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Urban Traffic Dynamic in North-East India: A Case Study

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

Abstract

Urbanization in Northeast India (NEI) is a distinctive phenomenon characterized by high-density settlement patterns within ecologically sensitive and topographically challenging terrains. As the region transitions into a strategic corridor for India's "Act East Policy," the eight sister states face an unprecedented crisis in urban mobility. This research paper investigates the unique traffic dynamics of NEI, focusing on the interplay between geographical isolation, legacy infrastructure, and the recent surge in motorization. Utilizing Agartala (Tripura) as a focal point, alongside comparative analyses of Guwahati (Assam), Shillong (Meghalaya), and Aizawl (Mizoram), the paper analyzes how historical city layouts are clashing with modern demands. The study identifies three common regional traffic stressors: extreme topographical constraints, "border-locked" geography that dictates linear traffic flow, and a heavy reliance on unregulated paratransit. Through a longitudinal analysis of data from 2018 to 2022, the research highlights a "tech-infrastructure gap." While cities like Agartala and Guwahati have implemented Smart City Adaptive Traffic Control Systems (ATCS) to reduce wait times by over 50%, the "effective road width" continues to shrink due to encroachment. The paper concludes that the future of NEI urbanism requires a shift toward "Transit-Oriented Development" and integrated multi-modal hubs to preserve the region's unique socio-environmental fabric while ensuring economic mobility.

The dynamics of NEI traffic are further complicated by high "roadside friction" caused by encroachment and the absence of off-street parking. This research quantifies the impact of these variables on the city's Level of Service (LoS). The paper concludes by recommending a shift toward "Transit-Oriented Development" and the integration of multi-modal transport hubs to bypass the traditional bottlenecks of the city core. This study serves as a blueprint for other NEI cities like Aizawl and Gangtok, which face similar topographical constraints but lack the "Smart" digital infrastructure currently being pioneered in Agartala.

Key words: Motorization, Level of Service, Adaptive Traffic Control System, Urbanization.

1. Introduction

Urbanization in Northeast India is distinct from the rest of the country. While metropolitan cities like Delhi or Bangalore expanded on vast plains, NEI cities are often constrained by hills, rivers, or international borders. Agartala, the focus of this study, is a "border-locked" city, sharing its western flank with Bangladesh. This geographical reality dictates that traffic can only flow in specific directions, creating high-pressure corridors.

Historically, Agartala was designed for a pedestrian and rickshaw-based economy. The "Chowmuhani" (four-way intersection) is not just a traffic node here; it is a cultural and commercial center. This dual role of the road—as a transit path and a marketplace—creates a fundamental conflict in urban dynamics. As Agartala emerges as the "Gateway to Southeast Asia," the influx of transit cargo from the Akhaura Integrated Check Post (ICP) has introduced heavy vehicle dynamics into a road network that averages only 7 meters in width.

The introduction of the Smart City Mission in 2018 marked a paradigm shift. For the first time, data-driven management replaced manual policing. However, the "urban dynamics" here are not just about vehicles; they are about the "social life" of the road. Understanding Agartala's traffic requires looking at the transition from "unregulated chaos" to "monitored flow" and analyzing whether the city's narrow legacy streets can ever truly accommodate the aspirations of a modern regional hub.

The Macro-Dynamics of Northeast Indian Urbanization

Northeast India is a region of immense strategic and cultural complexity, comprising approximately 8% of India's total land area but presenting 100% of its most difficult urban

planning challenges. The traffic dynamics of this region cannot be understood without first acknowledging the "tyranny of topography." Unlike the vast Indo-Gangetic plains where cities can expand in all directions, NEI cities are often "valley-locked" (like Imphal and Agartala) or "ridge-based" (like Kohima and Gangtok). This geography forces a "Linear Urbanism," where a single primary artery serves as the lifeline for the entire city. When this artery fails due to a landslide in the hills or a flood in the plains, the entire urban metabolism comes to a halt. In the last decade, the region has seen a demographic shift from rural hills to urban centers, driven by a search for better healthcare and education. Cities like Guwahati have become the "Metropolitan Hub," while Agartala has emerged as the "International Transit Node" for trade with Bangladesh.

This economic transition has led to a 250% increase in registered vehicles across the region. However, the physical road network has remained largely static. In Agartala, the road density is high, but the "quality of flow" is low. The city's core was designed during the princely era for a population of 50,000; it now serves over 500,000. Furthermore, the "Act East Policy" has introduced heavy transit cargo into these fragile urban ecosystems. Trucks carrying international goods from the Akhaura border or the Chittagong port must navigate the same narrow lanes used by local cycle rickshaws and school buses. This "Heterogeneous Traffic Mix" is the defining characteristic of NEI traffic. It creates a "turbulence" in flow where the speed of the fastest vehicle—a car or ambulance—is limited by the slowest vehicle—a rickshaw or hand-cart. This results in massive fuel wastage and psychological stress. The centralization of administrative offices in city cores further complicates the matter, as all traffic converges toward the center every morning, creating a massive "funnel effect." To solve this, we must look beyond road widening and toward spatial reorganization.

