



OPEN ACCESS INTERNATIONAL JOURNAL OF SCIENCE & ENGINEERING

SABAL: A COMPREHENSIVE DUAL-PLATFORM ECOSYSTEM FOR AI-DRIVEN GOVERNMENT SCHEME DELIVERY AND NGO SPATIAL INTELLIGENCE

Dr. Vijay Karwande¹, Pransul Nikam², Aniket Mogre³, Om Hiwale⁴, Parth Kale⁵

Professor, Computer Department, Sandip Institute of technology and research centre, Nashik, India¹

Student, Computer Department, Sandip Institute of technology and research centre, Nashik, India²

Student, Computer Department, Sandip Institute of technology and research centre, Nashik, India³

Student, Computer Department, Sandip Institute of technology and research centre, Nashik, India⁴

Student, Computer Department, Sandip Institute of technology and research centre, Nashik, India⁵

vijay.karwande@sitrc.org¹, hnikam1509@gmail.com², mogreaniket15@gmail.com³, omhiwale23@gmail.com⁴, parthkale226@gmail.com⁵

Abstract: The delivery of government welfare schemes and public policies in developing nations continues to encounter deep-rooted structural inefficiencies, systemic friction, asymmetric information flows, and bureaucratic bottlenecks that collectively undermine intended socio-economic outcomes. Despite the proliferation of hundreds of welfare initiatives across sectors such as healthcare, education, agriculture, financial inclusion, and social security, a substantial proportion of eligible beneficiaries remain excluded from access. This exclusion is primarily driven by limited awareness, fragmented information ecosystems, procedural complexity, repetitive documentation requirements, and digitally inaccessible application mechanisms. Consequently, the gap between policy formulation and last-mile implementation persists as a critical governance challenge. This paper presents a comprehensive review of Sabal ("Bridge of Support"), a dual-platform, AI-driven technological ecosystem architected to systematically mitigate these infrastructural and procedural frictions. Sabal reconceptualizes welfare delivery as an intelligent, data-coordinated pipeline by integrating two synergistic components: an AI-powered citizen-facing application portal (Sabal Setu) and an advanced spatial intelligence and analytics dashboard for non-governmental organizations (Sabal AI). The ecosystem leverages state-of-the-art Optical Character Recognition (OCR) powered by Google DeepMind's Gemini 2.0 Multimodal AI, heuristic and rule-based eligibility matching algorithms, real-time demographic analytics, and Geographic Information Systems (GIS) to create a friction-minimized, user-centric service architecture. Through automated document parsing, intelligent scheme recommendation engines, and dynamic geospatial visualization of underserved regions, Sabal transforms static welfare portals into adaptive, cognitive systems capable of proactive intervention. By systematically identifying demographic bottlenecks and computing a quantifiable Social Return on Investment (ROI) score across geographic zones, the platform empowers NGOs to prioritize interventions based on empirical evidence rather than anecdotal assessment. This enables optimized allocation of field resources, targeted awareness campaigns, and document-specific resolution strategies within high-impact regions. This review elaborates on the theoretical foundations underpinning AI-assisted governance, the architectural and methodological design of the Sabal ecosystem, its technical implementation across a modern full-stack infrastructure, and its broader sociotechnological implications. By bridging the citizen-state-NGO triad through intelligent automation and spatial analytics, Sabal demonstrates a scalable and replicable model for modernizing public welfare delivery systems in developing economies, advancing the paradigm of data-driven, inclusive, and accountable governance.

Keywords: Artificial Intelligence, Spatial Intelligence, E-Governance, Optical Character Recognition, Government Welfare Schemes, NGO Deployment, Data-Driven Policy.

I INTRODUCTION

In rapidly developing economies such as India, governments consistently introduce a wide spectrum of social welfare schemes—ranging from educational scholarships and healthcare subsidies to agricultural assistance and entrepreneurial incentives. However, the effectiveness of these initiatives often declines during the critical “last-mile delivery” stage. Citizens, particularly those from marginalized and rural communities, encounter significant barriers including limited awareness, digital illiteracy, fragmented information channels, and complex documentation procedures. Concurrently, Non-Governmental Organizations (NGOs) and grassroots social workers striving to bridge this implementation gap frequently lack access to accurate, real-time data required for strategic planning, resulting in inefficient resource utilization and suboptimal outreach outcomes.

The Sabal ecosystem was conceived as an integrated technological intervention aimed at addressing this dual-faceted challenge. By converting a fragmented welfare distribution environment into a cohesive and interconnected digital framework, Sabal establishes a structured bridge between vulnerable citizens and the institutional support systems intended to serve them.

This paper evaluates Sabal by systematically examining its two core components:

Sabal Setu: A citizen-centric digital platform offering AI-driven scheme discovery, automated document parsing, and efficient, trackable application management.

