



# Smart Complaint Management System for Digital Gram Panchayat

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**Abstract:** Digital governance has a vital role to play in enhancing public services in rural areas. In the context of Gram Panchayat, there are certain difficulties in efficiently handling citizen complaints due to manual processing, lack of transparency, and delayed response systems. This paper introduces a Smart Complaint Management System for Digital Gram Panchayat, which helps citizens to file complaints online while ensuring efficient handling of complaints by the administrators. The suggested system utilizes web technologies to efficiently process complaints, track, and notify the citizens regarding the status of the complaint, helping to enhance transparency, accountability, and efficiency in rural governance systems.

**Keywords:** Digital Governance, Gram Panchayat, Complaint Management System, E-Governance, Web Application [10] Government of India, "Digital India Programme and Rural Development," Ministry of Electronics and Information Technology, New Delhi, India, 2020.

## I. INTRODUCTION

Gram Panchayat is the fundamental unit of local self-governance in India's rural administrative structure. It is entrusted with the responsibility of delivering essential public services to citizens residing in villages, including drinking water supply, road maintenance, sanitation, electricity, and various public welfare schemes under government initiatives. With a population of over 65% residing in rural areas, the efficiency and responsiveness of Gram Panchayat governance directly impacts the quality of life for hundreds of millions of citizens across the country.

Despite their critical role, Gram Panchayats have historically operated with traditional manual processes for handling citizen grievances and service complaints. Citizens are required to visit Panchayat offices in person, submit handwritten applications, or rely on verbal communication with local officials. These conventional methods are often plagued by inefficiencies, including the loss of complaint records, untracked resolution processes, and a general lack of accountability among responsible officials. The outcome is a significant trust deficit between citizens and local governance bodies.

The rapid proliferation of internet access and mobile devices across rural India, catalyzed by government initiatives such as the Digital India Programme and BharatNet broadband connectivity project, has created a new opportunity. It is now feasible to deploy web-based digital systems in rural settings that were previously inaccessible due to infrastructure constraints. E-Governance has emerged as a transformative paradigm that leverages information and communication technologies (ICT) to enhance the delivery of government services, increase transparency, and foster citizen participation.

This paper proposes and describes the design, architecture, and implementation of a Smart Complaint Management System (CMS) for Digital Gram Panchayat. The system enables citizens to register service complaints through an online web portal, receive real-time status updates, and interact with Panchayat administrators in a structured and transparent manner. Administrators benefit from a centralized dashboard that enables efficient complaint categorization, assignment to responsible departments, status tracking, and analytics-driven decision-making. The system aims to bridge the communication gap between rural citizens and local government, ultimately improving the quality and responsiveness of public service delivery.

The remainder of this paper is organized as follows: Section II reviews related work in E-Governance and complaint management systems. Section III describes the problem statement. Section IV outlines the objectives of the study. Section V presents the proposed system architecture. Section VI explains the system methodology. Section VII covers



implementation details. Section VIII reports testing and experimental results. Section IX concludes the paper with future scope.

## II. RELATED WORK

The domain of E-Governance and digital complaint management has attracted considerable research attention over the past two decades. Heeks [1] established foundational frameworks for implementing E-Governance in developing countries, emphasizing the importance of contextual design that accounts for local infrastructure limitations and user literacy levels. His work highlights that technology adoption in public administration must be accompanied by organizational change management to be effective.

Gupta and Jana [2] conducted a comprehensive analysis of E-Governance initiatives in India and identified key challenges including digital divide, limited ICT infrastructure in rural regions, and resistance from government officials accustomed to manual processes. They concluded that E-Governance implementations require phased rollouts with robust training programs to achieve sustainable adoption. Their findings are particularly relevant to the rural Gram Panchayat context where digital literacy among both citizens and officials may be limited.

Sharma [3] examined digital transformation strategies in rural governance and proposed a layered service delivery model that progressively digitizes government functions based on citizen readiness and infrastructure availability. The study demonstrated a 40% improvement in service delivery time in districts that adopted digital complaint management tools compared to those still relying on manual processes. This empirical evidence strongly supports the case for deploying digital systems at the Gram Panchayat level.

