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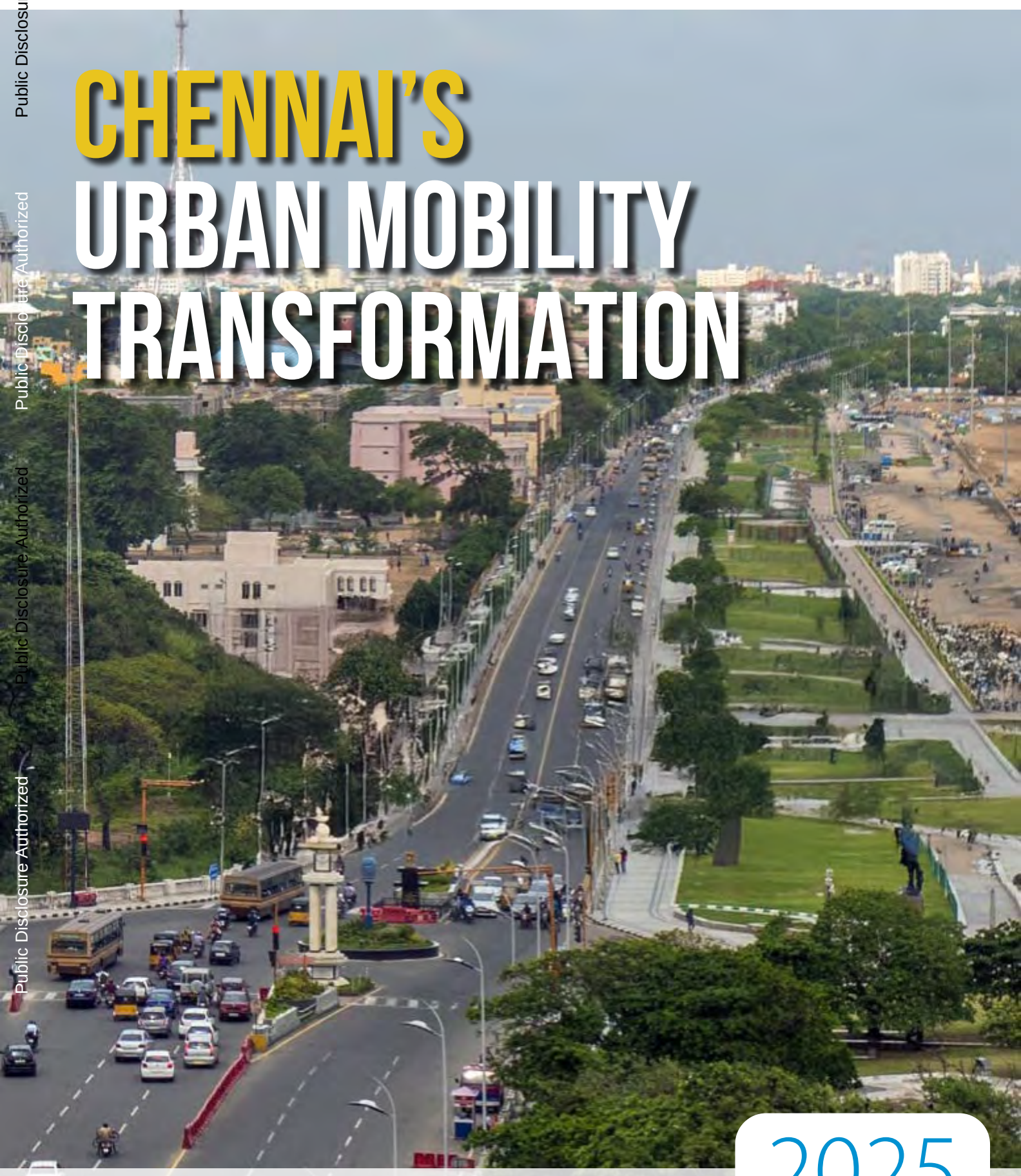
CHENNAI'S URBAN MOBILITY TRANSFORMATION



2025

EDITED BY GERALD OLLIVIER & SHYAM SRINIVASAN

METROPOLITAN TRANSPORT CORPORATION (CHENNAI) LTD
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GENDER & POLICY LAB GREATER CHENNAI CORPORATION

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Chennai's Urban Mobility Transformation

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A COMPENDIUM

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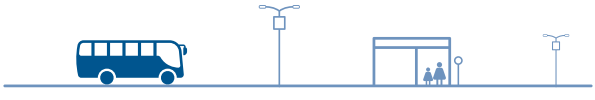

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Foreword by Auguste Tano Kouamé, Country Director for India, World Bank

India's cities are rapidly evolving, and with that evolution comes both major opportunities and complex challenges. Chennai, one of the country's most vibrant metropolitan areas, exemplifies this transformation. It is my pleasure to introduce this Compendium on Chennai's Urban Mobility Transformation, which captures the significant progress that Chennai has started making in reshaping its urban mobility system. Chennai offers valuable lessons not just for Indian cities but for urban centers worldwide.

The Chennai City Partnership, a collaboration between the Government of Tamil Nadu and the World Bank, with co-financing from the Asian Infrastructure Investment Bank (AIIB), reflects what can be achieved through dedicated partnerships and a shared vision. The first phase of the partnership, the Sustainable Urban Services Program (SUSP), has driven innovative reforms in institutions and service delivery across multiple sectors, including urban mobility. A broad range of analytical studies on urban mobility and spatial development have also been undertaken in support of ongoing planning exercises such as the Comprehensive Mobility Plan and the Third Master Plan. These efforts represent a foundational phase and a commitment to making Chennai a city where mobility is not just easier, but safer, more inclusive, and environmentally sustainable.

Strengthening urban mobility is crucial for the future of cities like Chennai. Mobility connects people to opportunities—jobs, education, healthcare, and social connections—and how we move through our cities directly affects the quality of life for millions. By enhancing public transport and making streets safer for pedestrians and cyclists, Chennai is taking important steps to tackle challenges like emissions, traffic congestion, and road accident fatalities, while also promoting social equity and economic growth.

The journey detailed in this compendium is a testament to the criticality of collaboration. It illustrates how integrated land use and transport planning, gender-responsive initiatives, and data-driven insights can help cities like Chennai navigate the pressures of rapid urbanization while building a more sustainable and inclusive future. The Green, Resilient, Inclusive, and Safe (GRIDS) framework featured in this compendium provides a thoughtful and comprehensive approach that I believe will resonate far beyond Chennai's borders.

The lessons from Chennai's experience are profound. This city's commitment to rethinking its urban mobility systems serves as an example of how cities can turn complex challenges into opportunities for innovation and progress.

I extend my sincere gratitude to the Government of Tamil Nadu and the many partners who have contributed to this ambitious work. The World Bank is proud to be part of Chennai's journey, and it is my hope that this compendium will inspire other cities around the world to pursue similar paths towards a more sustainable and inclusive urban future.

Sincerely,
Auguste Tano Kouamé
Country Director for India,
The World Bank

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Foreward by Mr. T.Udhayachandran, IAS, Principal Secretary to Government - Finance, Government of Tamil Nadu

Chennai is at a crucial juncture in its urban development. As one of India's largest and most rapidly growing cities, we are undertaking multiple actions to ensure that our urban mobility systems evolve to meet the needs of our citizens. This compendium captures the extensive work undertaken by the Government of Tamil Nadu and its partners under the Chennai City Partnership for modernizing and strengthening Chennai's transportation infrastructure, laying the groundwork for a future where mobility is more inclusive, sustainable, and efficient.

The Government of Tamil Nadu has been committed to a transformative vision for Chennai's mobility. Over the last few years, we have established new institutions such as the Chennai Unified Metropolitan Transport Authority (CUMTA) and the Gender and Policy Lab under the Greater Chennai Corporation (GCC). Together with the Chennai Metropolitan Development Authority (CMDA), and the Metropolitan Transport Corporation (MTC), the government has driven forward a range of ambitious reforms. These include the reinvention of bus service delivery through the introduction of a Public Transport Service Contract (PTSC) between the government and MTC, efforts to improve multimodal integration to ensure seamless connectivity, and the redesigning of several of our streets under the Mega Streets initiative to make them safer and more accessible for all road users.

We are also acutely aware of the challenges posed by rapid motorization and the increasing reliance on private vehicles. To address these, we are working on expanding public transport with the ongoing construction of Chennai Metro Phase 2, and augmentation of MTC's bus services, thus expanding non-motorized transport options and ensuring better first and last-mile connectivity. Enhancing road safety and making our transport systems more inclusive—particularly for women and vulnerable groups—are central to our efforts.

These reforms are aimed not only at improving service delivery but also aligning Chennai's urban mobility with broader goals of sustainability and climate resilience. Our work to future-proof the city against climate risks, such as floods and extreme weather events, is embedded in every aspect of our planning and implementation.

The Government of Tamil Nadu has collaborated with many stakeholders, including the World Bank and the Institute for Transportation and Development Policy, to achieve these milestones. I extend my sincere gratitude to all the teams and partners who have contributed to this monumental effort.

While we have started laying strong new foundations, the journey is far from over. Chennai is in the process of charting the future of urban mobility and spatial development through the ongoing development of the Third Master Plan and the Comprehensive Mobility Plan. The lessons from this compendium will be incorporated into these efforts. With a clear vision and sustained efforts, Chennai is poised to lead the way in urban mobility innovation, creating a city where movement is safe, efficient, and sustainable for all.

Sincerely,
T.Udhayachandran, IAS
Principal Secretary to Government - Finance,
Government of Tamil Nadu

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Acknowledgments

This compendium was developed as part of the World Bank's India: Urban Mobility Programmatic Advisory Services and Analytics activity led by Gerald Ollivier (Lead Transport Specialist). The team would like to thank Jen Jungeun Oh (Practice Manager, Transport, South Asia) for her strategic advice and direction in the preparation of this compendium and Pooja Kulkarni, IAS, CEO, Tamil Nadu Infrastructure Development Board, and her team, Jayanth Raghavan and Venkatesh Kumar, for coordinating the Chennai City Partnership and providing comprehensive feedback from the various departments to this compendium.

The compendium was edited by Gerald Ollivier and Shyam Srinivasan (Transport Specialist). Individual technical and summary notes were written by respective authors as indicated in the notes. The team would like to thank the co-authors from the Greater Chennai Corporation, the Gender and Policy Lab, the Chennai Metropolitan Development Authority, and CUMTA for their co-authorship of selected articles. Rashi Grover (Consultant) was instrumental in coordinating with the wide range of authors and peer reviewers for this compendium.

The team would also like to thank internal and external reviewers for providing valuable feedback and comments on the compendium. The list of reviewers is given in the table below.

The report was copy edited and designed by Colorcom, under the guidance of Sarah Natasha (Consultant).

No.	Topic	Authors	WB reviewer	External reviewer
1	Integrated Land Use and Transport Planning	Qingyun Shen, Abhijit Sankar Ray, Seetha Raghupathy (the World Bank), and Anshul Mishra, IAS, (CMDA)	Fuad Malkawi (Senior Urban Specialist, SAWU4)	Dr Sanjeev Kumar Lohia (Consultant, The World Bank)
2	Augmenting Bus Service Delivery	Ravi Gadepalli, Gerald Ollivier, and Shyam Srinivasan	Fatima Arroyo (Senior Urban Transport Specialist, Program Leader, ILCDR)	Dr OP Agarwal (CEO, World Resources Institute)
3	Fostering multimodal integration	Ravi Gadepalli, Jai Malik, Shyam Srinivasan, and Gerald Ollivier	Georges Bianco Darido (Lead Urban Transport Specialist, ITRGK)	Dr OP Agarwal (CEO, World Resources Institute)
4	Designing sustainable complete streets and roads (including life cycle approach-alternatively separate topic)	Jaishree Jindel (the World Bank), Dr GS Sameeran, IAS, BV Babu (GCC), Kasinath Anbu, Shyam Srinivasan, and Gerald Ollivier (the World Bank)	Wei Winnie Wang (Lead Infrastructure Specialist, Program Leader, IECDR)	Aswathy Dilip (Managing Director, ITDP, India) AV Venugopal (Program Manager - Healthy Streets and Partnerships, ITDP, India) Varsha Vasuhe (Associate - Urban Development, ITDP, India)

No.	Topic	Authors	WB reviewer	External reviewer
5	Achieving Urban Mobility Resilience	Rashi Grover, Shyam Srinivasan, and Gerald Ollivier	-	Kiran Gowda (Advisor-Transport Sector, CDRI)
6	Developing Gender Responsive Urban Mobility Systems in Chennai	Mitali Nikore, Sarah Natasha, and Gerald Ollivier (the World Bank), Meera Sundararajan and C. Vaishnavi (Gender and Policy Lab, Chennai)	Kaliat Ammu Sanyal, Extended Term Consultant, Social Development, SAR	Kalpana Viswanath (Co-founder of Safetipin)
7	Developing A Metropolitan Road Safety Plan	Krishnan Srinivasan, Sudeshna Mitra, Shyam Srinivasan, and Gerald Ollivier	Said Dahdah (Lead Transport Specialist, ITRGK) Dipan Bose (Senior Transport Specialist, ISAT2) Marisela Ponce De Leon Valdes (Transport Specialist, ITRGK)	Pawan Mulukutla (Executive Director, WRI)
8	Strengthening Metropolitan Transport Governance	Shyam Srinivasan (the World Bank), Jeyakumar Iyamperumal (CUMTA), and Gerald Ollivier (the World Bank)	Daniel Alberto Benitez (Senior Transport Economist, ITRGK)	Dr OP Agarwal (CEO, World Resources Institute)
9	Data-Driven Urban Futures: Preparedness for Leveraging Data in Indian Urban Planning	Jai Kishan Malik, Shyam Srinivasan and Gerald Ollivier	Aiga Stokenberga (Senior Transport Economist, ILCT1)	-
10	Practical Use Cases of Leveraging Data for Urban Mobility Planning	Jai Kishan Malik, Shyam Srinivasan and Gerald Ollivier	Aiga Stokenberga (Senior Transport Economist, ILCT1)	-

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Abbreviations

AFC	Automatic fare collection
AI	Artificial Intelligence
AIIB	Asian Infrastructure Investment Bank
AMS	Asset Monitoring System
ANPR	Automatic Number Plate Recognition
AVLS	Automatic Vehicle Location System
BRT	Bus Rapid Transit
CBA	Cost-benefit analysis
CCP	Chennai City Partnership
CDRI	Coalition for Disaster Resilient Infrastructure
CEO	Chief Executive Officer
CMA	Chennai Metropolitan Area
CMDA	Chennai Metropolitan Development Authority
CMP	Comprehensive Mobility Plan
CMRL	Chennai Metro Rail Limited
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
CNN	Convolutional neural networks
CPL	City Planning Labs initiative
CRSAP	Chennai Road Safety Action Plan
CSCL	Chennai Smart City Limited
CUMTA	Chennai Unified Metropolitan Transport Authority
DCR	Development Control Regulations
DPR	Detailed Project Report
DSC	DataSmart Cities Strategy
ERP	Enterprise Resource Planning
FAME	Faster Adoption and Manufacturing of Electric Vehicles Scheme
FASTER	Fusion Analytics for Public Transport Event Response
FGD	Focus Group Discussions
FSI	Floor Space Index
GCC	Gross Cost Contract
GCP	Greater Chennai Police
GCTP	Greater Chennai Traffic Police
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gas
GIS	Geographic Information System
GoI	Government of India
GoTN	Government of Tamil Nadu
GPL	Gender and Policy Lab
GPP	Green Public Procurement
GPS	Global Positioning System
GRSF	Global Road Safety Facility
GTFS	General Transit Feed Specifications
ICCC	Integrated command and control center
IFM	Integrated Flood Management
IIT	Indian Institute of Technology
ILUTP	Integrated land use and transport planning
INR	Indian Rupee
IPT	Intermediate public transport
iRAP	International Road Assessment Program
IRC	Indian Roads Congress
IRS	Institute of Remote Sensing
ITDP	Institute for Transportation and Development Policy
IUDP	Integrated Urban Development Platform
IUDX	Integrated Urban Data Exchange
IUO	India Urban Observatory
JICA	Japan International Cooperation Agency
JnNURM	Jawaharlal Nehru National Urban renewal Mission
KPI	Key Performance Indicator
LCA	Lifecycle Cost Assessment
LTA	Land Transport Authority Singapore
LTOC	Land Transport Operations Center Singapore
LVC	Land Value Capture

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MCIC	Major Capital Infrastructure Coordination Office
MLD	Mobile Phone Location Data
MMI	Multimodal integration
MoHUA	Ministry of Housing and Urban Affairs
MORTH	Ministry of Road Transport and Highways
MPD	Master Plan Delhi
MRTS	Mass Rapid Transit System
MTC	Metropolitan Transport Corporation
MTU	Municipal Transport Undertaking
NACTO	National Association of City Transportation Officials
NAPCC	National Action Plan on Climate Change
NCMC	National Common Mobility Card
NDSAP	National Data Sharing and Accessibility Policy
NEBP	National Electric Bus Program
NMSH	National Mission on Sustainable Habitat
NMT	Non-Motorized Transport
NULP	National Urban Learning Platform
NUTP	National Urban Transport Policy
NYC	New York City
OCC	Operations Control Center
ODP	Open Data Platform
PCMC	Pimpri Chinchwad Municipal Corporation
PM	Prime Minister
PTSC	Public Transport Service Contract
PUVMP	Public Utility Vehicle Modernization Program
RSAP	Road Safety Action Plan
RSC	Road Safety Cell
RWA	Resident Welfare Association
SDG	Sustainable Development Goal
SIGMA	Georeferenced Information System for Mobility and Accessibility
SMART	Specific, Measurable, Achievable, Relevant, and Time-bound
SMP	Second Master Plan
SOP	Standard Operating Protocol
SPT	Safety Performance Targets
STU	State Transport Undertaking
SUSP	Sustainable Urban Services Program
SUTP	Scheme for Urban Transport Planning
SWWE	Social Welfare & Women's Empowerment
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited
TAZ	Transportation analysis zone
TMP	Third Master Plan
TN	Tamil Nadu
TNeGA	Tamil Nadu e-Governance Agency
TNGIS	Tamil Nadu Geographical Information System
TOD	Transit-Oriented Development
TOZ	Transit Oriented Zone
TRANSIP	Transport Systems Improvement Project
ULB	Urban Local Body
UNDRR	United Nations Office for Disaster Risk Reduction
UPPM	Urban Project Planning and Management
URDPFI	Urban and Regional Development Plans Formulation and Implementation
USD	United States Dollar
UTF	Urban Transport Fund
VGF	Viability Gap Funding
VRU	Vulnerable road user
WB	World Bank
WRI	World Resources Institute

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Photo credit: CUMTA

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INTRODUCTION: CHENNAI'S URBAN MOBILITY TRANSFORMATION

Gerald Ollivier[1] and Shyam Srinivasan[2]

INTRODUCTION

Everyone needs to go places. Cities around the world are grappling with the challenges of moving people efficiently, safely, and sustainably. This compendium explores how cities can address complex urban mobility challenges using the city of Chennai, India as an example. The compendium showcases Chennai's achievements in laying the foundation for improved mobility while also discussing existing and emerging challenges. In doing so, the compendium aims to stimulate dialogue and offer insights that policymakers and practitioners can use for tackling similar challenges in their cities.

BACKGROUND

Chennai, the capital of Tamil Nadu, is the fourth largest city in India and a hub for commerce, culture, and education. The 'pre-2022' Chennai Metropolitan Area (CMA) is the fourth most populous region in India, covering 1,189 sq km with a population of nearly 11 million. Chennai is also the country's fourth-largest urban economy driven by electronics, manufacturing, automobiles, and information technology. As the city is growing rapidly, the Government of Tamil Nadu (GoTN) officially notified an 'expanded CMA' boundary in 2022, with an area of 5,904 sq km including important satellite towns.

Similar to coastal cities across the world, Chennai is increasingly vulnerable to natural disasters and climate change. CMA has faced several extreme weather events recently: (i) floods primarily from heavy rainfall during the monsoon months or from cyclonic activity in the Bay of Bengal, such as the floods of 2015, which caused 422 deaths, economic losses of around US$3 billion,[3] and significant damage to infrastructure; (ii) post-monsoon cyclones and storm surges which increase flood risks; (iii) sea-level rise due to climate change which could exacerbate the effects of urban floods; (iv) tsunamis, such as the Indian Ocean tsunami in 2004 that inundated coastal communities along the Tamil Nadu coast, and led to 206 fatalities in Chennai;[4] (v) heatwaves, with studies[5] of Indian cities that include Chennai, observing strong effects of heatwaves on mortality; and (vii) earthquakes to a lesser degree, as Chennai lies in the high-risk seismic zone III, but is not as seismically active as the northern and northeastern parts of India.

Chennai is rapidly urbanizing, which is placing increasing demands on its urban mobility infrastructure and services. The population of pre-2022 CMA has grown steadily over the last two decades, from 7.1 million in 2001 to 11.2 million in 2021, with further increases expected over the coming decades. Nearly 75 percent of these residents are in the densely populated urban core of Chennai.

Chennai is rapidly urbanizing, which is placing increasing demands on its urban mobility infrastructure and services. The population of pre-2022 CMA has grown steadily over the last two decades, from 7.1 million in 2001 to 11.2 million in 2021, with further increases expected over the coming decades.[6] Nearly 75 percent of these residents are in the densely populated urban core of Chennai.

Chennai has a relatively extensive urban mobility system but is facing an increasing reliance on private vehicles. While the city has expanded, major economic activities have remained close to the city center. An origin-destination analysis using mobile phone data showed high inflows into the core city during morning peak hours and high outflows during evening peak hours. Limited affordable housing and inadequate public transport coverage have increased trip lengths and motorized trips. The median trip length in the

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pre-2022 CMA has increased from a range of 2 to 4 km in 2008 to 4 to 6km in 2023.[7] Buses have traditionally formed the backbone of public transport in the CMA, but their mode share has decreased from nearly 50 percent in the 1980s to 16.1 percent in 2023.[8] Despite significant rail investments, including the MRTS and the Chennai Metro, the rail mode's share has remained low at around 5 percent. The combined share of non-motorized transport (NMT) and walking has fallen from a high of around 40 percent in 1984 to 28 percent in 2023.[9] Use of personal motorized vehicles has risen sharply and formed around 41 percent of the mode share in 2023 with two-wheelers alone accounting for 34 percent of all trips.[10] Lack of multimodal integration and first and last mile connectivity to mass transit systems have contributed to the declining public transport mode share.

There is scope for improvement to enhance safety for women and vulnerable road users in the city. Chennai is widely recognized as one of the safest Indian cities for women, with several initiatives and policies in place to enhance safety and accessibility. However, there is still scope for improvement, particularly in addressing safety concerns for women and vulnerable road users. According to a 2023 Gender Safety Perception Survey conducted by Gender Lab, 16 percent of women surveyed in public places and transit points reported experiencing some form of harassment over the preceding three months, including on public buses. This highlights the importance of continuous efforts to ensure a safer environment while also acknowledging the city's ongoing strides toward creating a more inclusive and secure public space for women. Road safety is a city-wide issue with high road crashes and fatalities, and despite several successful state level road safety initiatives, CMA[11] witnessed 1,385 road deaths in 2022.[12]

The Chennai City Partnership (CCP) between the Government of Tamil Nadu and the World Bank, with co-financing support from AIIB, has fostered meaningful progress on urban mobility. The first phase of the partnership, the Sustainable Urban Services Program (SUSP) started in February 2022, focusing on institutional and financing changes for driving service delivery improvements in multiple sectors. The Tamil Nadu Infrastructure Development Board in its role as the nodal agency for the CCP, has effectively stewarded implementing agencies to achieve significant reforms in their respective sectors. In urban mobility, SUSP has supported the establishment of the Chennai Unified Metropolitan Transport Authority (CUMTA) and the Gender and Policy Lab, introduced reforms for enhancing bus service delivery and financed a pilot program for transforming streets and neighborhoods in the city. A series of analytical studies were conducted to inform the city's transformation and ongoing preparations for the Third Master Plan (TMP) and the Comprehensive Mobility Plan (CMP). Key analyses and conclusions from these studies are presented in this compendium.

> The compendium starts by exploring the green dimension of the GRIDS framework. The first four topics discuss approaches for reducing greenhouse gases and air pollutant emissions in line with the ASI framework, by reducing travel demand, fostering modal shifts to public and non-motorized transport, and accelerating the transition to electric mobility for bus transport.

KEY THEMES

The compendium uses Green, Resilient, Inclusive, Development-focused and Safe principles (GRIDS) as an organizing framework for effectively diagnosing and addressing the urban mobility and spatial development challenges confronting cities. In articulating the response and recovery approach to the COVID-19 pandemic, the GRID framework was coined by the World Bank in 2021.[13] *Green* refers to solutions that sustain natural capital, including climate, to ensure that today's decisions do not undermine future growth. *Resilient* refers to investments in risk management to prepare for shocks such as climate change, pandemics, natural hazards, and socioeconomic and financial shocks. *Inclusive* refers to providing equal access to opportunities and resources for people who may otherwise be excluded or marginalized, including women, children, and the differently abled. *Development-focused* refers to generating economic opportunities through accessibility and making efficient use of resources. To contextualize the framework in the transport sector and to emphasize the importance of road safety, the authors added 'Safe' as the last dimension, yielding the GRIDS framework. Mobilizing Private Sector Capital at Scale and creating Strong and Coordinated Institutions are identified as

cross-cutting enablers.

Individual GRIDS dimensions could have their own organizing frameworks, which are cited under respective chapters in the compendium. For instance, the Avoid-Shift-Improve (ASI) framework is commonly used when discussing transport sector decarbonization and efficient use of resources. Separate frameworks such as the Safe Systems approach for road safety and distinct pillars of interventions on gender issues have also been introduced in the respective chapters.

This compendium discusses ten critical urban mobility challenges faced by cities in India and around the world that are being addressed through the CCP. Structurally, the document is divided into two main sections: (i) summary notes, which distill key messages from the technical notes and are targeted at policymakers and (ii) technical notes, which detail the approaches adopted in Chennai and international best practices under each topic. The notes are all illustrated with real-world data and experiences from Chennai. This compendium only covers challenges that are directly part of the ongoing CCP while excluding some other relevant topics for the GRIDs agenda like travel demand management.

The compendium starts by exploring the *green* dimension of the GRIDS framework. The first four topics discuss approaches for reducing greenhouse gases and air pollutant emissions in line with the ASI framework, by reducing travel demand, fostering modal shifts to public and non-motorized transport, and accelerating the transition to electric mobility for bus transport.

- **Chennai is currently developing its Third Master Plan and Comprehensive Mobility Plan (CMP), which will set the direction for urban mobility and spatial development in the city over the next two to three decades.** The contemporaneous development of these plans presents unique opportunities for pursuing ***Integrated Land Use and Transport Planning***, which is the subject of the first note. The note describes the comprehensive approach that Chennai is adopting across different geographical scales going from the metropolitan region and new townships earmarked for intensive development, to corridors along which the metro lines are being developed, to the core city and selected neighborhoods. The note also discusses how Transit Oriented Development principles[14] can be applied systematically for creating an environment that fosters concentrated development in areas of high public transport accessibility and leveraging private sector investments.

- **Quality, accessible, and well-integrated public transport systems are the backbone of urban mobility in any city.** Buses have traditionally been the workhorses of public transport in Chennai but have been on the decline in terms of capacity, service quality, and mode share. The second note on Augmenting Bus Service Delivery describes the structural reforms introduced under SUSP in the form of a Public Transport Service Contract between the government and the state transport undertaking responsible for bus operations. Such an approach aims to strengthen accountability in exchange for greater certainty of government support and facilitates the adoption of e-buses. Besides buses, Chennai also has an expanding network of metro and suburban rail, but these systems are currently operating below capacity. The third note discusses the importance of Fostering Multimodal Integration for strengthening intermodal linkages for promoting public transport usage in the city.

- **A livable city is also a walkable city with vibrant neighborhoods.** Cities around the world that are well known for their quality urban environments have prioritized transforming their streets, putting pedestrians and cyclists first, and deprioritizing personal vehicles. The fourth note on ***Designing Sustainable Complete Streets*** describes the structured approach that Chennai is following for improving its streetscape. The approach combines above ground improvements for improving road safety, organizing parking, and reducing encroachments with below ground improvements for improving stormwater drainage and streamlining the management of utilities.

The compendium then looks at the second GRIDS dimension of *resilience*. The above efforts will come to nought if Chennai does not future proof urban mobility by enhancing climate resilience. Chennai's increasing vulnerability to floods has been described earlier. The fifth note looks at ***Strengthening Urban Mobility Resilience*** and presents a structured approach for identifying and safeguarding infrastructure and systems against the devastating effects of climate change.

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The compendium then delves into the dimension of inclusion. Sustainable transport needs to be inclusive. Frequently and unfortunately, urban mobility systems around the world have fallen short of catering to the needs of women and vulnerable groups such as the elderly and differently abled. Chennai has acted decisively in this regard. The sixth note on Enabling Gender Informed Mobility gives the details of the Gender and Policy Lab, a new institution which is already having an impact on improving the safety and inclusivity of Chennai's public spaces and public transport systems. The lab is leading efforts along four pillars: (i) assessing the ground situation, (ii) strengthening planning and policies, (iii) building capacity and raising awareness, and (iv) improving infrastructure and services.

The all-important dimension of *safety* which involves reducing road crashes and saving lives is dealt with next. The alarming number of road traffic fatalities in Chennai calls for a comprehensive approach for improving road safety in the city. The seventh note on ***Developing a Metropolitan Road Safety Plan*** describes the approach taken in Chennai for tackling the road safety issue from multiple angles: institutions, infrastructure, and enforcement.

The compendium concludes with three notes that explore the cross-cutting enabler of *strong and coordinated institutions* in greater detail. The common feature in every world class city is governance. A city of the scale and complexity of Chennai needs strong and coordinated institutions. The eighth note on ***Strengthening Metropolitan Transport Governance*** shares the story of CUMTA, which is one of a handful of unified metropolitan transport authorities in India. The note presents CUMTA emerging role as a nodal agency for ensuring a coherent approach for enhancing urban mobility in the city. As one of its key mandates, CUMTA is spearheading the use of big data and analytical tools for improving the planning and delivery of urban mobility infrastructure and services via the Digital Chennai initiative. The last two notes on ***Leveraging Data for Planning and Operations*** cover international best practices for leveraging big data for urban mobility and the groundwork being laid in Chennai to extend such efforts to the city.

CONCLUSION

Chennai's challenges and experiences are by no means unique. About 400 million people who live in growing cities in India, and those elsewhere in the developing world, are also facing challenges related to rapid urbanization, declining quality and modal share of public transport, as well as increasing climate risks. What we propose here in this book as a green, resilient, inclusive, and safe development pathway for Chennai is therefore equally relevant to other cities.

The compendium paves the way for continued interventions that will make lasting impacts on the ground. Chennai is seeking to bring its urban mobility system on par with best international practices by laying new foundations. The approaches discussed in this compendium, if well implemented and scaled, can help Chennai achieve its sustainable development potentials. Beyond Chennai, with open dialogue and knowledge exchange, cities around the world can transform their urban mobility landscapes together. It is our hope that the takeaways from Chennai presented in this compendium will inspire and guide other cities facing similar challenges. We also encourage readers to share their experiences in Chennai as it continues its journey. Together, we can reimagine urban spaces and create transport systems that are not only functional but also foster healthier, more sustainable cities for all.

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Endnotes

1 Gerald Ollivier is a Lead Transport Specialist at the World Bank.
2 Shyam Srinivasan is a Transport Specialist at the World Bank.
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Section 1: Summary Notes On Chennai's Urban Mobility Transformation

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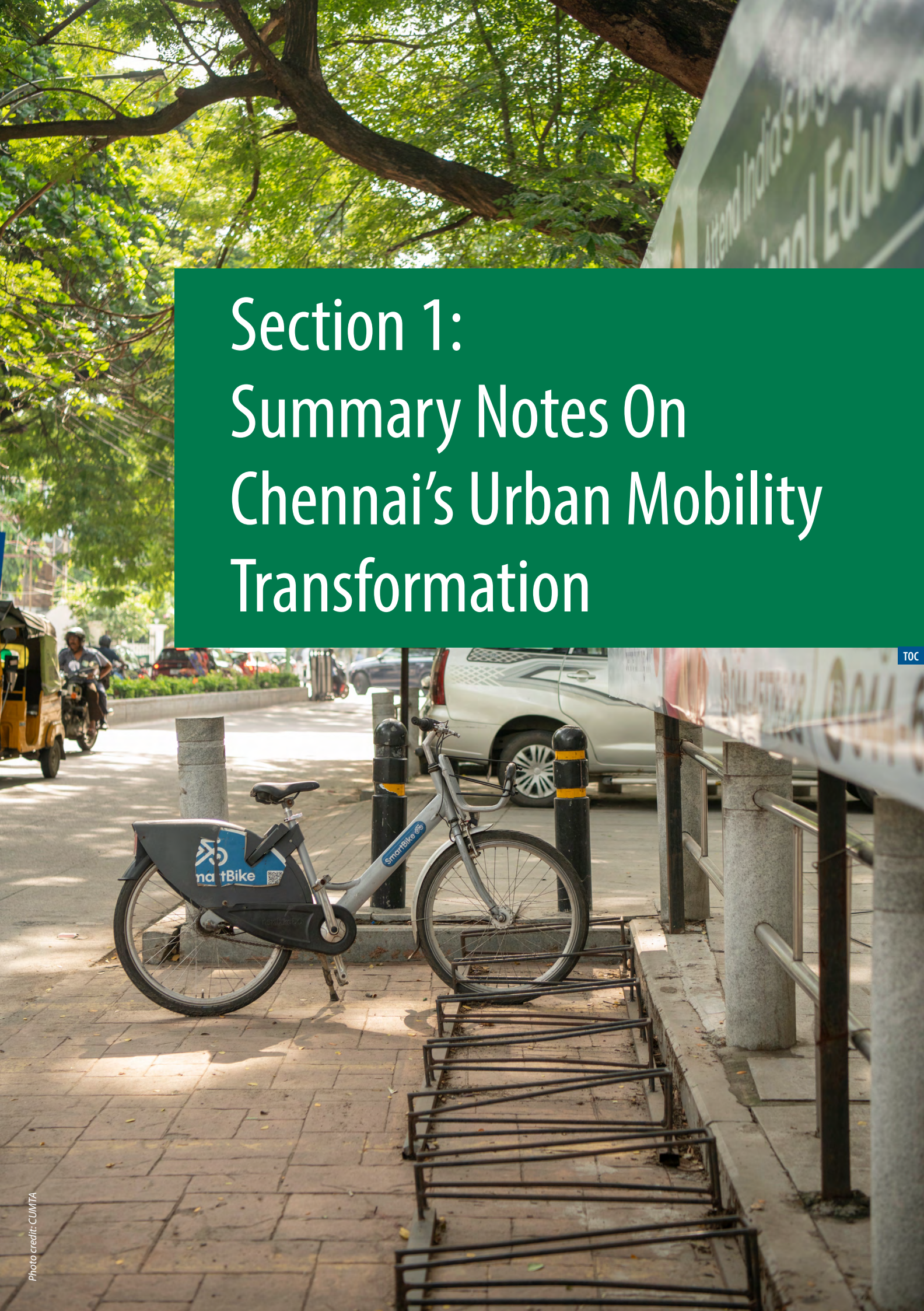

Photo credit: CUMTA

1. INTEGRATED LAND USE AND TRANSPORT PLANNING

Qingyun Shen,[1] Abhijit Sankar Ray,[2] Seetha Raghupathy,[3] and Anshul Mishra[4]

INTRODUCTION

India's rapid urbanization necessitates effective urban planning for ensuring a sustainable, resilient, and inclusive growth path for the country. The traditional model of following a master plan in most Indian cities focuses primarily on physical land use separation and zoning, which lacks integration of multi-sectoral strategies and investment coordination across sectors such as transport, housing, economy and utilities. This siloed planning approach has led to inefficient investments and leapfrogging urban expansion, with a negative impact on infrastructure, climate resilience and compact growth.

Chennai's planning history reflects an evolving relationship between land use and transport planning, highlighting past challenges and the need for integrated approaches. Integrated Land Use and Transport Planning (ILUTP) strategically links land use growth patterns with transport planning. It reduces travel needs by promoting sustainable transport modes (for example, public transport and non-motorized transport (NMT)) through mixed land use patterns. ILUTP adoption pioneers such as Singapore, Portland, and the State of Victoria in Australia, have demonstrated ILUTP's role in promoting sustainable urban growth patterns. In India, ILUTP has been tested in a few cities, with a focus on transit-oriented development (TOD). Effective adoption of ILUTP requires policy, institutional, physical, and data integration, along with a clear and coordinated vision and strategic objectives. The differences between predominant master planning and mobility planning approaches and ILUTP application in India are listed in Table 1.1.

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TABLE 1.1: DIFFERENCES BETWEEN PREDOMINANT PLANNING APPROACHES AND ILUTP APPLICATION IN INDIA

Predominant Master Planning (MP) Approach	Predominant Mobility Planning Approach	Integrated Land Use and Transport Planning (ILUTP)
• Vision focused on spatial planning outcomes, lack of strategic directives	• Vision focused on transport planning outcomes with limited influence on MP	• Coordinated vision factoring in spatial and transport planning and aligning transport capacity and demand stemming from MP • Clear goals, objectives, and strategic directives requiring such alignment

Predominant Master Planning (MP) Approach	Predominant Mobility Planning Approach	Integrated Land Use and Transport Planning (ILUTP)
• Focus on land use planning and zoning	• Focus on transport infrastructure and interventions, including traditional modes and NMT	• Cross-sectoral – across jurisdictions at all scales
• Siloed approach – inadequate focus on aligning multi-sectoral inputs	• Lack of alignment with the statutory master plan preparation timelines	• Integrated spatial and transport plan, with supporting Development Control Regulations (DCRs)
• Top-down citizen engagement (typically)	• Lack of a feedback loop with MP regarding job and population distribution	• An enhanced and holistic stakeholder engagement process with rapid iterations
• Lack of robust implementation mechanisms		• Clear implementation strategy with performance metrics
• Performance focused on outputs		• Performance focus on outcomes

This note summarizes the rationale, challenges, and solutions related to the adoption of an ILUTP approach in Indian cities using Chennai as an example. It emphasizes the importance of coordinating planning efforts of the urban development, transport management, and infrastructure investment agencies for creating sustainable, efficient, and livable urban environments. It also highlights the success factors and recommendations that are critical for effective preparation and implementation of ILUTP, including high-level government direction for institutional coordination and capacity building, technical interventions to inform evidence-based planning strategies, commitment, and agreement on sufficient and innovative funding sources, as well as public accountability, stakeholder engagement, and monitoring and evaluation mechanisms.

APPROACH IN CHENNAI

The ILUTP Work Plan and Road Map in Chennai

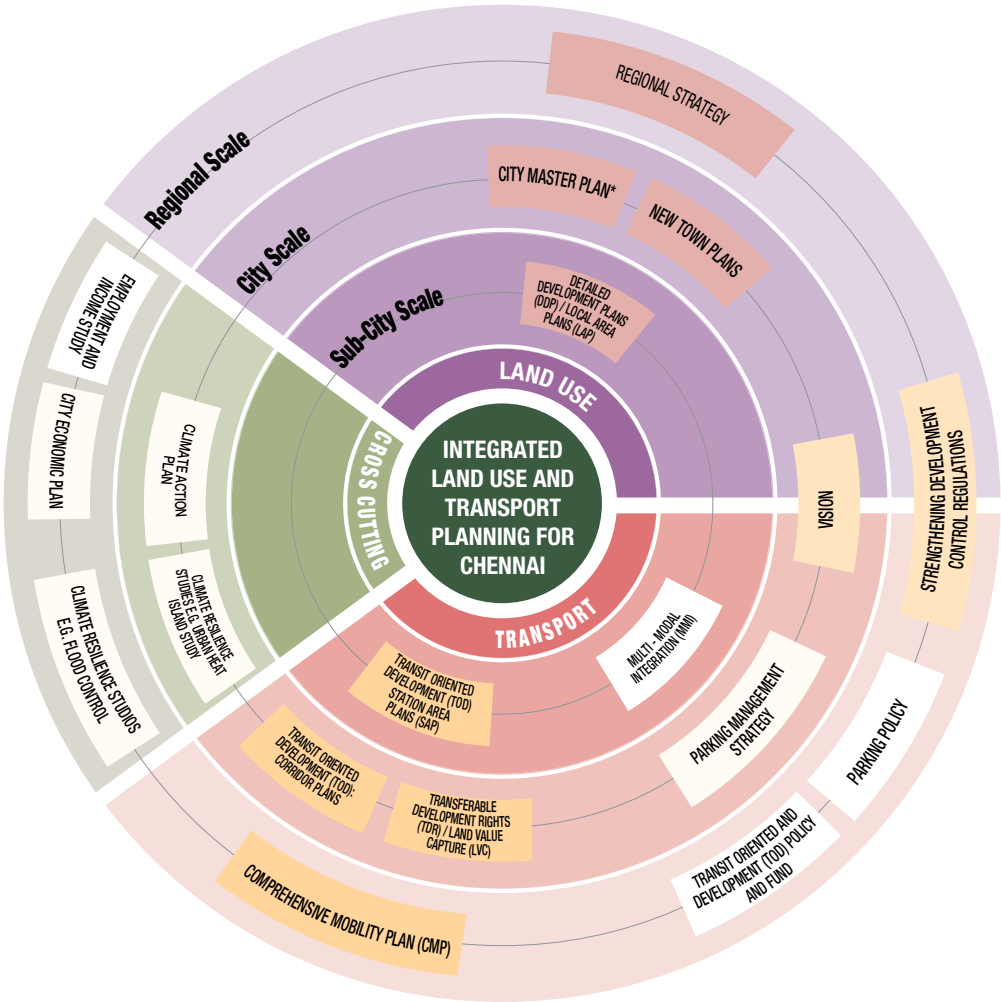
As the fourth largest metropolitan area and among the top five fastest growing cities in India, Chennai faces multiple challenges including climate change, coastal erosion, rise in informal settlements, housing deficit, urban sprawl, inadequate public transport and resultant congestion and air pollution, as well as pressure to sustain economic growth and job creation. One key issue was that the earlier plan's attempts to integrate economic and spatial planning and aligning the city's economic growth aspiration were only partially achieved due to certain challenges in implementation. While there have been efforts to encourage mixed use and avoid segregated land use patterns across metropolitan areas in India, it is still worth noting that as the urban development expands, there is an increasing trend of potential spatial mismatch if traditional Euclidean Zoning approaches are followed. This could result in urban sprawl, create a negative impact on average labor productivity as well as negative environmental consequences. Other compounding factors include inadequate regulatory mechanisms, capacity and human resource challenges, and the lack of evidence-based urban planning. In response, the Government of Tamil Nadu (GoTN) and its key planning institutions turned to ILUTP to address these challenges in a holistic way and steer urban development towards a more green, resilient, inclusive, and sustainable growth path.

Chennai's 60-year planning history has also observed an evolving relationship between land use planning and transport planning, from being disconnected and siloed to becoming coordinated and integrated. The First Master Plan (1976-1996)[5] and the Second Master Plan (2008-2026)[6] both recognized the role of transport, but spatial and transport planning were prepared in sectoral siloes. One of the critiques of the First Master Plan was that it was divorced from economic planning and infrastructure coordination. The Second Master Plan (SMP) had three major issues across formulation

(absence of a well-defined institutional coordination mechanism, staffing shortages, and delays due to legal proceedings), implementation (lack of specific action and a phased implementation strategy), and monitoring (lack of a robust monitoring framework). The SMP itself faced a disconnect between transport and land use planning with no mobility plan in place at the time of its preparation. Consequently, transportation projects have often been conceived outside statutory master plans. Realizing the drawbacks and weaknesses in the previous two master plans, two major planning efforts have been taken up in sequence: the Comprehensive Mobility Plan (CMP) for the expanded Chennai Metropolitan Area of 5,904 sq km led by the Chennai Unified Metropolitan Transport Authority (CUMTA) and the Third Master Plan (TMP) for a CMA of 1,189 sq km led by the Chennai Metropolitan Development Authority (CMDA).

CMP and TMP (the Plans) will be prepared in a coordinated manner following the ILUTP model for developing an evidence-based, resilience-informed implementable plans that are effective for sustainable growth over the next two decades. CMP is expected to feed into the TMP seamlessly to enable true land use and transport planning integration. Meanwhile, CMDA and CUMTA have commissioned intensive technical studies on key topics (Figure 1.1). These studies and planning instruments cover a full spatial scale from the regional level to the metropolitan/city and sub-city level to ensure a consistent application of ILUTP for guiding development.

FIGURE 1.1: VARIOUS STUDIES AND PLANS IN THE ILUTP FRAMEWORK FOR CHENNAI.



** Vision Study | Strategic Institutions | Strengthening Assessment and Action Plan for CMDA | Comprehensive Shoreline Development Project | Study on Land Value and Density Distribution | Review and Recommendations for Strengthening of TNCDBR (20190 | Study on Urban Heat Island Effect in Chennai | Demand and Supply Pattern of Housing | Integrating Blue-Green Infrastructure (BGI) for Blood Disaster and Risk Reduction | Special Distribution of Employment and Income Categories and Agglomeration Economies | Development of Sustainable Economic Growth Strategic Plan | Mainstreaming Climate Action in Chennai Third Master Plan | GHG Emissions Inventory and Building In-house Inventory Capacity | Open Space Strategy for CMA | Mainstreaming of Integrated Flood Control | Social Facilities Plan | Neighbourhood Planning Guidelines | Urban Design Guidelines | Gender Inclusive for CMA*
Source: Authors' compilation in collaboration with CMDA.

Challenges and Solutions

The Chennai experience brought forth challenges and potential solutions for addressing them:

i. Institutional Coordination and Capacity Building of Government Institutions

As different agencies are responsible for preparing their respective plans with their own preparation and implementation cycles, establishing a framework for coordination with oversight at the highest administrative level is necessary for an effective adoption of ILUTP. Key actions include: (i) establishing a high-level committee comprising of executive and political representatives from key departments and agencies for ensuring effective coordination and sectoral stakeholder buy-in; (ii) setting up a technical advisory committee with subject experts on both Plans for providing quality assurances and technical advice; (iii) empowering the leadership of land-use and transport planning agencies and identifying champions as nodal persons for coordination for both Plans; and (iv) establishing regular reviews/ updates of the plans during the implementation for course correction as needed.

ii. Technical Interventions and Quality of Data Collection and Analysis

Having credible, updated data for informing evidence-based planning decisions is a fundamental building block for ILUTP. In Chennai, a Digital Chennai platform is being designed and established in coordination with key government agencies which will be able to work on a common digital platform for ensuring that the baseline data used for both Plans is consistent. Interactive models can be applied for providing real-time inputs in different scenarios, thereby serving as significant data points for policy decisions. As more technological innovations emerge, cities can choose the most applicable and feasible ILUTP techniques and tools that are easy to access and understand and are cost-effective for informing planning for decision-making.

iii. Public Accountability and Trust Building

Uncertainty in public acceptance is one of the key impediments in the adoption of ILUTP. For achieving effective public participation and citizen buy-in, extensive and effective stakeholder engagement throughout the life cycle of the planning preparation is critical. In Chennai, both CUMTA and CMDA have conducted intensive citizen engagement activities through surveys and stakeholder meetings for preparing CMP and TMP. For understanding travel demand and behavior in the expanded CMA, CUMTA has hired a consultant to conduct a primary survey of 50,000 households. Similarly, CMDA has engaged citizens through online platforms, in-person interviews, and zonal meetings for collecting inputs from a wide range of citizens' groups for the exercise. Nearly, 45,044 citizens were engaged in this visioning exercise across CMA.

> These studies and planning instruments cover a full spatial scale from the regional level to the metropolitan/city and sub-city level to ensure a consistent application of ILUTP for guiding development.

iv. Funding and Implementation Strategies

For ILUTP to become a reality, planning agencies need to include feasible implementation and funding strategies at various levels with high-level buy-in. At the preparation stage, the planning and transportation authorities need sufficient funds for developing an information base and agreeing to the city-level ILUTP model which may include updating/preparing a statutory land use plan and preparing the CMP. Financing for these activities can be through state government budgetary allocations or by tapping into national schemes and missions. During execution, CMP and TMP should include appropriate investment plans and innovative financing strategies for key investment projects. Public-private partnerships and land-value capture measures can be applied where feasible for leveraging the private sector to co-finance specific infrastructure investments envisioned under ILUTP. Such engagements can also be through an off balance-sheet model (for example, a revolving fund) where additional revenue is captured for improving the sustainability of investment projects.

v. Monitoring and Results Review

Short, medium and long-term strategies with a corresponding budget and roadmap of action should be prepared for implementing ILUTP. Both CMP and TMP will set up a clear results framework with key performance indicators (KPIs) for monitoring implementation progress. These KPIs should be

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SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) and will align with the planning vision for the city. The results framework and KPIs must be selected through stakeholder consultations as the monitoring and achievement of these KPIs will need collaboration with multiple sectoral departments. During the conceptualization of the results framework and KPIs, the planning agencies also need to identify data sources for measuring progress, the designated agencies with roles and responsibilities for data collection, reporting and validation, and an independent evaluation process for monitoring the performance of each agency that is responsible for a task.

EXPECTED IMPACT

ILUTP's efforts in CMA are expected to transform urban planning, leading to sustainable, resilient, and inclusive development. ILUTP efforts in CMA represent a paradigm shift in planning from traditional zoning and land use mapping towards a more integrated and strategic approach that aims to bring about green, resilient, inclusive development and more productive spatial growth in the long run. While CMP and TMP are still being prepared, the active participation of both CMDA and CUMTA in the preparation is expected to lead to two highly intertwined and consistent documents supported by prioritized investment projects that will translate planning into an urban development reality on the ground. To resolve the bottlenecks in institutional capacities and inter-agency coordination, CUMTA and CMDA are pursuing continuous on-the-job training with World Bank support. Application of new technologies, data, and analytical methods has also been an instrumental part of the uplifting in planning performance in these two institutions.

TAKEAWAYS FOR OTHER CITIES

The Chennai experience can offer lessons for other cities. The salient takeaways include:

- **Ecosystem approach to ILUTP adoption:** Effective planning interventions across the regional, metropolitan/city, and sub-city/neighborhood level.
- **Aligned plan preparation timelines:** Development of the CMP and TMP concurrently enables the synchronization of land use and transport planning.
- **Institutional coordination:** Synergized interventions, establishment of a technical advisory committee, and identification of focal persons/ champions for coordination by lead agencies for spatial planning (CMDA) and transport planning (CUMTA) provides a foundation for developing synchronized plans.
- **GIS based digital platform:** The Digital Chennai platform being contemplated by GoTN would provide a common data platform for ensuring that the baseline data used for spatial and transport plans is consistent.
- **Public participation:** Extensive citizen engagement activities undertaken through surveys by CUMTA and CMDA for plan preparation has enabled understanding citizen's aspirations, travel demands and behavior which will be used for informing the Plans.
- **Leveraging external assistance:** Chennai has effectively co-opted development partners, civil society, academia, private sector, and citizens which has helped provide valuable inputs to the CMP and TMP.

CONCLUSION

Global experiences have shown that ILUTP can promote resilient, inclusive, and sustainable urban growth by reducing travel demand, thereby addressing congestion, carbon and air pollutant emissions, energy consumption, and infrastructure investment costs. Despite the challenges with such an integration, the window of opportunity is now open for Chennai given the simultaneous development of its CMP and TMP. A new paradigm shift can not only set the future growth of this metropolis on the right path that is resilient and sustainable, but it will also become a lighthouse for other large fast-growing cities in India and other countries.

Please click here to access the technical note on this chapter.

Endnotes

1 Qingyun Shen is a Senior Urban Specialist at the World Bank.
2 Abhijit Ray is a Senior Urban Specialist at the World Bank.
3 Seetha Raghupathy is a Senior Urban Planning Consultant for the World Bank.
4 Anshul Mishra is the Member Secretary of Chennai Metropolitan Development Authority (CMDA).
5 G.O. (Ms) No.2395, dated 04.12.1976.
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Photo credit: CUMTA

2: AUGMENTING BUS SERVICE DELIVERY

Ravi Gadepalli,[1] Gerald Ollivier, and Shyam Srinivasan

INTRODUCTION

Bus based public transport is critical for addressing the mobility challenges faced by cities in developing countries. Buses offer a cost effective, agile, space, and energy efficient means of public transport, which can cater to the increasing travel demands of growing urban populations. Despite their obvious benefits, bus services in developing countries have often fallen short of meeting travel demand and users' quality expectations.

Across India, increasing the share of buses is key to reducing traffic congestion and improving air quality and road safety. Many states have a public transport authority (PTA), that is, a state transport undertaking (STU), a municipal transport undertaking (MTU) or a special purpose vehicle (SPV) exclusively created for ensuring bus service delivery. PTAs exhibit varying degrees of involvement across India. Some PTAs only focus on planning, contracting, and managing bus services while the operation of services is contracted to private operators. Several PTAs also own a part or the whole of their fleets and operate them through in-house staff. Improving buses has also been prioritized as a part of successive national-level funding programs such as the Jawaharlal Nehru National Urban Renewal Mission (JNURM) for internal combustion engine (ICE) buses (2007-2014).

More recently, India made significant strides in transitioning from ICE to electric buses (e-buses) through programs like the Faster Adoption and Manufacturing of Electric (and Hybrid) Vehicles (FAME), the National Electric Bus Program (NEBP), and the PM e-Bus Sewa program.[2] A combination of aggregated and standardized procurement has resulted in significant cost reduction through bankable contracts which partially address earlier challenges.

However, despite these policy, regulatory, and institutional enablers, bus services for urban and rural mobility needs have often fallen short of meeting increasing travel demands and users' quality expectations. A key barrier in scaling up bus services has been financial constraints faced by PTAs due to a continuous growth in operating costs caused by staff and fuel cost increases not being matched by the growth in revenue as the fares are set based on affordability considerations. Government support for bus services is limited to discretionary funding for capital and operational expenditure via the annual budget process. Without certainty of long-term government support, many public bus agencies are unable to undertake long-term fleet expansion and improvements in service quality. This has also been the case in Chennai, which faced a steady decline in the quantity and quality of public bus services.

Recognizing the urgent need for change, GoTN with support from the World Bank prioritized the transformation of bus services as a critical pillar of CCP. The program aims to make MTC bus services world-class through a comprehensive strategy which combines a multi-year business plan with a PTSC.

This note explains key institutional reforms for improving the quality of bus services as part of the Chennai City Partnership (CCP) between the Government of Tamil Nadu and the World Bank with AIIB co-financing. The Chennai example offers several takeaways of value for other cities looking to reinvigorate their bus services. This note can also inform decision makers about the key bus reforms undertaken in Chennai.

APPROACH IN CHENNAI

The Chennai model of transforming bus services. Addressing the financial sustainability of PTAs through assured viability gap funding (VGF) by the government while also improving their cost efficiency and customer centricity are essential for transforming bus services in India. Chennai has institutionalized a public transport service contract (PTSC) which provides a replicable example for other cities.

The Metropolitan Transport Corporation (MTC), an STU owned by GoTN, is the sole public bus service provider in Chennai. While MTC has consistently performed well on efficiency indicators such as fuel efficiency and ridership per bus, fleet and service levels have not kept pace with users' travel needs and expectations.

Recognizing the urgent need for change, GoTN with support from the World Bank prioritized the transformation of bus services as a critical pillar of CCP. The program aims to make MTC bus services world-class through a comprehensive strategy which combines a multi-year business plan with a PTSC.

Business plan. In July 2023, GoTN approved a long-term (10 year) vision and a medium-term (5 year) business plan for guiding the transformation of MTC's services. The vision is for MTC to be an integral part of Chennai citizens' daily lives by providing world class, customer-centric, and sustainable public bus services. Under the vision, the average daily bus ridership seeks to increase from 2.8 million in 2023 to 5.3 million by 2032, with an increase in fleet size to 7,578. Key performance indicators have been defined for monitoring MTC's performance efficiency and customer satisfaction.

Specific timelines for targets such as adoption of electric buses, improving fuel efficiency, network coverage, passenger information systems, digital ticketing systems, customer satisfaction levels, and safety and security have been identified under the Business Plan. The plan seeks to bring the bus network to financial sustainability, backed by improved performance and improvements in efficiency, supported by predictable viability gap funding from the government. This seeks to unlock a higher level of service through a change in the service mix and improving fleet utilization (to 87 percent), fostering seamless integration with other modes. It will build on guidance from a diverse representation of commuters of different genders.

The Public Transport Service Contract (PTSC). To formalize the commitment towards service transformation, a PTSC was signed between the Government of Tamil Nadu and MTC starting in 2023 which will gradually cover the entire fleet. PTSC ensures VGF for capital and operational expenses over a five-year period, subject to MTC meeting its performance targets. It has established clear roles and responsibilities for concerned agencies, regular reporting of performance, timely disbursement of funds, and an annual review of targets and the Business Plan.

Shift from operations to service delivery through gross cost contracts (GCC) to private operators. For fleet augmentation, MTC will introduce alternative business models such as deploying 1,000 electric buses on a GCC basis under the Chennai City Partnership. Under this arrangement, MTC will sign contracts with private operators who will be responsible for fleet provision and operations. This will allow MTC to streamline operations and focus on service planning and delivery management, instead of owning and operating the e-buses. In parallel, MTC will renew its fleet under in-house operations, leveraging support from various other sources such as KfW.

EXPECTED IMPACT

Bus service reforms in Chennai are well underway and are expected to improve bus service delivery in the city. The Business Plan was approved by the Government of Tamil Nadu in July 2023. PTSC was subsequently approved and operationalized in September 2023 and MTC had initially received the necessary budgetary allocation for year 1 covering 10 percent of its fleet. Building on the results achieved in the first year, GoTN advanced the PTSC timeline by a year and has now

decided to reach 100% VGF support in four years instead of the five originally planned. Accordingly, GoTN will now cover 50 percent of MTC's VGF requirements in year 2, 70 percent in year 3 and 100 percent by year 4. Additionally, a program management unit (PMU) has now been set up for implementing PTSC effectively over its five-year tenure, including tracking and reporting on key performance indicators, updating the Business Plan annually, and advancing efficiency improvement goals set for MTC. Other cities and states could accelerate bus service reforms by adopting the business plan linked PTSC approach with minor modifications suiting the local context. MTC also concluded the procurement of 500 e-buses using gross cost contracts in November 2024, to be followed by a second phase of 500 e-buses, with the bus deployment expected to be carried out in phases through 2025 and 2026. The prices quoted for GCC (INR 77.16 per km for Non-AC and INR 80.86 per km for AC e-buses) deliver more than 20 percent savings in operating costs for MTC. These results mark an inflection point in the technology and business model preferences for MTC and validate the transition model proposed under SUSP.

TAKEAWAYS FOR OTHER CITIES

- **Assurance of support in exchange for better services:** A rolling five-year funding commitment tied to service enhancement and efficiency improvements fosters accountability and supports long-term planning and investments for better service delivery.
- **The transformation process**: The Business Plan and PTSC process in Chennai, focusing on customer-centric service delivery, electrification, digitalization, and KPI-based monitoring provides an interesting blueprint for consideration by other cities.
- **Building consensus on KPIs and targets**: The Chennai experience underscores the importance of a collaborative, iterative process for selecting achievable KPIs and targets to ensure stakeholder commitment and durability.
- **Transformation with timelines**: Chennai's phased PTSC implementation allows adaptation over five years, but other cities may opt for full coverage initially with moderate KPI targets based on fleet capacity.
- **High care with high expectations**: The successful implementation of PTSC requires strong oversight, re-skilling, and capacity augmentation, supported by a contract management committee for annual reviews.

CONCLUSION

Cities/states intending to transform bus services to world-class standards can do so by developing the necessary building blocks adopted by Chennai -- a long-term vision, a business plan for defining service improvement targets and financial implications, and a PTSC for formalizing the government funding commitment for achieving the vision and deploying new buses within this framework. Such funding commitment enables PTAs to achieve savings in procurement of e-bus services by building confidence in the bankability of contracts.

Please click here to access the technical note on this chapter.

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Endnotes

1 Ravi Gadepalli is a Consultant at the World Bank.
2 Convergence Energy Services Limited. 2022. The Grand Challenge' for Electric Bus Deployment: Outcomes and Lessons for the Future.

3: FOSTERING MULTIMODAL INTEGRATION

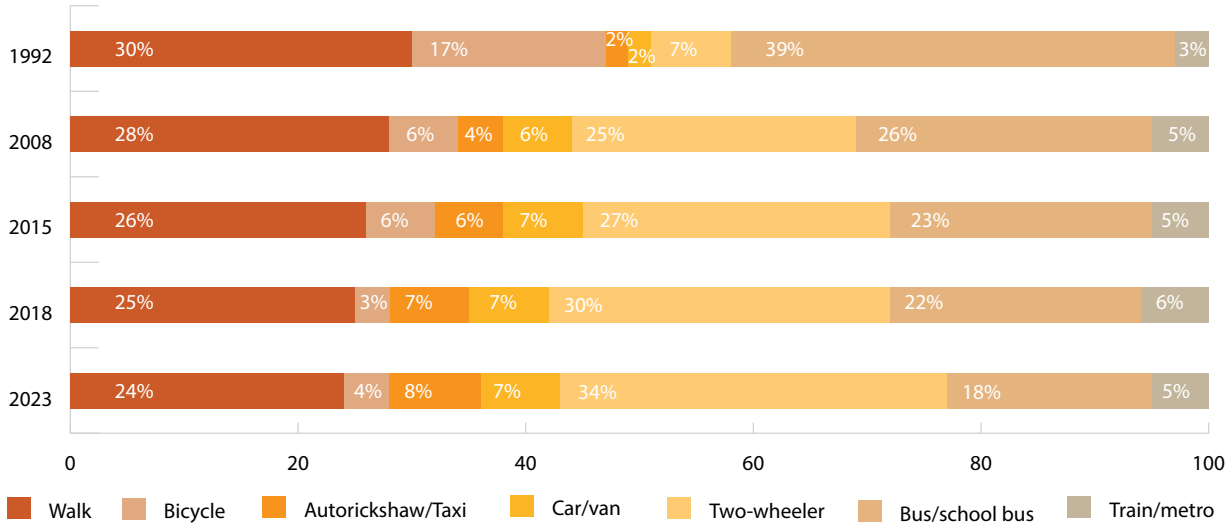
Ravi Gadepalli, Jai Malik,[1] Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

Chennai's growing metropolitan area faces the complexities of increasing mobility needs, changing travel preferences, and evolving demand patterns. The city needs a comprehensive strategy for integrating its diverse transportation modes and meeting its mobility demands efficiently. With a burgeoning population and increasing urbanization, the demand for efficient transportation solutions is more pressing than ever. Despite considerable strides in expanding public transit options, the declining mode share of public transport combined with increasing dependence on private (2W) transportation (Figure 3.1), signal the need for a holistic approach for multimodal integration (MMI). MMI aims to provide seamless connectivity across modes such as buses, metros, trains, auto-rickshaws, taxis, and private vehicles for reducing friction in interchanging between modes thus making public transport more attractive for users. This will lead to enhancing accessibility, reducing congestion, and improving overall urban mobility for the residents of Chennai.

This note outlines some of the key takeaways in MMI from experiences in Chennai. Chennai's vision for MMI encompasses physical infrastructure, operational planning, and institutional and technological measures aimed at optimizing connectivity and efficiency across the city's transportation network.

FIGURE 3.1: MODE SHARE TRENDS IN CHENNAI SINCE 1992



Source: CMP Interim Report II, CUMTA (2024).

APPROACH IN CHENNAI

Cities typically strengthen MMI by creating an institutional set-up for integrated planning, improving physical connections between modes, integrating route network planning and scheduling across public transport services, regulating paratransit services, and fostering Mobility as a Service (MaaS) initiatives for improved passenger information and ticketing across modes to enhance overall travel experience.[2,3]

The Chennai Unified Metropolitan Transport Authority (CUMTA) is the institutional anchor driving MMI in Chennai. One of the crucial steps in achieving MMI is establishing an institutional anchor for planning, coordinating, and implementing transportation projects in partnership with various agencies responsible for roads, buses, and metro rail services. CUMTA was established in 2010 and reformed in 2020 to serve as a bridge among various government entities like the Greater Chennai Corporation (GCC), the Metropolitan Transport Corporation (MTC), the Chennai Metropolitan Development Authority (CMDA), and the Chennai Metro Rail Limited (CMRL) as well as private players such as paratransit operators and on-demand services for the coordinated development of the public transport system in the city. CUMTA acts as a nodal agency for advancing MMI initiatives and ensuring integration of diverse transportation modes in the city.

Physical integration planning guidelines, design, and implementation. In enhancing MMI for improved user experience, Chennai and other cities are prioritizing physical integration at mass transit stations including infrastructure for pedestrians, cyclists, and bus users for accessing metro and suburban rail systems. For this, CUMTA plans to develop a city-wide MMI strategy by classifying interchange nodes into key typologies, identifying essential elements for each station type, developing conceptual designs, and preparing implementation and monitoring plans for improving ease of access for pedestrians, cyclists, and users of the public transport modes. A guideline document defining the type of physical infrastructure investments needed at each station typology is proposed to be developed followed by detailed implementation ready designs. The Kilambakkam Skywalk project will be taken up as the first such project for providing connectivity between the bus terminal and the proposed rail halt station (a new halt station proposed by CUMTA as part of MMI).

CUMTA acts as a nodal agency for advancing MMI initiatives and ensuring integration of diverse transportation modes in the city.

Operational integration through the bus network redesign and paratransit regulations. The bus route network served by MTC is proposed to be redesigned for meeting evolving travel demand patterns in Chennai and complementing the suburban rail and expanding metro rail systems. The proposed plan will strengthen the core services provided by MTC as a main-haul public transport system and introduce feeder services to rail-based mass-transit systems in one comprehensive network strategy. This will benefit from MTC's fleet expansion plans and stakeholder engagement strategies for providing a simple yet comprehensive route network evolution plan. Paratransit services providing informal-public transport like services, are proposed to be regulated and reorganized for enhancing efficiency and integration. CUMTA plans to map the existing paratransit services and develop a plan for the fleet size and network evolution in the future for complementing the bus, metro, and suburban rail services while also incorporating the needs of their operators. A framework for integrating paratransit services with public transport regulations and enhancing their service quality will build on learnings from similar recent efforts in Jakarta and Manila. These cities are attempting to formalize and consolidate operators into companies which provide coordinated services while removing unhealthy competition on the streets.

Technological integration for MaaS[4] Chennai aims to simplify user experience in multiple public transport modes through technological integration efforts for providing real-time journey planning and integrated digital ticketing across public transport modes and later include on-demand modes of transport, commonly known as MaaS. CUMTA is currently developing a mobile application for integrated real-time information and digital ticketing for public transport. Additionally, MTC and CMRL have also issued contracts for open loop smart card (NCMC)-based ticketing systems that can be used across these systems. It is expected that such mobile and smart card-based systems can later be expanded to integrate information and ticketing of on-demand modes of transport thereby graduating to MaaS.

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EXPECTED IMPACT

In Chennai, initiatives for MMI aim to realign transportation networks with changing demographics and travel patterns. By improving access across modes at interchange points, optimizing routes, and enhancing reliability, these initiatives seek to provide faster, more efficient, and reliable public transit services leveraging on multiple transit options. The initiatives would ultimately encourage greater public transit usage and address challenges faced by residents and employees.

TAKEAWAYS FOR OTHER CITIES

Cities can learn valuable insights from the initiatives taken by GoTN in Chennai and other cities for enhancing multimodal integration:

- **Establishing cross-institutional authorities:** Creating centralized bodies like CUMTA streamlines decision-making and coordination among various transportation agencies, as also seen in London and Barcelona.
- **Prioritizing user-centric journeys:** Simplifying travel experiences through single-ticketing systems and integrated physical infrastructure, inspired by London's Oyster card and Singapore's walkway networks, encourages modal shifts away from private vehicles.
- **Fostering data sharing:** Sharing data among governments and private entities, as seen in Chennai's plans to adopt standardized data formats like GTFS, enables informed decision-making and improves operational efficiency, drawing takeaways from London's unified APIs and Finland's comprehensive data integration.
- **Leveraging informal paratransit services:** Integrating informal paratransit services into formal transportation networks, as demonstrated in Jakarta, enhances accessibility and last-mile connectivity, emphasizing strategic planning, stakeholder engagement, and infrastructure upgrades.

CONCLUSION

This note summarized the various building blocks for MMI being planned and implemented in Chennai. Chennai's proactive approach led by CUMTA offers a replicable framework for other cities for navigating similar challenges, emphasizing the importance of interagency coordination and stakeholder engagement across all user groups and relevant private service providers such as three-wheeler and on-demand service providers. As these initiatives continue to unfold, the realization of increased public transport usage and the associated benefits is anticipated to materialize, contributing to the long-term vision of sustainable urban mobility.

Please click here to access the technical note on this topic.

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Endnotes

1 Jai Malik is a Young Professional at the World Bank.

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Photo credit: CUMTA

4: DESIGNING SUSTAINABLE, COMPLETE STREETS IN INDIAN CITIES

Jaishree Jindel,[1] Dr GS Sameeran,[2] BV Babu,[3] Kasinath Anbu,[4] Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

This note discusses the challenges and solutions related to Complete Streets in Indian Cities, with particular focus on Chennai. The increasing trend of urbanization, changing land use, and limited options in public and non-motorized transport has led to the increased use of private vehicles, raising concerns about accessibility, road safety, and emissions. Internationally, city and street designs are evolving for addressing these aspects. Dense urban structures and sustainable transport with Complete Streets are being advocated for improving mobility and safety, enhancing livability and mitigating climate change. This is in line with the famous inverted 'mobility pyramid' for prioritizing sustainable mobility. This note documents the application of the Complete Streets approach by GCC on selected streets in Chennai. Chennai's experience offers several takeaways for other cities in developing countries looking at enhancing sustainable mobility and transforming the urban environment.

Complete Streets[5] can enable seamless, safe, and convenient commute and access for all regardless of age, gender, and abilities. The concept aims to achieve inclusive, compact cities through the rejuvenation of streets and neighborhoods, linking the infrastructure design with the functions of the streets, surrounding land-use, densities, and enhancing safety and climate resilience. The design principles extend to both above ground and underground infrastructure. Above ground, the focus is on promoting non-motorized modes through equitable distribution of space, speed management, improving access to public transit modes, multimodal integration, and enhancing road safety. Underground, the focus is on ensuring increased availability of streets and utilities for seamless movement and enhanced quality

GCC manages roads, stormwater drains, streetlights, and other municipal functions within the core city (426 sq km). The state level Highways and Minor Ports Department is responsible for ring roads, bypasses, and highways. CMDA is the nodal planning agency for CMA of 5,904 sq km. CUMTA is the nodal agency for the planning and delivery of integrated seamless transport in Chennai. Utilities' agencies like the Chennai Metropolitan Water Supply and Sewerage Board manages water supply and sewage systems in CMA, and the state level Tamil Nadu Generation and Distribution Corporation Limited manages electrical power generation and distribution statewide

and livability in the neighborhoods. Utilities are generally shifted below ground in a planned and integrated manner. Many cities like Paris, Singapore, Rotterdam, and New Orleans, have also transformed existing open/vacant spaces such as city parks, playgrounds, and post-industrial zones into landscapes to improve urban flood resilience using blue-green interventions.

Global evidence suggests that Complete Streets approaches yield a range of direct and indirect benefits. Research suggests that designing a street for walking and cycling (wide footpaths, pedestrian refuge, traffic-calming measures, and treatment for people with disabilities) can reduce pedestrian crash risks by as much as 28 percent.[6] Complete Streets can encourage shifts to public transport, walking, and cycling. In **Tianjin, the People's Republic of China,** development of 132 km of Complete Streets across six urban core districts and improving accessibility around 96 metro stations led to 175,000 and 261,000 additional daily trips by metro and walking and cycling respectively (2022) and an overall 34 percent bike mode share (2020). Complete Streets can also improve the economic vibrancy of neighborhoods. In Tianjin, economic vitality increased by 18 percent in the upgraded streets compared to 3 percent in non-improved streets. Similarly, **Lancaster, California** witnessed a doubling of tax revenues from improved streets with the opening of 48 new businesses and the creation of 802 permanent jobs between 2007 and 2012. In four years of street redevelopment (2016), the city attracted US$ 130 million in private investments and generated US$ 273 million in economic output.[7]

There is potential to improve the safety and convenience of Chennai's road network for pedestrians and cyclists. Chennai, with a current road network of around 2,780 km has highways, bypasses, and other roads passing through the city. Local roads in Chennai city are centers of cultural and commercial activity and are commonly used by pedestrians and cyclists but have limited pedestrian friendly infrastructure leading to road safety concerns. CMA witnessed an average of 1,150 deaths annually between 2012 and 2022,[8] highlighting the urgent need for tackling the road safety challenge systematically. 57 percent of all road fatalities are motorcyclists and 37 percent are pedestrians and cyclists.[9] Women are impacted disproportionately as they walk more, accounting for around 60 percent of the pedestrian casualties. While local roads have lower fatality rates as compared to major arterial roads, non-fatal road crashes are common and generally involve two wheelers and pedestrians with 45 percent of local roads posing high crash risks for pedestrians.[10] Chennai has also faced a declining availability and quality of buses; consequently a declining public transport mode share and high motorization - leading to both reduced access by walking and increased road safety concerns. A World Bank analysis estimated that in CMA, residents can, on average, access only 30 percent of the jobs in 60 minutes by public transport. This was attributed to the uncoordinated growth of the public transit network with urban sprawl, inconvenient first and last mile connectivity, and lack of multimodal integration.

Complete streets required inter-agency coordination for successful and sustainable implementation. Like most urban centres, Chennai also has a complex administrative mesh of city, state, and national level agencies with varying geographical coverage working on planning, designing, and implementation of streets, road safety, public transit and utilities - making coordination difficult and time consuming. GCC manages roads, stormwater drains, streetlights, and other municipal functions within the core city (426 sq km). The state level Highways and Minor Ports Department is responsible for ring roads, bypasses, and highways. CMDA is the nodal planning agency for CMA of 5,904 sq km. CUMTA is the nodal agency for the planning and delivery of integrated seamless transport in Chennai. Utilities' agencies like the Chennai Metropolitan Water Supply and Sewerage Board manages water supply and sewage systems in CMA, and the state level Tamil Nadu Generation and Distribution Corporation Limited manages electrical power generation and distribution statewide.

APPROACH IN CHENNAI

GCC is a front runner in adopting the NMT policy[11] with an ambition of allocating 60 percent of its transport budget for walking and cycling networks. Over 140 km of roads have been made safe and accessible, benefiting over 0.5 million people daily. NMT infrastructure has been designed for specific neighborhood clusters through the Chennai Street Design Project. GCC developed 17 km of cycle tracks in the city in June 2018 under the Smart Cities Mission. From 2014 to 2018, the city took pro-active measures like establishing a dedicated Special Projects Department for overseeing NMT measures. Around 80 technical staff trained in Complete Streets by ITDP in collaboration with Anna University (a local university), and visits for decision makers and engineers

were organized to learn from Indian and international best practices. The success of the Pondy Bazaar project, a vibrant pedestrian street and plaza, motivated GCC to expand initiatives such as strengthening coordination among departments, conducting public consultations, and building the capacity of engineers and planners city-wide.

Building on this, GCC developed a Mega Streets program that aligns with Complete Streets approaches. It aims to rejuvenate streets and neighborhoods by linking above ground and underground infrastructure with the function, land-use, and densities along selected road segments. The program involves six neighborhoods with varying infrastructure levels and socioeconomic status (Adyar, Anna Nagar, Mylapore, Nungambakkam, Tondiarpet, and Velachery) and is being piloted through a project including upgrading 12 km of local roads, supported by the World Bank under the Sustainable Urban Services Program (SUSP). The program aims to achieve transformation in five key areas:

(a) ***Promoting walkability*** by increasing the length of uninterrupted footpaths with adequate width and the number of at-grade (signalized) pedestrian crossings, especially close to mass transit nodes. Pedestrian facilities are to be universally accessible with ramps and tactile paving. Traffic calming measures and clear segregation of pedestrians and road users will enhance road safety.

(b) ***Enhancing uninterrupted, safe walking spaces, and livability*** by shifting utilities underground, constructing public toilets and convenience facilities, and adding green and street furniture for enhancing the vibrancy and attractiveness of these areas to the public.

(c) ***Facilitating access to and usage of public transport modes*** through enhancements and integration of pedestrian infrastructure near transit nodes and clear signages for improving way finding.

(d) ***Improving climate resilience*** through constructing stormwater drains, bio swales, connecting with larger open spaces along the streets for slow-soak-store, and incorporating other nature-based solutions.

(e) ***Promoting efficient lifecycle management of assets*** by using recycled material for construction and reducing construction waste, wherever appropriate. For ensuring the longevity and sustainability of interventions, the contractors' scope may include five years of maintenance with appropriate KPIs.

These five areas of transformation were converted into a detailed set of key performance indicators (KPIs) which consist of 15 attributes and 45 parameters for tracking progress. Design development involved as-is spatial mapping, assessment and concept designs, engagement with stakeholders, and site visits for finalizing detailed designs (please refer to Technical Note 4 for details).

Cycling also has a potential role in Chennai for enhancing last mile connectivity. Even cities with hot weather conditions like Singapore are promoting cycling for last mile connectivity and short trips. To facilitate cycling, the streetscape in Chennai can be enhanced with traffic calming measures at the neighborhood level, segregated cycling lanes leading to mass transit stations, and improving the quality, width, and continuity of footpaths for shared use by cyclists. There is potential to expand the initial attempts taken to provide cycling lanes into a strong cycling network in future phases.

Critical Areas of Focus for Chennai. The success of the planned Complete Streets interventions in Chennai hinges on a few key factors moving forward:

- **Continued inter-agency coordination throughout the project lifecycle** – planning, designing construction, supervision, and maintenance. This can be supported by standardization of data collection and sharing of the data/utility survey involving digital integration under the Digital Chennai initiative to be led by the Chennai Unified Metropolitan Transport Authority (CUMTA).
- **Detailed mapping of underground utilities**. While some agencies have initiated such surveys, it is important to include the 3D as-built coordinates of the utilities to update and add to the base map. GCC aims to integrate data with its existing GIS platform and those of other utility agencies.
- **Translation of approaches and takeaways into guidelines.** Chennai aims to update its Complete Streets guidelines based on project experience and latest developments in the sector like blue-green infrastructure, nature-based solutions, utility integration and GIS mapping, material circularity, and the creation of a public realm.
- **Mainstreaming of street development** through adequate focus on street development in Chennai's Comprehensive Mobility Plan, guidelines in the

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master plan, neighborhood and TOD plans, and adoption by other urban local bodies within CMA.

