERS

APDPMS has implemented a deliberate workflow optimisation initiative that has reduced internal processing levels within ULBs and UDAs by approximately 50%. Traditional building permission workflows in large ULBs involved sequential file movement through multiple officer tiers — assistant, deputy, joint director, and commissioner — each adding handling time without necessarily adding scrutiny value for routine applications.

The reformed APDPMS workflow concentrates human judgment at decision points where it genuinely matters: cases where AutoDCR® identifies non-compliant parameters, applications triggering external NOCs, or projects above floor area thresholds requiring senior officer sign-off. For fully compliant plans below threshold sizes, the system's automated approval pathway minimises unnecessary human interventions, reserving officer time for applications that genuinely require professional assessment.

8. STRATEGIC CONCLUSION: A BLUEPRINT FOR VIKSIT BHARAT 2047

The Andhra Pradesh Development Permission Management System stands as a comprehensive, field-tested model for transforming one of the most historically complex interfaces between citizens and urban local government — the building permission process — into a transparent, automated, citizen-first experience aligned with the Viksit Bharat 2047 vision.

APDPMS demonstrates that eliminating corruption-prone cash handling, reducing approval timelines to days for compliant applications, and enforcing officer accountability without additional bureaucratic layers is achievable not through expensive new institutions, but through intelligent platform design, rigorous workflow integration, and a genuine political commitment to citizen service excellence.

The system's core achievements — cloud-based access across 123 ULBs and 21 UDAs, AI-driven AutoDCR® plan scrutiny, deemed approval as an institutional accountability tool, multi-agency NOC integration, digital fee payment through CFMS, and GIS-anchored spatial governance — collectively transform the DT&CP from a reactive approval office into a proactive guardian of planned, lawful, and transparent urban development.

APDPMS establishes that modern governance does not require building new bureaucratic layers — it requires empowering existing institutional frameworks with the right technology, clear accountability rules, and uncompromising citizen orientation. This is Andhra Pradesh's contribution to the Viksit Bharat 2047 blueprint for development permission reform across India.

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CHAPTER 15
AI Tapaal: AI for the Government Workforce and Digital Correspondence Management in Nagpur Zilla Parishad

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ABSTRACT

AI Tapaal is an artificial intelligence enabled digital correspondence and case management system developed for the office workflow of Nagpur Zilla Parishad. Zilla Parishad is a vast institution, often described as a "mini assembly", because it deals with many departments, elected representatives, field offices and citizen-facing schemes. Earlier, incoming tapaal did not follow one central path: some letters came directly to the Chief Executive Officer, some were received by the General Administration Department, and many reached departments directly. Each department had its own clerk for inward and outward movement. As a result, central monitoring was weak, tracking of each application was difficult and the leadership did not get real-time visibility of pendency. Zilla Parishad headquarters received nearly 200 to 400 applications daily, all processed manually. Sorting took hours, routing errors were common, service timelines were not monitored, and departmental performance could not be reviewed instantly. AI Tapaal addresses this by enabling batch scanning, AI-based reading, summarisation, department suggestion, CEO review, digital routing, SLA tracking, applicant acknowledgement and dashboard monitoring. The system reduces the administrative burden on clerks and officers while improving transparency, accountability and citizen service delivery.

Index Terms: Artificial intelligence, AI for government workforce, case management, correspondence tracking, inward outward management, SLA monitoring, data-driven governance, e-Governance.

Selected Sub-theme: AI for the Government Workforce - recognizing AI that reduces administrative burden for government employees. Also relevant to Data-Driven Administrative Reforms and Citizen Service Delivery, AI-based Governance for All, AI and Digital Infrastructure for Secure Public Services, and Grassroots Governance 2.0: Digital, Decentralised, Data-Driven.

1. INTRODUCTION

Zilla Parishad Nagpur is a large district-level governance institution handling multiple public service departments, elected-body references, administrative approvals, citizen grievances, scheme-related correspondence and inter-office communication. In administrative language, the Zilla Parishad is often described as a "mini assembly" because many subjects relating to rural development, education, health, finance, works, agriculture, women and child development, water supply, general administration and panchayat governance converge in one institutional structure.

The scale of this institution creates a serious correspondence management challenge. Every day, Zilla Parishad headquarters receives approximately 200 to 400 applications, letters, reminders, directions, grievances and official references. These documents may come from citizens, Gram Panchayats, Panchayat Samitis, departments, elected representatives, higher government offices or internal offices. Each document must be received, recorded, understood, routed to the correct department, acted upon and monitored until closure.

Earlier, the tapaal flow was fragmented. Some tapaal came directly to the Chief Executive Officer (CEO), some was received by the General Administration Department (GAD), and some reached individual departments directly. Each department maintained its own inward and outward handling through a clerk. Because there was no single central inward-outward movement and no unified monitoring layer, it was difficult to know the exact status of every application across the institution.

AI Tapaal addresses this problem as an AI for the Government Workforce initiative. It is not merely a citizen-facing portal; it is an internal administrative intelligence layer that reduces the burden on government employees. By reading, summarising and routing correspondence, it helps clerks, departmental

staff, Heads of Department and senior officers manage high-volume paperwork with better speed and accuracy. It converts a dispersed manual system into a traceable digital case-management workflow while preserving the existing hierarchy of the office.

