IIP International Multidisciplinary Research Journal
IIPIMRJ

An Online Peer-Reviewed / Refereed Journal
Vol: 02 No. Issue IV, (October-December) (2025)
Impact Factor: GSRD-IF: 5.001
ISSN: 3049-2734 (Online)

INTEGRATED GEO-SPATIAL MONITORING OF SOLID WASTE FLOW, HOTSPOTS AND VEHICLE ROUTING IN JALGAON CITY (MH)

[1]Sapana S. Sonawane., [2]Dr. D. B. Nalawade, [3]Dr. Vishal S. Gholap

[1] Research Student, Dept. of Geography, Chhatrapati Shivaji College Satara, A Constituent College of Karmaveer Bhaurao Patil University, Satara, Maharashtra.

[2] Associate Professor, Dept. of Geography, Chhatrapati Shivaji College Satara, A Constituent College of Karmaveer Bhaurao Patil University, Satara, Maharashtra.

[3] Assistant Professor, Dept. of Geography, Chhatrapati Shivaji College Satara, A Constituent College of Karmaveer Bhaurao Patil University, Satara, Maharashtra.

Article Info

Article History:
Received: 15th Dec 2025
Accepted: 19th Dec 2025
Published: 20th Dec 2025

Keywords:

GIS & GPS,
Solid Waste,
Jalgaon City

ABSTRACT

Solid Waste Management (SWM) is one of the most critical urban environmental challenges in rapidly expanding Indian cities. This study uses GIS and GPS-based spatial techniques to map waste generation intensity, dumping hotspots, collection-route efficiency, and service coverage across Jalgaon City. Ward-wise spatial analysis revealed unequal waste load distribution, weak segregation, and high landfill dependency. GPS tracked collection routes indicated vehicular overlap and inefficiency in transport time. GIS based density mapping confirms that 40 to 55% of waste originates from dense residential-commercial belts. The study demonstrates how spatial science can strengthen decision-making and improve municipal waste governance.

Plagiarism Check Report:
Tool Used: Turnitin
Date of Report: Dec 18, 2025
Similarity Index: 7%
Remarks: No significant matching text. All citations and matches are properly referenced. The manuscript is considered original.

How to Cite: Sonawane, S. S., Nalawade, D. B., & Gholap, V. S. (2025). Integrated geo-spatial monitoring of solid waste flow, hotspots and vehicle routing in Jalgaon City (MH). IIP: International Multidisciplinary Research Journal (IIPIMRJ), 2(IV), pp. 1047–1053.

INTRODUCTION

Urbanization has become one of the most defining processes of the 21st century, leading to unprecedented growth of municipal solid waste across developing countries. In India, nearly **160,000 MT/day** of municipal waste is generated, out of which only 25–30% is scientifically processed, while the remaining fraction enters open dumping grounds, water channels, peri-urban agricultural lands and unregulated landfill sites **(Gour et al., 2023).** Solid Waste Management (SWM) therefore represents not only a sanitation challenge but also a multidimensional environmental issue impacting soil quality, groundwater regimes, surface water contamination, public health, transportation corridors and urban land-use patterns. Rapid population increase, rising consumerism, changing lifestyle and market expansion accelerate municipal waste production, intensifying the pressure on urban governance systems **(Sk., Qamar & Sethy, 2023).**

Jalgaon City in northern Maharashtra is one such emerging urban centre facing waste accumulation, irregular segregation, inefficient routing and increasing landfill dependency. The city currently produces approximately **280 MT/day** of municipal waste, of which biodegradable fraction is dominant, indicating a high potential for compost recovery and circular waste economy models. However, lack of data-based planning, limited processing infrastructure, and absence of spatial monitoring has led to unbalanced disposal patterns and environmental stress zones within the municipal boundary **(MPCB, 2024).** Conventional waste planning often considers total quantity but ignores **where** the waste is generated, transported or dumped a critical factor for scientific decision-making.