EXPECTED IMPACT

Referring to international examples, Complete Streets approaches can have several benefits for Chennai. Assuming 50 km of street upgrades spread over multiple implementation phases, the improved walkability, modal shift to public transport and non-motorized transport, improved road safety, and reduced congestion and air pollution are expected to yield significant economic benefits. Comparable projects in Tianjin (China) and Karachi (Pakistan) achieved post-project economic returns of 53 percent and over 16 percent respectively.[12] By encouraging shifts to public transport, walking, and cycling, it is anticipated that there will be a saving of approximately 109,000 tons of GHG emissions over 20 years.

TAKEAWAYS FOR OTHER CITIES

- **Performing context-specific street analyses.** Streets need to be analyzed based on their current land use and future role, considering each street's unique characteristics and avoiding the 'one-size-fits-all' approach.
- **Gathering data on underground utilities for improving the efficiency of Complete Streets.** Issues on mega streets in brownfield locations pertaining to shifting or relaying of existing operational utilities are compounded by little or no data on the exact location (3-dimensional), alignment, capacity, age, or conditions of underground utilities. Documentation, spatial mapping, and sharing standardized data through effective coordination and inter-agency communication for minimizing unplanned and unbudgeted changes are a must.
- **Strengthening inter-agency coordination.** Given that inter-departmental coordination is imperative, a framework for standardization of survey methods, data formats, and sharing protocols across agencies should be formulated and adopted. Incremental planning or retrofitting with IT support can further effective implementation.
- **Focusing on neighborhood-level implementation.** Implementing Complete Streets at the neighborhood level will create stronger network effects. Incorporating this approach into city planning such as master and local area plans, is more efficient and supports the creation of a connected network.
- **Providing maintenance and enforcement**. Enforcing the maintenance of built infrastructure is crucial for long-term economic benefits and sustainability. Complete Streets should include low-maintenance elements and technology solutions for ensuring proper maintenance and management of assets.
- **Adopting green public procurement approaches**. These approaches can improve sustainability (depletion of non-renewal sources) by addressing the increased demand for construction material, by focusing on low-carbon construction methods and a circular economy approach for construction and demolition waste. Addressing a sustainable design and procurement through GPP will not only improve resilience quotients of the upgraded streets but also positively impact urban environment.
- **Engendering community ownership**. For successful implementation, scalability, and maintenance, a community's role as both the end-users and caretakers of the interventions is vital. Engaged communities help address challenges such as waste segregation and illegal parking. Effective communication plans and feedback mechanisms are essential for proactive public engagement.

CONCLUSION

To meet the growing urbanization and mobility demand, cities increasingly need to focus on dense walkable green development with integrated land use and transport for greenfield areas. The existing areas will also need efforts for redeveloping and retrofitting the streets and roads. Complete Streets approaches provide a solution to this and will help improve walkability, road safety, inclusion, and decarbonization. The experiences from GCC and Chennai offer valuable takeaways for other cities on planning, designing, and integrating streets.

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Endnotes

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4 Kasinath Anbu is a Senior Consultant at the World Bank.

5 https://www.transportation.gov/mission/health/complete-streets

6 Smart Growth America. 2021. Dangerous by Design.

7 CNU Journal (2016). Blog. Robert Steuteville. New streetscape spurs downtown turnaround.

8 Road accidents in India, TRW, Ministry of Road Transport and Highways, Government of India, 2022.

9 Data from the Greater Chennai Traffic Police.

10 DIMTS analysis for the Chennai Road Safety Action Plan, 2023.

11 Chennai Non-Motorized Transport Policy, 2014.

12 ICR reports of the projects (the World Bank).

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Source: Deccan Herald

5: ACHIEVING URBAN MOBILITY RESILIENCE

Rashi Grover[1], Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

Urban mobility resilience is a critical aspect of urban resilience. It refers to the transportation system's ability to withstand and recover from disruptions, whether caused by natural hazards, accidents, or other unforeseen events. This note focuses on Chennai[2], which, similar to coastal cities across the world, is increasingly vulnerable to natural disasters and climate change, and discusses the approach adopted in Chennai to assess climate change vulnerabilities and identify the measures to strengthen urban mobility resilience. The Chennai example offers useful takeaways for other cities facing similar challenges.

Chennai is exposed to two main categories of extreme weather events: floods (fluvial, pluvial, coastal)[3] and heatwaves. Figure 5.1 presents a timeline of extreme weather events in Chennai. These extreme weather events have a severe impact on lives, livelihoods, and infrastructure.

Existing initiatives in Chennai. Chennai has adopted a multifaceted approach to disaster risk management in urban mobility that includes improvements in infrastructure, coordination among various agencies, and strategic planning for resilience and sustainability. GoTN, working closely with GCC and other municipal corporations in CMA, has taken several steps for enhancing disaster risk management such as: (i) establishing an integrated command and control center (ICCC) for coordinating disaster management efforts, (ii) improving its stormwater drainage system - stormwater drains are provided with rainwater harvesting systems at 30 m intervals for recharging the groundwater table in the city, and (iii) developing city resilience strategies to better prepare for natural disasters. Chennai is part of the Water as Leverage (WaL) initiative that aims to develop groundbreaking, innovative approaches for tackling the immense climate and water challenges in three cities in Asia. Chennai has also been selected as the first in a series of urban flood mitigation projects. The Integrated Urban Flood Management activities for the Chennai Basin Project under the National Disaster Mitigation Fund (NDMF), which also includes central assistance of INR 5,000 million will help develop a broader framework for urban flood management in Chennai.

> Chennai has adopted a multifaceted approach to disaster risk management in urban mobility that includes improvements in infrastructure, coordination among various agencies, and strategic planning for resilience and sustainability.

APPROACH IN CHENNAI

A systematic approach to improving urban mobility resilience. The increasing frequency of disasters in cities like Chennai underscores the importance of urban resilience against climate change, or climate resilience. Climate resilience is the capacity of a system, community, or interconnected systems to withstand, recover from a hazard, and adapt to the impact of climate change. A systematic approach to building climate resilience typically involves assessing and

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FIGURE 5.1 TIMELINE OF EXTREME WEATHER EVENTS IN CHENNAI

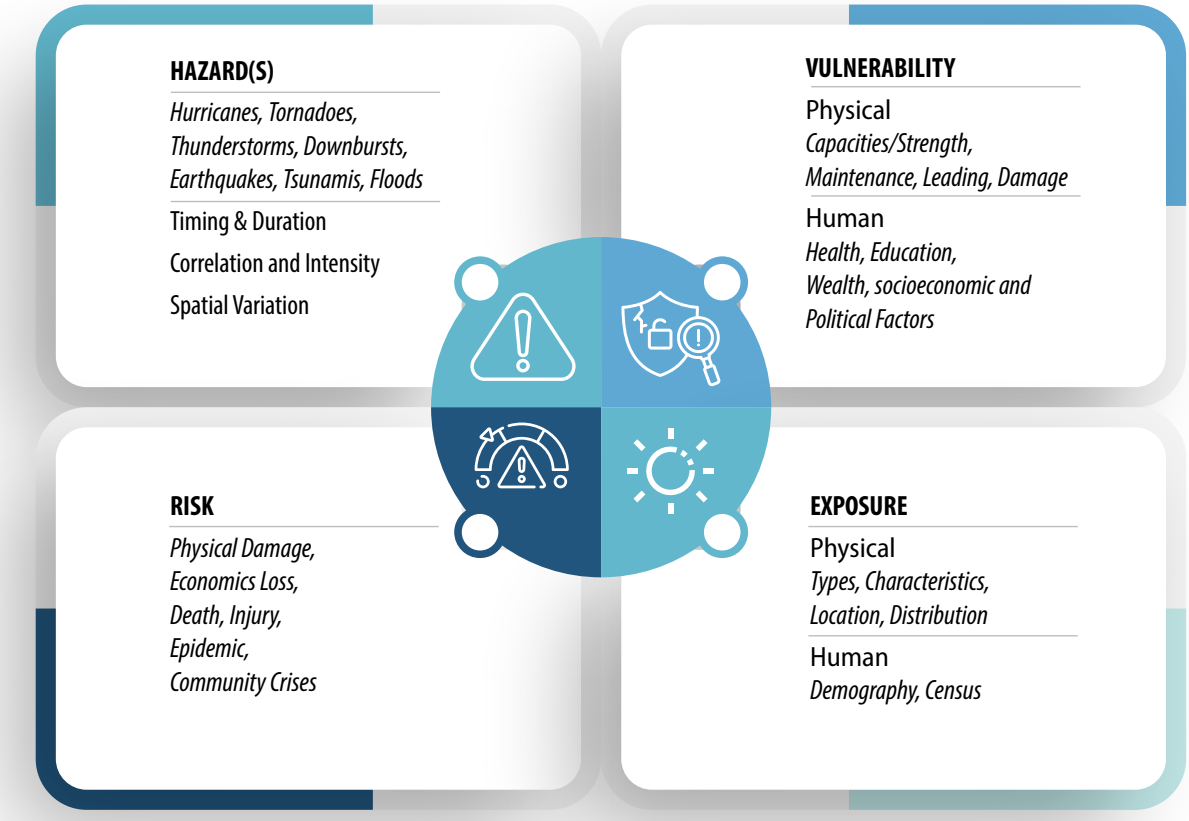
Source: Authors' illustration.

taking measures for managing disaster risks defined by UNDRR as 'the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.' In general, disaster risk lies at the intersection of hazard, exposure, and vulnerability (Figure 5.2).

designating an exposed element as critical, for instance, critical roads and road elements were defined as roads/ links in the urban road network in Chennai which cater to substantial traffic volumes and are critical for maintaining acceptable service levels.

- Physical vulnerability to floods was assessed for five broad categories of critical transport infrastructure -

FIGURE 5.2: DISASTER RISK AT THE INTERSECTION OF HAZARD, EXPOSURE, AND VULNERABILITY[4]



Source: Disaster Risk Management Through the DesignSafe Cyberinfrastructure. Int J Disaster Risk Sci 11, 719–734.

An approach that considered these dimensions was applied in Chennai, albeit with modifications based on resource availability. In 2022-2023, a technical study on *Resilient Urban Mobility and Services in Chennai* was undertaken with funding from the Government of Japan (Global Facility for Disaster Reduction and Recovery (GFDRR) and the World Bank, in close collaboration with government agencies, including CMDA, CMRL, GCC, and MTC.[5] This study defined risk as a function of hazard and vulnerability.

Vulnerability of critical infrastructure[6] in Chennai. Critical urban mobility infrastructure was assessed based on three types of vulnerabilities: physical, systemic, and socioeconomic. Specific criteria were used for

roads and road elements, structures such as bridges/ flyovers, freight transport, and mass transit systems like suburban rail, the mass rapid transit system (MRTS), MTC, and the Chennai metro. The results showed that several bridges and flyovers in the city were nearing their serviceability age, suggesting scope for using intelligent transport systems (ITS) in integration with the Chennai smart city programs for reducing disruptions to services during disaster events. With three major water bodies crossing through the city and most of the MRTS and metro rail systems built along them, special attention needs to be paid to the accessibility of these stations for providing the minimum operational ability during floods. Alternative routes for passenger and freight movement were identified along roads that were comparatively more resilient during disaster events.

- A systemic vulnerability assessment was also done to study accessibility to the identified critical lifelines during disaster events. For instance, it was observed that travel to hospitals in certain areas was expected to take 20 percent longer than usual.
- Further, a socioeconomic vulnerability assessment showed that the central part of CMA, particularly the core city under GCC's jurisdiction had high to very high socioeconomically vulnerable zones when it comes to transport. Vulnerability in the southern and northern zones was exacerbated by deficiencies in stormwater drainage.

Based on these hazard analyses and three aspects of vulnerability, a list of transport elements at risk in CMA was generated (Table 5.1). Critical elements falling under the *Very High* category of vulnerability as defined for that element were classified 'Risky Assets', while all other vulnerable elements were not found to be risky but were vulnerable to different degrees.

Recommendations for boosting urban mobility resilience. Based on the risk assessments, a comprehensive set of recommendations for improving climate resilience of the urban mobility infrastructure was developed. An overarching recommendation relates to financing measures for enhancing climate resilience. The financing of resilience enhancement measures in the urban transport systems in Indian cities requires different mechanisms from those used for regular investment and maintenance, considering the need for contingency funds and the supplemental allocation for improved resilience based on probability of risks and expected impacts. Prioritizing projects according to the highest cost-benefit ratio based on economic, environmental, and social factors (for urban transport infrastructure) is therefore important.

Further specific recommendations were organized along the following themes: (i) structural, referring to the construction and maintenance of physical infrastructure; (ii) data and technology, including how they could enable contingency measures during disasters for ensuring a minimal level of services and access to critical lifelines; and (iii) measures relating to institutions and communications in and around disasters. Several recommendations are already being taken up and are being implemented by GCC, CUMTA, and other agencies in Chennai. At the same time, Chennai can learn from other cities/countries that have successfully

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TABLE 5.1: OVERALL RISK ASSESSMENT OF URBAN TRANSPORT ELEMENTS

Risk Assessment of Urban Transport Elements		
Roads	**MTC Depots/Terminals**	**Sub-urban & MRTS Stations**
• Arunachala Street • 8th st. • Anna Main Road • VR Ramanathan Road • Annamalai Nagar 1st Street • 14th Avenue • Pantheon Road • Mogaper Estate Road	• Mandaveli Bus Deport cum Terminal • T Nagar Bus Depot cum Terminal • Ambattur Industrial Estate	• Chetpet sub-urban railway station • Kodambakkam sub-urban railway station • Light house MRTS station
Bridges	**Flyovers**	**MTC Routes**
• St. Andrews Bridge • Laws Bridge • Harris Bridge • Alandur Abraham Bridge • Santhome Bridge • Naduvankarai Bridge • Nungambakkam Bridge • Saidapet Bridge	• Doveton Flyover • Pantheon Flyover • Thirumangalam Flyover • CMBT Flyover	• Route_15 • Ropute_15G • Route_S18 • Route_S15 • Route_S147X • Route_27B • Route_S86
	Freight	
	• Chennai port to Maduravoyal to ORR to Peripheral road • Manali Oil Refinery road • NH Bypass	

Source: Resilient Urban Mobility and Services in Chennai, 2023

used some of these approaches, including resilience in building codes (China), using nature-based solutions (Malmö, Barcelona), building neighborhood 'greenways' (Portland, Oregon), setting up integrated multimodal transport systems (Zurich, Delaware), and setting up traffic control centers (Beijing) – some of them fully virtual (Oklahoma).

EXPECTED IMPACT

To illustrate the impact of embedding climate resilience measures in urban mobility infrastructure, a cost-benefit analysis (CBA) for fixing damages to the Vadapalani bus stand during Cyclone Nivar was conducted as a high-level assessment. The CBA showed that nature-based solutions were most effective in boosting climate resilience and gave the highest returns on investment.

TAKEAWAYS FOR OTHER CITIES

Chennai's experience offers valuable takeaways for other cities looking at strengthening the resilience of urban transit and mobility systems.

- **Urban mobility resilience requires continuous data gathering and analyses of changing conditions.** Data permeates the strategy for enhancing climate resilience at all stages – before, during, and after disaster events. Before disasters, the city needs data for identifying the weakest links in the system to prioritize retrofits, monitoring changes in urban hydrological response caused by urban growth, watershed land changes, and climate change for taking proactive measures. During disasters, the city can leverage data for dynamically managing travel demand and traffic for maintaining access to critical lifelines. Post disaster, the city can undertake rapid assessments for prioritizing reconstruction and recovery efforts.
- **Urban transport agencies need to embed climate resilience considerations into the planning and design of infrastructure by default.** Climate resilience needs to become a core part of the psyche of urban transport agencies and should feature in day-to-day decision making. To intervene effectively, agencies need new skills including traffic modeling and impact prediction and management during floods; planning and execution of preventive maintenance, retrofit, and proactive post-flood repairs; catastrophic flood preparedness and response plans; and post-disaster damage and needs assessments.

CONCLUSION

Chennai is applying a multifaceted, systematic approach for building climate resilience that offers valuable takeaways for other cities looking at strengthening resilience in urban transport and mobility services. Prioritizing climate resilience in the decision-making matrix for projects is the first essential step in enhancing the resilience of urban transport and mobility services. Structural measures that directly impact the resilience levels of the urban transport system need to be complemented with the effective use of data and technology, and stronger institutions, capacities, and communications. Planning for urban growth, green spaces, and land use is directly related to the magnitude and level of damage by urban floods and inter-agency coordination is key to achieving success in dealing with the damages.

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Endnotes

1 Rashi Grover is a Consultant at the World Bank.
2 Chennai Metropolitan Area, the focus of this study, encompasses the central city of Chennai and its suburbs distributed in Kanchipuram, Chengalpattu, and Thiruvallur districts.
3 Citizen Matters (2023). Article. Dr S Janakarajan. Chennai needs an integrated water management system to prevent floods and drought.
4 Pinelli, J.P., M. Esteva, and E.M. Rathje et al. (2020). Disaster Risk Management Through the DesignSafe Cyberinfrastructure. Int J Disaster Risk Sci 11, 719–734.
5 "Resilient Urban Mobility and Services in Chennai" by Taru Leading Edge Pvt. Ltd. and partner organizations – Urban Mass Transport Company Limited (UMTC) and GoAscendal.
6 Physical structures, facilities, networks, and other assets, which provide services indispensable to the social and economic functioning of society, and necessary for managing disaster risk.


Source: Shutterstock

6: DEVELOPING GENDER RESPONSIVE URBAN MOBILITY SYSTEMS IN CHENNAI

Mitali Nikore[1], Sarah Natasha[2], Gerald Ollivier, Meera Sundararajan[3], and C. Vaishnavi[4]

INTRODUCTION

Gender is a key socio-demographic variable that has a big influence on women's travel behavior but is often the least understood. Women face barriers in using public transport at every stage of a journey because of design elements that are not gender informed - during access and egress, waiting at stops and transfers, boarding and alighting, and inside a vehicle.

Despite women being amongst the biggest users of public transport, public transport systems across Indian cities do not fully understand their needs. Chennai has championed efforts to ensure the safety and convenience of women in public transport, by offering free travel on certain state-operated buses,[5] providing women-only buses and metro coaches,[6] installing cameras and panic buttons on buses,[7] and collecting gender disaggregated data.[8] There are further opportunities to make public transport services responsive to the needs of women and persons of minority genders, which in particular, focus on access, affordability, and safety. This includes collecting gender-sensitive data to adjust transport services, along with addressing safety concerns and network design catering to women's travel patterns. This could enhance women's access to work and educational opportunities, ultimately improving their financial independence and agency. Transport planning is not gender informed due to various systemic and societal factors, leading to a lack of comprehensive strategies that address the diverse needs of all genders, perpetuating inequalities in urban mobility. International examples of gender mainstreaming in urban planning (for example, Vienna) can be adopted with suitable modifications by Indian cities.

This note discusses Chennai's approach in increasing gender inclusivity in urban mobility and public transport. Highlighting Chennai's initiative of establishing a Gender and Policy Lab (GPL) in the Greater Chennai Corporation (GCC), this note discusses how Chennai's model offers valuable insights for other cities who are aiming to improve gender inclusivity in urban mobility and public spaces.

GPL's twin objectives are improving women's access to opportunities by improving safety and gender responsiveness in public spaces and public transport through a multi-pronged collaborative approach and mainstreaming gender inclusivity so that it becomes a process and a natural element in all city-level planning and decisions about service delivery.

APPROACH IN CHENNAI

While Chennai is considered relatively safer for women among southern cities, studies highlight the opportunities for improved gender-sensitive infrastructure and awareness to address mobility restrictions and underreporting of harassment cases. Southern cities in India, especially Chennai, are often regarded as relatively safer for women. However, World Bank-supported studies, such as a gap analysis conducted in 2021 and a GPL perception study in 2023, highlighted areas for improvement in ensuring women's safety and mobility in Chennai. The studies also identified gaps in gender-sensitive infrastructure and a lack of awareness about helplines available to women in distress, which may contribute to underreporting of harassment cases. Addressing these challenges is essential to further enhance Chennai's reputation as a safe and inclusive city for women.

GPL was operationalized in April 2022 as a part of the Chennai City Partnership between the Government of Tamil Nadu and the World Bank, aligning with 'Nirbhaya,' a national scheme to enhance women's safety which was already underway in Tamil Nadu. GPL works closely with implementing agencies of the Nirbhaya program, the Greater Chennai Corporation (GCC), the Metropolitan Transport Company (MTC), the Greater Chennai Police (GCP), and the Social Welfare & Women's Empowerment (SWWE) Department.

GPL's twin objectives are improving women's access to opportunities by improving safety and gender responsiveness in public spaces and public transport through a multi-pronged collaborative approach and mainstreaming gender inclusivity so that it becomes a process and a natural element in all city-level planning and decisions about service delivery.

GPL operates in a multi-stakeholder environment. Situated in GCC, the core GPL team comprises of three full time experts -- a team leader, a policy specialist, and a communications specialist. The team has formed a working group of high-level government officials across different departments in the Government of Tamil Nadu as well as city-level implementing agencies in Chennai. GPL is also advised by a voluntary advisory committee comprising of national and state-level academics and practitioners and a team of experts from the World Bank.

Initiatives taken by GPL – experiences from the first year

GPL's interventions are organized around a four-pillar framework. Drawing on the recommendations of the World Bank's Toolkit for Enabling Gender Responsive Urban Mobility and Public Spaces in India,[9] GPL's interventions are organized around a four-pillar framework: (i) assessing the ground situation; (ii) strengthening policies; (iii) building capacity and raising awareness; and (iv) enhancing infrastructure and services (Figure 6.1).

IMPACT

GPL's efforts are making Chennai city safer and more inclusive for women. The preliminary results from the first year show that GPL made substantial progress in the first year in identifying the primary factors contributing to the perceived lack of safety in the city. GPL is also working on standardizing gender-responsive elements in infrastructure design guidelines. Most notably, the GPL team has succeeded in raising awareness and enhancing the capacity of government agencies to understand the need for a gender-responsive urban mobility ecosystem in the city (Figure 6.2).

Going forward, GPL aims to expand its collaboration with other implementing agencies and external stakeholders like the MTC, CUMTA, and the Greater Chennai Police (GCP) and shift its focus from diagnostics to direct investments and implementation.

Similarly, considering the importance of Gender inclusiveness in urban development, the Chennai Metropolitan Development Authority (CMDA) intends to evolve its Third Master Plan for CMA as a Gender-inclusive plan. In this regard, CMDA has recently taken up a study titled 'To formulate strategies for Gender Inclusiveness in CMA' with the primary objective of mainstreaming gender-inclusive development in the Third Master Plan through spatial planning efforts. This study aims to develop practical and feasible strategies, measures, and recommendations to foster an inclusive, safe, accessible, and sustainable environment for all genders in the Chennai Metropolitan Area (CMA). It will specifically focus on addressing gender disparities from a spatial urban planning perspective by assessing key areas such as the availability, accessibility, and safety of infrastructure, mobility, and public spaces/facilities within the CMA.

FIGURE 6.1: GPL'S ACTIVITIES ORGANIZED UNDER THE FOUR-PILLAR FRAMEWORK

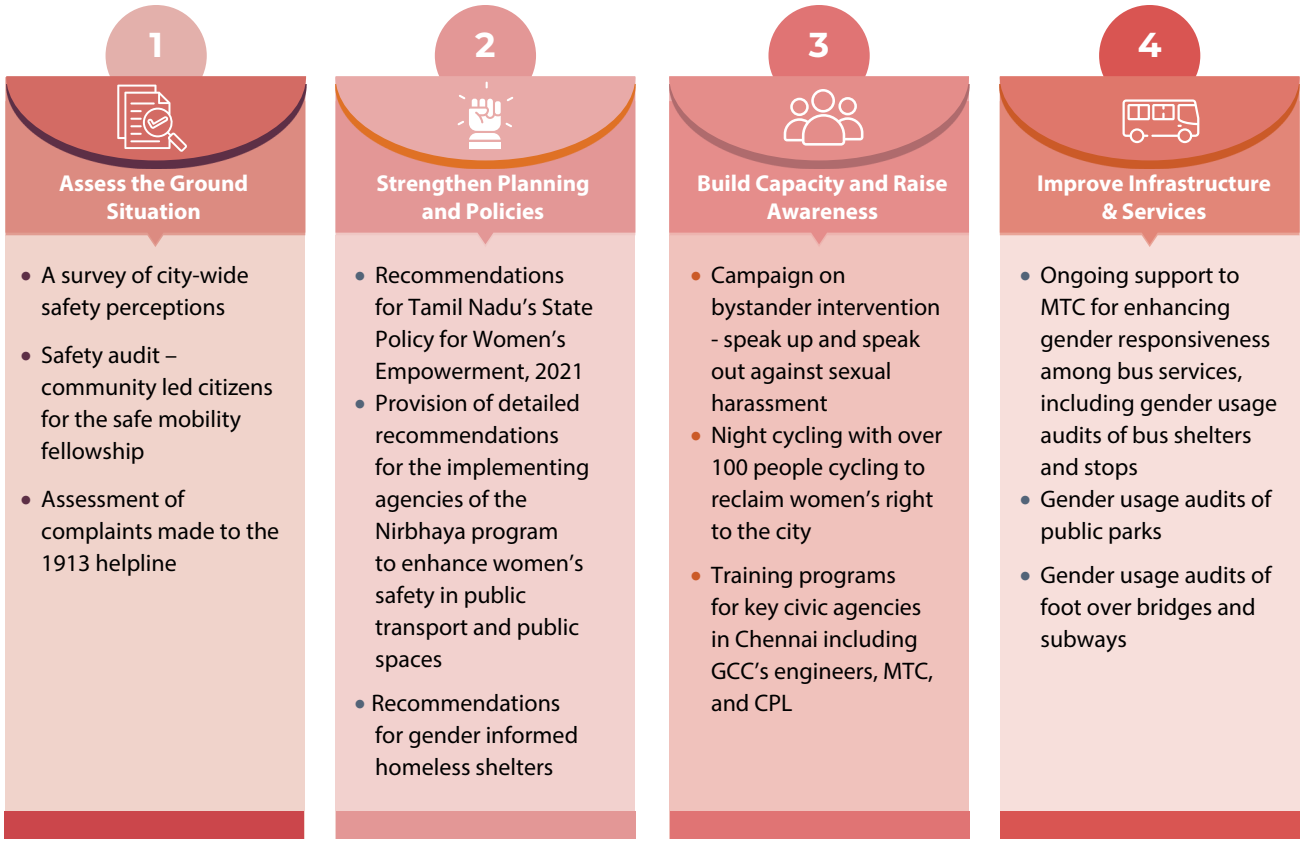

FIGURE 6.2: GPL'S KEY ACHIEVEMENTS IN YEAR ONE

Gender lens in guidelines and processes	Infrastructure and service upgrades	Enhancing citizen awareness
A manual with a checklist for a gender-informed bus stop design has been adopted by MTC	Comprehensive safety audits have led to proposals for enhancing safety at 23 public toilets, 43 approach roads, 10 bus stops, 5 bus terminuses and 18 railway stations; 65 streetlights have also been installed	The 1913 helpline is now recording the gender of the complainants and has introduced new categories for safety concerns in the public spaces
GPL's checklist for inclusive park infrastructure was set for implementation by GCC's Parks Department, including sexual harassment prevention training for park watchpersons	The Electrical Department has sanctioned 425 new streetlight posts in 152 locations, increasing nighttime visibility	Citizen awareness regarding responses to sexual harassment on buses and the use of the 181 helpline has increased
Gender considerations incorporated in the standard operating protocols for urban homeless shelters	Refurbishment of two foot over bridges by GCC and a review of GPL's recommendations for subway enhancements is underway	Public awareness about women's right to the city and access during late hours has increased
Three internal complaints committees have been established in GCC zones		

Source: GPL Annual Report (2023).

TAKEAWAYS FOR OTHER CITIES

GPL's experience offers valuable takeaways for other cities looking at strengthening gender responsive urban mobility, including:

- **Political will and leadership:** Political will and support of the senior leadership, especially in GCC were crucial for GPL to secure the cooperation of various agencies.
- **Alignment with government priorities:** Linking GPL activities with national programs like Nirbhaya created political support and allowed GPL to build on ongoing interventions.
- **Breaking down silos:** Coordination between different agencies involved in urban transport (like MTC and CMTA) was achieved through a working group. This allowed the sharing of data and resources for better outcomes.
- **Standardizing gender mainstreaming:** GCC and GPL have put processes in place to ensure that gender considerations are incorporated in all project proposals. GPL is also in the process of creating a Gender Inclusive Design Manual as a guide for future projects.
- **Data-driven approach:** Collecting and analyzing gender-disaggregated data through surveys and audits has helped understand how different genders use public spaces. This data is used for targeted improvements in infrastructure and services like better lighting or more women-friendly bus routes.

CONCLUSION

GPL's experience shows that civic agencies aspiring to launch interventions for developing gender responsive urban mobility ecosystems and public spaces need dedicated institutional mechanisms. With strong political will, a steadfast leadership, and a dedicated and skilled taskforce, cities can implement structured interventions at the program level for achieving the long-term vision of safer and more inclusive cities for all.

Please click here to access the technical note on this topic.

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Endnotes

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6 New Delhi, Chennai, Kolkata, Pune, Indore, Hyderabad.
7 Tamil Nadu, New Delhi, Uttar Pradesh, Kerala, West Bengal, Bengaluru.
8 CRUT, Odisha.
9 World Bank. 2022. India - Toolkit for Enabling Gender Responsive Urban Mobility and Public Spaces. © Washington, DC. http://hdl.handle.net/10986/38199 License: CC BY 3.0 IGO.

Photo credit: CUMTA

7: DEVELOPING A METROPOLITAN ROAD SAFETY ACTION PLAN: CASE STUDY FROM CHENNAI

Krishnan Srinivasan[1], Sudeshna Mitra[2], Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

Safety is at the heart of the sustainable mobility agenda and forms part of the UN's Sustainable Development Goals (SDGs). Road crashes are a global public health problem, particularly in fast-growing cities in developing countries. Cities worldwide are increasingly adopting the Safe System approach for pushing towards the goal of eliminating fatalities and serious injuries (Figure 7.1). This approach focuses on a human-centric method for road users' safety, looking beyond user behavior and the safety of motorized vehicles, to all aspects that can affect the safety of road users.

This note discusses the approach adopted in Chennai for tackling road crash fatalities and injuries based on the Safe System principles. The Chennai example could be instructive for other cities in India and elsewhere that are grappling with similar issues.

India is facing a mounting road safety problem. Road crashes took 168,491 lives in India in 2022, causing immense social, physical, and financial distress to individuals, families, and society; 54,230 (33 percent) of these fatalities occurred in urban areas, with 17,089 (11 percent) being recorded in 51 cities with a population over a million. While some metropolitan cities such as Mumbai, Kolkata and Delhi have addressed this problem and even reversed the trend, road safety remains a major challenge (Figure 7.2).

> Rising urbanization, disposable incomes, and aspirations, coupled with the low cost of motorcycles and lack of viable public transport options, have led to rapid motorization (especially of two-wheelers).

FIGURE 7.1: THE SAFE SYSTEM APPROACH

Source: Martin Small, and Tawia Addo-Ashong. 2021. Road Safety Strategies for African Cities: A Guide to Development. Washington, DC: SSATP

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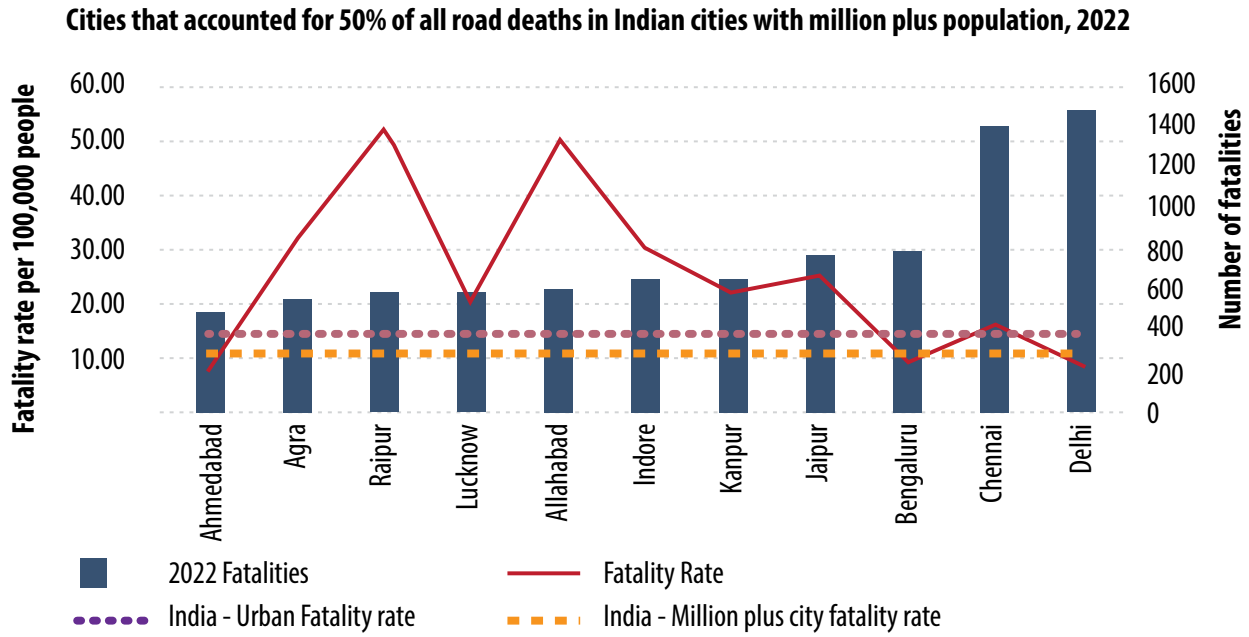
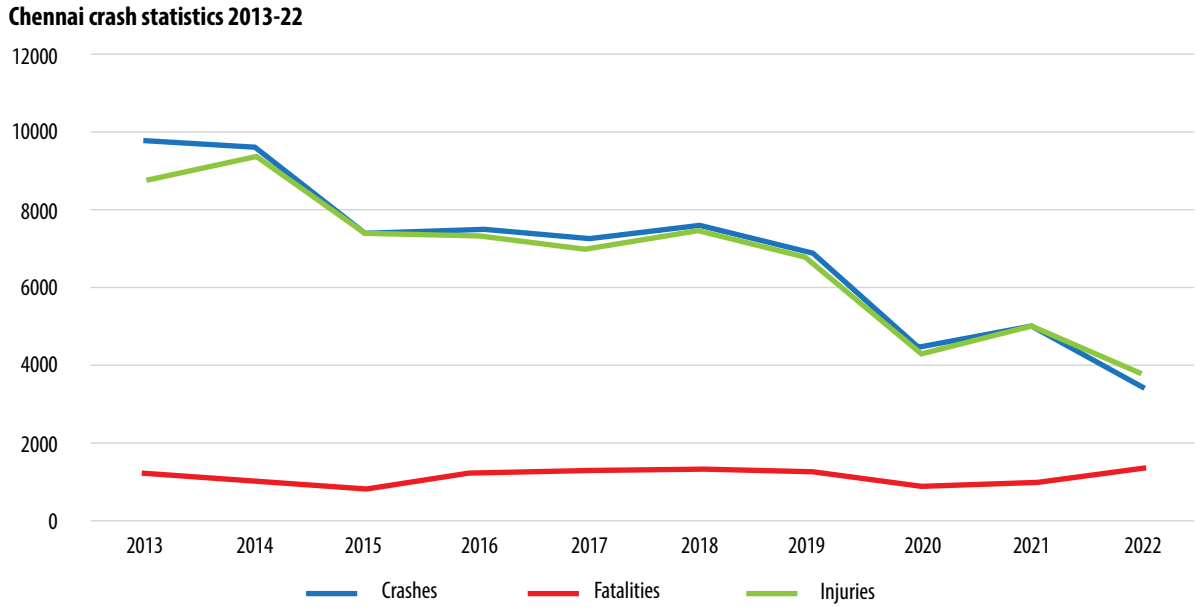
FIGURE 7.2: ROAD FATALITIES IN THE TOP 11 CITIES IN INDIA IN 2022



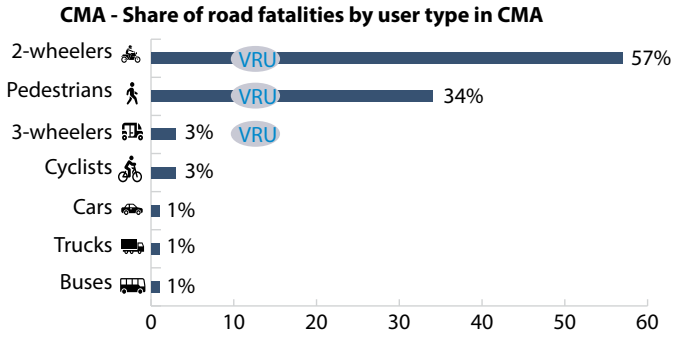
Source: Road Accidents in India (2022), TRW, MORTH, GoI (October 2022); WB analysis.[3]

FIGURE 7.3: CHENNAI ROAD CRASH STATISTICS, 2013-2022[4]



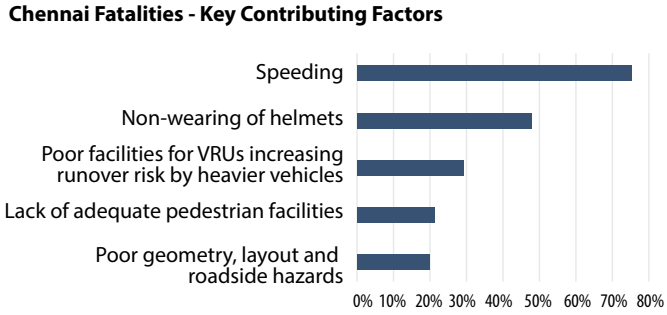
Chennai's road safety situation typifies that of other large Indian cities. While the road safety situation in CMA[5] seems to have improved over time with fatalities numbers showing considerable decline with increase in population, it continues to witness an average of 1,150 deaths annually (Figure 7.3), highlighting the urgent need for tackling the road safety challenges systematically. Vulnerable road users (VRUs -- pedestrians, motorcyclists, and cyclists) are most at risk of death from road crashes in Chennai. Motorcyclists made up 57 percent of all fatalities, with speeding and not wearing helmets being the key risk factors, and pedestrians accounted for another third (Figures 7.4 and 7.5), where collisions with motorcyclists was the main cause of death. Surveys in 2022 by DIMTS have shown that about 40 percent of the vehicles exceed posted speed limits, and a third of two-wheeler riders and almost all pillion riders do not wear helmets. Besides user behavior, road infrastructure and limited facilities for VRUs are other major contributors to fatalities with 89 percent, 70 percent, and 26 percent of roads rated 1 or 2-star (on a scale of 1 to 5 on the International Road Assessment Program (iRAP) classification of 1

FIGURE 7.4: ROAD FATALITIES BY USER TYPE IN CMA, 2019



Source: GCTP

FIGURE 7.5: CHENNAI ROAD FATALITIES - KEY CONTRIBUTING FACTORS



Source: DIMTS Report on CRSAP (Feb 2023); WB analysis.

carrying the highest risk), for pedestrians, cyclists, and motorcyclists respectively. These underscore a need for safer infrastructure, speed calming measures, and stronger enforcement of speed and helmet compliances.

Underlying issues. The road safety apparatus in India needs to keep up with motorization trends. Rising urbanization, disposable incomes, and aspirations, coupled with the low cost of motorcycles and lack of viable public transport options, have led to rapid motorization (especially of two-wheelers). Between 2009 and 2019, motorization in India increased at a faster pace than the lengths of the primary and secondary road networks.[6] This led to increased competition for road space, with vehicles prioritizing VRUs. Consequently, road crash fatalities increased by 20 percent, with the share of two-wheeler fatalities more than doubling over the same period. [7]

The road safety challenges are compounded by gaps in institutional arrangements and capacity. While there are often state and city level entities looking at different aspects of road safety, inter-departmental coordination for road safety management is an issue. Enforcement is resource intensive and therefore inadequate. Road safety agencies need improved technical capacity and exposure to safety best practices. The use of data for decision-making and benchmarking of road safety management performance is only emerging. Institutional arrangements for road safety in Chennai, as in most other Indian cities are dispersed across the works/highways, transport, and police departments, making monitoring of interventions and accountability difficult. This has implications for key safety elements such as speed limit setting. Further, safe speeds need to be better addressed in design and in the operation of roads for reducing the exposure of VRUs to safety risks.

APPROACH IN CHENNAI

Developing and implementing a Road Safety Action Plan for Chennai. International best practices emphasize a holistic approach in the development and implementation of road safety action plans (RSAPs) in cities with institutional/policy, infrastructure, enforcement, post-crash care, and speed management elements, all underpinned by systematic collection and analysis of accurate crash data for monitoring and evaluation.[8]

Recognizing the impact of annual city road fatalities, the Chennai Smart City Limited initiated the development of a Chennai Road Safety Action Plan (CRSAP)[9] based on the Safe Systems approach in 2020 and adopted it in 2023 with a vision of ***Safe Chennai Roads, free from fatal and serious injuries.*** CUMTA has since become the custodian of the CRSAP. Key issues and deficits under infrastructure, institutions, enforcement, and user behaviors were identified through a thorough analysis of available crash and non-crash data. These were systematically analyzed using a combination of the iRAP star rating methodology and crash rates to prioritize 469 km of road corridors for both capital intensive and mass action safety improvements. The benefit-cost ratio of the infrastructure improvements alone was 11:1, indicating a high return for an investment of just US$ 75 million in mass action treatments.

Key elements. In line with best practices, CRSAP comprises the following four key elements:

a. **Safety performance targets:** For achieving its vision, CRSAP has set Safety Performance Targets (SPT) till 2030 targeting some of the factors contributing to road crashes (Figure 7.6).

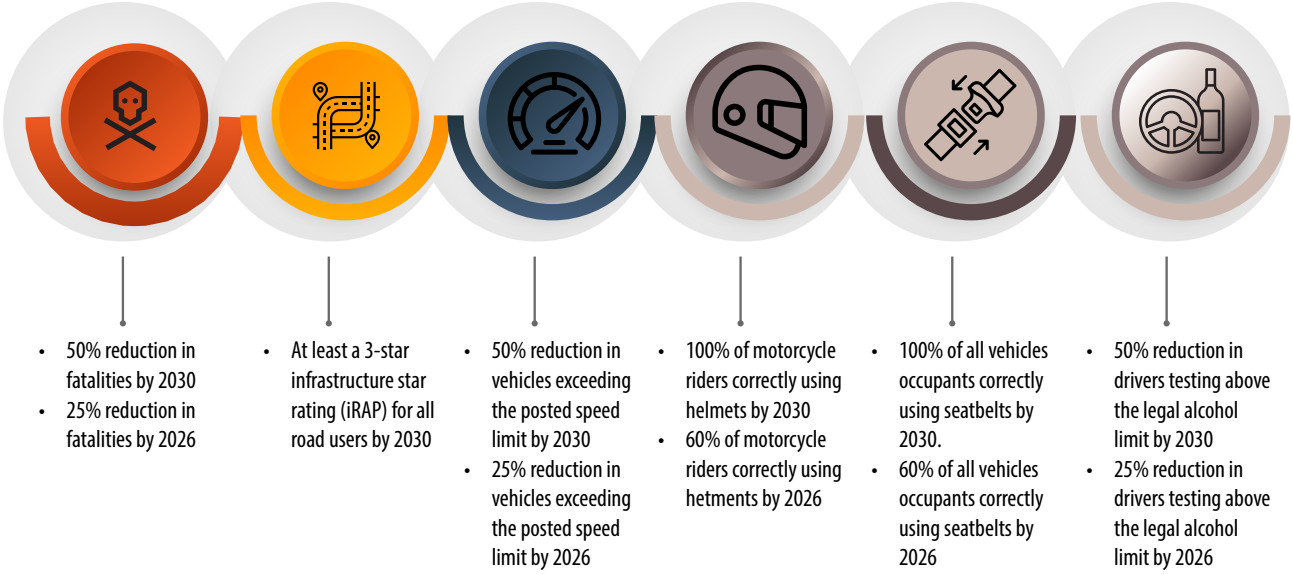
b. **Improved institutional arrangements:** CUMTA has established a Road Safety Cell (RSC)[10] for oversight, interagency coordination, and monitoring, evaluation and reporting of road safety interventions, outputs, and outcomes, and a Road Safety and Non-Motorized Transport Sub-committee to oversee implementation of CRSAP and related road safety initiatives in CMA.

c. **Interventions:** The top four priorities that Chennai has identified for its road fatalities are:

- **Safe roads and roadsides:** CUMTA is considering mass action and geometric treatments – pelican signals, speed humps/cushions and traffic calming measures, tabletops and refuge islands, road narrowing, speed tables, signalized pedestrian crossings, school zones, and gateway treatments at high crash risk locations for reducing pedestrian facilities, along with systematic templates for each type of measure for city-wide replication.
- **Safe road use:** The Greater Chennai Traffic Police (GCTP) has already installed Traffic Regulation Observation Zones on several city roads with Automatic Number Plate Recognition (ANPR) technology and digital cameras at junctions to automate monitoring of traffic violations and minimizing human interaction and errors.
- **Safe speeds:** In November 2023, GCTP mandated a uniform speed limit of 30 kmph in all residential areas, differential speed limits for vehicle classes, and a maximum speed limit of 60 kmph for light motor vehicles in the city.
- **Helmet-wearing:** Strict enforcement of helmet-wearing by GCTP has yielded good outcomes: a survey conducted under a World Bank study showed that helmet compliance in Chennai improved from ~20 percent in 2019 to ~65 percent in 2022, resulting in a ~48 percent reduction in two-wheeler fatalities between 2019 and 2022.[11] However, enforcement is needed for ensuring that pillion riders comply (about 78 percent did not wear helmets in 2023) and fasten their chin clip (36 percent of all riders did not wear helmets in 2023), to help reduce two-wheeler fatalities further.
- **Public awareness:** This is for enhancing the effectiveness of enforcement. Chennai is considering emulating the example of Coimbatore, where the Kutty Corps[12] project co-opted primary school children to nudge their family members to follow traffic rules.

d. **Improved reporting, monitoring, and evaluation arrangements:** Chennai has set up a robust monitoring and evaluation program to help implement and evaluate the strategy, performance, and delivery of action by each responsible agency.

FIGURE 7.6: CRSAP SAFETY PERFORMANCE TARGETS



Source: CRSAP (February 2023).

EXPECTED IMPACT

The institutional set-up in Chennai with representation from key stakeholder departments and systematic implementation of CRSAP's measures provides a shift in focus that could help the city more than halve its fatalities by 2030 and achieve the SDG goals.

TAKEAWAYS FOR OTHER CITIES

- **Robust institutions**: Arrangements in the form of either a dedicated lead agency or committees at high level executive and operational levels are vital for the coordination, management, and delivery of all city road safety activities.
- **Data-driven decision making**: Accurate data on incidence and type of crashes along with a detailed analysis and understanding the crashes' contributory factors and pedestrian and NMT volumes are essential for policy decisions, prioritizing public health issues, identifying interventions, monitoring trends, and assessing intervention programs in cities.
- **Forgiving roads and roadsides**: Cities should aim at developing a road transport system which accommodates human error and reduces human exposure to motor vehicle speeds/crash forces that may result in death or serious injury. Cities should also avoid building foot-over bridges and subways for addressing pedestrian-vehicle conflict, which often fail to incorporate user behavior.
- **Speed management**: Safety needs to be directly provided in cities by significantly reducing motor vehicle speeds in high pedestrian areas and indirectly by supporting safe motor vehicle movements in high-volume corridors.
- **Systematic, proactive assessment of roads:** Cities with highways passing through them should identify and prioritize mass action road safety treatment for above-grade infrastructure with a context-sensitive design for the streets below, especially where crashes are widely dispersed.

CONCLUSION

Formulating, adopting, and implementing a city road safety action plan along the Safe System's principles is an essential first step for metropolitan cities in low- and middle-income countries for reducing road death tolls. The plan should be supported by crash data, targeting the contributing risk factors, for achieving targeted safety performance goals. The success of the action plan also relies on strong institutional and governance arrangements, dedicated funding for implementing effective interventions across all pillars of road safety, and timelines and monitoring and evaluation arrangements. CRSAP is a unique example of an action plan that is concretely tied to a-priori-defined targets using multi-sectoral interventions, with potential for replication in other metros across India.

Please click here to access the technical note on this topic.

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Endnotes

1 Krishnan Srinivasan is a Consultant at the World Bank.
2 Sudeshna Mitra is a Transport Specialist at the World Bank.
3 Crash data from Avadi and Tambaram have been added to the figures in 2022, for alignment with data from previous years.
4 Crash data from Avadi and Tambaram have been added to the figures in 2022, for alignment with data from previous years.
5 Comprising Chennai City, Avadi, and Tambaram.
6 Primary comprising national highways that account for 2 percent of the total network, but with 40 percent of the country's total road traffic and secondary comprising state highways and major district roads that account for about 3 percent of the road network with another 40 percent of the total road traffic.
7 World Bank analysis of road crash statistics from GOI MORTH Road accidents in India reports, from 2009 to 2019.
8 Australia, Japan, New Zealand and several EU countries including Sweden have successfully used RSAPs for improved road safety outcomes.
9 DT NEXT (2020). Article. Road safety action plan to bring down accidents, fatalities in Chennai, suburbs.
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Photo credit: CUMTA

8: STRENGTHENING THE METROPOLITAN TRANSPORT GOVERNANCE

Shyam Srinivasan, Jeyakumar Iyamperumal[1] (CUMTA), and Gerald Ollivier

INTRODUCTION

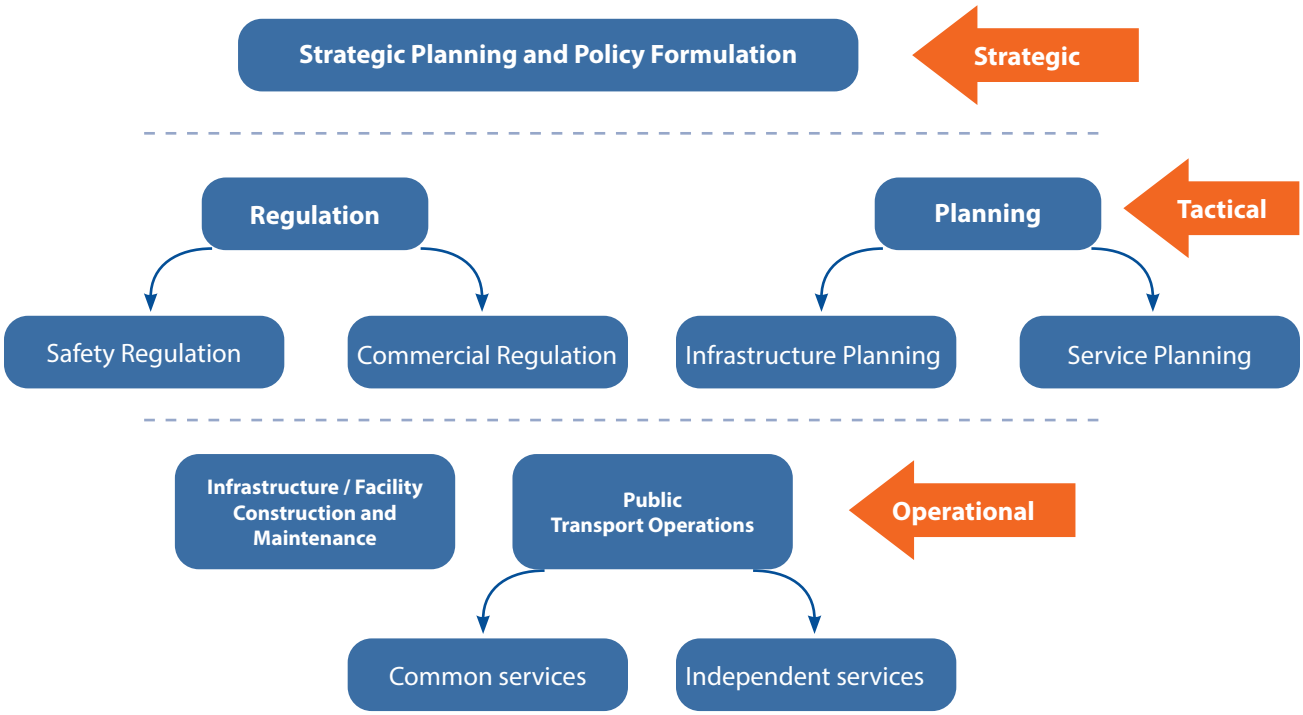
With rapid urbanization comes increasing demand for public services such as transport. Cities around the world are grappling with this challenge with mixed results. In cities with sustainable transport systems, the recipe for success often boils down to governance. This note explores the question of urban transport governance through the lens of Chennai, India, where a nodal agency, the Chennai Unified Metropolitan Transport Authority (CUMTA) was recently operationalized under the Chennai City Partnership between the Government of Tamil Nadu and the World Bank.

An urban transport system requires a variety of stakeholders for performing a range of activities. The full range of urban transport functions can be categorized under three levels of activities: *Strategic*, *Tactical,* and *Operational* (Figure 8.1). In cities around the world, multiple agencies at different levels of the government undertake these functions, often with overlapping mandates with some critical functions not being clearly assigned. This is true of many Indian cities, where a plethora of agencies across all levels of government (central, state, and city) have a stake in urban transport governance. The rules of the game are defined by a complex framework of acts, rules, regulations, and guidelines. Chennai is a case in point. Critical functions like multimodal integration, common ticketing or integrated transport and land use were dealt with by different departments with limited coordination prior to the establishment of CUMTA.

There is a strong need for decreasing institutional fragmentation in large cities. While it is not always possible or necessary to have a single lead agency undertaking the full range of functions, the bigger the city, the stronger the value proposition of a single agency. The Government of India has long recognized the value of coordination. The National Urban Transport Policy (2006) identified the need to strengthen coordination across urban mobility agencies and functions. The national Metro Rail Policy[2] of 2017 required cities seeking central assistance for metro projects to establish urban metropolitan transport authorities (UMTAs).

In September 2020, the CUMTA Act was amended to designate the Chief Minister of Tamil Nadu as the chairman of CUMTA, and the minister for housing and urban development as its vice-chairman. This set the stage for progress with operationalization that has been achieved since the World Bank-supported Chennai City Partnership: Sustainable Urban Services Program (SUSP) became effective.

FIGURE 8.1: FUNCTIONS TO BE PERFORMED IN THE PROVISION OF URBAN TRANSPORT



Source: Kumar & Agarwal (2013)[3]

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APPROACH IN CHENNAI

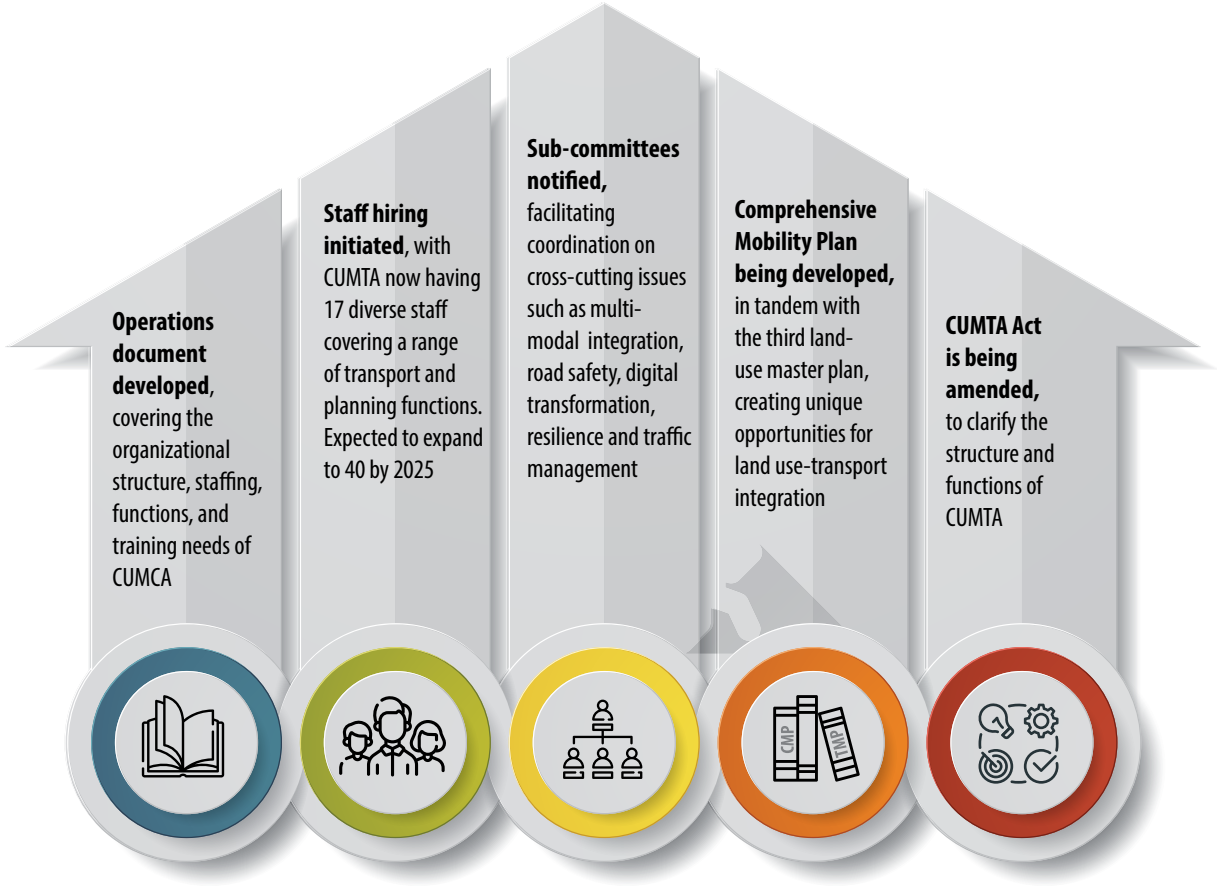
CUMTA's journey. CUMTA stands out as one of a handful of operational UMTAs across India. In November 2010, the Government of Tamil Nadu (GoTN) passed the CUMTA Act to establish the entity which would oversee, coordinate, promote, and monitor the implementation of traffic and transportation measures in CMA. Although around 17 UMTAs have been established thus far, the number of UMTAs backed by legislation is much more limited, including Hyderabad, UTTIPEC (Delhi), and Kochi. This makes CUMTA one of a handful of UMTAs backed by legislation, in the 46 million-plus cities in India.[4]

It took 10 more years for CUMTA's operationalization to begin in earnest. In September 2020, the CUMTA Act was amended to designate the Chief Minister of Tamil Nadu as the chairman of CUMTA, and the minister for housing and urban development as its vice-chairman. This set the stage for progress with operationalization that has been achieved since the World Bank-supported Chennai City Partnership: Sustainable Urban Services Program (SUSP) became effective.

CUMTA has adopted ***moving people and freight seamlessly through an integrated, sustainable, safe and resilient transport ecosystem*** as its vision. To help CUMTA realize its vision, five key actions are being pursued under SUSP to advance CUMTA along its operationalization roadmap (Figure 8.2).

When fully operational, CUMTA will be a planning and regulatory body, performing mainly strategic and tactical roles in the hierarchy of transport functions, whereas operational responsibilities will continue to be helmed by line agencies. CUMTA's steady state functions are summarized in Figure 8.3. CUMTA will be operationalized in three phases. Simpler and core functions of integrated planning and effective coordination have been prioritized up to now, with more complex functions requiring greater organizational strength to be added in the medium and long term. Well-defined maturity triggers have been developed in the operational document for guiding CUMTA's advancement to subsequent phases of operationalization. CUMTA's staffing will be expanded as it progresses through the phases and it will reflect the multi-disciplinary nature of urban mobility.

FIGURE 8.2: KEY STEPS TOWARDS OPERATIONALIZING CUMTA



Source: Authors' illustration

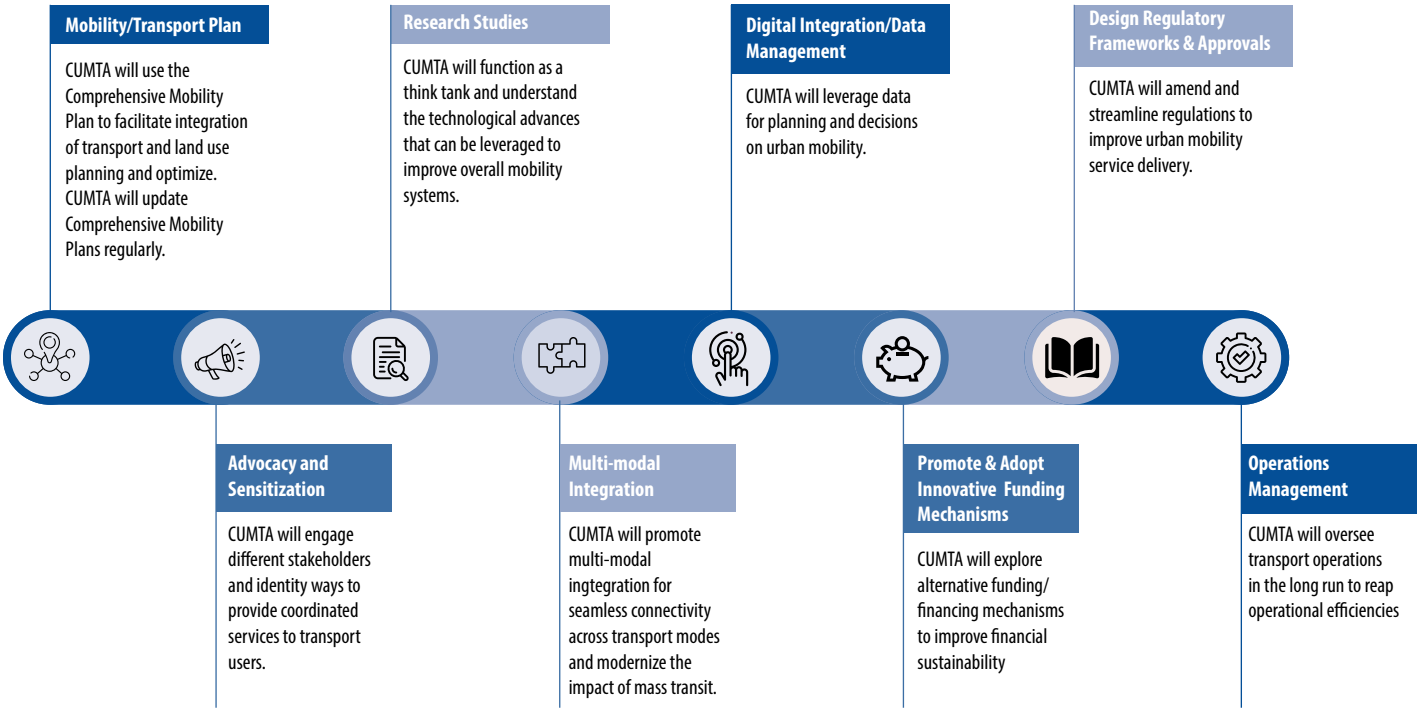
Assuming some control over sectoral funding allocations will be a significant milestone for CUMTA, targeted by 2027. In line with NUTP, an Urban Transport Fund (UTF) to be funded through novel funding sources such as additional property taxes and parking revenues is being mooted. UTF could be established when CUMTA is more mature, after close consultations with stakeholder agencies to ensure alignment.

EXPECTED IMPACT

CUMTA's impact on the urban mobility landscape in Chennai is emerging. Quantifiable impacts of new institutions materialize over time, and this is also true of CUMTA. However, there are some encouraging signs. The Government of Tamil Nadu is increasingly looking to CUMTA to take on cross-cutting functions which are not covered by existing agencies. Using the public consultation exercises as part of the Comprehensive Mobility Plan, CUMTA has become the face of the government for transport issues, and it has developed a strong social media presence. CUMTA is also advancing several marquee mobility initiatives in Chennai:

- **Revitalizing the Mass Rapid Transit System (MRTS).** CUMTA is playing a pivotal role in the eventual handover of MRTS in Chennai from the Indian Railways to the Government of Tamil Nadu, with the Chennai Metro Rail Limited as its operator. This is expected to improve MRTS' integration with Chennai metro.
- **Integrated ticketing.** CUMTA is developing an integrated ticketing application for improving user convenience for multimodal trips
- **Road safety.** CUMTA has partnered with the World Bank on several studies and convened key stakeholders to deliberate on road safety issues via the road safety sub-committee.
- **Digitalization.** CUMTA has engaged a consultant for the Digital Chennai initiative which aims to leverage urban mobility data for decision making and improving coordination on multi-year construction projects.

FIGURE 8.3: CUMTA'S FUNCTIONS IN THE STEADY STATE



Source: CUMTA Operations Document

CUMTA sub-committees have facilitated coordination on cross-cutting issues. Since CUMTA's mandate is coordination and stewardship of urban mobility in partnership with existing agencies, effective coordination mechanisms are a must. CUMTA has leveraged its sub-committees (multimodal integration, road safety and NMT, Digital Chennai, and urban resilience) and traffic management, as convening platforms for bringing together different agencies for decisions on cross-cutting issues, including the mobility initiatives.

TAKEAWAYS FOR OTHER CITIES

CUMTA's experience offers valuable takeaways for other cities looking at strengthening urban transport governance.

- **Fledgling agencies need strong champions.** CUMTA's establishment required a strong push from the senior management in Chennai. GoTN also saw the value of milestones and disbursement linked indicators under the World Bank funded SUSP to incentivize the achievement of key establishment milestones.
- **An organization is only as strong as its people.** The government's decision to appoint a seasoned officer from the Indian Railway Service is a signal of the important role that CUMTA is envisioned to play in the institutional landscape and has helped open doors. CUMTA's staff comprises open market hires and secondees from stakeholder agencies. A combination of fresh ideas and established public sector networks has helped CUMTA start its work quickly.
- **Lead agencies need opportunities to prove their worth.** CUMTA is leading a range of initiatives, providing opportunities for demonstrating thought, implementation leadership, and value addition.
- **It is a continuous process.** Lead transport agencies around the world took several decades to take shape and are continuously evolving. CUMTA too will evolve as it assumes its different functions and grows in strength and visibility.

CONCLUSION

CUMTA's journey offers valuable takeaways for other cities looking at strengthening institutional coordination in urban transport. CUMTA owes its success to a clear vision and backing from the highest levels of the government, an operational roadmap with a graduated approach to CUMTA assuming responsibilities, and opportunities for CUMTA to demonstrate its value to existing stakeholders. Bigger challenges are coming up such as assuming control of the funding allocations for the transport sector, a milestone under SUSP. In the meantime, CUMTA continues to find its feet and establish itself as a key node in the urban mobility institutional labyrinth.

Please click here to access the technical note on this topic.

Endnotes

1 Jeyakumar Iyamperumal is the Member Secretary at CUMTA
2 Metro Rail Policy (2017), Ministry of Housing and Urban Affairs, Government of India.
3 Kumar, Ajay and O.P. Agarwal (2013). Institutional Labyrinth: Designing a Way for Improving Urban Transport Services: Lessons from Current Practice.
4 Diagnostic Review and Report on Strengthening the CUMTA Act, Deloitte (2020), for the World Bank.

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Photo credit: CUMTA

9: DATA-DRIVEN URBAN FUTURES: PREPAREDNESS FOR LEVERAGING DATA IN INDIAN URBAN PLANNING

Jai Kishan Malik, Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

India's urban mobility infrastructure faces rapid growth, highlighting the need for innovative and efficient planning processes. As urbanization accelerates in India, accompanied by a surge in private vehicle ownership and population density, the country faces unprecedented challenges in urban mobility and planning. With an annual urban population growth rate of 3.2 percent and a 9 percent increase in motor vehicle population annually, the existing infrastructure is overwhelmed.[1,2] The Government of India has signaled the importance of data-driven smart cities by launching the DataSmart Cities Strategy (DSC). Anchored in responsible data practices aligned with the National Data Sharing and Accessibility Policy (NDSAP) and the Digital Personal Data Protection Bill, 2023, DSC seeks to harness the power of big data for revolutionizing urban mobility planning.[3] By establishing a robust digital infrastructure and promoting data standardization, India aims to foster efficient and effective urban planning.

Data platforms are crucial for data-driven urban planning, but effective governance is essential for addressing the challenges of handling vast datasets and coordinating stakeholders. Data platforms are pivotal portals for disseminating information for enhancing city functionality, reflecting a crucial shift towards data-driven urban planning. Big data's expansive scope and predictive capabilities play a pivotal role in creating efficient and sustainable urban landscapes. However, the challenges associated with handling vast datasets and coordinating with diverse stakeholders underscore the critical need for robust governance frameworks. The technical complexities involved in aggregating, modeling, and disseminating data necessitate a cohesive governance structure that extends beyond technological intricacies, emphasizing coordinated efforts among platform developers, academia, transport service providers, research & development startups, authorities, and travelers.

> Once operational, these tools will offer standardized data storage, sharing, and utilization frameworks, facilitating data-informed urban planning and efficient project management practices.

This note outlines some effective strategies that cities have implemented for using data for smart urban mobility planning. The document includes examples from Singapore, New York City, and London, as well as insights from Chennai, which is also integrating data into its planning.

APPROACH IN CHENNAI

Establishing a centralized agency with clear mandates and strong leadership is critical for integrating big data in the transport planning process. This is exemplified by CUMTA,[4] which underscores the need for

dedicated entities overseeing integrated urban transport measures, drawing inspiration from international models like Transport for London (TfL) and Singapore's Land Transport Authority (LTA). Addressing challenges related to data governance requires unified data repositories, consistent standards, and robust governance frameworks, as seen in Tamil Nadu's recent data policies.[5] CUMTA plays a key role in managing and analyzing big data for informed decision-making by strategically integrating city-level data. The agency is supported by a tiered governance structure and technical sub-committees facilitating effective implementation and innovations in urban mobility planning.

Investing in digital platforms for data management and strengthening the focal agency's technical capabilities are essential for data-driven planning. With CUMTA's focus on enhancing technical capacity and establishing key roles like Mobility and Spatial Development Data Architect, Senior Data Integration Engineer, and Junior Data Scientist, Chennai aims to leverage data for informed decision-making and sustainable urban development. The Digital Chennai initiative, supported by the Digital Chennai sub-committee, seeks to streamline urban planning and infrastructure implementation practices, fostering collaboration between various agencies and ensuring effective project oversight. Developing tools like IUDP (Integrated Urban Development Platform), UPPM (Urban Project Planning and Management), and the Asset Management Platform under consideration as part of the Digital Chennai initiative are crucial for transformative urban mobility and spatial development strategies, drawing inspiration from global models like New York City's Open Data initiative.[6] Developing these tools requires pre-emptive work, like the use-case identification for each stakeholder. Once operational, these tools will offer standardized data storage, sharing, and utilization frameworks, facilitating data-informed urban planning and efficient project management practices. Using these tools, Chennai will address challenges related to data discoverability, duplication, and security concerns, laying the foundation for a data-informed approach to urban planning and infrastructure development. These efforts are expected to lead to efficient urban mobility, promoting cleaner transport modes and preparedness for MaaS, ultimately contributing to enhanced sustainability, effectiveness, and resilience in the face of urbanization and climate-related challenges.

Cities need to establish a structured framework and protocols to systematically address flagged infrastructure planning issues identified by tools like IUDP and UPPM. This entails forming a committee comprising decision-makers from relevant agencies endowed with technical capabilities to review multi-sectoral projects for resolving emerging conflicts. Drawing from the example of Toronto's Major Capital Infrastructure Coordination Office (MCIC) established in 2008, cities like Chennai can learn from the MCIC's approach to utilizing GIS-based tools for monitoring infrastructure projects across multiple agencies and implementing additional dispute resolution protocols. For instance, agreements and protocols among participating agencies can prioritize specific project types based on their location, enhancing coordination, and streamlining infrastructure planning processes. Currently, the Tamil Nadu Geographic Information System (TNGIS) is responsible for collecting and organizing GIS data in the state and will be a key stakeholder in this committee.

Opening data to public and private entities, academia, and startups while balancing data privacy concerns is paramount for fostering innovation-driven urban planning. Cities can draw inspiration from global examples such as TfL and LTA in Singapore,[7] which actively engage with third-party private players for enriching their data ecosystems. By collaborating with companies like Waze, Apple, and CityMapper, these cities enhance their data landscapes and stimulate technological advancements and innovations. Such partnerships bring diverse expertise, resources, and perspectives to the table, leading to more comprehensive and innovative solutions to urban planning. However, this openness must be balanced by ensuring that data privacy concerns are addressed adequately. Striking this balance will promote transparency and citizen engagement and build trust, laying the foundation for a collaborative approach to urban planning that drives innovations and brings out the best ideas in a wide range of stakeholders. Integrating data from private sources for decision making should also be considered where feasible. Currently there is no provision of open data policy in the data policies formulated by the state of Tamil Nadu or the city of Chennai. Going forward, Chennai will benefit from opening the data while balancing privacy concerns.

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EXPECTED IMPACT

Chennai's data-driven initiatives are poised to advance urban mobility and planning. The formation of CUMTA and the Digital Chennai initiative signal a unified approach to data collection and analysis. Tools like IUDP and UPPM are expected to streamline project management and infrastructure development. Anticipated outcomes include more efficient urban mobility, promotion of cleaner transport modes, and preparedness for Mobility as a Service (MaaS). The initiatives aim to facilitate the successful implementation of large-scale projects, systematic asset management, and establish frameworks for prioritizing areas like road safety and climate resilience. Ultimately, these efforts should enhance sustainability, effectiveness, and urban resilience in the face of rapid urbanization and climate challenges.

TAKEAWAYS FOR OTHER CITIES

Chennai's approach to data-driven urban planning offers valuable lessons for other Indian cities:

- **Establish a centralized agency**: The creation of CUMTA demonstrates the importance of a dedicated entity with a clear mandate to oversee integrated urban transport measures.
- **Invest in technical capacity**: Chennai's focus on roles like Mobility and Spatial Development Data Architect underscores the need for specialized technical expertise.
- **Develop comprehensive data tools**: The planned IUDP and UPPM tools have the potential to address challenges in data management, integration, and project oversight.
- **Foster cross-agency collaboration**: Chennai's Digital Chennai highlights the potential for data repositories to foster interagency coordination and collaboration, provided suitable use cases can built upon such repositories to spark conversations on and trade-offs.

By adopting these strategies, other Indian cities can leverage data for more sustainable, effective, and resilient urban development in the face of rapid urbanization.

CONCLUSION

India's urban mobility infrastructure faces unprecedented challenges amidst rapid urbanization and a surge in private vehicle ownership. Recognizing the transformative potential of data-driven smart cities, GoI launched the DataSmart Cities Strategy (DSC) for revolutionizing urban mobility planning and fostering efficient and effective urban planning by establishing a robust digital infrastructure and promoting data standardization. However, the success of data platforms hinges on effective governance frameworks to handle vast datasets and coordinating with stakeholders. Examples from cities like London, Singapore, and New York City underscore the importance of partnerships with private entities for enriching data ecosystems and driving innovations in urban planning while striking a balance with data privacy concerns. In addition, cities must establish structured protocols for addressing flagged infrastructure planning issues systematically, as exemplified by Toronto's MCIC.

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Photo credit: Unsplash

10: PRACTICAL USE CASES OF LEVERAGING DATA FOR URBAN MOBILITY PLANNING

Jai Kishan Malik, Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

The advent of big data, fueled by automation and digitization, is heralding a paradigm shift in traditional transport planning methodologies. Beyond merely offering a deluge of information, big data empowers planners with unprecedented granularity in spatial and temporal insights previously unattainable through conventional means. This transformative force not only unravels intricate patterns in human movement but also introduces a dynamic dimension to urban mobility planning through continuous monitoring. The ability to detect emergent trends and adapting in real-time signifies a departure from static, exhaustive analyses and moving towards more agile and adaptive policy frameworks.

Diverse data sources beyond traditional datasets enrich urban transport planning. These include official registration data, commercial transactions like ticketing, tracking data from cell phones and internet use, infrastructure details, service delivery data like GTFS, CCTV based traffic volume counts, and real-time asset status. These sources enable informed, dynamic urban planning, fostering efficiency and responsiveness in transportation systems.

This note highlights the potential of big data analytics in forging informed and efficient urban planning strategies. By showcasing the following tangible use cases, it seeks to inspire a shift towards a smarter, data-driven approach to shaping the future of urban mobility services.

Big data use cases based on international experience

Integrating data in urban governance facilitates the creation of key performance indicators (KPIs) for comprehensive transport planning. KPIs can encompass diverse urban objectives, from equity to environmental impact. Using real-time data, decision makers can balance needs effectively and adjust projects for optimizing outcomes. Dynamic urban dashboards, exemplified by CityDashboard in London[1] and Sydney,[2] offer real-time insights into various city metrics. Indian cities like Chennai are recognizing the potential of new data sources for visualizing KPIs, enhancing decision-making processes. Embracing KPIs and advancing data governance can help cities navigate urban mobility complexities, and selecting projects based on their multifaceted impacts thus fostering sustainable development and citizen welfare. This approach, illustrated by the suggested World Bank's suite of indicators[3] for Chennai, emphasizes equity, resilience, and innovation in mobility planning, providing a roadmap for

> This shift towards continuous monitoring supports adaptive, citizen-centric policymaking globally. It addresses urban mobility's complexities and promotes inclusive, transparent governance.

cities to prioritize crucial aspects of transportation while ensuring data-driven, accessibility-informed decision-making.

Real-time data sources revolutionize evidence-based policymaking in urban governance, fostering agility and responsiveness. Cities like Bogotá showcase the efficacy of this approach,[4] using continuous monitoring for refining policies iteratively based on empirical evidence. With data-enriched visualizations, this transparent methodology builds public trust and encourages active engagement in planning processes. Bogotá's experience with traffic management policies, supported by real-time datasets like Waze for Cities,[5] exemplifies the tangible benefits of this approach. In Chennai, the Chennai Bus app and the Metro app provide real-time operational data to the public. Policymakers gain valuable insights by analyzing vast datasets with tools like Google BigQuery, enabling informed decision-making and more effective urban planning. This shift towards continuous monitoring supports adaptive, citizen-centric policymaking globally. It addresses urban mobility's complexities and promotes inclusive, transparent governance.