2. GOVERNANCE PROBLEM

The manual tapaal process created a hidden administrative cost. Since correspondence entered the institution through multiple channels, the office did not have one authoritative view of total receipts, pending cases, routing status or departmental workload. A letter received directly by one department could remain invisible to the central office. A letter placed before the CEO could require manual forwarding. A letter received by GAD could take time to reach the concerned department. This fragmentation weakened tracking and delayed accountability.

The first problem was decentralised inward and outward movement without central visibility. Every department had a clerk handling inward and outward registers. This arrangement worked at the departmental level but did not generate a single institution-wide picture. The CEO could not easily see how many applications were received on a given day, which departments had the highest pendency, which matters were delayed, or which references required priority attention.

The second problem was volume. With 200 to 400 applications arriving daily at Zilla Parishad headquarters, manual sorting consumed several hours. Clerks had to read letters one by one, identify the subject, decide the concerned department, make register entries and physically move papers. On heavy receipt days, even a small delay at the intake stage affected the entire administrative chain.

The third problem was routing error. In a multi-department institution, one application may relate to education, health, finance, works, Gram Panchayat, ICDS, agriculture or general administration. Manual classification depends heavily on the experience and judgement of the receiving clerk. Misrouting causes avoidable delay because the wrong department must return or forward the file again.

The fourth problem was weak SLA monitoring. Service timelines or internal deadlines were not visible in a unified dashboard. As a result, it was difficult to identify whether a case was still new, in progress, pending beyond timeline, completed or delayed. Senior review depended on manual registers, physical files, verbal follow-up and periodic reporting.

The fifth problem was lack of real-time departmental performance visibility. The CEO and senior leadership had no live view of department-wise workload, pendency, delayed cases, completion status or priority matters. This affected the ability to take early corrective action and made monitoring reactive rather than proactive.

3. SYSTEM DESIGN AND METHODOLOGY

AI Tapaal has been designed as a digital correspondence and case management system around eight functional layers: central receipt, batch scanning, optical reading and language handling, AI summarisation, department classification, CEO review, SLA-based routing, departmental action and audit-based closure. Together, these layers convert a letter into a trackable administrative case.

The system begins by creating a central digital intake. Instead of allowing correspondence to remain scattered across separate departmental registers, scanned documents are captured in the AI Tapaal system. Even if a document enters through the CEO office, GAD or a department, it can be digitised and brought into the common monitoring framework. This creates a single source of truth for inward correspondence.

The operator can scan 20 to 25 letters together and upload them in one batch. The system reads each letter, identifies the subject, extracts key details, prepares a short summary and suggests the likely department. This reduces repetitive manual typing and enables the office to process high daily volumes faster.

The AI component acts as a decision-support tool. It does not replace the authority of the CEO or department. It assists by summarising the content and recommending the concerned department. The CEO can approve the suggestion, change the department, mark priority, set an internal deadline or seek clarification. This ensures that the system remains administratively accountable and human-supervised.

After CEO review, the concerned Head of Department receives the case in a departmental queue. The HOD can accept and assign it to an officer or return it if the matter belongs elsewhere. Officers can update status, upload documents, add comments, prepare replies and mark completion. Every step is recorded with user and timestamp, creating an audit trail.

4. CORE INNOVATION

The core innovation of AI Tapaal lies in applying artificial intelligence to reduce the workload of the government workforce. Most digital governance projects focus on citizen interfaces, but AI Tapaal focuses on the internal employee burden that slows service delivery. Clerks, officers and senior administrators spend significant time reading, sorting, forwarding and tracking correspondence. AI Tapaal makes this work faster and more structured.

The first innovation is centralisation without over-centralisation. The system brings all inward correspondence into one digital monitoring layer while allowing departments to retain responsibility for action. This is important for a vast institution like Zilla Parishad, where work is distributed across many departments.

The second innovation is AI-assisted classification. The system reads administrative correspondence and suggests the department, helping reduce routing errors. This is especially useful where applications are long, handwritten, mixed in Marathi and English, or refer to multiple schemes and offices.

The third innovation is batch-to-case conversion. Manual registers treat each paper as a separate entry written one by one. AI Tapaal allows multiple letters to be scanned together and converted into individual digital cases, each with its own status, department, priority, deadline and audit history.

The fourth innovation is SLA and pendency visibility. Instead of waiting for manual reports, senior leadership can see how many cases are pending, completed, delayed, newly received or in progress. This transforms correspondence from a clerical activity into a measurable management function.

The fifth innovation is applicant acknowledgement. Once a case enters the system, acknowledgement can be sent by WhatsApp or email. This reduces uncertainty for citizens and decreases repeated visits or phone calls merely to confirm receipt.

5. ADMINISTRATIVE WORKFLOW

The workflow begins with receipt of applications and letters through any of the existing channels: CEO office, GAD or departments. The document is scanned and uploaded into AI Tapaal. The system reads the document, extracts basic details, prepares a summary and recommends the concerned department.

The case is then placed before the CEO or authorised reviewing authority. The reviewer can approve routing, change the department, assign priority, fix an SLA or send the matter for clarification. This step ensures that AI remains an assistant and not the final administrative decision-maker.

The department receives the case in its digital queue. The HOD assigns the case to the concerned officer or clerk. The officer acts on the matter, uploads relevant documents, updates status and prepares a reply. If the matter does not belong to that department, the HOD can return it with remarks, thereby creating a traceable correction instead of informal paper movement.

