Impact of Urban Sprawl on Travel Demand for Public Transport and Private Transport in PCMC (Pimpri - Chinchwad Municipal Corporation)

Prof. Dr. Minaxi Rai Sharma

Saurabh Ale, Mrudula Deshmukh , Gaurav Wagh , Vaibhavi Pangaonkar, Sharad Pawara

Students from Department of Civil Engineering, JSPM's Rajarshi Shahu College of Engineering, Tathawade- 411033, Pune, India.

ABSTRACT - What is Urban Sprawl?

Sprawl happens when urban development prioritizes space over density, often fueled by cheaper land on city outskirts, population growth, and car-centric planning. You get sprawling suburbs with big houses, wide roads, and lots of parking, but the trade-off is a fragmented urban fabric. For your project, think of bus stops as the glue trying to hold this messy sprawl together-except they're often stretched too thin to work well.

Key words: flexural test, bamboo reinforcement, Strength hybrid beam, cost analysis.

INTRODUCTION-

Urban sprawl refers to the uncontrolled expansion of urban areas into peripheral rural or undeveloped land, characterized by low-density housing, segregated land uses, and heavy reliance on automobiles. As cities grow outward rather than upward or in a compact form, the spatial distribution of homes, jobs, services, and amenities becomes more spread out. This change significantly influences travel behavior and demand for different modes of transport.

One of the most notable effects of urban sprawl is the increased reliance on private vehicles. In sprawling areas, destinations are typically located farther apart, making walking, cycling, or using public transportation less practical or convenient. As a result, residents tend to favor personal cars for commuting, shopping, and other daily activities. This leads to longer average trip lengths, higher vehicle ownership rates, and increased traffic congestion and emissions.

In contrast, public transport systems often struggle to remain viable and efficient in sprawling environments. Public transit—especially fixed-route services like buses or trains—relies on dense, concentrated populations to be cost-effective. Low-density developments reduce the number of potential riders per route, increase operational costs, and lead to longer, less direct routes with lower service frequency and reliability. Consequently, public transport becomes less attractive and further contributes to the preference for private vehicles.

It is a critical urban issue with far-reaching impacts on transport demand, environmental sustainability, and social equity. Its relevance lies in its direct influence on how cities function and grow, making it a central concern in developing sustainable and inclusive urban policies. Addressing its challenges requires a shift toward smart growth principles, compact development, and integrated land use and transport planning.

Urban sprawl, which became widespread in the mid-20th century—particularly in North America and parts of Europe—was driven by factors such as rising car ownership, affordable land on city outskirts, and policies favoring suburban development. Over time, this pattern of growth has significantly shaped travel demand and transportation infrastructure.

How it affect the transportation system

1. Longer Distances: Sprawl stretches homes and jobs apart, spacing bus stops too far to be walkable, cutting transit use.

2. Car Dominance: Low density makes frequent bus routes or dense stop networks impractical, pushing people to drive.

3. Congestion Hotspots: Key bus stops near highways or malls get clogged as drivers pile in, worsening traffic.

4. Costly Expansion: Extending roads and routes to sparse areas raises costs, but stops serve fewer riders, draining funds.

5. Weak Networks: Scattered stops mean longer trips and tough transfers, making transit less appealing.

Problem Statement:

Rapid Urban Growth in Pimpri Chinchwad and Transportation Challenges

Pimpri Chinchwad, Maharashtra, has ballooned from an industrial base in the 1970s to a metro hub of over 3 million, fueled by 4,000+ industrial units (e.g., Tata Motors, Infosys) and massive migration. Urban sprawl has pushed suburbs outward, with a rising middle class and workforce driving private vehicle ownership sky-high. Public transit-like the overstretched PMPML bus network and underperforming Rainbow BRTS (50 km, far below its 900,000-passenger goal)-struggles with sparse bus stops, poor frequency, and weak last-mile links. Traffic jams choke highways and key stops, while slow metro progress (e.g., Pimpri-Nigdi) and no long-distance rail force reliance on Pune, 20 km away. Migrant laborers face long, costly commutes, amplifying inequity. The city's transport system buckles under rapid, unplanned growth, worsening congestion, emission and access gaps.

