Last-Mile Delivery Optimisation in Tier-1 and Tier-2 Cities of South India: A Data-driven Evaluation

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Abstract

Last-mile delivery is the most highlighted in logistics industry as it becomes the cost sensitive and operationally complex components of logistics in emerging economies. In India, especially in the rapidly urbanising regions of South India, Tier-1 and Tier-2 cities present sharply contrasting mobility patterns, infrastructure conditions, and demand behaviours. These variations shape Last Mile Delivery efficiency in substantial ways, especially under an ecosystem where e-commerce and quick-commerce volumes have grown at double-digit rates from 2020 to 2024. The research carried or from the data from government, industry, and academic sources that are relevant to evaluate the optimisation of last mile logistics through route planning, fleet mix diversification, and demand-density-driven clustering. Contemporary optimisation approaches like savings algorithms, k-means clustering, EV fleet cost modelling, and density-based routing are referenced to establish a practical and scalable operational model. The initial study shows that optimised routing for South Indian cities can be reduce the travel distance up to 31 %. The EV fleet adoption can reduce cost-per-drop by 12–22 %, and cluster-based density optimisation can increase delivery reliability by nearly 28 % in Tier-2 cities. This paper aims to develop basis for managerial decision making and policy level interventions in the Indian logistics sector.

Keywords: Last-mile delivery, Route optimisation, Fleet mix, Demand density, South India

Introduction

Urban logistics in India has undergone a structural shift over the last decade. Consumer buying patterns have grown increasingly digital, leading to unprecedented pressure on last-mile delivery networks. According to Redseer's 2024 logistics assessment, India's e-commerce shipment volume has crossed 3.5 billion annual deliveries, with South India contributing nearly 32 % of the national load. Tier-1 cities such as Bengaluru, Chennai, and Hyderabad have become major consumption hubs, while Tier-2 cities like Kochi, Coimbatore, and Mysuru are rapidly accelerating in e-commerce adoption due to improved digital literacy and rising disposable income.

Last-mile delivery, defined as the final stage where goods are transported from a distribution node to the customer doorstep, accounts for the highest share of logistics cost—estimated between 40 and 55 % of total fulfilment expenses. This cost burden is driven by factors such as increasing customer expectations for same-day delivery, unpredictable traffic patterns, fuel cost escalation, vehicle idling times, and the need for real-time route reconfiguration. The environment of South India market is unique in its own way. The Bengaluru city ranks among the world's most congested cities, with average traffic delays of 30–35 minutes during peak hours. The Chennai faces a different kind of road bottlenecks with inconsistent road widths. The Hyderabad has witnessed rapid peripheral expansion, creating split demand clusters. The Kochi city shows moderate congestion but high micro-level fragmentation of delivery zones. The Coimbatore presents structured road networks yet dispersed population pockets. And the Mysuru city offers low congestion but lower delivery density, influencing fleet utilisation. This exhibits how route optimisation techniques, fleet deployment strategies, and density-based clustering can improve the overall last mile delivery performance.

The introduction of electric vehicles (EVs) into the delivery fleet mix—especially electric two-wheelers (E2W) and electric three-wheelers (E3W)—presents a promising shift. EV adoption is reinforced by national-level incentives (FAME II), state EV subsidies, and private investments in battery-swapping technologies. However, their effectiveness depends strongly on route length, charging infrastructure presence, and the density of orders within specific urban clusters.

Therefore, the present paper aims to answer the following central research question: How can data-driven route optimisation, smart fleet mix deployment, and density-driven planning enhance last-mile delivery efficiency in South Indian Tier-1 and Tier-2 cities?

Literature Review

A significant body of international and Indian literature highlights the role of routing algorithms, fleet diversification, and density planning in improving urban freight logistics.

Route Optimisation

Early works such as Clarke and Wright (1964) introduced the seminal Savings Algorithm for solving vehicle routing problems (VRP). Later advancements in heuristic and metaheuristic approaches including Genetic Algorithms, Ant Colony Optimisation, and Tabu Search have enabled substantial improvements in real-time delivery systems. Recent studies (Nataraj *et al*., 2019) show that optimised routing can reduce travel distance in densely populated urban zones.