Singh and Kaur [4] reviewed multiple E-Governance implementations in rural development programs and identified that complaint management was consistently the most demanded digital service by rural citizens. Their analysis revealed that citizens prioritized transparency of complaint status over speed of resolution, underscoring the importance of real-time notification mechanisms in any complaint management system designed for rural populations.

Kumar and Bansal [5] developed a web-based complaint management system for urban municipal corporations and reported significant reductions in average complaint resolution time, from 15 days using manual processes to 6 days with their digital system. While their system was designed for urban settings, the architectural patterns and technology choices they documented provide valuable guidance for rural adaptations. However, their system lacked multilingual support and offline capability, which are critical requirements for rural deployments.

Mishra and Tripathi [6] analyzed the role of digital governance in improving public service delivery in India and found that the absence of effective feedback mechanisms was the primary barrier to citizen satisfaction with government services. Systems that incorporated SMS and email notifications for complaint status updates saw significantly higher citizen engagement rates. This finding directly informed the design of the notification module in the proposed system.

Verma and Agarwal [8] proposed a smart governance framework specifically for rural administration that integrated mobile applications with backend web portals, enabling offline complaint submission with automatic synchronization when connectivity was restored. Their framework serves as an important reference for future enhancements of the proposed system. Ahmed and Rahman [9] demonstrated the effectiveness of AI-driven complaint categorization in reducing administrative workload by automatically routing complaints to appropriate departments, a feature that represents a promising direction for future development of the current system.

The existing literature collectively demonstrates that while complaint management systems have been successfully deployed in urban settings, rural areas continue to lack tailored digital solutions that account for their unique infrastructure, literacy, and connectivity constraints. The proposed Smart Complaint Management System for Digital Gram Panchayat addresses this identified gap by providing a lightweight, web-based solution specifically designed for rural governance contexts.

## III. PROBLEM STATEMENT

The current complaint handling mechanism in most Gram Panchayats across India relies entirely on manual, paper-based processes. When a citizen experiences a problem with a public service such as a water supply disruption, road damage, or sanitation failure, they must physically visit the Panchayat office during working hours to register their complaint.



This creates a significant accessibility barrier, particularly for citizens living in remote areas of the Panchayat jurisdiction, elderly residents, and working individuals who cannot take time off during office hours.

Once a complaint is registered, it is typically recorded in a physical register book and verbally assigned to a relevant department official. There is no standardized tracking mechanism to monitor the progress of complaint resolution. Officials responsible for addressing complaints have no formal accountability system, and complaints can remain unresolved for extended periods without any escalation mechanism being triggered. Citizens who wish to follow up on their complaints must again visit the Panchayat office in person, creating frustration and discouraging further civic participation.

The lack of digital records makes it impossible for Panchayat administrators to generate meaningful reports on complaint trends, identify recurring infrastructure problems, or evaluate the performance of service delivery departments. Decisions regarding resource allocation and infrastructure investment are therefore made without adequate data support, often resulting in suboptimal outcomes for the community. Additionally, the manual system creates opportunities for selective handling of complaints, undermining the principles of impartiality and equal service delivery.

Communication breakdowns between citizens and authorities further exacerbate these problems. Citizens are rarely informed about the status of their complaints unless they proactively follow up. This absence of feedback creates a perception of administrative indifference, eroding public trust in local governance. The cumulative effect of these systemic deficiencies is a significant reduction in citizen satisfaction with Gram Panchayat services and a weakening of the democratic accountability that local self-governance is meant to embody.

In summary, the key problems identified in the existing complaint management approach are: (1) lack of an accessible digital channel for complaint registration; (2) absence of unique complaint identification and tracking; (3) no automated notification system to update citizens on complaint status; (4) insufficient administrative tools for complaint assignment and monitoring; (5) inability to generate data-driven reports and analytics; and (6) poor accountability mechanisms for officials responsible for complaint resolution. The proposed Smart Complaint Management System is designed to systematically address each of these identified shortcomings.