During the process, the dashboard reflects status such as new, in progress, pending, completed, declined or past due. This allows weekly or daily review meetings to be based on real-time data rather than physical registers. Closure is recorded only after the department completes action and updates the case.

The workflow therefore establishes a complete digital life cycle: receipt, AI reading, summary, department suggestion, CEO review, departmental assignment, officer action, SLA monitoring, applicant acknowledgement and audit-based closure.

6. DASHBOARD AND NAGPUR REFERENCE INDICATORS

The dashboard reference for Nagpur Zilla Parishad shows the system operating as a management dashboard. It displays total tapaals, completed cases, pending requests and delayed requests. The uploaded dashboard view shows 256 total tapaals, 2 completed cases, 254 pending requests and zero delayed requests at the time of capture.

The dashboard also shows department-wise performance. Departments visible include CEO Office, General Administration Department, Gram Panchayat Department, Education Department, Finance Department, Health Department, Integrated Child Development Services and others. This is particularly important for a "mini assembly" institution because the leadership must monitor multiple departments simultaneously.

Time filters such as Today, This Week, This Month, Year and All help the office distinguish between daily inflow and cumulative pendency. Weekly abstract and priority office report views support routine review and urgent attention. The dashboard therefore gives the CEO a real-time administrative control panel for correspondence movement.

The major governance change is that every application becomes visible. Instead of scattered registers maintained by different clerks, the system creates a common view of receipt, department, status, action and delay. This makes it possible to identify bottlenecks early and take corrective action.

7. PUBLIC VALUE AND OUTCOMES

AI Tapaal creates value for citizens, clerks, departments and leadership. For citizens, acknowledgement by WhatsApp or email confirms that the application has entered the system. This improves trust and reduces the need for repeated physical follow-up.

For clerks, the system reduces repetitive manual work. Earlier, each clerk had to read, enter, forward and track papers manually. In a setting where hundreds of applications arrive daily, this burden is substantial. AI Tapaal helps clerks by reading and summarising documents, suggesting departments and maintaining the register automatically.

For departments, AI Tapaal creates clear queues and responsibilities. HODs can see what is assigned to them, officers can see what is pending, and the system records action taken. This reduces the risk of papers being misplaced, ignored or delayed without explanation.

For the CEO and senior leadership, the outcome is real-time visibility. The CEO can see workload, pendency, departmental performance, delayed matters and priority letters without waiting for manual compilation. This improves administrative discipline and enables data-driven review.

At the institutional level, AI Tapaal addresses the central weakness of the earlier system: absence of unified inward-outward movement and monitoring. It converts correspondence into a digital administrative transaction with ownership, timeline and audit trail.

8. RELEVANCE TO E-GOVERNANCE AND AI FOR THE GOVERNMENT WORKFORCE

The most appropriate recognition category for this initiative is AI for the Government Workforce, because the project directly reduces administrative burden for government employees. The system helps clerks

handle high daily volumes, supports HODs in managing departmental queues, assists officers in tracking assigned matters and gives senior leadership a real-time monitoring dashboard.

The initiative is also relevant to Data-Driven Administrative Reforms and Citizen Service Delivery. Every letter becomes a data point with department, subject, priority, status, SLA and action history. This information can be used for daily monitoring, weekly review, monthly analysis and identification of recurring issues.

AI Tapaal also supports AI-based Governance for All because it applies artificial intelligence to routine administrative work in a way that can be adopted by other Zilla Parishads, municipal bodies, departments and district offices. The problem of scattered correspondence and manual tracking is common across government institutions.

The secure digital governance dimension is equally important. Official correspondence may contain personal information, grievances, government directions and sensitive references. Therefore, the system must operate with role-based access, audit logs, secure storage and clear permission controls.

By combining decentralised departmental action with centralised visibility, AI Tapaal supports the broader vision of AI-enabled, data-driven and secure digital governance under Viksit Bharat 2047.

9. SECURITY, CONTROL AND ETHICS

AI Tapaal deals with citizen applications and official records. Therefore, confidentiality, integrity and availability of information are essential. Role-based access should ensure that users see only the cases relevant to their official role. CEO-level access may show all cases, while HOD and officer access should be limited to their departmental responsibilities.

Every action should be permanently logged. Assignment, rejection, reassignment, comment, attachment, status change, deadline extension and closure must carry user and timestamp details. This prevents informal alteration of administrative history and supports audit, inspection and Right to Information related verification.

AI must remain a support tool. The system can suggest the department and prepare summaries, but final routing, priority marking and SLA setting should remain with authorised officials. This human-in-the-loop design protects against automated misclassification and preserves administrative responsibility.

Automated acknowledgements should be carefully worded. They should confirm receipt and tracking, but should not create an impression that the requested relief has been approved. Reply drafting, if enabled, should always remain editable by officials before issue.

10. IMPLEMENTATION STRATEGY

The first implementation step is mapping the existing receipt channels: CEO office, GAD and department-level inward registers. This mapping is necessary because AI Tapaal must integrate the existing reality instead of assuming that all correspondence already enters through one window.

The second step is creation of a department master and user master. All departments, HODs, clerks, officers, roles, mobile numbers and email IDs should be configured. Standard categories such as grievance, scheme reference, financial approval, service matter, works proposal, education matter, health matter and Gram Panchayat matter can improve classification.

