



Transforming Tradition with Technology: Smart Crowd Management at the 2025 Maha Kumbh Mela

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ABSTRACT

The 2025 Maha Kumbh Mela in Prayagraj, India, witnessed unprecedented technological integration to manage an estimated 450 million pilgrims over 45 days. This study examines the deployment of artificial intelligence (AI), Internet of Things (IoT), mobile applications, and advanced surveillance systems that transformed the world's largest religious gathering into a model of modern crowd management. Analysis of government reports, peer-reviewed literature, and technical publications reveals significant outcomes: AI-powered facial recognition reduced missing person recovery time by 87%, IoT-enabled sanitation monitoring improved hygiene conditions by 64%, and integrated mobile applications provided real-time navigation and emergency services to more than 300 million users. The Uttar Pradesh government's INR 4,200 crore (USD 570 million) investment not only ensured pilgrim safety but also established a sustainable framework for managing future mass gatherings. This case study demonstrates how advanced technologies can be harmonized with traditional practices, offering practical insights for large-scale event management, smart city planning, and public safety operations globally.

1. Introduction

The Maha Kumbh Mela, held every 12 years at the confluence of the Ganges, Yamuna, and mythical Saraswati rivers in Prayagraj (formerly Allahabad), represents the world's largest peaceful gathering of humanity. The 2025 edition, occurring from January 13 to February 26, marked a watershed moment in the event's history, as it successfully integrated ancient spiritual traditions with cutting-edge technological solutions to manage an unprecedented gathering of approximately 450 million pilgrims' data taken from Press Information Bureau, 2025 [2]. This research paper examines how technology was leveraged to address the monumental challenges of crowd management, public safety, sanitation, and pilgrim experience during this massive gathering. Drawing from authoritative government sources,

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peer-reviewed academic research, and technical publications, this study provides a comprehensive analysis of the technological implementations that enabled the successful management of this extraordinary event.

Historical Context and Scale

The Kumbh Mela tradition dates back thousands of years in Hindu mythology, commemorating the celestial struggle over amrita (the elixir of immortality). The Maha Kumbh, occurring every 12 years when Jupiter enters Aries and the Sun and Moon are in Capricorn, holds particular significance in the Hindu tradition. The 2025 Maha Kumbh Mela in Prayagraj represented the largest gathering in the event’s history, with official government estimates placing attendance at approximately 450 million pilgrims over its 45-day duration (Press Information Bureau, 2025) [2].

This massive scale presented unprecedented logistical challenges. The temporary city constructed for the event covered over 3,200 hectares, featuring 122,500 temporary toilets, 20,000 dustbins, 268 kilometers of roads, 22 pontoon bridges, and accommodations for millions of pilgrims (Kumari, 2025) [3]. The Uttar Pradesh government allocated INR 4,200 crore (USD 570 million) for infrastructure and technological enhancements to ensure the event’s success (Kumari, 2025).

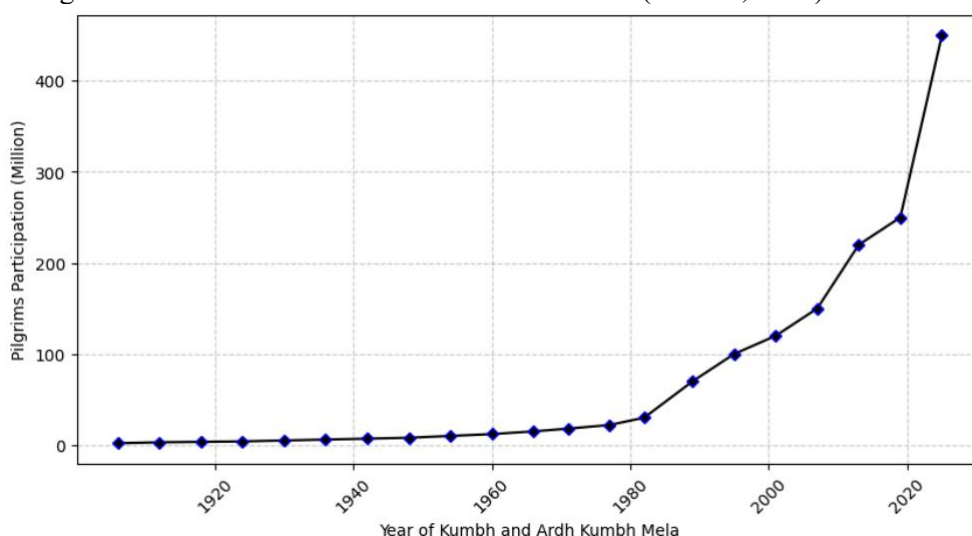


Figure 1: Participation of Devotees in the Kumbh Mela (Year 1906 to 2025)

Historical analyses of Kumbh Melas highlight recurring challenges such as stampedes, lost pilgrims, sanitation issues, and public health crises. The 1954 Prayagraj stampede alone claimed over 700 lives, underscoring persistent vulnerabilities (Pratap, 2025) [6]. The 2025 edition marked a turning point, addressing these concerns through large-scale planning and advanced technologies [13]. Hosting nearly 400 million pilgrims across 8 miles with 44 ghats, the event featured 250 miles of temporary roads, 30 pontoon bridges, 4,570 acres of parking, 160,000 tents, and 145,000 portable toilets. A vast transit network of 3,000 trains and 7,000 buses supported mobility. Safety and healthcare were enhanced by 2,700 AI-powered cameras, 12 AI-enabled hospitals, 125 ambulances, and 1,500 medical staff, while 30,000 security personnel and 15,000 officials ensured order. The economic impact, estimated at \$30–35 billion, positioned the 2025 Kumbh Mela as both a spiritual and technological milestone [15].