Data-driven insights transform urban asset management and operations, optimizing transportation systems' utilization, maintenance, and reliability. Big data technologies, spanning storage, processing, and analytics, facilitate dynamic optimization and policy formulation, exemplified by São Paulo's SIGMA platform, Seoul's TOPIS platform, and Singapore's FASTER system.[6] São Paulo's SIGMA platform integrates real-time GPS data with ticketing and socioeconomic information, informing route design and service frequency adjustments. Seoul's TOPIS is adept at harnessing a wide array of traffic-related data from its extensive traffic networks, ranging from bus movements and card system analytics to enforcement data. Singapore's FASTER system employs machine learning for predicting and mitigating transit disruptions, increasing system reliability and passenger satisfaction. These initiatives underscore the transformative potential of big data in enhancing urban transit planning, from real-time monitoring to incident prediction, optimizing services and improving overall reliability and efficiency.

Transitioning from traditional surveys to data-driven analyses can bring much greater granularity to transportation planning. This is exemplified by the study in Chennai on the adoption of mobile phone location data (MLD) for origin-destination (OD) matrices.[7] MLD enables granular and dynamic OD matrices, capturing travel patterns with precision and frequency. This shift enhances planning accuracy and timeliness, informing decisions based on current mobility trends. The World Bank study in Chennai demonstrates MLD's applicability, utilizing anonymized smartphone data to evaluate movement behavior and transit demand. Analyses techniques like trajectory analysis and clustering reveal high-density flows, informing network modifications and development strategies. MLD offers advantages over surveys, providing broader geographical and time coverage and higher sample sizes, while enabling real-time analysis. The study underscores MLD's transformative potential in transportation planning, paving the way for informed, data-driven decision-making in urban mobility. It can be difficult for city departments to regularly obtain such data from private providers. This process could be simplified if data access details were coordinated at the state or national government level, such as by signing memorandums of understanding with private data providers.

Unstructured data sources such as video footage, can be used for generating valuable and measurable KPIs with the help of machine learning algorithms. Advancements in machine learning and computer vision offer groundbreaking potential for enhancing road safety, particularly in near-miss detection and accident prevention. Technologies like convolutional neural networks (CNNs) enable the extraction of safety-related features from CCTV images, decoding complex urban dynamics. Critical steps, including image sensing and classification, form the foundation for constructing autonomous near-miss detection systems. Deep learning algorithms integrate with computer vision techniques to identify and analyze risk factors and near-miss types comprehensively. Case studies, like Addis Ababa's[8] road safety monitoring project, demonstrate the efficacy of computer vision analytics in evaluating traffic safety interventions. Chennai is developing deep-learning algorithms to detect, classify, and count vehicles and pedestrian traffic from video footage. By analyzing video footage from intersections, variables such as car speed, traffic volume, and incidents like near-hits and collisions are detected, providing valuable insights for policymaking and infrastructure improvements. This comprehensive approach enables the automatic quantification and analysis of risks, paving the way for more effective road safety strategies.

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While big data holds significant potential for revolutionizing transport planning with its expansive coverage and depth, practitioners must navigate its limitations with a discerning eye. Cities must deal with challenges such as the representativeness of the data, making the identification and mitigation of potential biases within the datasets crucial. At times, ground truthing may be needed. Privacy issues will also need to be navigated carefully. Given these multifaceted challenges, it is recommended that traditional data collection methods like targeted surveys, should continue to complement big data to ensure a balanced, ethical, and holistic approach to transport planning and the results of both analyses should be cross-referenced for enhancing a granular understanding of mobility patterns.

EXPECTED IMPACT

Chennai's nascent steps in data-driven urban mobility planning are setting the foundation for significant future improvements. The development of KPIs will facilitate more informed decision-making and resource allocation. Pilot studies using mobile phone location data could revolutionize public transport planning, optimizing routes and schedules based on actual travel patterns. CCTV-based pedestrian counts may enhance traffic management and pedestrian safety. These data-driven approaches are likely to lead to empirically grounded policy formulation, cost savings through automated data collection, and targeted infrastructure development. While immediate changes may not be dramatic, residents can anticipate gradual enhancements in public transport reliability, traffic flow, and pedestrian facilities, positioning Chennai on a trajectory similar to data-savvy cities globally.

TAKEAWAYS FOR OTHER CITIES

Cities embarking on data-driven urban mobility planning can learn from global examples:

- **Develop comprehensive KPIs**: Balance diverse urban objectives by creating metrics that encompass equity, development, and environmental impacts. This approach ensures that new transport projects align with broader urban goals and allows for granular performance evaluation over time.
- **Leverage real-time data for dynamic policymaking**: Implement continuous monitoring systems to enable swift policy adaptations. This agile approach, as seen in Bogotá, allows for iterative policy refinements based on empirical evidence, enhancing governance responsiveness to urban dynamics.
- **Enhance asset management through data analytics**: Utilize systems like São Paulo's SIGMA and Singapore's FASTER to optimize asset utilization, proactively identify maintenance needs, and improve service reliability. This data-driven approach can lead to more efficient route planning and frequency adjustments.
- **Transition to continuous data sources**: Supplement or replace traditional surveys with mobile phone location data and other real-time sources. This shift enables more precise and frequent capture of travel patterns, enhancing transportation planning accuracy and timeliness.

CONCLUSION

This note illustrated how diverse data sources revolutionize transport planning, offering unprecedented opportunities for sustainable and efficient urban mobility. From real-time evidence-based policymaking to enhancing asset management and transitioning from surveys to continuous data-driven analyses, each example showcases the power of big data. By leveraging continuous data streams, cities can adapt swiftly to changing dynamics and refine their policies iteratively. The diversification of data sources provides a comprehensive understanding of urban dynamics, facilitating informed decision-making. Moving forward, this note aims to raise awareness among urban mobility practitioners in India, highlighting the potential of data analytics for efficient urban planning. The showcased examples demonstrate a smarter era of urban mobility services, paving the way for continued exploration and innovations in the dynamic landscape of urban planning.

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Endnotes

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Photo credit: CUMTA

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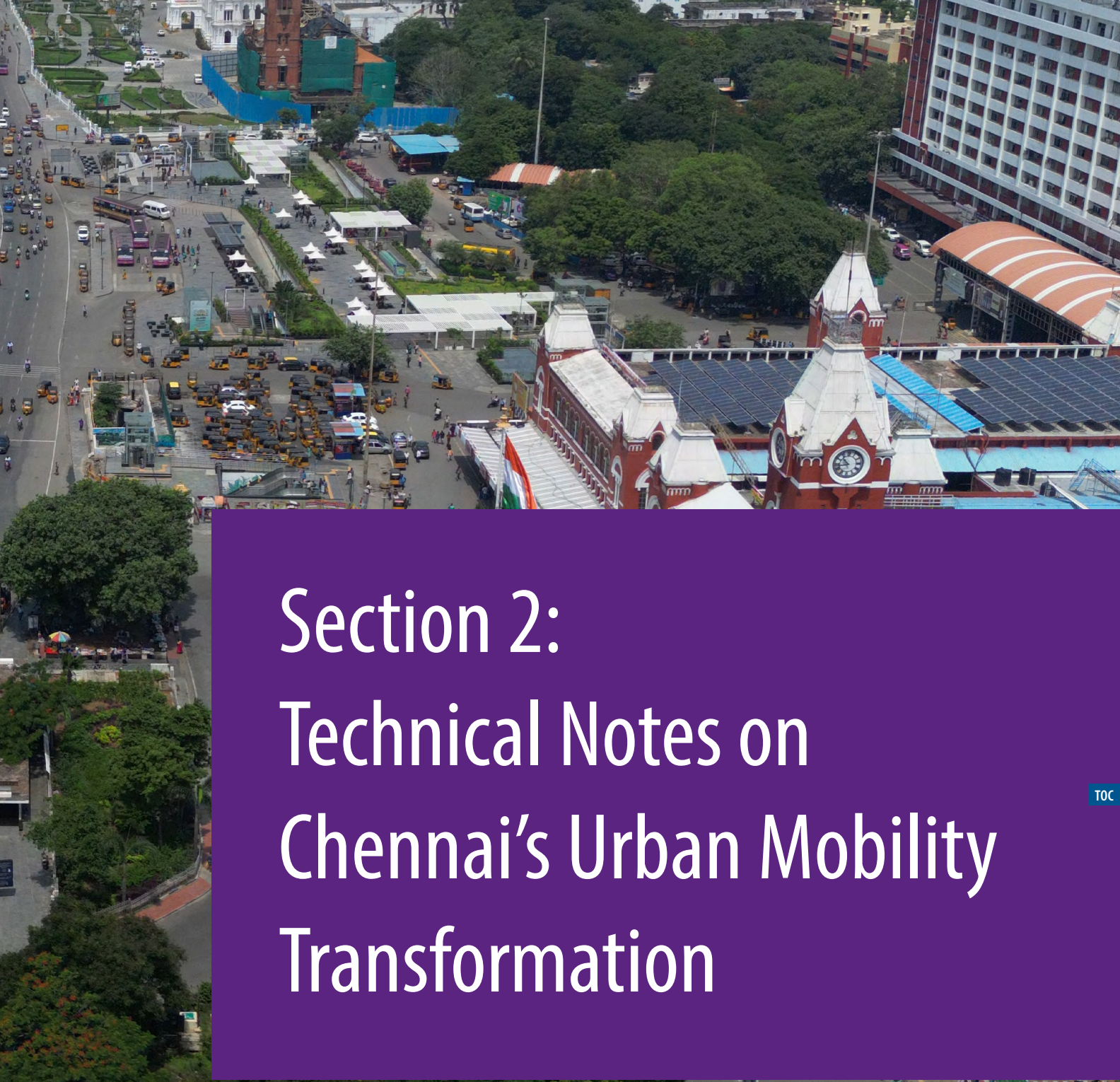

Section 2: Technical Notes on Chennai's Urban Mobility Transformation

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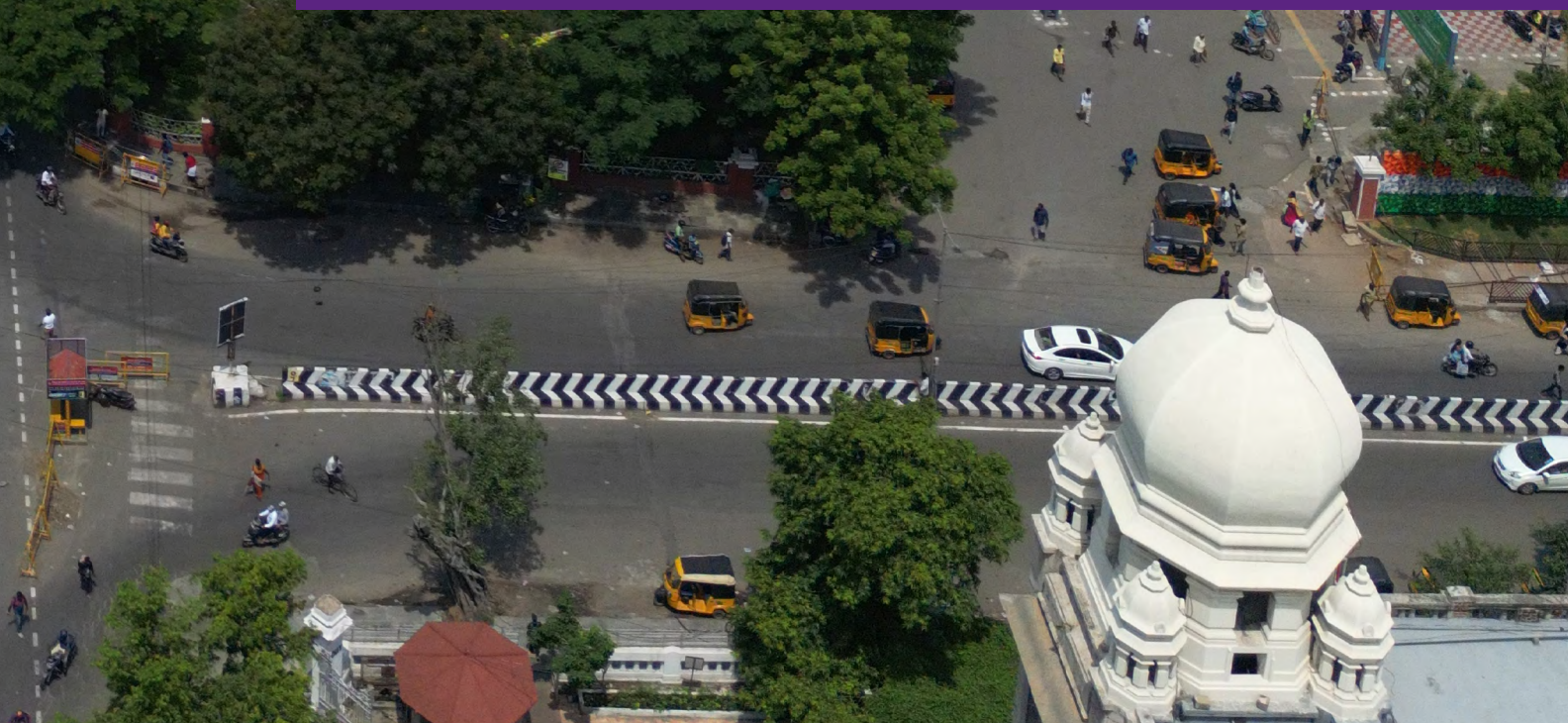


Photo credit: CUMTA

1: INTEGRATED LAND USE AND TRANSPORT PLANNING

Qingyun Shen[1], Abhijit Sankar Ray,[2] Seetha Raghupathy,[3] and Anshul Mishra[4]

INTRODUCTION

Effective urban planning is crucial for India's sustainable development amidst rapid economic transformation and urbanization. India is undergoing significant economic transformation where half the country will soon reside in cities, and most of the economic output will be generated in urban agglomerations. Proper planning and management of Indian cities over the next few decades would be critical to ensure a sustainable, resilient, and inclusive growth trajectory. A recent review of urban planning practice in India by NITI Aayog (2021) reveals a big gap to be filled: almost two-thirds of urban local governments do not have an active master plan[5] as the statutory instrument for guiding and regulating urban development. And where master plans exist, there is also room for improvement in the quality of these plans and the process of their preparation, to make them more data-informed, evidence-based, and fully participatory with adequate stakeholder consultations and citizen engagement for ensuring public buy-in. Additionally, departmental siloes could also undermine the quality and effectiveness of plan preparation and implementation. Different sectoral strategies and plans need to be better coordinated temporally and spatially to ensure consistent guidance and integration for urban management. Finally in cases where the quality of a master plan is satisfactory and sectoral plans are well integrated, cities sometimes face financial and/or institutional challenges in the implementation of these plans (especially due to lack of appropriate allocation of resources and inadequate monitoring) for realizing their development objectives. Sometimes, challenge also comes from the misalignment of master plan preparation timelines vis-à-vis the political timeframes of election cycles, as the latter is more aligned towards implementable projects that could be disconnected with the holistic vision backed by long-term planning.

Chennai's rapid growth necessitates a comprehensive approach to urban planning to address various emerging challenges. Chennai is the fourth largest metropolitan area and among the top five fastest growing cities in India. In the last 60 years, Chennai has grown in prominence from being a port city with a strategic location and rich cultural

> A comprehensive two-pronged approach that addresses both the enabling environment (for example, institutional frameworks) as well as output (for example, an integrated master plan that adopts a multi-sectoral approach) is being envisioned by GoTN and its key planning institutions.

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heritage to a large metropolitan area that is home to an agglomeration of information technology, manufacturing industries, and medical services. It also presented challenges for proactive urban planning practices to keep pace with the increasing demands of urbanization. One of the primary issues in earlier master plans has been weaknesses in the integration and synchronization of economic and spatial planning exercises, with insufficient focus on aligning the city's economic growth aspirations with appropriate and timely planning interventions. Other issues include inadequate regulatory mechanisms (for example, lack of implementation monitoring of master plans), capacity and human resource challenges (for example, staffing issues in planning departments), and the lack of evidence-based urban planning (for example, lack of effective use of data to inform planning and service delivery). Given the increasing challenges faced due to climate change, coastal erosion, rise in informal settlements, housing deficit, urban sprawls, inadequate public transport and resultant congestion and air pollution, as well as pressure to sustain economic growth and job creation, GoTN decided it was imperative to address urban planning in a holistic manner. For this, GoTN and CMDA opted to shift away from the traditional process focusing solely on land use zoning. A comprehensive two-pronged approach that addresses both the enabling environment (for example, institutional frameworks) as well as output (for example, an integrated master plan that adopts a multi-sectoral approach) is being envisioned by GoTN and its key planning institutions. To strengthen this further, a Comprehensive Mobility Plan (CMP) is being prepared for the larger metropolitan area (encompassing an area of 5,904 sq km), concurrently with Chennai Metropolitan Area's (CMA) Third Master Plan (TMP) (encompassing an area of 1,189 sq km) and will ensure synchronization of transport and land use planning, providing the foundation for adoption of Integrated Land Use and Transport Planning (ILUTP).

This note outlines the ILUTP approach, highlighting its benefits, challenges, and implementation steps, aimed at engaging key stakeholders in urban planning. It provides the rationale and advantages of adopting ILUTP, summarizes the typical challenges of ILUTP based on international and Indian experience, and outlines appropriate steps for preparing and implementing ILUTP in CMA based on the lessons learned. It is expected to draw attention and interest from policymakers, bureaucrats, and practitioners in urban planning and management and accelerate the adoption of ILUTP in other Indian cities and beyond.

The Rationale for a Paradigm Shift towards ILUTP

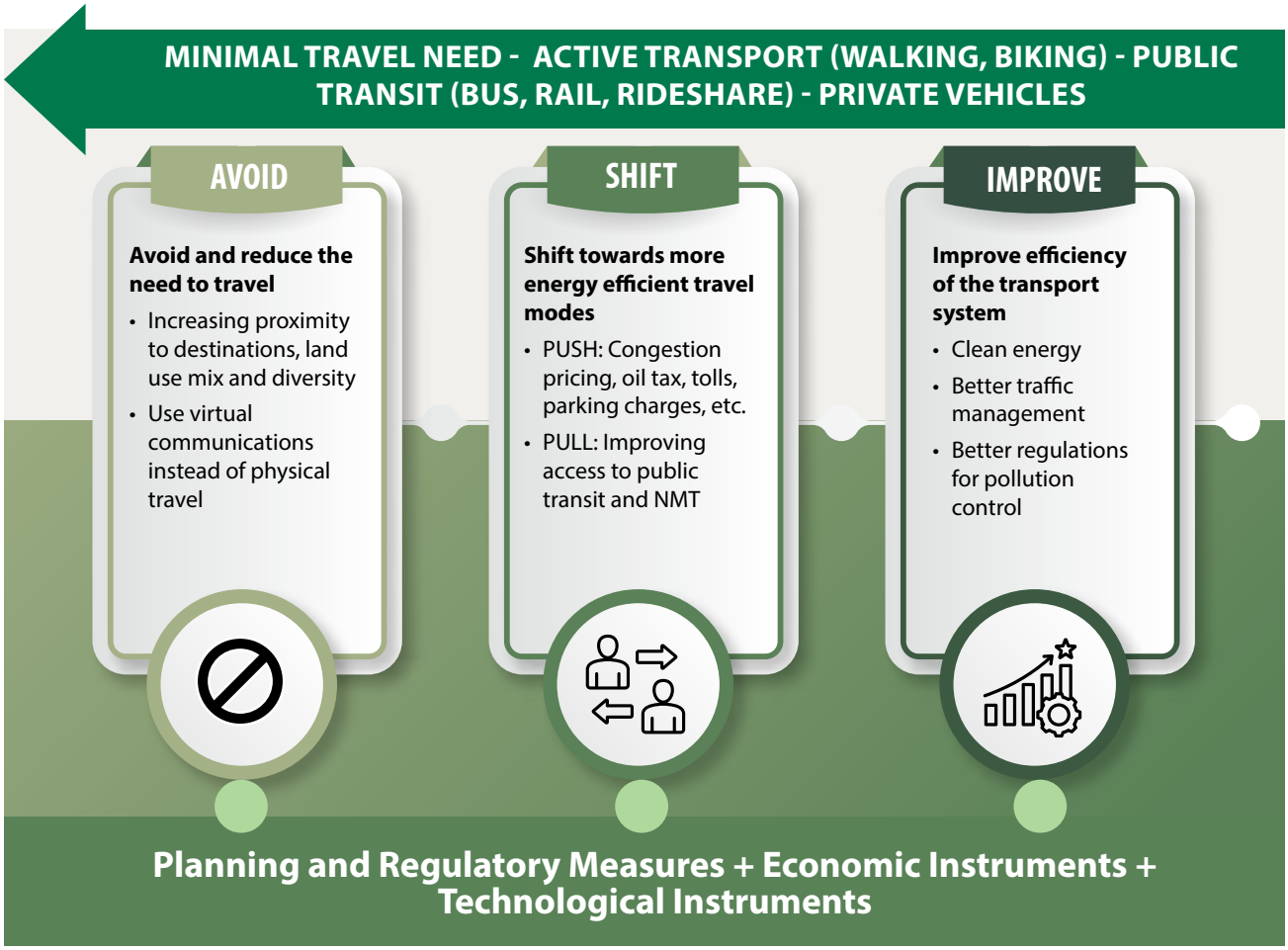
The concept of ILUTP refers to the development of planning instruments and associated institutional structures that allow urban land uses to be strategically linked to the transport systems in a city. ILUTP's overall objective is ensuring optimal provision of land for urban and regional growth while factoring in travel demand and impact and minimizing negative social and environmental impacts.

Traditional Euclidean zoning[6] often leads to spatial mismatches, resulting in several urban issues such as long commutes and high congestion. Traditional land use planning focuses heavily on the spatial distribution and separation of different land uses through zoning regulations – a planning practice prevalent in the 20th century termed Euclidean planning or Euclidean zoning. Cities which planned this way such as ones in North America, often end up with large residential developments far away from job centers. This *spatial mismatch* results in urban sprawl where long commuting distances for residents, high vehicular movement, and traffic congestion create a negative impact on average labor productivity (due to the higher costs of moving people, goods, and services) and negative environmental consequences such as higher pollution and carbon emissions along with social exclusion and segregation. A rich body of empirical research shows that higher levels of mixed land use tend to reduce commuting distances and congestion in cities.[7]

ILUTP addresses the issues arising from spatial mismatch and promotes economically thriving and sustainable urban growth by optimizing and mixing different land uses, reducing investments in trunk infrastructure, and minimizing motorized travel demand across the urban space. In addition, ILUTP promotes diverse, compact, and lively urban development patterns with concentration of jobs and housing near mass transit, and neighborhoods with jobs and amenities, which reduce travel distances and demand while promoting public transit and active transport. Further, reduced commute distances have positive impacts on human health and productivity. These two

effects correspond to the two fundamental building blocks of the Avoid-Shift-Improve model for sustainable urban transport and decarbonization (Figure 1.1). Interventions under the framework could help reduce the transport sector's GHG emissions and address issues like congestion and air pollution in Chennai. Figure 1.1 outlines the typical urban mobility and spatial planning initiatives that are followed under the Avoid-Shift-Improve (ASI) model. Specific interventions in Chennai are being detailed in the CMP.

FIGURE 1.1: THE AVOID-SHIFT-IMPROVE MODEL FOR MOVING TOWARDS SUSTAINABLE URBAN TRANSPORT[8]



BACKGROUND

Trends in Planning Practices in India and Chennai for ILUTP

In Indian cities, land use and transport planning are often conducted separately, leading to a disconnect which hampers integrated urban development. Land use and transport planning in Indian cities is traditionally undertaken as two separate activities in silos. Land use planning is the primary component of a master plan. Typically, transport planning is a chapter in the master plan but is often not optimally integrated with land use considerations. Although standalone urban mobility planning and the preparation of CMPs are gaining more traction in several Indian cities, they are rarely done in conjunction with the preparation process for the master plan. More often, mobility plans are mainly prepared by metro rail corporations or transport departments as part of the justification of major transport projects' investments as the primary response to projected increase in population and vehicles. This disconnect between land use plans and mobility plans in Indian cities is not only due to the different time horizons of these plans but also an institutional failure in inter-agency coordination. Land use plans are normally prepared by the urban planning authorities (state planning departments or urban development authorities) while mobility plans are usually prepared by transport authority(ies) or Unified Metropolitan Transport Authorities (UMTAs)[9] largely

TABLE 1.1: DIFFERENCES ACROSS PREDOMINANT PLANNING APPROACHES AND ILUTP APPLICATION IN INDIA

Predominant Master Planning (MP) Approach	Predominant Mobility Planning Approach	Integrated Land Use and Transport Planning (ILUTP)
• Vision focused on spatial planning outcomes, lack of strategic directives	• Vision focused on transport planning outcomes with limited influence on MP	• Coordinated vision factoring in spatial and transport planning and aligning transport capacity and demand stemming from MP • Clear goals, objectives, and strategic directives requiring such alignment
• Focus on land use planning and zoning • Siloed approach– inadequate focus on aligning multi-sectoral inputs	• Focus on transport infrastructure and interventions including traditional modes, NMT, etc. • Lack of alignment with the statutory masterplan preparation timelines • Lack of feedback loop with MP regarding job and population distribution	• Cross-sectoral – across jurisdictions at all scales • Integrated spatial and transport plan, with supporting Development Control Regulations (DCRs)
• Top-down citizen engagement (typically)		• Enhanced and holistic stakeholder engagement process with rapid iterations
• Lack of robust implementation mechanisms		• Clear implementation strategy with performance metrics
• Performance focused on outputs		• Performance focus on outcomes

in silos. Many of these authorities also currently lack expertise in holistic transport planning.

Despite its introduction in the 2006 National Urban Transport Policy, the adoption of ILUTP in Indian cities has been limited due to various challenges. The concept of ILUTP was first introduced in the National Urban Transport Policy (NUTP) in 2006.[10] To further promote ILUTP, the Government of India (GoI) introduced a Scheme for Urban Transport Planning (SUTP) in 2008, which also received modest attention in cities due to institutional coordination issues at the time.

Despite efforts to update NUTP and promote ILUTP, its adoption in Indian cities has been limited and often focused on Land Value Capture (LVC). Recognizing the shortcomings of NUTP 2006 and SUTP 2008, an updated NUTP was drafted for GoI in 2014 which called for cities to prepare an integrated master plan that would internalize the features of sustainable urban transportation. The draft NUTP 2014 also proposed that city planning should include both the city and peri-urban areas, as well as the regions around a city, which should be notified as local planning areas or metropolitan areas. Unfortunately, this draft policy never received official government approval, nor did it take effect in practice. In the last two decades, cities like Pune, Pimpri-Chinchwad, Mumbai, Bengaluru, Naya Raipur, Bhopal, Jaipur, Surat, and Kochi have brought in ILUTP primarily at the corridor level with a singular focus on maximizing LVC. The use of statutory planning exercises for promoting ILUTP at the metropolitan, city, and sub-city levels have been attempted only by a handful of cities like Ahmedabad, Bengaluru, Chennai, and Delhi. The differences across predominant master planning and mobility planning approaches and ILUTP application in India are listed in Table 1.1.

National policies and missions have increasingly recognized and promoted ILUTP for sustainable urban development in India. As the guiding document for Indian cities' planning practices, the first national-

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level planning guidelines, the Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines were developed by MoHUA in 1996. These were updated in 2014/2015 to incorporate emerging aspects in planning, including land use and transport integration at the planning stage and the need to prepare and integrate comprehensive mobility plans as part of the planning system. The updated URDPFI defines four layers of planning practice in the Indian Planning System Framework: a) Perspective plans that set out the vision/mission and/or high-level strategy for spatial development, usually at the state or metropolitan level; b) Regional plans that define in broad strokes, the spatial development structure and clusters of settlements covering both urban and rural areas of a metropolitan region; c) Development plans for urban and peri-urban areas that guide urban development, infrastructure investments and land use, usually called city master plans or comprehensive plans; and d) Local area plans that detail the land use plan, infrastructure networks, mobility and other services. Local area plans also have other denominations such as Town Planning Schemes, detailed development plans, and Zonal Plans.

The National Mission on Sustainable Habitat (NMSH) launched by GoI under its National Action Plan on Climate Change (NAPCC)[11] also recognizes the benefits of ILUTP with respect to environmental sustainability. NMSH calls for small and medium cities to improve urban planning and develop convenient public transport systems, thereby expanding the need for ILUTP to all towns and cities of India. Principles of Transit-Oriented Development (TOD) have also been promoted through the National Metro Policy (2017), the Green Urban Mobility Scheme (2017), and the Smart Cities Mission (2015). GoI issued a TOD guidance document under the Smart Cities Mission in 2016 for planning and implementing TOD plans but was deemed too late as it was issued after participating cities had already prepared their smart city plans.[12] Soon after, GoI published the National TOD Policy in 2017,[13] which sets out the framework and models for state governments to develop their own TOD policies that fit their own context and needs. The National TOD Policy (2017) has been the most influential policy document that guides and enables states and metropolitan areas to plan for and implement integrated urban and transit development projects along transit corridors and station areas. Together with other practical guidelines and toolkits, such as the World Bank's 3V approach[14] and the TOD Implementation Resources and Tools 2nd edition[15] published in 2021, cities and states are equipped with the knowledge and instruments to carry out the TOD principles from vision to reality.

Chennai's planning history reflects an evolving relationship between land use and transport planning, highlighting past challenges and the need for integrated approaches. Chennai's 60-year planning history with respect to land use and transport planning has shifted from being disconnected and siloed to coordinated and integrated. In 1972, CMDA was constituted as an ad-hoc body and the nodal planning agency for CMA. It later became a statutory body in 1974 under the Tamil Nadu Town and Country Planning Act. CMDA's roles and responsibilities include preparing a master plan and other development plans for promoting and securing CMA's planned development. So far, CMDA has prepared two master plans: The First Master Plan (1976-1996) and the Second Master Plan (2008-2026). While both plans recognized the importance of transportation, spatial and transport planning continued to be done in sectoral siloes. One of the critiques of the First Master Plan was that it was divorced from economic planning and infrastructure coordination. The Second Master Plan (SMP) process had three major issues across formulation, implementation, and monitoring. SMP's formulation faced challenges due to the absence of a well-defined institutional mechanism for coordination across agencies, delays in obtaining data (census/GIS), shortage of staff in the master plan unit as well as delays due to legal proceedings and changes in the political regime. From an implementation perspective, the lack of a consolidated list of specific actions and a phased implementation strategy impeded effective realization of the master plan. The absence of a monitoring framework with metrics for measuring progress and the lack of initiative on the part of monitoring committees led to shortcomings from a monitoring perspective. The plan itself faced a disconnect between transport planning and land use planning. At the time of SMP's preparation, no mobility plan was in place. Consequently, transportation projects have often been conceived outside SMP. For example, the Tamil Nadu Urban Infrastructure Financial Services Limited (TNUIFSL) proposed an elevated bus corridor in 2008 and the master plan had to accommodate the proposal. The six-lane Old Mahabalipuram Road IT corridor which was conceived outside the Second Master Plan has significantly altered the fulcrum of development. While it has enabled and accelerated economic growth, it has also led to unintended consequences for land use

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BOX 1.1: THE ILUTP APPROACH APPLIED BY CITIES AROUND THE WORLD

Some of the pioneers in using the ILUTP approach include Portland and Singapore,[2] both of which have strong political will from the administrative bodies to curb low-density urban expansion and achieve compact urban development as well as strong enforcement in implementing corresponding planning laws and regulations. The State of Victoria in southern Australia,[3] is a good example that has applied the ILUTP principles covering all tiers of the government, from a regional scale to city scale and sub-city scale. Clear leadership by a single steering agency makes it possible to trickle down through different planning layers and actions. Lastly, Chongqing[4] China, is a case in point for ILUTP's adoption in Asia.

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and urban expansion. Further, the benefits of adopting mechanisms have been engendered by using an ILUTP approach such as land pooling, TOD, and LVC which could not be realized.

Acknowledging the drawbacks and weaknesses in the previous two master plans, two major planning efforts are being taken up in sequence: CMP for the expanded CMA of 5,904 sq km led by CUMTA and the TMP for CMA of 1,189 sq km led by CMDA. This will ensure that CMP and TMP will be prepared in a coordinated manner (following the ILUTP model) for developing evidence-based, resilience-informed plans that are implementable and effective for sustainable growth over the next two decades.

International Experience with ILUTP

Over the last few decades, cities around the world have been paying more attention to the ILUTP approach given its benefits in promoting more sustainable urban growth and building long-term climate resilience of the city/region (Box 1.1).

Using analytical tools to show the benefits and impacts of ILUTP becomes critical in obtaining buy-in from the government leadership and other stakeholders.

In India, ILUTP has been recently tested in a few cities (Table 1.2). While these cities may not have labeled their approaches as ILUTP per se, the idea and concept of integrating mobility planning with land use planning is the key ingredient of these first attempts. One of the common features of such integrated planning practices in these Indian cities was that the TOD principles were highlighted as the primary tool for the integration of land use and transport planning.

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TABLE 1.2: CASE REVIEW OF SELECTED INDIAN EXAMPLES OF ILUTP'S APPLICATION

	Ahmedabad (Prahladnagar TPS)	Ahmedabad Development Plan (DP) 2021	Master Plan Delhi (MPD) 2021 and MPD 2041	Pimpri Chinchwad BRTS-TOD
Background of ILUTP's introduction	Introduced as part of a Town Planning Scheme (TPS)	Introduced in the Ahmedabad DP in 2021	Introduced in MPD 2021; expanded in MPD 2041	Introduced in 2010 as part of the BRTS project
Scale	Sub-city level	City level	City level	Sub-city level
Prior/ parallel reforms (if any)	Amendment of Town Planning and Urban Development Act, 1976 (land readjustment)	Special Regulations for Local Area Plans (LAPs) and Transit Oriented Zones (TOZs) introduced in the Development Control Regulation (DCR)	MPD 2021: TOD Policy notified (2016) MPD 2041 introduced: Land readjustment; special regulations for TOD schemes in DCR; street design regulations; TOD regulations	TOD standard developed by the city to measure the outcomes of its TOD initiative[16]

	Ahmedabad (Prahladnagar TPS)	Ahmedabad Development Plan (DP) 2021	Master Plan Delhi (MPD) 2021 and MPD 2041	Pimpri Chinchwad BRTS-TOD
ILUTP tool used	TPS Layout Plan	Development Plan (Master Plan)	Master Plan	TOD Plan
Integrated CMP	No	Yes (called Integrated Mobility Plan)	Yes	No
Institution responsible	Ahmedabad Urban Development Authority	Ahmedabad Urban Development Authority	Delhi Development Authority	Pimpri Chinchwad Municipal Corporation (PCMC)
Key ILUTP highlights	• TPS Layout Plan preparation process ensured ILUTP • 40% land available to the Ahmedabad Municipal Corporation (AMC) for improving infrastructure and creating land uses in alignment with the Development Plan (DP)	• ILUTP at three levels: strategic level, complete network and street level, and LAP[17] • 82 LAPs proposed within TOZs[18] • First LAP: C.G.Road Central Business District	• MPD 2021: ILUTP focused on bus rapid transit system (later scraped) and mass rapid transit system (MRTS) • MPD 2041: introduced TOD nodes; area regeneration including street widening, provision of affordable housing, and strategic regeneration;[19] development of TOD schemes with differential FSI for different land uses to encourage compact mixed-use development	• PCMC introduced a 130 km BRTS project • encouraged TODs around BRTS' transit nodes • TOD plans: aimed at integrated urban form and plans that strategically house people and jobs within walking distance of transit nodes
Funding Mechanism	• LVC including auctioning of serviced land increased property tax collections • TP Fund (revolving fund with revenue from older TPS), finances up-front, infrastructure costs eliminating the need to sell the land early, and reduces the need to seek loans[20]	• at DP level, through planning mechanisms, development premiums, and central/state financing[21] • at LAP level, financing through TPS' (planning mechanisms), additional FSI incentives and Transfer of Development Rights (TDR) tools (development premiums)	• recognizes need for innovative financing for TOD projects • no explicit funding mechanisms outlined • suggests public private partnerships (PPPs), LVC fees, central/state grants, and impact fees	• Initial financing through centrally sponsored scheme (JNNURM) and multilateral financing institutions • recovery through private sector engagement and PPPs

Apart from these cases, as more cities develop MRTS systems for decongesting the cities and increasing public ridership, ILUTP in the form of TOD corridors has been explored in other Indian cities, including Naya Raipur (Naya Raipur Development Plan 2031), Bengaluru (Namma Metro), Mumbai (Lines 7 and 2), and Cochin (water metro) with increasing levels of sophistication in approaches seen over time.

Building Blocks of ILUTP Adoption

From this case review, we can retrieve a common understanding on the basic building blocks of successful ILUTP adoption covering five dimensions of integration (Figure 1.2).

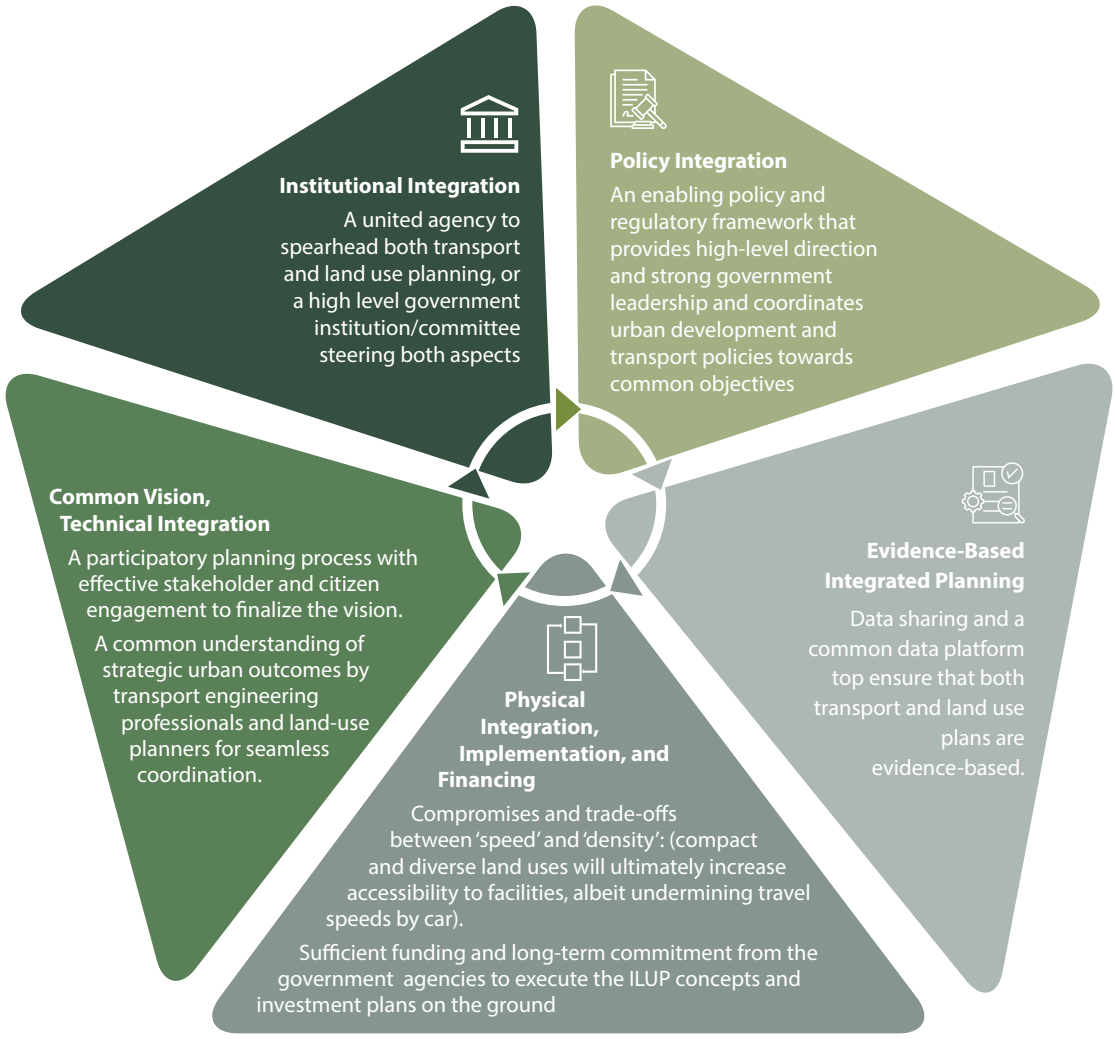
APPROACH IN CHENNAI

Chennai's Work Plan for adopting ILUTP in a Collaborative and Participative Way

Chennai is leveraging the preparation of its CMP and TMP to apply ILUTP principles for sustainable urban development. Informed by lessons learned from precedent cities, Chennai is currently using the window of opportunity when preparing its CMP and TMP to apply the ILUTP principles, with the hope of guiding the future growth in CMA towards a more green, resilient, and inclusive development path. Its roadmap will span during and after both plans are prepared and implemented, as summarized in the flow chart in Figure 1.3.

This flow chart shows the system of planning in a hierarchy from the regional level to the metropolitan/city level to the neighborhood level, which is consistent with the provisions in the URDPFI Guidelines 2016 prescribed by MoHUA. For addressing the typical challenge of misalignment in timelines for transport and land use planning, Chennai is preparing its CMP and TMP in parallel, with CMP having a few months' head start. CMP is expected to feed into TMP seamlessly so that a true integration of land use and transport plans will be realized via the TMP which is a statutory plan. Meanwhile, CMDA and CUMTA have commissioned intensive technical studies on key topics for ensuring evidence-based preparation of TMP (Figure 1.4). These studies and planning instruments cover a full spatial scale from the regional level (5,094 sq km of the expanded CMA) to the metropolitan/city level (1,189 sq km of the core CMA and emerging new towns), and sub-city scale (key transit corridors and neighborhoods) for ensuring consistent application of ILUTP for guiding development (Figure 1.4).

FIGURE 1.2: FIVE DIMENSIONS OF INTEGRATION IN ILUTP



Source: Authors' interpretation based on a literature review.

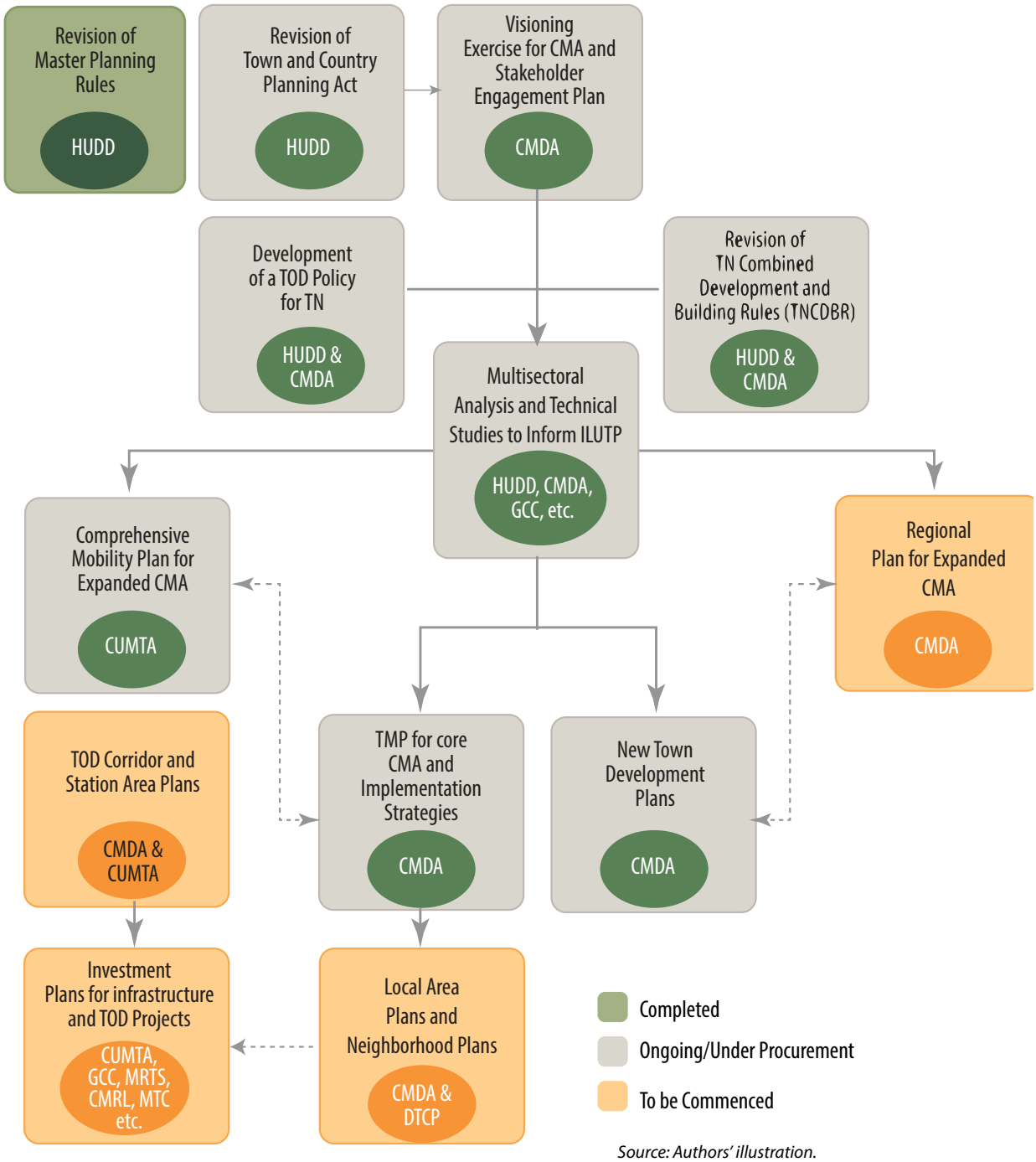
Challenges, Emerging Issues, and Solutions

During the process of rolling out ILUTP, planning agencies in Chennai also developed approaches for overcoming common challenges. These are key aspects that are essential for ILUTP's adoption in Chennai and could also be generalized to apply in other cities considering ILUTP exercises.

i. Institutional Arrangements and Capacity Building of Government Institutions

Without establishing institutional harmonization between spatial and transport planning, it is difficult to implement land use and transport integration policies.[22] As different agencies are responsible for preparing the respective plans with their own preparation and implementation cycles, establishing a framework for coordination, with oversight at the highest administrative level is necessary for

FIGURE 1.3: ROADMAP AND ILUTP'S CURRENT WORKFLOW OF ADOPTION IN CHENNAI



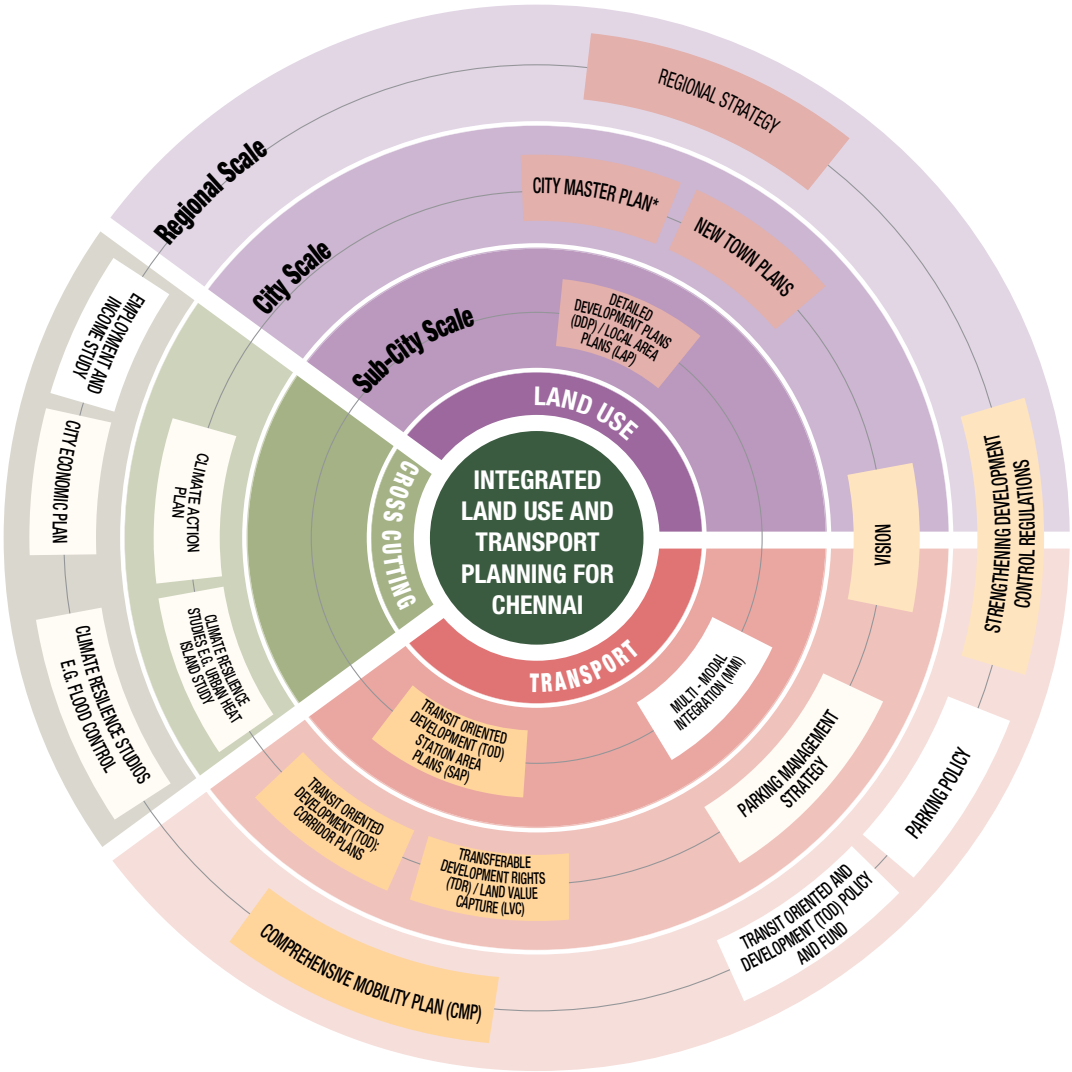
Source: Authors' illustration.

effective ILUTP adoption. Learning from good practices internationally and nationally, Chennai has envisioned the following steps for enhancing institutional coordination.

Chennai is establishing robust coordination mechanisms and leveraging synchronized planning timelines to effectively implement ILUTP.

- Firstly, GoTN is expected to establish a high-level committee comprising executive and political representatives from key ministries, departments, and agencies for ensuring effective coordination and sectoral stakeholder buy-in of TMP. This committee can foster effective downstream cooperation during planning approval and implementation stages.
- Secondly, CMDA and CUMTA will set up technical advisory committees comprising of subject experts on both CMP and TMP to provide quality assurances and technical advice to the high-level committee.
- Thirdly, the establishment and operationalization of CUMTA to lead CMP's preparation and implementation enables various transport

FIGURE 1.4: THE MULTI-SECTORAL ANALYTICAL FRAMEWORK FOR ILUTP IN CMA



** Vision Study | Strategic Institutions | Strengthening Assessment and Action Plan for CMDA | Comprehensive Shoreline Development Project | Study on Land Value and Density Distribution | Review and Recommendations for Strengthening of TNCDBR (20190 | Study on Urban Heat Island Effect in Chennai | Demand and Supply Pattern of Housing | Integrating Blue-Green Infrastructure (BGI) for Blood Disaster and Risk Reduction | Special Distribution of Employment and Income Categories and Agglomeration Economies | Development of Sustainable Economic Growth Strategic Plan | Mainstreaming Climate Action in Chennai Third Master Plan | GHG Emissions Inventory and Building In-house Inventory Capacity | Open Space Strategy for CMA | Mainstreaming of Integrated Flood Control | Social Facilities Plan | Neighbourhood Planning Guidelines | Urban Design Guidelines | Gender Inclusive for CMA*

Source: Authors' illustration.

agencies (including those in charge of rail, road, highway, metro, and bus systems) to be coordinated under a single vision. For metropolitan areas where UMTAs have not been set up (or are in the process of being set up) or for small and medium towns which do not have the basis for setting up an UMTA-like institution, a nodal agency for public transportation could be designated to coordinate with the planning authority. For example, the district road safety committees (DRSCs) are active and empowered at the district level (with the District Collector as the chairperson). These committees can be sensitized on integrated planning and can serve as the nodal agency.

- Fourthly, both CMDA and CUMTA have been (and plan to continue) actively participating in each other's key review meetings for CMP and TMP preparation, so that synchronization of land use and transport planning can be achieved at every stage, from data analysis to spatial strategies, to final planning recommendations.

- Lastly, it is opportune and fortunate for Chennai that both CMP and TMP were prepared almost at the same time, and both have similar planning horizons, enabling effective implementation of ILUTP temporally. In other cities where CMP is not in the same cycle as statutory master plans, they can use the opportunities when master plans need to be reviewed and updated to seek synergy and incorporate inputs from CMPs. Although existing state town and country planning acts mandate the development of statutory land use plans every 20 years, they also provide for these plans to be reviewed/updated every five years based on changing development trajectories.

Building institutional capacity is crucial for enhancing the planning and coordination capabilities of transport and master planning agencies in Chennai. Institutional capacity building for both transport and master planning agencies is essential for improving the quality of planning practices and performance. Under two World Bank-supported projects,[23] institutional assessments of both CMDA and CUMTA were done, including comprehensive diagnostics for identifying the gaps in human resources in terms of both number of planners and specialists as well as their proficiency/ qualifications. Accordingly, training and capacity building plans were prepared and recommended for enhancing their technical capacities. Beyond that, improving horizontal coordination and effective inter-agency communication are equally important, if not more. In Chennai, at a working level a multi-disciplinary team with champions or focal persons from both CMDA and CUMTA were identified for inter-agency coordination, everyday communication, follow-ups, and reporting to senior officials. These focal persons must be trained in ILUTP ideas for influencing others at work. Continued institutional strengthening and systematic capacity building of these planning agencies are therefore critical for addressing human resource requirements and filling the skill gaps. These can be accomplished through various initiatives including knowledge-exchange sessions/peer learning from cities that have successfully enabled ILUTP, industry-academia collaborations and continuous skill upgradation through internal and external training programs, for example, lecture series by experts and certification courses offered by national and international institutions. Various ongoing national missions provide ample opportunities and financing for undertaking these tasks.

ii. Technical Interventions and Quality of Data Collection and Analysis

Establishing a GIS-based digital platform is essential for ensuring data consistency and coordination in ILUTP. Having credible, consistent, and updated data for informing evidence-based planning decisions is a fundamental building block for ILUTP, as is the case for any effective planning and public decision-making process. Firstly, building a GIS-based digital platform for collecting data, updating, sharing, and analyses that allows preparing of a common base map and synchronization of spatial information across sectors for planning and investment coordination is the fundamental building block of ILUTP. In Chennai, a Digital Chennai platform is being designed and established in coordination among key government agencies including CUMTA, CMDA[24,25] and others. Once in place, CUMTA and CMDA will be able to work on a common digital platform for ensuring that the baseline data used for both CMP and TMP is consistent with an alignment between spatial planning of transport facilities and mobility

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interventions under CMP and land use planning under TMP, and vice versa. Direct integration of data layers can ensure true integration of baseline information and coordinated planning preparation across sectors.

Technological advances and innovations have significantly enhanced the capabilities of urban planners. The recent technological advances and rapid innovations in the last decade or more have also empowered planners to do their jobs more effectively and efficiently. Big data analyses such as using mobile phone or GPS signals for analyzing the travel behaviors on a large scale, can improve the accuracy in predicting and projecting demand among the population in a metropolitan area. Planning agencies can rely on advanced modeling tools to better analyze spatial data and carry out simulations for understanding the spatial impacts of different land use and transport interventions. Interactive models can provide real-time inputs for different scenarios, thereby serving as significant data points for policy decisions (Box 1.2).

A variety of ILUTP tools are available to help cities choose the most applicable and feasible techniques for planning There is no one-size-fits-all solution for all cities, and Indian cities should choose the most applicable and feasible ILUTP techniques and tools that can be accessible to planning agencies, are easy to understand, and convenient for informing decision-making (Box 1.2). During the TMP preparation in Chennai, CMDA will hire a top-notch planning consulting firm for exploring such modeling techniques for comparing alternative spatial strategies.

iii. Public Accountability and Trust Building

Effective public participation is crucial for the successful adoption of ILUTP, requiring extensive stakeholder engagement. Uncertainty in public acceptance is one of the key impediments in the adoption of ILUTP. For achieving effective public participation and citizen buy-in, expansive, extensive, and effective stakeholder engagement throughout the life cycle of the planning preparation is the key. In Chennai, both CUMTA and CMDA have conducted intensive citizen engagement activities through surveys and stakeholder meetings for CMP and TMP preparation, for example, for understanding travel demand and behavior.[26] Such large-scale citizen engagement activities, although quite costly and time-consuming, are necessary for ensuring that ILUTP is done properly and should be encouraged in all cities as a prerequisite for master planning.

iv. Funding and Implementation Strategies

Successful ILUTP implementation requires strategic planning and funding across preparation, execution, and sustainability stages. For ILUTP to become a reality, leading planning agencies need to include feasible implementation and funding strategies at various levels and senior government officials must take leadership in executing the planning vision/strategies across various time horizons. The ILUTP process can be classified into three broad categories for purposes of funding: preparation, execution, and sustainability. In the preparation stage, the planning and transportation authorities need sufficient funds for developing an information base, agreeing to the city-level ILUTP model which may include updating/preparing a statutory land use plan and preparing a CMP. Financing for these activities can either come through budgetary allocations made by the state government or by tapping into schemes such as SUTP and national missions.

Strategic investment and financing plans are crucial for the successful execution and sustainability of ILUTP. At the execution stage, if ILUTP has been carried out properly, CMP and land use plans should include appropriate investment plans and financing strategies for key investment projects. For cities initiating ILUTP activities for the first time, budgetary allocations from the state government and urban local governments may be required for implementing key catalytic infrastructure investments such as metro transit and public facilities, especially in cities where public-private partnership practices or land-value capture measures are not feasible yet. However, once these infrastructural investments are in place (and assuming they are responding to market demand), there should be increased revenues to be reaped by the government to recover the capital cost of such investments. This is particularly true for TOD zones, where land-based financing mechanisms are widely used both in India and abroad. Authorities can benefit from revenue sources such as increased property tax because of increased land prices of serviced land and

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BOX 1.2: MODELING TECHNIQUES AND TOOLS, AND USEFUL ILUTP TOOLS

The World Bank has assisted several cities and regions (for example, Chongqing, Amman, Morocco, and Mongolia) using scenario simulations for estimating the growth impacts of different land use and infrastructure investment patterns for informing decision-making among alternative planning proposals. It has also developed a series of digital planning capacity building programs through its City Planning Labs (CPL) initiative.1

Other useful ILUTP tools developed by international and national agencies include a gravity-based Integrated Transportation Land Use Package and the economic equilibrium CATLUS (Bartholomew and Ewing 2009; Outwater, et al. 2014; TRB 2013), the Smart Growth Area Planning (SmartGAP)2 developed by the US Environmental Protection Agency for simulating alternative land use and transportation scenarios.

Sources:
1. A new training course on spatial planning using digital tools is currently under development by CPL and will become available to client countries. For more information on CPL: https://collaboration.worldbank.org/content/sites/collaboration-for-development/en/groups/city-planning-labs.html.
2. www.epa.gov/smartgrowth/smartgrowth-index.

betterment levies, development charges, premium FSI/FAR fees, transfer of development rights, and auctioning of land parcels. Some cities with good credit ratings may be able to directly borrow from the capital market or international financing agencies (such as IFC which focuses on investing in emerging markets) for developing the initial infrastructure. Meanwhile, for states where PPP laws are in place, cities can also seek to engage with the private sector for co-financing specific infrastructure investments envisioned under ILUTP. Such engagements can also be through off balance-sheet models such as setting up a revolving fund (like a TOD fund, infrastructure fund or an affordable housing fund) where additional revenues are captured for financing the scaling-up of ILUTP activities wherein private sector equity, or even debt depending on project structuring, can be mobilized depending on the success of the initial ILUTP projects.

v. Monitoring and Results Review

Implementing ILUTP requires a clear strategy with a results framework and SMART (Specific, Measurable, Achievable, Relevant, and Time-Bound)[27] **key performance indicators (KPIs).** A clear strategy across short-, medium- and long-term timelines with a corresponding roadmap of action should be prepared for implementing ILUTP. Both CMP and TMP will set up a clear results framework with KPIs for monitoring the progress and achievements in planning implementation. These KPIs should be SMART and have indicators aligned with the planning vision for the city. A good ILUTP results framework may include both output-level indicators and outcome-level indicators. The former are directly connected to planning implementation in the short-term such as percentage of trips in non-motorized transportation and public transportation fleet emissions per kilometer.[28] The latter are more long-term goals relevant to the city's vision such as climate resilience and sustainability, access to opportunities through sustainable transport, compact urban growth, and enhanced health outcomes for citizens.

Selecting KPIs through stakeholder consultations are essential for effective monitoring and collaboration in ILUTP's implementation. The results framework and KPIs must be selected through stakeholder consultations led by the planning agencies as the monitoring and achievement of these KPIs will need collaboration and inputs from many other sectoral departments. During the conceptualization of such a results framework and KPIs, the planning agencies also need to identify the sources of data for measuring the progress on each KPI, the designated agencies with roles and responsibilities to collect, report, and validate the data, and finally an independent evaluation process for monitoring the performance of each responsible agency. Global good practices usually call for carrying out citizen feedback surveys and/or environmental and social audits by a credible third-party evaluation agency for providing transparent and objective assessments. Government commitment at a high-level is needed for reserving a budget for such evaluation studies.

Beyond all these interventions, aligning political mandates with plan preparation priorities is critical for ILUTP to succeed. Specifically, political buy-in at the highest level is required to steer the planning process. From an implementation perspective, the prevalent method of functioning of departments is siloed, with a budget-target-execute approach. This must change and pave the way for a plan-budget-execute mode. In addition, large budgetary decisions currently resting with engineering-led department heads should become the purview of ILUTP champions and planning leads who can promote a comprehensive planning approach. The strategic and regulatory environment should also encourage the private sector to visualize business opportunities through ILUTP interventions for long-term sustainability.

EXPECTED IMPACT

The ILUTP efforts in CMA are expected to transform urban planning, leading to sustainable, resilient, and inclusive development. The efforts for carrying out ILUTP in CMA are a paradigm shift in planning from traditional zoning and land use mapping towards a more integrated and strategic approach that aims to bring about green, resilient, inclusive development and more productive spatial growth in the long run. While CMP and TMP are still being prepared, the active participation of both CMDA and CUMTA in the preparation indicates that it is expected that these two documents will be highly intertwined and consistent with each other and be enforced with investment projects for translating the two planning documents on paper into urban development reality on the ground. To resolve the bottlenecks in institutional capacities and inter-agency coordination, continuous on-the-job training has been going on in both CUMTA and CMDA with World Bank support. Application of new technologies, data and analytical methods has also been an instrumental part of the uplifting in planning performance in these two institutions.

TAKEAWAYS FOR OTHER CITIES

The Chennai experience can offer lessons for other cities. The salient takeaways include:

- **Ecosystem approach to ILUTP adoption:** Effective planning interventions across the regional, metropolitan/city, and sub-city/neighborhood level (Figures 1.3 and 1.4).
- **Aligned plan preparation timelines:** Development of CMP and TMP concurrently enables the synchronization of land use and transport planning.
- **Institutional coordination:** Synergized interventions, establishment of a technical advisory committee, and identification of focal persons/champions for coordination by lead agencies for spatial planning (CMDA) and transport planning (CUMTA) provides a foundation for developing synchronized plans.
- **GIS based digital platform:** The Digital Chennai platform being established provides a common data-platform for ensuring that the baseline data used for spatial and transport plans is consistent.
- **Public participation:** Extensive citizen engagement activities undertaken through surveys by CUMTA and CMDA for plan preparation has enabled understanding citizens' aspirations, travel demands and behavior which will be used to inform the plans.
- **Leveraging external assistance:** Chennai has effectively co-opted development partners, civil society, academia, private sector, and citizens which has helped provide valuable inputs for CMP and TMP.

CONCLUSION

Global experience has shown that ILUTP can promote resilient and sustainable urban growth by reducing travel, relieving congestion, reducing emissions and air pollution, reducing energy consumption, and infrastructure investment costs. Moreover, a well-planned city with dense, mixed, and diverse land uses is likely to increase social inclusion. Built environments that are friendly to NMT modes will also allow the poor to reduce their transport costs and alleviate poverty while giving them more access to jobs and other opportunities. While there are many barriers in the preparation and implementation of such integrated land use and transport plans, the window of opportunity is now open for Chennai while its CMP and TMP are both in the making in parallel. The Chennai experience, as well as learning from other national and international good practices, indicate multiple learnings that Indian cities need to consider when introducing and scaling-up the ILUTP approach.

Endnotes

1 Qingyun Shen is a Senior Urban Specialists at the World Bank.
2 Abhijit Ray is a Senior Urban Specialists at the World Bank.
3 Seetha Raghupathy is a Senior Urban Planning Consultant for the World Bank.
4 Anshul Mishra is the Member Secretary of Chennai Metropolitan Development Authority (CMDA).
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6 The term 'Euclidean Zoning' dates to the early 20th century following a classic court case of Euclid vs. Ambler in 1922. In this case, Ambler Realty Company filed a lawsuit against the village of Euclid in Ohio, United States, claiming that the local zoning regulations were directly diminishing their property values and were unconstitutional. The case went to the US Supreme Court and the final ruling upheld the zoning ordinance and argued that such land use zoning was required for effective municipal planning.
7 There has been rich literature on such empirical research published in peer-reviewed academic journals, including notably, a meta-analysis done by Bartholomew and Ewing titled, 'Land use-transportation Scenarios and future vehicle travel and land consumption' (JAPA, 2008), Boarnet's review paper titled, 'A broader context for land use and travel behavior, and a research agenda' (JAPA, 2011), and more recently Sungwon and Bumsoo's paper titled, 'Comparing the impacts of local land use and urban spatial structure on household VMT and GHG emissions' (JTG, 2020), to name a few.
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25 Greater Chennai Corporation.
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27 For more information on how to design a SMART results framework, refer to the World Bank publication here: The World Bank (2012). Designing a Results Framework for Achieving Results: A How-to guide.
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Source: Anantakrishnan

2: AUGMENTING BUS SERVICE DELIVERY

Ravi Gadepalli[1], Gerald Ollivier, and Shyam Srinivasan

INTRODUCTION

Bus based public transport is critical for addressing the mobility challenges faced by cities in developing countries. Buses offer a cost effective, agile, space, and energy efficient means of public transport which can cater to the increasing travel demands of growing urban populations and changing mobility patterns in existing urban areas as well as new development centers.

Despite their obvious benefits, bus services in developing countries have often fallen short of meeting travel demand and users' quality expectations. This has been the case even in Chennai, where bus services are regulated and financed by GoTN while the Metropolitan Transport Corporation (Chennai) (MTC), a state transport undertaking (STU) is in-charge of planning, fleet ownership, operations, and maintenance. Chennai has been facing a steady decline in the quantity and quality of public bus services despite having an established institutional framework for bus services. The consequences of declining bus service standards are well known - increasing private vehicle usage and associated externalities like congestion, air pollution, road safety challenges, and a negative impact on overall livability in the city.

This note explains key institutional reforms introduced in Chennai for improving the quality of bus services. GoTN as part of the CCP between the state government and the World Bank started implementing structural reforms that will allow MTC to raise its bus services to world class standards as a key pillar for addressing Chennai's mobility needs and developmental goals. The Chennai example offers several takeaways of value for other cities looking at reinvigorating their bus services. Chennai adopted a three-pronged approach for reforms that involves: (i) development of a business plan approved by GoTN and MTC articulating MTC's long-term (10 year) vision and a medium term (5 year) financial plan for achieving this vision, (ii) signing of a Public Transport Service Contract (PTSC) between GoTN and MTC that formalizes the government's 5-year funding commitment for MTC for achieving service targets set under the Business Plan, and (iii) transition from in–house operations to gross cost contract (GCC) based bus service delivery to enable a shift in MTC's outlook from operations to service delivery. The first phase of this transformation includes procuring 1,000 electric buses under GCC as part of the Sustainable Urban Service Program (SUSP) of the Chennai City Partnership (CCP) between GoTN and the World Bank, with AIIB co-financing.

> The current fleet translates into ~220 buses per million population, well below the national benchmark of 600 buses per million population for metropolitan cities, and international best practice of 1,000 buses per million population as observed in cities like London and Bogota.

This technical note details out these key bus reforms undertaken by GoTN and MTC for providing a reference case study informing other cities, practitioners, and researchers.

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BACKGROUND

Chennai's public bus services have not kept up with travel demands due to rising urbanization. MTC, a STU owned by GoTN is the monopoly public bus service provider in Chennai. MTC owns and operates a fleet about 3,450 buses (March 2023), through its in-house staff and consistently performs well on internal efficiency indicators such as ridership per bus, fuel efficiency, and vehicle usage. MTC's fleet has declined steadily from its peak of 3,980 buses in 2016 and is currently at the same level as it was in 2011. Even among the operational fleet, about 47 percent of the buses have passed their scheduled age of retirement but continue operating due to lack of adequate funding for fleet renewal. Over this period, CMA has expanded from 1,500 sq km to 5,900 sq km, its population has increased from 12.2 million in 2011 to about 15.9 million in 2021, while the GDP of this area has been growing consistently at 7-8 percent per annum, all of which point to growing travel demand in the city. The current fleet translates into ~220 buses per million population, well below the national benchmark of 600 buses per million population for metropolitan cities, and international best practice of 1,000 buses per million population as observed in cities like London and Bogota.

Inadequate public transport combined with increasing per capita incomes have led to rapid motorization and a decline in public transport. Buses traditionally formed the backbone of public transport in CMA, but their mode share decreased from nearly 50 percent in the 1980s to 22 percent in 2018. Despite significant rail investments, including MRTS and the Chennai metro, the rail mode share has remained low at around 5 percent. The share of non-motorized transport fell from a high of 47 percent in the 1990s to 28 percent in 2018. Use of personal motorized vehicles rose sharply and formed 44 percent of the mode share in 2018, with two-wheelers alone accounting for 30 percent of the mode share. There were 91 cars, and 436 two-wheelers owned per 1,000 people by 2020. As a result, despite an annual budgetary expenditure of more than Rs 6,500 crore (~USD 800m)[2] on capital and operational expenditure of urban mobility initiatives across CMA, the city has witnessed increasing congestion and high incidence of road crashes and fatalities.

There are several barriers preventing the improvement of bus services. Financial constraints are the chief reason for the decline in bus services in Chennai. MTC has seen a steady growth of its in-house staff costs and fuel costs, which together constitute more than 80 percent of MTC's cost of operations. At the same time, revenue growth has been limited. Farebox revenue accounts for 90 percent of MTC revenues, in the form of tickets and reimbursements from the government for concessional travel provided to special categories of users, including vulnerable users, women, students, and the elderly. Besides such reimbursements, government support for bus services has been limited to discretionary funding for capital and operational expenditure via the budget process. Without certainty of long-term government support, MTC was limited in its ability to undertake long-term fleet expansion and service quality improvements till 2023.

APPROACH IN CHENNAI

A three-pronged strategy was developed as a part of CCP: Sustainable Urban Services Program (SUSP) for transforming MTC into a world-class public transport agency:

- **Business plan for service improvement and financial sustainability**: A business plan for MTC

BOX 2.1: VISION SETTING AND BUSINESS PLANNING

International examples of vision setting and business planning include the strategic Bus Plan for Victoria (Australia)[1] and the annual budget and business plan for London.[2] Victoria's Bus Plan outlines how the Victorian government will build on investments in bus services to deliver a modern, productive, environmentally sustainable bus network that increases the number of passengers. Transport for London's (TfL's) 2024 Business Plan sets out how TfL will continue to create a transport network that serves everyone's needs, while tackling pollution, supporting the UK economy, and building a safer, greener, and fairer city for all.

Sources:
[1] https://content.vic.gov.au/sites/default/files/2023-09/victorias-bus-plan-bus-reform-roadmap.pdf.
[2] https://tfl.gov.uk/corporate/publications-and-reports/business-plan.

outlining its long-term (10 year) vision for service transformation and a medium term (5 year) financial plan for achieving this vision were developed by MTC and approved by GoTN in July 2023. The Business Plan references international examples of vision setting and business planning (Box 2.1).

- **PTSC to formalize support and expectations**: A PTSC assuring timely and performance-linked funding for MTC was signed between GoTN and MTC in October 2023. It formalizes GoTN's 5-year commitment to provide viability gap funding (VGF) for capital and operational expenses, subject to MTC meeting mutually agreed on KPI targets. It also codifies the institutional mechanism for monthly KPI reporting, timely VGF disbursement, annual review of KPI targets, and Business Plan updates. The Public Service Obligation[3] and PTSCs issued by legal mandate in the European Union provided a useful framework for designing the PTSC for MTC.

- **Shift from operations to service delivery**: SUSP is also supporting MTC to gradually increase its focus on service planning and management by deploying 1,000 buses on a GCC basis for its service expansion. MTC is planning to procure low-floor electric buses (e-buses) as they are more user friendly and environmentally sustainable. The procurement of the first 500 e-buses was concluded in November 2024, the next phase is planned in 2025, and the buses will be deployed in phases in 2025 and 2026. The GCC based approach transfers the responsibility of financing, operations, and maintenance of the bus fleet to a private operator/service provider while GoTN and MTC retain the responsibility of regulating, planning, paying for services delivered, and overseeing operations while also absorbing revenue risks. GoTN's funding commitments in PTSC will ensure MTC's financial sustainability and timely payments to operators, who depend on the contracted revenues from MTC under GCC to raise the necessary financing for buses.

The following sections provide details of the Business Plan and PTSC to serve as an example for other cities looking to build institutional capacity to scale up bus services. GCC based procurement in Chennai will be informed by India's national-level efforts for improving bankability of electric bus contracts which have been covered extensively in other publications[4],[5] and are hence not repeated here.

The Business Plan

Multi-year business plans can be instrumental in long-term planning and providing a clear framework for institutional transformation over an extended time frame. MTC's Business Plan articulates the vision of the organization, strategic priorities for achieving this vision, and the outcomes envisaged within each priority area over a five-year horizon, and KPIs for systematically tracking progress towards achieving these outcomes. A financial model for quantifying costs, revenues, and financial needs for meeting the intended outcomes was developed to guide decision making. Agreeing on the vision and priority areas, KPIs and their targets involved several rounds of consultations between MTC's various departments and with GoTN's transport and finance departments with periodic inputs from the World Bank. An external consultant (Ernst and Young-EY) was also hired to support MTC in this process. Figure 2.1 presents a summary of the key elements of the Business Plan.

Vision

Under the Business Plan, MTC specified its long-term vision for the next 10 years as 'To be an integral part of Chennai citizens' daily lives by providing a world-class, customer-centric, and sustainable public bus service.' In quantitative terms, the vision means a targeted increase in ridership from 2.8 million passenger-trips per day in FY 2022-2023 to 4.6 million per day by FY 2027-2028, and 5.3 million per day by FY 2031-2032. This will effectively seek to arrest MTC's declining trend of ridership, and instead increase it by 90 percent by FY 2031-2032 relative to FY 2022-2023.

Strategic priorities and actions for achieving the vision

Seven strategic priority areas (Table 2.1) and 34 action points were identified for MTC for achieving its ambitious vision. Key actions which are relevant for other bus agencies are briefly described below:

- **Fleet replacement and augmentation:** MTC targets increasing its fleet from 3,454 in FY 2022-2023 to 7,578 by FY 2031-2032 to meet the ridership targets. This will require replacing 2,343 existing buses as they reach their retirement age and augmenting the fleet by another 4,124 buses. Therefore, MTC will need to procure 6,457 buses by FY 2031-2032 and plan for infrastructure and financial resources accordingly.

FIGURE 2.1: OVERVIEW OF THE BUSINESS PLAN FOR MTC, CHENNAI

Source: Authors' illustration.