The third step is pilot operation. For a limited period, daily letters can be scanned and processed through AI Tapaal while the office verifies whether department suggestions, summaries, acknowledgements and dashboards are accurate. Feedback from clerks and HODs should be used to improve workflow.

The fourth step is adoption of dashboard-based review. Once confidence is established, the dashboard should become the official basis for weekly review of pending cases, delayed matters and department-wise workload. This will shift monitoring from register checking to evidence-based administrative review.

The fifth step is continuous improvement. Misrouting patterns, repeated delays, high-volume categories and frequently pending departments should be analysed. These insights can improve training, staffing and internal process design.

11. KEY LEARNINGS

The first learning is that AI becomes meaningful in government when it reduces everyday employee burden. Reading and routing correspondence may appear routine, but in a large institution receiving 200 to 400 applications daily, this work consumes significant time and energy.

The second learning is that fragmented entry points require a unified monitoring layer. Since tapaal may come to the CEO, GAD or departments directly, the system must not depend only on one physical counter. It must capture correspondence from multiple sources and bring it into one dashboard.

The third learning is that dashboard visibility changes administrative behaviour. When pendency and department-wise workload are visible, follow-up becomes objective and timely. Officers know that delay is recorded, and leadership can intervene before matters become overdue.

The fourth learning is that preserving hierarchy improves adoption. AI Tapaal does not bypass the CEO, HOD or departmental officer. It gives them better tools and clearer information. This makes the system acceptable in a traditional administrative environment.

The fifth learning is that citizen trust begins with acknowledgement. Even before final disposal, a citizen feels heard when the application is acknowledged and tracked.

12. LIMITATIONS AND FUTURE WORK

The present paper is based on the operational concept, dashboard reference and institutional requirements of Nagpur Zilla Parishad. Further evidence should be collected after sustained use, including average time from receipt to assignment, average time to disposal, percentage of correct AI routing, number of acknowledgements sent, reduction in manual register work and percentage of cases completed within SLA.

Future work should include integration with e-office systems, email, WhatsApp business messaging, digital signatures and outward reply dispatch. This would create a complete correspondence life cycle from inward receipt to final outward communication.

The AI layer can be improved through feedback. Whenever the CEO changes a suggested department or an HOD returns a misrouted case, the correction can improve future classification. However, such learning should be governed carefully and periodically reviewed.

Future scale-up should include standard operating procedures, staff training, cyber security audit, backup and disaster recovery plan, retention policy, mobile access and bilingual Marathi-English templates for citizen communication.

13. CONCLUSION

AI Tapaal demonstrates how artificial intelligence can strengthen the government workforce by reducing clerical burden, improving routing accuracy and giving leadership real-time visibility. In a vast institution like Nagpur Zilla Parishad, where multiple departments function like a mini assembly and hundreds of applications arrive daily, correspondence management is not a small clerical function. It is the first step in citizen service delivery.

The earlier arrangement of separate departmental inward-outward registers, multiple receipt points and manual tracking created difficulty in monitoring every application. AI Tapaal provides a practical solution by creating a central digital monitoring layer while preserving departmental responsibility.

Its core contribution is the creation of a transparent case life cycle: receipt, AI reading, summary, department suggestion, CEO review, SLA tracking, departmental action, acknowledgement and audit-based closure. This makes every letter measurable, traceable and reviewable.

With proper security, training, feedback and integration, AI Tapaal can become a replicable model for AI-enabled public office management across large government institutions. It supports the national vision of AI-enabled, data-driven and secure governance by making everyday government work faster, more accountable and less burdensome for employees.

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CHAPTER 16
Towards Intelligent Pilgrimage Mobility Management: A Computer Vision Framework for Crowd and Traffic Flow Analysis

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ABSTRACT

Crowding and traffic congestion remain major challenges in pilgrimage destinations located in mountainous regions, where narrow roads and difficult terrain restrict mobility and emergency access. This study presents a spatiotemporal mobility analytics and forecasting framework for the Kainchi Dham temple region using Edge-AI and computer vision systems deployed over a five-month period. A vehicle monitoring system, TrafficEye, was installed at critical entry and exit corridors to obtain real-time classified vehicle counts, while a CrowdEye node was deployed at the temple entrance to estimate pilgrim inflow and outflow. The collected data was used to derive congestion trends, occupancy analysis, vehicle-to-pedestrian conversion metrics, temporal hotspot mapping, and route-wise traffic correlations. A Random Forest based forecasting framework was developed using temporal, lag, and rolling occupancy features to predict future pilgrim inflow and parking demand. The pilgrim forecasting model from the entry gate achieved a strong R^2 value of 0.9208, while vehicle forecasting achieved an R^2 of 0.9199. Additionally, parking demand forecasting in the region achieved an R^2 of 0.9891, demonstrating high accuracy in capturing temporal variations and peak congestion patterns. The proposed framework can support proactive and sustainable pilgrimage planning in mountainous regions.

