Smart Garbage Management System: A Web-Based Citizen Complaint and Administrative Resolution Platform

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Abstract: Rapid urbanization and population growth have led to an alarming rise in municipal solid waste, exposing critical failures in traditional garbage collection and reporting systems. This paper reviews sixteen smart waste management and web-based complaint system research works published between 2016 and 2026 and proposes the Smart Garbage Management System — a unified, full-stack web platform enabling citizens to submit geo-tagged, image-backed garbage complaints while administrators monitor, assign, and resolve them through a real-time dashboard. The system integrates a React.js frontend, Node.js/Express.js REST backend, MongoDB database, JWT authentication, and Multer image-upload middleware. A structured review of the literature identifies critical capability gaps in existing systems, and evaluation benchmarks drawn from prior work indicate that web-based complaint platforms achieve 45–72% reduction in resolution time and 38–40% gains in citizen re-engagement over offline systems.

Keywords: *Smart Garbage Management, Web Application, Complaint Tracking, Admin Dashboard, Node.js, MongoDB, Multer, React.js, IoT Waste Management, Real-Time Status, Citizen Reporting, Smart City.*

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I. INTRODUCTION

Urban solid waste management has become one of the defining infrastructure challenges of the 21st century. Global urban populations generate over 2.01 billion tonnes of municipal solid waste annually, a figure projected to reach 3.40 billion tonnes by 2050. Yet in most developing and middle-income cities, the systems governing waste collection remain firmly rooted in twentieth-century practice — fixed collection schedules, manual telephone-based reporting, and paper-based complaint logs that offer no real-time visibility, no structured accountability, and no pathway for citizens to verify whether their reports have been acknowledged or acted upon [1].

The consequences are concrete and measurable. Overflowing bins and uncollected garbage breed disease vectors, produce methane emissions, and signal civic dysfunction, eroding citizen trust in municipal governance. The

2016–2026 decade saw an explosion of research into IoT-based bin sensors, AI-driven waste classification, and GPS vehicle tracking. Yet a critical gap persisted: no affordable, unified, software-only platform combined citizen complaint submission with image evidence, admin-level complaint management, task assignment, and transparent status tracking in a single deployable web application.

Recent advances in full-stack web frameworks — particularly the MERN stack (MongoDB, Express.js, React.js, Node.js) — have made it feasible to build scalable, real-time civic platforms without specialized hardware. Combined with browser-native geolocation, RESTful APIs, and middleware-based image handling, these technologies enable a citizen-first complaint workflow that prior IoT-only or generic-portal solutions could not deliver.

The key contributions of this paper are:

- A structured review of sixteen smart waste management and web-based civic system research works (2016–2026), with per-paper methodology analysis, contribution summary, and limitation critique.
- A comparative analysis highlighting capability gaps across existing systems versus the proposed Smart Garbage Management System.
- A detailed proposal of an end-to-end MERN-stack platform integrating citizen complaint submission, image evidence upload, geo-tagging, JWT authentication, admin task assignment, and granular real-time status tracking.
- A methodology section covering each system module, technology stack, and expected evaluation metrics drawn from literature benchmarks.

II. BACKGROUND AND MOTIVATION

The intersection of IoT, web technologies, and municipal governance has produced several partial solutions over the past decade. Ultrasonic and IR sensors have been deployed to monitor bin fill levels. GPS-based routing has optimized collection vehicle dispatch. AI classification has been applied to segregation. More recently, web-based grievance portals have enabled structured citizen-to-government communication.

Despite this progress, three core problems persist. First, hardware dependency: most deployed systems require physical sensor installation at every monitored bin, creating capital costs that exclude resource-constrained municipalities. Second, citizen disengagement: surveys of the field consistently identify citizen-facing interfaces as the least addressed component, leaving the people most affected by waste mismanagement without a voice in the system. Third, lack of accountability: existing complaint mechanisms rarely provide image evidence, granular status tracking, or named task assignment, leaving complaints to vanish into opaque municipal workflows.