TABLE 2.1: OVERVIEW OF STRATEGIC PRIORITIES, OUTCOMES, AND KPIS AND THEIR TYPES DEFINED UNDER THE BUSINESS PLAN

Strategic priorities	Outcome	Key Performance Indicator (KPI)	KPI Type
Priority 1: Enhancing Journey Experience and Trust	Daily ridership (gender-wise)	Daily ridership on MTC buses including all categories of passengers (tickets and passes)	PTSC – Reportable
		Daily ridership per MTC bus including all categories of passengers (tickets and passes)	PTSC – Reportable

Strategic priorities	Outcome	Key Performance Indicator (KPI)	KPI Type
	Public transport will be accessible to all	Proportion of households living within a 10 min walk from bus stops	PTSC – Reportable
		Proportion of jobs holders living within a 10 min walk from bus stops	PTSC – Reportable
		Proportion of educational institutions within a 10 min walk from frequent transit points	PTSC – Reportable
	Journeys by public transport will be fast and reliable	Breakdown per 10,000 km	PTSC-VGF
		Percentage of on-time dispatch of trips (-5 / +5 minutes)	PTSC-VGF
		Trip efficiency (percentage of operated revenue trips against planned trips)	PTSC-VGF
		Km efficiency (percentage of operated revenue km against scheduled km)	PTSC-VGF
		Customer satisfaction score (gender wise)	PTSC-VGF
	Public transport will care of its customers	Time taken to address minor customer grievances (minor grievances do not require an investigation)	Internal Efficiency
		Time taken to address major customer grievances (major grievances require an investigation)	Internal Efficiency
		Percentage of calls that will be attended (call center response) (number of incoming calls vs calls attended (IVR system))	Internal Efficiency
Priority 2: Safe and Inclusive system for all	Transport system will be safe and secure	Number of blameworthy accidents per lakh km	Either PTSC Reportable or Internal Efficiency
		Reduction in number of security incidents in bus per lakh km (assault, sexual harassment, violence, pickpocketing, theft, intimidation of driver/ conductor)	Either PTSC Reportable or Internal Efficiency
Priority 3: Clean, Green and Resilient Mobility	Transition to electric buses	Procurement of electric buses in fleet (percentage of new fleet procured which will be electric – replacement and augmentation)	PTSC Reportable
	Fuel efficiency	Km/ltr – diesel (standard non-AC bus)	Internal Efficiency
		kWh/km (standard low floor AC bus)	Internal Efficiency
Priority 4: Smart Mobility	Transition to electronic ticketing/ AFCS	Proportion of digital ticket transactions in total ticket transactions	Either PTSC Reportable or Internal Efficiency
	Digital passenger information system	Proportion of fleet with functional PIS	Either PTSC Reportable or Internal Efficiency

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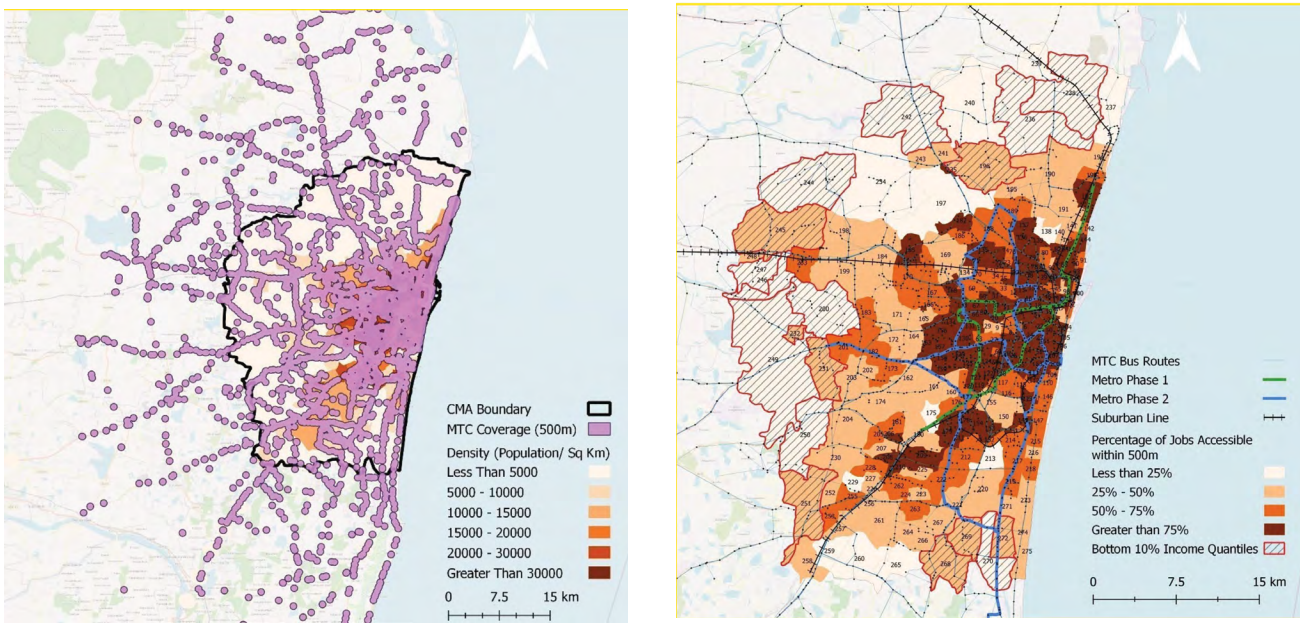
Strategic priorities	Outcome	Key Performance Indicator (KPI)	KPI Type
Priority 5: Operational Efficiency Improvement	Engineering	Fleet availability	Internal Efficiency
		Technician per bus	Internal Efficiency
	Operation	Vehicle usage (effective km per bus per day)	Internal Efficiency
		Driver-cum-conductor per bus	Internal Efficiency
		Conductor per bus	Internal Efficiency
		Total staff per bus	PTSC-VGF
	Administration	Administrative staff per bus	Internal Efficiency
Priority 6: Financial Sustainability	Financial sustainability	Cost recovery ratio (excluding depreciation, amortization, interest, and taxes)	Internal Efficiency
		Non-fare box revenue (percentage of fare box including reimbursement of concessional/free travel)	Internal Efficiency
Priority 7: Mobility through Collaboration	Collaborations	Involvement of commuters and other stakeholders in decision making (number of meetings)	PTSC Reportable
		Number of terminals with multimodal connectivity (percentage terminals with integration out of total potential)	PTSC Reportable

- **Network Redesign - Making the network simpler, faster, and more reliable:** MTC's bus network has remained relatively static over the years, even as several new demand centers have emerged across CMA. An accessibility analysis (see Figure 2.2) identified several areas with limited bus network connectivity. Furthermore, the expanding metro network along high demand corridors warrants rationalizing services which have significant service and demand overlap with the metro, and the addition of feeder bus services for improving access to the metro. Therefore, a city-wide bus route network redesign exercise will be

FIGURE 2.2: POPULATION AND JOBS ACCESSIBLE WITHIN 500M OF MTC BUS STOPS IN CMA

(Key findings from the accessibility analysis as part of the Business Plan for mapping the existing service coverage of the bus network in Chennai, and key service gaps to be addressed through a redesigned bus network)



Source: Business Plan, EY.

carried out for optimizing the deployment of existing and future bus fleets based on the emerging needs of bus users across Chennai. MTC aims to develop a network which is simple to recall for the users by reducing the number of routes and making them destination oriented, efficient by providing direct high-frequency connections between key demand centers, and reliable.

- **Bus priority measures:** MTC's journey speeds have declined significantly over the years, as reflected in a 15 percent reduction in daily bus-km between 2015-16 and 2022-23, due to traffic congestion. Bus priority measures such as exclusive bus lanes, priority signals for buses, and bus boxes at the head of intersections are being explored for increasing bus speeds along congested corridors, thereby encouraging modal shifts from private vehicles to buses.

- **Supporting infrastructure and multimodal connections:** Given the capacity constraints of existing infrastructure, expanding and improving supporting infrastructure such as depots and terminals were identified as critical for supporting the expanded fleet. Besides more buses, MTC correctly identified improving customer experience as a key priority. This is critically linked to the quality of infrastructure in terms of accessing, waiting, and boarding buses. Hence, the Business Plan identified key Multi Modal Integration (MMI) locations with high footfall such as interchanges between buses, suburban rail, metro stations, and nodes where several buses terminate as needing priority improvements in physical infrastructure and passenger information integration. Feasibility studies and market consultations indicated that some sites can be developed through the PPP mode while others needed the government to cover viability gaps. MTC has initiated action for developing supporting infrastructure through a combination of government-led as well as PPP-based involvement of private developers in exchange for allowing limited access to this land for other commercial activities.

- **Scheduling optimization for rebalancing costs and revenues**: The Business Plan's analyses also highlighted the scope for rationalizing staff costs through improved vehicle and crew scheduling practices. This will require moving from the current practice of relatively uniform service frequencies all day to higher frequency services during peak hours, and re-allocation of the crew accordingly.

- **Transition to electric buses:** Considering the favorable Total Cost of Ownership (TCO) over the lifecycle of the bus, improved ride quality and the substantial environmental benefits, electric buses (e-buses) were identified as the priority technology for upcoming fleet procurement. A total of 5,016 buses, which will constitute 85 percent of the augmented fleet and 64 percent of the replacement fleet, are planned to be electric, making the e-bus fleet share 66 percent by 2031-2032. Given the funding secured for some diesel buses and the current lack of feasibility for e-buses on some routes, about 2,562 diesel buses will also be procured. MTC will revisit these numbers during annual Business Plan updates, since e-bus technologies and cost economics are still evolving.

- **Moving towards a combination of service delivery models**: The Business Plan includes a combination of service delivery models for MTC: (i) in-house ownership and operations for existing buses; (ii) GCC-based operations for fleet expansion as already being adopted in several Indian and international cities; and (iii) potential net cost contract for on-demand premium services. The GCC model will allow MTC to focus on service design and customer satisfaction while the fleet ownership, operations, and maintenance are taken up by contracted operators for service expansion. A move towards GCC will reduce delivery costs, as observed across India, which will improve MTC's financial sustainability substantially. GCC for e-buses will also better allocate risks, by transferring those to the vehicle manufacturers and operators who are better positioned to address such risks. In parallel, the Business Plan recognizes the major contributions of the more than 8,200 drivers and several other supervisory staff currently employed by MTC. The Business Plan retains sufficient in-house operations for using the existing crew. Some staff will be up skilled to manage priorities like contract management and performance review of private operators in the new GCC paradigm.

- **Digital systems:** MTC is currently undertaking several information technology (IT) initiatives for real-time passenger information, automated fare collection systems, Enterprise Resource Planning (ERP) for management, and grievance redressal mechanisms through various government and externally financed projects. The Business Plan identified the need for effective integration between these initiatives as well as effective integration of passenger information and

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ticketing with other public transport modes.

- **Customer satisfaction, grievance redressal, branding, and communication**: The Business Plan emphasizes the need for greater focus on customer centric initiatives such as periodic customer satisfaction surveys on key attributes such as service quality, safety, comfort, ease of use, and crew behavior. MTC has now initiated action to carry out customer satisfaction surveys annually with the target of increasing satisfaction levels by 30 percent over a five-year period. Separately, activities for timely grievance redressal mechanisms as well as branding and communication initiatives have been identified for improving customer satisfaction.
- **Non-fare box-based revenue:** Such revenues are being explored to offset losses due to fares kept low for affordability. Development of PPP-based infrastructure to raise revenues as well as premium bus services which provide high-quality buses and demand-responsive routes have been studied. As explained earlier, only a few terminal sites are deemed suitable for PPP. Premium bus services have been identified as a promising model for attracting a new clientele to buses which is willing to pay more for a more comfortable and favorable route. However, the revenues from such services are not likely to significantly offset MTC's overall deficit.

Key Performance Indicators (KPIs) for measuring progress in the vision

Defining KPIs that better align with the vision, and incentivizing progress towards the KPIs are key elements of the Business Plan in Chennai. While MTC has already tracked several KPIs, most of them focus on productivity parameters such as daily-km of service, ridership, trip efficiency (percentage of scheduled trips performed), breakdowns, accidents, and crew per bus. Customer-centric measures such as accessibility, punctuality, and customer satisfaction have not been tracked. MTC identified the Business Plan KPIs that meet internal efficiency and customer satisfaction goals, while also considering MTC's ability to monitor them transparently and consistently. Further, MTC previously only tracked KPIs for internal efficiency management. While KPIs are reported to GoTN annually, they did not have any bearing on the funding allocated to MTC.

The Business Plan and PTSC now link the KPIs to funding allocation for MTC, thereby improving transparency in funding and encouraging efficient service delivery. The business planning exercise identified KPIs tied to each strategic priority area based on their importance and feasibility of measurement. Table 2.1 provides a summary of the strategic priority areas, associated outcomes, and KPIs and their classification. The KPIs are further classified into three categories according to their application:

i) **PTSC contractual KPIs:** These KPIs will be used by GoTN to track MTC's performance. The release of VGF will be contingent on the achievement of these KPIs.

ii) **PTSC reportable KPIs:** These KPIs will be reported by MTC to GoTN to track performance trends. While these KPIs will not have a bearing on the VGF allocation to MTC, they will have policy relevance and will inform overall decision-making regarding bus services.

iii) **KPIs for internal performance efficiency improvements:** These KPIs will be tracked by MTC and used for internal performance efficiency management which will in turn support it in meeting the KPIs listed under PTSC.

The targets for each KPI were defined based on improving gradually from their current to desirable levels over a five-year period. Determining the value of targets was an iterative process. MTC initially set targets based on internal deliberations on the practical challenges of improving performance. The targets were then reviewed by GoTN's transport and finance departments and were either approved or recommended for further improvements to meet performance expectations. MTC then finalized the KPI targets in concurrence with GoTN. The detailed stakeholder involvement in this process was key to moving towards a business plan and KPI targets which were mutually acceptable to both GoTN and MTC. Specific KPI targets have been excluded from this note as the Business Plan is internal to MTC.

PTSC

PTSC provides assured funding to MTC for the fleet covered each year, subject to MTC meeting its KPI targets for the PTSC-VGF category KPIs listed in Table 2.1. KPI targets apply to the fleet covered by PTSC for a given year and are set to be incrementally more stringent, as an efficiency improvement incentive for MTC to be eligible for funding from GoTN. Through this approach, PTSC codifies the relationship between GoTN and MTC and introduces transparency and consistency in funding support for MTC to reach its business plan's goals, moving

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away from the current practice of discretionary funding without formal linkages to performance efficiency. Detailed definitions of the KPIs and their targets are provided in PTSC along with other key terms such as timelines for KPI reporting, VGF disbursement, and scope for annual revision coinciding with the Business Plan's updates.

PTSC's key elements

- **Scope**: The PTSC signed between GoTN and MTC has a life of five years and adopts an incremental approach, covering 10 percent of the MTC fleet in year 1 and expanding its coverage to 30 percent, 50 percent, 70 percent, and 100 percent of the fleet in subsequent years. Therefore, from year 5 onwards, the entire MTC fleet will be covered by PTSC.
- **Annual VGF allocation**: MTC will prepare an updated business plan at the start of every year from year 2 of the contract, updating its service targets and funding requirements for the next financial year. Subject to the approval of the business plan, the necessary VGF for capital and operational expenses will be budgeted for the next financial year, beginning in April of the year. While the process of annual budgeting will happen even without a PTSC, PTSC serves as an objective and convenient vehicle for MTC for identifying specific depots and fleet to be considered for VGF allocation. MTC is also required to report on KPIs at the beginning and end of each year which will be considered for VGF allocation. This KPI linkage to VGF allocation makes PTSC an effective tool in driving performance efficiency while providing transparency and assurance of funding.
- **Periodicity of KPI reporting**: MTC will report VGF-linked and other reportable KPIs listed in Table 2.1 every month, as well as their consolidated statement at the end of the year.
- **VGF disbursement protocol**: VGF disbursement to MTC is contingent on two layers of pre-requisites:
    a. Achieving/maintaining trip efficiency of 70 percent will make MTC eligible for 90 percent of the VGF amount for the month, while achieving trip efficiency of 75 percent will make it eligible for 100 percent of the VGF. Trip efficiency is the percentage of actual trips out of the scheduled trips performed by the fleet covered under PTSC. Therefore, underperformance on this KPI will directly lead to MTC foregoing 10 percent of its VGF requirement. Given the baseline trip efficiency of 77 percent in FY 2022-2023 and the target to improve it further, it is expected that MTC will consistently meet the 75 percent target.
    b. The eligible VGF amount (of 90 percent or 100 percent) will be transferred to MTC as follows:
        i. 70 percent of the VGF amount will be disbursed at the end of every month to ensure adequate cashflow with MTC.
        ii. Another 20 percent of the VGF will be disbursed at the end of the year after adjusting the budgeted VGF against actual VGF MTC's needs.
        iii. The remaining 10 percent of the VGF, in case MTC is eligible for it, will also be transferred at the end of the year. However, this is contingent on MTC meeting individual KPIs:
            1. 2 percent weightage each will be given to three KPIs: Trip efficiency, earnings per km, and bus-staff ratio (number of staff per scheduled bus).
            2. 1 percent weightage each will be given to four KPIs: breakdowns per 10,000 km, percentage of on-time dispatch of buses, km efficiency (percent scheduled-km operated), and occupancy ratio (percent passenger-km of capacity availed).
            3. Each of these KPIs are given incrementally stringent targets over the five-year period to encourage MTC to improve efficiency. Even though trip efficiency is measured while determining initial eligibility for 90 percent/ 100 percent VGF, the KPI targets while disbursing the final 10 percent of the VGF have more stringent targets than the baseline requirement of 75 percent.
- **Contract management through a committee**: A committee comprising members from MTC and GoTN's transport and finance departments will oversee PTSC. The key tasks of the committee include identifying the KPI monitoring system, review of annual updates of the Business Plan covering service expansion and efficiency improvement targets of MTC along with the corresponding VGF. The committee is also empowered to make necessary amendments to PTSC including fleet coverage, KPI targets, and VGF mechanisms.

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- **Other elements**: Apart from all these, PTSC clearly defines the rights and obligations of the parties involved, reporting requirements by MTC, detailed definitions of the KPIs and their calculation methods, MTC's proposed service plan (with flexibility to adapt based on demand), and a detailed list of costs and revenues to be accounted for VGF calculations including their accounting codes.

Impact of PTSC on fare setting and concessional travel reimbursements

Fare setting of MTC buses has traditionally been carried out by GoTN balancing financing and affordability considerations. Even after PTSC, GoTN continues to retain the power for fare setting and periodic revisions as per the currently prevailing Government Orders. The VGF required based on these fares will be provided under PTSC. This way, MTC's ability to provide quality bus services is insulated from government decisions on fares which are often based on wider policy considerations.

Concessional travel reimbursements: Even in the absence of PTSC, GoTN has been funding MTC in the form of budgetary allocations for capital requirements for fleet procurement and reimbursement of concessional pass travel offered by MTC. While the capital needs will be subsumed under PTSC, prevailing Government Orders for the reimbursement of concessional bus passes will continue even after PTSC comes into effect. This has been incorporated in PTSC.

Operationalization of the Business Plan and PTSC

MTC and GoTN have initiated action for building the necessary institutional capacity for operationalizing priority activities proposed in the Business Plan and PTSC. Additionally, the proposed introduction of GCC based operations for service expansion, transition from diesel to electric buses, upgrading depot capacity to meet future needs, and provision of customer-centric services, require MTC to reorganize its institutional structure and build capacity to achieve the transformation. In addition to CCP, MTC is currently receiving technical and financial assistance from development partners such as the German Development Bank (KfW) and the Japan International Cooperation Agency (JICA) for fleet procurement, infrastructure upgrades, Intelligent Transport Systems (ITS) for digital transformation, and institutional capacity building. A specialized Program Monitoring Unit (PMU) with subject matter experts has been hired to support MTC in aligning projects from various development partners with the Business Plan's vision and for assisting in the institutional transformation. The experience from PMU will be used for building internal capacity for undertaking these activities in-house in the long-term. Internal capacity building will involve establishing SOPs for various activities like GCC management and ITS application as well as re-skilling staff for future needs. Restructuring the institution to accommodate new skillsets needed for the future such as customer engagement, gender inclusion, and environmental and social management will be taken up in due course.

EXPECTED IMPACT

Bus service reforms in Chennai are well underway and are expected to improve bus service delivery in the city. The Business Plan was approved by the Government of Tamil Nadu in July 2023. PTSC was subsequently approved and operationalized in September 2023 and MTC had initially received the necessary budgetary allocation for year 1 covering 10 percent of its fleet. Building on the results achieved in the first year, GoTN advanced the PTSC timeline by a year and has now decided to reach 100% VGF support in four years instead of the five originally planned. Accordingly, GoTN will now cover 50 percent of MTC's VGF requirements in year 2, 70 percent in year 3 and 100 percent by year 4. Additionally, a program management unit (PMU) has now been set up for implementing PTSC effectively over its five-year tenure, including tracking and reporting on key performance indicators, updating the Business Plan annually, and advancing efficiency improvement goals set for MTC. Other cities and states could accelerate bus service reforms by adopting such documents with minor modifications suiting the local context. MTC also concluded the procurement of 500 e-buses using gross cost contracts in November 2024, to be followed by a second phase of 500 e-buses, with the bus deployment expected to be carried out in phases through 2025 and 2026. The prices quoted for GCC (INR 77.16 per km for Non-AC and INR 80.86 per km for AC e-buses) deliver more than 20 percent savings in operating costs for MTC. These results mark an inflection point in the technology and business model preferences for MTC and validate the transition model proposed under SUSP.

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Chennai's approach to bus service reform can contribute to India's climate commitments, and national level programs. Government of India's Long-Term Low Emission Development Strategy (LT-LEDS)[6] launched at the 2022 United Nations Climate Change Conference (COP27) targets increasing public transport mode share and transitioning to electric mobility. Towards this, various national-level programs like aggregated procurement of e-buses and establishment of a Payment Security Mechanism (PSM)[7] are being taken up to improve project bankability and ensure timely payments to e-bus service providers. However, the success of these national level efforts is critically dependent on state and city level efforts to set up a vision for e-bus transition and service improvement backed by consistent funding. PTSC sets up a replicable template for items like the institutional structure, service enhancements, and e-bus adoption targets along with KPIs for efficiency monitoring that can be adopted by Indian cities and states across various scales of operations.

The Business Plan and PTSC can serve as blueprints for replication elsewhere in India and beyond. A long-term vision, business plan, and consistent funding commitment through a PTSC linked to the Business Plan are being developed for the first time in the Indian context. These documents have been developed through extensive consultation and legal vetting and can help other cities and states looking at accelerating bus service quality improvements and e-bus adoption.

TAKEAWAYS FOR OTHER CITIES

Chennai's bus service transformation journey offers takeaways that can benefit other cities:

- **Assurance of support in exchange for better services**: The five-year funding commitment in exchange for service enhancements and efficiency improvements is at the core of the Business Plan and PTSC. Other cities can employ similar approaches for strengthening accountability, while offering the certainty of government support for facilitating long term planning and investment to strengthen service delivery. In addition to long-term commitment, the periodicity and timeliness of funding are crucial for ensuring adequate cash flow with the bus agencies. Therefore, the governments may transfer most of the committed funding monthly and retain some amount to be reconciled at the end of the year for taking performance linked incentives and disincentives as well as any deviations between budgeted and actual funding needs.
- **The transformation process**: The hierarchy of activities undertaken as part of the Business Plan and the PTSC process in Chennai can serve as a blueprint for other cities. This includes setting a vision for customer-centric service delivery, key building blocks for service improvements like service enhancement, electrification, and digitalization, and KPI based monitoring of the progress towards achieving the vision.
- **Building consensus on KPIs and targets**: The Chennai experience highlights the need for a collaborative and iterative process in selecting KPIs and targets. KPI targets need to strike a balance between incentivizing service improvements, while being within the realm of possibility for the service delivery agency. Achieving consensus on targets through active consultations can ensure better commitment by the concerned stakeholders and the durability of targets.
- **Incremental transformation**: Chennai has chosen to extend the coverage of PTSC to MTC's fleet in phases over five years (going from 10 percent in year 1 to 30 percent, 50 percent, 70 percent, and 100 percent in year 5). While this gives time to GoTN and MTC to adapt to the new paradigm, the mechanics of such an approach can be complex. MTC will need to delineate the specific buses, depots, and routes to be included under PTSC each year, and determine KPIs and VGF requirements applicable to them. Depending on the context, other cities may choose to go to 100 percent right at the outset, with moderate KPI targets based on the ability of the entire fleet to meet them in the initial stages.
- **High care with high expectations**: Achieving multifold transformation in service, vehicle technology, and information technology adoption requires strong oversight and significant re-skilling and capacity augmentation in the bus agency for effectively managing the transition. The approach of setting up a contract management committee comprising GoTN and MTC's representatives that reviews the updated business plan, KPI targets, and VGF requirements every year provides an institutional anchor for ensuring PTSC's successful execution. Significant capacity development initiatives are being planned for MTC to tide over the transition.

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CONCLUSION

A combination of the Business Plan, PTSC, and GCC based procurement of electric buses by Chennai provides a replicable template for other cities and is also scalable to regional and national levels. Such a framework for public transport improvements can bring in more transparency, consistency, and efficiency in funding for public transport, thereby enabling the enhancements necessary for meeting developmental and environmental targets across developing countries.

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3: FOSTERING MULTIMODAL INTEGRATION

Ravi Gadepalli[1], Jai Malik[2], Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

To encourage people to use public transport and active mobility, cities need to compete effectively with the door-to-door connectivity provided by private vehicles. Travel patterns through public transport systems are generally multimodal. Even in cities with a predominant mode such as buses, commuters need to walk or cycle to and from bus stops to go places. Well-integrated transport systems allow users to transfer across modes with a reasonable amount of physical effort, time, and cost. Conversely, friction during intermodal transfers or large tariff differentials can discourage the use of public transport and push people to own and use personal vehicles.

This note discusses approaches for improving multimodal integration (MMI) in cities using the ongoing and planned efforts in Chennai. Given the multiplicity of modes and the ongoing expansion of its metro network Chennai is particularly interesting. Strengthening MMI is crucial for reaping the benefits of investments in public transport. Other cities that are in the process of expanding their public transport networks or are simply seeking to optimize their existing networks can gain from the Chennai example.

What is MMI?

Creating efficient, multimodal transportation systems is crucial for addressing the diverse commuting needs in urban areas. Transportation systems are often multimodal, encompassing various motorized modes of transport such as buses, metro systems, suburban trains, auto-rickshaws, taxis, and private vehicles (cars and two-wheelers)[3] as well as active modes requiring human effort such as walking, cycles, and cycle-rickshaws. Improving public transport modes complemented by investments in active mobility[4] to enable first and last mile access can significantly enhance the efficiency of services in meeting the diverse commuting needs in Indian cities and elsewhere.

> Even as public transport expands gradually, the number of personal cars and two-wheelers has grown at a rapid pace, with CMA now having more than 9 million registered personal vehicles, indicating the increasing mobility needs of the people, currently served by private vehicles causing congestion, poor air quality, and road safety hazards.

Intermodal transfer friction significantly impacts the attractiveness of public transportation. Friction during intermodal transfers can discourage people from using public transport and instead opt for private vehicles. Passengers may hesitate to choose public transportation due to the additional time and effort it entails. These challenges include cognitive burdens related to route planning, navigation, and uncertainties in timely arrivals and connections.[5,6] For instance, difficulties faced by passengers in accessing and leaving public transport modes have been identified as a contributing factor to lower-than-expected ridership in the Delhi metro.[7] Factors such as physical distances, condition of road infrastructure, a city's geography, land use, population

density, and income distribution influence public transport demand, ease of entering and exiting stations, wait times, and transfer times playing crucial roles in the overall travel experience.[8]

Effective MMI in public transport is crucial for enhancing urban accessibility. In the context of rethinking urban planning for improved accessibility, MMI in public transport is essential. It involves considering various dimensions for ensuring a seamless and efficient service for passengers. Network integration connects routes to provide access to diverse destinations, minimizing duplication of services. Timed transfers synchronize scheduled services to minimize transfer times, forming a pulsed hub network. Physical connections such as sheltered walkways and informative signages, facilitate smooth transfers. Information integration offers real-time guidance during transfers, while fare and ticketing integration ensures a unified and cost-effective system. By addressing these dimensions—network integration, timed transfers, physical connections, information integration, and fare integration—urban/transport planners can create a well-coordinated and user-friendly multimodal public transport system (refer to Chowdhury et al. 2018[9] for further details). Stockholm[10] and Singapore[11] have successfully implemented MMI, allowing passengers to easily transfer between different modes of transportation for efficient travel.

BACKGROUND

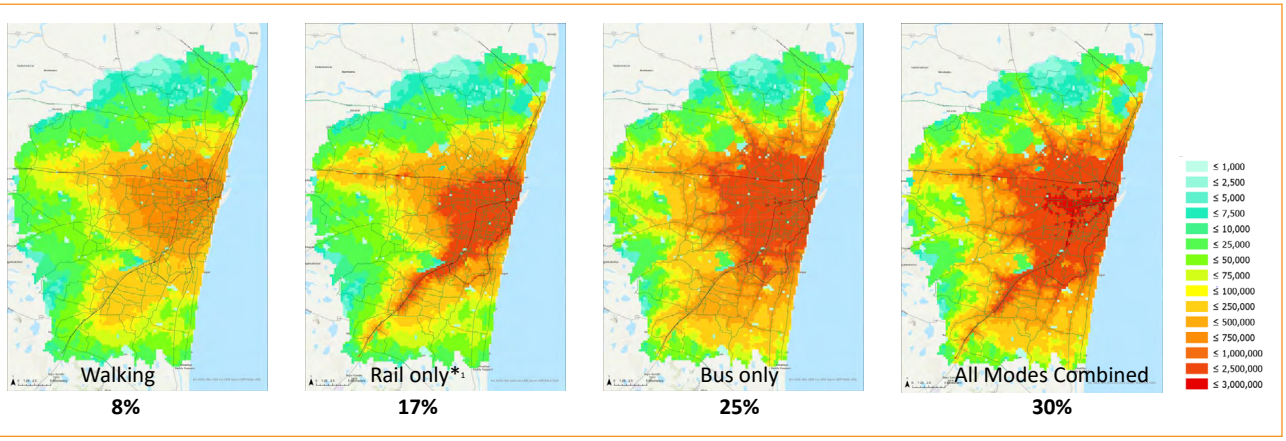
Chennai's diverse public transport systems are expanding to meet the city's growing mobility needs, but private vehicle usage continues to rise. Chennai presently has four different public transport systems. Buses have been the most used public mode of transport, as discussed in the preceding note on 'Augmenting Bus Service Delivery.' They are provided by MTC-Chennai with a fleet of ~3,400 buses running on 610 routes . Suburban rail lines that connect the core city to the rest of CMA and beyond have been operating for several decades, including the suburban rail system (89 km) and MRTS (19 km). To augment mass transit services further, the Chennai metro was inaugurated in 2015 and currently has a network length of 54 km. The city is expanding its metro network by another 118.9 km, while the bus fleet size is planned to be doubled by 2030. Apart from these formal modes of public transport, about 74,000 three-wheelers offer paratransit/intermediate public transport (IPT) services, which are point-to-point or corridor-based shared shuttle services. Even as public transport expands gradually, the number of personal cars and two-wheelers has grown at a rapid pace, with CMA now having more than 9 million registered personal vehicles , indicating the increasing mobility needs of the people, currently served by private vehicles causing congestion, poor air quality, and road safety hazards.[12]

Accessibility to jobs is directly impacted by the level of integration across different transport modes. Building on CMP 2019 data and the public transport network, accessibility to jobs by public transport was assessed across the Chennai metropolitan area, with a one-hour journey time. Accessibility to jobs through a multimodal strategy was **76 percent** higher than one that relied solely on rail, and **17 percent** higher than one using only the bus network. The cost of such integration was minimal compared to investment costs in the different modes illustrating the value of MMI in leveraging public investments (Figure 3.1).

Mode share of active mobility and public transport has declined over the years despite significant public investments. GoTN through its various civic agencies, infrastructure development authorities, and public transport utilities, invested about Rs 6,800 crore (~USD 820m) annually[13] for the five-year period between FY 2016 to FY 2020, covering capital investments in infrastructure and systems and operating subsidies (the World Bank, 2020).[14] Despite these investments, the mode share of public transport systems in Chennai has declined from 43 percent in 1992 to around 23 percent in 2023 (Figure 3.2).[15] Conversely, the growth in personal vehicles has outpaced growth in road infrastructure, leading to traffic congestions, road safety issues, and a negative impact on the quality of life.

While part of the decline can be attributed to users' preference for personalized mobility, a significant reason has also been the lack of integrated service provision across modes. The Draft Comprehensive Mobility Plan for Chennai (2019) identified the lack of land-use transport integration, lack of non-motorized transport facilities, and the lack of multimodal integration across all integration dimensions, led to the decline in public transport and the non-motorized transport mode's share. There is potential for improving MMI, with due consideration to urban development patterns and evolving customer preferences.

FIGURE 3.1: TOTAL JOBS ACCESSIBLE IN 60 MINUTES BY DIFFERENT MODES



Source: The World Bank based on draft CMP Chennai (2019).

MMI Approach in Chennai

GoTN aims to reverse these trends and recognizes the importance of MMI for achieving this. Various vision documents and development plans for Chennai[16] identify reducing personal vehicle usage and increasing public transport's share as key to addressing the current challenges and ensuring sustainable development in the city. Past studies have demonstrated how improving local and regional accessibility of mass transit systems through MMI initiatives like creating vibrant people centric spaces, developing neighborhoods that promote walking and cycling, and integrating public transport are the key to maximizing benefits from mass transit investments and urban value.[17],[18]

Building on these principles, GoTN has initiated a wide range of measures for improving MMI under four key pillars:

i) Institutional measures for MMI

ii) Physical integration between various modes to mass transit systems

iii) Operational integration between mass transit systems, including:

   a. Bus route network redesign

   b. Paratransit planning and regulation

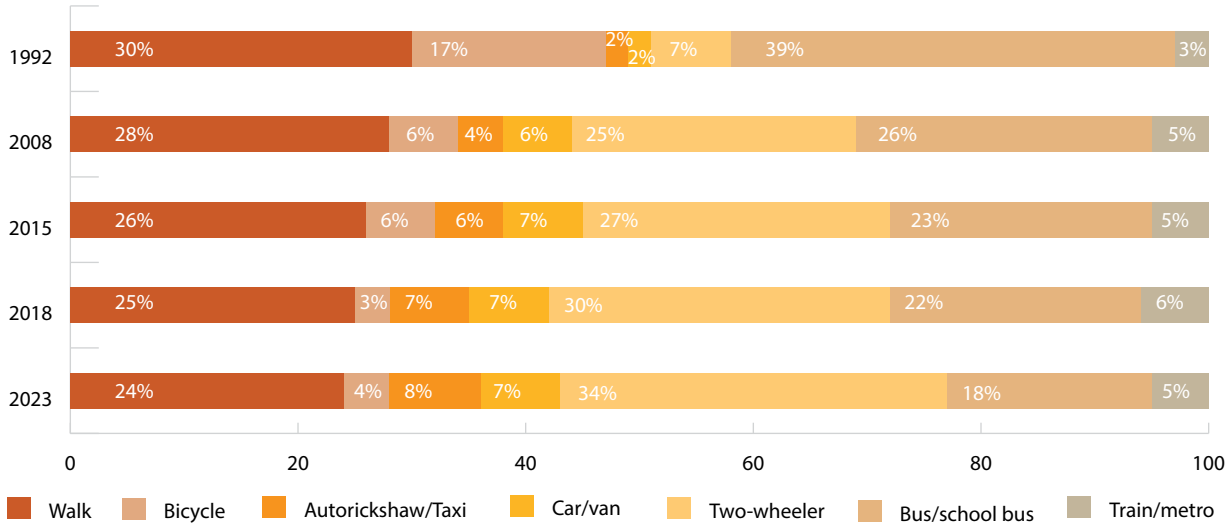
iv) Technological integration, including:

   a. Integrated journey planning

   b. Digital ticketing for public transport

   c. Transition towards Mobility as a Service (MaaS)

FIGURE 3.2: MODE SHARE TRENDS IN CHENNAI SINCE 1992



Source: CMP Interim Report II, CUMTA (2024).

The rest of this note explains the specific actions being undertaken under each of these areas of the intervention.

Institutional measures for MMI

Cities around the world have shown similar institutional reforms for enhancing MMI and improving travel experience. For instance, London established Transport for London (TfL)[19] as an integrated transport authority, while Barcelona created the Barcelona Metropolitan Transport Authority (ATM)[20] for coordinating various modes of transport. Vancouver implemented TransLink[21] to oversee regional transportation services. These institutional changes have led to more seamless and efficient multimodal transport systems in these cities.

Multimodal integration (MMI) in Chennai requires cross-agency collaboration and is facilitated by the Chennai Unified Metropolitan Transport Authority (CUMTA). MMI in Chennai is also a cross-cutting topic that often falls between the mandates of different agencies responsible for public transportation. For instance, providing sidewalks in the vicinity of metro stations requires collaboration between GCC and the Chennai Metro Rail Limited (CMRL). This is where the value of the Chennai Unified Metropolitan Transport Authority (CUMTA) as a nodal agency comes into play. CUMTA, established in 2010 and strengthened in 2020, serves as an institutional anchor with legislative support for facilitating initiatives that require coordination among multiple agencies. To advance MMI's initiatives, CUMTA has formed a dedicated MMI sub-committee involving various agencies. Further details on CUMTA's establishment and functions can be found in Technical Note 8 on 'Strengthening Metropolitan Transport Governance.'

Engaging informal paratransit operators through a dedicated agency like CUMTA is crucial for strengthening MMI. A dedicated agency like CUMTA can also fill the gaps in stakeholder engagement for strengthening MMI. Engaging informal paratransit operators to transition them into organized public transport is one example of this. Such engagement is currently lacking given the mandate of existing agencies to either regulate or deliver services, but not to organize private operators. Globally, transport authorities such as Transmilenio in Bogota, Colombia and the Executive Council of Urban Transport in Dakar (CETUD) in Senegal have successfully engaged informal paratransit operators to transition them into formal public transport systems.

Physical infrastructure integration for access and interchange facilities

A large city like Chennai requires a comprehensive approach for enhancing physical infrastructure integration for access and interchange facilities. As part of the construction of phase 2 of the Chennai metro, the Chennai Metro Rail Limited (CMRL) is improving connectivity across modes in the immediate vicinity of metro stations. CUMTA also plans to improve physical integration through a multi-pronged strategy that includes developing a city-wide physical MMI strategy and piloting physical MMI interventions at specific interchange stations. The envisioned MMI strategy involves classifying interchange nodes into key typologies, identifying essential elements for each station type, developing conceptual designs, and preparing implementation and monitoring plans that enhance universal accessibility by improving pedestrian experience in directly accessing mass transit as well as interchanging across modes. Figure 3.3 shows a detailed design of one such project being developed - the Kilambakkam Skywalk. The project aims to provide seamless connectivity between the bus terminal and the proposed rail halt station through a skywalk, avoiding pedestrian vehicular conflicts and enhancing passenger safety. Singapore's Yishun Integrated Transport Hub exemplifies effective design of interchange facilities to enhance travel convenience (Box 3.1).

Operations' integration across various modes

Chennai's public transport network faces challenges due to limited coordination among various transit systems. Chennai has a bus route network length of approximately 1,730 km which is covered through 610 MTC designated routes apart from the 54 km of operational metro and 108 km of suburban rail and MRTS networks. All these systems operate as an independent public transport services with limited coordination in network design. At the same time, the volume and patterns of travel demand have been evolving rapidly due to the growth in population, the emergence of new demand centers, and the reshaping of residential and job locations due to the evolution of the metro system.

Bus network redesign

Bus network redesigns play a crucial role in adapting to evolving travel patterns and optimizing public transport services. Metro rail systems generally expand over several years and reshape the travel patterns in cities by attracting jobs and residences to locate closer to them. Bus networks, on the other hand, offer the flexibility to respond to emerging travel patterns. Bus route rationalization typically involves adding new services and realigning existing ones to meet the demand optimally. Several cities around the world have reoriented their networks in response to changing travel demand patterns, particularly after the COVID-19 pandemic (Box 3.2).

The bus route network and service schedules in Chennai have remained relatively static over the years and have not evolved adequately to meet the ever-changing travel demand patterns in the city led by the expanding metro rail system as well as the natural growth of the city. Financial constraints have long hindered MTC's ability to expand its services through fleet augmentation. However, GoTN has recently approved the MTC Business Plan and a PTSC securing financial support for its service expansion in lieu of improving performance efficiency.

BOX 3.1: SINGAPORE'S YISHUN INTEGRATED TRANSPORT HUB

In Singapore, the Yishun Integrated Transport Hub is a leading example of designing interchange facilities and making travel convenient for riders. Situated in a town center, the hub serves residential areas around Yishun and Khatib. It is an air-conditioned bus interchange in Singapore, integrated with a shopping center and residential condominium. Connected to the Yishun MRT (mass rapid transit) station via an underpass, it features amenities like sports centers and polyclinics. Thus, it not only acts as a facility for the transfer of modes but also generates more travel demand through transit by creating opportunities for engaging in activities near the station. The hub boasts the integration of public transportation from four different service providers with four alighting and eight boarding berths, prioritizing commuter convenience.

Sources:
1. Yishun Bus Interchange, Land Transport Guru (2019).

BOX 3.2: MOVES TO RE-ORIENT BUS NETWORKS IN RESPONSE TO CHANGING DEMAND PATTERNS

The common theme observed across the following examples is the endeavor to make the bus network simpler, more frequent, and demand-oriented, which are principles that can be applied in Chennai. While London has adopted a continuous approach for seeking passenger feedback for network redesign every year, several other initiatives such as Victoria's Bus Plan in Australia,[2] the Better Bus program of the Washington metropolitan area,[3] the Bus Connects program of Dublin, Ireland,[4] and new public transport network of Auckland, New Zealand[5] have undertaken one-off overhauls of the entire bus network. While these bus network redesign activities can potentially be difficult to implement given the public memory associated with existing networks leading to inertia to adapt to a newer network these cities have actively consulted the citizens for identifying an improved network that maximizes benefits for the population which outweigh the marginal disbenefit caused to some users.

Sources:
1 Transport for London (2023). TfL sets out further new proposals for more than 400,000km increase in buses services in outer London. TfL
2 Engage Victoria (2023). Victoria's Bus Network Reform | Engage Victoria, State Government of Victoria.
3 Better Bus Story (2023). Better Bus Story | WMATA, Washington Metropolitan Area Transport Authority.
4 Busconnects (2023). Dublin network redesign, National Transport Authority, Ireland.
5 Auckland Transport (2018). New Public transport network, Auckland Transport.

The proposed plan for expanding MTC's fleet provides an opportunity to evaluate the performance of the existing bus network in meeting the emerging travel needs of Chennai's residents and establishing processes to evolve the network to provide demand-oriented services.

In this context, CUMTA is initiating a bus route network redesign exercise that will undertake the following activities for proposing a revised bus network layout that serves passenger needs more efficiently:

i) **Developing a framework for evaluating MTC's current route network performance** considering

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FIGURE 3.3: CONCEPTUAL DESIGN OF INTERCHANGE FACILITIES AT KILAMBAKKAM

Source: CUMTA.

various quantitative and qualitative metrics that evaluate network coverage, accessibility to activities, transfers across the network, network redundancies, service hours, and customer satisfaction, along with other necessary indicators.

ii) **Preparing a network re-development concept and strategy** that will balance passenger needs for increasing accessibility, frequency, and reliability of buses with the constraints of the operator (MTC) in terms of fleet size, depot capacity, crew availability, and other financial considerations through the following approach:

a. **A preliminary demand assessment** of the share of the bus fleet expansion to be allocated for (a) increase in frequency, (b) additional routes in existing service areas, and (c) expanding the bus service coverage in CMA (new and underserved developments).

b. **An overall network design concept and strategy** that will propose a hierarchy of bus routes (trunk routes/core network, complementary routes, service routes, feeder routes) according to their market fit. Cities like Seoul and Curitiba have taken up extensive bus network redesign work and combined it with color coding buses to indicate if it is a trunk, feeder, or neighborhood service, thereby helping users identify buses more easily. This approach will also serve as a guide and principle for the network design and stakeholder engagement in the future.

iii) **Proposing a stakeholder engagement approach** for effectively communicating and seeking feedback on the strategies and incorporating valid feedback from user groups, crew operating buses, and others.

iv) **Reviewing the depot infrastructure's capacity and location requirements** for meeting MTC's redesigned and expanded bus fleet size and identifying sites/routes across CMA.

v) **Evolving a business intelligence framework** for assessing the performance of the bus network periodically for identifying underperforming routes and reallocating them to other routes. This framework will inform the use of available data sources like the static and real-time general transit feed specifications (GTFS) feed, ticketing data, as well as other data sources on crew productivity and safety for monitoring the performance efficiency of the bus system.

vi) **Proposing a route-network evolution plan** covering the fleet deployment approach over the coming decade, including the buses and routes to be allocated in each hierarchy of the bus system, their peak and off-peak services, and incorporating flexibility needed for charging electric buses (bus).

The approach being adopted by Chennai provides an operations' integration framework through bus network redesign that will strengthen the core services provided by MTC as a main-haul public transport system as well as introduce feeder services to rail-based mass-transit systems within one comprehensive network strategy.

Paratransit planning and regulation

Paratransit services in Chennai fill the gaps left by formal public transport systems and are particularly popular for short-distance travel. Paratransit or IPT services are privately-operated commercial transportation services that use various vehicles such as cycle-rickshaws, taxis, auto-rickshaws (both three-seater and six-seater three-wheeler (3Wh) variants), Tata Magics, tempos, vans, mini-buses, etc. In Chennai, shared auto-rickshaw-based paratransit services offer high-frequency shuttle services along high-demand corridors that are unserved or underserved by formal public transport systems. These services are more expensive than MTC buses but cheaper than point-to-point services such as app-based on-demand three-wheelers and taxis and the traditional three-wheeler services hailed on the street. They are, therefore, a popular mode of transportation for short distances in Chennai, especially among women.

Paratransit services in Chennai, while meeting essential transportation needs, present significant governance challenges. While these paratransit services fulfil the demand for responsive transportation and deter increased reliance on personal two-wheelers and cars, they also pose significant governance challenges. These challenges include competition with city bus services, unauthorized parking, absence of service obligations, unregulated tariff practices, and potential safety and security risks for passengers, particularly women and individuals from marginalized genders. The government issues only contract carriage permits to these vehicles to provide point to point services, but they operate as stage carriage or public transport like shared services making their operations illegal. They continue operating illegally due to a soft regulatory regime that allows them to operate given their vital need to meet travel demands in the absence of adequate public transport services.

The absence of baseline data on paratransit services complicates efforts to regulate and integrate them into the urban mobility ecosystem. There's a lack of any baseline data on their operational characteristics like corridors of operation, typical service frequency, travel demand patterns, and financial performance. While all commercial vehicle permits require the vehicle to share live Global Positioning System (GPS) feed with the government for monitoring customer safety, lack of data standardization and analytical capabilities have led to a limited understanding of their service characteristics. As a result, it is difficult to ascertain their specific role in the mobility ecosystem in the city, which makes it even more challenging for developing comprehensive regulations to formalize their operations.

CUMTA plans to adopt the following approach to plan for paratransit services to meet Chennai's mobility needs effectively while also addressing the regulatory challenges of managing paratransit services and improving the regulatory ecosystem for their operations:

i) **Paratransit service network mapping** across CMA. This mapping exercise will identify key routes, service characteristics (such as frequency, service span and capacity, peak and off-peak hours), important terminals and nodes for multimodal connectivity, and permitted/non-permitted halting/waiting points to allow CUMTA to assess the level of complementarity of these services with other public transport modes.

ii) **Paratransit operators' surveys** to gather information on their operational and financial performance including ownership patterns, financing sources, vehicle types (including fuel) and capacities, daily-km of operations, and type of operation, that is, shared, point to point, or mixed, operating costs, and revenue trends.

iii) **Plan for re-organizing the existing paratransit services** to make them more commuter centric, integrated, and efficient with improved conditions for operators, with specific emphasis on women commuters and persons with disabilities.

iv) **Projections of the number of paratransit vehicles in the future** across CMA, over a 10- to 15-year horizon based on travel demand estimation and the expected evolution of public transit networks in Chennai with the addition of bus fleets and the expansion of Chennai metro.

v) **Improvement in women's participation in the paratransit sector** through skilling as well as policy, regulatory, infrastructure, and financing reforms necessary for reducing barriers to women's participation in the IPT sector.

The World Bank has supported the base work necessary for building such an open data platform for Chennai by creating a baseline GTFS for MTC, CMRL, and MRTS schedules.

vi) **Proposal for alternative regulatory arrangements** for paratransit governance such as area-licensing method, service obligations, and compensation mechanisms in areas with limited demand and public transport levels based on national and international best practices for paratransit governance.

vii) **Consensus building with various stakeholder groups** such as the Transport Commissionerate and GoTN's Transport Department as well as with the paratransit operators' unions for evolving a mutually agreeable solution for formalizing paratransit services and enhancing their service quality for users.

CUMTA will act as the necessary institutional anchor for implementing the plans and strategies recommended above for delivering integrated, efficient, commuter-centric, and inclusive paratransit services.

Integrating informal transit services into formal public transport systems has proven successful in various global cities, offering valuable lessons for Chennai. These efforts (Box 3.3) have provided valuable takeaways for cities like Chennai, which have similar informal transit services.

Technological integration for journey planning, ticketing, and MaaS

Integrating public transport information and ticketing on a single platform can enhance multimodality and ease of use in Chennai. Public transport users in Chennai currently use separate static systems for information and ticketing in the bus, metro, and suburban rail services. Except for the metro which allows smart cards for payment, most of the ticketing is cash based. Providing real-time public transport information and digital ticketing across all modes on a single platform will improve the ease of use and multimodality in the system significantly. By allowing on-demand transport services like Ola and Uber on the same platform, a MaaS offering can be provided to the users which allows them to make door to door journeys. Such MaaS systems, with a strong public transport system at its core, have demonstrated attracting mode shift towards public transport.[22] Chennai has initiated a series of steps towards technological integration across modes for achieving these objectives.

Real-time journey planning information

Open access to integrated journey planning can enhance user convenience by making transport information widely available. Enabling open access to integrated journey planning will allow the information to be available on multiple channels, thereby providing the best opportunity for it to be available to the users. This requires each public transport agency to develop its service schedule information in standardized and globally accepted data standards such as the general transit feed specification (GTFS) format and share it on an open data platform. The World Bank has supported the base work necessary for building such an open data platform for Chennai by creating a baseline GTFS for MTC, CMRL, and MRTS schedules. These GTFS files need to be updated to reflect the static schedules being operated currently and a real-time GTFS to reflect instantaneous position of vehicles needs to be developed afresh.

Real-time updates for bus schedules necessitate a robust Automatic Vehicle Location System (AVLS) to

BOX 3.3: INTEGRATING INFORMAL TRANSIT SERVICES: INTERNATIONAL EXAMPLES

The metropolitan area of Jakarta is home to 32 million people. However, the city has been successful in integrating informal microbus services, known as angkots, into its formal public transport system called Transjakarta as part of a comprehensive reform and the same is also being undertaken in Manila, Philippines under the Public Utility Vehicle Modernization Program (PUVMP).[2]

Sources:
1 ITDP (2021). Lessons Learned from Jakarta's Journey to Integrated and Resilient Transport Systems, Institute for Transportation & Development Policy (ITDP).
2 LTFRB (2024) Public Utility Vehicle Modernization Program (PUVMP) Land Transport Franchising and Regulatory Board (LTFRB), Department of Transportation, Government of Manila.

ensure accurate journey planning information. While the metro and suburban rail services follow relatively similar schedules and offer predictable services, bus services have more dynamically updated schedules as well as real-time disruptions to schedules based on varying traffic conditions. Therefore, a robust Automatic Vehicle Location System (AVLS) is needed for updating GTFS in real time and providing accurate information to users. MTC, with financial assistance from the Japan Infrastructure Cooperation Agency (JICA), is in the process of deploying an AVLS system that can provide real-time journey planning information in its own mobile applications as well as through open data platforms.

CUMTA's Digital Chennai initiative aims to enhance user experience by integrating static and real-time GTFS data on an open data platform. CUMTA is planning to include an open data platform in its planned Digital Chennai initiative wherein static and real-time GTFS data across public transport modes will be made available to various journey planning service providers such as Google maps and Moovit. The open data platform will provide a change in user experience given that passenger information across modes will now be available on a single platform instead of separate bus and metro journey planners being used currently.

Integrated digital ticketing through smart cards and mobile tickets

Digitalization of ticketing enhances operator efficiency and user convenience through integrated systems. Digitalization of ticketing reduces the cost of ticket issuance, revenue reconciliation, and payment settlement for the operators while improving user convenience through integrated ticketing, improved fare products, and interoperability of fare.[23] Integrated digital ticketing across public transport modes is typically provided either through smart cards or mobile ticketing solutions. The technical, financial, and commercial dimensions of integrated digital ticketing systems as well as the alternative technology pathways available and the approach for developing them are covered extensively in literature (NCMC, open loop cards, mobile ticketing, etc.).[24] This section focuses on the ongoing initiatives for establishing these systems in Chennai.

i) **Smart card based integrated ticketing**: CMRL was the first agency to issue smart cards in Chennai in the form of closed loop cards which work only inside its system. It later migrated to an open loop system with its banking partner State Bank of India, complying with the National Common Mobility Card (NCMC) guidelines issued by the Government of India. However, these cards weren't accepted in the bus and suburban rail systems until recently as they do not have the back end financial architecture to accept open loop card-based payments. MTC has now entered a Memorandum of Understanding with State Bank of India to provide electronic ticketing machines (ETMs) and the back-end software and revenue reconciliation support to accept open loop card-based payments. The program was rolled out across MTC in 2024. Even though the infrastructure creation within the suburban rail system may take longer, accepting the same card for payments across bus and metro routes will improve user convenience significantly. Building on this, Chennai can potentially work on Account Based Ticketing (ABT), which allows authorities to automatically cap payments on a daily/ weekly/ monthly basis after reaching a pre-determined threshold and allowing users to not worry about purchasing the right fare products like daily-pass and monthly pass. London's Oyster card and Hong Kong's Octopus card are pioneering examples of integrated mobility, linking various public transportation services with a single smart card. This integration simplifies fare payment and enhances the convenience of using multiple modes of transport, making it a model for other cities to follow.

ii) **Mobile (smart phone) based integrated ticketing** requires generating a quick response (QR) code in a mobile application which can be validated by the public transport system. Even here, CMRL has implemented its own mobile ticketing system while MTC is piloting its own systems separately. CUMTA has initiated the procurement[25] of a system integrator who will develop a mobile application that will provide integrated journey planning and mobile ticketing across bus, metro, and suburban rail systems. The system is being developed with an open architecture to allow third parties to also issue public transport tickets thereby improving access to mobile ticketing for users.

Mobility as a Service (MaaS) platform for Chennai

MaaS consolidates various transport services into a single digital platform, simplifying multimodal

travel for users. MaaS is the integration of, and access to, different transport services (such as public transport, ride-sharing, car-sharing, bike-sharing, scooter-sharing, taxi, car rental, ride-hailing and so on) in one single digital mobility offer.[26] This transfers the burden of integrating multimodal travel from the traveler to the MaaS provider, thus minimizing inefficiencies and additional costs for users having to navigate a myriad of fragmented transport services. In other words, this can be viewed as an integrated public transport ticketing system explained above with the addition of on-demand commercial transport services like paratransit and taxis. While MaaS platforms have been piloted across the European Union over the last 5-7 years, no Indian city has yet implemented a MaaS solution. To achieve this, the public sector must create the right enabling environment for information exchange and a level playing field for all modes and operators. A MaaS governance model must be outcomes- and goals-oriented so that policies such as pricing and space allocation can apply across modes but incentivize the most efficient and sustainable options. This will require the public sector to act as a facilitator and will rely on the development of analytical capacity, flexibility to try new models, and willingness to reform the regulatory environment.

CUMTA's digital ticketing platform aims to evolve into a comprehensive MaaS solution, reducing reliance on personal vehicles. The ongoing digital ticketing platform procurement by CUMTA envisions building the integrated public transport ticketing platform into a comprehensive MaaS solution for Chennai offering users as many alternatives as possible to personal vehicle usage. Integrated journey planning, public transport ticketing, and MaaS platforms for Chennai are at a development stage and may take until early 2025 to stabilize. However, the systematic approach to developing these systems is applicable even to other cities trying to foster such technological integration for reducing personal vehicle usage (Boxes 3.4 and 3.5).

EXPECTED IMPACT

In Chennai, initiatives for MMI such as the bus network redesign, aim to realign transportation networks with changing demographics and travel patterns. By rationalizing bus stop spacing, optimizing routes, and enhancing reliability, these initiatives seek to provide faster, more efficient, and reliable bus services, ultimately encouraging greater public transit usage and addressing challenges faced by residents and employees. Chennai is taking steps to integrate paratransit services into its transport system.

Ample evidence exists globally to establish the positive impacts likely to be generated by these initiatives. This has also facilitated improved coordination and trust between stakeholders, leading to collaborative efforts for creating sustainable business models and participating in transport bidding processes. Initiatives for promoting MaaS are expected to lead to a seamless integration of various transport modes, reducing traffic congestion, lowering emissions, enhancing accessibility and equity, stimulating economic growth, and optimizing transport resources.

TAKEAWAYS FOR OTHER CITIES

Cities can learn valuable insights from initiatives like those taken by GoTN in Chennai and other cities for enhancing multimodal transportation:

- **Establishing cross-institutional authorities:** Creating centralized bodies like the Chennai Unified Metropolitan Transport Authority (CUMTA) streamlines decision-making and coordination among various transportation agencies, as also seen in cities like London and Barcelona.
- **Prioritizing user-centric journeys:** Simplifying travel experiences through single-ticketing systems and integrated physical infrastructure, inspired by London's Oyster card and Singapore's walkway networks, encourages modal shifts away from private vehicles.
- **Fostering data sharing:** Sharing data among governments and private entities, as seen in Chennai's plans to adopt standardized data formats like GTFS, enables informed decision-making and improves operational efficiency, drawing takeaways from London's unified APIs and Finland's comprehensive data integration.
- **Leveraging informal paratransit:** Integrating informal paratransit services into formal transportation networks, as demonstrated in Jakarta, enhances accessibility and last-mile connectivity, emphasizing strategic planning, stakeholder engagement, and infrastructure upgrades.

BOX 3.4: FINLAND'S MAAS IMPLEMENTATION

Finland's pioneering MaaS implementation offers valuable insights for reducing traffic congestion and carbon emissions. Outside India, Finland has been a pioneer in implementing MaaS. The Finnish government enacted the Future Mobility Finland initiative which has helped tackle issues like traffic congestion and carbon emissions, which are also prevalent in many developing countries. Finland's MaaS' success is due to strong government support, strategic partnerships with transport operators and technology firms, and a commitment to digital connectivity and transparency. By offering a convenient and sustainable alternative to private vehicle use, Finland's MaaS model provides valuable insights for other countries.

Sources:
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BOX 3.5: LONDON'S MAAS IMPLEMENTATION

London's MaaS implementation leverages unified APIs, open data policies, and established infrastructure to enhance multimodal transport. In London, the implementation of MaaS has been marked by the use of Transport for London (TfL), the city's transport authority, which has played a crucial role with its strong open data policies, particularly for scheduled transport data such as routes and schedules. While there is an identified need for further openness, particularly regarding booking APIs, London's infrastructure supports MaaS with established smart ticketing services and a higher modal split, reflecting greater citizen familiarity and willingness to use diverse modes of transport. Overall, London's MaaS implementation benefits from a combination of strategic data sharing, policy support, and infrastructure readiness.

Sources:
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CONCLUSION

This note established the various dimensions of MMI based on international experience and the initial steps and plans in Chennai along these dimensions. While the MMI's dimensions are common across cities, exact solutions may vary across cities based on their local contexts. Establishing these systems requires a systematic effort involving detailed technical analyses and interagency coordination for achieving a city's long-term sustainable mobility goals. Chennai's approach of CUMTA as the lead agency coordinating across government agencies for advancing MMI provides a replicable template for other cities to adopt. The actual implementation and realization of the benefits of MMI in the form of increased public transport share is a work in progress and will require follow through on implementation of the initiatives described in the note.

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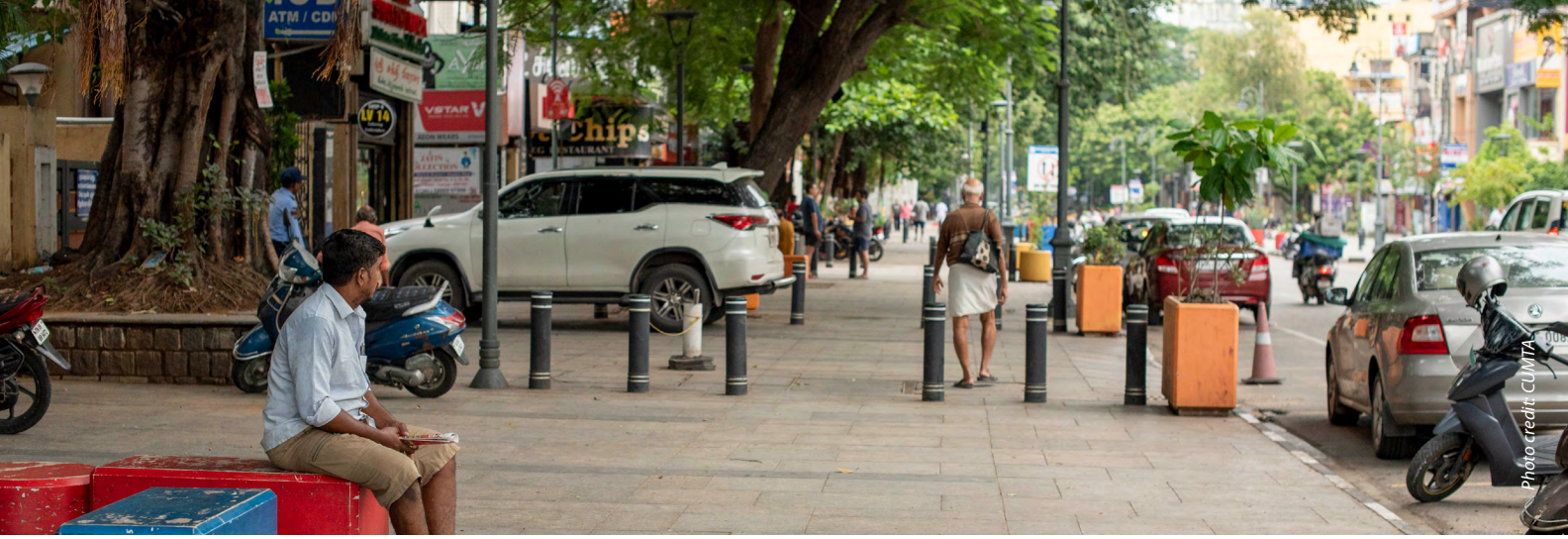


4: DESIGNING SUSTAINABLE COMPLETE STREETS IN INDIAN CITIES

Jaishree Jindel[1], Dr GS Sameeran,[2] BV Babu,[3] Shyam Srinivasan, Gerald Ollivier, and Kasinath Anbu[4]

INTRODUCTION

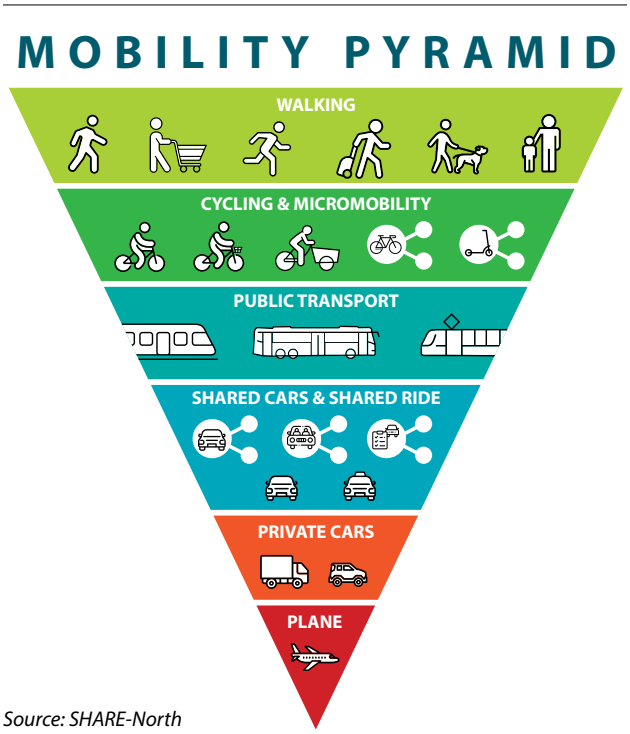
Internationally, city and street designs are evolving to adapt to urbanization and the changing ecological balance. Dense urban structures and sustainable transport options play a key role in future urban development. Thus, cities around the world are embracing the concept of Complete Streets for improving mobility, safety, and urban environment, enhancing livability and mitigating climate change. This is in line with the famous inverted 'mobility pyramid' for prioritizing sustainable mobility, which gives priority to the pedestrians, then to bicycles, followed by public transport, shared transport and finally to private vehicles (Figure 4.1). This note documents the application of the Complete Streets approach by GCC on selected streets in Chennai. Chennai's experience offers several takeaways which may be useful for other cities in developing countries, looking at transforming their streets and enhancing urban environments.

BACKGROUND

With rapid urbanization, cities and street designs need to adapt to become safe, inclusive, livable, and climate resilient. Cities have grown to accommodate changed demographics, lifestyles, and land uses as a response to managing increasing sprawls which, combined with inadequacies in public transport, walking, and cycling facilities have driven motorization. These trends have led to concerns about road safety, social inclusion, and sustainability. For instance, wide roads originally designed to service longer distance trips and passing through low density developments have become part of the city and are used by diverse road users and pedestrians, increasing road safety concerns; 50 percent of all road safety fatalities are pedestrians, cyclists, or motorcyclists, and 93 percent occur in low- and middle-income countries. Women are particularly vulnerable as they walk more, form 60 percent of pedestrian casualties, and use more public transport.[5] As cities continue evolving, ensuring safe mobility and managing interactions amongst the hierarchy of roads and streets, adjacent land uses and contexts is essential.

Complete Streets are designed to enable seamless, safe, and convenient commute and access for all regardless of age, gender, and abilities. The concept aims to achieve inclusive, compact cities through the rejuvenation of streets and neighborhoods, linking the infrastructure design with the function of the streets, surrounding land use and densities, and enhancing safety and climate resilience. The design principles extend to both above ground and underground infrastructure. Above-ground, the focus is on promoting non-motorized modes through equitable distribution of space, speed management, improving access to public transit modes, multimodal integration, and enhancing road safety. Underground, the focus is on ensuring increased availability of streets and shifting utilities underground in a planned and integrated manner for

FIGURE 4.1: MOBILITY PYRAMID

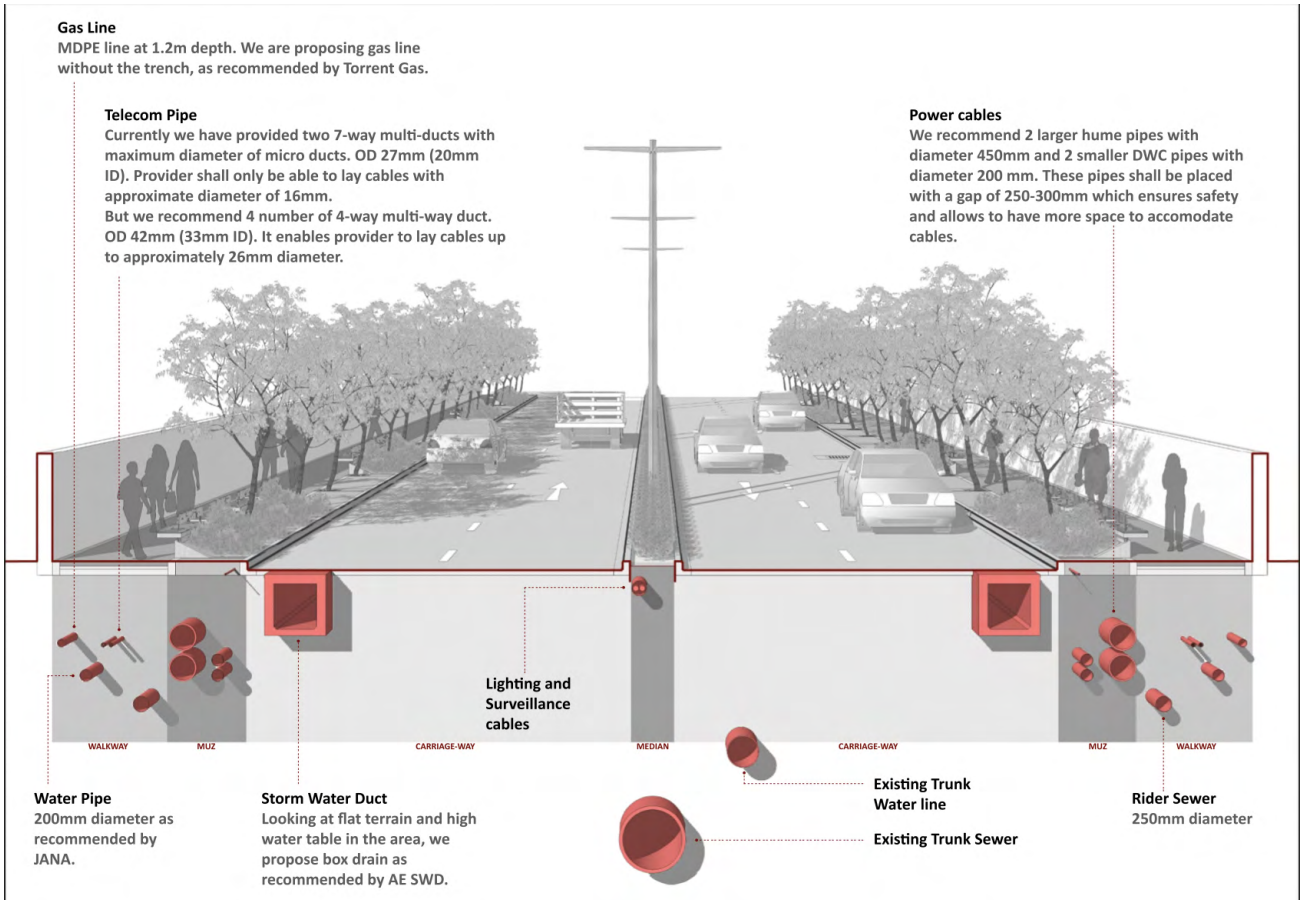


Source: SHARE-North

seamless movement and enhanced livability in the neighborhood. A typical Complete Streets cross section is depicted in Figure 4.2.

Global evidence suggests that Complete Streets approaches yield a range of direct and indirect benefits. Complete Streets help promote an equitable distribution of public space, encourage modal shifts to public and non-motorized transport, and reduce use of personal motorized vehicles. Complete Streets support calming the neighborhood traffic by promoting compact development and shifting short trips to active mobility modes. They also enhance street vitality and safety perceptions by increasing the number of eyes on the streets, improve air quality, and economic activity. Most importantly, research[6] shows that Complete Street designs result in fewer crashes, injuries, and deaths of pedestrians and cyclists especially women. Complete Streets often incorporate nature-based solutions such as bio swales and permeable pavements for reducing urban heat islands, absorbing rainwater, mitigating climate change impacts, and promoting health and equity. The

FIGURE 4.2: TYPICAL COMPLETE STREETS CROSS SECTION



Source: DPRs for Mega Street, GCC.

BOX 4.1: INTERNATIONAL EXPERIENCE WITH COMPLETE STREETS POLICIES AND GUIDELINES

To further the Complete Streets approaches, cities and several international agencies like Austin City Hall, National Association of City Transportation Officials (NACTO), have formulated policies and design guidelines. Austin City's Streets Policy states: 'A Complete Streets approach provides a unique opportunity to thoughtfully integrate and advance multiple objectives for our community, now and in the future, while delivering maximum benefits from both public and private investments.' NACTO's design guidelines have recommendations on street elements like lane width, pavement, curbs, speed management elements, bus priority elements, street furniture, nature-based stormwater management elements for application and categorizes them as per street hierarchy, usage, and development challenge. Chicago and Washington cities have taken the guidelines further by incorporating performance measures like evaluation and benchmarking tools. For instance, Washington city tracks revitalization on under-invested corridors based on five main goals: economic health, safe and multimodal transportation, community building, historical assets, and sustainable design. Chicago's Complete Streets Manual (2013) moves away from a vehicle throughput focused level of service (LOS) paradigm and recommends using no minimum vehicle LOS and instead prioritizes pedestrian LOS, emphasizing on no pedestrian delays of more than 60 seconds.

Sources:
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3. *Chicago Complete Streets Design Guidelines, Department of Transportation (2013).*

net effect is a better urban environment and enhanced health and quality of life. For instance, living on a street with 10 more trees can increase health perceptions to the same degree as USD 10,000 more in annual income or as being 7 years younger.[7]

Complete Streets approaches are often supported by policies and street design guidelines. Box 4.1 presents selected international examples of such guidelines.

Cities across the world such as Amsterdam, Tokyo, Tianjin, and Lancaster, California have seen benefits from Complete Streets implementation. Research suggests that designing a street for walking and cycling (wide footpaths, pedestrian refuge, traffic-calming measures, and treatment for people with disabilities) can reduce pedestrian risks by as much as 28 percent.[8] For example, in Long Beach, California, the focus was on providing mobility through all modes of transportation and encouraging multimodal travel. One year after construction, bicycle volumes increased 33 percent and pedestrian activity also increased by about 13 percent.[9] Details from these cities are:

- **Amsterdam, Netherlands**. Growing economy and increased vehicular traffic in the 1970s led to ~3,300 road crash casualties including 400 children in 1971 and led to intense public protests. By the mid-1980s, interventions for promoting people-friendly streets such as car free Sundays, segregated lanes for motorized traffic, pedestrians and bicycles, and reclaiming motorways for walking and cycling were implemented. Amsterdam and many other cities in Netherlands are now known for the quality of their streets and neighborhoods for walking and cycling, façade gardens, and nature-based solutions integrated in street design for improved climate resilience (Figure 4.3), Amsterdam recently reduced the traffic speeds to 30 kmph for 80 percent of the city roads and experts anticipate 20 to 30 percent decrease in severe accidents along with noise pollution due to traffic being reduced by 50 percent.[10]
- **Tokyo, Japan.** Japanese cities like Tokyo adopted an alternative approach of separating cars and people

FIGURE 4.3: A STREET IN AMSTERDAM

Source: https://shorturl.at/CeF88

FIGURE 4.4: A STREET IN TOKYO, JAPAN

Source - https://shorturl.at/KtBxR

on wide streets into lanes and developed narrow streets as shared streets with less than 30 km per hour speeds for vehicles.[11] These narrow neighborhood streets were developed on a human scale with little or no parking spaces such that car users found it uncomfortable and inefficient to drive through them and the streets were therefore friendly for pedestrians and cyclists. The no-parking policy indirectly improves street safety by nudging people away from purchasing cars that might otherwise be involved in crashes, and by increasing visibility on streets. Along with this, integrating walking and cycling with metro and high-speed rail networks has also helped Japan drastically reduce road accidents since the 1960s[12] (Figure 4.4).

- **Tianjin, People's Republic of China.** Tianjin, the 2024 Sustainable Transport Award winner, stands out as a transformative initiative focused on implementing Complete Streets at scale in a megacity, contrasting with the common trend of limited progress in urban walking and biking infrastructure. Once a leading biking city, Tianjin's shift towards car prioritization led to a decline in walking and biking conditions. The Urban Transport Improvement Project, with a total cost of US$145 million, including a US$100 million World Bank loan, marks the largest investment in improving streets for non-motorized transport in the World Bank's history. Tianjin expanded a program of Complete Streets across six urban core districts, enhancing 132 km of roads and improving accessibility around 96 metro stations. This led to 175,000 and 261,000 additional daily trips by metro and walking and cycling respectively (2022), and an overall 34 percent bike mode share (2020). Economic vitality increased by 18 percent in the improved streets as compared to 3 percent in non-improved streets.

FIGURE 4.5: A STREET IN CA, USA

Source: https://shorturl.at/Lbwf1

- **Lancaster, California United States.** In 2010 the city invested US$ 11.5 million to revamp its car-oriented Lancaster Boulevard design in central downtown to a lively, pedestrian-friendly road (Figure 4.5). According to estimates by the California Redevelopment Association, within four years the street attracted US$ 130 million in private investments and generated US$ 273 million in economic output. During 2007-2012, collisions reduced by 33 percent and injuries by 67 percent, tax revenues from the street doubled with the opening of 48 new businesses and creation of 802 permanent jobs plus 1,100 construction jobs.[13]

APPROACH IN CHENNAI

Relevance in the Indian context especially in Chennai

With increasing urbanization, the burden of motorized vehicles on roads and associated concerns of road safety and emissions are becoming challenging for Indian cities. Cities need to plan for efficient and safe mobility for newer areas being developed and the older areas undergoing alteration and gentrification. Complete Streets approaches with the range of benefits described above are therefore highly relevant in the Indian context. The subsequent sections of this note discuss the approach taken by Chennai, and on how Complete Streets approaches are being adopted to change the status quo.

Chennai is working on reducing road safety concerns and Complete Streets approaches can be helpful. The major road network in Chennai city is 2,780 km[14] long with a ring-radial pattern including four major national

highways (originating in the core city). These witnessed 7,580 crashes (2018) which reduced to 3,452 (2022). Between 2012 and 2022, Chennai had an average of 1,150 road crash fatalities annually, second only to Delhi.[15] Many roads (for example, the Grand Southern Trunk Road and the Inner Ring Road) which were once peripheral to the city have now become part of the core city and function more like urban arterial roads. These were constructed based on highway design codes, and now need to evolve with their new functions. Pedestrians are increasingly having to access economic and social opportunities along or across these roads, and high traffic volumes and speeds with limited pedestrian friendly infrastructure (such as footpaths, at grade crossings), have resulted in acute road safety issues; 65 percent of these roads pose a high crash risk for pedestrians.[16] Pedestrians also make up a higher share of fatalities (34 percent) along these roads compared to the average across CMA (33 percent). (Refer to Technical Note 5 on 'Road Safety' for more details).

Local roads in Chennai city (for example, Monegar Choultry road and Mint Street) are centers of cultural and commercial activity and are commonly used by pedestrians and cyclists. However, these roads have limited NMT infrastructure (footpaths, cycle lanes, and pedestrian refuge), resulting in users (particularly with more than 5 km long trip length) shifting to vehicular modes. While road crash fatalities are lower relative to the major arterial roads,[17] non-fatal road crashes are common and mostly involve two-wheelers and pedestrians (45 percent of these roads pose high crash risks for pedestrians).[18]

Public transport coverage, availability, and reliability is limited. The daily ridership of Metropolitan Transport Corporation (MTC) bus services reduced from 4.8 million per day in 2015-2016 to 3.2 million per day by 2019-2020. A World Bank study estimated that in the Chennai Metropolitan Area, residents can, on average, access only 30 percent of the jobs in 60 minutes by public transport. This was attributed to uncoordinated growth of the public transit network with city sprawls, inconvenient first and last mile connectivity, and lack of multimodal integration. (Refer to Technical Note 2 on 'Augmenting Bus Service Delivery' and Technical Note 3 on 'Multimodal Integration' for more details).

Chennai is prone to flooding and deploying nature-based solutions promoted in Complete Streets guidelines can help. In the last 50 years, Chennai has faced at least one flood every 10 years, and according to historic data this interval seems to be narrowing. Since 2000, the city experienced major floods in 2005, 2015, and 2023. Increased paved road surface, reduced soak zones clubbed with frequent extreme weather events have aggravated the problem. Integrated utility and infrastructure designing of the streets with concepts of material circularity, blue-green infrastructure, soak zones or nature-based solutions have major potential. Chennai's urban environment and livability also face high concerns due to approximately 3,000 metric tons of debris per day from construction activities being illegally dumped in public spaces. Promoting material circularity, life cycle cost assessments, and sustainable, green procurement as part of Complete Streets, will help lower the carbon footprint and further the city's re-use/milling policies. Bengaluru has incorporated material re-use guidelines in the building byelaws and design guidelines. Many cities such as Paris, Singapore, Rotterdam, and New Orleans have transformed existing open/vacant spaces such as city parks, playgrounds and post-industrial zones into water-prudent landscapes using green interventions (Box 4.2).[19]

Complex institutional arrangements are in place for streets and associated works in Chennai. GCC is responsible for major arterial roads barring highways (state and national), collector roads, and neighborhood streets totaling over 370 km along with stormwater systems, streetlights, city parks, and waste management within municipal limits (426 sq km and population of around 7.1 million). The Highways and Minor Ports Department, a state level agency is responsible for the design, implementation, and management of highways even if they are within city limits. CUMTA is the nodal agency for planning and delivery of integrated seamless transport in Chennai. It was established in November 2010, by the Government of Tamil Nadu through a Statutory Act and its jurisdiction extends to the whole CMA covering Chennai, Kancheepuram, Tiruvallur, Chengalpattu, and Ranipet. (Refer to Technical Note 8 on 'Strengthening Metropolitan Transport Governance' for more details). CMDA is the nodal planning agency for Chennai responsible for planning, coordinating, supervising, promoting, and securing the planned development of CMA. Two major utility agencies are the Chennai Metropolitan Water Supply and the Sewerage Board (CMWSSB) which is a statutory board of GoTN which provides water supply and sewage treatment in CMA and the Tamil Nadu Generation and

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BOX 4.2: INTEGRATED BLUE-GREEN-GREY SOLUTIONS UNDERTAKEN AS PART OF GREEN STREETS PROGRAMS

An 11-acre rooftop park in Bangkok's commercial district directs runoff into a retention system reducing pressure on underground drainage and sewer systems.