INDEX TERMS

Computer vision, Spatiotemporal analysis, machine learning, Crowding, Classified Traffic

1. INTRODUCTION

Religious tourism and pilgrimage activities attract millions of visitors annually and play a significant role in the cultural and economic landscape of many regions. However, the rapid increase in pilgrim inflow often creates severe challenges related to traffic congestion, crowd management, public safety, and environmental sustainability [1]. These challenges become more critical in mountainous temple regions where narrow roads, limited parking infrastructure, terrain constraints, and restricted mobility corridors significantly reduce the transportation carrying capacity. In recent years, several pilgrimage destinations have experienced sudden increases in popularity due to social media information exposure, tourism promotion, and improved accessibility, leading to unplanned traffic surges and overcrowding. Such conditions not only affect pilgrims visiting the temple but also disrupt the daily life and mobility of local residents living along the transportation corridors.

Traditional traffic monitoring methods, including manual surveys and static sensors, are often inadequate for continuously monitoring highly dynamic pilgrimage traffic environments [2]. Furthermore, obtaining reliable longduration traffic and crowd data in mountainous regions remains a major challenge due to infrastructure limitations and operational costs. Recent advancements in edge computing and computer vision provide an opportunity to develop intelligent, scalable, and real-time mobility monitoring systems capable of operating efficiently in remote environments [3]. A number of studies have employed computer vision, homography mapping, optical flow analysis, object tracking, crowd density estimation, motion analysis, and machine learning techniques to monitor pedestrian and vehicular movements, detect

congestion hotspots, analyze crowd behavior, and improve situational awareness for effective crowd management and public safety in large gatherings and urban environments [4-8].

This work presents a comprehensive spatio-temporal mobility analysis framework for a temple region using data collected from a distributed edge-computing-based computer vision system. Traffic Eye devices deployed at the entry and exit routes connecting the temple corridor from the Bhowali and Almora sides act as vision nodes to monitor classified vehicular movement, while the CrowdEye device monitored pilgrim entry and exit at the temple premises as in Figure 1. The collected data, spanning a period of five months, was used to analyze traffic density, congestion patterns, occupancy behavior, vehicle-to-pedestrian interaction, visitor retention characteristics, and temporal mobility hotspots.



Figure 1: *Device Deployments*

The proposed framework performs several advanced analytics, including congestion index estimation, occupancy rate analysis, peak hour factor evaluation, traffic hotspot mapping, vehicle-person ratio analysis, and route correlation analysis between multiple sensing locations. These analytics provide actionable insights for transportation authorities, temple administrators, and urban planners to understand traffic dynamics, evaluate the impact on local communities, and design evidence-based congestion mitigation strategies for sustainable pilgrimage management. The study demonstrates the potential of integrating edge AI and computer vision for intelligent transportation analytics in challenging mountainous pilgrimage environments.

2. METHODOLOGY

The proposed system is designed to perform continuous monitoring and spatio-temporal analysis of vehicular and pedestrian movement in a mountainous temple region using edge-computing-based computer vision devices. The methodology involves distributed traffic sensing, real-time vehicle and pedestrian counting, data preprocessing, temporal synchronization, occupancy estimation, and mobility analytics. The overall framework consists of three major sensing nodes deployed at strategic locations around the temple corridor.

Two edge-computing-based vision systems, namely Traffic Eye and Crowd Eye, were deployed as part of the sensing infrastructure for real-time mobility monitoring in the temple region. Two Traffic Eye devices were installed along the major access corridors connecting the temple from the Almora side (KT001) and Bhowali side (KT002) (see Figure 1). These devices continuously monitored classified vehicular movement entering and exiting the temple region. Each Traffic Eye unit consists of an outdoor camera, an onboard edge AI processing module, local storage, a wireless communication system, and a battery-backed power subsystem enclosed within a weather-protected housing. The devices perform real-time vehicle detection, classification, tracking, and direction-aware counting directly on the edge without requiring continuous

cloud processing. Vehicles were classified into categories such as buses, cars, light commercial vehicles (LCVs), motorized two-wheelers (MTWs), and pedestrians.

A separate Crowd Eye device was deployed at the main temple gate to monitor pilgrim entry and exit movement. The Crowd Eye system performs real-time pedestrian detection and bidirectional counting to estimate crowd inflow, outflow, and occupancy inside the temple premises. Since both systems process data locally and transmit only metadata instead of raw video streams, the framework reduces bandwidth requirements while enabling privacy-aware long duration monitoring. The edge-based architecture, low-power operation, autonomous deployment capability, and real time analytics make the proposed system highly suitable for remote and mountainous pilgrimage environments.



Figure 2: *a) Crowd Eye, b) Traffic Eye*

The collected datasets from the Traffic Eye and Crowd Eye devices consisted of timestamped classified vehicle counts and pedestrian movement observations recorded at regular intervals. Since the sensing systems were deployed in outdoor mountainous environments, occasional missing timestamps and irregular intervals were observed due to temporary network interruptions, environmental conditions, or power fluctuations. To ensure temporal consistency and analytical reliability, a comprehensive preprocessing pipeline was developed. Initially, all timestamps were standardized into ISO-8601 format and synchronized across all sensing nodes. Missing time slots were then identified by detecting temporal gaps greater than the expected sensing interval. Instead of directly applying conventional linear interpolation, a traffic-aware interpolation approach was adopted to preserve realistic traffic movement patterns and avoid abrupt artificial transitions in traffic flow. The interpolation process estimated missing values using neighboring temporal traffic behavior while maintaining directional consistency of entry and exit counts. All interpolated values were rounded to integer counts to preserve the physical interpretability of vehicle and pedestrian movement. Following interpolation, the datasets from multiple sensing nodes were aligned and merged to enable unified spatio-temporal analysis of vehicular congestion, temple occupancy, visitor retention, and regional mobility patterns over the five month observation period.

