IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026

DOI: 10.17148/IJARCCE.2026.154250

Smart Sanitation Complaint System Using QR Code,GPS Tracking, and Real-Time Image Verification

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Abstract: Urban sanitation management in Indian municipalities continues to suffer from slow, opaque, and paper-based complaint handling mechanisms that undermine citizen trust and delay resolution. This paper presents the Smart Sanitation Complaint System (SSCS), a lightweight web-based platform that enables citizens to report sanitation issues in under two minutes by scanning a location-specific QR code, capturing photographic evidence through the device camera, and auto-fetching GPS coordinates via the W3C Geolocation API. Complaints are timestamped and routed to the relevant ward authority dashboard in real time, eliminating manual data entry and ambiguous location descriptions. A comparative evaluation against traditional manual systems and existing mobile applications demonstrates that SSCS reduces average complaint registration time from 48–72 hours to under two minutes, improves location accuracy from manual descriptions to ±5 m GPS precision, and raises user satisfaction from 42% to 87% in pilot surveys. The system is implemented entirely using open-web standards (HTML5, CSS3, JavaScript) without requiring application installation, making it accessible on any smartphone. SSCS aligns with the Smart City Mission of India and contributes a replicable, low-cost digital infrastructure model for urban sanitation governance.

Keywords: Smart City, Sanitation, QR Code, GPS Tracking, Complaint Management System, Web Application, Geolocation API, Urban Governance.

I. INTRODUCTION

Urban sanitation is a cornerstone of public health, environmental sustainability, and quality of life. In India, over 400 million people reside in urban areas, and municipalities face significant pressure to maintain cleanliness in public spaces, markets, drainage networks, and waste collection points [1]. Despite substantial investment under the Swachh Bharat Mission and the Smart City Mission, a persistent operational bottleneck is the complaint handling mechanism—the process through which citizens report sanitation deficiencies and receive timely redress.

Traditional complaint systems rely on telephone hotlines, written complaint books at ward offices, or rudimentary online portals that require manual data entry. These approaches share three systemic weaknesses: (i) high registration effort discourages citizen reporting; (ii) vague location descriptions create ambiguity that delays field crew dispatch; and (iii) the absence of photographic evidence enables denial or under-prioritization of complaints. Collectively, these weaknesses result in long resolution times (typically 7–14 days for a blocked drain), low citizen satisfaction, and a culture of non-accountability.

The exponential penetration of smartphones—with over 750 million active users in India as of 2023—and the ubiquity of mobile internet access present a transformative opportunity. A web-based application that leverages QR codes, the Camera API, and the Geolocation API can reduce the entire complaint lifecycle from days to minutes, without requiring citizens to download or configure a native application.

This paper makes the following contributions:

- Design and implementation of SSCS, a zero-install web application for QR-initiated, GPS-verified, photo-evidenced sanitation complaint reporting.
- A comparative literature survey establishing the gap between existing solutions and SSCS.
- A formal system architecture and data flow specification using UML-style descriptions.
- Empirical evaluation of system performance and user satisfaction from a pilot deployment.
- Discussion of scalability, security, and integration with Smart City command centers.

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II. LITERATURE SURVEY

The domain of citizen-government complaint systems has evolved across three generations of technology, each addressing partial aspects of the problem.

A. Manual and Telephone-Based Systems

The earliest form of complaint registration relied on citizens visiting ward offices or calling dedicated helplines. Studies by Sharma et al. [2] found that less than 18% of sanitation complaints lodged via telephone were resolved within the stipulated response window, largely because the complaint description was the sole source of location information. These systems also introduced data transcription errors and offered no audit trail.

B. Online City Portals

Municipal corporations in Delhi, Mumbai, and Bengaluru have deployed web portals (e.g., BMC's "MCGM Connect") that allow citizens to submit text-based complaints. While these systems improve record-keeping, they still require the user to manually describe the location and category of the complaint. Rao and Nair [3] documented that 31% of portal submissions contained location errors severe enough to prevent proper dispatch, and average resolution time remained at 8.4 days.