Benthenheim Water Square in Rotterdam, an example of integrated multi-use blue-green-grey solution, a conventional play and sports areas with permeable surface that doubles as an unconventional stormwater catch basin.

Green street section in Sheffield with permeable lane surfaces, planters, and rain gardens to enable stormwater management.

The Bishan-Ang Mo Kio Park, Singapore uses blue-green infrastructure for flood control, biodiversity management, microclimate control and adds a high-quality public space asset to the city for recreation and educational use.

Source - https://shorturl.at/7rKoA

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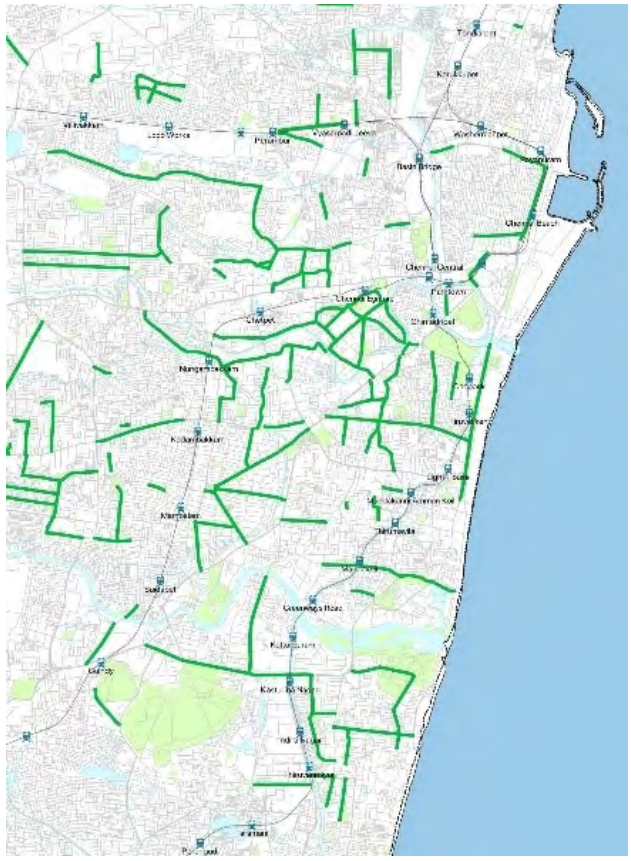
Distribution Corporation Limited[20] (TANGEDCO) which is the electrical power generation and distribution public sector undertaking for the state, including CMA.

Chennai's experience with Complete Streets

Recognizing the need for upgrading public spaces and the pedestrian environment, GCC[18] has undertaken a range of measures with Complete Streets principles embedded. In 2014, Chennai became the first city in India to adopt an NMT Policy which proposed for GCC to dedicate 60 percent of its transport budget for the development and maintenance of walking and cycling networks in the city. Between 2014 and 2018, GCC established a dedicated Special Projects Department for greater focus on the implementation of NMT projects. Around 80 technical staff were trained on Complete Streets by ITDP in collaboration with Anna University (a local university). Decision makers and engineers also visited Indian and international cities to learn from best practices first-hand. The city has adopted progressive street design guidelines with NMT as priority.[21] GCC transformed over 140 km of bus route roads into safe and accessible corridors benefiting at least half-a-million people daily (Figure 4.6). GCC designed NMT infrastructure for selected neighborhood clusters through the Chennai Street Design Project and created a vibrant pedestrian plaza at Pondy Bazaar in T-Nagar under the Smart Cities Mission. An impact assessment of the plaza in Pondy Bazaar showed that around 15 percent of the pedestrians accessing the space had shifted from other modes or had been generated by the street improvements, and the economic benefits due to increased property rents was 20 percent.[22] GCC also developed 17 km of cycle tracks in the city in June 2018 under the Smart Cities Mission.

The success and experience of the Pondy Bazaar project inspired GCC to scale up the initiative to multiple neighborhoods and take up a city-wide network level approach. To do this, GCC is working towards strengthening coordination with other line departments and utility agencies, holding consultations with the public, shopkeepers, vendors, and civil society, and building the capacities of its engineers and planners. The Institute for Transportation and Development Policy (ITDP) India has had a long-standing partnership with GCC and has supported the city in preparing the NMT policy[23] and Street Planning Manual,[24] implementing

FIGURE 4.6: MAP OF ROUTES WITH FOOTPATH UPGRADES, CHENNAI



Source: GCC.

Pondy Bazaar and other street improvement projects, and is playing a vital role in building the capacity of GCC engineers.

The Mega Streets program aligned with Complete Streets approaches, aims to rejuvenate streets and neighborhoods by linking above ground and underground infrastructure with the function, land use, and densities along selected road segments. The program aims to achieve transformation in five key areas:

i. ***Promoting walkability*** by doubling the length of uninterrupted footpaths with adequate width and increasing the number of at-grade (signalized) pedestrian crossings, especially close to mass transit nodes. Pedestrian facilities will be universally accessible with ramps and tactile paving. Measures such as lane diet at relevant places, traffic calming measures, and clear segregation of pedestrians and vehicle users, enhance road safety.

ii. ***Facilitating access to and usage of public transport*** modes through augmentation and integration of

pedestrian infrastructure near transit nodes, and clear signages for improving wayfinding. Re-alignment of bus stops, bus priority measures, and improvements in the first and last mile for streamlining access and public transport usage.

iii. ***Enhancing uninterrupted safe walking space and livability*** by shifting utilities underground, constructing public toilets and convenience facilities, and adding greens and street furniture for enhancing the vibrancy and attractiveness of these areas to the public.

iv. ***Improving climate resilience*** through enhanced focus on nature-based solutions along with engineering design. Constructing stormwater drains and allowing excess water to slow-soak-store with the help of bio swales, connecting road slope with open spaces (parks/forest/temple ponds) along the streets, and incorporating other nature-based solutions. Vancouver and Copenhagen offer examples of city-wide strategies to mitigate urban floods through nature-based stormwater management (Box 4.3).

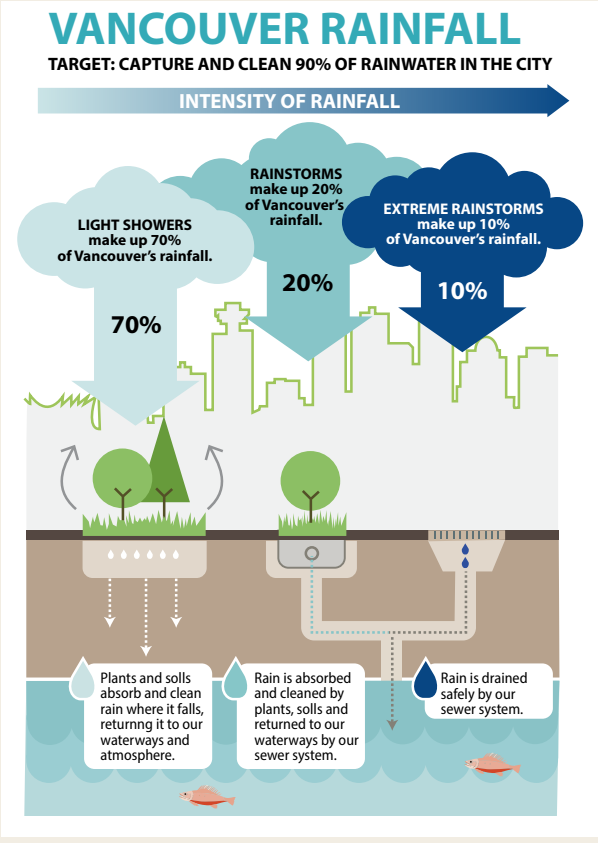
v. ***Promoting efficient lifecycle management of assets*** by using recycled material for construction and reducing construction waste, wherever appropriate. For ensuring the longevity and sustainability of interventions, the contractors' scope will include five years of maintenance with appropriate KPIs.

Cycling also has a potential role in Chennai in enhancing last mile connectivity. Internationally cycling is an important component of active mobility. There are cyclists even in cities with hot weather conditions, like Singapore given its potential to facilitate last mile connectivity and short distance trips. While the cycling mode share in Chennai is low at 1 to 2 percent, the move to include 11 km of cycling paths in the design of Mega Streets and neighborhood level planning for developing a network of walking and cycling lanes, are steps in the right direction. For facilitating cycling, the streetscape in Chennai could be enhanced with traffic calming measures at the neighborhood level, segregated cycling lanes leading to mass transit stations, and improving the quality, width, and continuity of footpaths for shared use by cyclists. For encouraging the use of bicycles, a strong network of cycling lanes will be important to explore as part of CMP under preparation. This can be explored in future phases.

BOX 4.3: CITY-WIDE STRATEGIES TO MITIGATE URBAN FLOODS THROUGH NATURE-BASED STORMWATER MANAGEMENT

Vancouver and Copenhagen offer examples of city-wide strategies to mitigate urban floods through nature-based stormwater management. Vancouver's hybrid rain city strategy focuses on adaptive management; stormwater infrastructure is flexible and adapts to varying rainfall conditions. Its 2019-2022 capital plan has identified an operating budget of US$70 million to implement green rain infrastructure, ensuring a phase-wise delivery of the initiative. Similarly, Copenhagen's cloud burst plan integrates urban planning, integrated blue-green-grey solutions, traffic, and hydraulic analysis with sound investment strategies to reduce flooding and improve urban livability. The plan conceived 300 projects of varying sizes and complexity, out of which the St. Kjeld's neighborhood was selected as the first climate adaptive community for pilot implementation of integrated blue-green-grey infrastructures.

Source: Living with water: integrating blue, green and grey infrastructure to manage urban floods, WRI India.



These five areas of transformation were converted into a detailed set of KPIs. The KPIs comprise of 15 heads and 45 parameters drawing from various guidelines such as the Complete Street Planning Manual of Chennai, Indian Roads Congress (IRC) guidelines, NACTO street guidelines, and nature-based solutions concepts into designs for arterial and non-arterial streets. These KPIs provide a clear basis for tracking inputs and outcomes for achieving Complete Streets objectives.

Mega Streets and network planning undertaken simultaneously. GCC is upgrading 12 km of local roads as a pilot, with support from the World Bank under the Sustainable Urban Services Program (SUSP) of the Chennai City Partnership (CCP) with an aim to scale up based on the learnings from this phase. The Mega Streets are spread across six neighborhoods - Adyar, Anna Nagar, Mylapore, Nungambakkam, Tondiarpet, and Velachery, covering diverse locations in terms of age of infrastructure and socioeconomic status. Neighborhoods and streets were selected based on a combination of qualitative and quantitative parameters like the existing state of infrastructure (land use, pedestrian volumes, accessibility of public transport, and accident hotspots), transformation potential, potential number of beneficiaries, ease of implementation, and stakeholder buy-in. Network level integration potential and impact assessment of a wider infrastructure were undertaken with the help of the integrated geographic information system (GIS) base maps. Sample streets were mapped to understand the scale of interventions like walkways, cycle networks, stormwater drainage, and utility sequencing at the network level with ITDP's support. Neighborhood level plans (with ~50 km of streets for upgrade) were prepared and one street within each neighborhood was selected for implementation at a time to minimize disruptions to residents and commuters. Design KPIs were set to implement and monitor the project (Table 4.1).

The KNK road in the Nungambakkam neighborhood is an illustrative example. The road has a meandering width even over a short section of 650m, with the narrowest section at just 10m, and the widest section at 30m, paved from property line to property line. Designing a consistent road section, with adequate space for sidewalks, bicycle/bus lanes, and parking (especially for two and three wheelers) while allowing for dense commercial activity along the road was difficult. High mixed vehicular traffic with pedestrian traffic, poor pedestrian crossings, and speed calming measures, combined with frequent property entrances, ramps or steps, and encroached footpaths, waterlogging in and around, prevented seamless connectivity for commuters. Unregulated on-street parking and overhead cables disrupted the streetscape, and poor lighting made it socially non-inclusive. As a result, even though the street is a major retail hub in a residential area, women and children did not use the street to the same degree as men.

The Complete Streets approach was systematically applied to KNK road. As shown in the illustrations in Figure 4.7, interventions were planned along each of the five key areas of transformation. Noteworthy design features include pedestrian priority street design, compact junctions with table-top street crossings, dedicated vending zones, augmented, and integrated underground utilities, and more greenery. Similar approaches are being applied to other roads besides KNK, as illustrated in Figure 4.8.

Spatial representation of various datasets was undertaken for the visual assessment of issues and design recommendations. An as-is mapping of roads was done based on primary and secondary data on road features, motorized and non-motorized traffic volumes, road crashes, public transit stops, paratransit services, trees, buildings with land-use and heights, and public conveniences. This was used for evaluation issues considering the location, function, and future uses of each street. This as-is assessment was studied in connection with the proposed design solutions keeping in mind the existing design, policy guidelines, and KPIs. Alternate design options were prepared for each street and junction, followed by an impact assessment. Consultations with GCC, utility departments (planning agencies), and the Greater Chennai Traffic Police (enforcement agency), were done for selecting a preferred design, followed by walking audits of the streets. The agreed designs were shared with stakeholder utility agencies for respective cost estimations and vetted through public consultations to include end-user needs and perspectives.

Throughout the process, extensive stakeholder consultations were undertaken for addressing stakeholder concerns. Perception surveys and focus group discussions (FGDs) with vulnerable community groups were prioritized even during the planning phase of the project. During the design phase, FGDs and one-to-one discussions were held with street vendors,

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FIGURE 4.7: ILLUSTRATION OF KNK ROAD

KNK road (Current)

KNK road (Proposed)

Source: GCC.

Resident Welfare Associations (RWAs), disability support NGOs, and commercial and residential property owners, including women, on design, social and environmental aspects. Stakeholder consultations with utility agencies and traffic police were undertaken to discuss and seek approval for interventions on provision of CCTV cameras, public conveniences, vending zones, parking, and traffic management.

Lack of existing data and updated maps for underground utilities limits the efficiency of Complete Streets. Mega Streets in brownfield locations entail shifting or relaying of existing operational utilities, which is a major challenge as it not only involves inconvenience during construction but also safety risks and requires provisions for service continuity and future planning. The challenge is compounded by little or no data on the 3-dimensional location, capacity, age, or conditions of underground utilities. Implementation of urban services projects (from metro rail to roads to water supply and sewerage projects), rely on effective coordination and inter-agency communication. This helps minimize unplanned and unbudgeted changes resulting in project delays and expensive cost over-runs. Therefore, under Mega Streets, GCC ensured that the contractors would collect the 3D as built coordinates of the utilities and enable integration of the data with their existing GIS platform.

Inter-agency coordination throughout the project lifecycle – planning, designing, construction, supervision, and maintenance – will be key. GCC put special emphasis on bringing together various stakeholders and line departments to effectively plan and implement comprehensive street re-development projects. Inter-agency coordination across multiple agencies and different hierarchies is always challenging and time consuming, yet it is a pre-requisite and is essential for connected development. Further, standardization of data collection and sharing of digital data/utility survey (of GCC and other agencies) is needed for integrated planning, delivery, and management of infrastructure. An attempt at digital integration through IT-based solutions for data sharing, planning, and sequencing infrastructure projects will be pursued under the Digital Chennai initiative to be led by CUMTA. (Refer to Technical Note 9 on 'Institutional Setup for Leveraging Data' for more details on Digital Chennai).

Sound contract management and cross learning. Through open competitive bidding GCC procured six qualified architectural and urban design firms for different neighborhoods. Each firm had diverse expertise: ranging from street design to compact cities with Transit Oriented Development (TOD), providing for active modes and public transit, road safety, use of nature-based solutions, material recycling, utility planning, gender inclusion, community engagement, and implementation experience in other Indian cities. While managing multiple different agencies and ensuring coordinated and coherent outputs across agencies was a challenging task, GCC turned it into an opportunity to: (a) bringing in design innovations and variety to mundane looking streets with complex problems, (b) promoting cross learning amongst agencies, and (c) developing a pool of qualified consultants.

FIGURE 4.8: TRANSFORMATION ENVISIONED ALONG OTHER MEGA STREETS UNDER SUSP

KNK road (Current)

KNK road (Proposed)

Anna Nagar (Current)

Anna Nagar (Proposed)

Pulla Avenue (Current)

Pulla Avenue (Proposed)

Eldams Road (Current)

Eldams Road (Proposed))

Source: GCC.

TABLE 4.1: DESIGN KPIS FOR MEGA STREETS UNDER SUSP

Attribute	Key Performance Indicator	Unit	Pre-design	Post- design
Walkability	Barrier free footpath - greater than or equal to 1.8m width (LHS and RHS)	Km	16.85	20.83
Cycling facilities	Segregated cycle lane (and cycle docking facilities)	Km	0	11.11
Inclusive design	Tactile pavers and warning tiles coverage, locational signages (LHS and RHS)	Km	0	31.4
Bus priority measures	Bus stops located within 25 m from junctions with safe pedestrian crossings at the intersection	Nos.	74	85
Road safety	Traffic calming measures: Table-top crossings, signages, narrowing carriage ways (LHS and RHS)	Nos.	0	118
Gender safety and security	Treatment at intersection (total)	Nos.	2	231
	At-grade		0	217
	Pedestrian refuge islands		2	14
Multimodal integration	Stands for IPT/last mile connectivity modes (autorickshaws, cycle rickshaws, e-rickshaws) should be in the multi-functional zone minimum 25m from the bus stops	Yes/No	No	Yes
Signages	Number of mandatory and regulatory signages	Nos.	51	656
Clean & green	Trees of native species on the sidewalk	Nos.	2,253	4,060
Resilience	Bio swales along the corridor (length)	Km	0	1.5

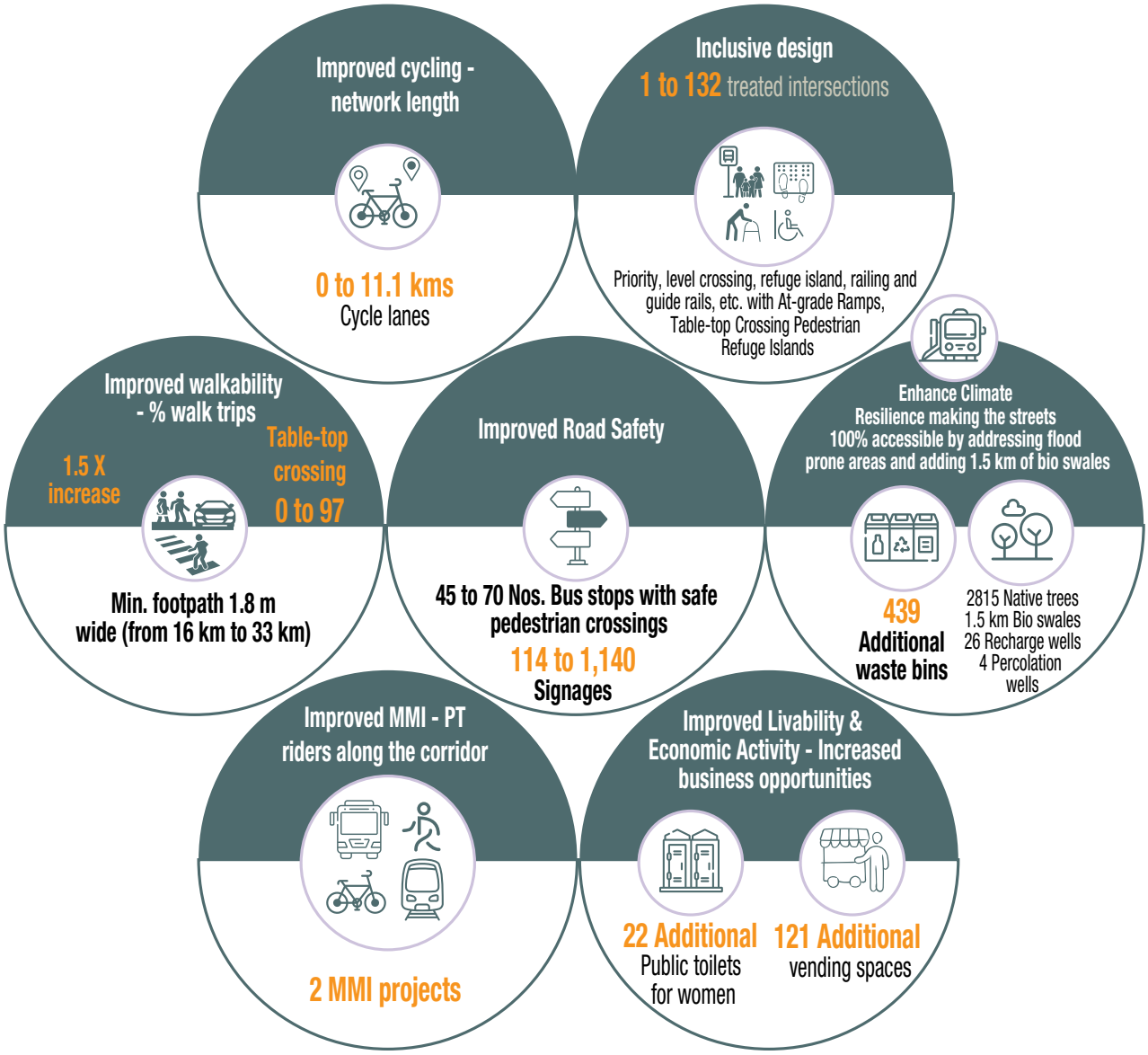
Augmenting institutional capacity and processes. Traditionally road construction has been about moving vehicles and addressing road throughput or volume by capacity ratio, whereas Complete Streets is about moving people and moving them safely. With the experience of pedestrianizing bus route roads and Pondy Bazaar, GCC has gained insights on furthering healthy streets. The city has also benefitted from the presence of local champions like ITDP to bring in sectoral knowledge and innovations, together with international and national expertise.

EXPECTED IMPACT

The Mega Streets projects have the potential to generate a range of economic benefits through improved walkability for existing pedestrians, safety benefits from reduced road accidents, overall reduced motorized travel by encouraging shorter trips (walking trips), better micro-climate, and reduced emissions. There will also be economic savings with modal shift and associated benefits due to the improved pedestrian and multimodal facilities. Mega Streets contribute to reducing road traffic fatalities, increased use of non-motorized and public transit along corridors, improving accessibility to jobs and livelihood options through sustainable transport, and reduced risk of flooding. Comparable projects in Tianjin (China) and Karachi (Pakistan) achieved post-project economic returns of 53 percent and over 16 percent respectively.[25] These interventions enhanced travel safety, reduced congestion and pollution, and improved walkability and amenities.

The transformation potential of developing 50 km of Mega Streets across the six selected neighborhoods in Chennai, based on the design developed by GCC, with World Bank support is shown in Figure 4.9. SUSP supports implementation of the first 12 km. The rest of

FIGURE 4.9: EXPECTED IMPACT OF 50 KM OF MEGA STREETS



Source: For information the World Bank internal assessment and source for graphics https://thenounproject.com/

the streets may be implemented in the future based on the availability of funds.

Using the Pedestrian Environment Review System's (PERS),[26] direct benefits to pedestrians were estimated as time and cost savings. The improvements were converted into benefits by relating them to the value of walking time, reflecting the average income in Chennai. Additionally, savings in GHG emissions were also estimated based on the modal shift to walking or non-motorized and public transport induced by the infrastructure upgradation and urban design. Approximately 109,000 tons of GHG emissions over 20 years was estimated as the difference in emissions generated from the traffic on the project corridors with and without the proposed interventions. The indirect benefits include time and effort savings for vehicular and pedestrian traffic, which can be attributed to avoiding inconvenience of frequent excavations for laying and re-laying of utilities,[27] however, the exact quantification of this is difficult.

Further, the city plans to monitor and update its Mega Streets guidelines based on implementation experiences of demonstration projects and for latest developments in the sector like blue-green infrastructure, nature-based solutions, utility integration and GIS mapping, material circularity, and public realm creation. Additionally, to continue the momentum towards a livable, connected city, Chennai intends to mainstream

the redevelopment of existing streets and development of new ones based on Complete Streets principles through inclusion of specific street development in its CMP, guidelines in the master plan, and neighborhood and TOD plans and adoption by other urban local bodies in CMA.

TAKEAWAYS FOR OTHER CITIES

- **Each street should be analyzed to reflect the context in which it is positioned currently with provisions for the role it is planned to play in the future.** Development of Complete Streets is a combination of above and underground transformation that needs to be contextualized based on the unique characteristics of each street (character, function, history of utility upgrades, and priorities). A one-size-fits-all solution is unlikely to succeed. While some streets may warrant shifting of utilities in ducts, some may need trenches and others can do with simpler solutions. The above-ground transformations for mobility have significant socioeconomic benefits, and immediate visibility for citizens. Like Chennai, detailed assessments of the current issues and correlation with the proposed solutions will help refine the functions based on the context and land use of the street.
- **Gathering data on underground utilities for improving the efficiency of Complete Streets.** Issues on Mega Streets in brownfield locations pertaining to shifting or relaying of existing operational utilities are compounded by little or no data on the exact location (3-dimensional), alignment, capacity, age, or conditions of underground utilities. Documentation, spatial mapping, and sharing standardized data through effective coordination and inter-agency communication is important for implementing integrated projects with minimum unplanned changes impacting overall efficacy and efficiency.
- **A framework for integrated utilities and streamlined inter-agency coordination is essential for scaling up Complete Streets approaches**. Integrated above and underground mapping, planning and development is an emerging field in India, with extensive conversations being undertaken at various levels including the national level. Cross-sharing of data and the central repository of utilities, road and other assets will help in faster and timely implementation. Standardization for surveys, data formats, and digital mapping and data sharing protocols need to be developed across agencies, with a differentiated approach based on financial and economic assessments for greenfield and redevelopment projects. Interventions in brownfield locations require a higher level of coordination across agencies and adoption of a systematic approach from planning to implementation. Complete Streets also tend to be geographically distributed, and under the ambit of different urban local bodies, making it difficult to implement quickly. The use of IT systems supported by a nodal planning and/ or coordination agency could help. Therefore, while cities may embrace an incremental approach towards planning (pilot neighborhoods or modest utility improvements aimed at reducing road cuts will help achieve a major positive impact on active mobility and livability) ensuring integration and connected development is a must.
- **Neighborhood level planning and implementation of Complete Streets should be pursued for integrated network level effects.** While Complete Streets implementation can be done one street at a time, cities achieve a greater impact by ensuring connectivity of walking, PT accessibility, inclusion, and utilities by network creation. Retro-fitting network of streets in existing neighborhoods needs coordination, planning, and most importantly ensuring least disruptions to existing services and inconvenience to residents and users. Compared to retrofitting, developing Complete Streets and networks in greenfield areas is a lot less complicated and less money and time consuming; thus, cities benefit by preparing walking/ cycling master plans and incorporating such approaches as part of local area development plans. Network level planning for both above ground transformation and underground utilities needs to be incorporated at various levels of city and metropolitan region planning (master plans, local area plans, TOD plans) and there is a need for developing a supporting ecosystem like guidelines, M&E of pilots, policy for low carbon construction, and nature-based solutions (for example, blue-green-infrastructure).
- **Need to ensure what is built also gets maintained and enforced for higher economic benefits and sustained gains**. Most cities work to maintain a fine balance between limited resources and

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adequate maintenance of the assets. Like in Chennai, Complete Streets designs should include elements and material with limited maintenance and factor in the maintenance of the interventions proposed as part of overall project cost. Further, maintenance should ensure that the sidewalks remain free from encumbrances like unauthorized parking, vendors, overhead wires, and other misuse. Adequate enforcement and awareness building is needed for this. Further, cities could capitalize on IT-based digital solutions to connect design, development, and asset management efficiently. Technology solutions will increasingly support integration with road safety for inclusive asset management, nature-based solutions for climate resilience, and a life cycle approach for efficiency of construction.

- **Lifecycle Cost Assessment (LCA) Approaches and Green Public Procurement (GPP) can improve sustainability of Complete Streets.** As more people migrate from rural to urban areas in search of better economic opportunities and quality of life, the demand for housing, infrastructure, including roads and commercial spaces escalate. This surge in construction activities leads to a greater demand for virgin construction material, a corresponding rise in construction and demolition (C&D) waste generation, and illegal waste dumping adding to pollution and GHG emissions. Adopting low carbon construction and a circular economy approach for construction and demolition waste are untapped opportunities for cities for reducing the waste management burden, thereby contributing to the country's climate mitigation targets while leveraging private sector expertise and resources. Cities keen on these could start by finalizing the rates for a C&D based input for construction. At the same time cities could undertake LCA assessments of key raw material used in street construction and evaluate alternates to ensure the least impact. Lastly, in their procurement methods cities could encourage measures (design, construction, and maintenance techniques) promoting sustainability and green development under GPP.

- **Institutional strengthening and capacity building**. Institutional strengthening by knowledge sharing, training, site visits, and regular workshops on technical and emerging concepts tailored to different stakeholders (decision-makers, engineers, consultants, and contractors) are important. Agencies can substantially benefit from partnering with think tanks (like Chennai and ITDP and C40) and expert organizations available locally, for regular and prompt hands-on support. Also, external experts on-boarded as program management support or quality supervision early in the project cycle can help in planning and implementation.

- **Community ownership of the interventions is critical for implementation, maintenance, and scalability**. Community involvement from being end users only to also being the caretakers of the interventions has always benefitted interventions and cities. Chennai historically has had highly engaged communities, which have helped address issues such as waste segregation, illegal parking, and traffic volunteering.[28] Similarly, agencies in other cities can ensure higher ownership, acceptance, and better maintenance (must for scalability also) of Complete Streets by leveraging communities by liaising regularly with different stakeholders (shopkeepers, RWAs, street vendors, pedestrians, and cyclists) for the efficient planning and execution of street development projects. Many cities around the world have prepared robust communication plans[29] to engage proactively with the public and have developed dedicated detailed links for the community to share their feedback.

CONCLUSION

To meet growing urbanization and mobility demands, cities increasingly need to focus on dense walkable green development with integrated land use and transport for greenfield areas. The existing areas will also need efforts to redevelop and retrofit streets and roads. Complete Streets approaches are key to this and will help improve walkability, road safety, inclusion, and decarbonization. The experiences from GCC and Chennai offer valuable takeaways for other cities on planning, designing, and integrating streets.

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Endnotes

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Source: The New Indian Express

5: ACHIEVING URBAN MOBILITY RESILIENCE

Rashi Grover,[1] Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

Urban mobility resilience is a critical aspect of urban resilience. It refers to the ability of a city's transportation systems to withstand and recover from disruptions, whether caused by natural hazards, accidents, or other unforeseen events. Urban mobility resilience ensures that cities can withstand disruptions, keep people connected, and recover swiftly, contributing to overall stability and well-being.

This note focuses on Chennai, which, similar to coastal cities across the world, is increasingly vulnerable to the impacts of natural disasters and climate change. The city is increasingly facing extreme weather events that have a severe impact on lives, livelihoods, and infrastructure. The floods in 2015 and 2020 are illustrative examples. In 2015, a devastating flood claimed 422 lives and caused damage and loss to property worth Rs. 146 billion.[2] Cyclones in 2020 (Nivar and Burevi) caused flash floods and disconnected most of the road network (see Box 5.1).

This note presents the approach adopted in Chennai to assess climate change vulnerabilities and identifying measures for strengthening urban mobility resilience. The Chennai example offers useful takeaways for other cities facing similar challenges.

BACKGROUND

India is one of the most vulnerable countries in the world to climate change and ranks fifth on the Global Climate Risk Index Report 2020. Rapid climate change has induced severe stress, including water stress, heatwaves, and droughts, severe storms, flooding, and associated negative consequences for health and

BOX 5.1: CYCLONE NIVAR (2020) AND ITS IMPACT ON CHENNAI

Cyclone Nivar, a very severe cyclonic storm, struck portions of Tamil Nadu and Andhra Pradesh in late November 2020. Starting November 23, 2020, Chennai, and other parts of northern Tamil Nadu saw gusty winds touching 60-70 kmph and experienced continuous downpours. The India Meteorological Department (IMD) had recorded 163 mm of rainfall in Chennai by November 25, 2020.

Water stagnation was reported in 53 places in Chennai. Power cuts occurred due to fallen trees. The cyclone left a trail of uprooted trees, damaged houses, and broken electric poles. Three people lost their lives, and three more were injured across Tamil Nadu. Vulnerable areas were evacuated, and people were shifted to relief centers. In terms of overall impact, Cyclone Nivar caused approximately US$600 million in damages in the affected regions. Despite the challenges, authorities worked to restore normalcy and mitigate the cyclone's effects in Chennai and neighboring areas.

Sources: Cyclone Nivar - Wikipedia; Cyclone Nivar: Several parts of Chennai inundated, Chennai News - Times of India (November 5, 2020); Cyclone Nivar: Glimpses of the Path of Destruction Left by Cyclone-Induced Rains, Winds (PHOTOS), Weather.com (November 27, 2020).

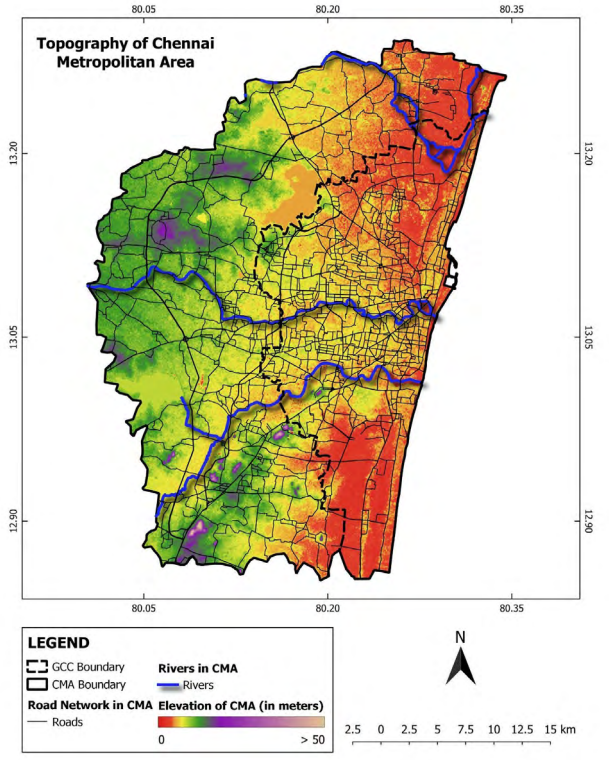
livelihoods. Although India's Nationally Determined Contribution (NDC) commitments focus more on climate change mitigation than adaptation, climate change-induced and natural hazards are expected to increase in intensity and frequency over the next decades. More than 800 million people, or 45 percent of the region's current population, lives in locations projected to become moderate to severe climate hotspots by 2050.[3] By some estimates, more than half of India's population is highly vulnerable to the impact of climate change. Infrastructure development should therefore contribute to climate change mitigation goals, while also ensuring resilience to climate risks.

India has taken several initiatives for addressing the issue of climate resilience in urban mobility. The National Action Plan on Climate Change (NAPCC), released by the Prime Minister in 2008, outlines a strategy for climate change adaptation and enhancing the ecological sustainability of India's development path. The plan includes eight National Missions that focus on promoting an understanding of climate change, adaptation and mitigation, energy efficiency, and natural resource conservation.[4] The National Urban Transport Policy (NUTP) aims to provide a sustainable transport system in urban areas. It emphasizes the need for a shift from personal vehicles to public transport, non-motorized transport, and intermediate public transport. The policy also focuses on the integration of land use and transport planning and the development of urban transport infrastructure. This provides an opportunity for systematically integrating resilience in planning concentration of activities and flows, while also considering interdependencies with other critical infrastructure systems (power, health, telecom).[5]

Being a coastal city makes Chennai[6] more vulnerable to the impact of climate change. Much of Chennai is low lying, and the terrain is flat, limiting options for natural drainage, as seen in Chennai's topography in Figure 5.1. The average elevation is around 6.7 m above mean sea level, with the highest point being at 60 m (200 ft). This is a significant contributor to the region's exposure to flooding.

There are various agencies implementing traffic and transportation schemes in CMA. While long-term planning and coordination is done by the nodal agency, CMDA, several other departments/agencies are involved in looking after various functions for planning, operating, and regulating the different modes of transport.

FIGURE 5.1: CHENNAI'S TOPOGRAPHY



Source: SRTM (shuttle radar topographic mission) Digital Elevation Model, Greater Chennai Corporation and open street map

This note focuses on Chennai's exposure to two main categories of extreme weather events: floods (fluvial, pluvial, coastal)[7] and heatwaves. Figure 5.2 presents a timeline of extreme weather events in Chennai.

- Violent storm surges and flooding during the northeast monsoons from September to November. Although some level of local flooding is an annual phenomenon in parts of the city, extreme flooding events are becoming increasingly frequent. Events such as heavy rainfall, high tides, storm surges, cyclones tsunamis, and sea level rise contribute heavily to coastal flooding, with severe impact on the public and infrastructure.
- Heatwaves typically occur in summer. There has been a marked rise in the number, frequency, and intensity of hot days (over 40 degrees C) in recent years. Heatwaves, without concomitant increases in precipitation, and improper management of groundwater, can lead to water shortages and increased stress for plants, particularly in arid regions.[8]

FIGURE 5.2: TIMELINE OF EXTREME WEATHER EVENTS IN CHENNAI

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APPROACH IN CHENNAI

Chennai is adopting a multi-faceted approach for disaster risk management in urban mobility that includes infrastructure improvements, coordination among various agencies, and strategic planning for resilience and sustainability (Box 5.2). The Government of Tamil Nadu, working closely with the Greater Chennai Corporation (GCC) and the municipal corporation in Chennai, has taken several steps for enhancing disaster risk management:

GCC has established an integrated command and control center (ICCC) for coordinating disaster management efforts (Figure 5.3). This center plays a crucial role in ensuring the serviceability of urban mobility infrastructure and continuity of services during disasters by coordinating with various agencies such as Traffic Police and MTC.[9] It manages weather and environmental information that enables real time monitoring of rainfall, rainfall distribution, and inundation in subways through flood sensors and flood cameras across the identified inundation vulnerable areas in Chennai city.

Chennai has focused on improving its stormwater drainage system. Stormwater drains are provided with rainwater harvesting systems at 30 m intervals for recharging the groundwater table in the city. The city has also engaged in sustainable urban development practices and has held workshops such as the one reported by the Indo-German Center for Sustainability, to discuss and plan for better disaster management and socioeconomic development under urbanization and climate change.[10]

The city has also been developing city resilience strategies to better prepare for climate induced extreme events or natural hazards. This includes innovative designs and interventions for climate-resilient flood management, integrated urban planning, and enhanced municipal resource mobilization, which can serve as models for other Indian cities vulnerable to climate and disaster risks.[11]

BOX 5.2 - INITIATIVES BY CHENNAI SMART CITY LIMITED (CSCL)

CSCL is a specialized organization created for carrying out Smart City projects in Chennai. To address the pressing issues of flooding and water scarcity in the city, CSCL has undertaken a comprehensive initiative that involves the identification of 210 water bodies distributed across 15 zones in Chennai. The primary goal of this strategic undertaking is restoring and enhancing these water bodies, thereby mitigating the adverse effects of flooding and alleviating water scarcity challenges in the region. Through the restoration of these water bodies, CSCL aims to contribute significantly to the overall resilience and sustainability of Chennai's urban environment.

A Systematic Approach for Improving Urban Mobility Resilience

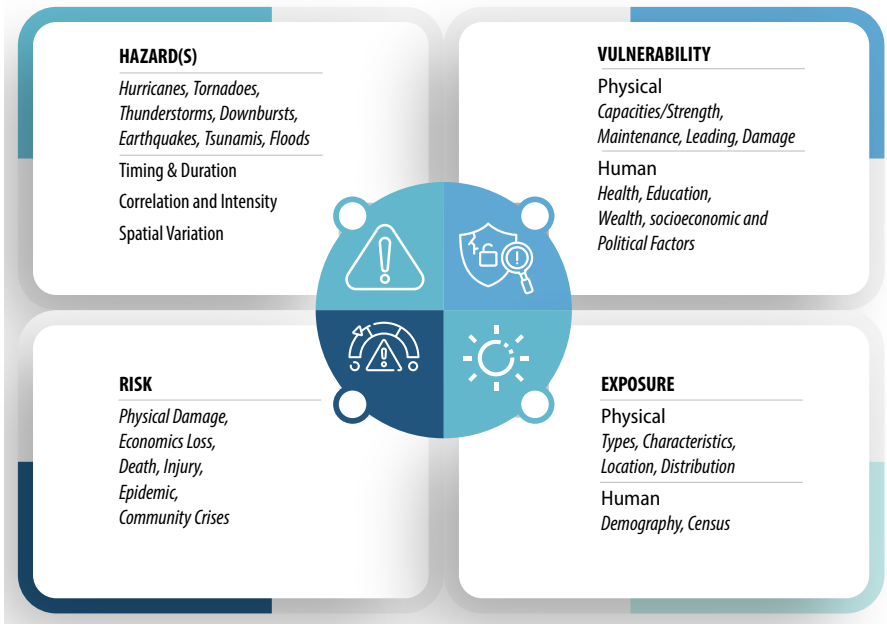
The increasing frequency of disasters in cities like Chennai underscores the importance of urban resilience against climate change, or climate resilience. Climate resilience is the capacity of a system, community, or interconnected systems to withstand, recover from a hazard, and adapt to the impact of climate change. Climate change adaptation refers to the process of adjusting to actual or expected climate change and its effects (IPCC AR5). Development, adaptation, and resilience are inextricably linked. Inclusive development is foundational for building adaptive capacity and resilience, while adaptation reduces climate vulnerability and impact, and safeguards development.

A systematic approach to building climate resilience is the need of the hour. This typically involves assessing and taking measures for managing *disaster risks*. According to UNDRR, disaster risk is defined as, 'the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.' A *hazard* is defined as a dangerous phenomenon, condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. *Vulnerability* describes the propensity or predisposition to be adversely affected, depending on the sensitivity of the system and its ability to cope with a hazard. *Exposure* is considered a function of risk assessment referring to people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. However, the term exposure is a necessary, but not sufficient, determinant of risk (Figure 5.4).

FIGURE 5.3: INTEGRATED COMMAND AND CONTROL CENTER (ICCC) ESTABLISHED BY GCC

Source: Authors' photo.

FIGURE 5.4: DISASTER RISK AT THE INTERSECTION OF HAZARD, EXPOSURE, AND VULNERABILITY[12]



Source: Disaster Risk Management Through the DesignSafe Cyberinfrastructure. Int J Disaster Risk Sci 11, 719–734.

An approach that considered these dimensions was applied in Chennai, albeit with modifications, based on resource availability. In 2022-2023, a technical study on '*Resilient Urban Mobility and Services in Chennai*' was undertaken with funding from the Government of Japan (GFDRR) and the World Bank, in close collaboration with government agencies, including CMDA, CMRL, GCC, and MTC. [13] The study aimed to review the current state of work/activities on flood risk and pandemics in Chennai and provide recommendations with options to undertake disaster risk assessment (hazard and vulnerability) of urban transport infrastructure and services in the city. In this study, risk was defined as a function of hazard and vulnerability. No new explicit exposure mapping study for understanding hazards and their exposure areas in CMA could be carried out as part of this study because of the high costs and time associated with such an exercise. However, exposure maps from existing studies by institutes such as the Indian Institute of Technology (IIT) Madras, Institute of Remote Sensing (IRS), Anna University, and the National Center for Coastal Research (NCCR) were used where applicable.

Vulnerability of critical infrastructure[14] in Chennai

Critical urban mobility infrastructure was assessed based on three types of vulnerabilities: physical, systemic, and socioeconomic. Key results from these assessments are presented in this section.

Physical vulnerability to floods was assessed for five broad categories of critical transport infrastructure - roads and road elements, structures such as bridges/flyovers, freight transport and mass transit systems like suburban rail, MRTS, MTC and Chennai Metro Rail (Table 5.1). Specific criteria were used for designating an exposed element as critical, for instance, critical roads and road elements were defined as roads/links in the urban road network in Chennai which caters to substantial traffic volumes and is critical for maintaining acceptable service levels. The results showed that most of the bridges and flyovers in the city were nearing their serviceability age, suggesting scope for utilization of Intelligent Transport Systems (ITS), in integration with the Chennai Smart City program, for reducing disruption to services during disaster events. With three major water bodies crossing the city and most of the MRTS and metro rail systems built along them, special attention needs to be paid to the accessibility of these stations for providing the minimum operational ability during floods. Alternative routes for passenger and freight movement were identified along roads that were comparatively more resilient during disaster events.

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TABLE 5.1: DETAILED PHYSICAL VULNERABILITY ASSESSMENT

Element	How physical vulnerability was assessed	Results of detailed physical vulnerability assessment
Roads	• Definition of a vulnerability index and determination of vulnerability indicators by measuring the network performance in two situations: a) with the network under normal conditions, before the occurrence of a disturbance; and b) with the network subject to disturbance on one or more of its links (interruption or impaired capacity). The difference between the two performance indicators (generally total trip cost or time) is the value of the vulnerability index. • Analysis of the vulnerability of a road network considering the importance of the roads based on the volume of traffic as per the Comprehensive Mobility Plan (2019) (arterials, sub-arterials, collector roads), their relative level of exposure to floods of varied return periods, and the ratio of road length to floods to total length. • The vulnerability assessment was flexible enough to consider both partially and fully damaged roads.	• Of the 26 critical road links in CMA (forming 5.9 percent of the total exposed road network in CMA) about 38 km (of a total ~60 km) were found to have high to very high vulnerability with capacity reduction above 75 percent during extreme events. • During a disaster, 35 percent of the network operated at a speed below 20kph compared to 26 percent on normal days, with an overall increase of 45 percent in vehicle hours travelled, and of 47 percent (from 0.47 to 0.69) in volume-capacity ratio.
Footpaths	• Identifying the critical footpath network. • Conducting a spatial analysis for the identified critical footpath network, wherein the footpath network was superimposed with flood depth maps. • Assessing the vulnerability based on their relative level of exposure with floods of varied intensity.	• Of the total 850 km network of footpaths in CMA, around 250 km (30 percent of the total footpath network) was likely to be inundated, with 6 percent in very high or high vulnerability categories.
Bus (MTC) depots/ terminals	• Rapid Visual Screening (RVS) for physical vulnerability assessment of critical urban transport buildings. • Public buildings chosen based on the inputs provided by local administration and self-assessment of the consultant. • The parameters chosen to represent the lumped vulnerability of individual buildings to hazard events after consultations with civil and electrical engineers, fire and rescue officers, and town and country planning officials. • Typical criteria (such as safety equipment, evacuation routes, fire alarm systems, electric insulation) used for vulnerability assessment of selected buildings for this study were defined across three categories: highly vulnerable, moderately vulnerable, and least vulnerable.	• Six bus (MTC) depots/terminals were found to be critical out of 33 MTC depots/terminals in CMA. • Additionally, 29 bus routes (of the total 830 in CMA) have 20 percent or more of their length in the critical network category.
Suburban railway stations/ MRTS		• Two suburban railway stations (out of 36 in CMA) and five MRTS stations (out of 17 in CMA) were found to be critical.

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Element	How physical vulnerability was assessed	Results of detailed physical vulnerability assessment
Bridges/flyovers	• Identification of all bridges and flyovers which fell within the realm of past floods inundating the study area. • Framing a set of parameters, which will govern the vulnerability of such structures against floods with scouring being the chief criteria based on specifications of IRC:5-2015, Standard Specifications and Code of Practice for road bridges, IRC:45 - 1972, Recommendations for estimating the resistance of soil below the maximum scour level in the Design of Foundation of Bridges, and IRC:78 - 2000, Standard Specifications and Code of Practice for road bridges, Section - VII, Foundation and Substructure. • Typical criteria (such as age, location, scour history, structural characteristics) proposed for vulnerability assessment of selected bridges and flyovers were defined across three categories: highly vulnerable, moderately vulnerable, and least vulnerable.	• 17 bridges (of a total 150 in CMA) and 11 flyovers (of a total 38 in CMA) were found to be critical.
Freight routes	• Mapping urban freight infrastructure facilities in the city required to move freight. • Assessing commodity wise demands in different parts/zones of CMA based on the survey data collected during the Comprehensive Mobility Plan for CMA (2019) and ranking priority supplies. • Linking the mapped freight infrastructure to the flood maps for identifying the critical facilities. • Assessing the importance of the critical links primarily for three critical commodities -- food supplies (perishable and non-perishable), medical supplies, and petrochemical goods, and then identifying alternate shortest detour routes in case of link failure. • Measuring the importance of a link by how many vehicles will be impacted when the link is completely disrupted.	• Only 1.2 percent of the road network of 11 critical freight routes studied was categorized as critical, very high, or high in vulnerability to floods.

A systemic vulnerability assessment studied accessibility as per the identified critical lifelines during disaster events. Systemic vulnerability assesses the vulnerability of critical lifelines, that is, facilities that play a major role in community response and recovery post disasters (for example, electric lines/power grids, utilities, hospitals, police or fire lifelines, and rescue lifelines). This was undertaken by developing isochronal maps for understanding which parts of the city were at risk and how quickly they might be affected, based on the travel time in each link during a disaster event. The identified critical lifelines were overlaid with the network during a disaster event and were assessed for the accessibility levels of those critical lifelines. It was observed from the isochronal analysis that travel to hospitals in certain areas was expected to take 20 percent longer than usual. Accessibility of the fire stations in six (of the 28) areas was expected to take 26 percent longer

than usual. Accessibility of three administrative offices, the traffic control room, the Police Commissionerate, and CMDA was likely to take 44 percent longer than usual (Figure 5.5).

A socioeconomic vulnerability assessment was done for understanding the impact of disaster events on different strata of the population. Socioeconomic vulnerability analyzes the implications of climate change on different sub-segments of the population based on literacy rate, income, and living standards. The Socio-economic Vulnerability Index (SeVI) was used for assessing the socioeconomic vulnerability of the urban mobility system, as per the formula: SeVI = Exposure x Sensitivity/Capacity. Flood hazard maps from existing models were used for identifying exposed road networks, terminals, stations, and bus stops. The analyses showed that the central part of CMA, particularly the core city under GCC's jurisdiction had *high* to *very high* socioeconomically vulnerable zones when it comes to transport. The high job opportunities, labor population, and flood zonation of these areas make them more vulnerable. Vulnerability in the southern and northern zones was exacerbated by deficiencies in stormwater drainage.

Based on this hazard analysis and three aspects of vulnerability, a list of transport elements at risk in CMA was generated (Figure 5.6). Critical elements falling under the *Very High* category of vulnerability as defined for that element were classified as 'Risky Assets', while all other vulnerable elements were not found to be risky but were vulnerable to different degrees.

Recommendations for boosting urban mobility resilience

Based on the risk assessments, a comprehensive set of recommendations for improving climate resilience of the urban mobility infrastructure was developed. Overall, enhancing climate resilience of urban transport and mobility services should be a core part of the decision-making matrix for prioritizing projects, especially given the magnitude of climate risks that Chennai faces. This extends to policies, planning, prioritizing projects, and financing and requires strong inter-agency coordination.

An overarching recommendation relates to financing measures for enhancing climate resilience. Climate finance in India is heterogeneous, fragmented, and decentralized with several public, private, national, and international actors playing important roles (Jha, 2014).

FIGURE 5.5: ACCESSIBILITY OF ADMINISTRATIVE BUILDINGS AND THE AIRPORT DURING A NORMAL DAY (LEFT) AND DURING A DISASTER EVENT (RIGHT)

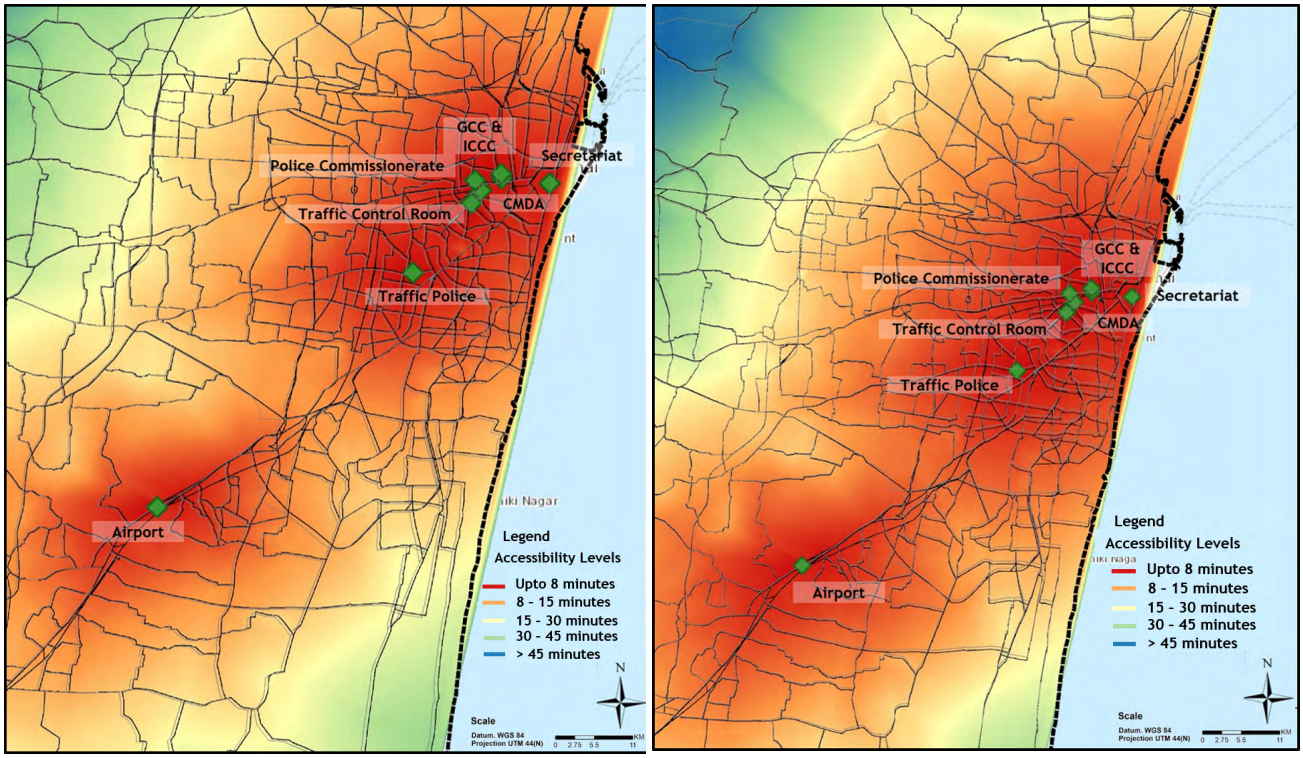

FIGURE 5.6: OVERALL RISK ASSESSMENT OF URBAN TRANSPORT ELEMENTS

Risk Assessment of Urban Transport Elements

Roads	MTC Depots/Terminals	Sub-urban & MRTS Stations
• Arunachala Street • 8th st. • Anna Main Road • VR Ramanathan Road • Annamalai Nagar 1st Street • 14th Avenue • Pantheon Road • Mogaper Estate Road	• Mandaveli Bus Deport cum Terminal • T Nagar Bus Depot cum Terminal • Ambattur Industrial Estate	• Chetpet sub-urban railway station • Kodambakkam sub-urban railway station • Light house MRTS station
Bridges	**Flyovers**	**MTC Routes**
• St. Andrews Bridge • Laws Bridge • Harris Bridge • Alandur Abraham Bridge • Santhome Bridge • Naduvankarai Bridge • Nungambakkam Bridge • Saidapet Bridge	• Doveton Flyover • Pantheon Flyover • Thirumangalam Flyover • CMBT Flyover **Freight** • Chennai ort to Maduravoyal to ORR to Peripheral road • Manali Oil Refinery road • NH Bypass	• Route_15 • Ropute_15G • Route_S18 • Route_S15 • Route_S147X • Route_27B • Route_S86

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The financing of resilience enhancement measures in the urban transport systems in Indian cities requires different mechanisms from those used for regular investments and maintenance. For example, emergency lines of credit or emergency budget lines are required for undertaking rapid repairs of modest scope without delay to enable the system to bounce back and reach normal operations after flood disasters. Annual upfront allocations for disaster response and recovery funds are needed to deal with the next layer of damages after flood disasters—well-defined procedures for rapidly accessing city-level and state-level reconstruction funds to deal with damages caused by catastrophic events. In addition, budget allocations for adaptation planning and climate-informed infrastructure development are advisable. Targeted insurance for specific infrastructure assets may be considered. Prioritizing projects according to the highest cost-benefit ratio based on economic, environmental, and social factors (for urban transport infrastructure) is therefore important.

Further specific recommendations are organized along the following themes: (i) structural, referring to the construction and maintenance of physical infrastructure; (ii) data and technology, including how they could enable contingency measures during disasters for ensuring a minimal level of services and access to critical lifelines; and (iii) measures relating to institutions and communications in and around disasters.

Structural recommendations

Structural recommendations cover measures relating to physical infrastructure, which are further divided into measures before and after disaster events.

The following measures can be undertaken before disaster events:

- ***Including climate resilience considerations such as vulnerability to floods in building codes and standards for urban transport buildings*** (that is, stations, depots, and terminals) for ensuring that urban transport infrastructure can adapt to climate change (Box 5.3). To successfully reduce vulnerability, building codes and standards must be well designed and periodically updated based on fresh estimates of climate change impacts.
- ***Building and retrofitting transport infrastructure for resilience:*** Even a rapid assessment can help identify the weakest transport system components in need of retrofit and upgrade to deal with floods

BOX 5.3: ROBUSTNESS IN BUILDING CODES IN CANADA

Canada used historical evidence from the 1985 Barrie tornado outbreak and found that many of the damaged homes were not tornado-proof due to the lack of anchorage. This was then implemented and included with modifications to the Canadian Standards Association specifications for construction.

Source: Chennai City Partnership: Resilient Urban Mobility and Services in Chennai

in a changing climate such as bus depots, bridges, pumping systems, and electrical traffic management systems. However, sometimes the weakest infrastructure links – particularly for mobility – are small but require a critical upgrade such as walkways or sidewalks connecting to bus stops or metro stations (last mile connectivity). In addition, the expansion or upgrade of the transport infrastructure needs new standards to account for probable climate change scenarios and their impact on floods, storm surges, and sea level rise, and make the new investments climate adapted.

- ***Proactive enhanced maintenance:*** Proactive maintenance and cleaning of the transport, drainage, and stormwater infrastructure, especially prior to the rainy season can be the most effective measure for enhancing the resilience of the transport system. The transport system's risk assessment can provide specific locations with the highest flood risk to help target cleaning and maintenance. Enhanced maintenance focused on pothole repairs, pavement sealing, bus stop repairs, and other weak points can help significantly with traffic conditions during floods.

- ***Implementing Nature based Solutions (NbS)*** by retrofitting the existing streets or reconstructing the streets to incorporate these measures. Based on the availability of space, local terrain, the regional weather and climate, aquifer recharge potential, and the local ecology, various measures could be used for the detention, retention, biofiltration, and infiltration of stormwater. *Green infrastructure* in a heavily urbanized city like Chennai which has limited open space and experiences high temperatures and heavy monsoons, will act as a buffer between the streets and the drains, thereby reducing the load on the stormwater drains during peak floods. NbS has been used for enhancing climate resilience and addressing multiple urban sustainability challenges in cities such as Melbourne, Boston, Cape Town, Mexico City, and Malmö (Sweden).[15] Box 5.4 shows how a project in Europe has applied NbS to urban development solutions.

BOX 5.4: INTEGRATING INFORMAL TRANSIT SERVICES: INTERNATIONAL EXAMPLES

NATure-based URban innoVATION is a 4-year project, funded by the European Commission and involving 14 institutions across Europe in the fields of urban development, geography, innovation studies, and economics.

Six cities (Barcelona, Utrecht, Leipzig, Malmö, Győr, and Newcastle) are partners in NATURVATION, which is helping realize the potential of NbS in responding to urban sustainability challenges.[1]

BiodiverCity delivered over 30 multifunctional green and blue NbS across Malmö between 2011 and 2017

'Passeig de Sat Joan' was redeveloped into one of the first green corridors in Barcelona, improving ecological and social connectivity within the city

Sources:

1. https://naturvation.eu/. 'Making Urban Nature Bloom: Four Years of Partnering for Nature-based solutions Across Europe' by ICLEI – Local Governments for Sustainability, Europe.

After disaster events, there is a need for proactive post-flood repairs of the transport infrastructure. In addition to the preparedness of the transport system before disasters, it is equally important to plan for repairs and reconstruction after floods. Proactive speedy repairs are vital for restoring the capacity of urban transport and mobility systems and reducing the economic and livelihood impact that these damages will cause for businesses and citizens. For reducing the cost and increasing the speed of these post-disaster repairs, contracts must be procured before the rainy season, and rapid post-flood damage assessments must be completed for issuing repair orders. A detailed post-disaster analysis - including a specific vulnerability analysis - is required to identify build-back-better investments to continue enhancing the system's resilience.

Specific recommendations for resilience across different locations for various urban transport elements have also been provided (Table 5.2).

Some of these structural recommendations are being taken up and implemented by GCC, including via the Mega Streets program launched in 2020 to facilitate seamless mobility for safe walking and cycling, in line with the draft 2014 National Urban Transport Policy (NUTP) (Figure 5.7). GCC's efforts at improving the stormwater drainage network were discussed earlier. Under Mega Streets, GCC is also testing nature-based solutions for improving climate resilience. These include bio swales and connecting with larger open spaces along the streets for slow-soak-store. Such nature-based solutions have been shown to be cost effective in improving climate resilience, as will be discussed under the results of the cost-benefit analyses below. Implementing sponge street types learning from international examples can help delay stormwater release and increase infiltration along street medians or edges, sidewalks, curb sides and intersections (Box 5.5).

Leveraging data and technology

The smart use of data and technology can be a powerful tool in enhancing climate resilience. The resilience of the city's transport and mobility systems requires continuous data gathering and analyses of changing conditions. The city needs data for identifying the weakest links in the system where retrofits should be prioritized, areas for improving traffic management for better network resilience during disasters, changes in urban hydrological response caused by urban growth, watershed land changes, and climate change. Key recommendations related to data and technology include:

- ***Smart traffic management before, during, and after flood emergencies:*** Smart traffic management systems can incorporate resilience in their design and operations by leveraging early weather warning systems for predicting flooding levels and impact on transit; informing traffic police and citizens of the impact ahead of rainstorms; determining traffic management changes to avoid crippling blockages; and informing special categories of users such as emergency vehicles, freight drivers, and school

BOX 5.5: NEIGHBORHOOD GREENWAYS, PORTLAND, OREGON

Over the last decade, the Portland Bureau of Transportation has worked to expand Portland's network of Neighborhood Greenways, or bicycle boulevards, to encourage walking and bicycling. Greenways are streets with low traffic volume and speed where bicycles, pedestrians, and neighbors are given priority. Portland currently has over 70 miles of greenways. Portland's operational performance guidelines for greenways include:

- Reduce vehicle speeds to 20 mph or less using speed bumps.
- Limit daily average to approximately 1,000 cars per day with the upper limit set at 2,000 cars by reducing auto cut-throughs using speed bumps and traffic diverters.
- Provide ample opportunities for people bicycling and walking to cross busy streets, at least 50 crossing opportunities per hour, with 100 crossing opportunities per hour as the preferred level of service.
- Guide bicyclists and pedestrians on the route using pavement markings and signages to let users know where the greenway goes and what is nearby.

Source: Chennai City Partnership: Resilient Urban Mobility and Services in Chennai; Portland.gov "What are Neighbourhood Greenways?"

TABLE 5.2: SUMMARY OF PROPOSED RESILIENT MEASURES PER URBAN TRANSPORT ELEMENT

Element	Return Periods	No. Critical locations	Unit	Examples of Resilient Measures
Road networks	1 in 25 years	27.8	Km	Adopting micro-surfacing technology to ensure water does not seep into the road bitumen leading to potholes.
	1 in 50 years	55	Km	Constructing processed steel slag roads.
	1 in 100 years	93.8	Km	Constructing pre-stressed/reinforced cement concrete grade M-20 and above pavements with cement/lime soil base with provisions of a sand blanket.
Storm drains	1 in 25 years	0.56	Km	Construction of stormwater drainages along the entire road network within CMA, as per CPEEHO guidelines.
	1 in 50 years	2.86	Km	
	1 in 100 years	3.58	Km	
Pedestrian footpaths	1 in 25 years	34.00	Km	Adopting permeable pavement footpaths for all new footpaths to be constructed. Increasing the slope of the combined kerb stone and gutter to 1 in 60 as per IS: 5758.
	1 in 50 years	29.00	Km	
	1 in 100 years	26.00	Km	
Structure-MTC depots	1 in 25 years	1	No.	Conduit and wiring work for internal electrical installations, replacing/protecting telephone and data communication.
	1 in 50 years	3	No.	With most of the depots/terminals being at an elevation of about 10 m, wet flood proofing is an essential resilient measure for all buildings in the area. Additionally, the depot requires major renovations and strengthening the workshop block including bus bays, service pits, and offices.
	1 in 100 years	6	No.	Retrofitting the following components of the upper structure for improving its resilience to stresses created due to any future floods in the city: • Fiber Reinforced Polymer (FRP) jacketing of beams/ slabs • FRP jacketing of beam-column joints
Suburban & MRTS railway stations	1 in 25 years	0	No.	No intervention proposed.
	1 in 50 years	3	No.	Adopting permeable surfacing parking lots, driveways or sidewalks include pervious concrete, porous asphalt, pervious interlocking concrete pavers or grid pavers around the station building.
	1 in 100 years	3	No.	
Bridges and flyovers	1 in 25 years	1	No.	Monitoring flood induced scouring of bridge piers using the Continuous Scour Monitoring Instrument.
	1 in 50 years	4	No.	Replacing the slab, girder of the bridge with a Pretension Steel Slab for better resilience.
	1 in 100 years	9	No.	Construction of new bridges/flyovers as per the existing traffic volume and loading and conducting a flood fragility analysis. Additionally, undertaking Rapid Visual Screening post disaster.

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FIGURE 5.7: DR RADHA KRISHNAN SALAI - BEFORE AND AFTER

Source: GCC

buses through dedicated channels about route impacts. Integrated multi modal transport systems in the event of disasters can help limit disruptions in transportation systems (Boxes 5.6 and 5.7).

BOX 5.6: INTEGRATED MULTI-MODAL TRANSPORT SYSTEMS IN ZURICH

The ZVV system in Zurich is an example of a successful integration of physical, policy, and technology interventions. Operated and financed by a public body under the authority of the Canton of Zurich, this multimodal system delivers a 'one ticket for everything' approach combining trams, boats, trains, buses, and cable cars. Intelligent Transportation Systems are integral to the functioning of the system, as is a governance structure that includes transport system operators, municipal authorities, and the regional government.

Source: Chennai City Partnership: Resilient Urban Mobility and Services in Chennai

- ***Traffic Emergency Management Plans:*** A *Traffic Emergency Management Plan* is recommended for all Indian cities. It includes planning and preparation before, during, and after emergencies. The plan determines the personnel and equipment required, communication protocols, and inter-agency coordination. During emergencies, the plan will identify traffic control and management action, emergency efforts at increasing roadway capacity, continuous public notification action, and emergency monitoring for adaptive responses. After emergencies, traffic management to allow for repair and reconstruction – depending on the severity of the floods – will be required (Boxes 5.8 and 5.9).
- ***Asset management systems:*** A new, holistic, and comprehensive approach to asset management is needed for optimizing existing infrastructure assets and making them more resilient. This approach should seek to get 'the best out of the asset' over its life cycle, across functions and tasks and the entire infrastructure system/network. As infrastructure will be affected by environment social and governance

BOX 5.7: THE RMIS PROJECT, DELAWARE

Regional Integrated Multimodal Information Sharing (RIMIS) Project is a web-based information exchange network connecting highway operation centers, transit control centers, and 911 call centers in the Delaware Valley. RIMIS will enable agencies to receive messages about incidents, construction and maintenance activity, and special events that impact highways and transit. This provides an invaluable source of real time and archived information for transportation planners and first responders helping foster better communication and information-sharing between the many agencies in the region. Source: Chennai City Partnership: Resilient Urban Mobility and Services in Chennai; Transportation Systems Management and Operations (TSMO), Delaware Valley Regional Planning Commission.

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BOX 5.8: TRAFFIC CONTROL CENTERS IN BEIJING

Traffic control centers provide a centralized hub for data aggregation, analysis, predictive modelling, and decision-making across the transport network. Many cities operate control centers for individual modes or infrastructure types, such as buses or highways. For example, the Beijing Traffic Control Center (BTCC) monitors a network of 50 smaller Operational Control Centers for the various rail lines operating in China.

The BTCC integrates systems, including SCADA, operator information, CCTV, passenger data, decision support and incident evaluation to receive and aggregate real-time information while also sharing rail line data, rail line videos and reports with other stakeholders in the network.

The system links to an Incident Evaluation System that triggers automatic or semi-automatic plans based on certain incidents, thereby ensuring that disturbances are resolved in a quick and coordinated way. Some cities are exploring the use of cross-sectoral control centers that manage transport demand across multiple modes simultaneously, or which bring together multiple city sectors to enhance the city's management capacity.

Source: Chennai City Partnership: Resilient Urban Mobility and Services in Chennai

(ESG) risks, this approach allows identifying the trade-offs between objectives and the enabling of more robust policy choices. Integrating capital planning, asset management, and resilience using add-on modules to the existing asset management system through incremental approaches is one of the possible approaches to embedding resilience and sustainability considerations in asset management.

- ***ICT tools for flood warning:*** One such tool is the integration of the existing Intelligent Transport System with a real time flood forecasting system for efficient mobility related decisions. Integrating traffic monitoring (CCTVs), water level sensors, and proposed street level sensors will further enable traffic operators at the Traffic Management Center (TMC) to activate flood warnings remotely or be alerted when the warning systems activate through the flood detection field devices. This could then also be used for monitoring traffic and control transportation systems such as traffic signals and VMS.

These digital tools are expected to be incorporated in the planned Digital Chennai initiative led by CUMTA. Digital Chennai aims to strengthen the planning and delivery of infrastructure and mobility services in CMA through digital tools and process change.

- The initiative will have as its base, an Integrated Urban Data Exchange (IUDX), a unified repository for all urban mobility, infrastructure, and spatial development data in CMA. Several use cases can be built on this unified repository, including systems for disaster management and urban mobility resilience. Existing systems such as ICCC and upcoming systems such as an ITS being led by GCC can also plug into the IUDX downstream.
- An asset monitoring system (AMS) is expected to be built on top of IUDX for monitoring the condition of infrastructure and identifying critical assets in need of repairs or replacement, to extend the life of the assets and optimizing the use of public funds. Climate resilience and adaptation and road safety considerations is expected to be built into the decision-making matrix of AMS.

Institutions and communication

An integrated approach to flood hazard management in CMA will require interaction between various disciplines, government departments, and sectors of the society. Synergy between the actions of various stakeholders is needed for the effective implementation of an integrated flood management (IFM) approach. The IFM approach entails various roles to be played by a complex set of actors to ensure coordination and cooperation across institutional and disciplinary boundaries (Figure 5.8).

Making resilience to extreme weather and natural disasters a part of the SOPs of agency planning for ensuring that resources are invested wisely, and services and operations remain effective. The SOPs should cover: (i) What is Transit System Resilience? describing different pathways that transit agencies in Chennai should take for improving resilience; (ii) action plan for charting the transit agencies' path to resilience; (iii) a step-by-step plan to help align public transit agencies in Chennai as part of a broader resilient community; and (iv) standalone tools and resources

BOX 5.9: FULL VIRTUAL TRAFFIC MANAGEMENT CENTER, OKLAHOMA

The Oklahoma Department of Transportation (ODOT) in partnership with the University of Oklahoma Intelligent Transportation Systems Laboratory, designed and deployed a low-cost, fully virtual traffic management center (TMC). The virtual TMC consists of a geographically distributed fault-tolerant network of desktops referred to as 'ITS Pathfinder' or 'ITS Consoles,' which can control the intelligent transportation system (ITS) devices visible on the statewide private ITS network.

Cost effectiveness: An integrated, multi-agency, centralized TMC will incur very high costs. As a result, ODOT opted for the low-cost, distributed, virtual TMC using commercial off-the-shelf desktop computers and an open-source GIS mapping software.

Interagency Collaboration: Currently, there are 45 agencies participating in this endeavor. ODOT has in place a memorandum of understanding with each agency. ODOT provides stakeholder agencies with ITS consoles. These can be deployed even in rural areas if there is an internet connection capable of supporting a secure virtual private network.

Source: Chennai City Partnership: Resilient Urban Mobility and Services in Chennai

such as worksheets, templates, example questions, and checklists.

Capacity building and training programs for institutions, as well as for local communities and children, are recommended for addressing the gaps identified in terms of the skills available on disaster risk reduction and preparedness. These should engage grassroot level organizations for data collection and mapping the environmental and public health information. Capacity building and professional development are also necessary for involved professionals such as road authorities, to better enable them to take steps towards mainstreaming green infrastructure in city planning and investment decisions. Specifically on disaster risk management: (i) organizing training programs for professionals in line departments and first responders on the incident response systems (IRS); (ii) developing an integrated command center for risk management and mainstreaming practices among the stakeholders, and (iii) investing in training and development of relevant personnel responsible for operating and maintaining existing and future ITS systems in Chennai, are all key. Training, both of agency personnel and of volunteers who come to assist in times of particularly devastating emergencies, is equally emphasized in traffic emergency management planning and preparation.

Chennai is already taking steps for improving institutional arrangements for urban mobility resilience. Various projects and plans that any department will undertake should consider how their work relates to transportation and mobility and coordinate with the transport departments to the same effect. The Traffic Management and Urban Mobility Resilience sub-committee is being formed as part of CUMTA and is envisaged to act as the nucleus of the institutional arrangement - coordinating, facilitating, and overseeing the activities of its constituents to meet the objective of mainstreaming resilience in urban mobility. For example, the state and city transport departments will coordinate with the stormwater drains department of GCC on the identification of vulnerable areas and development of a priority action plan for addressing them. Further, inter-institutional arrangements and the coordination of plans and investments between these departments will also be coordinated through CUMTA's resilience sub-committee. Through its stakeholder agencies the sub-committee will also undertake tasks like formulation of policy; setting up of norms, standards, guidelines, SOPs, and service level benchmarks; developing plans, undertaking research studies; and DPR preparation and tendering of works.

Through its stakeholder agencies the sub-committee will also undertake tasks like formulation of policy; setting up of norms, standards, guidelines, SOPs, and service level benchmarks; developing plans, undertaking research studies; and DPR preparation and tendering of works.

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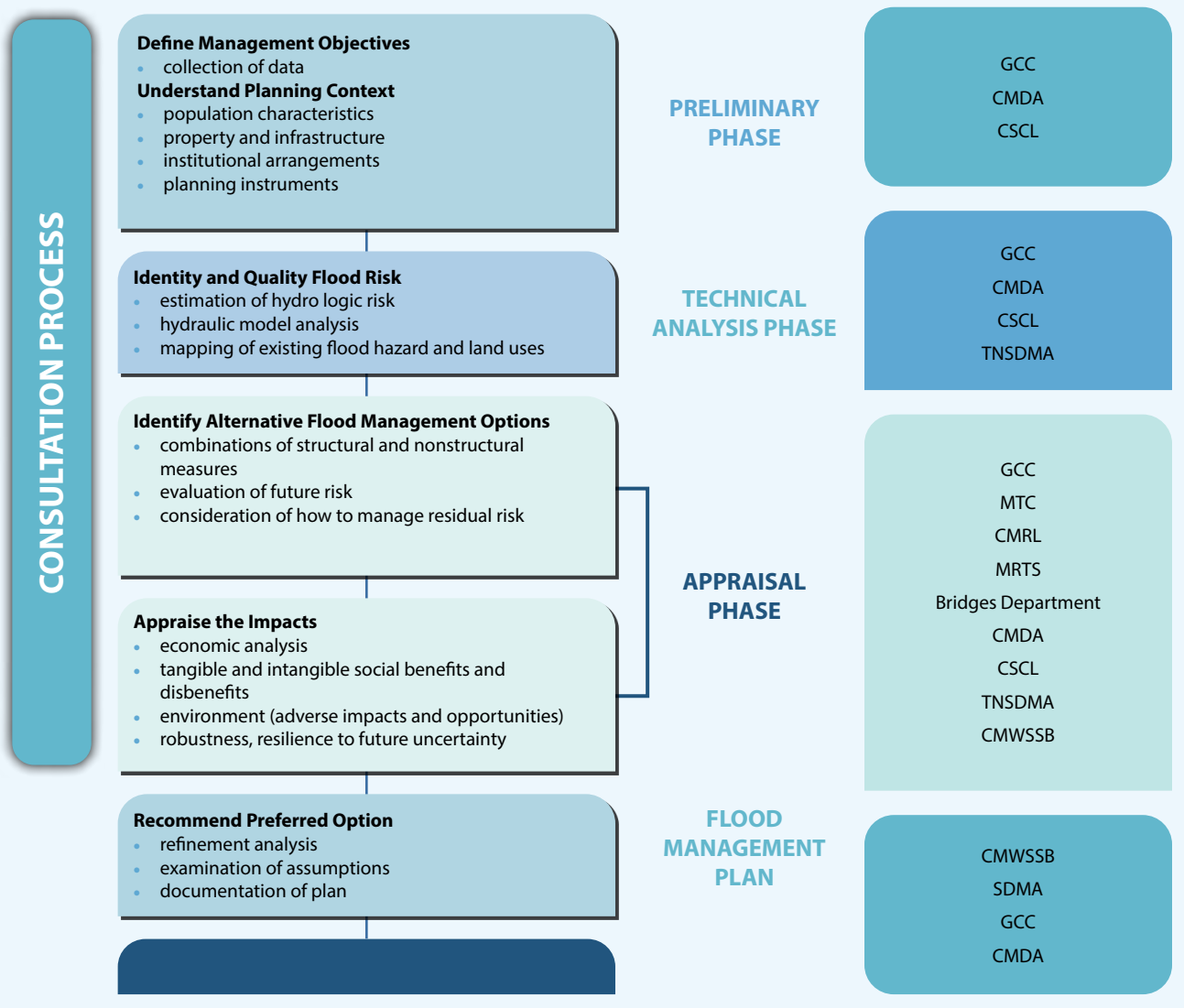
FIGURE 5.8: PROPOSED INSTITUTIONAL ARRANGEMENT FOR FLOOD MANAGEMENT WORKFLOW IN CHENNAI



Effective two-way communication with users is key. The resilience of an urban transport system should include not only the resilience of the infrastructure but should also support the resilience of mobility services and the resilience of users and their mobility needs. The latter needs an effective two-way communication system between the transport agencies and citizens. This system can: (i) identifying the specific priorities and preferences of users about where to enhance the resilience of the urban mobility system, noting that these priorities are different for different groups of citizens – from two-wheeler drivers to women and persons with disabilities; (ii) providing effective information channels to inform users about options, changes, risks, and actions taken before, during, and after flood events in a way that is understood and usable by all citizens; and (iii) offer information and seek feedback on specific investments for enhancing the system's resilience, as these construction activities will impact citizens in different ways.