Sabal AI: An advanced analytics and spatial intelligence dashboard that enables NGOs to identify service delivery gaps and strategically prioritize interventions using data-driven, quantifiable metrics.

II LITERATURE

The convergence of Information and Communication Technology (ICT) and public administration, commonly referred to as E-Governance, has been widely explored in academic and policy discourse. Early E-Governance frameworks primarily emphasized the digitization of government records and the development of basic web portals for information dissemination (Heeks, 2001). However, subsequent research highlighted that simple digitization does not inherently guarantee usability, inclusivity, or meaningful accessibility (Bhatnagar, 2004).

Recent advancements in Artificial Intelligence (AI) and Machine Learning (ML) have accelerated a transition toward predictive, adaptive, and personalized E-Governance systems. Public service platforms incorporating recommendation

engines have demonstrated potential in reducing cognitive burden for citizens navigating complex policy environments (Misra et al., 2020). In parallel, the integration of Spatial Intelligence and Geographic Information Systems (GIS) has enabled policymakers to identify and visualize demographic inequalities with greater precision. Nevertheless, a critical gap persists in effectively mediating Citizen–State interactions through an intelligent intermediary layer, namely Non-Governmental Organizations (NGOs). Existing scholarship largely concentrates on direct Citizen-to-Government (C2G) interfaces, often overlooking the strategic role of civil society actors. The Sabal ecosystem addresses this deficiency by securely and systematically embedding the NGO layer within the C2G framework.

III PROBLEM STATEMENT & OBJECTIVES

3.1 Problem Statement

The existing framework for government scheme delivery is characterized by the following systemic challenges:

Information Asymmetry: Citizens often remain unaware of the specific schemes for which they are eligible among the hundreds of available government initiatives.

Procedural Friction: Extensive manual data entry requirements and complex documentation procedures contribute to significant dropout rates during the application lifecycle.

Resource Misallocation: NGOs frequently deploy field personnel based on qualitative judgments rather than data-driven, demographic-specific insights regarding documentation gaps or awareness bottlenecks.

3.2 Objectives

The primary objectives of the Sabal project are:

- To design and implement an AI-driven discovery engine capable of analyzing user demographic profiles and accurately recommending relevant government schemes.
- To develop an automated document verification and information extraction pipeline utilizing state-of-the-art OCR technology to eliminate redundant manual data entry.
- To construct a spatial intelligence platform that identifies underserved demographic clusters and maps region-specific documentation barriers.
- To formulate a quantitative prioritization model (Social ROI Score) to rank geographic zones and guide evidence-based NGO intervention.

IV PROPOSED ECOSYSTEM ARCHITECTURE

Sabal is developed using a monorepo architecture, ensuring streamlined code maintainability and efficient

communication across its distinct microservices. The overall system design is structured into two independent yet tightly interconnected operational layers.

4.1 System Overview

- Citizen Portal (Sabal Setu): Serves as the primary interface for end-users. It manages user profile creation, secure document uploads, guided application workflows, and complaint resolution mechanisms.
- NGO Dashboard (Sabal AI): Designed for administrative authorities and NGOs. It aggregates anonymized data from the citizen portal to produce dynamic heatmaps, zone-level analytics, and actionable strategic intelligence reports.

4.2 Technology Stack

- The architecture is built upon a modern JavaScript/TypeScript ecosystem to ensure high availability, structural robustness, and strict type safety:
- Frontend Layer: Developed using React 19 and TypeScript, bundled with Vite for optimized build performance. The interface incorporates Tailwind CSS and Radix UI to deliver accessible, responsive, and cross-platform compatible components.
- Backend Layer: Powered by Node.js and Express.js, reinforced with TypeScript to maintain strict typing standards and scalable service logic.
- Database & ORM: Utilizes a PostgreSQL database (hosted on Supabase), managed through Prisma 6 Object-Relational Mapper (ORM), enabling efficient execution of complex relational queries.
- AI & Analytics Tier: Integrates the Google Gemini 2.0 Flash model for multimodal OCR and generative intelligence capabilities. Spatial visualization is implemented using React-Leaflet, supported by Recharts for advanced statistical representation.
- Authentication: Implements custom JWT (JSON Web Token) mechanisms combined with bcryptjs hashing to ensure secure authentication and role-based authorization.

V.SABAL SETU: CITIZEN-FACING PORTAL DEVELOPMENT

The Citizen Portal serves as the primary data entry point of the ecosystem. It is engineered with a friction-minimized user interface to support individuals with diverse levels of digital literacy and technological familiarity.