Here, **GIS** and **GPS** have transformed urban resource mapping by enabling ward-wise waste quantification, route optimization, hotspot identification and landfill suitability assessment. GPS tracking provides real-time travel distance, route repetition, idle time and operational efficiency of waste collection vehicles, while GIS visualizes spatial disparities, high-load zones, frequency gaps, and infrastructure distribution **(Pawar, Borase & Bhadane, 2025).** Cities like Pune, Indore and Mysuru have successfully integrated GIS-GPS-based waste intelligence networks, resulting in improved segregation, fuel efficiency and reduced landfill burden **(Kale, 2022; Singh & Mandal, 2023).**

Despite its clear advantages, such spatial technology-integrated assessment for Jalgaon City remains largely unexplored. Previous research mainly described waste quantities, composition and environmental concerns, but lacked ward-level mapping and GPS-based movement tracking. There exists a scientific need to develop spatial visual outputs that reveal *where* waste is densest, *where* services are weak, and *where* dumpsite expansion is occurring. This research therefore attempts to bridge this gap by integrating Geography, GIS, GPS and SWM parameters to evaluate Jalgaon's waste flow, collection route efficiency and disposal hotspot concentration. The findings aim to support policymakers in designing decentralized compost centres, optimizing transport paths, reducing landfill dependence, and shifting the city towards sustainable urban waste governance.

STUDY AREA

The present study has been conducted in **Jalgaon City**, an emerging urban centre located in the **Khandesh region of Maharashtra,** known for its commercial activity, transport connectivity and agricultural linkage with the Tapi–Girna river basin. Geographically, the city extends over **62.29 sq. km,** with an approximate latitudinal and longitudinal spread between **21°00' to 21°05' North** and **75°30' to 75°40' East (Fig. 1).** According to municipal records, Jalgaon hosts a population of nearly **4.6 lakh**, with dense residential clusters in the central core, market-dominated zones along the transport

corridors, and rapidly expanding peri-urban settlements on the fringes. The region exhibits a semi-arid tropical climate with hot summers and moderate rainfall, which directly influences waste decomposition rates and leachate migration risks. Land-use patterns show a mosaic of commercial hubs, educational institutions, vegetable mandis, mixed housing neighbourhoods and informal settlements collectively contributing to spatial disparities in waste generation and disposal. Administrative management lies under the **Jalgaon City Municipal Corporation (JCMC),** which undertakes daily waste collection, transport and processing functions. These heterogeneous socio-spatial characteristics make Jalgaon a suitable case for **GIS-GPS-based waste mapping**, enabling ward-wise waste intensity analysis, hotspot identification, and scientifically guided waste management planning.

