An Empirical Study of Parking Demand and its Impact on Urban Traffic Flow: A Case Study of Agartala City

Dr. Manish Pal, Professor, Department of Civil Engineering, NIT Agartala, West Tripura, Pin: 799046

Abstract

As the capital of Tripura, Agartala is experiencing a transition from a small administrative town to a bustling commercial hub. This shift has brought an exponential increase in private vehicle ownership, leading to a severe imbalance between parking demand and available infrastructure. This paper analyzes the spatial-temporal distribution of parking demand across major corridors like Battala, Kaman Chowmuhani, and Akhaura Road. Through field surveys and traffic volume counts, this study quantifies how on-street parking reduces "effective road width" and increases the Volume-to-Capacity (V/C) ratio. Results indicate that during peak hours, on-street parking reduces traffic speeds by up to 60%. The study concludes with a framework for a Smart Parking Management System (SPMS) tailored for Agartala's unique geography.

Key Words: Parking, Peak hours, Traffic volume counts.

1. Introduction and Problem Statement

The urban landscape of Agartala is characterized by a mix of historical narrow lanes and modernizing transit corridors. As the second-largest city in Northeast India, its population density has surged, bringing with it a motorized vehicle growth rate that exceeds 10% annually. Unlike planned cities, Agartala's core commercial areas were developed before the mass adoption of private automobiles.

The primary issue is "Encroachment for Stationary Vehicles." In urban economics, road space is a finite resource. When a significant portion of this resource is occupied by stationary vehicles, the "dynamic capacity" of the road—its ability to move traffic—diminishes. This creates a paradox where the city builds flyovers (like the Battala flyover) to speed up transit, only for the "last-mile" flow to be choked by unregulated parking at the base of these structures.

1.1 Background of the Study

Agartala, the capital of Tripura, serves as the economic, political, and cultural nerve center of the state. Over the last decade, the city has transitioned from a sleepy administrative outpost into a dense urban corridor. However, this growth has been asymmetrical. While the purchasing power of the middle class has led to an explosion in private vehicle ownership—specifically two-wheelers and small hatchbacks—the physical dimensions of the city's primary roads have remained largely static.

The problem of parking is essentially a problem of **"Stationary Traffic."** Urban planners often focus on moving vehicles, yet a private vehicle remains parked for an average of 95% of its lifespan. In Agartala, where the road network is constrained by historical settlements and the Haora River, the competition for curb space has reached a boiling point.

1.2 The Agartala Context

Agartala's road network follows a radial-circumferential pattern, but many of its core business districts (CBDs) like **Battala**, **Kaman Chowmuhani**, and **Melarmath** are characterized by "organic" growth. These areas feature high-density mixed-use developments. The lack of off-street parking facilities means that the "effective width" of a 10-meter road is often reduced to 6 meters due to unregulated on-street parking. This creates a permanent bottleneck, affecting not just private commuters but also emergency services and public transit.

1.3 Objectives of the Research

The primary objectives of this study are:

1. To quantify the gap between parking demand and legal supply in Agartala's high-traffic zones.
2. To analyze the correlation between on-street parking density and the reduction in vehicular flow speed.
3. To evaluate the "Cruising Time" (the time spent looking for parking) and its contribution to overall congestion.

4. To propose data-driven solutions under the Smart City Mission framework.

2. Literature Review

Previous studies on Indian Tier-II cities suggest that parking demand is not just a function of vehicle numbers, but of land-use patterns. In Agartala, land use is "mixed-use," where residential buildings often house commercial shops on the ground floor. Most of these buildings were constructed without adhering to the building by-laws that mandate basement parking.

The regional context of Agartala is also influenced by its proximity to the international border and its role as a transit point. This brings a high volume of paratransit vehicles (E-rickshaws and Autos), which often double-park to pick up passengers, compounding the congestion caused by private cars.

2.1 The Concept of "Induced Demand" in Parking

The works of **Donald Shoup (The High Cost of Free Parking)** serve as a foundational pillar for this study. Shoup argues that underpriced or "free" on-street parking acts as a hidden subsidy for car owners, encouraging vehicle use and leading to "parking saturation." In Agartala, the nominal or non-existent parking fees in many areas encourage long-term occupation of premium street space, which could otherwise be used for traffic circulation.

2.2 Impact on Road Capacity and Level of Service (LOS)

According to the **Highway Capacity Manual (HCM)**, the presence of parked vehicles on the side of a road introduces "lateral clearance" issues. Drivers in the adjacent lane naturally slow down to avoid potential collisions with opening car doors or pedestrians emerging from between parked cars. This phenomenon, known as the **"friction effect,"** reduces the saturation flow rate of the lane.

In Agartala, due to the extreme shortage of space, many vehicles resort to **perpendicular parking** on roads meant only for parallel spots, effectively killing two lanes of traffic.

2.3 The "Cruising for Parking" Phenomenon

Research by **Arnott and Inci (2006)** suggests that in dense urban cores, up to 30% of traffic consists of drivers circling the block looking for a spot. This "cruising" adds unnecessary vehicle kilometers traveled (VKT), leading to higher CO2 emissions and fuel wastage. In the context of Agartala's narrow arteries like **HGB Road**, a single car cruising at 5 km/h looking for a spot can cause a "moving bottleneck" that stretches for several hundred meters.