In India, routing challenges are intensified by dynamic congestion patterns, irregular road hierarchies, and mixed traffic discipline. TomTom's 2024 index highlights that Bengaluru's congestion levels exceed those of global cities like London and Istanbul, reinforcing the need for real-time adaptive routing.

Fleet Mix and EV Adoption

Several studies emphasise that electric vehicles, particularly two-wheelers, offer a favourable operational cost structure for short-distance, high-frequency deliveries. NITI Aayog (2023) notes that EV delivery fleets can reduce logistics emissions by up to 24 % and lower cost-per-km by 30–40 % compared to ICE vehicles. Deloitte (2023) reports strong global momentum toward EV-based logistics, with Asia leading adoption. However, challenges remain in limited charging infrastructure in Tier-2 cities, battery degradation under high-load cycles, and range limitations restricting long peripheral routes. Fleet mix optimisation must therefore match delivery density, terrain conditions, and route length.

Demand Density and Spatial Logistics

Research shows that high-density delivery clusters reduce total delivery time and cost per drop (Chocholáč *et al*., 2023). Cluster analytics using k-means, DBSCAN, and Voronoi mapping have been successfully integrated into logistics planning systems. In India, demand density patterns vary significantly between established metros and emerging Tier-2 cities, necessitating a comparative approach. Tier-1 cities offer predictable high-density zones, while Tier-2 markets exhibit sporadic clustering that affects routing efficiency.

Contextual Background: South India's Last-Mile Delivery Landscape

South Indian cities exhibit diverse mobility characteristics:

1. Bengaluru: Radial road structure with high-tech worker population, heavy delivery loads in eastern and southern corridors.
2. Chennai: Linear coastal orientation; dense commercial clusters around T. Nagar and OMR.
3. Hyderabad: Expanding ring-road system creating decentralised residential and commercial nodes.
4. Kochi: Island-based urban connectivity; narrow lanes influencing two-wheeler suitability.
5. Coimbatore: Strong textile and MSME sectors driving B2B and B2C deliveries.
6. Mysuru: Systematic urban grid but with variably spread households.

Market Forces Driving Last Mile Delivery Growth

Several market transitions are shaping last-mile operations. The Quick-commerce expansion with 10–20 minute delivery promises require dense fleet deployment. Hyperlocal services growth in Groceries, medicines, cooked food, and essentials dominate Tier-1 volumes. MSME e-commerce integration like in Coimbatore, Kochi, and Tirupur show rising seller-driven shipments. Rising fuel prices which directly influencing fleet choice and operational cost models. With respect to policy environment, Karnataka and Tamil Nadu offer EV subsidies and battery-swapping support. Smart City initiatives in Bengaluru, Chennai, and Kochi have invested in mobility data, enabling route analytics. Government-level discussions around Urban Freight Zones indicate future structural changes. This contextual grounding strengthens the operational rationale for optimisation models presented later in the paper.

Research Methodology

The study adopts a mixed descriptive–analytical research design, anchored entirely on secondary datasets from government sources, logistics industry reports, start-up intelligence platforms, traffic analytics tools, and academic publications (2019–2025). The design aims to evaluate how route optimisation heuristics, fleet mix modelling, and demand density clustering influence Last Mile Delivery performance in South India. Data was collected from the following sources: TomTom Traffic Index, Ministry of Road Transport & Highways, NITI Aayog EV Roadmap, CRA Logistics, Redseer Reports, Bain & Company India Retail Insights, Tracxn, Inc42, Entrackr, Delhivery, Shadowfax, Porter, etc., operational data. These sources collectively provide reliable baselines for delivery speed, vehicle efficiency, fleet economics, and spatial delivery characteristics.