No existing system comprehensively addresses all three problems within a single, citizen-facing, software-only platform. The proposed Smart Garbage Management System is designed to fill this gap.

III. SURVEY OF RELATED WORKS

This section critically reviews sixteen research works spanning 2016–2026 that address smart waste management, IoT-based bin monitoring, and web-based civic complaint systems. Each work is evaluated on its methodological approach, practical contribution, and limitations that motivate the design of the proposed system.

Catania and Ventura [1] applied the Smart-M3 semantic information sharing platform to enable interoperability between heterogeneous waste management IoT devices, demonstrating that data from diverse devices could be unified through semantic standards. However, the system was technically complex, required specialized middleware expertise, included no citizen-facing features, and addressed only IoT integration rather than complaint management.

Anagnostopoulos et al. [2] designed a cost-efficiency framework for IoT-based waste collection combining fill-level sensing, GPS vehicle tracking, and routing optimization. The work demonstrated 25–30% reduction in collection trips through dynamic routing. However, the framework focused exclusively on backend logistics and provided no public-facing interface for citizen reporting.

Kumar, Singh, and Gehlot [3] implemented an Arduino Uno-based bin monitoring system using an IR sensor for fill detection and a GSM SIM800 module to send SMS alerts to a designated municipal officer. It provided one of the earliest working prototypes of automated bin overflow alerts in the Indian context. SMS-based notification, however, is non-scalable, non-searchable, and provides no dashboard for pattern analysis or structured complaint management.

Lozano et al. [4] proposed a big-data analytics framework integrating IoT waste sensor data with demographic and geographic datasets to predict waste-generation hotspots through machine learning. The framework established that predictive waste management reduces collection costs by 20% and prevents overflow incidents by 35%. It requires substantial historical data and powerful computing infrastructure that most municipalities in developing economies cannot meet.

Joshi, Patil, and Deshmukh [5] developed a general-purpose citizen grievance web portal with complaint categorization, status tracking, and email notification. The system demonstrated a 45% improvement in complaint resolution rates and a 38% increase in citizen re-engagement compared to offline systems. The general-purpose design, however, lacked domain-specific features for waste

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management such as image upload, geolocation tagging, or integration with field collection workflows.

Bano, Anwar, and Wahid [6] proposed an end-to-end IoT clearance system integrating bin sensors with collection scheduling and a supervisor dashboard. While the workflow integration was complete, hardware dependency excluded citizen reporting and limited deployability.

Karthik et al. [7] deployed weight and level sensors in bins connected through NodeMCU to a Blynk cloud platform, visualizing bin states on a mobile dashboard across a university campus. It demonstrated sub-₹500 per-bin sensor cost and reliable sensor-to-cloud communication. Campus-scale deployment, however, did not address city-scale complexity, and no citizen complaint interface or admin task management was included.

Mahajan, Kamble, and Rokde [8] used a Raspberry Pi with a camera module to capture bin images at scheduled intervals and upload them to AWS S3, with a web dashboard displaying bin status images for supervisors. It introduced image evidence as a component of garbage monitoring. Image capture was hardware-automated rather than citizen-initiated, the AWS cost structure was prohibitive, and no complaint submission or status tracking was provided.

Ahmed, Islam, and Islam [9] deployed ultrasonic sensors in municipal bins connected via MQTT to a cloud platform, with a mobile dashboard for collection teams. The system monitored fill levels in real time and demonstrated a 30% reduction in unnecessary collection trips. However, the system required physical sensor installation at every monitored bin, provided no interface for citizens to report informal dumping, and included no complaint tracking.

Chaudhari et al. [10] built one of the first web applications for garbage complaint submission with basic location tagging, implementing a PHP and MySQL backend with an administrator login panel. The system confirmed the feasibility of the web-based complaint management approach but had no image upload capability, only binary status tracking, and the PHP/MySQL stack lacked the scalability needed for large-scale deployment.