C. Mobile Applications

Third-generation systems, such as "Fix-It" (USA) and "SWaCH Saathi" (Pune), introduced GPS capture and photo attachment from native mobile apps. These systems demonstrate measurably improved outcomes [4]: GPS reduces location error, and photo evidence reduces disputes. However, they require app installation, periodic updates, and device storage—barriers that reduce adoption, particularly among elderly and low-income users. Furthermore, app-based systems are platform-specific and require ongoing maintenance across iOS and Android ecosystems.

D. IoT-Based Solutions

Several smart-bin and overflow-sensor deployments (e.g., Bigbelly solar compactors, Sensoneo ultrasonic sensors) automate certain sanitation alerts without citizen involvement [5]. However, these systems are expensive to deploy (approximately ₹50,000–₹2,00,000 per unit), cover only fixed infrastructure (bins, drains), and do not support the broad class of ad hoc sanitation complaints such as illegal dumping or clogged public toilets.

E. Identified Research Gap

Table I summarizes the comparative landscape. No existing system simultaneously achieves QR-initiated entry, mandatory image capture, GPS location fetching, zero-install deployment, and low infrastructure cost. SSCS is designed to fill this gap.

Table I: Comparative Analysis of Existing Sanitation Complaint Systems

System / Study	GPS Tracking	Image Capture	QR-Based Entry	Real-Time Alert	Cost
Manual Complaint Form	No	No	No	No	Low
Online City Portals	No	No	No	Partial	Med
Mobile Apps (e.g., Fix-It)	Yes	Yes	No	Partial	Med
IoT-Based Sensors	Yes	No	No	Yes	High
Proposed System (Ours)	Yes	Yes	Yes	Yes	Low

III. PROPOSED SYSTEM

The Smart Sanitation Complaint System (SSCS) is a progressive web application that eliminates all registration barriers by reducing user action to four steps: scan, photograph, confirm, and submit. The design philosophy is grounded in three principles: zero-install deployment (browser-native APIs only), location certainty (GPS mandatory, not optional), and evidence-first reporting (camera capture before submission).

A. System Overview

Each sanitation zone (toilet block, waste collection point, drain, public park, etc.) is assigned a unique QR code that encodes a URL of the form:

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https://sscs.municipal.gov.in/report?zone=MH-NM-W14-T003
Scanning this QR code opens a pre-populated web form in the citizen's default browser. The zone identifier is embedded in the URL, eliminating manual category selection. The form then requests camera and location permissions.

B. Core Functional Modules

- QR Code Module: QR codes are generated using the QRCode.js library and printed on weatherproof vinyl stickers affixed at each zone. Each QR contains the zone ID, ward ID, and a cryptographic timestamp to prevent replay attacks.
- Camera Capture Module: The system invokes MediaDevices.getUserMedia({ video: true }) to activate the rear-facing camera. The captured JPEG is compressed to ≤200 KB using canvas.toBlob() before upload to minimize data costs on low-bandwidth connections.
- Geolocation Module: The Navigator.geolocation.getCurrentPosition() API fetches WGS-84 coordinates. A minimum accuracy threshold of 50 m is enforced; if not achieved within 10 seconds, the user is prompted to retry or enter their location manually.
- Submission Module: Complaint data (zone ID, GPS coordinates, image blob, category, timestamp, device fingerprint) is submitted via HTTPS POST to the backend REST API. A unique complaint ID (e.g., NM-2024-087432) is returned and displayed to the citizen.
- Admin Dashboard: Municipal staff access a React-based dashboard showing all complaints on a map layer (Google Maps API), filterable by ward, category, status, and date. Push notifications are sent via Firebase Cloud Messaging when a new complaint is assigned.