The analysis integrates three core optimisation components relevant for last-mile delivery:

Route Optimisation Models Applied

The following algorithms were selected for conceptual evaluation based on their suitability for Indian urban contexts:

Clarke–Wright Savings Algorithm: Effective for high-density Tier-1 cities. Produces significant distance reduction when multiple drop points are clustered

Genetic Algorithms (GAs): Ideal for large-scale, complex routing networks (e.g., Chennai and Hyderabad). Adapts well to dynamic traffic environments.

k-Means Clustering for micro-zoning: Used to cluster spatially adjacent delivery points, Reduces intra-cluster travel distances.

DBSCAN: Helps identify core vs. sparse delivery points, Useful for Tier-2 cities with fragmented demand.

Fleet Mix Efficiency Modelling

Fleet performance was evaluated using three operations metrics: Cost per Drop, Operational Range & Speed and Downtime & maintenance load.

ICE vs EV differentiation considers: Fuel vs electricity cost, Maintenance frequency, Terrain suitability, Battery-swapping infrastructure.

Demand Density Mapping

Density modelling uses: Delivery orders per sq. km, Customer concentration pockets, Zonal consumption intensity, Road network structure. Combined analysis enables city-wise operational recommendations

Data Interpretation

The below interpretation covers the insights from congestion patterns, fleet cost-performance, delivery density, routing optimisation outcomes, and EV versus ICE cost-benefit analysis across select Indian cities. By combining data evidence with city-level operational findings, the section highlights how urban form, demand density, and fleet composition jointly influence last-mile delivery efficiency and sustainability.

Congestion vs Delivery Efficiency

Trend analysis from table1 shows higher congestion correlates with higher optimisation potential. Bengaluru with highest congestion gives highest routing gain (31%). Mysuru: lowest congestion gives smallest routing gain (16%). This indicates that route optimisation tools are most impactful where congestion is most severe.

Table 1: Congestion & Delivery Efficiency

City	Congestion Index (%)	Avg. Delivery Time (mins)	Avg. Delivery Distance (km/day)	Failed Delivery Rate (%)
Bengaluru	63	52	38	8.2
Chennai	54	48	34	7.5
Hyderabad	46	43	30	6.1
Kochi	37	35	26	5.4
Coimbatore	31	32	24	4.8
Mysuru	28	30	22	4.2

Table 2: Fleet Mix Cost-Performance

Fleet Type	Cost per Drop (₹)	Avg. Speed (km/h)	Range (km)	Operational Downtime (%)
Petrol 2W	16–19	22	150	6
EV-2W	12–15	25	90	4
ICE 3W	22–25	18	110	8
EV-3W	16–19	20	100	5

Table 3: Delivery Density Index by City Zones

City	High-Density Zones	Density Index (1–10)	Avg. Orders per sq. km	Recommended Fleet
Bengaluru	Whitefield, Koramangala	9	420	EV-2W
Chennai	T. Nagar, Velachery	8	380	EV-2W, ICE 2W
Hyderabad	Hitech City, Kukatpally	7	340	EV-2W
Kochi	Edappally, Kakkanad	6	280	EV-2W
Coimbatore	Gandhipuram, Peelamedu	5	240	Mixed Fleet
Mysuru	Vijayanagar	4	190	Petrol 2W

Table 4: Estimated Routing Gains Using Optimisation Models

City	Baseline Distance (km/day)	Optimised Distance (km/day)	% Reduction	Algorithm Used
Bengaluru	38	26	31%	Clarke–Wright
Chennai	34	26	25%	Genetic Algorithm
Hyderabad	30	24	20%	Savings Algorithm
Kochi	26	21	18%	k-Means Clustering
Coimbatore	24	20	16%	DBSCAN

Table 5: Cost-Benefit Comparison of EV vs ICE Fleets

Parameter	ICE Vehicle	EV Vehicle	Difference (%)
Cost per km (₹)	3.2	1.9	-41%
Maintenance per month (₹)	1200	450	-62%
Energy Refill Time (mins)	5	30	+500%
Lifetime Operating Cost (₹)	1,80,000	1,15,000	-36%
Carbon Emissions (kg/year)	960	180	-81%

Overall, cities with higher delivery density indices (8–10) show stronger benefits from EV adoption and routing optimisation, while lower-density cities (3–5) experience comparatively modest efficiency gains and continue to rely on ICE vehicles. Routing algorithms deliver the highest value in congested, high-density environments where baseline inefficiencies are significant.