#### IV. OBJECTIVES OF THE STUDY

The primary objective of this research is to design, develop, and validate a comprehensive Smart Complaint Management System tailored for the operational context of Digital Gram Panchayat. The following specific objectives guide the study:

The first objective is to design and implement a digital complaint registration portal that enables Gram Panchayat citizens to submit complaints related to public services from any internet-enabled device at any time, eliminating the need for physical visits to the Panchayat office. The portal must be user-friendly and accessible to individuals with limited digital literacy.

The second objective is to develop an administrative dashboard that provides Panchayat officials with a centralized interface for viewing, categorizing, assigning, and updating the status of all registered complaints. The dashboard should support role-based access control to ensure appropriate information is available to each type of user.

The third objective is to implement a real-time complaint tracking mechanism that allows citizens to monitor the progress of their submitted complaints through a unique complaint identification number, providing transparency into the resolution process at every stage.

The fourth objective is to build an automated multi-channel notification system that proactively informs citizens about changes in their complaint status through email and SMS alerts, reducing the need for manual follow-up and improving perceived government responsiveness.

The fifth objective is to create a reporting and analytics module that generates actionable insights from complaint data, enabling administrators to identify recurring service failures, monitor departmental performance, and make evidence-based decisions regarding resource allocation and infrastructure maintenance priorities.

The sixth objective is to ensure the system is built on open-source, cost-effective technology stack that can be maintained and extended by local IT resources without significant ongoing licensing costs, making it financially sustainable for rural local government bodies with limited budgets.



## V. PROPOSED SYSTEM ARCHITECTURE

The Smart Complaint Management System for Digital Gram Panchayat is architected as a multi-tier web application following the Model-View-Controller (MVC) design pattern. The system comprises five primary functional modules that interact through a centralized relational database. The architecture is designed for scalability, allowing the system to serve multiple Gram Panchayats within a district from a single deployment, with data isolation maintained at the Panchayat level.

### A. User Registration and Authentication Module

The User Registration Module provides citizens with the ability to create personal accounts on the Complaint Management System portal. During registration, citizens provide their full name, mobile number, email address, residential address within the Panchayat jurisdiction, and Aadhaar-linked identification for verification purposes. The system assigns each registered citizen a unique User ID that serves as their permanent identifier across all system interactions.

Authentication is implemented using secure session-based login with bcrypt password hashing to protect user credentials. The system supports role-based access control with three distinct roles: Citizen (complaint submission and tracking), Department Officer (complaint resolution), and Panchayat Administrator (full system access and oversight). This role hierarchy ensures that sensitive administrative functions are accessible only to authorized personnel.

### B. Complaint Submission Module

The Complaint Submission Module provides citizens with a structured online form through which they can register complaints related to Gram Panchayat services. The form captures the complaint category (from predefined categories including drinking water supply, road and infrastructure, sanitation and waste management, street lighting, public health, and general services), a detailed textual description of the problem, the specific location within the Panchayat area, and the date of occurrence. Citizens may optionally attach photographic evidence in JPEG or PNG format to strengthen their complaint.

Upon successful submission, the system automatically generates a unique alphanumeric Complaint ID comprising the Panchayat code, year, and a sequential number (e.g., GP-CBE-2024-00452). This ID is immediately displayed to the citizen and simultaneously sent via SMS and email for future reference. All complaint data is stored in the centralized MySQL database with a timestamp and associated user ID, creating a complete audit trail from initial submission through final resolution.

### C. Complaint Management Module

The Complaint Management Module constitutes the administrative core of the system, providing Panchayat officials with comprehensive tools for complaint oversight. The administrative dashboard presents a real-time summary of all complaints, categorized by status (Pending, In Progress, Resolved, Escalated), category, and department. Administrators can apply filters and sort complaints by date, priority, category, or resolution time to efficiently manage their workload.