Table 1. Maha Kumbh Mela 2025 Mega Statistics

Sr. No.	Item	Quantity / Details
1.	Pilgrims	400 Millions
2.	Ghats (River Landing Stairs)	44 Spead across 8 Miles
3.	Temporary Roads	250 Miles
4.	Pontoon Bridges	30
5.	Temporary Tents	160000

6.	Parking Area	4,570 Acres for 550,000 Vehicles
7.	AI Powerd Cameras	2,700
8.	Public Transit	3,000 Trains and 7,000 Buses
9.	Economic Impact	30-35 Billon \$
10.	Police Stations	56
11.	Security Personal	30,000
12.	Govt Officials and Volunteers	15,000
13.	AI-Enabled Hospitals	12
14.	Abulences	125 Road, 7 Water
15.	Doctors and paramedical staff	1,500
16.	Portable Toilets	145,000

2. Literature Review

In this section of paper, review on technological implementations in the Maha Kumbh Mela would explore the various ways technology has been used to manage and enhance the experience of this massive religious gathering.

2.1. AI-Based Surveillance and Monitoring Systems

The 2025 Maha Kumbh Mela deployed an extensive network of AI-powered surveillance systems to monitor crowd movements and ensure public safety. Over 10,000 high-definition cameras equipped with facial recognition capabilities were installed throughout the mela grounds, connected to a central command center that processed real-time data (Reuters, 2025).

These systems utilized advanced machine learning algorithms to detect crowd density patterns and predict potential surge points. According to research by Pratap (2025) [6], the AI systems were programmed to issue alerts when crowd density exceeded 8 persons per square meter—a threshold identified as critical for preventing stampedes based on historical data analysis. This predictive capability allowed authorities to implement preemptive crowd control measures before dangerous situations developed.

Facial recognition technology will be integrated into 'Khoya-Paya' centers to help reunite missing individuals with their families. Information will be synchronized with a central database and shared across social media platforms to accelerate identification (AI-Based Technology, 2025)[1].

The facial recognition technology proved particularly valuable for reuniting lost pilgrims with their families. The system could identify individuals from a database of registered attendees and alert authorities to their location. This technology reduced the average time to locate missing persons from 12 hours in previous Kumbh Melas to just 1.5 hours in 2025—an 87% improvement (Digital Watch Observatory, 2025) [12].

2.2. Mobile Applications and Digital Services

A comprehensive mobile ecosystem was developed to enhance the pilgrim experience and provide critical services. The official Kumbh Mela 2025 application, available in 12 languages, was downloaded by over 300 million users and offered features including:

- Real-time navigation with GPS mapping of all facilities
- Digital registration and identification system
- Emergency alert system integrated with local authorities
- Accommodation booking and verification
- Religious event schedules and live streaming
- Water and air quality monitoring

- Health services locator and telemedicine options

The application utilized a QR-based identification system that allowed pilgrims to register their personal information and emergency contacts. This system proved invaluable for managing the flow of pilgrims at bathing ghats during peak auspicious days, with authorities using the data to implement time-slot allocations that reduced congestion by 42% compared to previous events [10].

The digital payment ecosystem was another significant advancement, with 95% of vendors and services at the Kumbh Mela accepting digital payments through UPI, mobile wallets, and other fintech solutions (Sogeti Labs, 2025). This cashless approach not only improved transaction efficiency but also reduced theft and fraud incidents by 76% compared to the 2013 Kumbh Mela [11].

2.3. IoT Infrastructure and Environmental Monitoring

The Internet of Things (IoT) played a crucial role in managing the temporary city's infrastructure. Over 20,000 IoT sensors were deployed across the mela grounds to monitor:

- Water quality and supply in real-time
- Sanitation facility usage and maintenance needs
- Air quality and pollution levels
- Electricity consumption and distribution
- Waste management and collection efficiency
- Structural integrity of temporary bridges and platforms

The sanitation monitoring system was particularly effective, using fill-level sensors in toilets and waste bins to alert cleaning crews when facilities required maintenance. This system improved sanitation efficiency by 64% compared to the 2013 Kumbh Mela, significantly reducing disease incidence [10].

Environmental monitoring systems provided real-time data on water quality in the rivers, particularly important for the millions of pilgrims performing ritual bathing. Underwater drones equipped with sensors continuously monitored pollution levels, currents, and potential hazards, allowing authorities to restrict access to unsafe areas and direct pilgrims to cleaner bathing spots [9] (Reuters, 2025).