3. RESULTS AND DISCUSSION

The proposed edge AI-based mobility monitoring framework successfully enabled continuous long-duration monitoring of vehicular and pedestrian movement in the temple region over a period of five months. The deployed Traffic Eye and Crowd Eye systems generated reliable timestamped traffic metadata that was used to analyze congestion behavior, occupancy dynamics, and temporal mobility patterns across

the temple corridor. A sample image proving the accuracy of the detection is given in Figure 3. The preprocessing and traffic-aware interpolation pipeline ensured temporal consistency in the datasets despite occasional missing observations caused by environmental and network-related interruptions.



Figure 3: *Classified counts of objects from a)KT001 b) KC001*

Figure 4 shows a temporal heatmap of pedestrian activity captured by the Crowdeye device, where color intensity represents the combined entry and exit counts across different times of the day. Higher intensity (red) indicates greater crowd movement, while lighter colors indicate lower activity. The data reveals consistent daily patterns, with major peaks occurring during the morning hours (06:00-07:00 and 09:00-10:00) and a secondary peak around 15:00-16:00.

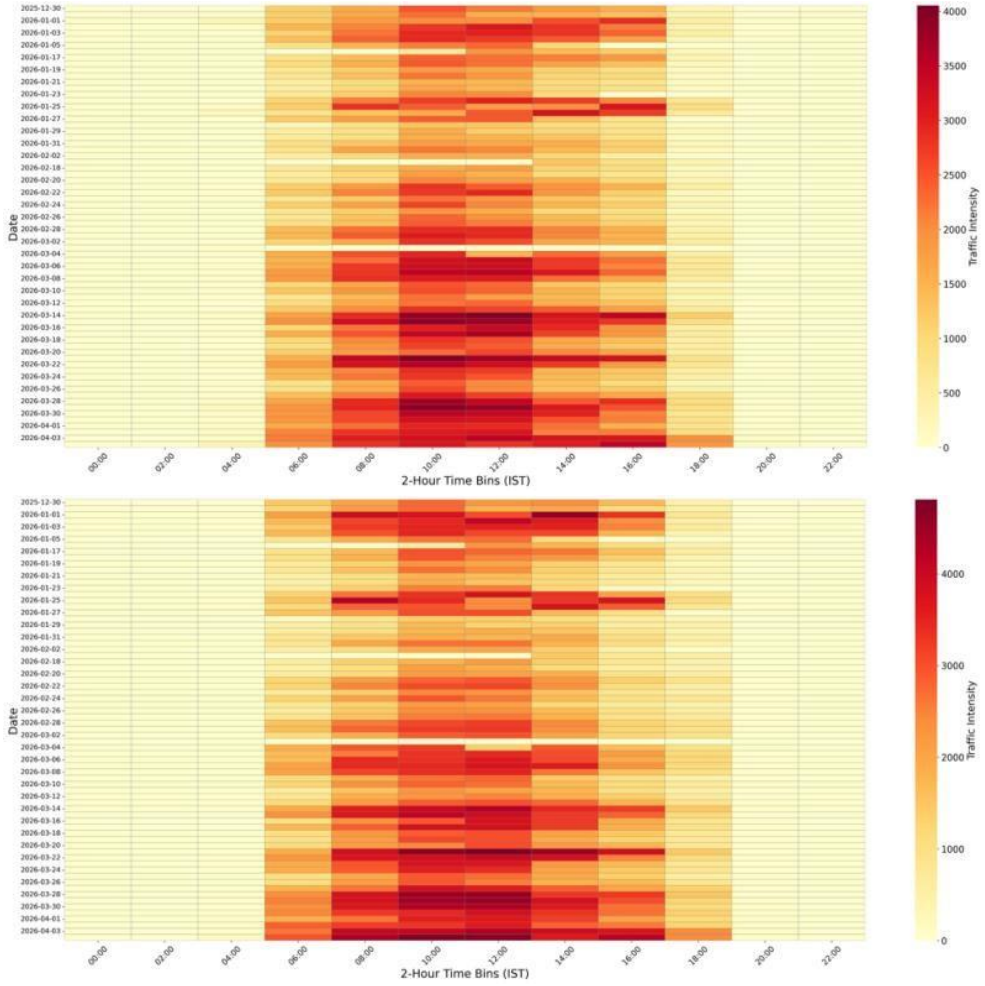


Figure 4: *Temporal crowd flow at the temple gate*

The heatmaps in Figures 5 and 6 show the temporal distribution of vehicle traffic passing through the Kainchi Dham route from 30 December 2025 to 7 April 2026, with traffic intensity varying by both date and time of day. For KT001 (Almora side) as in Figure 5, traffic volumes remain relatively low during the late-night and early-morning hours, begin increasing after around 07:00 AM, and reach their highest levels between 09:00 AM and 05:00 PM. The most intense traffic activity is observed during weekends and peak pilgrimage periods, particularly from January through early April, indicating significant daytime movement toward and from Kainchi Dham. Traffic gradually decreases after 06:00 PM, with substantially lower volumes during the night. For KT002 (Bhowali side) as given in Figure 6, a similar daily pattern is observed, with traffic building up from the morning and remaining elevated throughout the daytime hours. However, the overall vehicle volumes are noticeably higher than those recorded at KT001, suggesting that the Bhowali approach experiences heavier traffic demand. Peak activity is concentrated between 08:00 AM and 06:00 PM, with several days showing exceptionally high traffic intensity, reflecting the importance of this corridor as a major access route to Kainchi Dham.