Each complaint record in the administrative interface displays the complete submission details alongside a status history timeline showing every action taken since initial registration. Administrators can update complaint status, add internal notes visible only to officials, assign complaints to specific department officers, set target resolution dates, and escalate unresolved complaints that have exceeded their resolution deadline. The module incorporates automated escalation logic that flags complaints remaining unresolved beyond a configurable threshold (default: 7 days) for immediate administrator attention.

### D. Notification Module

The Notification Module serves as the communication bridge between the system and its users, ensuring all stakeholders are kept informed of complaint lifecycle events without manual intervention. The module is triggered by specific system events including complaint registration, status change (Pending to In Progress, In Progress to Resolved), assignment to a department officer, escalation due to resolution delay, and final resolution with satisfaction feedback request.

Notifications are delivered through three channels: in-system alerts visible on the citizen dashboard upon login, email notifications to the registered email address, and SMS messages to the registered mobile number. The SMS gateway integration ensures that citizens without consistent internet access can still receive complaint updates. All notification



events are logged in the database for audit purposes, and notification preferences can be configured by individual citizens based on their channel preferences.

### E. Reporting and Analytics Module

The Reporting and Analytics Module transforms accumulated complaint data into actionable intelligence for Panchayat administrators and elected representatives. The module generates both pre-built standard reports and supports custom report generation based on user-defined parameters. Standard reports include: Monthly Complaint Summary (total received, resolved, pending, and average resolution time by category); Department Performance Report (complaint volume and resolution rate by department); Geographic Hotspot Analysis (complaint density by village ward); and Trend Analysis (month-over-month comparison of complaint categories).

Data visualizations are rendered as interactive charts and graphs using Chart.js, including bar charts for category distribution, line graphs for resolution time trends, and pie charts for status breakdown. These visual representations enable administrators to rapidly identify patterns and outliers that would be difficult to detect from raw tabular data. The module supports data export in PDF and Excel formats for offline sharing and inclusion in official Panchayat reports submitted to district and state government authorities.

## VI. SYSTEM METHODOLOGY

The development of the Smart Complaint Management System followed the Agile Software Development Lifecycle (SDLC) methodology, which is particularly suited for systems with evolving requirements and the need for iterative stakeholder feedback. The development process was organized into the following sequential phases:

### F. Requirement Analysis

The requirement analysis phase involved structured interviews with Gram Panchayat officials at three Panchayats in Coimbatore district, a citizen survey administered to 150 respondents across different demographic groups, and a technical audit of existing complaint handling processes. The survey revealed that 78% of respondents had experienced difficulty following up on complaints submitted to the Panchayat, and 84% expressed willingness to use a mobile-accessible online portal if one were available. These findings directly shaped the functional requirements specification for the system.

### G. System Design

The system design phase produced a comprehensive set of design artifacts including the Entity-Relationship (ER) diagram for the database schema, UML Use Case diagrams illustrating actor-system interactions, Data Flow Diagrams (DFDs) mapping information flow through system modules, and wireframe mockups for all user interface screens. The database schema was designed with normalization to third normal form (3NF) to eliminate redundancy while maintaining query performance. The ER diagram encompasses six primary entities: User, Complaint, Category, Department, Notification, and Resolution.

### H. System Development

The system was developed using a carefully selected technology stack optimized for reliability, ease of deployment in resource-constrained environments, and developer availability in the local context. The front-end was built using HTML5, CSS3, and JavaScript with Bootstrap 5 framework for responsive design, ensuring the portal renders correctly across desktop browsers, tablets, and smartphones. The back-end was implemented using Python 3.9 with the Flask micro-framework, chosen for its lightweight footprint and straightforward deployment characteristics. The database layer uses MySQL 8.0, which provides robust relational data management with strong community support and available technical expertise. The Twilio API was integrated for SMS notification delivery, and SMTP-based email notifications were implemented using Python's smtplib library.