EXPECTED IMPACT

To illustrate the impact of embedding climate resilience measures in urban mobility infrastructure, a cost benefit analysis (CBA) for fixing damages to the Vadapalani bus stand during Cyclone Nivar was conducted as a high-level assessment. The analysis included damage, recovery, and restoration costs, including reconstruction of roads and walls, labor costs for retrofitting, reconstruction, maintenance, logistics, and operation costs for pumping out the inundated water. Greenhouse gas (GHG) emissions accounting was also undertaken as part of the CBA. The costs of the different

types of reconstruction were calculated with reference to a schedule of rates from GCC and PWD. Suggestions from the stakeholder departments on logistics, labor costs, and number of days were also considered. It was identified during stakeholder consultations that flood inundation for prolonged durations on the roads was the major cause of the damages to roads and walls. To address this, improved *grey infrastructure* solutions and nature-based solutions were considered in addition to regular reconstruction.

Analyses show that nature-based solutions have the highest return on investments. A comparison (Table 5.3) of regular reconstruction, improved grey solutions, and nature-based solutions, brings out that nature-based solutions perform the best. These are followed by improved grey solutions and regular reconstruction, which are ranked *Low* and *Unacceptable* in the tangible benefits categories respectively. Further, nature-based solutions have the highest cost-effectiveness in terms of the difference between the net tangible benefit and the cost of recovery from damages. These benefits include both tangible benefits that relate to reduction in damage costs and environmental protection, and intangible benefits to the environment (improved biodiversity), society (cleaner air), and infrastructure (improved groundwater table).

The cost benefit analysis showed the best effective measures in terms of sustainability, climate resilience, and less environment impact. The analysis can be done for other recommendations, but the availability of data and costs (damage costs, schedule of rates, miscellaneous rates, and logistics) for different parameters of each recommendation is a challenge.

TAKEAWAYS FOR OTHER CITIES

Chennai's experience offers valuable takeaways for other cities looking at strengthening the resilience of their urban transit and mobility systems.

- **Urban mobility resilience requires continuous data gathering and analyses of changing conditions.** Indian cities are growing rapidly with new transport infrastructure and a rapidly changing urban landscape. The resilience of a city's transport and mobility system requires continuous data gathering and analyses of changing conditions. Data permeates the strategy for enhancing climate resilience at all stages – before, during, and after disaster events. Before disasters, the city needs data for identifying the weakest links in the system where retrofits should be prioritized, and monitoring changes in urban

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TABLE 5.3: PERFORMANCE MATRIX FOR VARIOUS RECONSTRUCTION SOLUTIONS*

		Intangible Benefits (scores)			
Cumulative		**High**	**Medium**	**Low**	**Unacceptable**
		Intangibles not applicable			
Tangible Benefits (INR)	**High**	Nature Based Solutions (3.1 million)			
	Medium				
	Low			Improved Grey Solutions (1.72 million)	
	Unacceptable	Regular Reconstruction (0.03 million)			

**Tangible benefits are as shown in the table. Intangible benefits are shown as high, medium, low, and unacceptable.*

Cost effectiveness = Net tangible benefits – damage costs (INR)			
Roof Material	**Damage costs**	**Net tangible benefits**	**Cost-effectiveness**
Regular reconstruction	24,76,000	28,700	-24,47,300
Improved grey solutions		17,22,000	-7,54,000
Nature based solutions		30,99,600	6,23,600

hydrological response caused by urban growth, watershed land changes, and climate change for taking proactive measures. During disasters, the city can leverage data for dynamically managing travel demand and traffic for maintaining access to critical lifelines. Post disaster, the city can undertake rapid assessments for prioritizing reconstruction and recovery efforts.

- **Urban transport agencies require a mindset shift and new skills for enhancing the resilience of the transit and mobility systems.** Climate resilience needs to become a core part of the psyche of urban transport agencies and should feature in day-to-day decision making. To intervene effectively, agencies need new skills including traffic modeling and impact prediction and management during floods; planning and execution of preventive maintenance, retrofit, and proactive post-flood repairs; catastrophic flood preparedness and response plans; and post-disaster damage and needs assessments.

CONCLUSION

Chennai is applying a multi-faceted, systematic approach to building climate resilience - one that offers valuable takeaways for other cities looking at strengthening resilience in urban transport and mobility services. Prioritizing climate resilience in the decision-making matrix for projects is the first essential step for enhancing the resilience of urban transport and mobility services. Structural measures that directly impact the resilience levels of the urban transport system need to be complemented with effective use of data and technology, and stronger institutions, capacities, and communications. Planning for urban growth, green spaces, and land use is directly related to the magnitude and level of damage due to urban floods, and inter-agency coordination at the municipal and, in some cases the upstream river basin level is key to achieving success. *Urban transport authorities should not be passive actors in this coordination – the information they collect on the impact of floods on traffic and mobility is invaluable for other agencies' plans and preparedness actions.*

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Endnotes

1 Rashi Grover is a Consultant at the World Bank.
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6: DEVELOPING GENDER RESPONSIVE URBAN MOBILITY ECOSYSTEMS IN CHENNAI

Mitali Nikore,[1] Sarah Natasha,[2] Gerald Ollivier, Meera Sundararajan,[3] and C. Vaishnavi[4]

INTRODUCTION

Decoding the meaning of gender responsive urban mobility. Gender is a key socio-demographic variable that influences travel behavior but is often the least understood. Gender responsive urban mobility requires civic agencies to understand the mobility needs of all genders and designing public transport facilities which cater to these needs. Since such facilities are in public spaces, there is also a need to improve access, affordability, and safety in public spaces.

This note establishes the need for gender responsive[5] urban mobility solutions in Indian cities. It discusses the example of Chennai, where a Gender and Policy Lab (GPL) has been established by the government to bring this issue into focus. GPL has undertaken a range of initiatives for improving women's safety and participation in public transport and public spaces, following a structured four-pillar framework. The Chennai approach could be instructive for other cities looking at advancing the gender mobility agenda.

BACKGROUND

Despite women being amongst their biggest users, public transport systems across Indian cities do not fully understand their needs. Across Indian cities, women are more likely to rely on shared modes of transport as opposed to private vehicles, with between 30 percent to 50 percent women across 30 major cities citing public transport as their main mode of travel.[6] Recent surveys in the Delhi-National Capital Region (NCR) showed that nearly 56 percent of the women relied on public transport, versus only 44 percent men (the World Bank, 2023). In a first effort made to gather information with respect to women's travel patterns in a city, a citywide perception study on women's safety and mobility, conducted by GPL in 2023 showed that 40 percent of the travel undertaken by women was for work while 36 percent was for buying household essentials and 20 percent was for education. Bus was the most used means of transportation, followed by autorickshaws. Chennai has championed efforts to ensure the safety and convenience of women in public transport, by offering free travel on certain state-operated buses,[7] providing women-only buses and metro coaches,[8] installing cameras and panic buttons on buses,[9] and collecting gender disaggregated data,[10] there is still a significant need to deeply understand their requirements and implement data-driven initiatives for making public transport services responsive to the needs of women and persons of minority genders.

Lack of safe public transport options deters women from stepping into public spaces. Women's mobility is more likely to be impacted by unsafe experiences and personal safety concerns. As a result, women are often hesitant to travel alone, particularly late at night. Even when a woman does not face direct violence, the fear of what might happen,[11] lack of effective grievance

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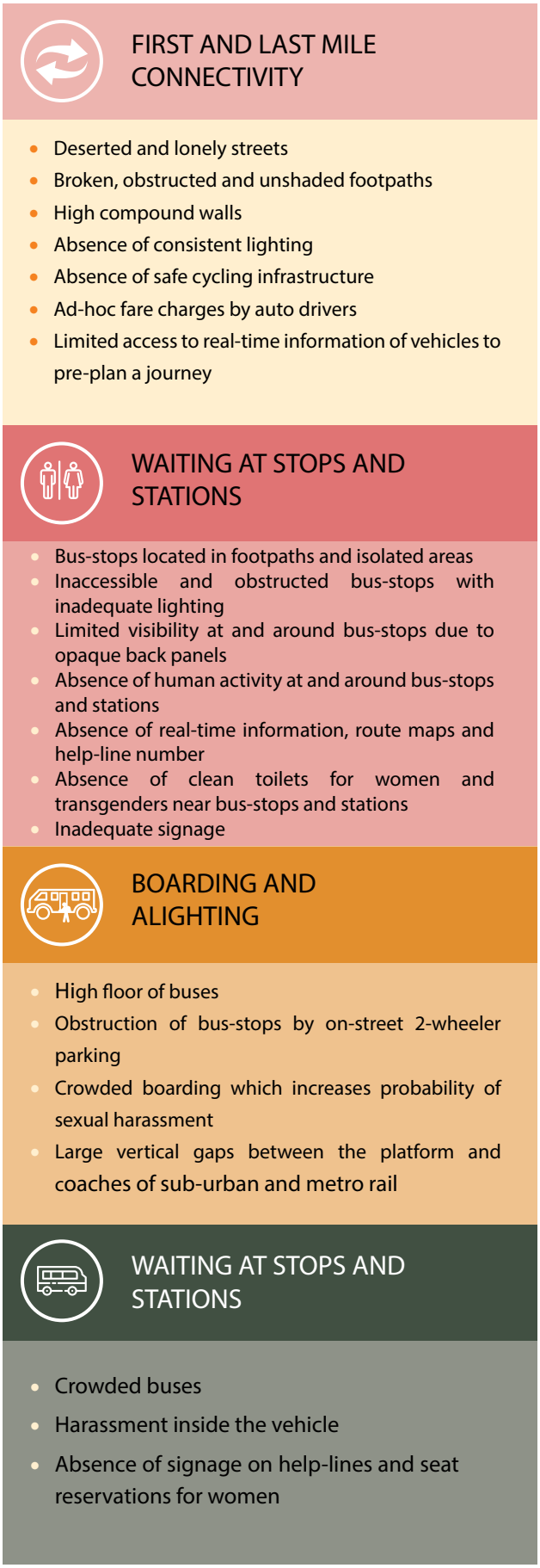
redressal mechanisms, and dysfunctional emergency helplines remain deterrents.

While Chennai is considered relatively safer for women among southern cities, studies highlight the need for improved gender-sensitive infrastructure and awareness to address mobility restrictions and underreporting of harassment cases. Southern cities in India, especially Chennai, are often regarded as relatively safe for women. However, World Bank-supported studies, such as a gap analysis conducted in 2021 and a perception study in 2023, highlighted areas for improvement in ensuring women's safety and mobility in Chennai. These studies revealed that safety concerns sometimes lead women to restrict their movements, particularly during certain times of the day when they perceive harassment to be highest. The studies also identified gaps in gender-sensitive infrastructure and a lack of awareness about helplines available to women in distress, which may contribute to underreporting of harassment cases. Addressing these challenges is essential to further enhance Chennai's reputation as a safe and inclusive city for women.

Women face barriers in using public transport at every stage of their journey owing to design elements that are not gender informed - during access and egress, waiting at stops and transfers, boarding and alighting, and inside the vehicle (Figure 6.1). Women tend to travel shorter distances within a limited geographical radius and are more likely to travel with dependents during off-peak hours for unpaid care work, often referred to as mobility of care. Moreover, given the need to balance household and work responsibilities, women typically combine multiple tasks necessitating several short trips, that is, trip chaining, rather than taking a unimodal, long trip from origin to destination. Consequently, they end up paying higher fares for frequently changing direction, modes of transport, and breaking their journeys. They also have off-peak needs that are often underserved.

Mobility barriers restrict women's choices for education and employment. Several studies have found that mobility concerns about commuting safely to workplaces, commuting during late evening hours, or commuting further than a particular radius are among the most common impediments to women's workforce participation, education, and skilling opportunities. These mobility barriers can therefore impact women's aspirations for work and education and ultimately their financial independence and agency.

FIGURE 6.1: GENDER SPECIFIC BARRIERS ACROSS THE PUBLIC TRANSPORT JOURNEY



Source: The World Bank (2022). India - Toolkit for Enabling Gender Responsive Urban Mobility and Public Spaces. http://hdl.handle.net/10986/38199

Transport planning is not gender informed due to various systemic and societal factors. Government agencies typically lack technical capacity such as gender mobility specialists, contributing to the lack of understanding and consideration of the unique mobility needs and patterns of different genders. Stakeholder consultations, which are crucial for inclusive planning, are often limited and do not reach as many women as men. This lack of representation can lead to plans that inadequately address the needs of all genders. Additionally, systems for collecting and analyzing gender-disaggregated data on travel patterns and behavior at the city-level remain underdeveloped. Without such data, it is challenging to accurately understand and address the different mobility needs of men, women, and persons of minority genders. Current policies often fail to mandate the inclusion of gender perspectives in urban mobility planning, resulting in insufficient resource allocation. These gaps lead to a lack of comprehensive strategies addressing the diverse needs of all genders, perpetuating inequalities in urban mobility. Vienna is a long-standing example of gender mainstreaming in urban planning and its model can be adopted by Indian cities suited to local conditions (Box 6.1).

BOX 6.1: GENDER MAINSTREAMING IN URBAN PLANNING, CITY OF VIENNA

Vienna has carried out more than 60 initiatives that have used gender mainstreaming, including street lighting projects, widening pavements for buggies, additional seating, apartment complexes and social housing designed by and for women, and improving the safety of shortcuts and alleyways by adding mirrors.

The key features include:

- Gender sensitive transport planning: Large-scale survey of gendered transportation use was carried out, which resulted in a long-run focus on improving pedestrian access.
- Gender budgeting: There is a legal obligation to carry out gender budgeting.
- Increasing women's representation: There are binding targets for a balanced gender ratio at all levels of decision making.
- Gender-sensitive infrastructure in parks: Special focus is planned on safety features, such as footpaths being clearly visible and parks being well-lit.

APPROACH IN CHENNAI

The Gender and Policy Lab in Chennai

Enhancing women's safety in Chennai has been a longstanding government priority. The Government of India launched a national scheme for enhancing women's safety, Nirbhaya, in 2012-2013. The scheme focuses on improving women's safety in public spaces through improvements in policing (for example, more women officers, women's distress helplines, better infrastructure for rape kits) and enhancing investments in safe urban infrastructure, and creating one stop centers for survivors.[12] Between 2015 and 2023, Chennai was among 8 Indian cities implementing the Safe Cities component of Nirbhaya, with a budget of nearly Rs 425 crore allocated by the Government of India and Government of Tamil Nadu. The Nirbhaya program was implemented through the collaborative efforts of multiple organizations: GCC, MTC, the Greater Chennai Police (GCP), and the Social Welfare and Women's Empowerment Department (SWWE).

A gender gap assessment for urban mobility ecosystems in Chennai revealed major women's safety issues. A detailed gender gap assessment supported by the World Bank in 2021 revealed several areas which required attention by the implementing agencies involved in the Nirbhaya program. Safety emerged as a major concern among women across all modes of public transport. Women shared facing sexual harassment at all times of the day and the harassment increased in the evenings and night. Pervasive lack of awareness of the 181 and 1091 helplines for women in distress compounded the challenge. Moreover, lack of gender sensitive infrastructure on buses, metro rail, and at stations and terminals, including the absence of women's toilets, difficulty in boarding/alighting, and crowded vehicles emerged as key barriers to their mobility. The assessment recommended the establishment of a nodal agency for streamlining the interventions under Nirbhaya and coordinating across implementing agencies for impact.

GPL was established with a vision of enhancing women's safety and inclusion in Chennai city. It was established through funds from the Nirbhaya program in February 2022 and became a nodal agency in GCC.

GPL was operationalized as a part of the Chennai City Partnership between the Government of Tamil Nadu and the World Bank, and officially launched in April 2022 (Figure 6.2). The objectives of GPL are:

- Improving women's access to opportunities by improving safety and gender responsiveness in public spaces and public transport through a multi-pronged collaborative approach.
- Mainstreaming gender inclusivity so that it becomes a process and a natural element in all city-level planning and service delivery decisions.

GPL is building a coalition of partners for gender responsive urban mobility in Chennai. It plays a crucial role in convening government departments, civil society organizations, elected representatives, and academic institutions with the objective of providing women with safe, comfortable, and accessible public spaces. Of note, it works closely with implementing agencies of the Nirbhaya program, GCC, MTC, GCP, and SWWE apart from CUMTA and CMRL for effective coordination and leveraging synergies even within the government. Figure 6.3 summarizes GPL's role and structure.

GPL's organizational structure. GPL operates in a multi-stakeholder environment. The core GPL team comprises of three full time experts including a team leader, a policy specialist, and a communications specialist. The team supports a working group of high-level government officials from different departments, responsible for setting the vision for the city. GPL is advised by a voluntary advisory committee comprising national and state-level experts including academics and practitioners, as well as by a team of experts from the World Bank.

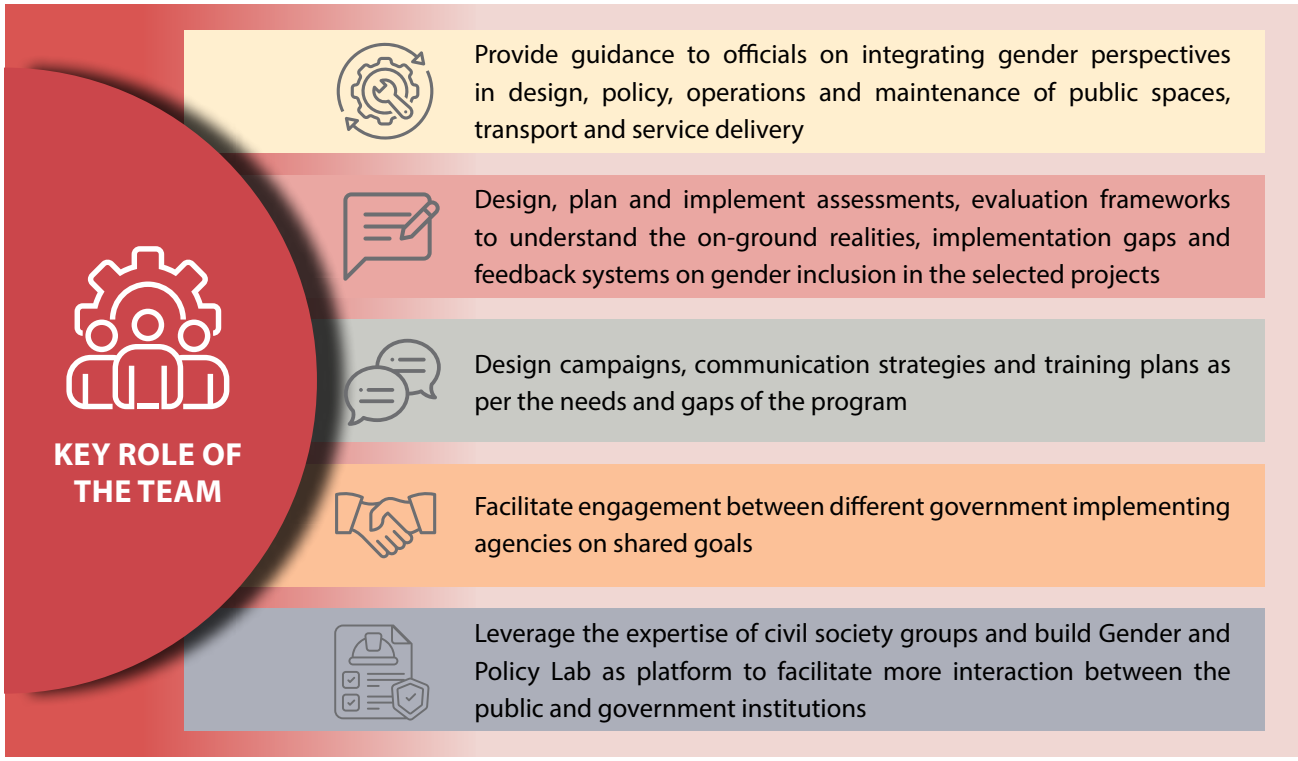
Initiatives of the Chennai Gender and Policy Lab – experience in the first year

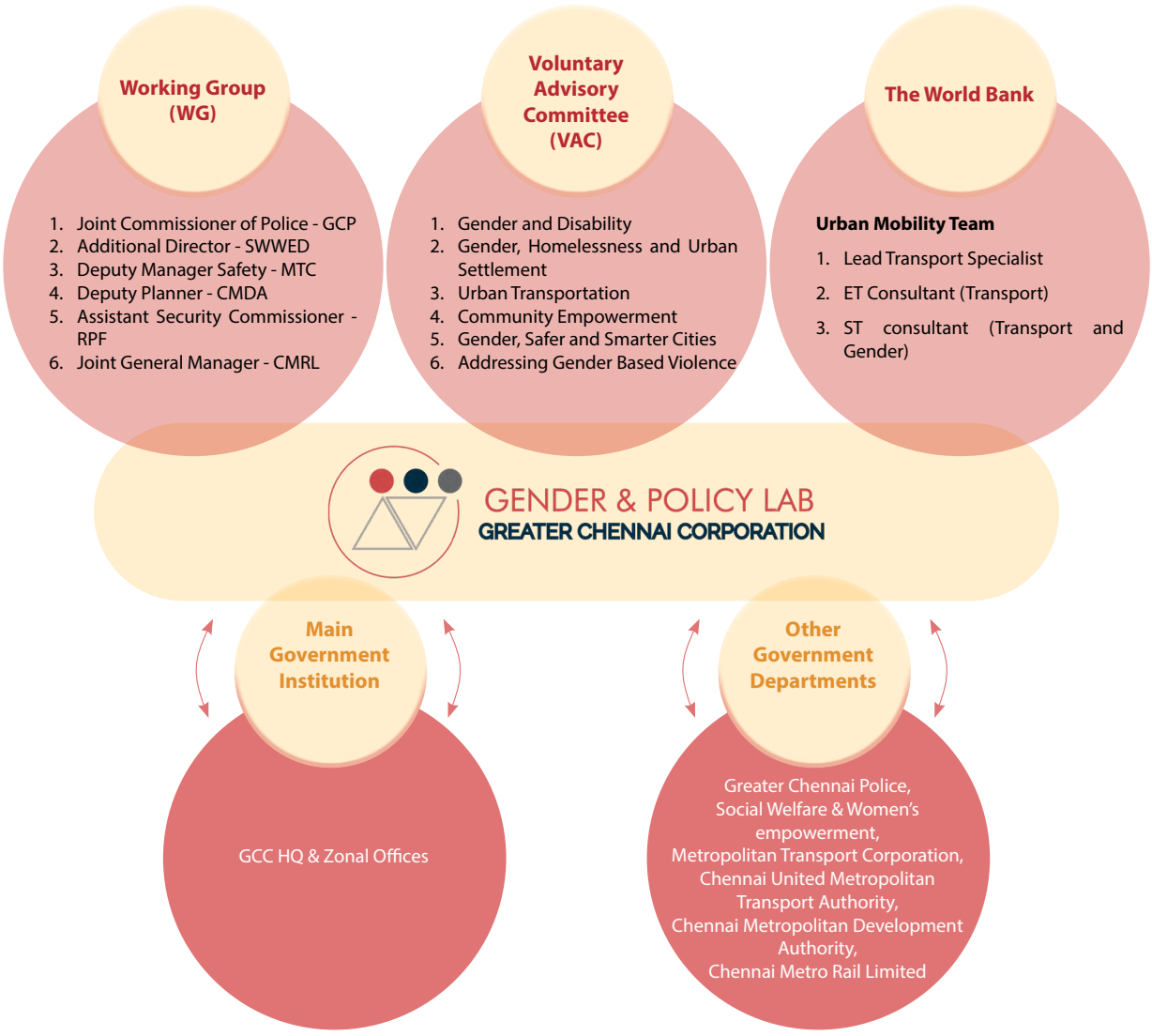
Key elements of a gender responsive urban mobility program. The World Bank's Toolkit for Enabling Gender Responsive Urban Mobility and Public Spaces in India[13] recommends interventions for addressing gender-based barriers in urban mobility and public spaces under four pillars (Figure 6.4) to be pursued simultaneously:

FIGURE 6.2: LAUNCH EVENT OF GPL (APRIL 2022)

Source: The WB team.

FIGURE 6.3: KEY ROLES AND ORGANIZATIONAL STRUCTURE OF THE GPL TEAM



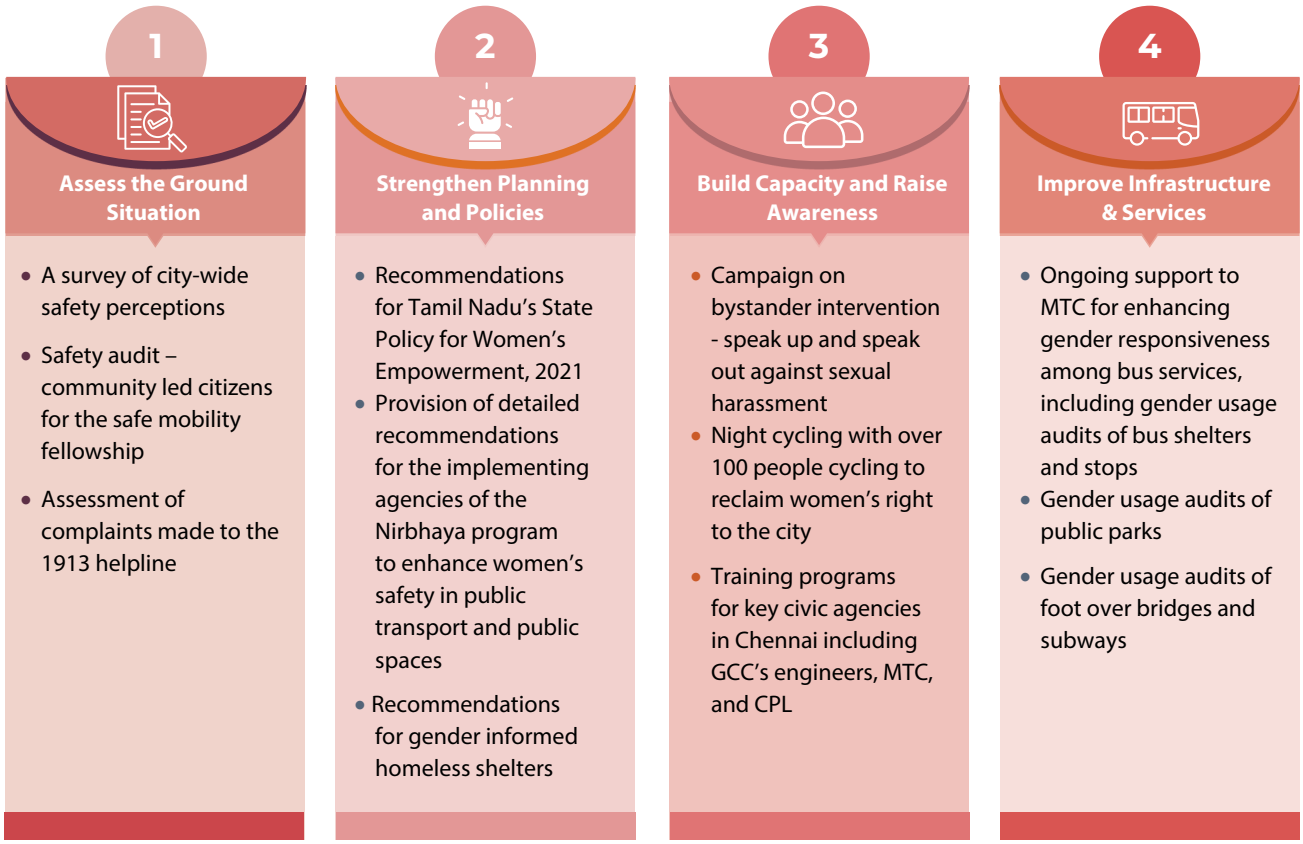


Source: GPL Annual Report (2023).

Pillar I	Assessing the ground situation for understanding gender-disaggregated mobility patterns, safety concerns, and expectations of women commuters, policies, mindsets of duty bearers and right holders, and level of gender inclusivity in the built infrastructure and transport services.
Pillar II	Strengthening policies, supporting legislations, regulations, guidelines, plan documents, and other manuals, by suitably incorporating a gender lens.
Pillar III	Building the capacity of duty-bearers responsible for implementing policies, plans, programs, and projects and raising awareness among duty-bearers and rights holders at the community level.
Pillar IV	Improving the design of the infrastructure and introducing gender responsive services for improving the inclusion and safety of public transport and public spaces.

GPL is exemplary in putting theory to practice. GPL has structured its efforts on the four-pillar framework. A brief snapshot of the key activities undertaken by GPL under each pillar is presented in Figure 6.5 (based on its first annual report).

FIGURE 6.4: FOUR PILLAR FRAMEWORK – KEY ELEMENTS OF THE GENDER RESPONSIVE PROGRAM



Source: The World Bank (2022). India - Toolkit for Enabling Gender Responsive Urban Mobility and Public Spaces. http://hdl.handle.net/10986/38199

FIGURE 6.5: GPL'S ACTIVITIES ORGANIZED UNDER THE FOUR-PILLAR FRAMEWORK

Pillar 1	Pillar 2	Pillar 3	Pillar 4
Assessing the ground situation	**Strengthening planning and policies**	**Building capacity and raising awareness**	**Improving existing infrastructure**
City-wide safety perceptions survey • With an aim to understand gender differences in mobility needs & factors leading to lack of safety, a survey of 3,000 respondents (2,400 women, 100 transgenders, 500 men) was held at households, transit points, public spaces • Based on the MTC's ticketing data, the top 10 routes spreading across 250 locations covering 500 bus shelters and the surrounding 50m ecosystem have been assessed to prioritize infrastructure in these routes • Consultations and studies have been held to understand usage of parks , public toilets, community halls, beaches.	Recommendations for Tamil Nadu's State Policy for Women Empowerment, 2021 • Highlighted linkages of gender responsive urban mobility with economy, education, skilling, and elimination of violence against women	Speak Up, Speak Out Against Sexual Harassment • Bilingual safe mobility campaign in Tamil and English in MTC buses over 2 days • Publicized panic buttons installed in buses through street plays • Bilingual informative flyers with 5 key steps to follow if one faces sexual harassment distributed to over 600 persons • Initiated a city wide campaign in August 2024 on bystander intervention using two short video films made to build awareness. Launched by the honorable mayor at a public park, the campaign incorporates on ground and social media based initiatives to reach the public with the tag line "Thappunu therinja Pattunu Kelu" (If you think something is wrong, question it	• 81 Bus stops have been sanctioned as the result of Gender Lab's study on Bus routes for a cost of Rs.12 crores • 3 Pedestrian pathways identified through the mobility study are being prioritized and developed for a cost of Rs. 4 crores • 16 gyms for women under the brand, 'Empowher' havebeen established across the city with Gender Lab's list of women friendly gym equipments as part of Mayor Announcement • 30 new parks developed under the TNHUB scheme adapted the Gender and Policy Lab's checklist for gender inclusive infrastructure during the DPR process • 176 Locations in 2023 and 151 locations in 2024 have been provided new lights based on 1913 dark spot identification

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Pillar 1	Pillar 2	Pillar 3	Pillar 4
			
Assessing the ground situation	**Strengthening planning and policies**	**Building capacity and raising awareness**	**Improving existing infrastructure**
Safety audits – the citizens for safe mobility initiative was held where a group of 22 citizens were trained to undertake safety audits across 47 locations in the city • 196 points closely studied for security, cross verifying response time through 100 police helpline	Developed inputs for the Chennai Intelligent Transport System to make it gender informed	• Training for 162 high/ higher secondary and middle school teachers on implementing gender training for children in classes 8th and 9th through a gender club program conducted every week in the school • Impact assessment of the training in middle schools has indicates positive results in terms of knowledge andbehavior change with more interactions between boys and girls and some parents reporting greater participation of male children in household chores. The program is now being implemented in 49 schools in the extended areas of GCC.	
Gender gap assessment of women workers in solid waste management • Visits by GPL team to the areas managed by the GCC contracted companies engaged in solid waste management to understand the specific needs of solid waste management workers of which most are women .	Recommendations for gender informed homeless shelters • Advisory provided to the Health Department and the shelters team • The grievance redressal process in 1913 helpline has been improved to capture	Night cycling ride with over 100 individuals cycling to reclaim women's rights to the city	

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Pillar 1	Pillar 2	Pillar 3	Pillar 4
			
Assessing the ground situation	**Strengthening planning and policies**	**Building capacity and raising awareness**	**Improving existing infrastructure**
• In the year 2024, a joint study has been conducted by GPL in collaboration with the LEAD at KREA University team to understand the problems faced by women who work in public spaces. This study that has covered a sample of 491 women including 411 women engaged in solid waste management, 30 in platform based delivery and 50 in postal services.	gender -specific infrastructure concerns from citizens • A citywide gender inclusive infrastructure manual covering 16 infrastructures handled by the Urban Local body has been prepared after audits and extensive consultations		
Assessment of complaints every year made to the 1913 helpline • Almost 230,000 complaints made to the helpline between July 2021- July 2022 assessed to gauge women's safety concerns		Training programs for key civic agencies in Chennai • Gender mainstreaming training with GCC engineers • Safety audit training for GCC, MTC, CPL, and other agencies • Review of 181 helpline with the SWWE department	

Source: GPL Annual Report (2023).

As an illustration of specific initiatives led by GPL, a city-wide perception study on the safety of women in public transport was completed in 2023. The study illustrates GPL's convening power and thought leadership when it comes to understanding women's perspectives on public transport and identifying concrete solutions for addressing them. The GPL team conceptualized this first-of-its-kind study in India in partnership with the World Bank, consulting several implementing agencies in Chennai including the Social Welfare Department, the wider teams at GCC, GCP, CMRL, MTC, and other relevant stakeholders. Based on a survey of 3,000 respondents across Chennai, the results of the perception study broke many previously held myths about gendered mobility patterns. This study now forms a bedrock for future planning for safety and inclusion related interventions in the city.

Results from local area safety audits prompted the installation of streetlights and public toilets, giving GPL the momentum to initiate citywide improvements in a

FIGURE 6.6: KEY RECOMMENDATION AREAS FOR BUS SHELTERS AND STOPS

Source: GPL Annual Report (2023).

single comprehensive bus stop project. GPL conducted visits to numerous bus stops across the city and gathered inputs from women for developing a comprehensive manual on bus shelter design and locations. The manual incorporates national accessibility guidelines and includes recommendations from international sources on bus stop locations (Figure 6.6). These recommendations have been integrated into the tender for the construction, renovation, and maintenance of modern bus shelters, with work set to commence shortly.

CURRENT IMPACT

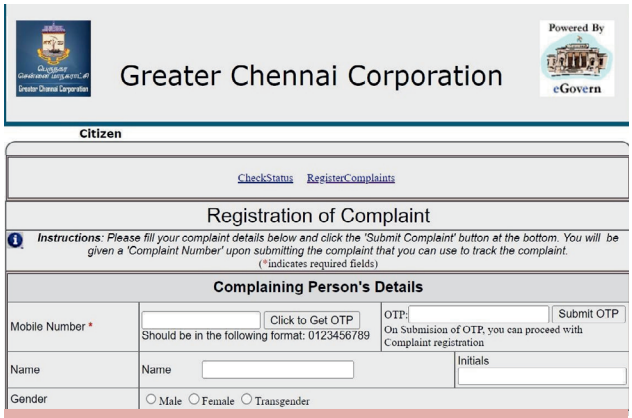
GPL's efforts are making Chennai city safer and more inclusive for women. Preliminary results (Figure 6.7) show that GPL has made substantial progress in its first year in identifying the primary factors contributing to the perceived lack of safety in the city. It is also working towards standardizing gender-responsive elements in infrastructure design guidelines. Most notably, the GPL team has succeeded in raising awareness and enhancing the capacity of government agencies to understand the necessity for gender-responsive urban mobility ecosystems in the city.

Way forward for GPL. GPL aims to expand collaborations with various government agencies and external stakeholders, shifting from evaluations to direct investments and action. It will craft gender-focused guidelines for all mobility and infrastructure initiatives and assist government departments in developing gender-responsive budgets, with the goal of ensuring that public spaces and transportation are safe, inclusive, and accessible. Furthermore, GPL intends to strengthen partnerships with external entities like consulates, bilateral and multilateral financing agencies, academic bodies, think tanks, and the private sector drawing on their expertise and resources to enhance safety and inclusivity for women and gender minorities in Chennai.

In the short term, the GPL team plans on working with relevant city-level agencies on finding solutions to challenges highlighted in the Safety Perception study undertaken in 2023, including increasing awareness of the 181 helpline, improving street lighting, visibility, and walkability in the city, as well as devising clear response mechanisms to incidents of sexual harassment. The GPL team plans to undertake a safety audit of key areas identified as unsafe in the safety audit, and work with GCP for enhancing patrolling. Moreover, the GPL team also plans to increase cooperation with MTC to expand services on bus routes frequented by women. In addition, the GPL team wishes to expand capacity building activities for all agencies including both technical and gender sensitization training. GPL is also

FIGURE 6.7: GPL'S KEY ACHIEVEMENTS IN YEAR ONE

The GPL team has provided detailed recommendations to the Nirbhaya program implementing agencies and different departments in the Government of Tamil Nadu for enhancing women's safety in public transport and public spaces.



As a result of all safety audits, plans to enhance safety at 65 locations for lights, 23 for public toilets, 43 approach roads, 10 bus stops, 5 bus terminuses, and 18 railway stations submitted to relevant authorities.

The Electrical Department has successfully addressed inadequate street lighting by sanctioning 425 new light posts across 152 locations, enhancing nighttime visibility and safety.

A manual with a checklist for gender-informed bus stop design has been developed and adopted by MTC.

Progress is underway with the refurbishment of two foot-over-bridges by GCC and a review of GPL's recommendations for subway enhancements.

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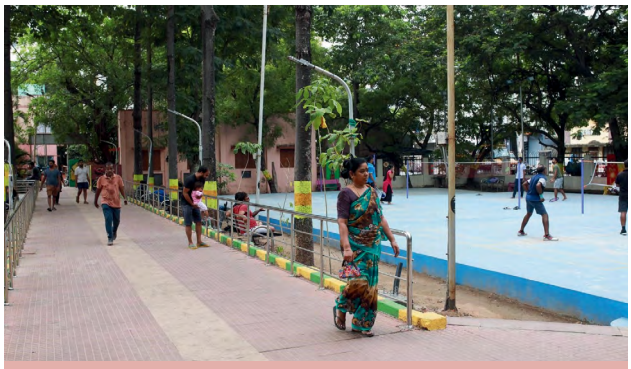

GPL's checklist for inclusive park infrastructure is set for implementation by GCC's Parks Department, including sexual harassment prevention training for park watchpersons.

Three internal complaints committees have been established in GCC zones to address workplace grievances.

As a result of all safety audits, plans to enhance safety at 65 locations for lights, 23 for public toilets, 43 approach roads, 10 bus stops, 5 bus terminuses, and 18 railway stations submitted to relevant authorities.

Gender considerations have been incorporated in the Standard Operating Protocols for Urban Homeless Shelters, and the criteria for NGO partnerships have been refined.

Citizen awareness regarding responses to sexual harassment on buses and the use of the 181 Helpline has significantly increased.

Public awareness about women's rights to accessing the city during late hours has seen growth.

Sources: GPL Annual Report (2023); the WB team.

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developing a gender handbook for urban planning that will bring together all the gender inclusive requirements in infrastructure development for the city.

Similarly, considering the importance of Gender inclusiveness in urban development, the Chennai Metropolitan Development Authority (CMDA) intends to evolve its Third Master Plan for CMA as a Gender-inclusive plan. In this regard, CMDA has recently taken up a study titled 'To formulate strategies for Gender Inclusiveness in CMA'.With the primary objective of mainstreaming gender-inclusive development in the Third Master Plan through spatial planning efforts. This study aims to develop practical and feasible strategies, measures, and recommendations to foster an inclusive, safe, accessible, and sustainable environment for all genders in the Chennai Metropolitan Area (CMA). It will specifically focus on addressing gender disparities from a spatial urban planning perspective by assessing key areas such as the availability, accessibility, and safety of infrastructure, mobility, and public spaces/facilities within the CMA.

TAKEAWAYS FOR OTHER CITIES

GPL's experience offers valuable takeaways for other cities looking at strengthening gender responsive urban mobility:

- **New entities need a combination of technical knowledge, political will, and dedicated leadership to succeed.** While some of the success factors relate to the technical expertise available both within the GPL team and through the support offered by the voluntary advisory committee and the World Bank teams, progress would not have been possible without strong political will, leadership, and collaboration between civic agencies.

- **City level activities that are well aligned with state and national governments' priorities are more likely to receive support and generate political will.** Linking GPL activities with state and national priorities through the Nirbhaya program created a strong political will. The establishment and functioning of the Gender Lab were in line with the flagship national level Nirbhaya program. This allowed GPL's interventions to get high priority in the implementing agencies. Moreover, being a young woman herself, the Mayor of Chennai also prioritized GPL's activities and lent her support, particularly for initiatives aimed at raising awareness amongst communities.

- **Coordination is key to breaking down silos across agencies - essential for the cross-cutting efforts required for enhancing gender responsive urban mobility**. In addition to partnerships with the Nirbhaya program implementing agencies, GPL activities were also linked with the implementation of CCP.[14] This allowed GPL to form partnerships with not only MTC (a Nirbhaya program implementing agency), but also with the Chennai Unified Metropolitan Transport Authority, the Chennai Mass Rapid Transit System, and the Chennai Metro Rail Corporation, which are all involved in CCP implementation. Representatives from these organizations formed a collaborative working group to break down operational silos, allowing for mutual benefits from shared efforts. For instance, MTC plans to collect gender disaggregated ticketing data soon. Once collected, this data will be used by GCP to augment patrolling on routes heavily used by women, demonstrating a practical approach to leveraging shared data for improved safety and service.

- **Continuous capacity building efforts are critical for equipping officials in implementing agencies with relevant skills and technical tools for gender mainstreaming**. Over the last two years, GPL, in partnership with the World Bank and several other agencies, has organized gender sensitization training and technical training on gender mainstreaming for officials from GCC, CUMTA, and MTC.

- **Gender mainstreaming becoming a standard requirement for the clearance of all project proposals is key to inclusive mobility.** All proposals, tender documents, studies, and policies regarding public transport and public areas were vetted by GPL to ensure that they incorporated gender perspectives. In the last two years, GPL has contributed to the design of smart streets, bus stops, parks, and public restrooms by specifying requirements for gender sensitive infrastructure and services in tender documents. Additionally, GPL is presently supporting CUMTA in the development of the comprehensive mobility plan, aiming to cater to the specific requirements of all genders. GPL has initiated a significant project by commissioning the creation of a Gender Inclusive

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Design Manual, tailored to the local context in the Chennai metropolitan area. This manual is intended to serve as a comprehensive guide for infrastructure project agencies, enabling them to incorporate gender considerations in the planning, design, and construction of public spaces. These initiatives mark a critical step towards creating more inclusive and equitable urban environments.

- **Gender disaggregated data is critical for developing infrastructure and service enhancements for inclusive mobility.** Under CCP, GPL has initiated processes for the collection and analysis of gender-disaggregated data, which includes surveys and focus group discussions involving both users and non-users across all genders. Safety audits are being conducted to gather extensive information about the utilization of public spaces by women and individuals of minority genders, leading to infrastructural improvements such as enhanced street lighting and footpaths. In addition to this, GPL has mandated the collection of gender-disaggregated data in the tender for the automatic fare collection system for MTC buses. This data will facilitate informed route planning, scheduling, and the implementation of gender-sensitive services. GPL scrutinizes data from surveys, audits, and group discussions, converting it into actionable projects equipped with schedules and financial plans. This approach streamlines project execution, making the outcomes and requirements transparent to decision-makers.

CONCLUSION

Cities are innovation hubs with large markets that can attract investments, knowledge, and skilled personnel and lead to innovations thereby generating economic opportunities. It is projected that Indian cities could contribute up to 70 percent of India's GDP by 2030 (MoHUA 2021).[15] There is a growing aspiration amongst women, girls, and other gender minorities to take advantage of better employment, education, healthcare, and leisure that cities provide. Indian urban local bodies and public transport authorities are also increasingly recognizing the gender-disaggregated needs of diverse commuters and users of public spaces.

GPL's experience has shown that civic agencies aspiring to launch interventions for developing gender responsive urban mobility ecosystems and public spaces need dedicated institutional mechanisms. With strong political will, steadfast leadership, and a dedicated skilled taskforce, cities can implement structured programmatic interventions for achieving their long-term vision of safer and more inclusive cities for all.

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Endnotes

1 Mitali Nikore is a Consultant at the World Bank
2 Sarah Natasha is a Consultant at the World Bank
3 Meera Sundararajan is the Team Leader at the Gender and Policy Lab, Greater Chennai Corporation
4 C. Vaishnavi is the Policy Expert at the Gender and Policy Lab, Greater Chennai Corporation
5 Gender-Responsive Urban Mobility refers to the design, planning, and implementation of transportation systems and infrastructure that actively considers and addresses the diverse mobility needs and challenges faced by different genders. This approach aims to create inclusive, safe, and accessible transportation options that ensure equitable access for all individuals, regardless of gender.
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Photo credit: Anantakrishnan

7: DEVELOPING A METROPOLITAN ROAD SAFETY ACTION PLAN: CASE STUDY FROM CHENNAI

Krishnan Srinivasan[1], Sudeshna Mitra[2], Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

Safety is at the heart of the sustainable mobility agenda, and forms part of the UN Sustainable Development Goals (SDGs) (Figure 7.1).[3] Road crashes are a global public health problem, particularly in fast-growing cities in developing countries. Rising urbanization and disposable incomes are leading to rapid motorization without commensurate systemic changes to ensure the safety of all users: pedestrians, cyclists, motorcyclists, and four-wheeler occupants.

Cities worldwide are increasingly adopting the Safe System approach to push towards the goal of eliminating serious road trauma (Figure 7.2)**.** This approach looks beyond road user behavior and the safety of motorized vehicles to inclusiveness and every major element of the road traffic system, which affects safety.[4] It is particularly relevant to Indian cities where road safety issues abound, as do opportunities, levers, and the drive to improve the situation.

This note discusses a systematic approach to tackling rising road crash fatalities in Indian cities based on the Safe System principles and describes the relevance of road safety action plans to align stakeholders and impel action on road safety, using Chennai's example.

FIGURE 7.1: UNITED NATIONS' SUSTAINABLE DEVELOPMENT GOALS RELATED TO SAFETY

03 GOOD HEALTH & WELL-BEING	Ensure healthy lives and promote well-being for all at all ages	**3.6** **By 2020, halve the number of global deaths and injuries from road traffic accidents**
11 SUSTAINABLE CITIES AND COMMUNITIES	Make cities and human settlements inclusive, safe, resilient and sustainable	**11.2** **By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, natably by expanding pubic transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.**

Source: United Nations

FIGURE 7.2: THE SAFE SYSTEM APPROACH

Source: Small and Addo-Ashong (2021)

BACKGROUND

Road safety scenario in Indian cities

India faces a mounting road safety problem. Road crashes took 168,491 lives in India in 2022, causing immense social, physical, and financial distress to individuals, families, and society; 54,230 (33 percent) of these fatalities occurred in urban areas, with 17,089 (11 percent) recorded in the 51 cities with a population over a million.[5] While the share of urban road fatalities in India is lower than that in the European Union (40 percent),[6] urban road safety is a pressing concern considering that urbanization is set to almost double in India by 2030.

The road safety apparatus in India has not kept up with motorization trends. Rising urbanization, disposable incomes, and aspirations, coupled with the low cost of motorcycles and lack of viable public transport options, has led to rapid motorization (especially of two-wheelers). Between 2009 and 2019, motorization in India increased by 159 percent and that of two-wheelers by 166 percent. Consequently, road crash fatalities increased by 20 percent, with two-wheeler fatalities more than doubling over the same period. During the last 60 years, the length of the primary and the secondary road networks[7] increased annually by only 2.95 percent and 1.93 percent respectively,[8] whereas the vehicle population grew at a CAGR of 11.05 percent (Figure 7.3).[9] This led to increased competition for road space, and vehicles are often prioritized over vulnerable road users like pedestrians.

It is not all bad news. Some Indian cities have already successfully reversed their road crash situation through concerted action. For instance, between 2013 and 2022, New Delhi, Mumbai and Kolkata reduced their road fatalities by 20 percent, 26 percent and 58 percent respectively Comprehensive road crash data analysis and its annual reporting[10] and high-level monitoring have helped city agencies in these two cities with formulating and implementing data-driven interventions under all road safety pillars. Experience from developed countries also shows that a systematic approach to road safety can keep road crash trauma down, even as motorization goes up. This suggests that there is room to correct the course of road safety in Indian cities.

Chennai's road safety situation typifies that of other large cities in India in terms of a growing population, high levels of urbanization and motorization, and a high number of fatalities. Eleven cities including the big metros of Chennai, Delhi, Bengaluru, and Ahmedabad accounted for half of all city fatalities in the country in 2022 highlighting the need to focus on road safety in cities (Figure 7.4).

At first glance, the road safety situation in Chennai seems to have improved over time (Figure 7.5). The number of reported road crashes and injuries in CMA[11] has more than halved in the last decade from ~10,000 in 2013 to ~4,000 in 2022, but the number of fatalities has held steady, with an average of 1,150 fatalities in the same period. The severity of crashes and likelihood of death has in fact risen over time, highlighting the urgent need to tackle the road safety challenge systematically. ~4,000 in 2022, but the number of fatalities has held steady, with an average of 1,150 fatalities in the same period. The severity of crashes and likelihood of death has in fact risen over time, highlighting the urgent need to tackle the road safety challenge systematically.

Analyses reveal that vulnerable road users (VRUs - pedestrians, motorcyclists, and cyclists) are most at risk of death in road crashes in Chennai. Motorcyclists made up 57 percent of all fatalities, with pedestrians accounting for another third (Figure 7.6). For motorcyclists, speeding and/or non-wearing of helmets were key contributors. Speeding was a contributing factor in 75 percent of all road crash fatalities, whereas not-wearing helmets was a contributing factor in 48

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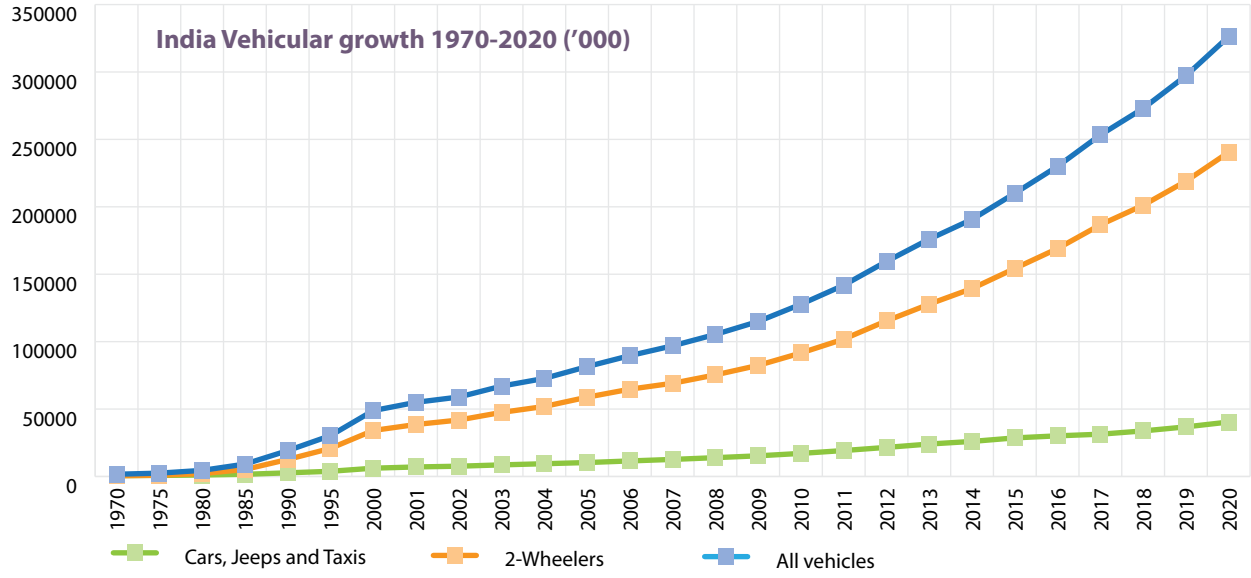
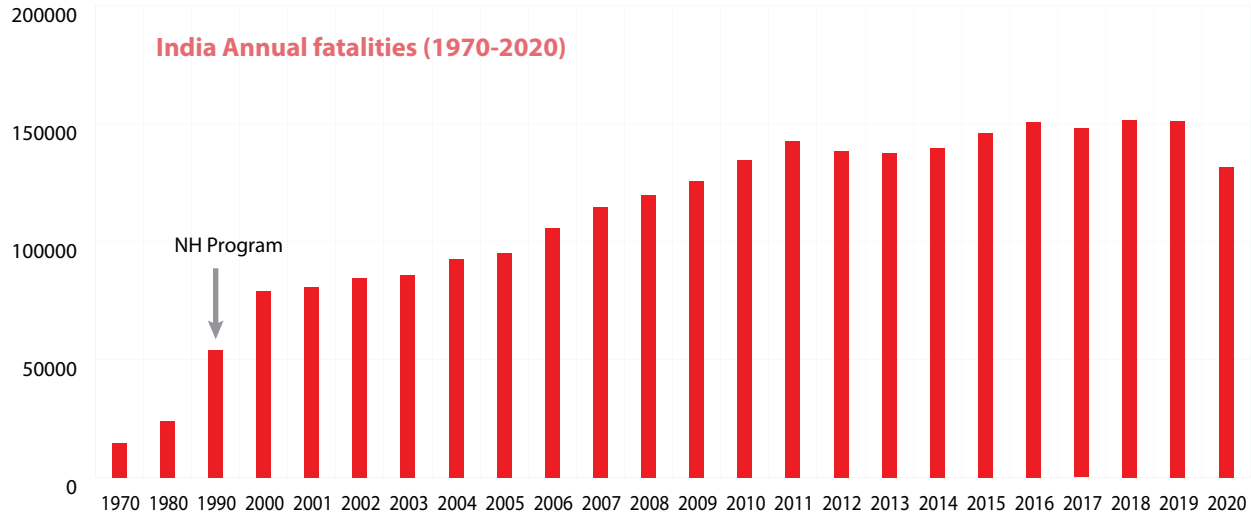
FIGURE 7.3: MOTORIZATION VIS-A-VIS ROAD FATALITIES IN INDIA 1970-2020

Rapid Motorization



Vehicle CAGR: ~11%

Rising Road Traffic Deaths



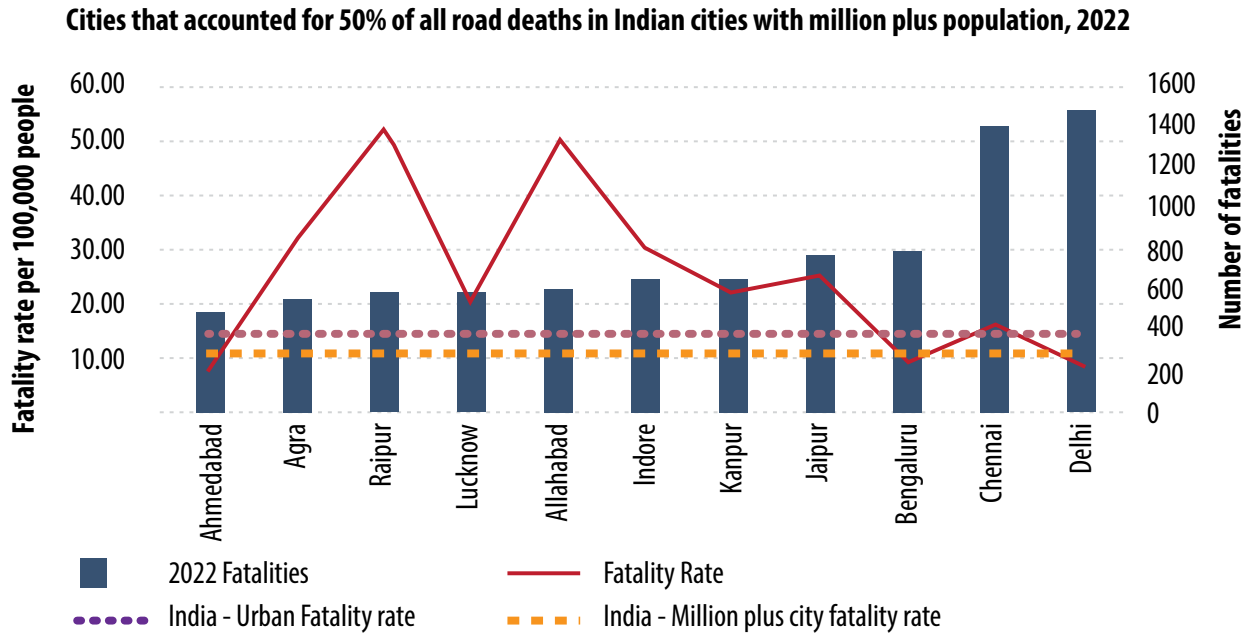
> 10-fold increase in fatalities

Source: Road Accidents in India 2012 through 2020, TRW, MORTH, GoI, New Delhi, October 2023; WB analysis.

percent of the fatalities (Figure 7.7). Most pedestrian fatalities were due to collisions with motorcyclists. Observational surveys revealed that nearly 40 percent of the vehicles exceeded posted speed limits in the city. In 2022, 32 percent of the two-wheeler riders and 97 percent of the pillion riders did not wear helmets. This points to a need to strengthen enforcement against speeding and not wearing helmets.

Road infrastructure and limited facilities for VRUs are major contributors to fatalities. Based on the International Road Assessment Program (iRAP) classification, 89 percent, 70 percent, and 26 percent of roads are rated 1 or 2-star (on a scale of 1 to 5 with 1 carrying the highest risk), for pedestrians, cyclists, and motorcyclists respectively. The high instance of speeding suggests the need for speed calming measures. Almost

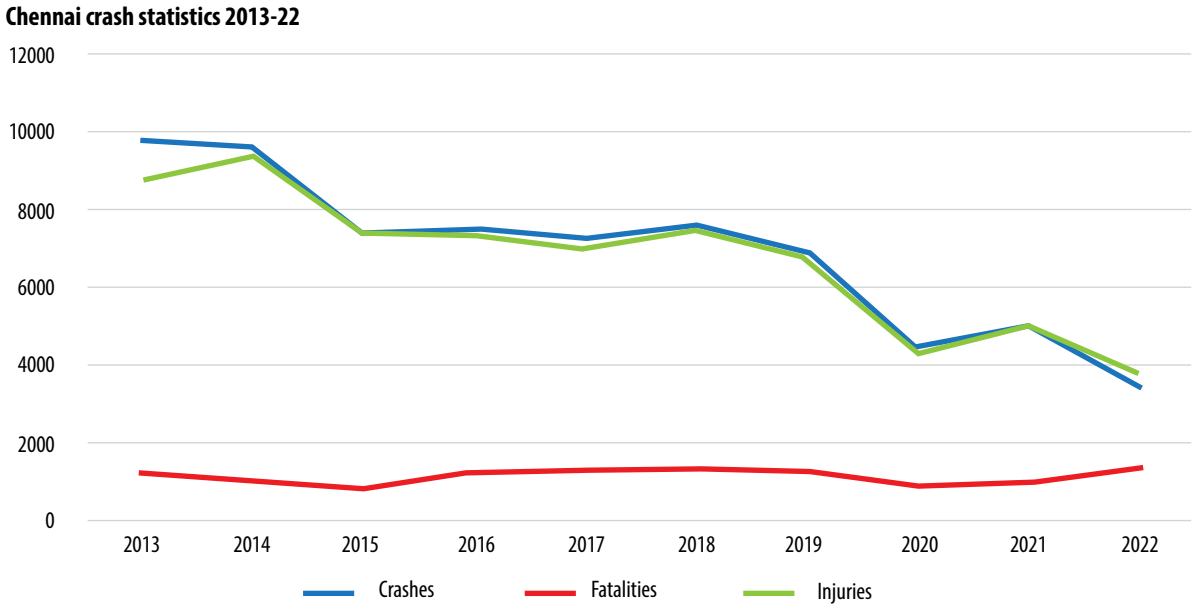
FIGURE 7.4: ROAD FATALITIES IN THE TOP 11 CITIES IN INDIA IN 2022



Source: Road Accidents in India – 2022, TRW, MORTH, GoI, October 2022; WB analysis.

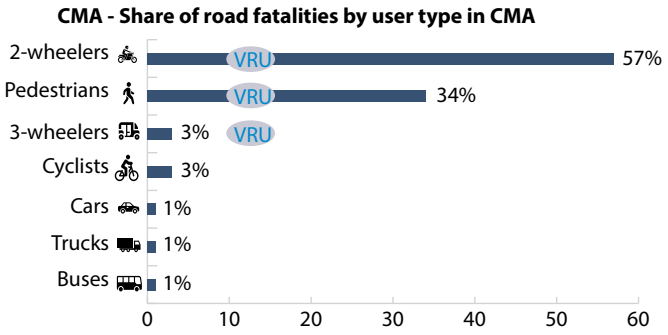
half of the motorcyclist fatalities and 41 percent of the pedestrian fatalities were due to impact with cars, trucks, and buses, highlighting the need for safer infrastructure for these users. At the central level, the Indian Roads Congress (IRC) is now formulating a new code for motorized 2-wheeler lanes. The Ministry of Road Transport and Highways (MORTH) recently proposed to develop such facilities on state highways and urban roads, which should help minimize safety risks to two-wheeler riders.[12] 64 percent and 29 percent of pedestrian crashes were at mid-block locations and junctions respectively, highlighting the need for better location and number of pedestrian crossing facilities, and improved facilities and reduced speeds at junctions. The city can benefit from safer infrastructure design for addressing VRUs' diverse needs.

FIGURE 7.5: CHENNAI ROAD CRASH STATISTICS, 2013-2022



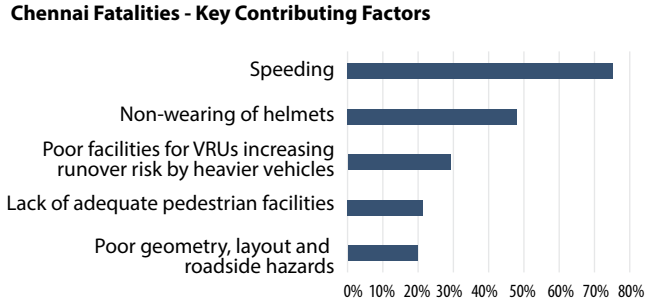
Source: Road Accidents in India, TRW, MORTH, GoI, 2022.

FIGURE 7.6: ROAD FATALITIES BY USER TYPE IN CMA, 2019



Source: GCTP.

FIGURE 7.7: CHENNAI ROAD FATALITIES - KEY CONTRIBUTING FACTOR



Source: DIMTS Report on CRSAP, Feb 2023; WB analysis.

Current efforts/initiatives/plans for reducing road traffic injuries

The Government of India, as well as the Government of Tamil Nadu have recognized the enormity and urgency of the road safety challenge and undertaken a range of actions (Figure 7.8). Notable among these is the enactment of the landmark Motor Vehicles Amendment Act in 2019 (see Box 7.1).

The reduction in road crashes in Tamil Nadu over the last decade is testimony to the government's efforts.[13] Tamil Nadu's road crashes came down by 7 percent between 2014 and 2019. Two-wheeler fatalities due to non-wearing of helmets fell by 28 percent from 2018 to 2019,[14] and emergency response times in urban areas came down by 4 minutes between 2016 and 2018 (with an average response time of 14 minutes).

Key underlying issues

The road safety challenges in India can be attributed to two key underlying issues: (i) rapid motorization combined with a vehicle-first mindset, and (ii) gaps in

BOX 7.1: KEY FEATURES OF THE MOTOR VEHICLES (AMENDMENT) ACT (MVAA), 2019

Road Safety Management: Mandates the creation of an independent apex body, the National Road Safety Board (NRSB), to set the national agenda and carry out the often-difficult coordination between the numerous agencies responsible for road safety in India and provide advice to the central and state governments on all aspects of road safety and traffic management. In addition, MVAA emphasizes the establishment of a nation-wide database that will highlight the cause of each crash.

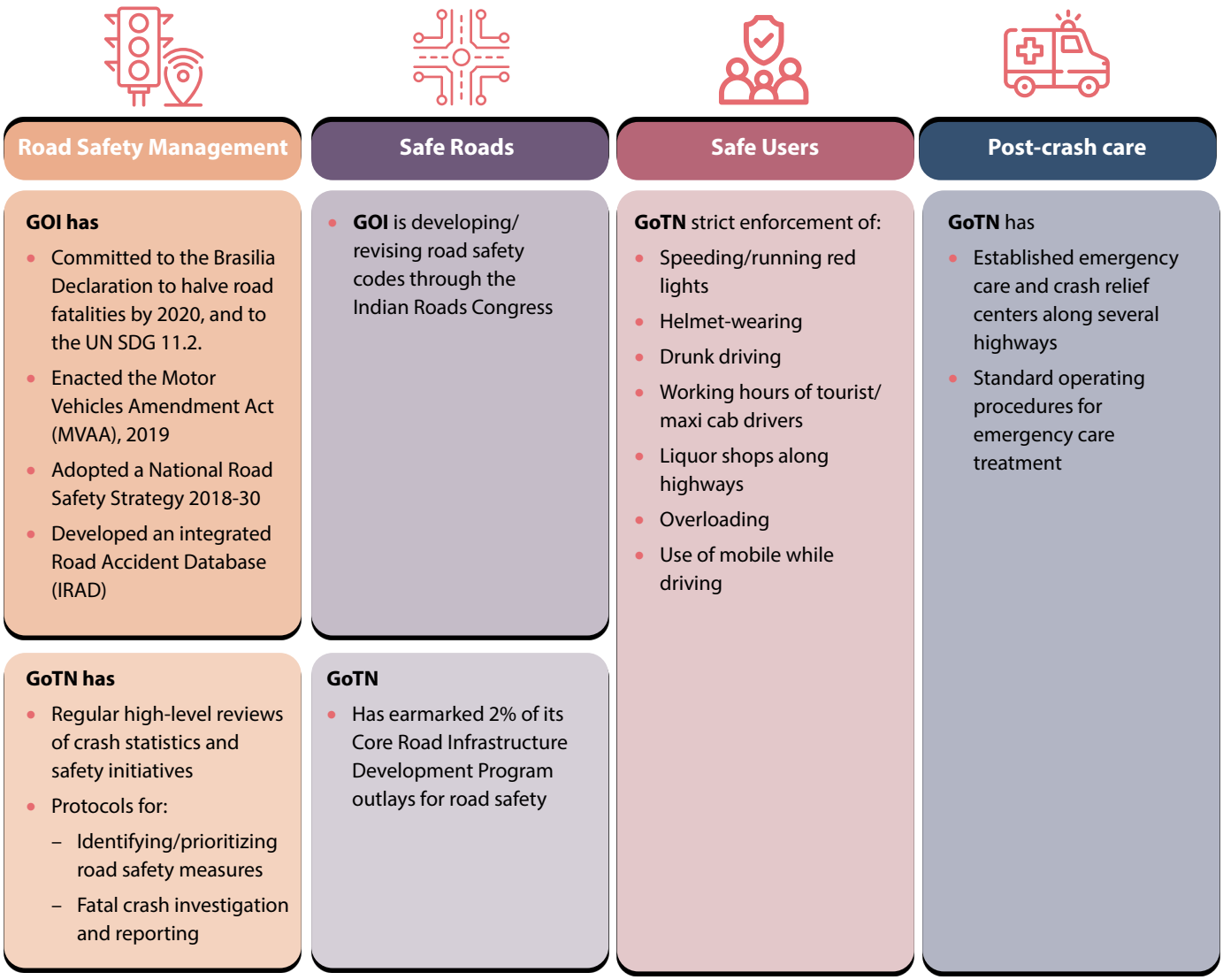
Safe Road Infrastructure: MVAA has provisions for holding all entities in road construction and maintenance - road agencies, contractors, consultants, or concessionaires - accountable for the roads constructed, including all new roads to undergo a safety audit during the design, construction, and operation stages.

Vehicle Safety: Strengthens vehicle regulations to bring India on par with major car manufacturing nations, by giving authorities the power to recall vehicles or vehicle components that are not found safe either for occupants and/or other road users. It includes provisions for the setting up of automated fitness centers throughout the country, with a centralized monitoring/audit mechanism in place.

Safe Road Users: MVAA streamlines the often-cumbersome systems for the registration of vehicles and the issue of drivers' licenses and reduces the need for manual interventions by enforcement agencies.

Post-Crash Care: Further strengthens the provisions of MVA to insulate Good Samaritans from harassment and prosecution when rendering emergency medical care/assistance, including transporting an accident victim to hospital, and provides for cashless emergency medical treatment.

FIGURE 7.8: EFFORTS AND INITIATIVES BY GOI AND GOTN IN ROAD SAFETY



Source: Learning from road safety outcomes in Tamil Nadu. Presentation by Transport Commissioner of Tamil Nadu, Road Safety Webinar by Gujarat Transport, Roads & Buildings Departments and the World Bank (November 2020). Document not available publicly.

institutional arrangements and capacity. These issues are elaborated below.

Motorization and a vehicle-first mindset. Urban development patterns and rapid motorization, met with a mindset that prioritizes vehicle movement over the safety of vulnerable road users, are contributing to road safety issues in the country. Cities such as Chennai have expanded over the last few decades along national and state highways and bypass roads which were once on their peripheries. These highways are now part of the core cities, and function more like urban arterial roads, but were constructed based on highway design codes, making them suboptimal for their evolved functions. The road safety challenge in India is exacerbated by rapid motorization, which is driven by growing urbanization and rising disposable incomes and aspirations, inadequate public transport, grossly inadequate facilities for VRUs like regular spaced crossings, and a heterogeneous traffic mix. Improvements in connectivity and better traffic flow for motor vehicles have been prioritized at the expense of VRUs and best practices in road safety.

Gaps in institutional arrangements and capacity. The road safety challenge is compounded by: (i) the absence of accountable and legally mandated entities at the state and city levels; (ii) gaps in institutional arrangements and lack of inter-departmental coordination for road safety management functions; (iii) low levels of enforcement; (iv) lack of technical capacity and limited exposure to best safety practices; and (v) limited use of data for decision-making and benchmarking of road safety management performance.

FIGURE 7.9: SETTING OF SPEED LIMITS IN CHENNAI

POSTED SPEED LIMIT
Maximum Speed allowed on a road section to be enforceable by law for overall safety

Roadway characteristics	The adjacent landuse	Traffic Characteristics	Other factors
• Type of Terrain • Functional Hierarchy	• Open • Residential/ Commercial/ Industrial • Educational	• AADT • %age of MTW • Presence of VRUs	• Lateral access points/cuts • Crash History • Footpath availability • Street lighting

Source: Presentation on Guidance Note for Speed Management, DIMTS, Chennai (15 December 2023).

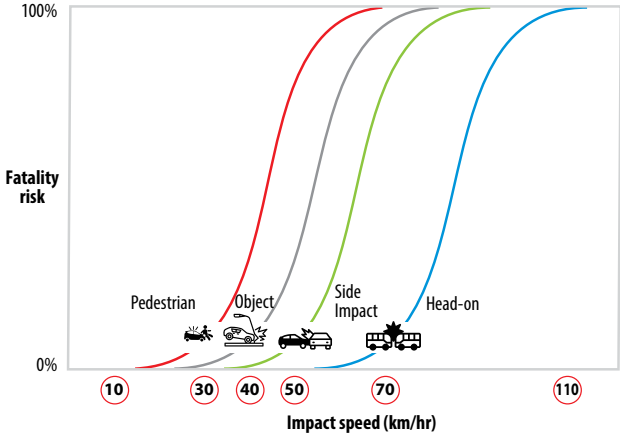
In most cities in India, institutional arrangements for road safety are dispersed across different state and district-level entities with limited accountability for delivery of road safety results at the city-level. As such, safety is not considered systematically in the design and operations of city road infrastructure. In Chennai too, this is the case with road safety responsibilities spread across the Highways and Minor Ports Department, Greater Chennai Traffic Police, and the State Transport Department.

Institutional fragmentation has real implications for road safety policies and enforcement. An example of this is the way speed limits are set in Indian cities. Ideally, the speed limit should be set by the road owning agency based on the functional class of the road, the predominant adjoining land use, number of lanes, traffic volumes, crash density, traffic mix, and other road environment features[15] (Figure 7.9). The speed limits need to be reinforced by infrastructure treatment which controls motor vehicles to a safe speed and is enforced by the police.

In practice, typically the design speed is taken as the posted speed limit, with little input from the works, transport, and police departments. The design speed is usually considered the maximum operating speed on a road from the perspective of motorized vehicles, and not based on all road users. As such, based on the current IRC standards, highways will be designed for a certain speed, based on their functional class, without regard to the adjacent land use, road, and traffic characteristics or other factors. Safety of vulnerable road users is meant to be addressed by reducing posted speed limits, traffic calming, and segregation of these modes by the district and city agencies. However, this is rarely done, exposing vulnerable road users to high crash risks.

In Australia, Netherlands, Norway, and Sweden, speed limits are set based on crash types, impact forces, and the human body's tolerance to withstand those forces. The risk of a fatality for a pedestrian involved in a motor vehicle crash, for example, sharply escalates beyond an impact speed of approximately 30 km/h (Figure 7.10). In OECD countries, speed limits in urban areas do not exceed 50 kmph with 30 kmph zones in areas where vulnerable road users (including children) are particularly at risk.[16]

FIGURE 7.10: FRAGILITY OF THE HUMAN BODY TO CRASH SPEEDS



Source: Job, RFS. and L.W. Mbugua (2020). Road Crash Trauma, Climate Change, Pollution and the Total Costs of Speed: Six graphs that tell the story. GRSF Note 2020.1. Washington DC: Global Road Safety Facility, the World Bank.

Determining a safe travelling speed for any road environment depends on the function, design, and use of the road. Table 7.1 shows safe speeds for several road types and potential conflicts – safe meaning a speed at which 90 percent of the crashes that take place will cause no serious injuries.[17]

TABLE 7.1: TYPICAL SAFE SPEEDS FOR ROAD AND SECTION TYPES

Road and section types combined with road users	Safe speed (kmph)
Roads and sections used by cars and vulnerable road users	30
Intersections with possible side-on conflicts between cars	50
Intersections with possible frontal conflicts between cars	70
Roads with no possible frontal or side-on conflicts between vehicles and no vulnerable road users present	100 +

The practical implications of this in Chennai are that in residential and high pedestrian areas, including junctions, motor vehicle speeds need to be significantly reduced to around 30 kmph. Speed reductions of just 5 kmph can reduce fatalities by up to 30 percent.[18] However, typically speed limits in Chennai (and other Indian cities) are set based on the design speeds for specific functional classes of roads, which may be much higher than what is appropriate given the urban context.

Developing and implementing a Road Safety Action Plan

International best practices

Cities around the world have sought to resolve road safety challenges using the Safe Systems approach. The primary goal is creating a safer and more sustainable transportation environment. A Road Safety Action Plan (RSAP) is often the instrument through which this approach is implemented. RSAP is a strategic framework designed for enhancing road safety in a country, state, or city. It is a comprehensive and coordinated effort aimed at reducing traffic-related crashes, injuries, and fatalities, while also addressing various aspects of transportation and urban planning. These action plans typically involve collaboration among multiple stakeholders, including government agencies, law enforcement, transportation and health authorities, community organizations, and other relevant entities. Australia, Japan, New Zealand, Sweden, and several EU countries have successfully used RSAPs for improved road safety outcomes (Box 7.2).

BOX 7.2: ROAD SAFETY ACTION PLAN 2022-2025, THE SWEDISH TRANSPORT ADMINISTRATION

Under the guidance of the Swedish Transport Administration, 33 authorities and stakeholders worked to set forth what they intend to do over the next four years to contribute to safe road traffic. That work resulted in the Road Safety Action Plan 2022–2025. The action plan contains a total of 250 measures, target six priority action areas (speed, sober driving, safe cycling, safety for pedestrians (focus on falls), suicide prevention and leadership for road safety). The plan is an important display window for Swedish road traffic safety work and enables various stakeholders to find links between their own operations and those of others. This action plan is the second of its kind since the Government decided to relaunch Vision Zero in 2016 and at the same time commissioned the Swedish Transport Administration to lead the collaborative efforts on road safety. The Swedish Transport Administration is the issuer of the action plan and is responsible for contents and conclusions of the report, while each authority and stakeholder are responsible for the implementation of their own measures.

A Metropolitan Road Safety Action Plan is essential for creating a safer and more efficient transportation system in urban areas. By addressing multiple facets of road safety and involving diverse stakeholders, these plans aim to create sustainable, inclusive, and secure metropolitan environments for all road users. They typically encompass a programmatic and phased approach to crash risk assessment and management (adapted from best practices) with targeted, multi-sectoral, and resourced actions in the short, medium, and long terms for achieving targeted reduction in

road crash fatalities. These are premised on a lucid road safety strategy with intermediate and final targets and indicators, a phased action plan for achieving the targets, and a monitoring and evaluation framework for assessing the effectiveness of the implemented actions.

International best practices emphasize a holistic approach in the development and implementation of RSAPs in cities with a combination of institutional/policy, infrastructure, enforcement, post-crash care, and speed management measures (Figure 7.11). All these should be underpinned by systematic collection and analysis of accurate and up-to-date data on road traffic crashes, injuries, and fatalities, for identifying patterns and trends and in formulating effective strategies and interventions.