Research Objectives

1. To Assess the Impact of Urban Sprawl on Public and Private Transport

Examine how Pimpri Chinchwad's rapid urban sprawl influences the performance, ridership, and infrastructure demands of public transport systems (e.g., PMPML bus network, Rainbow BRTS) compared to the escalating reliance on private vehicles. This includes analyzing shifts in travel patterns, road congestion levels, commuter costs, and environmental impacts like emissions, driven by the city's low-density expansion and industrial growth.

1.To Analyze Accessibility and Availability of Transport in Newly Developed Areas Investigate the extent to which transportation infrastructure-focusing on bus stop placement, route frequency, and the rollout of metro lines (e.g., Pimpri-Nigdi)-meets the needs of residents in Pimpri Chinchwad's newly developed, sprawling suburbs. This involves assessing walkability to transit points, service reliability, last-mile connectivity, and disparities in access for diverse groups, particularly low-income migrant workers reliant on affordable options.

Significance of the Study

This research is crucial because Pimpri Chinchwad's rapid urban sprawl exemplifies a growing challenge faced by industrial cities in India and beyond: balancing unchecked expansion with sustainable transportation. Understanding how sprawl impacts public and private transport sheds light on why private vehicle use is surging while systems like PMPML buses and Rainbow BRTS falter, directly affecting congestion, air quality,

and commuter costs. By analyzing transport accessibility in newly developed areas, the study addresses equity -ensuring migrant workers and residents aren't left stranded-while informing urban planning to curb car dependency and emissions. For policymakers, planners, and civil engineers, this work offers actionable insights to design efficient, inclusive transport networks, making Pimpri Chinchwad a model for managing growth in fast-urbanizing regions.

Scope and Limitations

Scope: The study focuses on Pimpri Chinchwad's urban sprawl, targeting its transportation systems-public (PMPML buses, Rainbow BRTS, metro plans) and private (cars, motorcycles)-and their performance amid rapid growth since the 1990s. It examines newly developed areas post-1997 expansion, assessing bus stop coverage, transit frequency, and road network impacts, with emphasis on industrial and residential zones like Hinjewadi and Bhosari. Data collection includes commuter patterns, infrastructure stats, and stakeholder inputs (residents, workers, planners)

1. Methodology

To assess the impact of urban sprawl on travel demand For public and private transport in Pimpri-Chinchwad (PCMC)**,** several types of data sources are typically used.

Primary Data Sources

1. Comprehensive Mobility Plan (CMP) – PCMC (2012 and Updates)

Use: Core source for understanding baseline travel patterns, future demand, mode shares, and urban growth.

Data Included:

- Household travel surveys
- Trip generation and attraction data
- Mode split (public vs. private)
- Future growth scenarios

Relevance: Directly assesses how spatial growth (urban sprawl) influences travel demand.

Source: PCMC/Urban Development Department (available on PCMC official site or Scribd CMP Report)

Secondary and Supplementary Sources

2. PCMC Urban Planning and Transport Department Reports

Department Reports

- **Use**: Track infrastructure development, BRTS network, metro projects, and traffic counts.
-
- **Data Included**:
  - o Vehicle registration trends
  - o Land use changes
  - o Public transport usage statistics

Relevance: Helps correlate infrastructure expansion with travel demand trends.

Source: https://www.pcmcindia.gov.in

3. Census of India & National Sample Surveys

- **Use**: Understand demographic and socio-economic shifts driving urban sprawl and transport demand.

Data Included:

Population density changes

Employment centers and commuting distances

Vehicle ownership rates

Relevance: Useful for linking population growth to increased transport demand.

Source: https://censusindia.gov.in

4. RTO (Regional Transport Office) Data – Pune Region

- **Use**: Private vehicle registration trends and traffic volume growth.