IV. SYSTEM ARCHITECTURE AND METHODOLOGY

Figure 1 illustrates the end-to-end data flow of SSCS. The architecture follows a three-tier model: presentation layer (citizen browser), application layer (REST API server), and data layer (relational database + object storage).

[Figure 1: System Architecture Diagram]
Citizen → QR Scan → Browser (Camera + GPS) → HTTPS POST → REST API → MySQL DB + Firebase Storage
Admin Dashboard ← REST API (GET /complaints) ← MySQL DB

Fig. 1: SSCS System Architecture (Three-Tier Model)

A. Complaint Submission Workflow

The workflow follows a strict seven-step sequence enforced by the frontend state machine:

1. Citizen scans zone-specific QR code with any smartphone camera application.
2. Browser loads SSCS complaint form; zone ID is parsed from URL query string.
3. User grants camera permission; rear camera activates for photo capture.
4. User captures image of the sanitation issue; image is previewed for confirmation.
5. Geolocation API fetches GPS coordinates (latitude, longitude, accuracy).
6. User selects complaint category from pre-populated list (10 categories derived from SBM taxonomy) and optionally adds a text description.
7. Form submits via HTTPS POST; server returns complaint ID with estimated resolution date.

B. Technology Stack

Table II: Technology Stack and Justification

Layer	Technology / Tool	Purpose
Frontend	HTML5, CSS3, JavaScript (ES6)	UI rendering and client-side logic
Camera API	MediaDevices.getUserMedia()	Real-time image capture from device camera
Geolocation	Navigator.geolocation (W3C)	Fetch precise GPS coordinates
QR Code	QR Code Generator library	Encode location-specific complaint URLs
Backend	Node.js / PHP (REST API)	Handle complaint submission and routing
Database	MySQL / Firebase Firestore	Store complaints, metadata, media
Admin Panel	React.js / Bootstrap Dashboard	Municipal authority interface

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C. Data Security and Privacy

All data is transmitted over TLS 1.3. Images are stored in a private Firebase Storage bucket accessible only to authenticated admin accounts. GPS coordinates are stored as floating-point values in the database and are never exposed to third parties. Device fingerprints are hashed using SHA-256 and are used solely for duplicate-complaint detection within a 24-hour window. The system complies with India's Information Technology Act, 2000 and the draft Digital Personal Data Protection Act, 2023.

V. IMPLEMENTATION

SSCS was implemented and piloted across 12 public sanitation zones in Ward 14, Navi Mumbai Municipal Corporation (NMMC) over a period of six weeks (September–October 2024). A total of 248 QR code stickers were affixed at toilet blocks, garbage collection points, and open drains.

A. Frontend Implementation

The citizen-facing interface is a single-page application (SPA) written in vanilla JavaScript with no external framework dependencies. This design choice reduces the initial payload to under 80 KB (gzipped), ensuring sub-3-second load times on 3G connections. CSS media queries enable a responsive layout on screens ranging from 320px (feature phones) to 1440px (desktop).

Camera access is initiated only after the user explicitly taps the 'Capture Photo' button, respecting browser permission UX patterns. Error handling covers three failure modes: camera permission denied (fallback to file upload), geolocation timeout (manual entry prompt), and network failure (offline queue with Service Worker).

B. Backend Implementation

The REST API is built with Node.js (Express.js) and exposes six endpoints: POST /complaints (create), GET /complaints/:id (status check), GET /complaints (admin list with filters), PATCH /complaints/:id/status (update resolution status), GET /zones/:id (zone metadata), and POST /zones (admin zone registration). The API is stateless and horizontally scalable behind an NGINX reverse proxy.

Duplicate detection uses a spatial index (MySQL POINT type with R-tree index) to flag complaints within 50 m of an existing open complaint of the same category submitted within the past 24 hours. Duplicate submissions receive the existing complaint ID rather than creating a new record, reducing database bloat and preventing double-dispatch of field crews.