According to Figure 7, the vehicle composition at both locations is dominated by cars, accounting for 60.1% (423,026 vehicles) at Almora and 64.9% (677,471 vehicles) at Bhowali, indicating that private vehicles are the primary mode of travel on the Kainchi Dham route. Motorized two-wheelers (MTW) and light commercial vehicles (LCV) form the next largest categories, while buses contribute only a small share of the total traffic, with overall vehicle volumes being significantly higher at Bhowali (1,043,894 vehicles) than at Almora (703,341 vehicles).

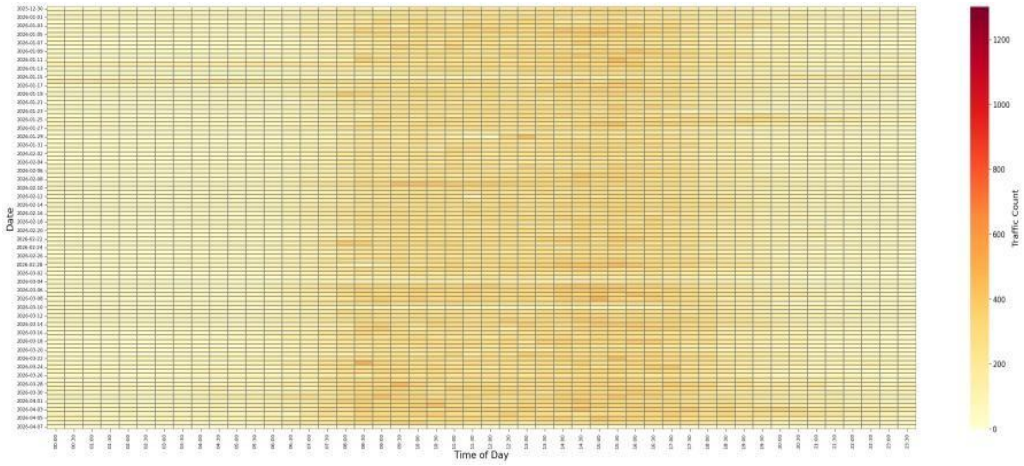


Figure 5: *KT001 Vehicle Movement Hotspot Colormap*

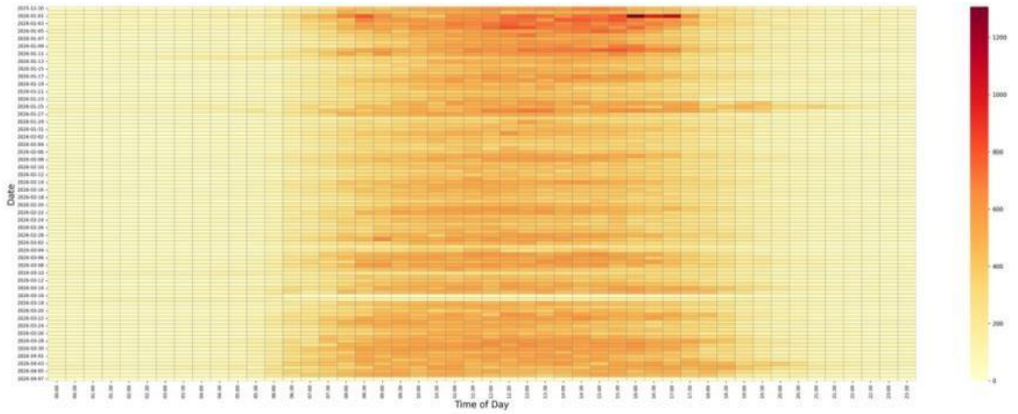


Figure 6: *KT002 Vehicle Movement Hotspot Colormap*

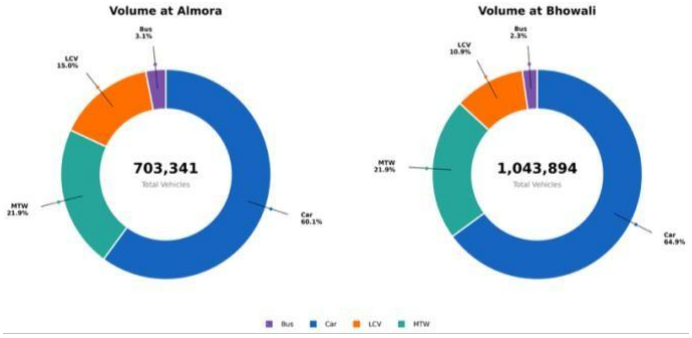


Figure 7: *Vehicle Composition Distribution*

The forecasting RandomForest based framework as in Figure 8 achieved strong predictive performance, with the KC001 model attaining an MAE of 3.70 and an R2 score of 0.9208, while the vehicle-based KT forecast achieved an MAE of 8.85 and an R2 score of 0.9199, indicating high temporal consistency and reliable crowd inflow prediction across both sensing modalities. From the vehicular data of KT001 and KT002, an approximation of pilgrims is taken as bus, car, and MTW would bring in 25, 5, and 2 pilgrims respectively. A RandomForestRegressor model was developed using temporal, lag, and rolling occupancy features to forecast temple parking demand 30 minutes ahead from smoothed multi-location vehicle flow data. The forecasting of parking demand in the region was evaluated as in Figure 9 by comparing the actual vehicle occupancy values in the test dataset with the predicted occupancy generated by the trained model over the same