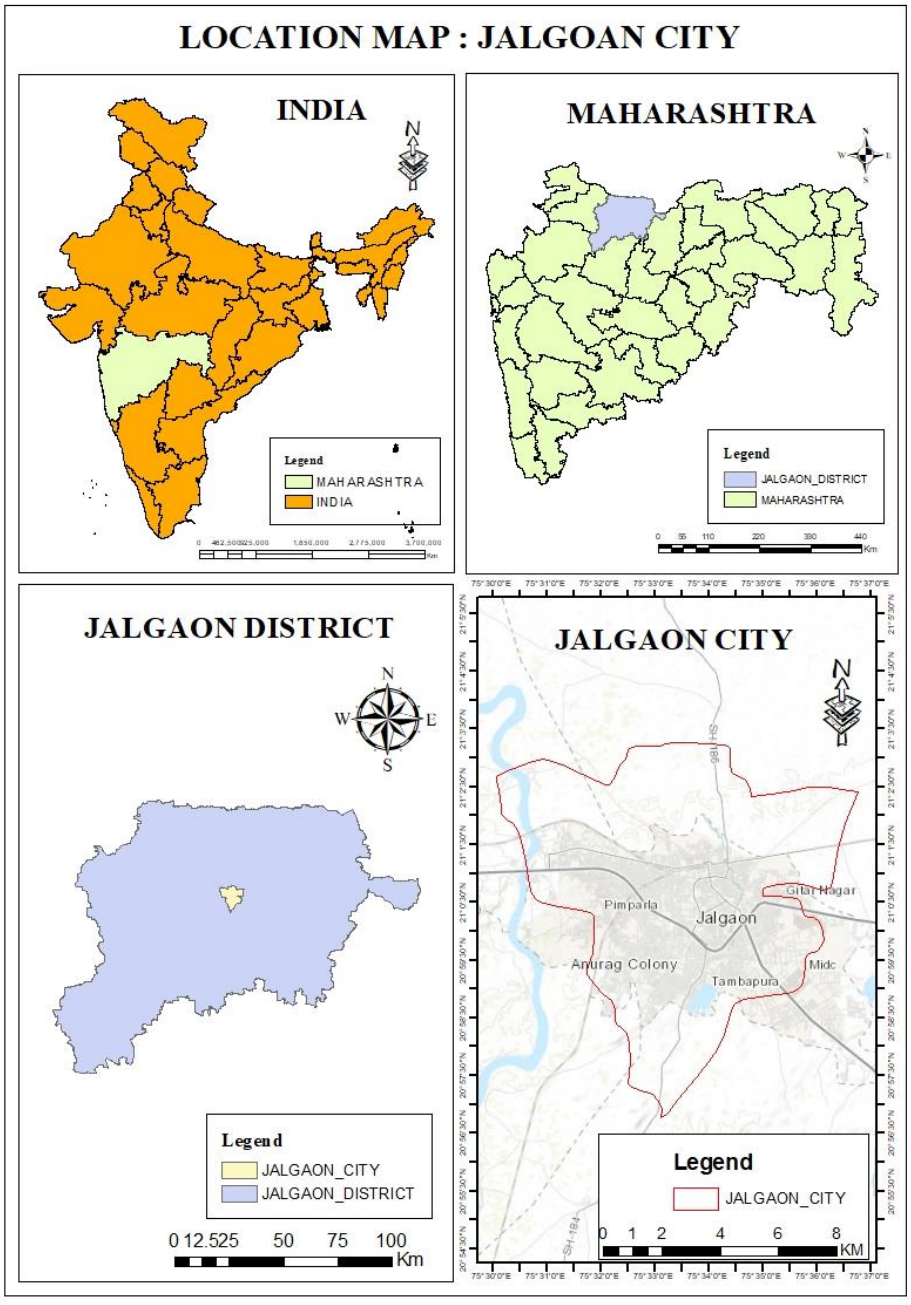

Fig. 1

METHODOLOGY

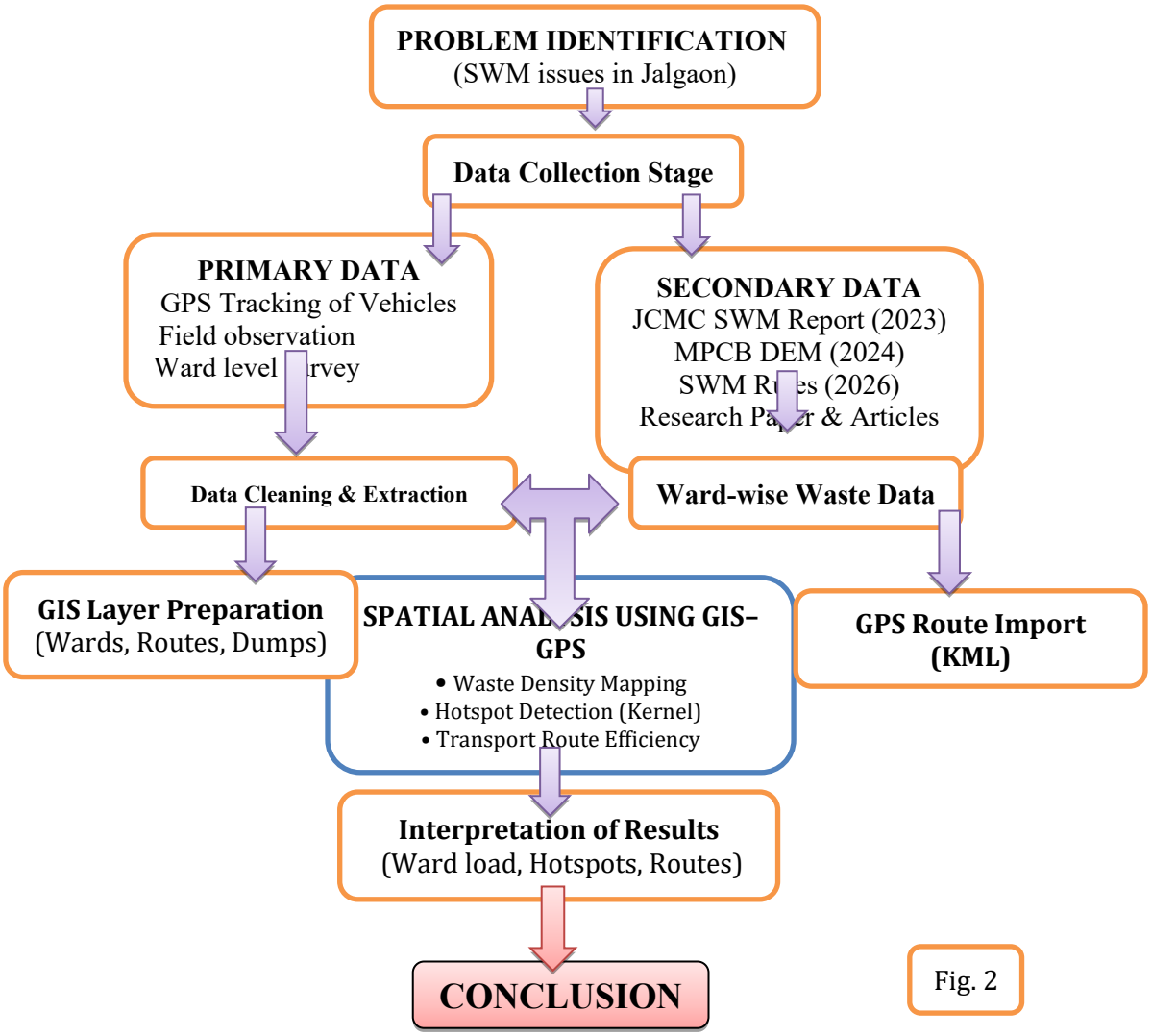

Fig. 2

OBJECTIVES

1) To analyse ward-wise solid waste generation using GIS & GPS mapping.
2) To identify collection efficiency, dumping hotspots, and spatial gaps in waste management.

RESULTS AND DISCUSSION

The GIS & GPS based spatial evaluation of solid waste management in Jalgaon City provides clear evidence of unequal waste generation, uneven route performance and localized dumping pressure across different municipal wards. The analysis was carried out using ward-wise waste generation data, GPS vehicle tracking logs and GIS mapping layers of collection routes, disposal sites and processing units. The integrated output is summarized in the following sections.

The analysis of ward-wise solid waste generation, GPS based route tracking, dumping site concentration and spatial density mapping revealed significant intra-urban variations in Jalgaon City. GIS generated thematic layers indicated that the city produces approximately **280 MT/day of municipal waste**, of which **58.5% is biodegradable**, **25.5% inert matter**, while recyclable components such as paper, plastic and glass collectively contribute only **12.05%**. **Table 1** summarises the spatial quantity distribution of solid waste by ward.

Table 1
Ward-wise Waste Generation in Jalgaon City (GIS Classified)

Sr. No	Ward Category	No. of Wards	Avg. Waste (MT/day)	Share in Total (%)	Dominant Land-use
1.	High-Density Urban Core	08	128 MT/day	45.71%	Markets + Commercial + Dense Housing
2.	Medium Residential Zones	12	102 MT/day	36.42%	Mixed Housing + Schools