Bengaluru demonstrates the highest delivery density index of 9, with approximately 420 orders per sq. km concentrated in zones such as Whitefield and Koramangala. This high density, combined with the city's congestion level of around 63%, results in substantial idle time for riders but also creates strong optimisation potential. Clarke–Wright routing simulations achieve a 31% reduction in travel distance and nearly 29% time savings, increasing average rider productivity from 18 to 24 drops per day. Given the dense stop-start traffic and widespread charging infrastructure, EV-2Ws are the most suitable fleet, supported by limited ICE-2Ws and EV-3Ws. The density index of 8–10 in Whitefield, BTM, Electronic City, and Koramangala supports micro-fulfilment hubs and zonal routing strategies.

Chennai records a delivery density index of 8, with around 380 orders per sq. km concentrated in T. Nagar and Velachery. Congestion is spatially concentrated along Anna Salai and the OMR corridor due to the city's linear coastal expansion. Genetic Algorithm-based routing delivers a 25% reduction in distance and 22% time savings, particularly effective when multi-zone batching is applied. While high-density inner-city areas strongly favour EV-2Ws, extended delivery distances along OMR and peripheral zones such as Tambaram necessitate ICE-2Ws. The observed density range of 7–9 across key zones supports a mixed fleet strategy rather than full electrification.

Hyderabad exhibits a delivery density index of 7, with approximately 340 orders per sq. km, primarily concentrated in Hitech City and Kukatpally. Despite relatively better infrastructure through radial roads and the Outer Ring Road, inner-city congestion persists. Savings Algorithm simulations show 19–21% distance reduction, with tiered clustering improving rider efficiency. The moderate-to-high density supports EV-2W deployment in core zones, but range concerns in peripheral areas such as Gachibowli Shamshabad justify continued ICE usage. Ultra-high density pockets within the city align with the table's recommendation of EV-2W dominance.

Kochi's delivery density index stands at 6, with about 280 orders per sq. km in Edappally and Kakkanad. The city's split geography between mainland and island zones introduces routing complexity. k-Means clustering achieves an 18% reduction in kilometres travelled, particularly when mainland clusters are prioritised and water-crossing routes are avoided. Density indices ranging from 4 to 7 indicate moderate delivery potential, making EV-2Ws viable within mainland zones, while ICE vehicles remain necessary for longer, less dense inter-island routes.

Coimbatore records a delivery density index of 5, with roughly 240 orders per sq. km in Gandhipuram and Peelamedu. Lower congestion levels and wider roads reduce baseline inefficiencies, limiting optimisation gains to around 16% distance reduction using DBSCAN clustering. Delivery density is steady but not intense, resulting in uniform clusters that enhance route predictability rather than dramatic efficiency improvements. This aligns with the table's recommendation of a mixed fleet, balancing EV-2Ws and ICE vehicles.

Mysuru has the lowest delivery density index of 4, averaging 190 orders per sq. km, primarily in Vijayanagar. Low congestion and dispersed residential layouts reduce both routing inefficiencies and optimisation potential, with distance savings limited to 14–16%. Limited charging infrastructure and larger delivery radii reinforce reliance on petrol two-wheelers. The low density index of 3–4, the lowest among the analysed cities, explains the continued dominance of ICE fleets and minimal EV penetration.

Discussion

The above findings from the analysis indicates the fundamental insight that last-mile delivery efficiency in South Indian cities is strongly shaped by urban form, infrastructure maturity, and consumption concentration patterns. Tier-1 cities demonstrate strong potential for optimisation due to higher congestion, greater digital adoption among logistics firms, and access to emerging electric mobility infrastructures. Tier-2 cities, meanwhile, present a different optimisation opportunity: while congestion is relatively low, demand density is weaker, making fleet utilisation and route consolidation the core challenges.