Dongre, Kulkarni, and Desai [11] implemented a hybrid approach combining IoT fill-level sensors with a web application allowing citizens to submit reports for locations without sensors, using Firebase for real-time synchronization. Firebase introduced vendor dependency, the admin interface lacked task assignment, and citizen complaint image uploads were not supported.

Guerrero, Maas, and Hogland [12] conducted a systematic cross-country analysis of solid waste management challenges in developing-nation cities, establishing a globally referenced framework for understanding municipal waste failure modes. The study is analytical rather than technological, providing no system implementation or digital solution.

Mishra, Sharma, and Tiwari [13] developed a MERN-stack garbage management web application with user authentication, complaint submission, and a basic admin view, tested with 50 pilot users. It confirmed that the MERN stack delivers sub-200 ms API response and high concurrent-user support on modest hardware. The system, however, lacked image upload capability, GPS-based location tagging, granular status tracking, and analytics dashboards.

Rajalakshmi et al. [14] built a web application with user registration, complaint submission, and an admin dashboard using Django and PostgreSQL, achieving a 72% reduction in complaint resolution time in a six-month municipal pilot. The system demonstrated complete end-to-end functionality but lacked image upload, GPS location tagging, and mobile-responsive design.

Vikram et al. [15] originally proposed a Wi-Fi-based wireless sensor network for home automation; the architecture was adapted in 2022 municipal pilots for waste-bin level monitoring. It demonstrated that Wi-Fi sensor networks offer lower per-node cost than cellular-based systems for dense urban deployments. The approach requires municipal Wi-Fi infrastructure, and no citizen complaint interface, web application, or admin management component was developed.

Pardini et al. [16] conducted a comprehensive survey of 67 IoT-based solid waste management systems published between 2010 and 2018. As the most cited survey in the field, it confirmed that citizen engagement remains the least addressed component across all surveyed systems — a finding that is the strongest single motivation for the proposed citizen-centric design.

Table 1: System Modules and Technology Stack

Module	Stack	Function
Frontend Portal	React.js + Axios	Citizen registration, complaint form, status view, image preview
Backend API	Node.js + Express.js	REST endpoints for auth, complaints, assignment, status updates
Authentication	JWT + bcrypt	Secure session management for citizens and administrators

Module	Stack	Function
Database	MongoDB (Mongoose)	Stores users, complaints, status history, assignment metadata
Image Upload	Multer Middleware	Handles photographic complaint evidence with size validation
Geo-Tagging	Browser Geolocation API	Captures GPS coordinates with optional street address resolution
Admin Dashboard	React + Chart.js	Real-time complaint monitoring, task assignment, analytics

IV. EVALUATION METHODOLOGY

The system will be evaluated against benchmarks established by prior literature, summarized in Table III. Rajalakshmi et al. [14] achieved 72% reduction in resolution time in a six-month pilot; Joshi et al. [5] reported 45% improvement in complaint closure; Mishra et al. [13] confirmed sub-200 ms API response on the MERN stack. These results provide realistic targets for the proposed integrated system.

Table 2: Performance Benchmarks and Targets

Metric	Baseline (Manual/Legacy)	Proposed System Target
Average Complaint Resolution Time	5–9 days	40–60% reduction
Complaint Closure Rate	55–65%	85–95%
Citizen Re-Engagement Rate	Low (no feedback loop)	≥ 40% improvement
API Response Latency	N/A	< 200 ms (Mishra benchmark)
Image Evidence Coverage	0%	100% of submitted complaints
Hardware Deployment Cost	₹500–5000 per bin	Zero (software-only)

Comprehensive experimental evaluation using a real-world municipal pilot is planned as the next phase of development.

V. COMPARATIVE ANALYSIS

Table I summarizes the methodologies, contributions, and limitations of the reviewed works relative to the proposed Smart Garbage Management System. The analysis reveals a clear pattern: individual research contributions address isolated components of the waste-management pipeline, but no existing system integrates citizen complaint submission, image evidence, admin task assignment, and granular real-time status tracking into a single, software-only platform.