time period. Both time series were plotted against their corresponding timestamps, and model performance was quantified using MAE (16.41), RMSE (34.21), and R^2 (0.9891) to assess prediction accuracy. The close overlap between the actual and predicted occupancy curves demonstrates that the model successfully captures the temporal variations and peak demand patterns in parking utilization. The higher accuracy indicates excellent predictive performance, highlighting the model's suitability for forecasting parking demand and supporting proactive parking management, traffic regulation, and visitor planning at Kainchi Dham.

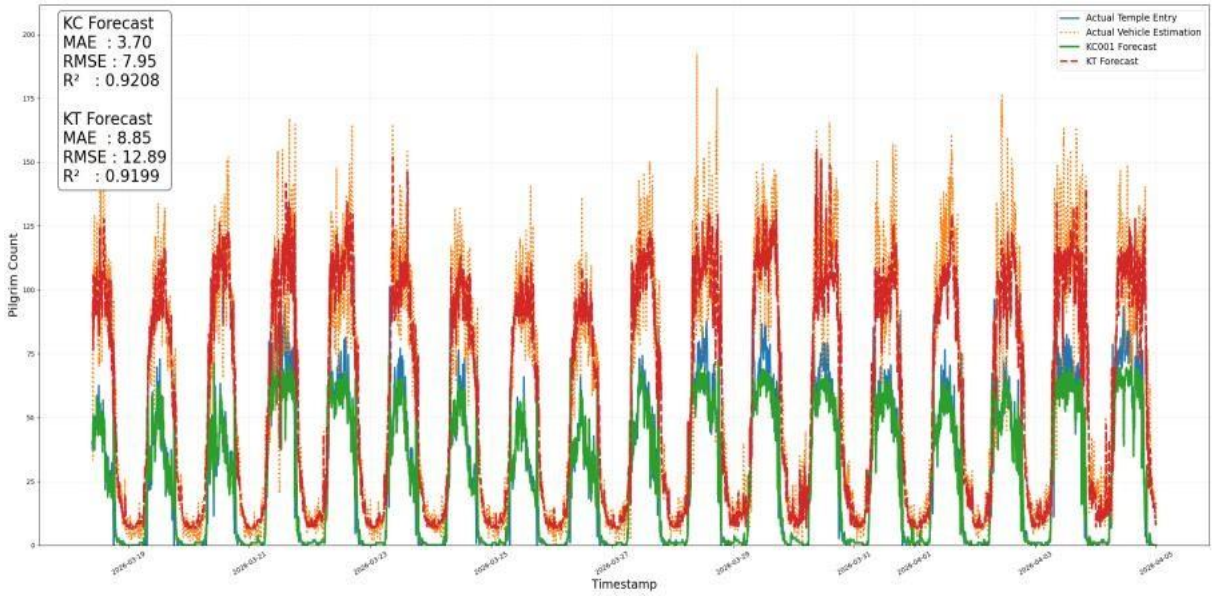


Figure 8: *Temple Pilgrim Forecast*

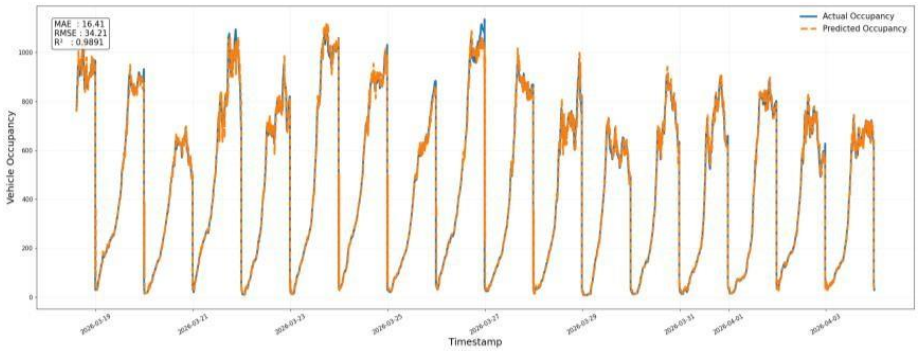


Figure 9: *Prediction for Parking Demand in the region*

4. CONCLUSION

This study utilized TrafficEye and CrowdEye devices to collect and analyze traffic data at Kainchi Dham, providing valuable insights into vehicular movement patterns and congestion trends. The analysis revealed that the KT002 (Bhowali side) approach experiences significantly higher traffic volumes, making it the primary congestion hotspot and highlighting the need for infrastructure upgrades and improved traffic management measures to ensure smoother traffic flow. Vehicle composition analysis showed that cars constitute the majority of incoming traffic, indicating a strong reliance on private vehicles for accessing the temple. Additionally, predictive models were developed to forecast future pilgrim counts and vehicular demand, demonstrating high accuracy and providing a useful tool for proactive traffic planning, parking management, and infrastructure development at Kainchi Dham.

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