VI. RESULTS AND DISCUSSION

System performance was evaluated across three dimensions: quantitative complaint metrics, user experience, and admin efficiency. Data was collected over six weeks from 248 deployed QR codes across 12 sanitation zones.

A. Quantitative Performance Metrics

Table III: Performance Comparison — Traditional vs. SSCS

Performance Metric	Traditional System	Proposed System
Avg. Complaint Registration Time	48–72 hours	< 2 minutes
Location Accuracy	Manual (error-prone)	GPS (±5 m accuracy)
Image Evidence Attached	Rarely	Mandatory
Avg. Resolution Time	7–14 days	2–4 days (est.)
User Satisfaction (Survey)	42%	87%
Duplicate Complaints	High (~30%)	Low (< 5%)

The most significant improvement is in registration time: the median time from a citizen noticing a sanitation issue to a complaint being logged in the system fell from 3.2 days (traditional) to 87 seconds (SSCS). This is primarily because SSCS eliminates the need to travel to a ward office or navigate a multi-page portal.

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B. User Experience Survey

A post-pilot survey was administered to 93 citizens who used SSCS during the pilot period. Key findings:

- 91% of respondents rated the QR-scan-to-submit flow as 'Very Easy' or 'Easy'.
- 87% expressed satisfaction with the complaint tracking feature (SMS notification on status change).
- 78% stated they would recommend SSCS to neighbors compared to 31% for the existing portal.
- 6% encountered geolocation failures (resolved by manual location entry fallback).

C. Admin Dashboard Effectiveness

Municipal staff reported a 62% reduction in time spent on complaint data entry and phone-based follow-up. The map-based dashboard allowed ward supervisors to cluster nearby complaints and dispatch a single field crew for multiple issues, reducing fuel costs and response overhead. The photo evidence feature resolved three disputes in which contractors had marked complaints as resolved without performing remediation.

D. Limitations

The pilot revealed two limitations that require future work. First, 14% of QR codes sustained physical damage (peeling, graffiti) within four weeks, suggesting a need for more durable enclosures. Second, approximately 9% of users over the age of 60 required assistance with the camera permission flow, indicating a need for simplified onboarding or multilingual audio guidance.

VII. CONCLUSION AND FUTURE WORK

This paper presented the Smart Sanitation Complaint System (SSCS), a zero-install, QR-initiated, GPS-verified web application that reduces sanitation complaint registration from days to under two minutes. The system addresses the three core weaknesses of traditional complaint mechanisms—high registration friction, location ambiguity, and absence of evidence—through the combined application of QR codes, the W3C Camera API, and the Geolocation API.

Pilot evaluation across 12 sanitation zones in Navi Mumbai demonstrated a 97% reduction in registration time, GPS-grade location accuracy, mandatory photographic evidence, and an 87% citizen satisfaction rate. The use of open web standards and a lightweight frontend architecture ensures accessibility on low-end Android devices without application installation, making SSCS suitable for deployment across diverse socioeconomic contexts.

SSCS directly supports the Smart City Mission's Digital Infrastructure pillar and can serve as a replicable template for municipalities across India and other developing nations facing similar urban sanitation governance challenges.

Future Work

- Integration with Smart City Command and Control Centers (ICCC) via open APIs.
- AI-powered automatic complaint categorization from captured images using a CNN classifier.
- Multilingual voice interface (Hindi, Marathi) for elderly and low-literacy users.
- Predictive analytics dashboard to forecast sanitation hotspots using historical complaint density maps.
- Blockchain-based immutable audit log for complaint lifecycle events to prevent tampering.

ACKNOWLEDGMENT

The authors wish to thank the Navi Mumbai Municipal Corporation (NMMC) for granting access to sanitation zones during the pilot study, and Prof. Kanchanmala More for her expert guidance throughout this research. We also thank the student volunteers of A.C. Patil College of Engineering who assisted with QR code deployment and survey administration.

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DOI: 10.17148/IJARCCE.2026.154250

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