APPROACH IN CHENNAI

Chennai's Road Safety Action Plan

Recognizing the impact of annual city road fatalities, CUMTA initiated the development of a Chennai Road Safety Action Plan (CRSAP)[19] in 2020, and adopted it in 2023, with a vision of ***Safe Chennai Roads, free from fatal and serious injuries*** for improving the road safety outcomes in CMA. CRSAP aims to sustainably reduce road crash related deaths in CMA by 25 percent by 2026 and by 50 percent by 2030,[20] in line with the Government of India's international commitment. It seeks to enhance the city's institutional capacity, policy and monitoring framework by taking multi-sectoral measures targeting: (i) Institutional capacity for improved road safety management; (ii) engineering measures for safer roads; (iii) enforcement measures targeted at improving safer user behavior; and (iv) post-crash care measures.

Key issues and deficits under infrastructure, institutions, enforcement, and user behavior were identified through a thorough analysis of available crash and non-crash data. For instance, the Road Accident Database Management System (RADMS) was used for clear and accurate data on road crashes, and these were systematically categorized and analyzed through a combination of infrastructure risk rating using the International Road Assessment Program (IRAP) star rating methodology and crash rates (Figure 7.12) to prioritize critical intersections and road corridors for safety improvements for each category of users (Figures 7.13-7.16).

A total of 469 km of the riskiest corridors were prioritized for treatment. An analysis based on the methodology in Figure 7.13 indicated that a combination of infrastructure measures such as mass action and capital-intensive treatments[21] on the prioritized roads

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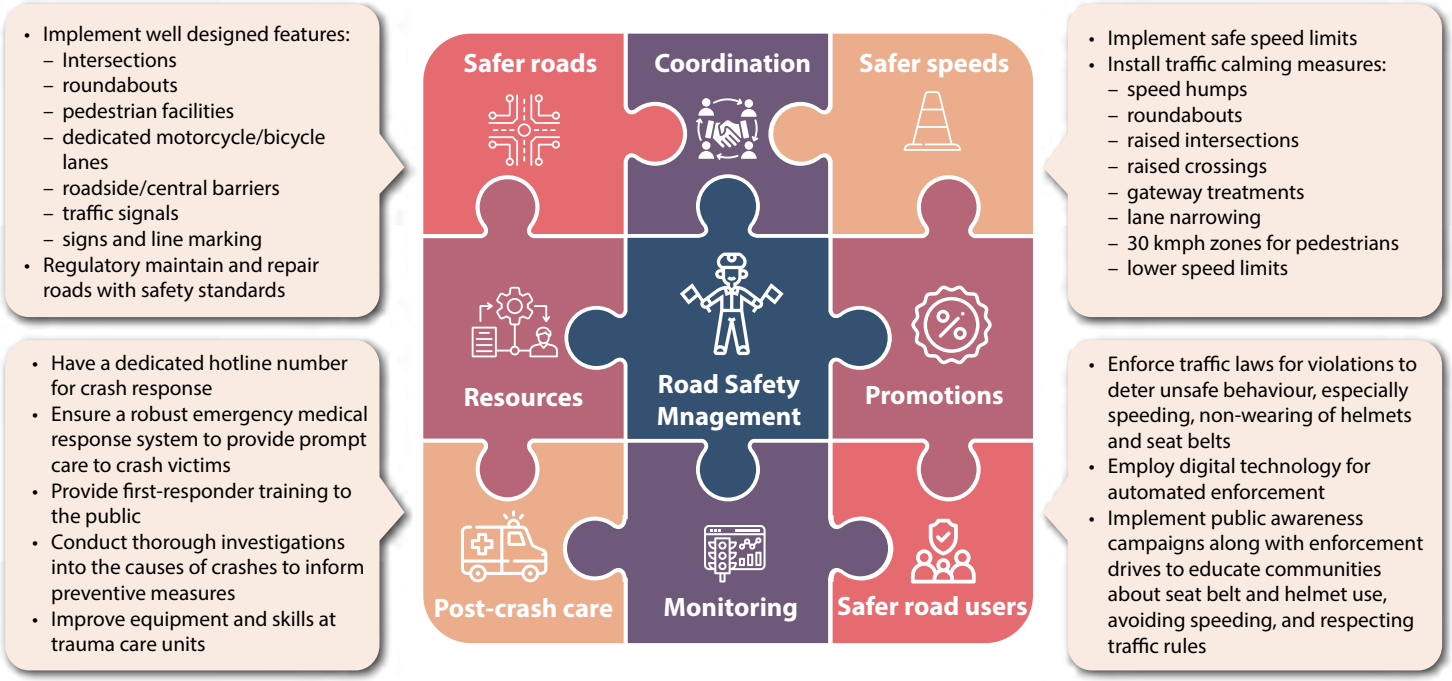
FIGURE 7.11: KEY ELEMENTS OF BEST PRACTICE ROAD SAFETY ACTION PLANS



Source: Authors' illustration.

FIGURE 7.12: ANALYSIS OF CRASH DATA IN CHENNAI

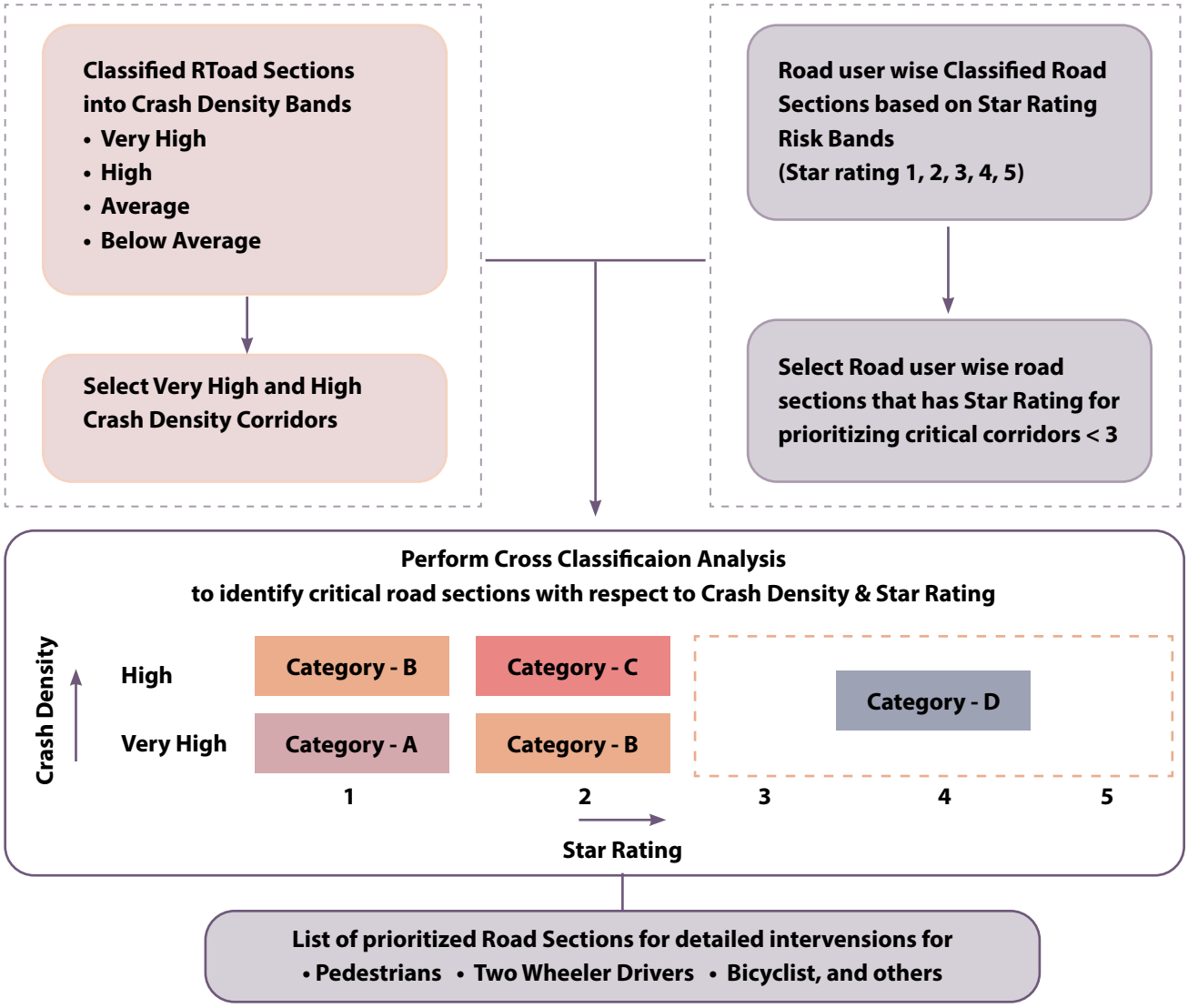
Comprehensive analysis of 470 km of high-risk, high volumes roads:

- iRAP star rating and analysis
- Crash data analysis
- Blackspot analysis
- Road network characteristics and safety assessment
- Non-crash data analysis
  - Speed
  - Helmet-wearing
  - Seatbelt-wearing
  - Mobile use

Findings:

- 55% of roads surveyed - below 3-star for pedestrians
  - Poor facilities for pedestrians to walk alongside or cross the road (67% of fatalities)
  - High motor vehicle traffic speeds, which expose pedestrians to greater risk of injury
- 35% of roads – below 3-star for cyclists
- 26% of roads – below 3-star for 2-W riders
- Road network characteristics and safety assessment
  - High number of fatalities due to non-wearning of helmets and speeding

FIGURE 7.13: METHODOLOGY FOR PRIORITIZING ROADS FOR SAFETY IMPROVEMENTS IN CHENNAI



Source: Figures 7.13-7.16: Review and Findings Report 2, Consultancy Services for preparing road safety action plan for CMA, DIMTS (April 2022).

and junctions, reduction of average vehicle speeds by 2.5 kmph, and full compliance with helmet-wearing will result in a savings of 818 fatalities a year (or a 58 percent reduction from the current year's fatalities). The benefit-cost ratio of the infrastructure improvements alone was 15:1, indicating a high return for an investment of about $75 million in mass action treatment.

Key elements of Chennai's Road Safety Action Plan

CRSAP comprises of four key elements:

i. **Safety performance targets:** To achieve its vision, CRSAP has set Safety Performance Targets (SPTs) till 2030 targeting the factors contributing to road crashes (Figure 7.17).

ii. **Improved institutional arrangements:** Chennai has taken meaningful steps to reduce institutional fragmentation and improve road safety governance. CUMTA has established a Road Safety Cell (RSC)[22] with the following responsibilities - oversight, interagency coordination, monitoring, evaluation, and reporting of road safety interventions, outputs, and outcomes (Figure 7.18). A Road Safety and Non-

FIGURE 7.14: PRIORITIZED CORRIDORS FOR TWO-WHEELERS

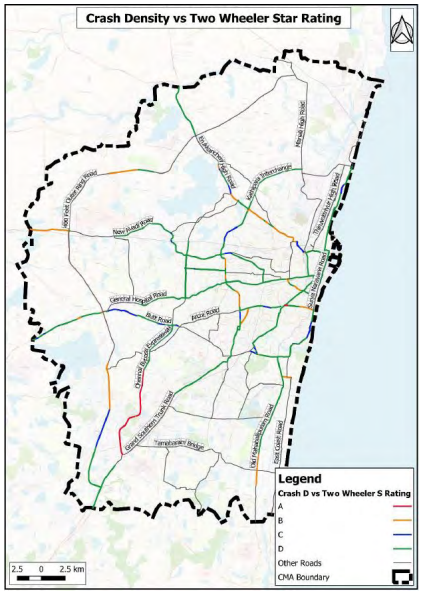


FIGURE 7.15: PRIORITIZED CORRIDORS FOR PEDESTRIANS

FIGURE 7.16: CRITICAL INTERSECTIONS FOR IMPROVEMENT

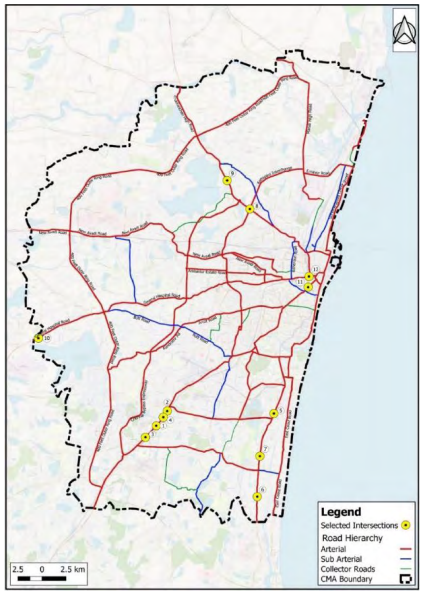
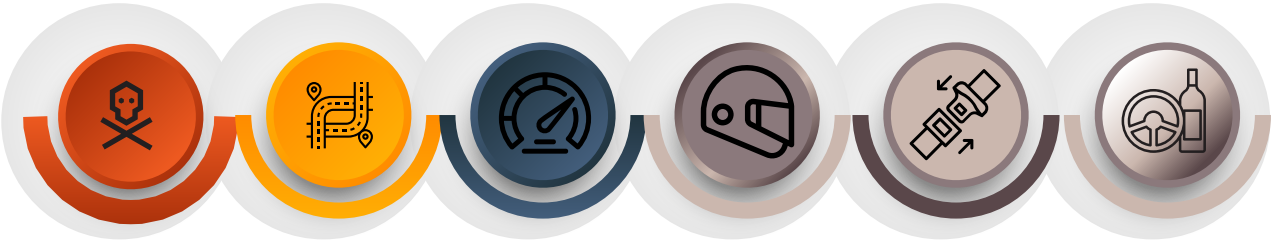


FIGURE 7.17: CRSAP SAFETY PERFORMANCE TARGETS



- 50% reduction in fatalities by 2030
- 25% reduction in fatalities by 2026

- At least a 3-star infrastructure star rating (iRAP) for all road users by 2030

- 50% reduction in vehicles exceeding the posted speed limit by 2030
- 25% reduction in vehicles exceeding the posted speed limit by 2026

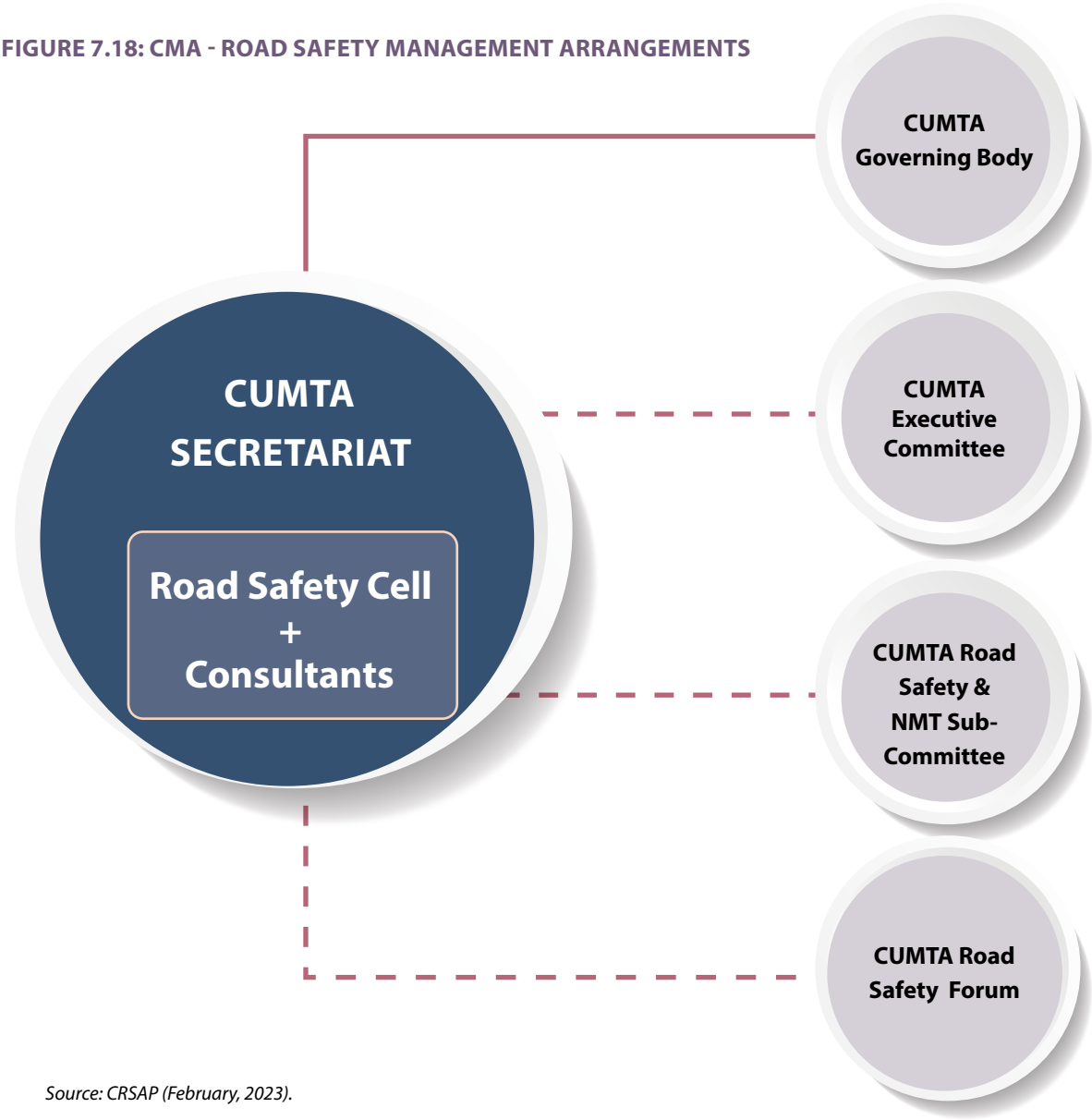
- 100% of motorcycle riders correctly using helmets by 2030
- 60% of motorcycle riders correctly using hetments by 2026

- 100% of all vehicles occupants correctly using seatbelts by 2030.
- 60% of all vehicles occupants correctly using seatbelts by 2026

- 50% reduction in drivers testing above the legal alcohol limit by 2030
- 25% reduction in drivers testing above the legal alcohol limit by 2026

Source: CRSAP (February 2023).

FIGURE 7.18: CMA - ROAD SAFETY MANAGEMENT ARRANGEMENTS



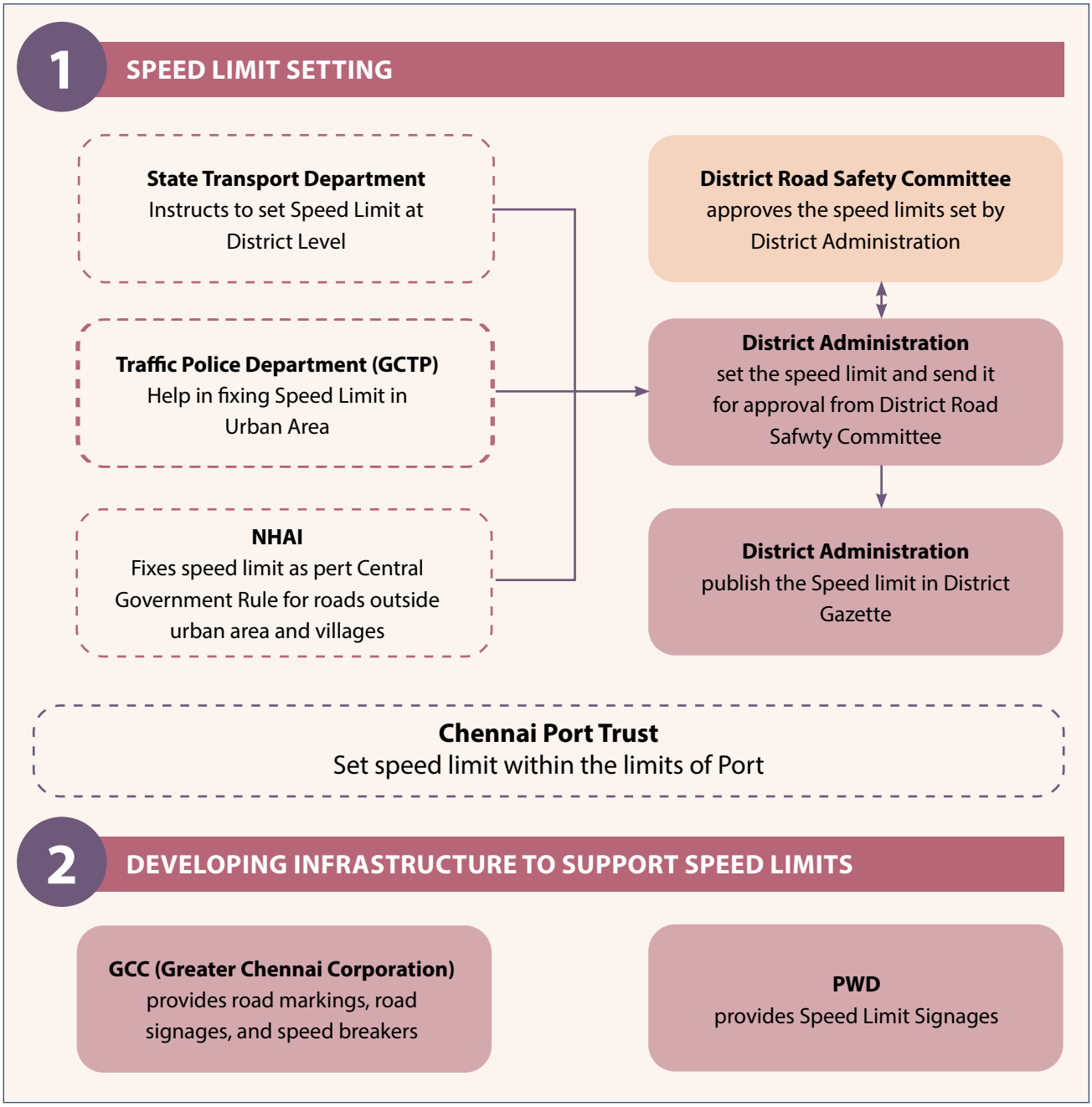
Source: CRSAP (February, 2023).

Motorized Transport Sub-committee has also been set up to oversee implementation of CRSAP and related road safety initiatives in CMA, which has been conferring regularly on various road safety issues in the city. To maximize its impact, CUMTA needs to be fully empowered, and its capacity built for all aspects of road safety management, including the power to set speed limits within CMA (Figure 7.19).

The Road Safety Cell will evolve into a full-fledged road safety management unit within 3-5 years (Figure 7.20)

iii. **Interventions**: Experience in OECD and developed countries shows that roadside enforcement of speed, drink driving, and seat belt wearing is extremely effective in deterring unsafe roadside behavior.[23] In the urban context, in Auckland, New Zealand there was a 30 percent reduction in fatalities on 880 km of roads where speed limits were adjusted.[24] Similarly, London saw a 25 percent reduction in fatal or serious injury crashes due to the introduction of 20mph zones.[25] Paris and New York City have respectively designated low speed zones for pedestrians and prioritized the treatment of left-turn pedestrian and bicyclist injuries under its Vision Zero initiative (Boxes 7.3 and 7.4). Closer home, fatality reductions of more than 50 percent and 22 percent on WB-financed safe corridors demonstration projects on state highways in Karnataka and Andhra Pradesh respectively, were achieved primarily due to a combination of road infrastructure, enforcement, and post-crash care activities. Interventions need to be targeted for tackling the key contributing factors for crashes in Indian cities.

FIGURE 7.19: PROCESS OF SPEED LIMIT SETTING IN CHENNAI



Source: Interim Report, Road Safety and Engineering Management for the CMA under UMSD, DIMTS (November 2023).

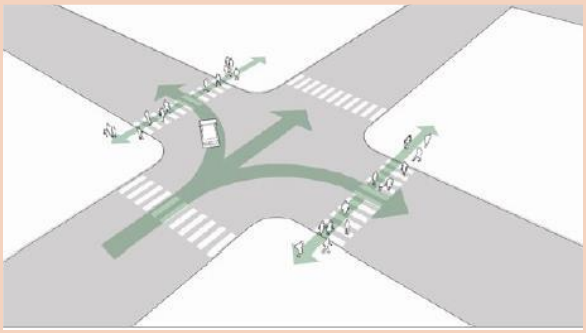
Accordingly, the top four priorities that Chennai has prioritized to reduce its road fatalities are:

- **Safe roads and roadsides**: CUMTA is considering mass action and geometric treatment – wider footpaths, kerb extensions, pelican signals, speed humps/cushions and traffic calming measures, tabletops and refuge islands, road narrowing, speed tables, signalized pedestrian crossings, school zone and gateway treatment, and improved road markings and signages at high crash risk locations for reducing pedestrian facilities. The city plans to implement these interventions along 469 km of the riskiest roads identified through the prioritization exercise. Considering that safety is often neglected in street design, road designs were thoroughly vetted to improve facilities and minimize safety risks for VRUs in line with IRC and other relevant guidelines. Systematic templates for what conditions warrant each type of measure have also been developed for city-wide replication (see Figures 7.21-7.24).

BOX 7.3: PEDESTRIAN HEAD STARTS AND TURN CALMING AT INTERSECTION IN NYC

The New York City Department of Transportation has prioritized the treatment of left-turn pedestrian and bicyclist injuries and started a turn calming program under its Vision Zero initiative. Between 2015 and 2022, the city installed almost 5,000 Leading Pedestrian Intervals (LPIs) at priority Intersections.

These signals hold traffic for several seconds at the beginning of the pedestrian 'Walk' phase, allowing pedestrians or cyclists to establish their presence in the intersection before turning traffic is permitted to proceed Also, it has started a Turn Calming program, with several types of treatment at junctions.



BOX 7.4: LOW SPEED ZONES IN PARIS

Paris has designated low-speed zones known as "Zone de Rencontre," where vehicles must yield to pedestrians. These zones prioritize pedestrian safety by reducing vehicles speeds and enhancing pedestrian comfort and accessibility

- **Safe road use**: GCTP has already procured and installed Traffic Regulation Observation Zones on several city roads with ANPR technology, red light violation and speed dome cameras at junctions for automating monitoring of traffic violations, minimizing human interaction and errors in the issue of traffic penalties. It is also planning enhanced and random enforcement of the limits and helmet-wearing using both fixed and mobile cameras for improving deterrence and the certainty of detecting and penalizing traffic offenders.

- **Safe speeds**: In November 2023, based on a study, GCTP mandated a speed limit of 30 kmph in all residential areas and a maximum speed limit for light motor vehicles of 60 kmph (which is still high by Safe System standards for arterials) in Chennai. Enforcement of these limits will help reduce speed-related crashes and fatalities in Chennai significantly. However, speed surveys under a recent WB-GRSF study show that the maximum 85th percentile speeds for arterials in Chennai is 50 kmph. Therefore, a further rationalization of speed limits may be needed based on the operational speeds and the factors mentioned above. Safe speed limits, along with their enhanced enforcement will help GCTP in reducing road traffic deaths and injuries due to speeding. CRSAP has detailed action plans associated with each set of interventions. As an example, Table 7.2 illustrates the action plan for speed management.

TABLE 7.2: ACTION PLAN FOR SPEED MANAGEMENT

Targets	• 50% reduction in vehicles exceeding the posted speed limits by 2030 • 25% reduction in vehicles exceeding posted speed limits by 2026
	**Rationale:** A 5% reduction in average speed can result in a 30% reduction in fatal crashes[26] Chennai Baseline: 27% of vehicles exceeding the posted speed limit (2021)
Actions	• Recalibrate posted speed limits on high-risk corridors • Digital enforcement through cameras at high-risk locations • Deploy a small fleet of mobile camera vehicles randomly rotated around hundreds of sites to tackle speeding and improve general deterrence • Use interceptors to target high-speed locations to generate spot challans • Conduct highly visible activity, which has been well publicized – advising motor vehicle drivers that they face a significantly increased risk of detection • Strictly apply roadside challans and license suspensions • Use speed display boards to inform motorists of their speed to slow them down • Run awareness campaigns through road safety videos at road transport offices • Demarcate low-speed zones around schools to reduce risks to school children
Timeline	• 48 months
Funding	• Road Safety Fund and GCTP budget allocations

- **Helmet wearing**: Strict enforcement of helmet-wearing by GCTP has yielded good outcomes: a survey conducted under a WB-GRSF study revealed that helmet compliance in Chennai improved from ~20 percent in 2019 to ~65 percent in 2022, resulting in a ~48 percent reduction in two-wheeler fatalities between 2019 and 2022. However, while helmet wearing of the main rider has improved, about 78 percent of the pillion riders do not wear helmets, and 36 percent of all riders do not fasten their chin clips. More than 90 percent of women pillion riders don't wear helmets. Strict enforcement of the helmets for pillion riders including women will help reduce two-wheeler fatalities further.

- **Public awareness**: Enforcement is most effective when combined with public awareness campaigns for changing behavior. In this regard, the Kutty Cops project launched in Coimbatore by GoTN for primary school children to play a cop in their houses and ensure that their family members are responsible drivers and follow all traffic rules is worthy of emulation in Chennai and other cities.

iv. **Improved reporting, monitoring, and evaluation:** A robust monitoring and evaluation program is important for supporting implementation. Ideally, this should help evaluate the strategy, performance toward targets, and delivery of actions by each responsible agency. Once an action plan has been adopted, there needs to be ongoing reporting by each responsible agency against each action. This reporting task can highlight early implementation issues and allow the governing body to take decisions or provide direction regarding agency priorities. A quarterly report is recommended, and at least an annual report is essential. Each of these elements needs to be identified as a part of the action plan and overseen by the city's road safety governance structure. In Chennai, the reporting arrangements have been proposed as shown in Figure 7.25.

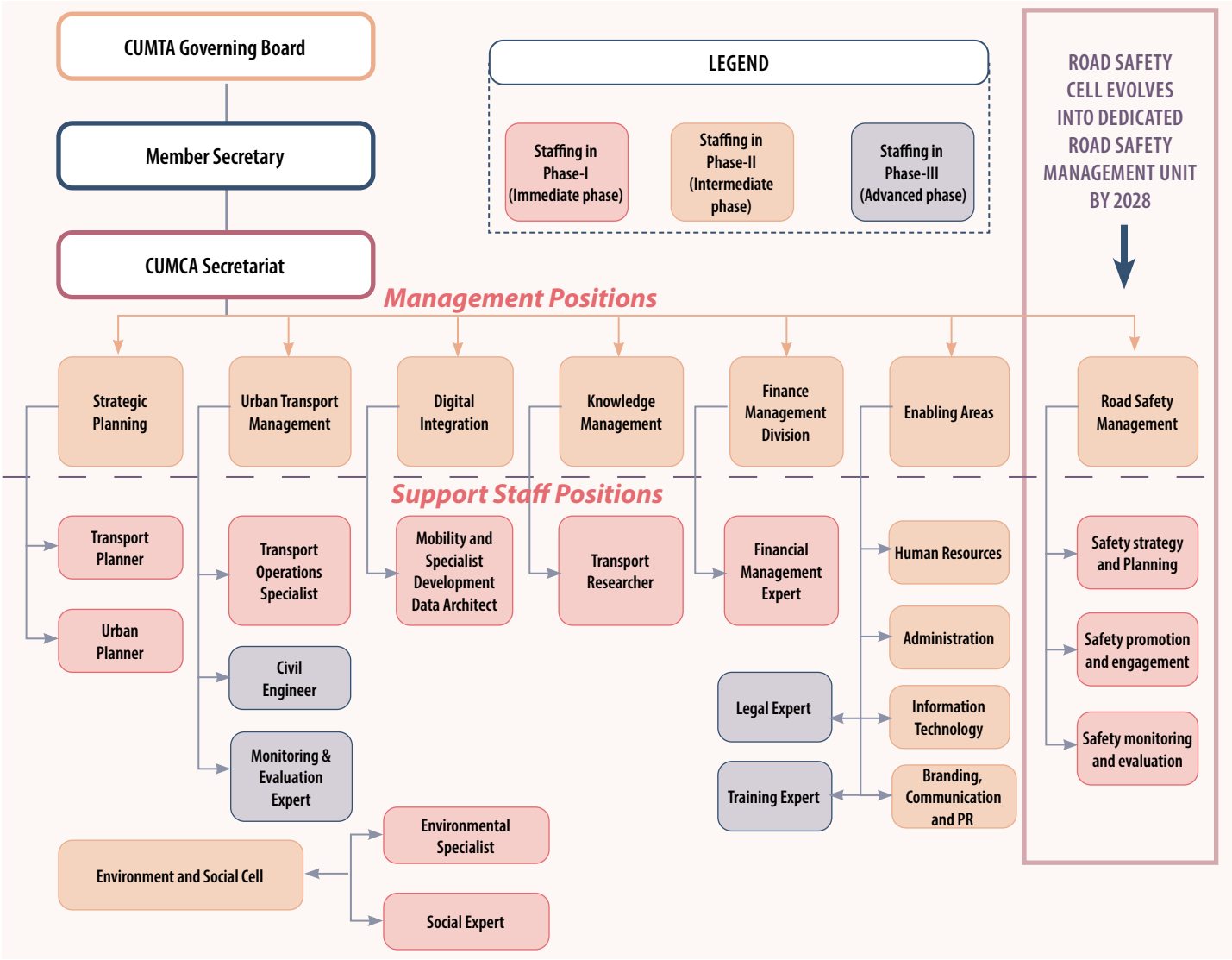
EXPECTED IMPACT IN CHENNAI

The institutional set up in Chennai with representation from key stakeholder departments and systematic implementation of CRSAP provides a shift in focus that aims to halve its road fatalities by 2030 and achieve the SDG goals.

TAKEAWAYS FOR OTHER CITIES

- **Robust institutions:** Arrangements in the form of either a dedicated lead agency or committees at high level executive and operational levels are vital for

FIGURE 7.20: CUMTA - ENVISAGED FULL-FLEDGED ROAD SAFETY MANAGEMENT UNIT

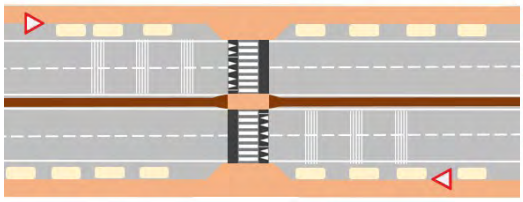


Source: Presentation to CUMTA Road Safety Sub-committee for discussion on CRSAP by the World Bank and DIMTS (August 2022).

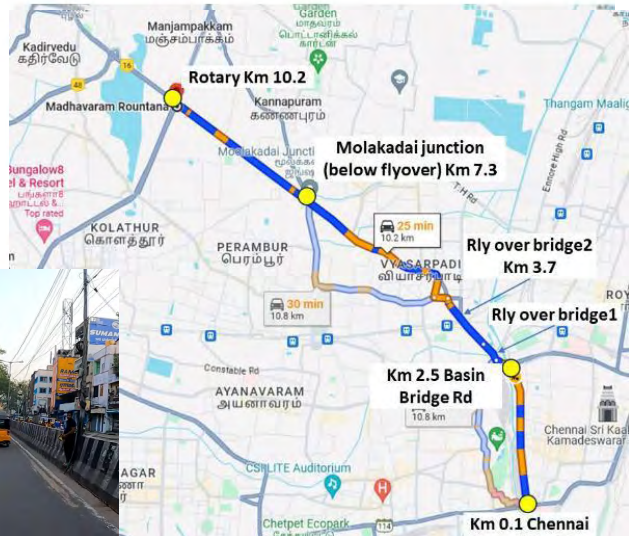
FIGURE 7.21: EXISTING SITUATION AND RECOMMENDATIONS FOR PEDESTRIANS ON GNT ROAD

Recommendations:

B2 : Table-top type (Unsignalized Raised) Cossing on divided road



Km 0.1, 0.4, 0.6, 0.8, 1, 4.8, 4.9, 5.3, 5.6, 6, 6.2, 6.7, 7.3, 8, 8.4, 8.8, 10.2



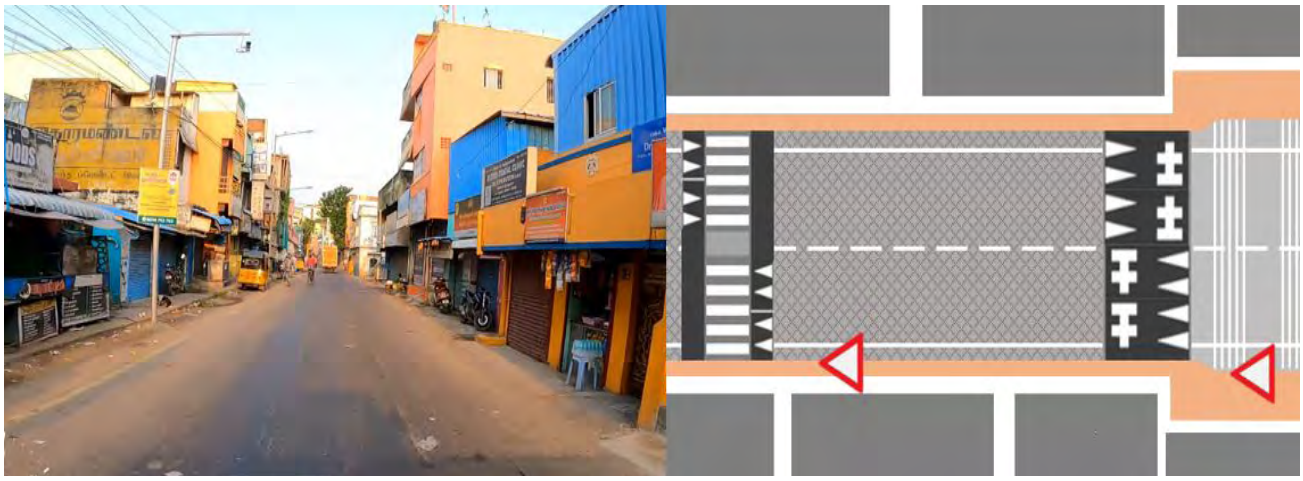
Source: Road Safety Audit of Pedestrian Infrastructure and iRAP Star Ratings of Designs of roads in CMA, Presentation by Asian Institute of Transport Development, Chennai (December 2023).

FIGURE 7.22: CURRENT SITUATION AND RECOMMENDATIONS FOR PEDESTRIAN SAFETY ON VELACHERY BYPASS ROAD

Sl. No.	Road safety treatment tamplate	Vhainage, km
1	B2 : Table-top types (unsignalize raised) Crossing on divided road	0, 0.4, 0.9, 1.2
2	B4 : Table-top crossing at unsignalized intersections on divided road	1.1
3	D2 : Pedestrian crossing at signalised intersections	1.5, 1.8, 2
4	FP4 : Footpath - provision (no footpath exists)	0, to 0.3; and 0.06 to 2

Source: Same as that for Figure 7.21.

FIGURE 7.23: CURRENT SITUATION ON GNT ROAD, ALONG WITH RECOMMENDATIONS FOR SHARED STREET WITH TRAFFIC CALMING



Source: Same as that for Figure 7.21.

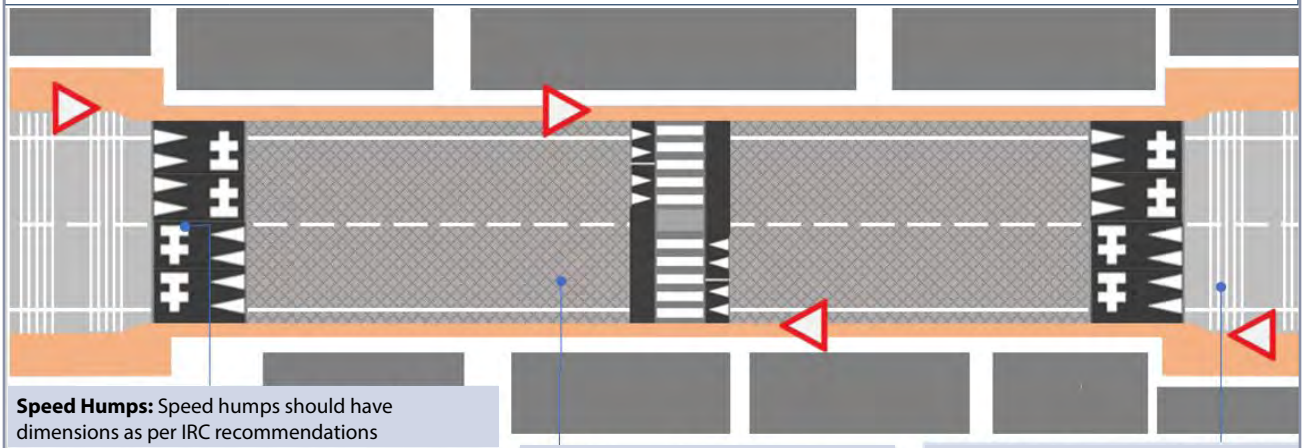
coordination, management, and delivery of all city road safety activities.

- **Data-driven decision making:** Accurate data on incidence and type of crashes along with a detailed analysis and understanding of the crash's contributory factors and pedestrian and NMT volumes are essential for policy decisions, prioritizing public health issues, identifying interventions, monitoring trends, and assessing intervention programs in cities.
- **Forgiving roads and roadsides:** Cities should aim to develop a road transport system which accommodates human error and reduces human exposure to motor vehicle speeds/crash forces that may result in death or serious injury. Cities should also avoid building pedestrian over-bridges and subways to address the pedestrian-vehicle conflict, as these often fail to incorporate user behavior.
- **Speed management:** Safety needs to be directly provided for in cities by significantly reducing motor vehicle speeds in high pedestrian areas and indirectly by supporting safe motor vehicle movements on high-volume corridors.
- **Systematic, proactive assessment of roads:** Cities with highways passing through them should identify and prioritize mass action road safety treatment for

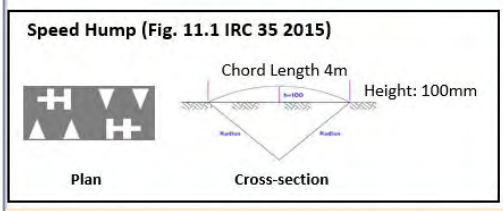
FIGURE 7.24: TEMPLATE FOR A SHARED STREET WITH TRAFFIC CALMING

Road Improvement Template No.: ST	**Shared Street with traffic Calming**	Shared Street	Table-top crossing	Speed hump

Shared street can be created on sections where the road width is inadequate for providing exclusive space for pedestrian to walk along. Shared street should have speed humps (or table-top type crossings) at the start and end and raised table-top type crossings at frequent intervals based on pedestrian crossing demand. Texurws pavement surfacing is also recommended on such sections. This is provided to create a safe, slow-speed section and is effective in lowering crash risk of VRUs. The crossing and traffic calming should have specifications as per IRC and should have adequate build quality. Typical drawing of a shared street with raised pedestrian crossing and traffic calming is shown below.



Speed Humps: Speed humps should have dimensions as per IRC recommendations



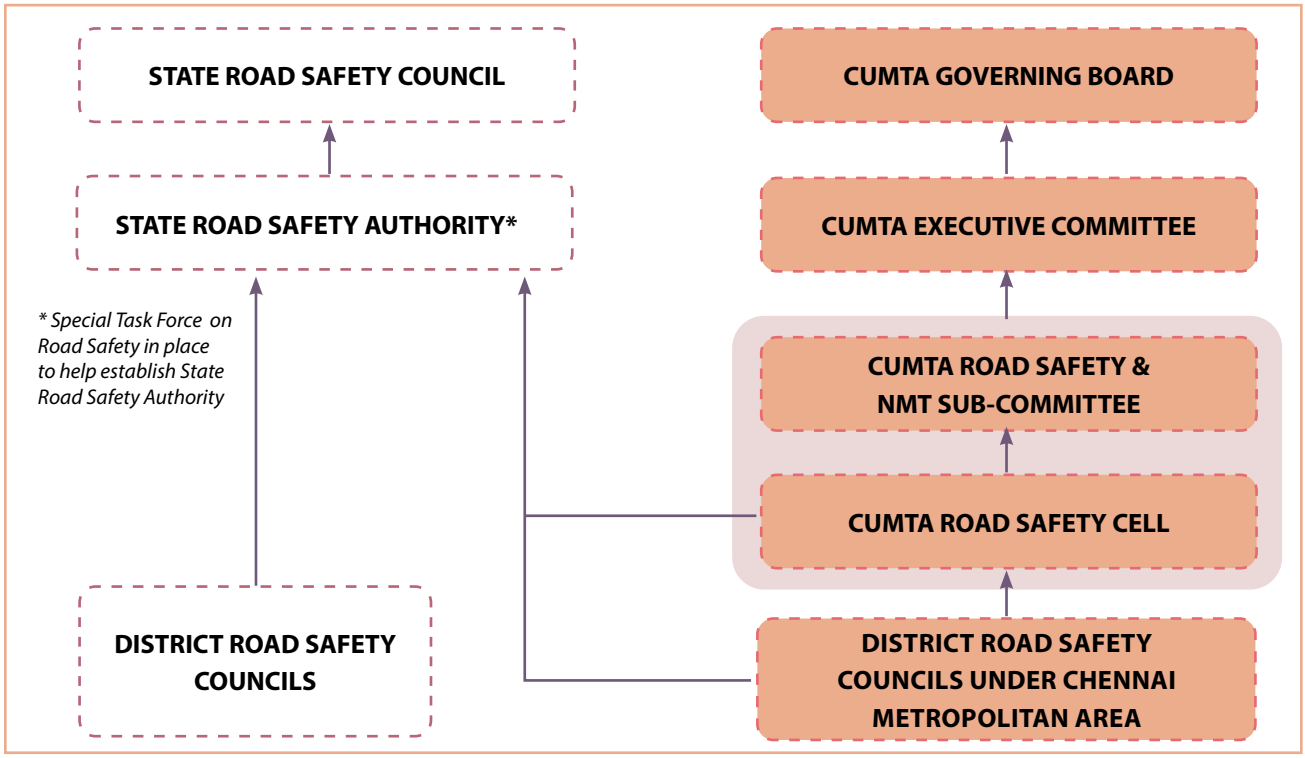
Texured Pavement: Texured pavement is suggested in the shared street area for speed reduction.

Signage and Marking: Signage and marking should be as per IRC specifications

Improved Visibility: Transverse bar marking (TBM) should be provided for better visibility. Road studs or RRPMs shall be provided on both sides of the section along the edge line marking for better visibility during nighttime. Street lighting should be adequate

Design details of pedestrian crossing at intersections is covered in IRC 103-2022 (section-6.7.1 and section-7). Transverse Bar Marking (TBM) as per IRC 99-2018 and MoRTH circular RW/NH-29011/01/2019-S&R (P&B). IRC 99-2018 (section-3 and 2.3.5). The designs should consider IRC manual on universal accessibility IRC SP 117-2018.

FIGURE 7.25: ROAD SAFETY REPORTING ARRANGEMENTS IN CHENNAI



Source: Same as that for Figure 7.20.

above-grade infrastructure and context-sensitive design for the street below, especially where crashes are dispersed across the road network.

CONCLUSION

Formulation, adoption, and implementation of a city road safety action plan along the Safe System principles is an essential first step for metropolitan cities in low- and middle-income countries in reducing their road death tolls. The plan should be premised on a thorough analysis of crash data for understanding key issues and contributing factors. It should comprise of targeted safety performance targets and interventions under each road safety pillar/theme, related institutional and governance arrangements, high-priority projects (both infrastructure and non-infrastructure), and accountable agencies along with timelines and monitoring and evaluation arrangements. CRSAP is a unique example of an action plan that is concretely tied to a-priori defined targets using multi-sectoral interventions, with potential for replication in other metros across India.

Endnotes

1 Krishnan Srinivasan is a Consultant at the World Bank
2 Sudeshna Mitra is a Transport Specialist at the World Bank
3 United Nations Sustainable Development Goals
4 Martin Small and Tawia Addo-Ashong (2021_ Road Safety Strategies for African Cities: A Guide to Development. Washington DC: SSATP.
5 Transport Research Wing, Ministry of Road Transport and Highways, New Delhi (2023).Road accidents in India 2022.
6 ITF (2020). Best Practice for Urban Road Safety: Case Studies. International Transport Forum Policy Papers, No. 76, OECD Publishing, Paris.
7 Primary comprising National Highways that account for 2 percent of the total network, but with 40 percent of the country's total road traffic and secondary comprising state highways and major district roads that account for about 3 percent of the road network, with another 40 percent of the total road traffic.
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19 DT NEXT (2020). Article. Road safety action plan to bring down accidents, fatalities in Chennai, suburbs.
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26 Save LIVES - A road safety technical package. Geneva: World Health Organization (2017). Licence: CC BY-NC-SA 3.0 IGO.

Photo credit: CUMTA

8: STRENGTHENING METROPOLITAN TRANSPORT GOVERNANCE

Shyam Srinivasan, Jeyakumar[1] and Gerald Ollivier

INTRODUCTION

With rapid urbanization comes increasing demand for public services such as transport, housing, water, healthcare, and education. Cities around the world are grappling with this challenge with mixed results. In the transport sector, urbanization has often resulted in increased private vehicle use, with attendant issues like congestion, air pollution, increased greenhouse gas emissions, road accidents, and a diminished quality of life.

In cities with sustainable transport systems, the recipe for success often boils down to governance. Urban Transport Governance refers to the systems and processes through which diverse actors plan and deliver transport infrastructure and services in a city. It is widely recognized in literature that urban transport governance is of paramount importance with a direct impact on the quality of urban mobility systems.[2]

This note explores the question of urban transport governance through the lens of Chennai, India, where a new nodal agency, Chennai Unified Metropolitan Transport (CUMTA) Authority was recently operationalized. The establishment of CUMTA represents an attempt by the government to reduce institutional fragmentation in the transport sector in Chennai. Once CUMTA assumes its full range of functions, it is expected to improve urban mobility planning and service delivery through articulating a clear vision, identifying priority areas for interventions, developing action plans, proposing sectoral funding allocations, and coordinating across multiple agencies with a stake in urban mobility.

The note traces CUMTA's origins and journey so far, draws on international experience to explain some of its design choices, and looks ahead at CUMTA's future. In doing so, it offers useful takeaways for other cities facing similar challenges.

BACKGROUND

An urban transport system requires a variety of stakeholders for performing a range of activities. Based on a framework developed by Van de Velde (1999), Kumar & Agarwal (2013) categorized the full range of urban transport functions under three levels of activities: *Strategic*, *Tactical,* and *Operational*, as explained below and summarized in Figure 8.1.

- ***Strategic* functions include defining the broad objectives and service characteristics of an urban transport system.** This could entail developing a transport vision and a comprehensive mobility plan, assessing infrastructure, and financing needs, identifying financing sources, defining the role of public and private sectors, and developing institutional frameworks.
- ***Tactical* functions include detailed planning at the project level and regulations.** For infrastructure, this could involve demand projections and economic,

financial, environmental, and social assessments. For services, this could involve network and route planning, establishing key performance indicators, developing contractual terms, coordinating across multiple operators, and monitoring and evaluation. Regulatory functions comprise of safety regulations (driver and vehicle licensing, setting and enforcing traffic rules, and traffic management), and commercial regulation (route permits for public transport services and fare setting).

- ***Operational* functions cover infrastructure and services.** Infrastructure construction and maintenance falls under this layer, as do public transport operations which can be further divided into the operations of common and independent services. Common services are those required by all operators such as the provision and upkeep of bus and passenger terminals, passenger information systems, revenue sharing across modes, accident recovery, dispute resolution and public relations. Independent services refer to the day-to-day operations of buses, metros, trams, and parking facilities.

In cities around the world, multiple agencies at different levels of government undertake these functions, which could lead to overlapping mandates, while some critical functions are not clearly assigned. This is true of Chennai and many Indian cities, where a plethora of agencies across all levels of government (central, state, and city) have a stake in urban transport governance. The rules of the game are defined by a complex framework of acts, rules, regulations, and guidelines. Some aspects are governed by laws enacted by the Union Parliament and others by the state legislature. The Chennai case is illustrated in Figure 8.2. Critical functions like multimodal integration, common ticketing or integrated transport and land use were not covered prior to the establishment of CUMTA.

There is a strong need for decreasing institutional fragmentation in large cities. While it is not always possible or necessary to have a single lead agency undertaking the full range of functions, the bigger the city, the stronger the value proposition of a single agency.

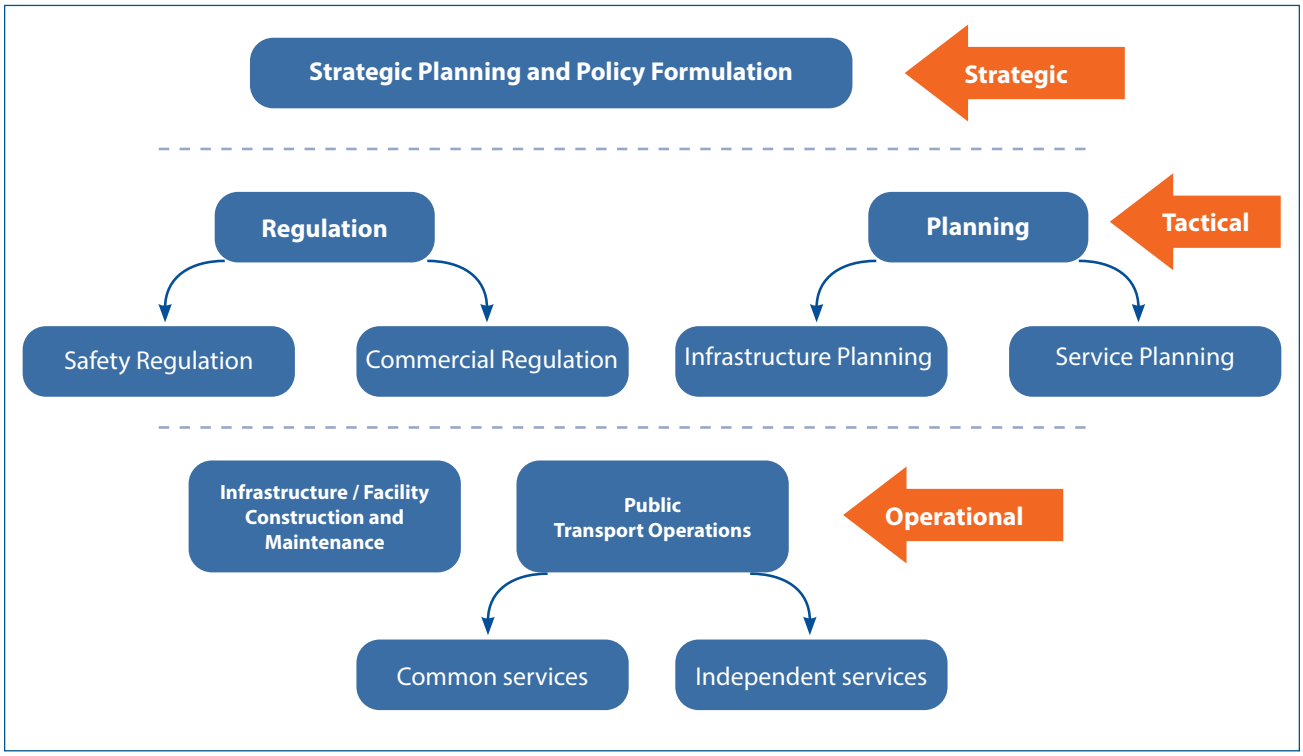
APPROACH TAKEN IN CHENNAI

CUMTA's Journey in Chennai

The Government of India has long recognized the value of coordination. The National Urban Transport Policy (2006) identified the need for strengthening

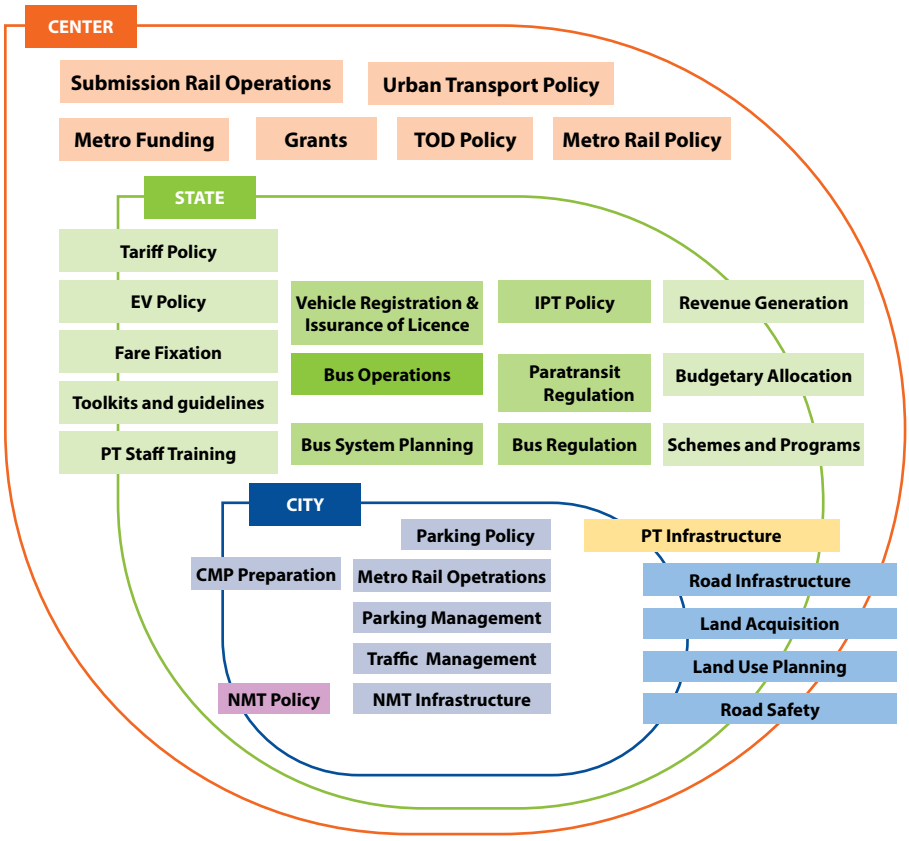
TOC

FIGURE 8.1: FUNCTIONS TO BE PERFORMED IN THE PROVISION OF URBAN TRANSPORT



Source: Kumar and Agarwal (2013).

FIGURE 8.2: SPLIT OF URBAN TRANSPORT FUNCTIONS IN CHENNAI PRE-CUMTA



Function	Jurisdiction
Grants	Center
IPT Policy	State
Bus Operations	Region
Parking Policy	City
Review Generation	Centre and State
NMT Policy	Centre and City
PT Infrastructure	State and City
Road Infrastructure	Center, State and City

Urban Transport Functions are scattered across all levels of government. Certain functions are exclusive to a particular level of government, while others are carried out by two or more levels of government.

Crucial functions such as multi-modal integration, common ticketing, land use and transport integration are not covered by any agency.

Source: Deloitte for the World Bank

coordination across urban mobility agencies and functions. The national Metro Rail Policy[3] of 2017 required cities seeking central assistance for metro projects to establish urban metropolitan transport authorities (UMTAs) for cities.

CUMTA was established via a statute in November 2010, but it took 10 more years for CUMTA's operationalization to begin in earnest. In September 2020, the CUMTA Act was amended to designate the Chief Minister of Tamil Nadu as the Chairman of CUMTA, and the Minister for Housing and Urban Development as its Vice-Chairman. This set the stage for the progress with operationalization that has been achieved since the World Bank-supported Chennai City Partnership: Sustainable Urban Services Program (SUSP) became effective in February 2021.

Today, CUMTA stands out as one of a handful of operational UMTAs across India. There were several key choices that were made in the establishment of CUMTA and continue to be made as it keeps on evolving. In this section, these choices are examined along six critical dimensions to be considered when setting up lead urban transport agencies:[4]

- Legal basis
- Jurisdiction
- Functions
- Personnel profile and size
- Management structure and accountability
- Financing arrangements

Legal Basis

The legal approach for forming a lead agency varies based on context. The lead agency's role is sometimes assumed by an existing government entity at the state or municipal levels. Alternatively, a separate entity can be established for performing the role, through different approaches: (i) via dedicated legislation; (ii) by leveraging existing legislation applicable to commercial entities; (iii) via a government order in the absence of an explicit legislation; or (iv) agencies with different jurisdictions such as several municipal corporations, coming together to establish the entity.

While each approach has its pros and cons, best-in-class international agencies have dedicated legislative mandates:

- Existing entities such as municipal corporations often have cross-sectoral mandates (education, health, solid waste management), and transport may not receive focused attention. State level transport departments may not be attuned to the needs of the citizens in a particular city.
- Where there are separate entities, government orders or leveraging existing legislation for commercial entities may be more expedient. Establishing committees via government orders could bring different stakeholder agencies to the table, but such committees are unlikely to endure without dedicated staffing. Corporate entities can operate along commercial lines and therefore attract talent but may not be able to assume regulatory or financial oversight functions.
- This leaves dedicated legislation as the preferred arrangement for establishing a lead agency. While it takes time to draft and pass legislation, lead agencies formed this way are legally independent, and typically have their own staff and financial resources. Transport for London, Land Transport Authority (LTA), Singapore, and Ile-de-France Mobilites are examples of lead agencies with legislative backing.

The approach adopted in Chennai follows international best practices. CUMTA is backed by a statutory act. In November 2010, the Government of Tamil Nadu (GoTN) passed the CUMTA Act to establish the entity which would oversee, coordinate, promote, and monitor the implementation of traffic and transportation measures in the Chennai Metropolitan Area (CMA). Although around 17 UMTAs have been established thus far, the number of UMTAs backed by legislation is much more limited, including Hyderabad, UTTIPEC (Delhi), and Kochi. This makes CUMTA one of a handful of UMTAs backed by a dedicated act, out of 46 million-plus cities in India.[5] In September 2020, the CUMTA Act was amended to designate the Chief Minister of Tamil Nadu as the Chairman of CUMTA, and the Minister for Housing and Urban Development as its Vice-Chairman.

Jurisdiction

Jurisdictions of lead agencies vary based on context, ranging from single municipality to a metropolitan region. In cities such as Ahmedabad, the mandate of lead agencies is limited to a single municipality, given the size of the municipality and that it covers a large part of the urban extent, and in Singapore, which is an island city-state, the mandate extends to the entire city. However, several other cities such as Paris (France) or Lagos (Nigeria) have travel demand across municipalities within a metropolitan region, requiring lead agencies that can undertake infrastructure and service planning on a metropolitan scale. In such cities, municipalities generally retain some local functions such as parking, traffic management, and the construction and maintenance of local roads.

CUMTA is intended as a lead agency for the Chennai Metropolitan Area (CMA). CUMTA's mandate was originally limited to the pre-2022 CMA of 1,189 sq km, which excluded key satellite towns. In October 2022, CUMTA's mandate was expanded in tandem with the expansion of CMA to 5,904 sq km. With this, CUMTA can plan on a metropolitan scale, in close coordination with four municipal corporations - Greater Chennai, Tambaram, Avadi, and Kancheepuram.

Functions

The set of functions assumed by lead agencies varies considerably across cities internationally. Going back to the framework in Figure 8.1, cities have found different ways of defining responsibilities for lead agencies, considering the institutional landscape prior to their formation, and the size and strength of lead agencies as summarized in Box 8.1 and Figure 8.3.

CUMTA has adopted ***'Moving people and freight seamlessly through an integrated, sustainable, safe and resilient transport ecosystem'*** as its vision. When fully operational, CUMTA will be a planning and regulatory body, performing mainly strategic and tactical roles in the hierarchy of transport functions, whereas operational responsibilities will continue to be helmed by line agencies. CUMTA's steady state functions are summarized in Figure 8.4.

One of CUMTA's key functions is developing and continuously updating CMP for CMA. CUMTA is in the process of updating an earlier draft of CMP which was restricted to pre-2022 CMA. CMP offers an opportunity for CUMTA to establish itself in the institutional milieu. CMP will set the long-term vision for urban mobility in CMA and define a clear implementation and financing roadmap for its implementation, which CUMTA can subsequently administer and track systematically in conjunction with line agencies.

BOX 8.1: FUNCTIONS ASSUMED BY LEAD AGENCIES INTERNATIONALLY

In most cities considered, lead agencies assume strategic and tactical functions, notably strategic planning and policy setting and infrastructure and service planning. This is the case in Lagos, London, Paris, Singapore, and Vancouver. In some of these cities, the lead agencies only cover infrastructure and service planning for public transport (for example, Ile-de-France Mobilites, Paris), with the central government retaining control over national highways and municipalities over local roads. However, in some cases, the lead agency's mandates also extend to roads such as LTA, Singapore.

Lead agencies largely tend not to assume regulatory functions such as traffic management and enforcement, or driver licensing and registration. Traffic management and enforcement tends to be performed by law enforcement agencies, whereas driver licensing and vehicle registration functions tend to be performed by central or state level, rather than city level entities. Singapore, being a city-state is a notable exception in terms of driver licensing and vehicle registration.

Responsibility of infrastructure construction and maintenance and common facilities for public transport such as bus stops and terminals vary. TfL, LTA, and Translink in Vancouver assume responsibility for such facilities, whereas in Paris and Lagos, these are left to either central or municipal entities.

Lead agencies generally do not operate public transport services but retain responsibility for service planning. This reflects the difference in functions, with service planning undertaken with a focus on public transport as a public good, whereas transport operations are commercially driven.

Across cities internationally, lead agencies tend to assume their functions over time, especially since they are formed in relatively mature institutional landscapes. CUMTA will be operationalized in three phases. Simpler and core functions of integrated planning and effective coordination have been prioritized up to now, with more complex functions requiring greater organizational strength to be added in the medium and long term. Well-defined maturity triggers have been developed in the operational document to guide CUMTA's advancement to subsequent phases of operationalization. CUMTA's staffing will be expanded as it progresses through the phases and reflect the multi-disciplinary nature of urban mobility.

Personnel profile and size

The staff strength of lead agencies needs to match their mandates. Given varying mandates across agencies, staff strength can vary from tens of staff

FIGURE 8.3: FUNCTIONS ASSUMED BY LEAD TRANSPORT AGENCIES ACROSS CITIES INTERNATIONALLY. SOURCE: KUMAR AND AGARWAL (2013)

City	Lead Agency	Strategic Planning	Transport Policy Planning	Fare Setting	Infrastructure & Service Planning	Driver licensing/ Vehicle registration	Traffic Management & Enforcement	Infrastructure construction & maintenance	Common facilities	Public transport operations
Lagos	LAMATA	✓	✓	✓	✓	X	X	X	X	X
London	TfL	✓	✓	✓	✓	X	✓	✓	✓	X
Paris	IDFM	✓	✓	✓	✓	X	X	X	X	X
Singapore	LTA	✓	✓	X	✓	✓	✓	✓	✓	X
Vancouver	TansLink	✓	✓	✓	✓	X	X	✓	✓	X

(LAMATA, Lagos) to several hundred (Ile-de-France Mobilites) to several thousand (TfL, LTA). Depending on staff strength, entities either assume full control for a certain layer of responsibility such as service planning or work with other entities/line agencies which may have their own teams performing such functions.

In CUMTA's case, the staff strength is expected to grow as it assumes greater responsibility. As of March 2024, two years since its operationalization began in February 2022, CUMTA had 17 full time staff. In phase II (years 2 to 5), CUMTA will have 57 staff, and in a steady state, beyond 5 years, CUMTA is expected to have around 100 staff. While these numbers were codified in CUMTA's operations document prepared under SUSP, the numbers could change based on CUMTA's evolution over time. CUMTA's envisioned staff strength reflects its role as a coordinating entity. CUMTA will function as a coordinating entity which will guide the efforts of line agencies.

In line with its mandate, CUMTA staff have domain expertise in transport and urban planning, data integration, environmental and social safeguards, gender, procurement, and financial management.

Management structure and accountability

Internationally, lead transport agencies typically have a decision-making body led by a senior politician or bureaucrat, supported by a Chief Executive Officer (CEO) and a technical secretariat.

CUMTA has a similar structure, with an innovation to smoothen decision making (Figure 8.5). Instead of having a single governing board, CUMTA has adopted a two-tier governance structure, with a governing board led by the Chief Minister of Tamil Nadu, and an executive committee led by the Chief Secretary of Tamil Nadu. Overall, the two-tier structure ensures that all agencies with a stake in urban transport in CMA are represented at the highest levels on the governing board, while devolving day-to-day decision making in line with the overall policy and strategy to the executive committee which would be easier to convene.

- The governing board has the ministers of transport and housing and urban development as vice-chairpersons and includes representation at the secretary-level from key government departments such as finance, transport, housing, and urban development.

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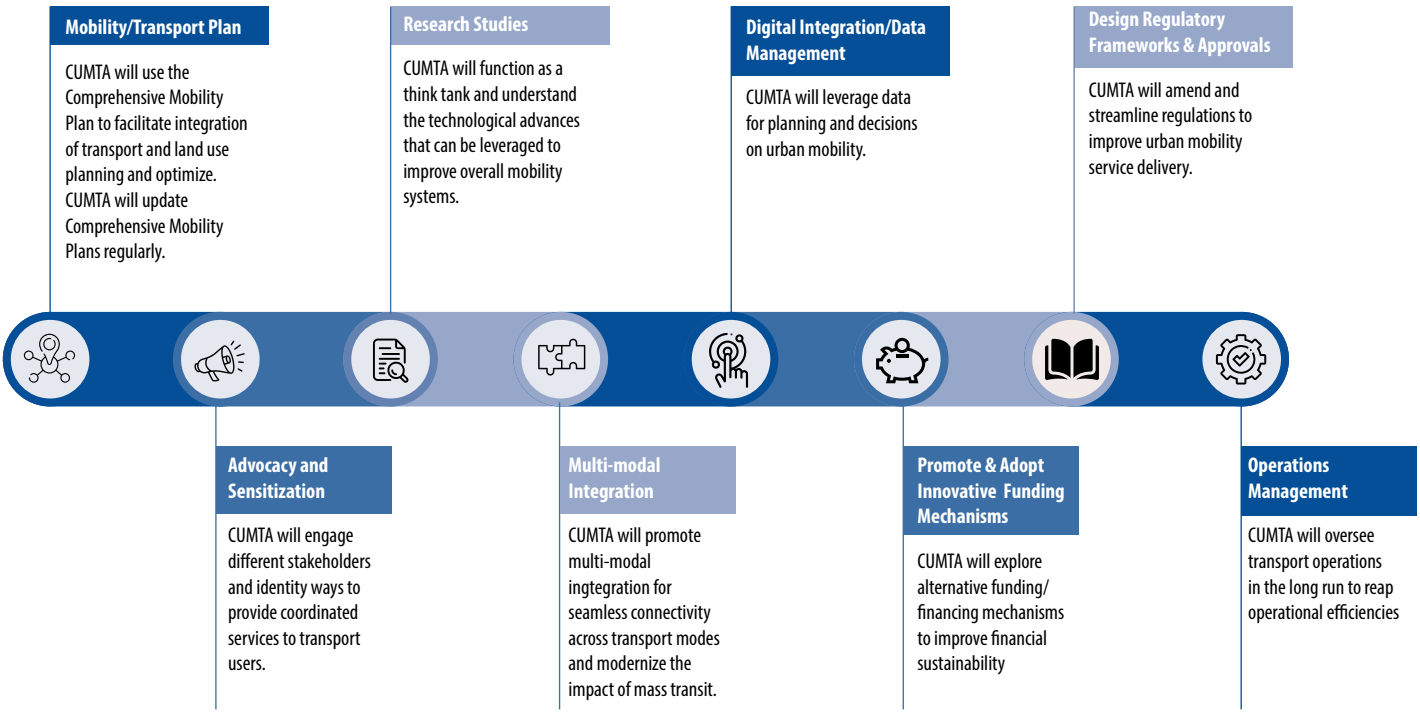
FIGURE 8.4: CUMTA'S FUNCTIONS IN THE STEADY STATE



Source: CUMTA Operations Document.

- The executive board includes representation from finance, transport, housing, and urban development departments, as well as line agencies with a stake in urban transport such as GCC – a municipal corporation, CMDA, which is responsible for land-use planning for CMA, and public transport operators MTC and CMRL.

CUMTA sub-committees have facilitated coordination on cross-cutting issues. Since CUMTA's mandate is the coordination and stewardship of urban mobility in partnership with existing agencies, effective coordination mechanisms are an existential need. CUMTA has leveraged its sub-committees, on Multimodal Integration, Road Safety and NMT, Digital Chennai, and Urban Resilience and Traffic Management, as convening platforms for bringing together different agencies for decisions on cross-cutting issues, including the mobility initiatives.

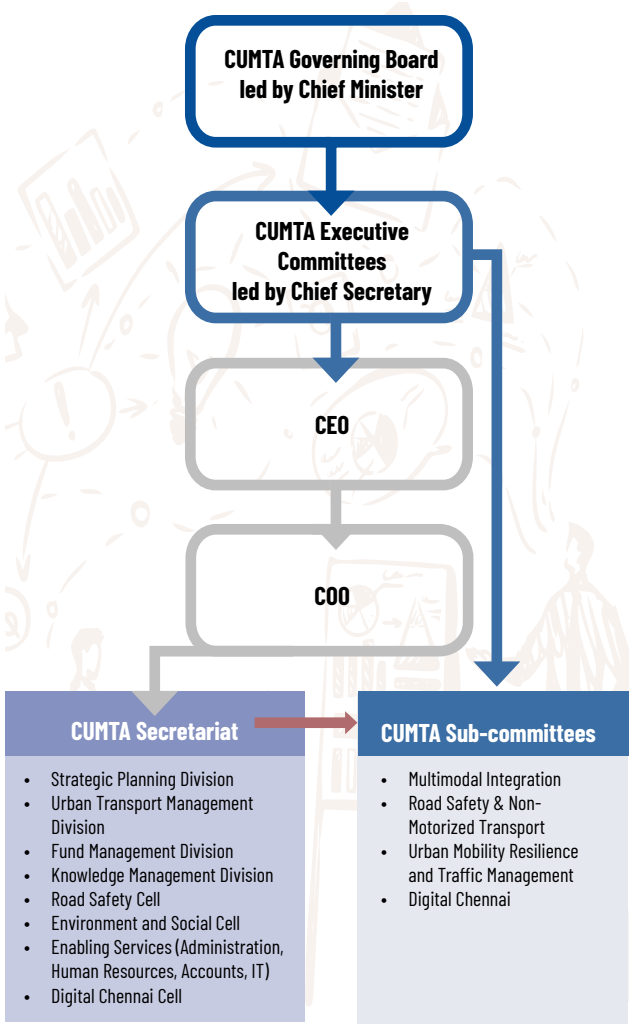
Financing arrangements

International experience shows that it is extremely important for lead agencies to have sufficient financial wherewithal to carry out their coordinating role effectively. Control over budgeting and allocation of funds for the transport sector is a key complement to any legal mandate to perform a coordinating role. Across cities such as Singapore, Paris, and London, lead agencies have their own sources of revenue such as license fees, congestion charging, and parking revenues, or a reliable source of subvention from state and/or central budgets.

CUMTA will eventually control funding allocations for the transport sector in CMA. In the initial stages, while CUMTA does not have any of its own revenue generation, the finance department is expected to seek CUMTA's concurrence for allocations to line agencies such as MTC, CMRL, and GCC. In the steady state, when CUMTA has its own funding sources, it can fund urban transport projects directly out of its kitty, in addition to assuming sectoral funding oversight.

CUMTA is currently funded out of state budgetary allocations, but an Urban Transport Fund (UTF) under CUMTA's control could enhance its role in the sector. NUTP recommends that cities establish UTFs for ensuring dedicated funds for meeting urban transport needs in cities. In line with this recommendation, a UTF is being mooted in Chennai to be placed under CUMTA's control. The UTF could be funded through novel funding sources such as additional property taxes, additional development charges, and transfer and development rights charges, recognizing the added value brought by transport infrastructure to property valuations in the city. The establishment of UTF will give CUMTA much more control over sectoral funding allocations. This should be done once CUMTA is mature and has already demonstrated its value in the institutional landscape. Any control over funds, targeted by 2027, could be delegated to CUMTA after in-depth consultations with stakeholder agencies for ensuring buy-in and alignment.

FIGURE 8.5: CUMTA'S STRUCTURE



Source: Authors' illustration.

EXPECTED IMPACT

CUMTA's impact on the urban mobility landscape in Chennai is emerging. Quantifiable impacts of any new institution materialize over time, and this is also true of CUMTA. However, there are some encouraging signs.

The Government of Tamil Nadu is increasingly looking to CUMTA to take on cross- cutting functions which are not covered by existing agencies. Via the public consultation exercises as part of the Comprehensive Mobility Plan, CUMTA has become the face of the government for transport issues and has developed a strong social media presence. CUMTA is also advancing several marquee mobility initiatives in Chennai:

- **Revitalizing the Mass Rapid Transit System (MRTS).** CUMTA is playing a pivotal role in the eventual handover of MRTS in Chennai from the Indian Railways to the Government of Tamil Nadu, with the Chennai Metro Rail Limited as the operator. This is expected to improve integration of MRTS with Chennai Metro.
- **Integrated ticketing.** CUMTA is developing an integrated ticketing application for improving user convenience for multimodal trips.
- **Road Safety.** CUMTA has partnered with the World Bank on several studies and convened key stakeholders to deliberate on road safety issues via the road safety sub-committee.
- **Digitalization.** CUMTA will soon be appointing a consultant for developing system requirements for the Digital Chennai initiative which aims to leverage urban mobility data for decision making and improving coordination on multi-year construction projects.

CUMTA sub-committees have facilitated coordination on cross-cutting issues. Since CUMTA's mandate is the coordination and stewardship of urban mobility in partnership with existing agencies, effective coordination mechanisms are a must. CUMTA has leveraged its sub-committees on Multimodal Integration, Road Safety and NMT, Digital Chennai, and Urban Resilience and Traffic Management, as convening platforms for bringing together different agencies for decisions on cross-cutting issues, including mobility initiatives.

KEY TAKEAWAYS FOR OTHER CITIES

CUMTA's experience offers valuable takeaways for other cities looking at strengthening their urban transport governance.

- **Fledgling agencies need strong champions.** While CUMTA had legislative backing as far back as 2010, getting CUMTA on its feet took a strong push from the senior management in Chennai. The Government of Tamil Nadu also saw the value of milestones and disbursement linked indicators under the World Bank funded SUSP, to incentivize the achievement of key establishment milestones.
- **An organization is only as strong as its people.** As is the case in most organizations, the importance given to an organization depends on its people. The government's decision to appoint a seasoned officer from the Indian Railway Service to head CUMTA is a signal of the important role that CUMTA is envisioned to play in the institutional landscape and has helped open doors. CUMTA's staff comprises open market hires and secondees from stakeholder agencies. A combination of fresh ideas and established public sector networks has helped CUMTA start its work quickly.
- **Lead agencies need opportunities to prove their worth.** Governments need to manage the initial years of a lead agency like CUMTA carefully for ensuring that they are firmly established in the institutional landscape. CUMTA is leading a range of initiatives as described above, providing opportunities for demonstrating thought and implementation leadership and value addition.
- **It is a continuous process.** Lead transport agencies around the world took several decades to take shape and are continuously evolving. CUMTA too will evolve as it assumes its different functions and grows in strength and visibility.