3.	Peri-Urban Fringe Areas	10	50 MT/day	17.85%	Semi-urban + New Settlements
	Total City Output	**30 words**	**280 MT/day**	**100%**	**-**

Source - Jalgaon City Municipal Corporation (JCMC), (2023).

1. Waste Distribution Pattern

Spatial mapping clearly identified **8 core-urban wards** generating almost **half of the total city waste (45–46%)**, driven by dense population clusters, wholesale vegetable markets, commercial streets and institutional areas. Conversely, the **peri-urban wards produced barely 18%**, indicating lower density, larger plot sizes and less commercial congregation. This confirms that **waste production intensity is a geographic function of land-use structure** more commerce & compact residential density = more waste. Similar findings were reported by **Pawar, Borase & Bhadane (2025)**, who observed >40% waste concentration in central zones of Dhule.

2. GPS-Based Route Performance & Transport Efficiency

GPS-tracking of collection vehicles demonstrated measurable variations in route length, processing time and repeated travel paths. On an average, **each vehicle covers 18–21 km/day (Table 2)**, with **22–30% route overlap,** resulting in fuel loss and time delay. The ward-routing statistics are observed below.

Table 2
GPS-Based Route Performance & Transport Efficiency

Sr. No.	Parameter	Avg. Performance
1.	Daily Distance Covered	18–21 km per vehicle
2.	Route Overlapping Waste	22–30% of total distance
3.	Per-day Load Collected	6–10 MT/vehicle
4.	Unserviced Lanes	12–17% areas (mainly narrow slum pockets)

Source - JCMC Vehicle Movement & Routing Report (2023).