- **Data Included**:

   Traffic Survey :

- No. Of Vehicle at particular hour
- Development of roads in 1981-2025
- Number of 2-wheelers, 4-wheelers
- Vehicle age and emissions profile

- **Relevance**: Indicates rising dependence on private vehicles due to urban sprawl.
- **Source**: Pune RTO / Maharashtra State Transport Portal

5. ITDP India / Urban Transport Reports

- **Use**: Provides qualitative and quantitative assessments of public transport infrastructure (BRT, Metro).
- **Data Included**:
  - o   BRT ridership data
  - o   Mode shift analysis
  - o   Service accessibility by income group
- **Relevance**: Highlights gaps in public transport caused by rapid horizontal urban growth.

6. Satellite and GIS-Based Land Use Maps (e.g., Bhuvan, Google Earth Engine)

- **Use**: Urban sprawl measurement using remote sensing and GIS.

Data Included:
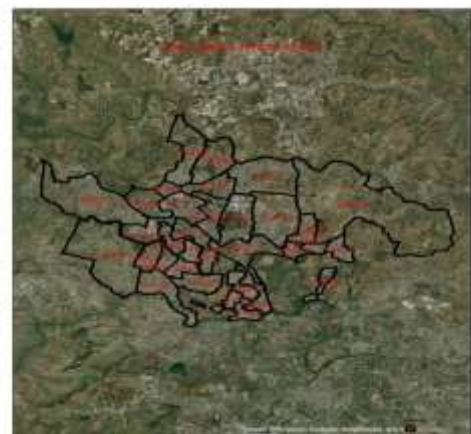
Topographical Survey:

Built-up area expansion over time

Sprawl index

Changes in land cover

Population Survey

- Area oF Land per population
- Number of person per vehicle

- **Relevance**: Enables spatial correlation with travel demand zones.
- **Source**: ISRO Bhuvan, NRSC, Google Earth Engine

Limitations:

The research is constrained by time and data availability-real-time traffic or ridership figures may be incomplete or outdated. It focuses on Pimpri Chinchwad, limiting generalizability to other cities with different growth drivers. Accessibility analysis may overlook micro-level barriers (e.g., pedestrian safety) due to broad scope, and metro impacts are speculative as projects remain underway. Primary data collection (e.g., surveys) depends on participant response, potentially skewing results.

Literature Review

Urban sprawl in Pimpri-Chinchwad has significantly influenced travel demand, leading to increased reliance on private transport and challenges for public transportation systems .

1. Population Growth and Vehicle Proliferation

Pimpri-Chinchwad's population surged from 1.7 million in 2011 to an estimated 3 million by 2025, while the number of vehicles increased by 700% over the same period. This rapid growth has resulted in a vehicle density of 663 vehicles per 1,000 residents, with two-wheelers comprising 75% of the total vehicle fleet.

2. Public Transport Challenges

Despite the introduction of the Rainbow Bus Rapid Transit System (BRTS) and the addition of over 450 electric buses, public transport remains underfunded and underutilized. A study by the Institute for Transportation and Development Policy (ITDP) revealed that Pimpri-Chinchwad's bus fleet operates at half the recommended capacity, with only 26 buses per lakh population compared to the Ministry of Housing and Urban Affairs' guideline of 60.

3. Modal Split and Travel Behavior

Data indicates that 59% of trips in the city are made on foot, 18% by bicycle, and 10% by bus. However, two-wheelers dominate the roads, comprising 80% of vehicles, while four-wheelers account for 10%. This shift towards personal vehicles is attributed to the inadequacies of public transport and the city's sprawling development.

4. Infrastructure and Traffic Congestion

Key areas like Bhosari, Pimple Saudagar, and Hinjewadi frequently experience gridlocks, disrupting daily commutes. The city's limited infrastructure, including only three underpasses on the bypass road, underscores the urgent need for comprehensive traffic planning.

5. Policy and Planning Initiatives

The Pimpri-Chinchwad Municipal Corporation (PCMC) has approved a revised Development Plan (DP) to address the city's burgeoning population, projected to rise to 6.1 million by 2041. The DP includes infrastructure upgrades such as minimum road widths of 18 meters for new roads and 12 meters in densely populated areas, as well as provisions for electric vehicle charging stations, bus terminals, and a multimodal transport hub.