Table 3: Comparative Analysis of Reviewed Systems vs. Proposed System

Sl. No	Title of the Paper	Authors& Year	Methodology	Key Contribution	Limitation
1	Smart-M3 Semantic IoT Platform for Waste Monitoring	Catania & Ventura et al. 2016 [1]	Semantic IoT Middleware	Platform-agnostic waste management via semantic interoperability across heterogeneous IoT devices	No citizen-facing features; complex middleware expertise required
2	Cost-Efficient IoT Waste Collection Framework	Anagnostopoulos et al. 2016 [2]	IoT + GPS Routing	25–30% reduction in collection trips through dynamic sensor-driven routing	No web-based public interface for citizens
3	Smart Garbage Monitoring Using Arduino & GSM	Kumar, Singh & Gehlot et al. 2017 [3]	Arduino + IR + GSM SMS	Earliest working prototype of automated bin overflow alerts in Indian context	SMS-based notification is non-scalable, non-searchable, no dashboard

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4	Sustainable Smart Cities Through Big Data & IoT	Lozano et al. 2018 [4]	Big Data + IoT + ML	35% reduction in overflow incidents; 20% cost reduction via predictive analytics	Requires substantial historical data and computing infrastructure
5	Citizen Grievance Redressal Using Web Technologies	Joshi, Patil & Deshmukh et al. 2018 [5]	PHP Web Portal	45% improvement in complaint resolution; 38% increase in citizen re-engagement	Generic design lacks waste-specific image upload & geo-tagging
6	Real-Time Garbage Monitoring with Raspberry Pi	Mahajan, Kamble &Rokde et al. 2019 [6]	Raspberry Pi + AWS S3	Introduced image evidence as a component of garbage monitoring	Hardware-captured, not citizen-initiated; high AWS cost
7	Efficient Solid Waste Management Using IoT	Karthik et al. 2019 [7]	NodeMCU + Blynk Cloud	Sub-₹500 per-bin sensor cost with reliable sensor-to-cloud communication	Campus-scale only; no citizen interface or admin task management
8	IoT-Based Solid Waste Management: A Survey	Pardini et al. 2019 [8]	Survey of 67 Systems	Established citizen engagement as the least addressed component across the field	Survey-only, no implementation or system contribution
9	IoT-Based Smart Waste Management System	Ahmed, Islam & Islam et al. 2020 [9]	Ultrasonic Sensors + MQTT	30% reduction in unnecessary collection trips through threshold alerts	Requires sensor at every bin; no citizen complaint interface
10	Web-Based Garbage Management with Real-Time Tracking	Chaudhari et al. 2021 [10]	PHP + MySQL Web App	First web app for garbage complaints with basic location tagging	No image upload; binary status; PHP/MySQL scalability limits
11	Smart Garbage Collection Using IoT and Web	Dongre, Kulkarni & Desai et al. 2021 [11]	IoT + Firebase Real-Time DB	Hybrid IoT-plus-web approach extends coverage beyond sensor locations	No image upload; no admin task assignment; vendor lock-in
12	Solid Waste Management Challenges (Developing Cities)	Guerrero, Maas & Hogland et al. 2021 [12]	Cross-Country Analytical Study	Globally referenced framework for municipal waste failure modes	Analytical only; no digital solution proposed
13	Smart Garbage Management Using MERN Stack	Mishra, Sharma & Tiwari et al. 2021 [13]	MERN Stack Web App	Sub-200ms API response; high concurrency on modest hardware	No image upload; no GPS; no granular status tracking
14	Smart Waste Management with Web App & Admin Dashboard	Rajalakshmi et al. 2021 [14]	Django + PostgreSQL	72% reduction in complaint resolution time in 6-month municipal pilot	No image upload; no GPS tagging; not mobile-responsive
15	Wi-Fi WSN for Bin Monitoring	Vikram et al. 2022 [15]	Wi-Fi WSN + NodeMCU	Lower per-node cost than cellular WSN for dense urban deployments	Requires municipal Wi-Fi infrastructure; no citizen interface
16	Smart Garbage Management System (Proposed)	Proposed System et al. 2025 [16]	MERN + Multer + JWT + Geo-Tagging	End-to-end web platform: citizen complaints, image evidence, admin task assignment, granular status, zero hardware	Under active development and evaluation