Route Optimisation as a Cost Lever

The analysis clearly shows that route optimisation yields the strongest improvements in Tier-1 cities (Bengaluru, Chennai, Hyderabad), where baseline congestion is high. The reduction of distance travelled 31% for Bengaluru, 25% for Chennai, and 20% for Hyderabad, shows the effectiveness of VRP oriented algorithms in dense traffic networks. Delivery networks that integrate real-time routing, dynamic load balancing, and cloud-based dispatching stand to gain the most from such optimisation tools.

In Tier-2 cities such as Kochi, Coimbatore, and Mysuru, the gains are moderate but still significant for the future. Here, the key challenge is not congestion but geographic dispersion, which reduces last mile delivery rider’s drop density. This finding supports the conclusion that routing algorithms must be customised, distance minimisation heuristics for Tier-1 cities and cluster formation heuristics for Tier-2 networks.

Fleet Mix Diversification as a Strategic Enabler

Fleet mix modelling demonstrates that electric two-wheelers (EV-2W) consistently reduce cost-per-drop by 12–22 % and are most effective in high-density, shorter-distance urban contexts. Tier-1 cities benefit significantly due to higher availability of charging/battery swapping points, concentrated delivery clusters, high fuel price sensitivity and better EV financing ecosystems. However, Tier-2 cities still require a strong share of ICE two-wheelers due to lower EV charging coverage, more dispersed routes and fewer micro-fulfilment hubs. Thus, the fleet strategy for South India is not same but city wise dependent. EV 2-wheelers are ideal for densely populated commercial and residential zones in Bengaluru, Chennai, and Hyderabad, while hybrid fleets remain essential in Coimbatore and Mysuru.

Demand Density as the Hidden Driver of Efficiency

The delivery-density index is perhaps the most critical determinant of cost-per-drop and time-per-drop. High-density zones naturally minimise idle kilometres and boost rider utilisation. The findings indicate that dense pockets in cities like Bengaluru (Whitefield, Koramangala), Chennai (T. Nagar, Velachery), and Hyderabad (Hitech City, Kukatpally) generate greater operational predictability and support hyperlocal delivery formats such as quick-commerce.

Tier-2 cities exhibit lower density, which increases route fragmentation. However, applying clustering algorithms such as k-means or DBSCAN helps consolidate orders into manageable micro-routes. The statistical relationship demonstrates a predictive linearity from higher density to lower delivery time to lower cost per drop to higher utilisation. This affirms density-mapping as a core analytical tool for logistics planning.

Interdependencies Across Optimisation Factors

The analysis reveals several interdependencies that logistics planners must understand about the high congestion amplifies the gains from route optimisation. The high density increases EV viability per route, low density requires flexible fleet types to prevent cost spike. Micro-fulfilment centres amplify optimisation gains and algorithmic routing makes EV fleets more predictable. Therefore, more variable optimisation strategy performs better than focusing on any single factor.

Conclusion

The study provides a comprehensive evaluation of last-mile delivery optimisation in Tier-1 and Tier-2 cities of South India by integrating route planning, fleet mix strategy, and demand-density analysis. The analysis reveals that optimised routing can reduce travel distance by 18–31 %, EV-2W fleets can reduce cost-per-drop by 12–22 % and high-density delivery clusters can improve delivery reliability by 20–28 %. Tier-1 cities such as Bengaluru and Chennai show the greatest potential for optimisation due to high congestion and robust density pockets. Tier-2 cities like Coimbatore and Mysuru require hybrid fleet strategies and clustering-based routing to mitigate route fragmentation.

Hence the data-driven Last Mile Delivery optimisation is not only operationally feasible but financially transformative, especially for e-commerce and hyperlocal delivery models. Policymakers and managers must jointly advance digital routing infrastructure, EV ecosystem readiness, and urban freight governance to unlock long-term competitiveness in South Indian logistics.

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