### I. System Testing

A multi-level testing strategy was employed to validate system correctness, reliability, and usability. Unit tests were written for all critical backend functions using Python's unittest framework, achieving 87% code coverage across the application modules. Integration testing verified that all modules interacted correctly, with particular attention to the complaint submission workflow, notification triggering, and database transaction integrity. Performance testing was conducted using Apache JMeter to simulate concurrent user loads of up to 200 simultaneous users, confirming that system response times remained below 2 seconds under peak load conditions. User Acceptance Testing (UAT) was conducted with a group of 20 participants including Panchayat officials and citizens, whose feedback was incorporated into the final system refinements.



### J. System Deployment

The system was deployed on an Apache web server running on Ubuntu 22.04 LTS. The deployment configuration includes Nginx as a reverse proxy for improved performance and SSL/TLS certificate management via Let's Encrypt for secure HTTPS communication. The MySQL database is configured with automated daily backups stored on a separate volume to prevent data loss. The deployment environment is hosted on a cloud virtual machine, ensuring high availability and the ability to scale resources in response to growing usage. System monitoring is configured using standard logging tools to track uptime, error rates, and performance metrics.

## VII. IMPLEMENTATION DETAILS

The Smart Complaint Management System is implemented as a responsive web application accessible from any modern browser on desktop or mobile devices. The system's user interface has been designed following principles of simplicity and clarity, with particular attention to usability for individuals with limited digital experience. Form fields include contextual help text and input validation with clear error messages to guide users through the complaint submission process.

The Flask application is organized into blueprints separating citizen-facing routes, administrative routes, and API endpoints. The database interactions are managed through SQLAlchemy ORM, which provides a clean abstraction layer and facilitates database migration management using Flask-Migrate. Session management uses Flask-Login with secure cookie-based authentication and CSRF protection implemented via Flask-WTF to prevent cross-site request forgery attacks.

The complaint submission form implements client-side validation using JavaScript to provide immediate feedback before data is sent to the server, reducing unnecessary server load and improving the user experience. File upload functionality for photographic evidence enforces a maximum file size of 5MB and validates that uploaded files are genuine image formats by checking file headers rather than relying solely on file extension. Uploaded images are stored in a designated server directory with randomly generated filenames to prevent enumeration attacks.

The administrative dashboard uses AJAX calls to refresh complaint statistics without requiring full page reloads, providing a more responsive and modern user experience. Chart.js is integrated for rendering complaint analytics visualizations directly in the browser. The notification system uses a background scheduler (APScheduler) running within the Flask application to periodically check for complaints requiring escalation and trigger notifications without manual administrator intervention.

Database queries are optimized using indexed columns on frequently searched fields including complaint status, category, submission date, and assigned department. Connection pooling is implemented to efficiently manage database connections under concurrent load. The system architecture allows horizontal scaling by deploying additional application server instances behind the Nginx load balancer if user volumes exceed the capacity of the initial single-server deployment.

## VIII. TESTING AND EXPERIMENTAL RESULTS

The system was subjected to comprehensive testing across four dimensions to validate its functional correctness, integration integrity, performance under load, and usability from end-user perspectives. Testing was conducted over a period of three weeks using both automated testing frameworks and structured human evaluation sessions.

### K. Functional Testing

Functional testing covered all system use cases using a test case library of 84 test cases mapped to the functional requirements specification. All critical-path test cases related to complaint submission, status update, notification dispatch, and report generation passed successfully in the final test run. Edge case testing identified and resolved issues with special character handling in complaint descriptions, attachment file size validation boundary conditions, and SMS notification retry logic for failed deliveries. The final functional test pass rate was 96.4% (81 of 84 test cases passed on the first execution).

### L. Performance Testing

Performance testing using Apache JMeter simulated concurrent user loads ranging from 10 to 200 simultaneous users performing complaint submission and status query operations. At a load of 50 concurrent users, average page response time was 0.8 seconds. At 100 concurrent users, average response time increased to 1.4 seconds, remaining within the



acceptable threshold of 2 seconds. At 200 concurrent users, average response time was 1.9 seconds, approaching but not exceeding the threshold. Database query optimization using indexed lookups was critical in maintaining performance at higher load levels, reducing query execution time by approximately 65% compared to initial unoptimized queries.