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VI. PROPOSED MODEL

Fig 1: System Process Workflow

The proposed Smart Garbage Management System is an end-to-end web-based complaint management platform built on the MERN stack. It enables citizens to submit geo-tagged, image-backed garbage complaints while administrators monitor, assign, and resolve them through a centralized real-time dashboard. Each module is independently developed and loosely coupled, enabling modular upgrades without disrupting the overall system.

A. Citizen Portal (Frontend)

Citizens register and log in with JWT-authenticated sessions. Through a structured submission form, they provide a textual description, location (GPS coordinates or street address), and a supporting photograph. The React.js frontend renders complaint history, status timeline, and image previews with mobile-responsive layouts.

B. Authentication and Authorization

JWT tokens secure all API interactions, with role-based access separating citizen and administrator privileges. Passwords are hashed via bcrypt, and refresh-token rotation extends session security without requiring repeated logins.

C. Complaint Submission and Image Upload

The Multer middleware handles photographic evidence uploads with type and size validation. Each complaint receives a unique ID, a timestamp, GPS coordinates captured via the browser Geolocation API, and an initial Pending status upon submission.

D. Administrator Dashboard

Administrators access a centralized dashboard displaying all complaints with status, submission time, image-evidence thumbnail, and location. Complaints can be assigned to named field collection teams and updated through three status stages: Pending (submitted, awaiting admin review), In Progress (assigned, collection team dispatched), and Completed (garbage collected, issue resolved).

E. Backend API and Database

The Node.js + Express.js REST backend exposes endpoints for authentication, complaint CRUD, status transitions, and analytics. MongoDB (via Mongoose) stores users, complaints, status history, and assignment metadata. The schema is designed for horizontal scalability across municipal deployments.

VII. OPEN CHALLENGES AND RESEARCH GAPS

Based on the literature review, the following critical research gaps remain inadequately addressed by existing systems:

- No unified citizen-to-admin platform combining complaint submission, image evidence, admin task assignment, and granular status tracking in a single system.
- Absence of image-based complaint evidence in citizen-submitted reports; existing image coverage is hardware-captured only.
- Hardware-dependency barrier — most systems require IoT bin installation, creating capital costs that exclude resource-constrained municipalities.
- Lack of granular, multi-stage status tracking with timestamps and resolution notes.
- No admin task assignment functionality routing specific complaints to named field collection teams.
- Persistent citizen-engagement gap; surveys confirm citizen-facing interfaces are the least addressed component across the field.
- Limited scalability of legacy web stacks for city-scale concurrent load without significant re-architecture.

The proposed Smart Garbage Management System is designed to address each of these gaps through its modular, software-only MERN architecture described in Section V.

VIII. CONCLUSION

This paper presented a systematic review of sixteen smart waste management and web-based civic complaint research works published between 2016 and 2026, with per-paper methodology analysis, contribution assessment, and limitation critique. The review establishes that while the literature has produced excellent partial solutions — IoT bin monitoring, GPS routing, AI classification, and generic complaint portals — no single system delivers the complete integration of citizen complaint submission, image-based evidence, admin task assignment, real-time status tracking, and zero hardware deployment required for accessible, scalable municipal garbage management.

The proposed Smart Garbage Management System directly addresses all identified research gaps within a unified MERN-stack web platform. The system requires no specialized hardware, is deployable by any municipality with a web server, and is expected to deliver quantifiable improvements in complaint resolution time, citizen transparency, and administrative accountability. Literature benchmarks support the targeted performance: Rajalakshmi et al. achieved 72% resolution-time reduction in a six-month pilot, Joshi et al. reported 45% improvement in complaint closure, and Mishra et al. confirmed sub-200 ms API response on MERN stack under concurrent load.

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