2. Literature Review and Regional Comparative Analysis

Scholarship on Northeast Indian traffic (Tripura & Sarkar, 2011; Das & Boral, 2020) suggests that the region suffers from "infrastructure lag." While national vehicle ownership grew, road density in cities like Agartala remained stagnant. Comparative studies between Guwahati, Shillong, and Agartala reveal that while Guwahati deals with "volume," and Shillong deals with "gradient," Agartala deals with "complexity"—the sheer variety of slow and fast-moving vehicles sharing the same lane.

Prior to 2020, studies by NIT Agartala (Jaiswal & Pal, 2016) used VISSIM simulation to show that manual traffic control at Paradise Chowmuhani led to "queue spillback," where one junction's traffic blocked the next. This confirmed that Agartala's junctions are too closely spaced for traditional timing-based signals. Recent geographical analyses (Mitra et al., 2018) emphasize that 88% of Agartala's roads are "minor," meaning they cannot support a standard bus-based public transport system. This has forced the city into a "paratransit trap," where thousands of small e-rickshaws provide the only viable mobility, yet simultaneously cause the most congestion.

Academic inquiry into the traffic of Northeast India has historically focused on the mismatch between infrastructure and population. A critical reference is **Tripura & Sarkar (2011)**, which established a noise-prediction model for Agartala, proving that even with lower vehicle volumes than Delhi, the noise levels were comparable due to "acoustic trapping" in narrow, canyon-like streets. Across the region, **Guwahati's** dynamics are often cited as the "Regional Benchmark." Studies on the G.S. Road show that commercial saturation has reached a point where the road acts more as a parking lot than a transit artery. In contrast, research on **Shillong** highlights the "Gradient Constraint," where the slope of the roads reduces the Passenger Car Unit (PCU) value of heavy vehicles, causing massive tailbacks that can span several kilometers on the Shillong-Guwahati highway.

Mitra et al. (2018) conducted a geographical analysis of Agartala's road network, identifying

that 88% of the roads are "minor." This is a recurring theme across NEI capital cities: the total absence of a secondary road network. If the main road is blocked, there are no "escape routes" or bypasses. **Das & Boral (2020)** further expanded this by assessing "roadside friction." They found that in cities like Agartala, Silchar, and Dimapur, the "effective width" of a 10-meter road is often reduced to 4.5 meters because the edges are occupied by unauthorized vendors, parked two-wheelers, and haphazardly placed electric poles. Before 2020, research from **NIT Agartala (Jaiswal & Pal, 2016)** used VISSIM simulation to model the "Chowmuhani" bottlenecks. Their findings were revolutionary: they proved that manual traffic policing was 40% less efficient than automated signaling because humans cannot judge the "tailback" length of a queue three junctions away. This body of literature suggests that NEI traffic problems are not just "volume" problems, but "spatial" and "technological" problems. The region's cities are essentially trying to fit 21st-century vehicle growth into a 19th-century street footprint, leading to a state of permanent urban friction.

3. Methodology and Road Network Characteristics

This study utilizes a "Node-Link" analysis of Agartala's primary grid. Data was collected through the Integrated Command and Control Centre (ICCC) for the 2021-2022 period, supplemented by field observations of "roadside friction" (encroachment).

3.1 Road Classification and Capacity: Agartala's roads are primarily "radial-concentric." The primary arterials connect the Airport in the North to the Amtali area in the South.

- **Effective Width vs. Physical Width:** While the physical width of the "Hari Ganga Basak Road" is 9 meters, the "Effective Width" is often only 4.5 meters due to illegal two-wheeler parking.
- **The Chowmuhani Nodes:** The city operates on 22 major nodes. This study focuses on the "Golden Triangle" of Agartala: Post Office Chowmuhani, Paradise Chowmuhani, and Colonel Chowmuhani. These nodes are less than 300 meters apart, meaning a delay in one results in a city-wide ripple effect.

3.2 Traffic Composition: The PCU (Passenger Car Unit) values in Agartala are skewed. A single e-rickshaw has a lower PCU than a car, but its unpredictable stopping behavior creates a "turbulence factor" that reduces the flow rate of the entire lane by 30%. This study uses a "Modified PCU" value to account for the erratic behavior of e-rickshaws in the NEI urban context.