The literature highlights that urban sprawl in Pimpri-Chinchwad has led to increased private vehicle usage and challenges for public transportation systems. While initiatives like the Rainbow BRTS and infrastructure upgrades are steps towards addressing these issues, sustained investment in public transport and comprehensive urban planning are essential to mitigate the impacts of sprawl and promote sustainable mobility.

Data Analysis:

1. Define Objectives and Hypotheses
Possible hypotheses:

- Urban sprawl increases reliance on private vehicles due to lack of transit accessibility.
- Sprawling neighborhoods have longer commute distances, shifting mode choice.
- Public transport demand is higher in denser, mixed-use zones.

You'll need both spatial and non-spatial datasets:

2. Data Collection

Data Type	Variables/ Fields	Sources
Land Use & Built-up Area	Land cover change, built-up expansion	Satellite data (Bhuvan, Google Earth Engine), PCMC GIS Dept.
Population & Demographics	Ward-level population, income,	Census of India, PCMC

Data Type	Variables/ Fields	Sources
	employment centers	
Travel Demand	Trip counts, mode choice, trip distance	CMP report, Travel Surveys, ITDP, RTO
Transport Network	Roads, BRTS, Metro routes	PCMC, PMPML, MahaMetro
Vehicle Ownership	Two-wheelers, four-wheelers by area	RTO Pune
Public Transport Usage	Ridership data, frequency, coverage	PMPML, ITDP

3. Urban Sprawl Measurement

Use GIS/Remote Sensing techniques

a. Sprawl Metrics:

- Built-up area growth (1990–2020)
- Urban footprint expansion
- Sprawl Index = (Built-up Area)/(Population Density)

b. Tools:

- ArcGIS/QGIS
- Google Earth Engine (for NDVI, built-up classification)
- Bhuvan or NRSC India data

4. Spatial Analysis (GIS-Based)

Overlay and correlate transport demand with urban form:

- **Buffer Zones** around BRTS/Metro stations to assess accessibility
- **Choropleth Maps** of:
  o Vehicle ownership per ward
  o Public transport usage per ward
- **Hotspot analysis** for congestion/vehicle density
- **Proximity analysis**: How far new developments are from transit corridors

5. Travel Demand Analysis

Statistical and modeling techniques:

a. Descriptive Statistics

- Mode share by zone
- Average trip length
- Vehicle ownership trends

b. Regression Analysis

To understand how land use variables affect mode choice:

c. Multinomial/Logit Models

Predict likelihood of choosing public or private transport.

- **Result and Conclusion: -**

Public Transport Improvement Plan

- Metro: Operational, under construction & Proposed
Proposed BRTS corridors.

- PMPML: Bus Augmentation, New Routes, Bus Terminal & Depots
Inter City Bus Terminal.

- Railway Proposal & Airport Connectivity.

Study Area

Category	Administrative Units	Area (Sq.km)
A. Urban Centres		
2. PCMC		181
Sub-Total (A)		**954**
B. Special		

Category	Administrative Units	Area (Sq.km)
Planning Area		
1. MADC		9
2. MIDC		98
Sub-Total (B)		108

Population & Employment Forecast (in Lakhs)
Population

Area	2011	2024	2034	2044	2054
PCMC	17.27	33.69	48.48	66.05	77.19
Cantonment	1.99	1.99	2.19	2.29	2.39
Rest of PMR	12.06	21.80	28.61	35.06	41.33
Total	66.87	103.78	133.53	166.67	192.72

Employment

Area	2011	2024	2034	2044	2054
PCMC	6.76	14.82	21.33	29.85	36.44
Rest of PMR	5.42	10.07	14.10	17.68	20.87
Total	27.54	45.67	59.95	76.71	91.04

Forecasts based on historical trends, land-use plans, growth patterns, and accessibility.

Vision & Goals
Vision:

"Transform Pimpri Chinchwad into India's most livable habitat through a people-centric, sustainable environment with seamless integration of land-use and transportation systems prioritizing safety, accessibility, and convenience."