2.4 Global vs. Local Solutions

While Western cities have moved toward "congestion pricing" and "park-and-ride" systems, Indian Tier-II cities like Agartala face unique challenges:

- **High Paratransit Volume:** The dominance of E-rickshaws (Totos) creates a different parking dynamic compared to car-centric Western cities.
- **Mixed Land Use:** Since residential and commercial zones are intertwined, "night-time parking" (residents) and "day-time parking" (shoppers) overlap, leaving the roads with no "recovery time."

2.5 Gaps in Existing Literature

Most existing studies on parking in India focus on mega-cities like Delhi or Bangalore. There is a significant lack of empirical data regarding North-Eastern state capitals like Agartala, which have different topographical constraints and socio-economic drivers. This paper aims to fill that gap by providing localized data tables and intersection-specific analysis.

3. Methodology and Data Collection

To quantify the impact, a "Parking Accumulation Survey" was conducted over a 12-hour period (8:00 AM to 8:00 PM). Data was categorized into three segments:

1. **Parking Duration:** How long a vehicle stays in one spot.
2. **Parking Turnover:** How many different vehicles use the same spot in a day.
3. **Traffic Flow Speed:** Measured using the "Floating Car Method" through congested zones.

Table 1: Parking Accumulation Data (Excel Extract)

Location ID	Landmark/Intersection	Road Width (m)	Legal Capacity (ECS)	Peak Demand (ECS)	Deficiency (%)
AGT-CBD-01	Battala Market	9.5	110	485	77.30%
AGT-CBD-02	Kaman Choumuhani	12	150	390	61.50%
AGT-CBD-03	Post Office Choumuhani	8.5	60	310	80.60%
AGT-CBD-04	Maharaj Ganj Bazar	7	40	420	90.40%
AGT-CBD-05	Melarmath	10.5	90	280	67.80%
AGT-CBD-06	Akhaura Road	14	200	350	42.80%

4. Analysis of Parking Demand vs. Supply

The data in Table 1 reveals a "Parking Deficit" exceeding 70% in 3 out of 4 primary zones. When the deficit is this high, the "Search for Parking" (Cruising) becomes a major traffic component.

The Mathematical Correlation:

The relationship between parking and flow can be expressed by the reduction in "Saturation Flow." If S is the saturation flow of a clear road, and w_p is the width occupied by parked cars, the new capacity S_{adj} is significantly lower. In Agartala, where average road widths are 7-9 meters, a single row of parked cars (2.5m) reduces capacity by nearly 35%.

Table 2: Impact on Average Speed (km/h)

Time Interval	Two-Wheelers (Units)	Four-Wheelers (Units)	Autos/E-Rickshaws	Total Occupancy (%)
08:00 - 09:00	450	120	280	35%
10:00 - 11:00	1,200	450	650	82%
12:00 - 13:00	1,550	580	800	110% (Overload)
14:00 - 15:00	900	350	500	65%
17:00 - 18:00	1,400	520	950	98%
19:00 - 20:00	1,100	400	700	75%

5. Traffic Flow and Delay Analysis

The delay caused by parking is not just linear; it is exponential. When a vehicle maneuvers into a parallel parking spot, it creates a "bottleneck effect." In Agartala's narrow corridors like HGB Road, one car parking can stop a line of 20-30 vehicles for up to 45 seconds.

Table 3: Delay and Fuel Wastage Estimation (Daily)

Road Segment	Avg. Speed: Clear Road (km/h)	Avg. Speed: With On-Street Parking (km/h)	Speed Reduction (%)	Volume/Capacity (V/C) Ratio
HGB Road	32	12	62.50%	1.45
BK Road	35	18	48.50%	1.12
Mantribari Road	28	9	67.80%	1.6

Central Road	30	14	53.30%	1.25

This data suggests that parking inefficiency is not just a spatial problem but an environmental and economic one for the citizens of Tripura.

6. Socio-Economic Impact and Public Perception

Interviews with local shopkeepers in Maharaj Ganj Market reveal a dual-edged sword. While shopkeepers desire parking for their customers, they themselves occupy the street front with their own vehicles for 8-10 hours a day. This "Low Turnover" parking prevents new customers from accessing the area.

Furthermore, the pedestrian experience in Agartala is compromised. When cars occupy the shoulders, pedestrians are forced into the center of the road, leading to a higher risk of accidents and further slowing down vehicular traffic as drivers must navigate around people.

7. Smart City Solutions and Policy Recommendations

Agartala's "Smart City Mission" provides a window of opportunity. The following strategies are proposed based on the data:

1. **Multi-Level Car Parking (MLCP):** Rapid completion of the Old Motor Stand MLCP is critical.
2. **Variable Message Signs (VMS):** Digital boards at entry points (like Radhanagar) informing drivers of parking availability to reduce "cruising."
3. **Pedestrianization of Old Agartala:** Making certain stretches of the main market "Pedestrian Only" during peak hours, supported by peripheral parking lots.
4. **E-Rickshaw Dedicated Bays:** Organizing the paratransit sector so they do not obstruct the main flow while waiting for passengers.

8. Conclusion and Future Scope

The study concludes that parking demand in Agartala has reached a critical threshold. Without immediate intervention, the city's average peak-hour speed will likely drop to walking speeds (4-5 km/h) within the next three years. The "supply-only" approach is no longer viable; Agartala must move toward "Demand Management" via digital enforcement and tiered pricing.

Future Research: Future studies should focus on the "Elasticity of Parking Demand"—how much a parking fee increase would reduce private vehicle trips in Agartala.

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