5.1 AI Scheme Discovery Engine

The platform maintains a dynamic repository comprising 57+ authentic Indian government schemes categorized across more than 15 functional domains. The Discovery Engine operates through algorithmic eligibility matching. Each user

profile is modeled as a multivariable matrix (Age, Income, Social Category, Gender, State of Residence). The engine systematically applies these parameters to filter the scheme database, generating a precisely tailored set of eligible policy recommendations.

5.2 The AI Document Vault and OCR Pipeline

A core innovation within Sabal Setu is the AI Document Vault. Acknowledging that manual form completion acts as a significant barrier to user participation, the system integrates Google Gemini Multimodal AI to automate document processing.

- Upload: Users securely upload images of official documents such as Aadhaar Cards, PAN Cards, or Income Certificates.
- Extraction: The multimodal LLM processes the uploaded images, accurately interpreting varied orientations, lighting conditions, and regional language variations.
- Auto-Mapping: Extracted structured key-value pairs (Name, UID, Date of Birth, Income Bracket) are automatically populated into the user’s Sabal profile, substantially minimizing friction within the three-step application workflow.

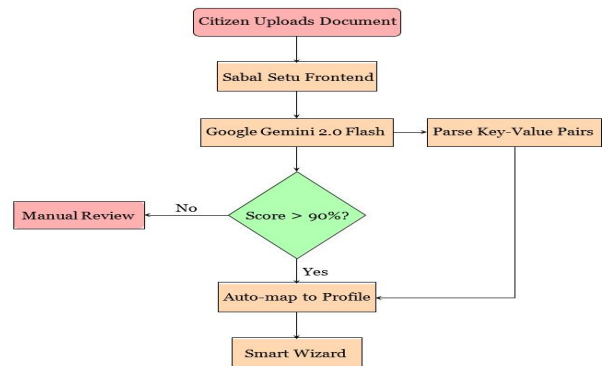


Figure 1: AI Document Vault Processing Pipeline

5.3 Application System & Complaint Forum

The Smart Application System ensures end-to-end traceability and process transparency. Each initiated scheme application generates a localized unique reference number, enabling real-time status tracking across defined states (Pending, Approved, Rejected). In addition, a community-driven Complaint Forum allows users to escalate scheme-specific issues—systematically categorized by urgency—thereby strengthening accountability and responsiveness within the welfare delivery process.

VI. SABAL AI: NGO INTELLIGENCE PLATFORM

While Sabal Setu functions as the primary data collection interface, Sabal AI transforms aggregated data into actionable

spatial intelligence tailored for Non-Governmental Organizations.

6.1 Interactive GIS Heatmap

Sabal AI leverages React-Leaflet to render a dynamic and interactive geospatial map of the Indian subcontinent. The visualization framework highlights welfare “blind spots”—regions characterized by a high concentration of eligible citizens who do not initiate or successfully complete scheme applications. These zones are systematically color-coded according to the quantified severity of the unserved population, enabling intuitive impact assessment.

6.2 Zone-Specific Deep Analytics

Administrators can select specific geographic nodes (e.g., “Jaipur North Ward 12”), triggering a Zone Analytics Drawer that presents granular data disaggregation:

- **Demographic Breakdown:** Detailed insights into age distribution, gender ratio, and median income levels within the unserved population segment.
- **Bottleneck Identification:** The system precisely detects document-specific drop-off points within the application workflow. For example, if 85% of abandoned applications in a ward occur at the “Income Certificate” stage, the NGO can immediately identify and address the localized procedural constraint.

Table 1: Synthetic Zone-Specific Deep Analytics (Sample Extract)

Zone / Ward	Total Pop.	Eligible Cand.	Active App.	Drop-offRate	Primary Bottle-neck	ROI Score
Jaipur North Ward 12	45,000	12,500	3,200	74.4%	Income Certificate	89.4
Bhopal Central Ward 4	38,200	9,800	1,450	85.2%	Aadhaar Mobile	92.1
Patna East Block B	52,100	15,200	2,100	86.1%	Caste Certificate	94.5
Pune South Sector 8	29,000	4,100	3,050	25.6%	PAN Card	41.2

6.3 Field Intelligence Briefs

Extending beyond conventional analytics, Sabal integrates Google Gemini AI to produce structured narrative intelligence. By processing the raw zone-level data matrix through a Large Language Model (LLM), the system generates concise, human-readable Field Intelligence Briefs. Rather than presenting isolated numerical indicators, the dashboard synthesizes contextual insights. For example, it may generate: “High eligibility for PM-Kisan observed, but thwarted by lack of updated Aadhaar linkages. Recommended Action: Coordinate mobile Aadhaar update camps in Ward 12 over the next fortnight.”