Goals & Targets:

Goal	Target Description	Timeline
Mode Share	Public Transport: 50% of all trips	30 years
	Non-Motorized Transport (NMT): 35% of all trips*	10 years
Accessibility to Public Transport	80% population within 500m of bus stops (12 buses/hr)	5 years
	50% population within 500m of MRT stations	10 years
Jobs near Transit	60% jobs within 500m of bus stops (12 buses/hr)	5 years
	40% jobs within 500m of MRT stations	10 years
Parking Management	On-street paid parking on 30% of arterial roads	5 years
	On-street paid parking on 50% of arterial roads	10 years
	Implement IT-based parking systems	5 years

Goal	Target Description	Timeline
Electric Vehicle Adoption	10% penetration across all vehicles	5 years
	25% electrification of PMPML bus fleet	2 years
Road Safety	50% reduction in fatal accidents by 2030	5 years

Note: NMT share excludes public transport access trips. Including walk/cycle access, total NMT share rises to 70% by 2054.

Public Transport Improvement Plan
Metro Network
- **Operational:** 33.1 km (PCMC–Swargate, Vanaz–Ramwadi)
- **Under Construction:** 33.5 km (Hinjawadi–District Court, PCMC–Nigdi, Swargate–Katraj)

BRTS Corridors

Corridor	Length (km)
Ravet–Rajgurunagar via Chakan	37.8
Ravet–Talegaon Dabhade	14.1
Chandani Chowk–Hinjawadi	28.6
Total	**117.0**

PMPML Bus System
- **Existing:** 2,030 buses (473 electric), 367 routes, 12.3 lakh daily ridership.

- **Proposed Fleet Expansion:**

Year	Population (Lakhs)	Buses Required	E-Buses
2024	103.79	6,500	1,625
2034	133.55	8,000	2,400
2044	166.69	10,500	5,250
2054	192.74	15,000	15,000

- **New Routes:** 18 routes (641.9 km) identified for 2024–2054.

- **Terminals:** Redevelop 10/26 existing terminals; add 11 new terminals.
- **Depots:** Redevelop 5/16 existing depots; add 14 new depots.

Road Improvement Plan
Key Projects
- **Missing Links:** 909 gaps (552 km); prioritize 48 links (30 km).
- **Road Widening:** 419 km (283 km 2→4 lane, 89 km 4→6 lane, 47 km 6→8 lane).
- **Ring Roads:**
  o Intermediate Ring Road (70 km, planning)
  o PMRDA Inner Ring Road (83 km, land acquisition)
  o MSRDC Outer Ring Road (137 km, land acquisition)
- **Grade Separators:** 17 new flyovers/underpasses.
- **RoBs/RuBs:** 20 new; 7 widenings (e.g., Chande-Nande Bridge, Magarpatta RoB).
- **River Bridges:** 14 new; 6 widenings.
- **Junction Improvements:** 143 junctions (channelization, signal optimization, parking restrictions).

NMT Improvement Plan
Pedestrian Infrastructure

- **Footpaths:**
  o PCMC: 266 km (new)

Bicycle Network
- **Existing:** 62 km (PMC & PCMC).
- **Proposed:**
  o PCMC: 170 km

Other Plans: -
Truck Terminals & Logistics Hubs

- 7 logistics hubs (e.g., Talegaon, Chakan).

Multimodal Integration Hubs
26 hubs integrating metro, rail, PMPML, MSRTC (e.g., Pune Station, Shivaji Nagar, Bhakti Shakti).

Parking Management

- **On-Street Paid Parking:** 8 in PCMC

Cost Estimate (₹ Crore)

Proposal	Phase 1 (2024–34)	Phase 2 (2035–44)	Phase 3 (2045–54)
Public Transport			
Bus Augmentation/Terminals/ Depots	13,247	12,075	22,500
Road Infrastructure			
Ring Roads	3,582	–	–
Road Widening	2,552	381	734

Proposal	Phase 1 (2024–34)	Phase 2 (2035–44)	Phase 3 (2045–54)
Missing Links	1,921	511	129
RoBs/Bridges/Grade Separators	964	105	–
Junction Improvements	36	–	–
Parking/Lighting	54	–	–
NMT Infrastructure			
Footpaths	461	–	–
Bicycle Tracks	167	–	–
Pedestrian Facilities	77	–	–
Logistics	258	192	–