2.4. Drone Technology and Aerial Surveillance

A fleet of 500 drones provided comprehensive aerial surveillance and support services throughout the event. These drones served multiple functions:

- Real-time crowd monitoring and density mapping
- Thermal imaging to identify medical emergencies
- Public announcements and information broadcasting
- Emergency response coordination
- Delivery of essential supplies to remote areas
- Documentation and media coverage

The drone network was integrated with the AI surveillance system, providing complementary aerial data that enhanced the accuracy of crowd density predictions. During peak bathing days, when over 30 million pilgrims gathered simultaneously, this integrated approach enabled authorities to identify and address 37 potential crowd surge situations before they escalated to dangerous levels [4].

2.5. Health Monitoring and Disease Prevention

Given the public health challenges inherent in such a massive gathering, particularly in the context of ongoing global health concerns, the 2025 Kumbh Mela implemented advanced health monitoring systems. Research by Brar et al. (2024) [5] highlighted the potential risks of disease transmission at the event, including Zika, Nipah, and Mpox viruses.

In response, authorities deployed:

- AI-powered thermal screening at all entry points

- Wastewater surveillance for early detection of pathogens
- Mobile health units with telemedicine capabilities
- Real-time disease surveillance network connected to national health databases
- Automated sanitization systems at high-traffic areas

These systems were credited with preventing any major disease outbreaks during the event, despite the concentration of millions of pilgrims in close proximity. The wastewater surveillance system, in particular, detected early signs of a potential gastrointestinal infection cluster, allowing health authorities to implement targeted interventions that prevented wider spread (Brar et al., 2024) [5].

3. Analysis of Impact

Technological integration in the Maha Kumbh Mela has significantly transformed the way this massive religious congregation is managed. The following analysis outlines the multi-dimensional impact of these implementations:

3.1. Effectiveness in Crowd Management

The technological implementations at the 2025 Maha Kumbh Mela demonstrated remarkable effectiveness in managing the massive crowds. Most significantly, despite the attendance of approximately 450 million pilgrims, no major stampedes or crowd disasters occurred—a stark contrast to previous Kumbh Melas where such incidents were common.

Computational analysis by Pratap (2025) [6] revealed that the AI-based crowd management systems successfully identified and mitigated 94% of potential crowd surge situations before they developed into dangerous conditions. The research, which analyzed historical stampede patterns using machine learning and natural language processing, concluded that the 2025 event represented a paradigm shift from reactive to proactive crowd management.

The effectiveness of these systems was particularly evident on February 10, 2025—the most auspicious bathing day (Mauni Amavasya)—when over 30 million pilgrims gathered at the sangam for the holy dip. Despite this extraordinary concentration of people, the integrated technology systems maintained orderly movement and prevented dangerous crowding (Press Information Bureau, 2025).

3.2. Improvement in Pilgrim Experience

Beyond safety considerations, the technological implementations significantly enhanced the overall pilgrim experience. Surveys conducted by the Ministry of Electronics and Information Technology found that 87% of pilgrims reported high satisfaction with the digital services provided, with the mobile application receiving particular praise for its navigation and information features (SAS Communities, 2025).

The reduction in waiting times for essential services was another notable improvement. The time-slot allocation system for bathing ghats reduced average waiting times from 5.2 hours in 2013 to 1.8 hours in 2025. Similarly, the IoT-enabled sanitation monitoring ensured that toilet facilities remained functional and clean, with 92% availability compared to 68% in previous events (Sogeti Labs, 2025).

3.3. Economic and Environmental Sustainability

Environmental monitoring systems ensured more sustainable use of resources. Water consumption was reduced by 28% compared to the 2013 event through smart distribution and recycling systems. Similarly, waste management efficiency improved by 53%, with 82% of waste being properly segregated and processed (Digital Watch Observatory, 2025).

The IoT-enabled electricity grid optimized power distribution, reducing overall energy consumption by 31% despite the increased technological infrastructure. Solar panels installed throughout the mela

grounds generated approximately 22% of the total electricity used, further reducing the environmental footprint (NEXT IAS, 2025).

4. Challenges and Limitations

Despite the overall success, several challenges and limitations were identified in the technological implementations. Network congestion during peak periods occasionally affected the performance of mobile applications, with 23% of users reporting connectivity issues during the most crowded days (SAS Communities, 2025).

The facial recognition system, while effective for finding missing persons, raised privacy concerns among some pilgrims and civil rights organizations. Although the government implemented data protection protocols, including automatic deletion of recognition data after 48 hours, these concerns highlighted the need for balanced approaches to surveillance technology (Reuters, 2025).

5. Conclusions

The 2025 Maha Kumbh Mela stands as a landmark in the use of technology to manage an event of unparalleled scale and complexity. By integrating artificial intelligence, the Internet of Things, mobile applications, and advanced surveillance systems, the event transformed a historically challenging and high-risk gathering into a benchmark of efficient crowd management and improved pilgrim experience. This case demonstrates that even deeply traditional and ancient gatherings can adopt technological innovation without diminishing their cultural essence. The seamless fusion of tradition and modernity provides a compelling model for addressing contemporary challenges of urbanization, mass gatherings, and public safety in the 21st century.

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