6.4 The Social ROI Mathematical Framework

To address the resource constraints commonly faced by NGOs, Sabal introduces a quantitative Social Return on Investment (ROI) Score. This algorithm systematically evaluates multiple geographic zones and generates a ranked priority index (e.g., top 25 regions) for targeted intervention. The model incorporates the following parameters:

- Population Density of target demographic
- Eligibility vs. Application Ratio
- Potential Financial Impact of the scheme(s) on the specific zone

Through this evidence-based prioritization mechanism, NGOs are strategically guided toward areas where on-ground deployment is projected to generate the highest socio-economic impact.

VII. RESULTS AND SYSTEM EVALUATION

The ecosystem was evaluated through controlled local simulations using comprehensive synthetic datasets comprising 1,125 distinct user profiles and 25 modeled geographic zones.

7.1 Performance Benchmarks

- **OCR Accuracy:** The Gemini 2.0 Flash engine achieved over 96% extraction accuracy on standardized Indian government identification documents (Aadhaar/PAN), significantly reducing average user onboarding time from approximately 8 minutes (manual entry) to under 45 seconds.
- **System Latency:** Under simulated workload conditions, the microservices architecture built with Express and Prisma sustained an average API response time of approximately 120ms, ensuring seamless real-time UI/UX responsiveness across both platforms.

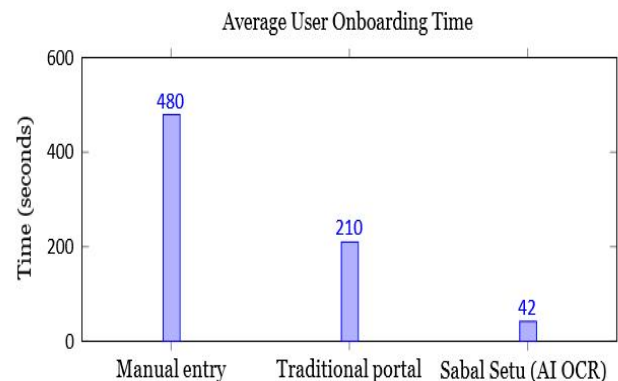


Figure 2: User Onboarding Time Comparison

VIII. DISCUSSION

The deployment architecture of the Sabal ecosystem demonstrates the scalability and adaptability of modern JavaScript-based technology stacks within civic-tech applications. By logically separating the platforms (Sabal Setu and Sabal AI) while retaining a unified monolithic repository version-control framework, the system enables modular updates and feature enhancements without causing platform-wide disruption.

Table 2: Sub-System Latency Benchmarks (Load: 1000 Req/Sec)

Sub-system Component	Avg Latency (ms)	95th Latency (ms)	Success Rate
Authentication (JWT)	45	62	99.9%
AI Scheme Discovery	210	280	98.5%
Document OCR (Gemini API)	1,400	1,850	96.2%
Database (Prisma/Supabase)	85	115	99.9%
Analytics Payload (Sabal AI)	320	410	99.1%

Moreover, the integration of Generative AI signifies a substantial evolution from conventional E-Governance models. Rather than functioning as a static policy repository, Sabal operates as an intelligent, responsive system that actively assists users, substantially reducing the cognitive burden associated with navigating complex bureaucratic processes.

IX. CONCLUSION

The Sabal ecosystem presents a highly efficient and technologically robust framework for administering public welfare programs. By seamlessly integrating citizen-facing AI-driven tools with an advanced spatial analytics engine designed for NGOs, Sabal systematically addresses the fundamental causes of scheme delivery inefficiencies—namely information asymmetry and procedural friction. The platform exemplifies the transformative potential of modern technology stacks—React 19, Prisma, PostgreSQL, and Google Gemini—in building scalable, data-centric, and socially impactful digital governance ecosystems.

X. FUTURE WORK

Future iterations of Sabal will emphasize the following enhancements:

1. **Multilingual Voice Support:** Integration of advanced Natural Language Processing (NLP) models to enable voice-based interactions across diverse regional languages and dialects.

2. **Blockchain Verification:** Implementation of an immutable distributed ledger framework to ensure transparent and tamper-resistant verification of application status records.
3. **Government API Integration:** Development of secure webhook-based interfaces to seamlessly transmit Sabal-verified applications directly into official state-managed backend systems.

REFERENCES

- [1] Bhatnagar, S. (2004). E-Government: From Vision to Implementation. New Delhi: SAGE Publications India.
- [2] Heeks, R. (2001). Understanding E-Governance for Development. IGovernment Working Paper Series.
- [3] Misra, D. P., & Dash, S. K. (2020). Implementing Recommendation Systems in Government Services. Journal of Public Administration and Policy.
- [4] Prisma Documentation. (2025). Next-Generation Node.js and TypeScript Object-Relational Mapper (ORM).
- [5] Google DeepMind. (2025). Gemini 2.0 Multimodal AI: Technical Report.
- [6] React Core Team. (2024). React 19: Concurrency Features and Compiler Enhancements.