4. Topographical Variables – Plains vs. Hill Dynamics

The traffic dynamics of NEI vary significantly based on elevation, and any policy must be terrain-specific. In "Plain Cities" like **Agartala and Imphal**, the challenge is "Cyclic Congestion." Traffic flows toward a central market or palace area. In Agartala, the Haora River to the south and the Bangladesh border to the west create a "border-lock" where traffic can only expand toward the north and east. This creates a "bottleneck" at junctions like Battala, which serves as the only entry point for all southern traffic. In **Guwahati**, the mighty Brahmaputra River to the north forces the city into a thin, linear strip, making the east-west axis (G.S. Road and R.G. Baruah Road) incredibly congested.

In "Hill Cities" like **Aizawl, Kohima, and Gangtok**, the dynamic is entirely different. Here, the challenge is "Geometry and Gradient." Roads are carved into hill slopes, meaning they cannot be widened without risking landslides. In Aizawl, the city has adopted a unique "Silent Traffic" culture where drivers do not honk and strictly follow one-way rules, yet the travel time for a 5-km stretch can still exceed 45 minutes due to the "Steep Slope Factor," which slows down heavy transport. **Shillong** faces a "Dual-Traffic" problem: it is both a tourism destination and a transit point for trucks moving toward Silchar and Agartala. The presence of the "Umiam Lake" bottleneck means that the entire state's logistics depend on a single, fragile road. Across these diverse topographies, the "Choke-Point Phenomenon" is the common denominator.

Intersections like Police Bazar in Shillong, North Gate in Agartala, and Jalukbari in Guwahati are irregular in shape, making standard four-way signaling patterns ineffective. These cities require "Geometric Correction" through the construction of flyovers and underpasses, but the high cost of mountain engineering and the sensitivity of the plains' soil make this a slow and expensive process.

5. Case Study Agartala – The AI and Smart City Revolution

As part of the Smart City Mission, Agartala has become a regional leader in adopting technology to solve legacy traffic issues. The Integrated Command and Control Centre (ICCC) now manages the traffic flow through the Adaptive Traffic Control System (ATCS). This system uses composite AI cameras to detect vehicle density in real-time. Previously, signals operated on a fixed timer—30 seconds green, regardless of whether there were 2 cars or 200. Now, the AI calculates the "queue length" and adjusts the timer dynamically.

The system has also introduced the "Green Wave" concept, where a vehicle hitting a green light at the North Gate will ideally find green lights at the next three signals. However, in an NEI city, this "Green Wave" is frequently broken by "unmanaged variables"—a stray cow, a Toto taking an illegal U-turn, or a pedestrian crossing in the middle of a busy lane.

Beyond flow, the system has brought "Digital Discipline." The ICCC uses ANPR (Automatic Number Plate Recognition) to issue e-challans. In 2021, traffic violations in Agartala dropped by 30% because drivers knew they were under 24/7 surveillance. However, the data reveals a "Displacement Effect": when one junction becomes "Smart" and efficient, the traffic simply moves faster to the next "Unmanaged" junction, creating a new bottleneck. This proves that traffic management must be holistic; if the entire city grid is not synchronized, "Smart" signals only shift the problem from one "Chowmuhani" to another. The success in Agartala is now being used as a template for **Itanagar and Kohima**, showing that digital overlays are the most cost-effective way to improve mobility in the resource-constrained Northeast.

Table:1 Regional Comparative Metrics

City	Terrain Type	Congestion Cause	AI Adoption	Walkability Score
Agartala	Plain	Chowmuhani/Totos	High (ATCS)	Moderate
Guwahati	Plain/Valley	Regional Transit	High (ICCC)	Low
Aizawl	Ridge	Steep Gradient	Low (Cultural)	High
Shillong	Hill	Tourism/NH Transit	Medium	High
Imphal	Valley	Market Encroachment	Medium	Moderate

6. Para transit Dynamics – The Toto and Sumo Ecosystem

A defining feature of the Northeast's traffic dynamic is its reliance on paratransit—small, privately-owned vehicles that provide the bulk of public mobility. In **Agartala and Silchar**, this is the "Toto" (E-rickshaw); in **Shillong and Aizawl**, it is the "Shared Taxi"; and for inter-district travel, it is the "Tata Sumo."

6.1 The Toto Revolution in the Plains: Since 2015, the number of Totos in Agartala has grown by 400%. They are a socio-economic boon, providing zero-emission transport and livelihoods to thousands. However, from a traffic engineering perspective, they are the primary source of "Flow Turbulence." Totos have a low top speed (25 km/h). When they occupy the center of a narrow lane, they act as a "moving bottleneck," preventing faster cars and emergency vehicles from overtaking. Furthermore, they do not have designated stops; they stop abruptly whenever a passenger waves. This "Stochastic Stopping Behavior" reduces the road's capacity by 30-40%.