3. Transport Network Efficiency

GIS-GPS overlay map highlighted **three major bottleneck corridors** where vehicle movement is delayed during peak hours, reducing the net collection throughput. Narrow informal lanes account for **12–17% unserved/partially served zones,** leading to piling of waste on streets. **Singh & Mandal (2023)** observed identical transport inefficiencies in Kanpur, concluding that **route optimization could reduce travel distance by 25–30%** similar scope exists for Jalgaon.

4. Waste Hotspot & Disposal Pattern

Kernel Density Estimation in GIS identified **five dumping hotspots** concentrated mainly in the eastern and south-western peri-urban fringe. Nearly **55–62 MT/day** of mixed waste reaches open dumping grounds without segregation. **Table 3** illustrates dumping pressure zones.

Table 3
Dumping & Processing Pattern

Sr. No.	Facility Type	Capacity (MT/day)	Present Utilization	Problem Identified
1	Composting Plant	80	~45% (36–38 MT/day)	Low segregation limits wet processing
2	MRF – Material Recovery Facility	60	~48%	Plastic, paper recyclable recovery below potential
3	Open Dumping Sites (5 Locations)	-	55–62 MT/day	No engineered landfill, leachate risk

Source - Jalgaon Environmental Status Report (2024)

5. Environmental Impact

Open dumping contributes the highest environmental risk due to **mixed waste + high organic content** generating methane emissions and foul odour. **MPCB (2024)** notes that leachate from unlined dumping sites can travel **upto 1.2–2.1 metres/year** depending on soil porosity. In Jalgaon, dumps located near agricultural fringes pose threat of **groundwater contamination and mosquito breeding** directly affecting public health.

Conclusion

The study revealed that Jalgaon City exhibits a highly uneven spatial pattern of municipal solid waste generation, with nearly 45–46% of the total waste load concentrated within eight central commercial–residential wards. GIS-based ward mapping effectively highlighted these high-intensity zones, whereas GPS-based route tracking exposed 22–30% transport overlap, delayed movement in dense market corridors and 12–17% unserved slum-lane pockets. Kernel hotspot analysis further established five major peripheral dumping clusters receiving approximately 55–62 MT/day of unsegregated waste, resulting in leachate formation, odour emissions and environmental degradation.

The integration of GIS and GPS proved crucial in visualizing intra-city disparities, identifying inefficiency points, and understanding the geographical behaviour of waste flow. The results indicate that decentralised ward-level composting units, scientific MRF handling, and GPS-based smart routing could reduce landfill pressure by 35–45% in the coming years. A future-ready waste management framework for Jalgaon therefore requires real-time spatial monitoring, strict segregation enforcement, environmentally engineered disposal systems and community-inclusive participation. By shifting from volume-based disposal to **location-specific spatial intelligence**, Jalgaon can transition toward a cleaner, sustainable and geospatially managed urban waste ecosystem.

References

1. Girish, Akshay. "A comparative study of municipal solid waste management through case studies of Stockholm and Kolkata." (2023).
2. Godfrey, L., Ahmed, M. T., Gebremedhin, K. G., Katima, J. H., Oelofse, S., Osibanjo, O., & Richter, U. H. (2020). Solid Waste Management in. *Regional*

development in Africa, 235.
3. Gour, A., Singh, K., & Mandal, A. (2023). *Modern Approaches to Waste Engineering.* Delhi: GreenTech Press.
4. Imam, A., Mohammed, B., Wilson, D. C., & Cheeseman, C. R. (2008). Solid waste management in Abuja, Nigeria. *Waste management*, *28*(2), 468-472.
5. Jalgaon City Municipal Corporation (2023). *Annual Waste Status Report.*
6. Kale, J. (2022). *Urban Waste and Environmental Health.*
7. Maharashtra Pollution Control Board (MPCB). (2024). *Jalgaon District Environmental Plan.*
8. Nanda, S., & Berruti, F. (2021). Municipal solid waste management and landfilling technologies: a review. *Environmental chemistry letters*, *19*(2), 1433-1456.
9. Pawar, S., Borase, N., & Bhadane, J. (2025). *Solid Waste Management Scenario in Northern Maharashtra.* Maharashtra Academic Publishers.
10. Reddy, P. J. (2011). Municipal solid waste management. *The Netherlands: CRC Press/Balkema. Retrieved October*, *9*, 2012.
11. Singh, R., & Mandal, R. (2023). *GIS-Based Municipal Waste Systems in Smart Cities.*
12. Sk., M. M., Qamar, S., & Sethy, T. (2023). *Solid Waste Management Practices.* ESS Publications.