### M. User Acceptance Testing

User Acceptance Testing was conducted with a group of 20 participants including 12 citizens of varying age groups (18-65 years) and 8 Panchayat officials. Participants were asked to complete a series of tasks including account registration, complaint submission, complaint status tracking, and (for officials) complaint status update and report generation. Task completion rates were 95% for citizen tasks and 100% for administrative tasks. Post-session surveys using a 5-point Likert scale revealed mean satisfaction scores of 4.3 for ease of use, 4.5 for information clarity, and 4.1 for overall system usefulness. Qualitative feedback highlighted the SMS notification feature as the most valued aspect of the system.

### N. Comparative Analysis

A comparative study was conducted between the manual complaint handling process and the proposed digital system using data from a 4-week pilot deployment at a Gram Panchayat in Coimbatore district. The pilot period recorded 127 complaints registered through the digital system. Average complaint resolution time reduced from 18.3 days (manual baseline) to 7.2 days (digital system), representing a 60.7% improvement. Citizen satisfaction with complaint handling, measured via post-resolution SMS surveys, improved from 2.8 to 4.2 on a 5-point scale. Administrative time spent on complaint management activities reduced by an estimated 45%, as automated notifications eliminated the need for manual status communication with citizens. These results demonstrate the significant practical impact of the proposed system on Gram Panchayat service delivery efficiency.

## IX. CONCLUSION AND FUTURE SCOPE

This paper presented the design, development, and evaluation of a Smart Complaint Management System for Digital Gram Panchayat, addressing the critical gap in digital governance infrastructure for rural local government bodies in India. The proposed system systematically resolves the inefficiencies inherent in manual complaint handling by providing a structured web-based platform for complaint registration, tracking, assignment, resolution, and analytics.

The system's modular architecture, comprising the User Registration, Complaint Submission, Complaint Management, Notification, and Reporting and Analytics modules, provides a comprehensive solution that serves the needs of both citizens and Panchayat administrators. The technology stack selected — Python Flask, MySQL, HTML5/CSS3/JavaScript — provides a reliable, cost-effective, and maintainable foundation appropriate for the resource-constrained environment of rural local government.

Experimental results from pilot deployment and structured testing demonstrate compelling improvements in key service delivery metrics: a 60.7% reduction in average complaint resolution time, a 50.4% improvement in citizen satisfaction scores, and a 45% reduction in administrative effort related to complaint management. These outcomes validate the core hypothesis that digital transformation of complaint management processes can meaningfully improve the quality and responsiveness of Gram Panchayat governance.

Several promising directions for future enhancement of the system have been identified. First, the development of a native mobile application for Android (the dominant platform in rural India) would eliminate the barrier of browser-based access and enable push notification delivery, further improving citizen engagement. Second, integration of Geographic Information System (GIS) mapping would enable geographic visualization of complaint hotspots, providing administrators with spatial intelligence to prioritize infrastructure interventions. Third, the application of Natural Language Processing (NLP) and machine learning techniques for automatic complaint categorization and priority scoring would reduce the manual administrative burden of complaint triage and improve routing accuracy.

Fourth, integration with other E-Governance platforms operated by state and district government bodies would enable seamless escalation of complaints that fall outside the jurisdiction of the Gram Panchayat, ensuring citizens receive appropriate assistance regardless of which government body bears responsibility. Fifth, the addition of multilingual support to accommodate regional language preferences would significantly improve accessibility for citizens who are not comfortable operating in English or Hindi. Finally, the incorporation of a citizen feedback and rating mechanism for resolved complaints would create a continuous improvement loop that incentivizes quality service delivery and provides evidence-based performance assessment for Panchayat officials.



In conclusion, the Smart Complaint Management System for Digital Gram Panchayat represents a meaningful contribution toward the vision of an empowered, transparent, and citizen-centric rural governance system in India. The system aligns with the national objectives of the Digital India Programme and demonstrates how appropriately designed ICT solutions can serve as powerful enablers of good governance at the grassroots level.

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