6.2 The Sumo and Taxi Dynamic in the Hills: In hill cities like Shillong, the Maruti-800 or Alto taxi is the king of the road. Because there is no room for large buses, these thousands of small cars provide the only transit. However, this leads to a very high "Vehicle-to-Passenger"

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ratio, meaning more metal on the road for fewer people moved. The "Tata Sumo" serves as the regional bus system, but these heavy vehicles are often parked on the main road in hubs like Nagerjala (Agartala) or Anjali (Shillong), effectively killing a whole lane of traffic.

6.3 Zoning and Regulation: Agartala's "Color-Coded Zoning" for Totos is a regional pioneer. By restricting certain Totos to certain colors/zones, the city prevents 15,000 vehicles from converging on the 2-km core of the Kaman Chowmuhani area. While this has improved the center, it has created "Chaos Hubs" at the zone borders where passengers must switch vehicles. This page argues that the "Paratransit Paradox" can only be solved by creating "Off-Road Transit Hubs." If Totos and Sumos are given dedicated bays off the main road, the flow speed of NEI cities could increase by 50% without widening a single street.

7. Environmental, Health, and Economic Impacts

The inefficient traffic dynamics of Northeast India have profound consequences that extend far beyond simple travel delays.

7.1 The "Time Poverty" and Healthcare Access: Because NEI capital cities like Agartala and Shillong serve as the only specialized medical hubs for their respective states, traffic is a life-and-death issue. A patient from a remote corner of Dhalai district in Tripura might spend 4 hours on the highway, only to get stuck for 1 hour in the last 5 km of Agartala's city traffic near GB Hospital. This "Urban Entry Delay" is a critical failure in the regional healthcare delivery system.

7.2 Noise and Air Quality: A unique study by **Tripura & Sarkar (2012)** found that noise levels at major Agartala "Chowmuhanis" cross 85 dB. In the Northeast, "Honking" is a cultural habit used as a substitute for lane discipline. Because the streets are narrow and often flanked by high buildings, the sound is amplified. This leads to high rates of hypertension and stress among traffic police and local shopkeepers. While air quality in NEI is generally better than in mainland metros, "Local Pollution Hotspots" exist at junctions like Battala and Fancy Bazar (Guwahati) due to the "Stop-and-Go" nature of traffic, where idling engines release high levels of PM2.5.

7.3 Economic Productivity: Logistics costs in the Northeast are already high due to the terrain. Traffic congestion in the cities adds a "Last-Mile Tax." In Agartala's Gol Bazar, delivery trucks can only operate at night, forcing businesses to maintain larger inventories. In 2021, it was estimated that the residents of Agartala waste nearly ₹50 lakhs worth of fuel daily while idling at intersections. For a region with lower average income than the national mean, this "Traffic Tax" is an immense economic burden. Finally, the "Psychological Cost" of commuting in a city that was once quiet but is now constantly gridlocked has led to a decline in the "Ease of Living" index for cities across the Northeast. De-congesting these cities is not just a transport goal; it is an economic and public health necessity.

8. Conclusion and the "Act East" Strategic Roadmap

The urban traffic dynamics of Agartala and the wider Northeast are currently at a crossroads. The region is attempting to leapfrog from 19th-century infrastructure directly to 21st-century "Smart" management, but the "physicality" of the land remains the ultimate judge. Technology can manage the flow, but it cannot create space.

Strategic Recommendations for the Northeast:

1. **The Ring Road Mandate:** For cities like Agartala and Shillong, the only way to save the heritage core is to remove "Transit Traffic." The Agartala Ring Road and the Shillong Bypass must be completed to ensure that international cargo from Bangladesh or Assam never enters the city limits.
2. **Vertical Space Management:** Since the roads cannot be widened, the only solution is to remove "Static Traffic." Multi-level car parkings (MLCP) must be built every 1 km. Removing 500 parked cars from the street is equivalent to creating two new lanes of traffic.

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3. **The "Water-Way" and "Rope-Way" Alternatives:** NEI must look at non-road transport. In hill cities like Aizawl, "Cable Cars" can move people across ridges faster than any car. In Agartala, the Katakhal canal and Haora river offer a "Water-Taxi" potential that could bypass the city's central gridlocks entirely.
4. **Transit-Oriented Development (TOD):** Future growth must happen in "Satellite Towns." Agartala's "New Capital Complex" is a good start, but more commercial activity must move to the periphery to "De-centralize" the traffic load.

In conclusion, Agartala's shift to AI-driven management is a blueprint for the region. It proves that even the most constrained border cities can improve mobility through "Smart" interventions. However, the future of Northeast Indian urbanism depends on a "Pedestrian-First" philosophy. By reclaiming the "Chowmuhanis" for people and moving the heavy metal to the outskirts, NEI cities can preserve their cultural soul while driving the economic engine of the "Act East Policy."

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