CONCLUSION

CUMTA's journey offers takeaways for other cities looking at strengthening institutional coordination in urban transport. CUMTA owes its success so far to a clear vision and backing from the highest levels of the government, an operational roadmap with a graduated approach to CUMTA assuming responsibilities, and opportunities for CUMTA to taste success and demonstrate its value to existing stakeholders. Bigger challenges are coming up such as assuming some control over funding allocations for the transport sector, a milestone under SUSP. In the meantime, CUMTA continues to find its feet and establish itself as a key node in the urban mobility institutional labyrinth.

Endnotes

1 Jeyakumar is the Special Officer at CUMTA.
2 Kumar, Ajay and O.P. Agarwal (2013). Institutional Labyrinth: Designing a Way for Improving Urban Transport Services: Lessons from Current Practice; Kennedy, C., E. Miller, A. Shalaby, H. Maclean, and J. Coleman
3 Ministry of Housing and Urban Affairs, Government of India (2017). Metro Rail Policy 2017.
4 Kumar and Agarwal (2013).
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9: DATA-DRIVEN URBAN FUTURES: PREPAREDNESS FOR LEVERAGING DATA IN INDIAN URBAN PLANNING

Jai Kishan Malik, Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

Two prominent trends have emerged in the realm of advancing urban mobility planning – smart cities and harnessing big data. The fusion of these trends converges in mobility data platforms, pivotal portals designed to purposefully disseminate information for enhancing city functionality. Big data, with its expansive scope and predictive capabilities, plays a pivotal role in creating efficient and sustainable urban landscapes. It is important to clarify in this context that big data encompasses not just the enormous datasets typically associated with the term, but also more traditional data sources such as vehicle registration records, network usage data, and transportation infrastructure information, which have a vital role in complementing and enriching our analyses.

The challenges associated with handling vast datasets and coordinating with diverse stakeholders underline the critical role of governance frameworks in ensuring the success of mobility data platforms. The technical complexities involved in aggregating, modeling, and disseminating data necessitate a cohesive governance framework. This framework extends beyond the realm of technological intricacies, emphasizing the need for coordinated efforts among diverse stakeholders, including platform developers, transport service providers, authorities, and travelers.

This note discusses the vital governance mechanisms that underpin the effectiveness of mobility data platforms, exploring their intricate relationship with technical features.

Urban Mobility Challenges in India: An Opportunity for Innovative Solutions and Big Data Integration

India is grappling with a rapidly growing urban population, witnessing a 3.16 percent annual increase, while the motor vehicle population is growing at an alarming rate of 9 percent per year. In 2011, 31 **percent** of the country's population, totaling 377 million individuals, resided in urban areas, a number projected to surge to 600 million by 2031. The

A transformative shift towards data-driven urban planning is being led by the Ministry of Housing and Urban Affairs (MoHUA) in India through its DataSmart Cities Strategy (DSC). Recognizing the pivotal role of city data, DSC focuses on three pillars - people, process, and platform - for cultivating a culture of data usage in governance.

urbanization trend is expected to contribute significantly to GDP, with urban areas reaching 70 percent of GDP by 2030.[1,2] However, the surge in private vehicle ownership, exemplified by the rapid increase from 55 million in 2001 to 326 million in 2020 is overwhelming the existing infrastructure.[3] This surge, coupled with a population density 13 times that of the United States and three times that of China, poses a critical challenge to urban mobility and planning in India.[4]

In addition to these challenges, India is also faced with transport governance challenges. For instance, as per NUTP 2018, the urban local bodies (ULBs) in the major cities must prepare a CMP to plan for local mobility challenges adequately. However, an analysis by Verma et al. (2021)[5] explains how CMPs in Indian cities typically establish targets (for example, increase in modal share of public transit by a specific percentage) but do not present strategies for achieving those targets. Among other reasons could be that ULBs do not have the right tools for monitoring mobility trends in their cities to be able to devise effective strategies for achieving their targets.

The Government of India has recognized the value of big data in enhancing urban mobility. In the recent MOVE summit,[6] India declared that it is in the process of rethinking its strategy for urban mobility. By embracing the use of big data for efficient urban mobility planning, India aims to introduce new technologies (for example, shared mobility) and improving public transportation for enhancing mobility in Indian cities. A transformative shift towards data-driven urban planning is being led by the Ministry of Housing and Urban Affairs (MoHUA) in India through its DataSmart Cities Strategy (DSC). Recognizing the pivotal role of city data, DSC focuses on three pillars - people, process, and platform - for cultivating a culture of data usage in governance. Underpinning this approach is the appointment of city data officers (CDO) and forming city data policies (CDP), promoting a non-hierarchical and collaborative governance structure at the city, state, and national levels. MoHUA's emphasis on a privacy-first approach aligns with NDSAP, ensuring responsible data collection, processing, and sharing. This strategic alignment with NDSAP reflects the government's commitment to ethical data practices.

For operationalizing DSC, MoHUA has established a robust digital infrastructure, including the National Urban Innovation Stack (NUIS), comprising of core data infrastructure, enabling services, and an urban solutions platform. Initiatives such as the Open Data Platform (ODP), India Urban Data Exchange (IUDX), India Urban Observatory (IUO), and the National Urban Learning Platform (NULP) exemplify practical steps taken for implementing this strategy. ODP serves as a central repository for machine-ready data, IUDX facilitates secure data access for planning, IUO manages data for analytics and decision-making, and NULP addresses training needs in the urban ecosystem. This holistic strategy, fortified by concrete platforms and informed by NDSAP, underscores the government's commitment to ushering in a new era of data-centric urban planning.

Other initiatives such as the National API policy, National Geospatial Policy 2022, and the Consent Management Framework by GoI send a clear signal to state and city-level authorities to embrace a data-driven culture. Through the establishment of governance structures, promotion of data standardization, and the creation of a digital infrastructure, the government aims to foster efficient and effective urban planning, aligning with global best practices. The multi-layered approach outlined in DSC, integrated with diverse data policies, positions India at the forefront of leveraging data for transformative urban governance and underscores its commitment to harnessing the power of information for sustainable urban development.[7] A few global examples of cities that have integrated big data in urban planning are given in Box 9.1.

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BOX 9.1: INTEGRATION OF BIG DATA FOR URBAN PLANNING: LESSONS FROM GLOBAL CITIES

The incorporation of big data in urban planning has become a pivotal aspect of enhancing city functionality and sustainability. This box explores key initiatives in London, Singapore, and New York City (NYC) for deriving insights applicable to urban planning endeavors in India.

Transport for London (TfL) has been at the forefront of integrating big data in transport and urban planning. Since 2014, TfL has implemented an open data strategy, publishing real-time information on various aspects of the transport system in popular and common formats (for example, XML, JSON) which has made data

accessible and usable for developers. This includes stations, facilities, transit status, disruptions, accessibility, fares, walking, cycling, and air quality. In addition, the agency also actively seeks partnerships with private companies like Waze, Apple, and CityMapper. This collaborative approach has enriched the transport data landscape, fostering an ecosystem where various companies contribute and benefit from shared data. The use of TfL's data for transport planning spans real-time commuter information, route optimization, air quality monitoring, and infrastructure development for cycling and walking. There are now over 13,000 developers and 600 apps which are actively using this data stream as inputs in their projects.[8]

The Land Transport Authority (LTA) in Singapore has demonstrated a successful model for integrating big data in urban planning. LTA collaborates with entities like IBM Watson Lab and Microsoft for data analytics and real-time data sharing. The DataMall web portal serves as a repository for both static and dynamic/real-time information related to land transport. DataMall has led to the development of numerous third-party apps and transport business models. One example is the launch of the application Beeline which uses anonymized privately operated bus data as an input and provides demand driven bus routes.

New York City collects and manages big data for city transport planning through its comprehensive Open Data initiative. Established in 2009 and legally mandated by 2012, the NYC Open Data portal has seen substantial growth, with over 3,000 datasets available. The success of these initiatives hinges on an active and powerful central authority including open data coordinators, the NYC open data team, and the chief open platform officer, which enables coordination across various institutes. Strategic priorities for NYC's Open Data initiative include improving user experience, strengthening the city's capacity, and building communities. The initiative reflects a commitment to transparency, government efficiency, and data-informed decision-making. NYC Open Data has played a pivotal role in initiatives like Spatial Equity NYC, where citizens are empowered to visualize inequalities in public spaces, health, mobility, and the environment.[9,10]

A common thread among these global cities is the emphasis on partnerships for leveraging the potential of big data for urban planning. London actively collaborates with third parties, fostering a vibrant ecosystem where various entities contribute to and benefit from shared data. Singapore, with its focus on innovation and business orientation, engages in partnerships with big international companies, aligning with national strategies. In the transformational phase, it is crucial for cities to recognize the need for collaborations and partnerships. While internal activities are essential, the dynamic landscape of urban planning demands a collaborative ecosystem. This is evident in the approaches of cities like London and Singapore, where the synergy between the public and private sectors propels the integration of big data into the fabric of urban planning.

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BACKGROUND

Urban Planning Challenges in Chennai

Chennai, a thriving metropolis, and the fourth-largest urban economy in India is rapidly urbanizing. CMA is home to 10.9 million people. The metropolitan area officially expanded its boundaries in 2022, and now encompasses key economic satellite towns. This has positioned Chennai as an innovation-driven economy and a vital growth engine for the nation. Its 78.6 billion USD economy is driven by the manufacturing of electronics and automobiles and providing IT services.

Chennai's rapidly growing economy is also faced with many urban mobility challenges. Chennai is susceptible to natural calamities like floods, cyclones, sea-level rise, tsunamis, heatwaves, water scarcity, and earthquakes in varying degrees. The impact of these events extends beyond immediate threats, influencing the efficiency and longevity of urban mobility infrastructure, particularly in the face of extreme weather

events like floods that disrupt transport networks and services. An origin-destination analysis done by Ukkusuri et al. (2022 for the World Bank)[11] indicates that economic activities remain concentrated near the city center, while the city is expanding, leading to longer trip lengths and a surge in motorized trips. The mode share for buses and non-motorized transport has decreased, while personal motorized vehicles, particularly two-wheelers, have seen a sharp rise. This transition in transportation modes has significant environmental consequences, with transportation contributing 16 percent of the greenhouse gas emissions in Chennai.[12] Moreover, limited affordable housing and insufficient public transport coverage exacerbate the challenges, restricting economic opportunities for a substantial portion of the population who lack private transport means.

As Chennai evolves, integrating big data becomes pivotal for tailored and innovative solutions to its unique challenges. Big data enables real-time infrastructure monitoring for proactive responses to extreme weather situations, ensuring continuous urban mobility. It supports evidence-based policy formulation, promoting sustainable transport and bridging economic accessibility gaps.

Challenges in Using Data Effectively

In Chennai's urban planning landscape, the task of data integration poses significant challenges due to the diverse nature of datasets spread across various key stakeholders. The involved departments encompass a wide spectrum, including GCC, CMDA, CUMTA, CMRL, MTC, Southern Railways (SR), Tamil Nadu e-Governance Agency (TNeGA), the Revenue and Disaster Management Department, CMWSSB, Tamil Nadu Water Supply and Drainage Board (TWAD), Tamil Nadu Generation and Distribution Corporation Ltd (TANGEDCO), Greater Chennai Police (GCP), Highways & Minor Ports Department (HMPD), TNRSP, Torrent Gas, Water Resource Department (WRD), and academics and think tanks relevant for the project. Additionally, other pertinent departments in the expanded CMA contribute to the complexity of the data landscape.

The datasets critical for urban planning are rich and diverse. TANGEDCO collects information on sector-wise consumption and demand, spanning industries, commerce, transport, and households. CMWSSB gathers details on water consumption, including month-wise and year-wise metrics, total water supply losses, actual water supplied, and the status of properties with or without municipal water connections. Public transport-related data such as accessibility, vehicle numbers, terminals, schedules, and routes, are collected by CMRL, MTC, and the Railways. Property tax details, environmental data from air quality sensors, surveillance feeds, rain sensors, and information on road works and infrastructure projects are maintained by GCC. Additional datasets from GCP, GCTP, CMDA, and CSCL cover various aspects, including police stations' locations, traffic signals, intersections, route optimization, master plan data, and layers of mobility resilience and road safety.

The city can also potentially access datasets from third party data providers such as Call Data Records from telecommunication companies. The utility of such data sources was demonstrated through a World Bank study on mobility patterns in Chennai, using anonymized smartphone data obtained from Unacast Inc. and Quadrant. In practice, the city's attempts at gathering and using such privately collected data for regular decision making have not taken off primarily due to the cost of such data.

Despite the availability of valuable data across different agencies in the city, there is a notable underutilization of this data for drawing insights and creating actionable intelligence for city governance. This lack of coordination among agencies leads to budget and time inefficiencies, duplication of data collection, frequent road cuts disrupting the public, inability to prioritize key areas for investments in the city (for example, road safety, climate resilience), and lack of long-term planning in the city.

Many reasons are restricting data sharing among agencies operating in Chennai. First, the existing data collection efforts by various agencies are siloed. Second, the absence of a unified data repository and inconsistent data standards exacerbate the problem. Third, the protocols and frameworks for sharing data in the city are still in the nascent stages. Fourth, technical and human resource capacity constraints pose significant roadblocks for organizations to embrace advanced technologies and improved processes. Finally, the lack of an integrated data platform (geoportal) adds to the challenges, preventing seamless uploading, access, and utilization of data for spatial planning, thereby resulting in fragmented urban planning and service delivery.

APPROACH IN CHENNAI

Addressing these challenges requires a concerted effort for establishing a unified data repository, implementing consistent data standards, enhancing data sharing mechanisms, and developing robust data governance frameworks. The recent policies issued by Tamil Nadu signify a positive step for addressing data-related challenges in Chennai. The Tamil Nadu State Data Policy 2022[13] released by the government emphasizes the pivotal role of high-quality data in fostering good governance and informed decision-making. Encouraging the use and sharing of open data, the policy aims to enhance transparency and citizen services. This comprehensive framework provides a foundation for effective governance and promotes data-driven decision-making. The policy document outlines key principles and guidelines for leveraging data for the benefit of the city and its residents.

The Tamil Nadu government has also established the Tamil Nadu e-Governance Agency (TNeGA), a specialized agency responsible for designing and implementing the e-governance framework in the state. TNeGA has the technical capacity to store, manage, and analyze spatial and geographical data in different formats. The recent data policy in Tamil Nadu makes it mandatory for all government agencies in the state to share their datasets with TNeGA. The Tamil Nadu GIS (TNGIS) platform has been especially created for storing and managing spatial and non-spatial datasets from various agencies and using them for efficient implementation of infrastructure plans in the state.

Drawing inspiration from the state level guidelines, Chennai has been a frontrunner in taking steps which will transform its governance structure and technical capabilities to prepare itself for using big data in urban planning.

Data Governance: CUMTA's role

Despite TNeGA, a metropolitan-level organization is required for data used in urban transport planning. The Government of Tamil Nadu has signaled the need for using data for transport governance through a comprehensive data policy and facilitated the required infrastructure through the establishment of TNeGA at the state level. However, services are often delivered at the city level through departments like CMRL, GCC, and MTC that are also responsible for storing and administering the data generated through the delivery of the services provided by them. This process of data generation by multiple agencies at the city level requires an institution at the metropolitan level that systematically synthesizes the data. The objective of this institution must be broader than that of individual service-providing agencies in the city for facilitating the integration of data from multiple sources for more informed decision-making in the city.

The establishment of CUMTA in November 2010 marked a crucial initiative by GoTN for addressing the challenges of integrated and sustainable urban mobility in Chennai. CUMTA was created for filling institutional gaps and resolving overlaps among various agencies involved in urban transport in CMA. This move was aimed at streamlining efforts and fostering collaboration for enhancing the efficiency of urban transportation. The amendment to the original act in September 2020, placing the Chief Minister of Tamil Nadu as the Chairman and the Minister in charge of the housing and urban development department as the Vice-Chairman, highlighted the government's commitment to effective governance in the transport sector. As CUMTA undertakes functions to oversee, coordinate, promote, and monitor the implementation of traffic and transportation measures, including the promotion of mass passenger transport systems, its role aligns with the broader goals of optimizing urban mobility. The formation of CUMTA is integral to the ongoing efforts for improving Chennai's transportation landscape and its functions resonate with the city's endeavor to leverage data-driven solutions for enhanced planning and decision-making.[14]

Besides being strategically positioned to integrate data from the many agencies operating at the city level in Chennai, CUMTA is also expected to have the technical capacity to manage and analyze big data. It is expected that CUMTA will play a pivotal role in capturing, consolidating, and coordinating the systematic storage and accessibility of digital data and maps related to mobility demand, supply, performance, and resilience. By establishing secure channels of regular data exchange and developing a digital data repository, CUMTA will ensure the effective collation and analysis of data from various urban transport agencies. The agency will undertake big data analysis for enhancing transport, promoting cleaner modes, and facilitating the emergence of Mobility as a Service (MaaS). Moreover, it may explore data monetization, publish analytical

reports through predictive and prescriptive analyses, and will manage a command-and-control center.

CUMTA adopts a tiered governance structure for effective decision-making and implementation. Tasks such as policy formation, mobility plans, and plan reviews are managed at the top level by the governing board. The executive committee, the second tier, executes on-ground plans, implements the governing board's decisions, proposes public transport initiatives, advocates technology solutions, provides suggestions, facilitates coordination, and manages the transport fund. CUMTA is also supported by sub-committees that provide strategic knowledge on niche topics and undertake specific tasks proactively. Sub-committees are topic specific, and their scope includes policy formulation, research studies, and program management. Currently CUMTA has sub-committees on Road Safety, Multimodal integration, Traffic Management and Urban Mobility Resilience, and Digital Chennai.

The Digital Chennai Initiative

CUMTA is leading a new initiative - Digital Chennai – focusing on conducting comprehensive studies and data collection activities, encompassing spatial and non-spatial data, emphasizing data's crucial role in shaping urban development and transportation strategies. Under Digital Chennai, it is envisioned that effective data management can be achieved through adherence to carefully curated data standards, sharing policies, and verification mechanisms for the reliability of the data. These standards and policies are pivotal for successfully leveraging data for planning and decision making in Chennai.

CUMTA formed the Digital Chennai sub-committee to facilitate coordination on this initiative. The sub-committee is aimed at enhancing urban planning and infrastructure implementation practices. This includes strengthening institutions in the delivery of sustainable spatial planning, facilitating coordination between various implementing agencies to prevent conflicts, optimizing resources and time, and achieving efficient integrated infrastructure implementation practices. It is also envisioned that the sub-committee will review relevant studies, establish an integrated mobility data platform for storing and accessing various types of mobility data, and foster inter-agency coordination on the digital aspects of urban mobility. Additionally, the sub-committee is positioned to play a key role in overseeing the development of digital solutions for urban mobility and operationalizing the data policy for CMA.

The Digital Chennai initiative centers around two key components: the Integrated Urban Development Platform (IUDP) and the Urban Project Planning and Management (UPPM) tool. IUDP and UPPM are expected to be pivotal components of the Digital Chennai initiative, focusing on transformative strategies for urban mobility and spatial development. These tools aim to revolutionize data integration and streamline project management across agencies and departments in CMA.

IUDP is expected to serve as a unified digital platform for the delivery of services in the city and project management. It will address key challenges such as data discoverability, duplication, and security concerns. By integrating, storing, and sharing both spatial and non-spatial data, IUDP will facilitate modular analytics for a comprehensive understanding of the city services' performance. It is planned that the tool will include various use cases, including monitoring mobility service delivery, mapping utilities and transport infrastructure, and enabling urban planning and emergency services. IUDP's goal is establishing a comprehensive, multi-layered framework for data management within CMA. This framework envisions multiple layers: data collection, processing and integration, AI & ML for simulation and analytics, and a decision-support layer with stakeholder-specific use-cases. While TNEGA's TNGIS currently provides the data collection layer at the state level, the additional layers will be developed through the Digital Chennai initiative. To enhance urban-level focus and leverage domain expertise, agencies like CUMTA, CMDA, and GCC will complement TNGIS' capacity, particularly for urban and transport-specific GIS applications.

The UPPM tool will be designed for enhancing project planning, management, and coordination for multi-agency urban projects. It will address challenges like identifying conflicting projects in the early stages, lack of coordination, and insufficient data. By describing projects in a GIS platform with real-time updates and KPI tracking, the UPPM tool will provide a centralized solution for effective project oversight. The tool aims to streamline project documentation, improve coordination, and provide a standardized approach to infrastructure project planning and monitoring. Furthermore, UPPM can be integrated with the PM Gati Shakti platform for macro-

level project management and planning. To create a comprehensive ecosystem, UPPM will also integrate with existing digital tools in Tamil Nadu, such as the TN tender portal, eOffice, eMunetram, and TNGIS, facilitating seamless processes for conceptualizing, approving, and monitoring projects.

The IUDP and UPPM tools will offer practitioners a comprehensive, real-time, and integrated solution for data-driven decision-making and efficient project management. These tools will lay the foundation for a data-informed approach to urban planning and infrastructure development in Chennai, contributing to enhanced sustainability and effectiveness.

EXPECTED IMPACT

Chennai has taken many meaningful steps for facilitating the effective use of data generated by multiple agencies in the city for urban and transport planning. This includes the formation of CUMTA, which is endowed with institutional powers to gather data from various city agencies and the technical capacity to store and analyze the gathered data. The Digital Chennai initiative has clearly signaled to various agencies in the city, external consultants, and knowledge partners about the city's intent to collect data in a unified manner and use it for efficient transport governance. Finally, the Digital Chennai sub-committee is working towards developing tools like IUDP and UPPM which will bring the vision of Digital Chennai to reality.

The envisioned impacts include an efficient urban mobility, promotion of cleaner modes of transport, and preparedness for MaaS. Moreover, the exploration of data monetization and the publication of analytical reports through predictive and prescriptive analyses are expected to contribute to informed governance and sustainable urban development. The Digital Chennai initiative is expected to: i) facilitate successful implementation of large infrastructure projects involving multiple agencies and planned in phases over many years; ii) lead to systematic management of assets in the city (for example, roads, bridges); and iii) establish a robust framework for selecting priority areas for the city such as road safety and climate resilience.

The proposed IUDP and UPPM further underline Chennai's commitment to efficient project oversight and streamlined infrastructure development. By addressing challenges related to data discoverability, duplication, and security concerns, these tools could revolutionize data integration and project management practices across various agencies and departments in Chennai.

Together, these initiatives are anticipated to lay the foundation for a data-informed approach to urban planning, contributing to enhanced sustainability, effectiveness, and resilience in the face of urbanization and climate-related challenges.

Way Forward for Chennai

The slew of efforts in Chennai will set the stage for the city to use big data to facilitate intelligent urban planning. The following initiatives might be given priority by the city under the Digital Chennai program for fortifying it even more:

Chennai will benefit from a standardized template for data collection and studies on urban mobility planning. As part of the third master plan development process for CMA, the city has commissioned around 50 studies addressing various themes, including the built environment, economy, digitalization, climate resilience, and transportation services. Private organizations and outside consultants are given charge of conducting these studies. Chennai can leverage data gathered for effective urban planning by rapidly establishing a unifying framework for integrating knowledge and the data acquired. This presents an opportunity for the sub-committee on Digital Chennai to create a study template so that the knowledge that is produced under these independent studies can be integrated and used more effectively. Furthermore, the format in which the data is gathered and disseminated for these planned investigations should be standard.

Chennai needs a structured set of protocols and a comprehensive framework for addressing the identified issues systematically. This objective may be realized through the establishment of a committee composed of decision-makers such as directors and general managers from relevant agencies. Empowered with technical capabilities, this committee will undertake a review of multi-sectoral and long-range projects and possess the authority to adjudicate on emerging issues and conflicts. Furthermore, the committee will be empowered to formalize recommendations aimed

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at enhancing coordination policies among diverse agencies and refining the procedures for reporting key performance indicators.

Chennai can glean valuable lessons from the Major Capital Infrastructure Coordination Office (MCIC) founded in Toronto in 2008. MCIC uses GIS-based tools for monitoring the planning of infrastructure projects spanning multiple agencies in the city, thereby identifying conflicts during the planning phase. However, MCIC also has additional protocols for dispute resolution. For example, it has established agreements and protocols among participating agencies for prioritizing specific project types based on their locations.

TAKEAWAYS FOR OTHER CITIES

Based on the learnings from Chennai and other cities across the world, the following highlight the key guiding principles for urban planners in India who aspire to leverage big data for efficient urban planning:

- **Establishing a centralized agency with a clear mandate and strong leadership**: The establishment of CUMTA in November 2010 highlights the importance of a dedicated agency with a clear mandate. CUMTA's strategic positioning emphasizes the need for a centralized entity to oversee, coordinate, and promote integrated urban transport measures. Other Indian cities can draw inspiration from CUMTA in Chennai, and international examples like Transport for London (TfL) and the Land Transport Authority (LTA) in Singapore, which have successfully integrated big data in their transport and urban planning by centralizing efforts and fostering collaboration among various agencies.
- **Enhancing technical capacity for driving the data revolution**: CUMTA's focus on creating essential roles such as the Mobility and Spatial Development Data Architect, Application & Software Developers, Cloud Specialist and the Lead Data Integrator underscores the significance of enhancing technical capacity for successful data integration. These roles play a crucial part in managing, planning, designing, and supporting data platforms, ensuring the adequacy, accuracy, and legitimacy of the data.
- **Developing tools like IUDP and UPPM**: The proposed IUDP and UPPM tools will be pivotal components of the Digital Chennai initiative, focusing on transformative strategies for urban mobility and spatial development. Drawing inspiration from global cities like New York City, which has a comprehensive Open Data initiative since 2009, Indian cities can benefit from similar tools for addressing challenges related to data discoverability, duplication, and security concerns. Tools like IUDP and UPPM can offer a standardized framework for data storage, sharing, and utilization, laying the foundation for a data-informed approach to urban planning.
- **Fostering partnerships with third-party private players**: International cities like New York and Singapore actively collaborate with third parties, fostering vibrant ecosystems where various entities contribute to and benefit from shared data. A few international examples of cities that have successfully partnered with third-party private players are given in Box 9.2. Data monetization can be a strong incentive for governments to consider data partnerships.
- **Ensuring privacy concerns and making public data accessible**: After ensuring privacy concerns, making public data easily accessible to everyone is crucial for transparency and citizen engagement. Cities like New York have successfully implemented Open

BOX 9.2: INTERNATIONAL EXAMPLES OF PARTNERSHIPS WITH THIRD-PARTY PRIVATE PLAYERS

Cities can learn from international examples such as TfL in London, which actively engages in partnerships with private companies like Waze, Apple, and CityMapper, enriching the data landscape and fostering an ecosystem for shared data. Collaborations with third-party private players can contribute to technological advancements and innovations in urban planning. Singapore, with its focus on innovations and business orientation, engages in partnerships with big international companies. Indian cities can emulate this collaborative approach for leveraging the potential of big data for urban planning. Partnering with private players can bring diverse expertise, resources, and perspectives to the table, contributing to more comprehensive and innovative solutions.

Data initiatives, providing citizens with access to a vast array of datasets. Indian cities can adopt similar measures for enhancing transparency, government efficiency, and data-informed decision-making. Striking a balance between data accessibility and privacy considerations is key to building trust and fostering a collaborative approach in urban planning.

CONCLUSION

The evolving landscape of urban planning in India necessitates innovative approaches for tackling complex challenges and the integration of big data emerges as a crucial paradigm shift. Traditional reliance on actively collected data through surveys has limitations, including small sample sizes and infrequent collection intervals. This technical note underscores the transformative potential of big data, acquired passively from sources like mobile phones and social media, offering continuous, real-time insights into human mobility patterns for effective urban planning. Drawing inspiration from global cities like London, Singapore, and New York, Indian transport and urban planners can glean key takeaways. Firstly, the establishment of a centralized agency, exemplified by CUMTA with a clear mandate and strong leadership is pivotal. Secondly, enhancing technical capacity, as seen through CUMTA's crucial role, drives the data revolution. Thirdly, developing tools like the Integrated Urban Data Platform (IUDP) and Urban Project Planning and Management (UPPM) are essential for standardized data utilization. Fourthly, fostering partnerships with third-party private players, as demonstrated by international collaborations, can bring innovations to urban planning. Finally, ensuring privacy concerns and making public data accessible strike a balance vital for transparency and citizen engagement. As Indian cities embark on leveraging big data for urban planning, these key principles will serve as a comprehensive guide for informed and sustainable decision-making.

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10: PRACTICAL USE CASES OF LEVERAGING DATA FOR URBAN MOBILITY PLANNING

Jai Kishan Malik, Shyam Srinivasan, and Gerald Ollivier

INTRODUCTION

Technological innovations are generating new data sources that could transform traditional transport planning. Data generation as a byproduct of automation and digitization is emerging as a transformative force with unprecedented opportunities in urban mobility planning. Big data not only presents a wealth of information but also elevates the granularity of spatial and temporal details beyond the confines of traditional surveys. Its unique potential lies in identifying patterns previously elusive through conventional methods. The raw nature of big data analyses, free from assumptions in purposeful data collection, facilitates a deeper understanding of the movement of human beings in time and space, offering insights into time-of-day dynamics and day-to-day fluctuations. Yet, it is important to clarify that in this context, big data encompasses not just the enormous datasets typically associated with the term but also more traditional data sources such as vehicle registration records, network usage data, and transportation infrastructure information, which have a vital role in complementing and enriching our analyses. Continuous monitoring, offered by some big data sources, introduces a dynamic dimension to transport planning. The ability to detect unforeseen trends and changes (for example, natural disasters) provides a platform for more contingent planning, steering away from exhaustive upfront analyses. This opens the door for trial-and-error approaches, leveraging continuous feedback for gradual policy adjustments through a series of nudges rather than a sudden and drastic policy.[1,2]

Urban transport planning is increasingly enriched by a diverse array of data sources, extending beyond traditional research-oriented datasets. Table 10.1 summarizes the broad categories of data sources that can be leveraged for urban mobility planning. The categorization is inspired by OECD (2013)[3] but tailored to the specific case of urban mobility planning. The first includes data related to *official registration or licensing requirements* (for example, vehicle registration data, license data). Data such as ticketing data from public transportation and taxi ridership form the category of *commercial transaction data*. The *tracking data* category includes the sources of new data services made available due to cell phone and internet use. These include data from navigating smartphone apps, call detail records data, and data from other kinds of tracking such as CCTV images at traffic intersections. Data about the *mobility infrastructure* such as roads, footpaths, and cycle paths,

Chennai's initial steps in leveraging big data for urban mobility planning, while modest, are laying crucial groundwork for a data-driven future. These efforts, including the development of KPIs, pilot studies using mobile phone location data (MLD), and CCTV-based pedestrian counts, are positioning the city on a trajectory like data-savvy metropolises like Seoul, São Paulo, and Singapore.

can be critical in creating indicators such as accessibility measures or walkability scores of neighborhoods. Another dataset category includes information about the *delivery of services*. For instance, many public transportation agencies worldwide distribute relevant information about their transit system like schedules, routes, fares, and transit details, through the General Transit Feed Specification (GTFS). Having data in a universal format is beneficial for benchmarking service delivery and comparing across geographies. GTFS data can also be made available in real-time. Finally, regularly updated, or real-time data on the status of assets and facilities maintained by the agencies such as traffic signals and train service alerts, can inform smart urban planning.

This technical note aims to create awareness among urban mobility practitioners in India about the kind of data analytics that can be conducted using these new data sources for informed and efficient urban planning. The following section showcases some of the use cases of big data analytics, which has enabled a smarter way to plan for urban mobility services.

TABLE 10.1: CATEGORIZATION OF A TYPICAL DATASET USED IN URBAN MOBILITY PLANNING

Category of Data	Typical example in urban mobility planning	Specific links	Typical owners of the data
Government and other registration records	Vehicle registration and transfer data	Vehicle registration in New York	Government-state level
Commercial transactions	Ticketing data at public transportation	Farecard Transactions on Public Transport in Singapore	Public transport operators
	Taxi ridership data	TNC data in Chicago	Private taxi companies
Tracking data	Location-based database from smartphone apps	Spectus, Unacast	Third-party apps
	Data from navigation apps	Waze for Cities	Third-party apps
	Call detail records data of phone calls and SMS exchanges	Orange's Data for Development	Third-party apps
	CCTV images at traffic intersections	Traffic Images	Government-city level
Infrastructure data	Data on cycling/walking lanes, cycle parking, and signals	Tfl data on active mobility	Government- city level
	Building activity/land-use data	Building activity data, Australia	Government- city level
	Road infrastructure	Road infrastructure data maintained by Singapore	Government- city level
	Public transportation data: bus/ rail stops, locations and lines	Public transport infrastructure data in Singapore	Government- city level
	Public toilets' location data	Tfl data on toilets	Government- city level
Service delivery data	Operations data for public transportation - fares, schedules, routes (real-time and static)	GTFS	Government- city level
	Car park availability data	Singapore's Car Park availability data	Third-party apps
Asset management data	Real-time operational status of assets like traffic lights, train lines, and train service alerts	Singapore's dynamic data	Government or private service providers

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Typical Use Cases of Big Data Analytics in Urban Mobility

This section discusses the transformative potential of big data and analytics in shaping urban mobility planning. By exploring concrete examples from cities worldwide, this section showcases the diverse applications and promising outcomes emerging at the intersection of big data and urban planning. Specifically, the section covers five sets of use cases from India and internationally: (i) KPIs for smart cities, (ii) use of continuous monitoring and trial-and-error approaches for urban policy innovations, (iii) machine learning and computer vision for road safety, (iv) big data for public transport in Sao Paulo, Singapore, and Seoul, and (v) use of call data records for discerning mobility patterns in Chennai.

Case 1: Key Performance Indicators: Planning, Measurement, Real-Time Insights, and Visualization for Smart Cities

Cities and urban areas are complex and dynamically evolving. Big data, high-speed internet connectivity, and advanced data analytics have led to the generation of real-time KPIs in cities with fine spatial granularity. These KPIs offer a way for the cities to have measurable targets for their long-term vision and periodically track the success of the initiatives taken for achieving their goals.

KPIs play a crucial role in urban mobility planning, fostering efficient resource allocations and strategic decision-making. Globally, investments in urban transport underscore the critical role of mobility in driving economic prosperity. Notably, Singapore's partnership with the International Telecommunication Union (ITU) in 2015 exemplifies the adoption of KPI frameworks for measuring progress in becoming a Smart Nation.[4] In India, data integration for urban mobility is in its nascent stages, hindering comprehensive decision-making. Addressing this challenge requires robust data governance frameworks and governmental support for digital mobility solutions. By embracing KPIs and advancing data governance, cities can navigate the complexities of urban mobility, fostering sustainable development and enhancing citizen welfare. Well-structured KPIs can help cities track progress on urban mobility goals, prioritize projects, and evaluate the outcomes of discrete projects.

Under the Chennai City Partnership, CUMTA and the World Bank[5] outlined a data-driven and accessibility-informed mobility framework in CMA. This framework includes six objectives – Green, Resilient, Inclusive, Efficient Development, Safe, and Innovative – reflecting the city's development priorities. A suite of 70 indicators derived from international best practices and covering various dimensions of sustainable transport was suggested for measuring these objectives. Some of these indicators will be integrated in the forthcoming update of CMA's comprehensive mobility plan, emphasizing equity in transport access and public transportation modes including Chennai Suburban Rail and ride-hailing services. The selection of internationally used KPIs is expected to facilitate comparisons and enable prioritization of crucial aspects of mobility. Additionally, the approach recommends using data standards and real-time indicators, providing a holistic understanding of CMA's mobility while facilitating informed decision-making. It is important to note the challenges that cities face in this area. One of the key challenges is updating and maintaining data and monitoring these KPIs. Updating the GRIDS KPI in CUMTA's CMP every couple of years requires investment in data capture and data processing.

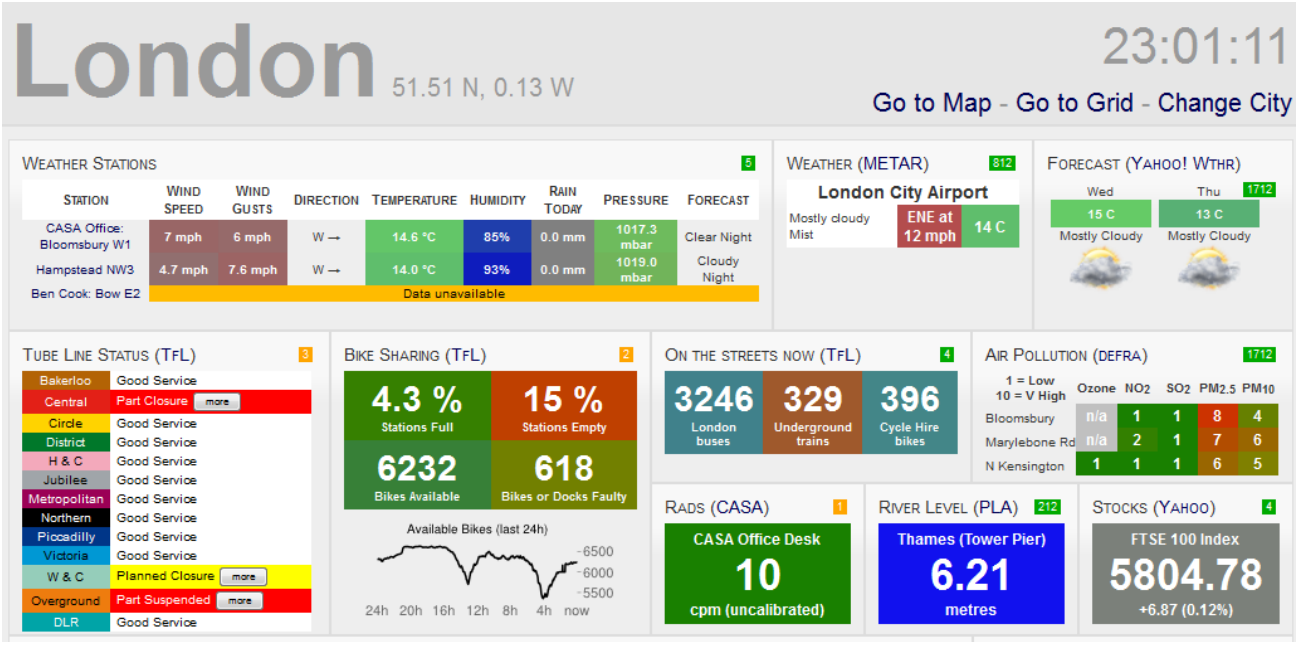
KPIs have varying data requirements, and cities may prioritize them based on development needs and data availability. Some indicators can be calculated using data from authorities and open data sources. For example, in the Chennai framework, a KPI – *connected footpath network* – requires a geospatial footpath network and locations of points of interest. These simple indicators can help identify areas that need improvements and gaps in mobility. Indicators used at a later stage are more complex and require specific infrastructure or surveys for gathering data. One example is the *cost of congestion* KPI, which requires traffic flow speeds along corridors during peak and non-peak hours. Such a KPI can be reliably generated using data like Waze for Cities data, described in more detail below. Policymakers in cities can prioritize indicators based on the needs of their cities and how easily this data can be shared.

A natural progression after cities start collecting KPIs is the development of dynamic urban dashboards. These dashboards offer a comprehensive approach for collecting, storing, and displaying a diverse range of real-time and trend data for key city metrics. Box 10.1 illustrates the case of the CityDashboard in the United Kingdom.

BOX 10.1: DASHBOARD IMPLEMENTATION IN THE UNITED KINGDOM

CityDashboard,[6] is a data-driven website offering real-time metrics for various cities in the United Kingdom. Each city's live metrics are presented as widgets on the main page, continuously updated without refreshing (Figure 10.1). The platform collects data from third-party open data platforms and city data platforms, normalizes it, and archives it, providing users with an updated city overview without straining data sources. The data is served in CSV, JSON, or HTML widget formats, acting as a rudimentary API for different research and application projects. The platform supports 8 cities, including London, with the flexibility to add new widgets rapidly. It visualizes data on an interactive map. Using APIs from JQuery, OpenLayers, and Google, a variety of data providers are the source of the data used in the display. Viewers can watch real-time data on public transportation operations, traffic camera feeds, and the availability of public bikes. The dashboard also includes data from fields other than transportation - the stock market, weather, air pollution, river levels, electricity consumption, Twitter trends related to London, and the city's happiness index. Sydney's CityDash[7] showcases a highly advanced application for such dashboards. The backend API of CityDash is integrated with the real-time GTFS feed of Transport for NSW (TfNSW) for creating a transportation map displaying the real-time locations of different modes of transportation such as buses, trains, ferries, and light rail. Furthermore, the integration of CityDash with Google Analytics generates data on how users interact with the platform, which is critical for generating insights into how such platforms are being used by the public.[8,9]

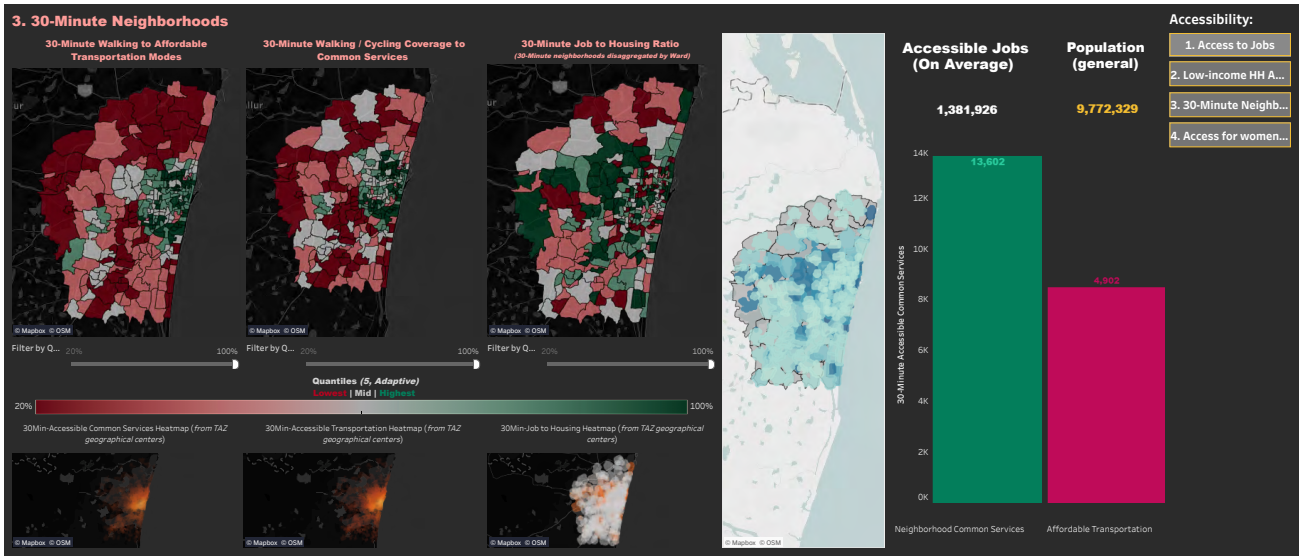
FIGURE 10.1: SNAPSHOT OF THE CITYDASHBOARD IN LONDON



Source: Borrelli et al. (2016).[10]

One of the goals for cities is streamlining data collection and investing in technical capabilities that allow the development of dashboards like those in London and Sydney. Several Indian cities are now planning on utilizing new data sources for generating and visualizing KPIs, albeit static, at a high level of spatial granularity. For instance, in an ongoing engagement with Chennai, the World Bank demonstrated how the city can generate visual KPIs using already available data.[11] As seen in Figure 10.2, one of the KPIs measures how easily women access jobs using active modes and public transportation in the Chennai metro area, at the level of transportation analysis zones (TAZs). To carry out this analysis, the dataset included maps containing information on TAZ boundaries, population distribution, points of interest, road network, and GTFS feed from public buses and railways. Other KPIs measure the performance of the city in terms of the resilience of the transport network, environmental impact, and safety.

FIGURE 10.2: ACCESSIBILITY ANALYSIS FOR WOMEN IN CHENNAI



Source: World Bank analyses.

Case 2: Leveraging Continuous Monitoring and Trial-and-Error Approaches in Urban Policy Innovations

Real-time data sources are enabling dynamic and flexible policymaking. In the realm of urban policy innovations, the conventional approach of exhaustive analysis before implementation can be resource-intensive and time-consuming. The paradigm shift towards continuous monitoring, fueled by the wealth of real-time data from sources like the Waze for Cities[12] dataset, opens up new avenues to adjust policies during implementation. Rather than committing to rigid, one-size-fits-all strategies, this approach enables a series of iterative nudges—gradual adjustments based on ongoing feedback. Continuous monitoring facilitates a trial-and-error methodology, allowing policymakers to adapt swiftly to evolving urban dynamics.

This shift is particularly impactful in the context of traffic management policies, as exemplified by Bogotá's experience. Ivarsson and Stokenberga's (2022)[13] analysis of the city's policy modifications in 2022, derived from real-time data, highlights the tangible benefits of this approach as explained in Box 10.2. Furthermore, the anticipated types of data, enriched with visualizations, align seamlessly with the growing trend of public participation in planning processes. The transparent, data-driven nature of continuous monitoring not only fosters public trust but also encourages active engagement. Visualizations have become a powerful tool, translating complex data into accessible formats that resonate with the broader public, fostering a sense of inclusivity in the decision-making process. As cities worldwide grapple with the complexities of urban mobility, this paradigm shift towards continuous monitoring emerges as a beacon for more adaptive, citizen-centric policymaking.

BOX 10.2: BOGOTA'S EXPERIENCE WITH DATA DRIVEN TRAFFIC MANAGEMENT

Context: Bogotá faces significant traffic congestion (ranked eighth globally in 2021). To tackle this, the city introduced Pico y Placa in 1998, a pioneering vehicle restriction policy. Despite its success in reducing congestion, air pollution, and accidents, it led to increased car ownership, particularly among high-income households. In 2020, the authorities introduced PyP Solidario, allowing car owners to pay for passes to opt out of restrictions, aiming to curb the incentive for additional car purchases by offering a cost-effective alternative to buying new vehicles.

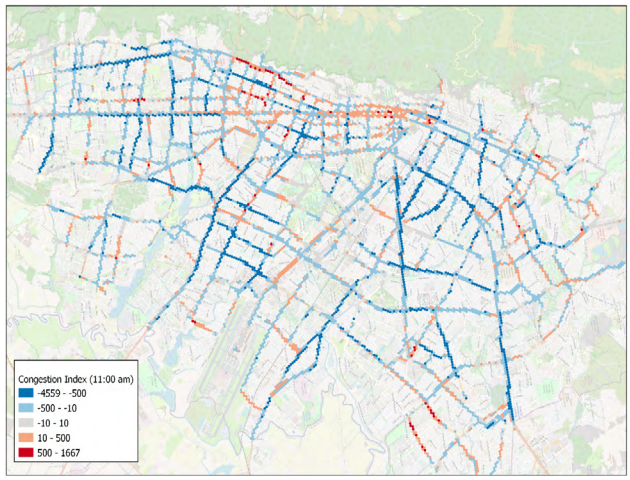
Analysis: A World Bank study created an hourly congestion index for major roads in Bogotá using the Waze for Cities dataset to assess the impact of a 2022 policy modification in Bogotá. Changes in the Congestion Index[14] hourly profile indicated altered travel patterns, with residents adjusting their commute times, resulting in reduced congestion during mid-day hours. Comparing October 2021 and March 2022, the analysis revealed a notable 11 percent average reduction in congestion on weekdays (Figure 10.3).

Dataset: The dataset used, a part of the Development Data Partnership, offers valuable, frequent, and granular traffic data to government partners. With over 140 million monthly drivers reporting incidents and irregularities, it provides billions of data points. Shared freely through the partnership since 2014, the dataset includes traffic alerts, traffic accidents, and traffic irregularities, aiding public sector, transport, and urban planning. Analyzing this data using Google BigQuery, H3, and Dask facilitates informed decision-making for planners.

Case 3: Road Safety: Harnessing Machine Learning and Computer Vision for Near-Miss Detection and Traffic Crash Prevention

Advancements in machine learning, computer vision, and an analysis of CCTV images present a groundbreaking avenue for enhancing road safety monitoring, particularly in the context of near misses and traffic crashes. In the past decade, machine intelligence and computer vision have proven highly successful in pattern recognition, offering a novel dimension to urban understanding. Computer vision, leveraging technologies like CNN and deep learning, holds immense potential for understanding the intricate dynamics of near misses. By extracting safety-related features from images, be it still images or multi-frame captures of complex daily life scenes, these technologies can decode various layers of city elements, including the built environment, human interactions, transportation, traffic, and natural infrastructure. **For constructing an autonomous and multifunctional system for near-miss detection, seven critical steps have been identified.** These steps range from sensing and classifying the physical environment to integrating all algorithms, utilizing computer vision techniques such as image classification, segmentation, object detection, action recognition, and scene awareness. Through the integration of deep learning and computer vision algorithms and risk factors the types of near misses and their impact can be meticulously identified and analyzed. This comprehensive approach offers a transformative means of automatically quantifying and analyzing risks, providing valuable insights for policymaking in the realm of road safety. The seamless integration of these algorithms creates a robust dataset that not only addresses existing knowledge gaps but also enables more effective regression models for understanding causality and the impact of various risk factors on different types of near misses. Box 10.3 showcases one of the implementations of computer vision algorithms.[15]

FIGURE 10.3: HOURLY CONGESTION INDEX DIFFERENCE FROM OCTOBER 2021 VERSUS MARCH 2022 AT 11:00 AM



Source: Ivarsson and Stokenberga (2022).

Chennai has conducted some pilot studies for implementing comparable algorithms in the city. The city has created new models that can extract quantifiable measures (for example, the number of pedestrians at a crossing in one hour) from CCTV footage such as vehicle counts and pedestrian numbers at traffic intersections (Figure 10.4). The aim of these pilot programs is to eventually replace manual traffic counts with automated data collection processes. This is expected to lower the cost of data collection and allow for more frequent data collection.

FIGURE 10.4: CUMTA'S IN-HOUSE MODEL USED FOR CALCULATING PEDESTRIAN COUNT (LEFT) AND VEHICLE COUNT (RIGHT) FROM CCTV IMAGES

BOX 10.3: ADDIS ABABA: USING IMAGE DATA FOR MONITORING ROAD SAFETY

Context: In 2017, Addis Ababa, Ethiopia, faced a high annual road fatality rate of 25.3 per 100,000 people, surpassing the global average. In response, the Government of Ethiopia and the World Bank initiated the Transport Systems Improvement Project (TRANSIP) for enhancing mobility in Addis Ababa and also road safety nationwide. With over 70 percent fatal crashes involving pedestrians particularly impacting the poor, the project aims to redesign street infrastructure and implement road safety measures.

Analysis: The impact evaluation's first phase was carried out by the World Bank,[16] with an emphasis on road safety. Video footage from cameras placed at crossings designated for rehabilitation under the TRANSIP initiative was subjected to computer vision analytics. They trained an image detection method via homography mapping of junction points. Then, crucial variables including car speed, traffic volume, the number of jaywalkers, and, most importantly, incidents like near-hits, near-collisions, and accidents were found using computer vision analytics. The purpose of this thorough investigation was to evaluate how well the TRANSIP program had improved traffic safety at specific crossings.

Dataset: Video footages from cameras installed at the intersections.

Case 4: Big Data Integration for Smart Public Transportation in São Paulo, Singapore, and Seoul

Public transport agencies are strategically investing in big data technologies for harnessing valuable insights and facilitating automation from sensor data in smart public transportation planning. These technologies span three key categories: data storage (for example, Hadoop, Data Lakes, and NoSQL databases), data processing (for example Spark, Hadoop, and data governance), and data analytics (for example, Spark, cloud computing, edge computing, and artificial intelligence). The Hadoop ecosystem, renowned for its reliable and scalable distributed processing, has been extensively used in intelligent transportation systems, enhancing processing efficiency for tasks such as analyzing mass GPS data. Applications in passenger behavior analysis encompass trip purpose, start time, mode choice, frequency, duration, and route selection, utilizing technologies like automatic fare collection (AFC) and automatic passenger counting (APC). Operation optimization involves dynamic scheduling for meeting fluctuating demands, leveraging real-time data from AFC, and the automatic vehicle location (AVL) systems. Additionally, big data plays a crucial role in policy applications, informing strategic transit planning through insights into passenger travel patterns and habits. The integration of these technologies is paving the way for transformative advancements in public transportation planning.[17] Boxes 10.4-10.6 illustrate the integration of big data for smart public transportation in São Paulo, Singapore, and Seoul.

BOX 10.4: SIGMA REVOLUTIONIZING SÃO PAULO'S TRANSPORT LANDSCAPE

In the city of São Paulo, public transportation is used for about 8.1 million journeys every day or one-third of all trips. Of these, 63.5 percent—or 21 percent of all trips—involve using the bus system as the primary means of transportation. Enhancing the effectiveness of a network this size necessitates a significant amount of management, monitoring, and planning work. The bus services in the city are managed by *São Paulo Transportes* (SPTrans). SPTrans already follows a data-driven approach for transport planning. SPTrans collects electronic ticketing data and GPS fleet tracking from various modes of transportation in the city such as the São Paulo Metro and Rail systems (CPTM), the metropolitan bus network (EMTU), taxi services, and the São Paulo Municipal Transit Agency (CET). The data is currently stored in the Operational Control Center for Buses (OCC) and technicians in the agency generate insights on an ad hoc basis for monitoring the public transport system and transport planning in the city.

Sao Paulo is planning to modernize OCC by equipping it with a robust platform - the Operational Management and Monitoring System (SMGO) – designed to automatically compile real-time GPS based operations data of the bus fleet in the city. Furthermore, OCC will be equipped with the capabilities - Georeferenced Information System for Mobility and Accessibility (SIGMA) - to perform data analytics and provide real-time performance indicators moving beyond location-based tracking. This will include OD matrices for each bus stop, indicators of the utilization of bus services by analyzing ticketing data, and the socioeconomic characterization of the user base by analyzing ticketing data, location data, and the socioeconomic zoning data of the city. The output from SIGMA will also be used for medium-term planning such as bus service route design, frequency setting, and connectivity with other modes of transportation.

BOX 10.5: SINGAPORE'S FASTER[18] SYSTEM FOR INCIDENT MANAGEMENT

Singapore has an efficient rail-based mass transit system managed by the Land Transport Operations Center (LTOC) – a unit under the Land Transport Authority (LTA), enabling the smooth movement of many living in the city-state. Like any other transport network in the world, the eventual breakdown of assets disrupting services is inevitable. The key to a resilient mobility system is in accurate prediction of breakdowns in advance and a well-designed set of protocols for mitigating the impact of the disruptions. In the longer term, good asset management with maintenance planning support is essential for reducing the severity and frequency of breakdowns and not overwhelm the maintenance staff of the transit network. Prior to 2016, LTOC relied on the qualitative assessment of the veteran staff for prioritizing areas for maintenance in the transport network and judging the impact of a breakdown if one occurred. This became impractical once the transit system in Singapore grew in size and complexity.

With LTOC's operations LTA has access to real time data on the condition of assets and public transport operations. LTOC collects real-time data from rail assets such as trains, signals, platform doors, power supply systems, sensors on tracks, and communication systems. Real-time data of passengers on the platforms is also collected from Wi-Fi network logins, cellular data, and fare cards from public transport and taxis. In addition, LTOC also stores and regularly updates data from management operations and scheduling and financial reports.

With such real time data, LTA is better positioned to manage assets and enhance service reliability. LTOC developed two data analytic software systems for managing immediate breakdown events in the network thus managing assets in the longer term. The first system - Fusion AnalyticS for Public Transport Event Response (FASTER) – uses machine learning algorithms for processing real-time asset degradation data, ridership data, and linkages in the transport network for predicting disruptive incidents before they occur. FASTER also assesses the severity and impact of an incident and integrates data from other modes – roads and buses – to present a comprehensive view of the entire transport network. This allows LTOC staff to quickly respond to the situation. For instance, by deploying additional trains for handling the backlog of passengers. This intervention has increased the reliability of the rail transit service, which is a crucial factor in increasing the ridership of a transport mode.

BOX 10.6: SEOUL'S TOPIS [19]SYSTEM FOR TRAFFIC OVERSIGHT AND MANAGEMENT

Seoul's Transport Operation & Information Service (TOPIS) acts as an integrated nerve center for the city's traffic oversight and management. It functions as a robust system that collates information from several traffic-associated entities, which include systems for bus management, traffic card operations, automated enforcement, and coordination with national and city road agencies. As the driving force behind Seoul's Intelligent Transport System (ITS), TOPIS empowers the city's traffic networks with advanced IT solutions, supported by a dedicated team structured into several divisions that focus on different aspects of transport and traffic management.

TOPIS is adept at harnessing a wide array of traffic-related data from its extensive traffic networks, ranging from bus movements and card system analytics to enforcement data. It taps into multiple platforms that work in conjunction for assessing the complexity of traffic patterns, deciphering congestion factors, and then dispensing necessary traffic updates to commuters and transport administrators. The system integrates cutting-edge information technology to lift the accuracy of its surveillance and management functions, capacitating a real-time feedback loop and fostering the innovation of user-centric traffic services and utilities.

The implementation of TOPIS is pivotal in reshaping Seoul's traffic landscape, leading to a tangible improvement in urban transport's effectiveness. Its refined management protocols have been instrumental in enhancing vehicular flows, curbing traffic mishaps, and effectively managing impacts from abrupt transit disruptions. Insights gleaned from comprehensive traffic data analytics enable proactive forecasting of travel patterns, fortifying the foundation for future transport-related policymaking. The ensuing public satisfaction and improved punctuality of Seoul's public transportation services underscore the system's far-reaching benefits, including a disciplined parking ethos propelled by automated enforcement processes.

The strategic integration of big data analytics in São Paulo, Seoul, and Singapore exemplifies the potential for transformative advancements in public transportation planning and traffic management, from real-time monitoring to incident prediction, optimizing services and enhancing the overall reliability and efficiency of urban transit systems.

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Case 5: Unlocking Urban Mobility Insights: A Case Study from Chennai using Mobile Phone Location Data

New databases using mobile phone location data (MLD) are emerging as powerful sources of information in understanding travel patterns in each region. One of the most basic applications of using MLD is identifying the origins and destinations (OD) of trips using clustering algorithms. These eventually help in generating the OD matrices and travel flow distributions in a region at an aggregated level. Another application is categorizing trips and activities made by individuals in MLD. This can be done using rule-based algorithms (for example, the location of individuals at night at home and trips made from home in the morning hours on weekdays are work trips) and by combing MLD with points of interest data. Other applications include the categorization of travel modes (walking, cycling, car, public transit) used for the trip with the help of neural networks and clustering algorithms. MLD offers many benefits when compared to traditional data collection methods – surveys – for these applications. First, owing to the increased penetration of mobile phones and internet connections in most places, MLD offers a much higher geographical coverage and sample size than traditional surveys. Second, an analysis using MLD can be done at any point in time, whereas data collection through surveys tends to be time and cost-intensive, limiting the frequency with which they can be used for data collection.[20]

The World Bank commissioned a study in Chennai to demonstrate the applicability of MLD in India. The study used anonymized and privacy-enhanced smartphone location data obtained from Unacast Inc. and Quadrant, covering 18 months from January 2020 to June 2021, focused on the greater Chennai area. The analysis aimed to evaluate movement behavior, considering the mode of travel, trip generation and attraction regions, and distances traveled for accessing new facilities and

corresponding inequalities. The overall sampling rate for the study area was approximately 0.23 percent in January 2020, representing around 22,500 users. Transit OD matrices were extracted from the mobile phone data in January and February 2020, involving data cleaning, a trajectory analysis, modal split, and k-means clustering to distinguish between walking, driving, and transit modes. The OD matrices were then scaled up to account for representativeness and an overall multiplier was applied for addressing data sparsity. The resulting transit OD matrix for an average weekday evening peak hour depicted flows between origin and destination traffic analysis zones (TAZs). The study observed high-density flows along the diagonal, indicating trips to nearby TAZs. Central zones attracted a significant number of trips during the morning peak hours, generating substantial flows during the evening peak hours (Figure 10.5). Suburban regions generated trips to various destinations, while central areas showed inter-TAZ flows with both inbound and outbound trips during peak hours. The findings contribute valuable insights for evaluating transit demand, identifying potential development areas, and informing modifications to the transit network in Chennai.

MLD was also employed for analyzing disruptions in urban mobility before, during, and after Cyclone Nivar in November 2021. This analysis showcased the stark impact of the cyclone on access to transit stops, particularly for those living farther than 1 km away, evidencing the disparity in accessibility during such disasters. Further breakdown by transport modes highlighted sustained disruptions even a week post-cyclone, underscoring long-term impacts. Additionally, hypothetical flooding scenarios were assessed by combining accessibility analyses with flood maps from past events. This identified transit stops, particularly in the south-western parts of Chennai, as highly prone to loss of access during floods. These methodologies provided granular insights into how disaster events disproportionately affect accessibility to transit, revealing areas and population segments that could benefit from targeted resilience measures such as the construction of new transit stops.

EXPECTED IMPACT

Chennai's initial steps in leveraging big data for urban mobility planning, while modest, are laying crucial groundwork for a data-driven future. These efforts, including the development of KPIs, pilot studies using mobile phone location data (MLD), and CCTV-based pedestrian counts, are positioning the city on a trajectory like data-savvy metropolises like Seoul, São Paulo, and Singapore. As these initiatives mature, Chennai can expect to see gradual but significant improvements in its transportation ecosystem. The KPIs will enable more informed decision-making, guiding resource allocation and urban planning strategies with measurable metrics. The MLD studies, if expanded, could revolutionize public transport planning by optimizing routes and schedules based on actual travel patterns, potentially boosting ridership through enhanced efficiency. Traffic management stands to benefit from the CCTV studies, informing signal timing and pedestrian infrastructure improvements in key areas. These data-driven approaches will likely lead to more empirically grounded policy formulation, moving away from assumption-based strategies. Over time, the city may see cost savings through automated data collection methods, reducing reliance on manual surveys. The insights gained from these analyses could guide targeted infrastructure development, ensuring that the investments align with actual mobility needs. While residents may not experience immediate dramatic changes, they can anticipate incremental improvements in public transport reliability, traffic flows, and pedestrian facilities. Most importantly, these foundational steps are creating a robust base for future innovations, setting Chennai on course to join the ranks of cities where data is leveraged effectively for comprehensive urban mobility planning.

TAKEAWAYS FOR OTHER CITIES

An analysis of the examples of data used for urban mobility planning cited above highlights the following key takeaways for other cities:

- **Balancing urban needs through data-driven KPIs.** The integration of data in urban governance facilitates the creation of KPIs, enabling a holistic approach to transport planning. These KPIs can encompass diverse objectives such as equity, development, and environmental impacts. By leveraging data, decision-makers can balance these needs effectively, ensuring that new transport projects align with broader urban goals. Moreover, these KPIs aid in evaluating project performance over time at a granular level enabling

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adjustments for optimizing outcomes and addressing evolving urban challenges.

- **Real-time evidence-based policymaking.** Continuous big data sources offer a dynamic platform for evidence-based policymaking in urban governance. Policymakers can adapt strategies swiftly by monitoring real-time data streams, responding to changing urban dynamics, and emerging challenges. This approach fosters agility and responsiveness in governance, allowing for iterative adjustments based on empirical evidence. As demonstrated in cities like Bogotá, real-time monitoring facilitates a trial-and-error methodology, enabling policymakers to refine policies iteratively and enhance their effectiveness over time.
- **Enhancing asset management and operations.** Data-driven insights are pivotal in improving the management and operations of urban assets such as buses and metro systems. Through real-time data collection and analysis, cities can optimize asset utilization, proactively identify maintenance needs, and enhance service reliability. For example, São Paulo's use of GPS-based data analytics enables real-time monitoring of bus fleet operations, leading to more efficient route planning, frequency adjustments, and connectivity enhancements.
- **Augmenting surveys with data-driven analysis.** The shift towards using continuous data sources allows cities to reduce reliance on traditional surveys for generating origin-destination (OD) matrices. By harnessing mobile phone location data and other real-time sources, cities like Chennai can create more granular and dynamic OD matrices, capturing travel patterns with higher precision and frequency. This transition enhances the accuracy and timeliness of transportation planning, enabling cities to make informed decisions based on current mobility trends and behaviors.

Limitations of Big Data for Transport Planning

While big data holds significant potential for revolutionizing transport planning with its expansive coverage and depth, practitioners must navigate its limitations with a discerning eye. Despite the large quantities of data available, challenges often arise regarding its representativeness, as passive data collection is not always tailored for mobility analysis and may lack comprehensive socio-demographic details, predominantly due to privacy constraints. Consequently, it is crucial for researchers to identify and mitigate potential biases in the datasets. At times, reliance on big data might necessitate ground truth validation, yet this

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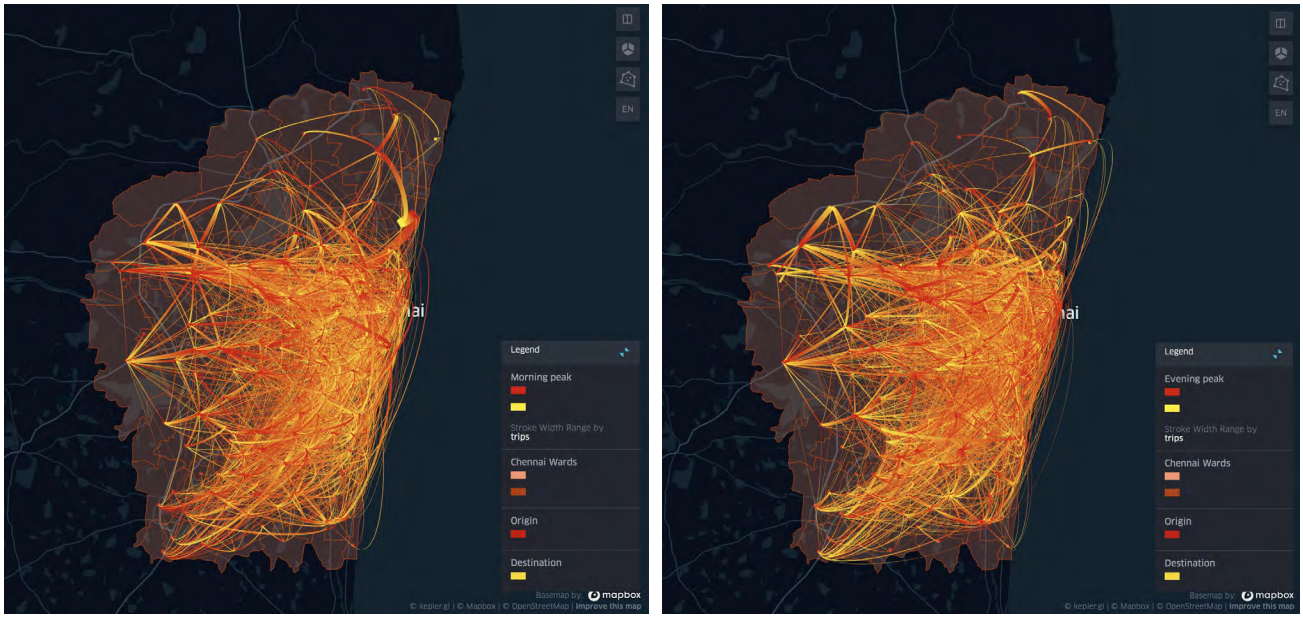
FIGURE 10.5: VISUALIZATION OF TRANSIT TAZ-BASED OD FLOWS



Source: World Bank analyses.
Note: The width of the arc shows the magnitude of the trips. During the morning peak the central regions attract a high number of trips.

process can be complicated when pre-processed data lacks transparency in its methods, or if the ground truth is derived from the same datasets used for constructing the big data. Moreover, uncertainties concerning the continuity and consistency of non-purpose-oriented data supplies, often controlled by external providers with shifting priorities, pose additional risks. Technological evolutions may also introduce compatibility issues that diminish the data's long-term utility unless common standards are put in place. Not to mention, privacy concerns and ethical considerations add layers of complexity to using such data, as filtration for anonymity can dilute its granularity and usefulness. Given these challenges, it is recommended that traditional data collection methods, like targeted surveys, continue to complement big data to ensure a balanced, ethical, and holistic approach to transport planning. Readers may refer to Milne and Watling (2019)[21] and Bonnel and Munizaga (2018)[22] for more information.

CONCLUSION

The integration of big data and advanced analytics in urban mobility planning represents a pivotal moment in transforming traditional approaches. The technological innovations discussed in this note underscore the potential of leveraging diverse data sources for revolutionizing transport planning, offering unprecedented opportunities for sustainable and efficient urban mobility. Big data's ability to provide nuanced insights, free from the constraints of conventional surveys, allow for a deeper understanding of human movement in time and space.

The diversification of data sources, as outlined in this technical note, show the richness and breadth of information that can be harnessed for urban mobility planning. From official registrations to real-time data on asset status, each category offers a unique perspective, contributing to a comprehensive understanding of urban dynamics. The universal format of data, exemplified by the General Transit Feed Specification (GTFS), facilitates benchmarking and cross-geographical comparisons, fostering a global dialogue on best practices.

Moving forward, this technical note aims to create awareness among urban mobility practitioners in India regarding the potential of data analytics for informed and efficient urban planning. This note demonstrated how big data analytics has ushered in a smarter era of urban mobility services. From dynamic urban dashboards offering real-time insights to the integration of continuous monitoring and trial-and-error approaches in policy innovations, and from harnessing machine learning for road safety to the transformative potential of smart public transportation, each use case serves as a testament to the transformative power of big data in shaping the future of urban mobility. These examples not only highlight the current state of the field but also pave the way for continued exploration and innovation in the dynamic landscape of urban planning.

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Photo credit: CUMTA

CONCLUDING REMARKS

Shyam Srinivasan and Gerald Ollivier

TAKING STOCK

Cities around the world are faced with complex urban development challenges. This Compendium shares the experience of Chennai as an example of a city in the global south which is attempting to grapple with these challenges through urban mobility and spatial planning reforms. Over ten notes, the Compendium describes the ongoing and planned efforts in Chennai, together with relevant international examples. In doing so, the Compendium offers key takeaways for other cities facing similar challenges.

The Compendium uses GRIDS as its organizing framework. The framework is comprehensive and serves as a useful frame of reference for cities looking to improve the status quo in terms of urban mobility and spatial development.

The Compendium started by exploring the 'Green' dimension, documenting efforts to reduce travel demand through integrated land use and transport planning and promoting modal shifts to public and non-motorized transport.

- The first topic on ***Integrated Land Use and Transport Planning*** described the simultaneous development of the Third Master Plan together with a Comprehensive Mobility Plan. The note underscored the importance of: (i) institutional coordination and capacity building to foster land use-transport integration, (ii) the collection and use of data to inform evidence-based planning, (iii) extensive stakeholder consultations to create a shared vision and ownership of development plans, (iv) robust implementation and financing roadmaps to convert plans into reality, and (v) meaningful results frameworks with key performance indicators to facilitate monitoring and fine tuning plans.
- The second topic on ***Augmenting Bus Service Delivery*** described Chennai's transformation of bus-based public transport through a multi-year Business Plan, a Public Transport Service Contract (PTSC) between the government and the state transport undertaking, and a transition to gross cost contracts for bus services, as opposed to in-house operations. The note demonstrated the value of PTSC which provides assurance of public support in exchange for greater accountability. The note also highlighted the importance of gradual change, the need for consensus in designing and implementing KPIs, and the need for strong oversight and capacity building.
- The third topic on ***Fostering Multimodal Integration*** touched on an important ingredient to encourage modal shifts to public transport. Expanding public transport is unlikely to realize the full potential of such systems, without accompanying measures to ensure seamless connectivity across modes. Chennai's approach of appointing a nodal agency to take charge of integration, adopting a customer centric approach in prioritizing improvements, and plans to formalize and integrate informal paratransit services as a complement to state sanctioned services, could serve as a blueprint for other cities.
- The fourth topic on ***Designing Sustainable Complete Streets in Indian Cities*** touched on the potential

to transform streets into vibrant urban spaces, thereby enhancing the overall livability in cities. The note laid out an approach to such transformation including context-specific analyses and stakeholder consultations, clear vision and KPIs for above ground and underground improvements, strengthening inter-agency coordination, adopting green public procurement approaches for improving circularity and engendering community ownership.

The Compendium then turned to the 'Resilient' dimension, given Chennai's vulnerability to floods. The fifth topic on ***Achieving Urban Mobility Resilience*** laid out a systematic approach to diagnosing the vulnerability of urban mobility infrastructure and services, and approaches to enhance their climate resilience. The note highlighted the need for a resilience-first mindset in safeguarding existing assets, and in designing and building new infrastructure. The note also highlighted the importance of data in assessing vulnerability and monitoring the condition of the assets.

The 'Inclusive' dimension was discussed next, with the sixth note on *Developing Gender Responsive Urban Mobility Ecosystems*. The note outlined a four-pillar approach adopted by the Chennai Gender and Policy Lab to mainstream gender considerations in the planning and delivery of urban mobility infrastructure and services. The note underscored the importance of strong political will and support from the senior leadership for gender mainstreaming interventions, the need to coordinate efforts across agencies and engender mindset shifts in some cases, and the need to build in gender considerations into protocols for designing and implementing projects.

The Compendium placed significant emphasis on the 'Safe' dimension. The seventh topic on ***Developing a Metropolitan Road Safety Action Plan*** discussed the use of such plans as a tool for improving road safety in urban contexts. The note discussed the Safe Systems approach which touches on infrastructure, institutions, and enforcement dimensions to curb road crashes and fatalities. The note highlighted the importance of robust institutional mechanisms and coordination, and data driven decision making. The note also called for more forgiving roads and roadsides, recognizing that infrastructure needs to account for human error, and discussed approaches to tackle speeding and helmet wearing, which were key underlying causes of road crash fatalities.

The last three notes delved into the cross-cutting enabler of 'Strong and Coordinated Institutions.' Almost every topic in the Compendium underscored the importance of institutional coordination in the urban mobility arena. The eighth topic on ***Strengthening Metropolitan Transport Governance*** presented the story of CUMTA, which is a new nodal agency for transport in CMA. The note highlighted the design and operational features of CUMTA, based on international experience, and described the value of such an entity in the institutional mix in CMA. The note recognized the importance of high-level backing for new entities, the need for nodal agencies to demonstrate their value without being seen as a threat to existing arrangements, and the need for continuous evolution in capacity and function.

The ninth topic on ***Preparedness for Leveraging Data in Indian Urban Planning*** focused on governance mechanisms to ensure the success of mobility data platforms in urban contexts. The note described the planned Digital Chennai initiative which aims to create a common repository for urban mobility and spatial development data in CMA and a project planning and monitoring tool to strengthen coordinated planning and delivery of infrastructure. The note highlighted the importance of CUMTA as a nodal agency helming the initiative, the need for data repositories based on a common set of data standards which are continuously updated, the need to address privacy concerns, and forging third-party data partnerships.

The tenth topic on ***Practical Use Cases for Leveraging Data for Urban Mobility Planning*** highlighted potential use cases which could be built on top of data repositories, based on Indian and international examples. The note highlighted data's potential to transform decision making on urban mobility and spatial development in complex urban environments like Chennai.

While comprehensive in its scope, other relevant topics were intentionally excluded from the Compendium. The transition to electric mobility has not been discussed, as the electric vehicle (EV) adoption initiatives are commonly pitched at the state or even national levels in India, as opposed to being confined to the metropolitan level. Urban logistics and parking are other topics of relevance in urban contexts, but have been excluded, while allowing time for conversations on these topics to mature in Chennai.

THE ROAD AHEAD

It is a matter of priorities. While each of the above topics are urgent and critical in their own regard, policymakers and practitioners need to confront the question of priorities. Cities, including Chennai, are not starting from a zero-base. Existing systems, institutions, and infrastructure need to be considered when deciding what comes next. Cities can also pursue multiple agendas simultaneously, so it may not be necessary to take things a step at a time. The following paras make a case for a certain order of priority which may be relevant in Chennai and other cities with similar challenges.

- **Focus on institutions and coordination.** A recurring theme across the spectrum of topics in the Compendium was the need for strong institutions and coordination. Chennai has taken a step forward by establishing CUMTA as a nodal agency for urban mobility. Such nodal agencies have a critical role to play in several cross-cutting topics such as mobility planning, multimodal integration, road safety, and gender mainstreaming, which individual agencies may not be able to pursue effectively on their own.

- **Leverage planning exercises to induce paradigm shifts.** Large scale planning exercises such as master plans and comprehensive mobility plans are rare opportunities to course correct and reimagine cities. They offer opportunities for cities to look beyond individual projects and initiatives and adopt long term frameworks for sustainable development. Cities would do well to develop such plans, and revisit them periodically to ensure their relevance.

- **Save lives immediately.** There is no need to wait to save lives. Road safety issues are often a result of mindsets and coordination failures, rather than a question of cost. With nodal agencies such as CUMTA in place, cities could pursue targeted interventions informed by data to reduce road crashes and fatalities and start saving lives immediately.

- **Promote public transport, walking, and cycling.** Cities around the world need to reverse the inexorable trend towards private vehicles, which comes with a whole host of issues – greenhouse gas emissions, congestion, road safety issues, and an overall worse off urban environment. Attention to detail matters. Beyond just expanding mass transit, cities need to improve the user experience through strengthening multimodal integration, first and last mile connectivity, build complete streets that encourage citizens to go out and walk, and find ways to improve public transport service delivery.

- **Embed climate resilience considerations into infrastructure planning and design by default.** Cities around the world are increasingly needing to grapple with climate change induced extreme weather events. Trends suggest that such events would only become more frequent and severe, calling for a strong and systemic focus on climate resilience. Without measures to safeguard existing assets, and building new assets that are climate resilient, cities risk wasting significant resources and suffering significant disruptions to lives and livelihoods.

The Compendium can contribute to the ongoing preparation of the Comprehensive Mobility Plan which offers a plethora of opportunities for improving urban mobility. The World Bank is supporting CUMTA's development of the Comprehensive Mobility Plan (CMP) under SUSP. CMP will combine the traditional four-step travel demand modeling approach, with clearly defined KPIs organized along the GRIDS framework to develop a plan that drives towards the right outcomes.

- Traditional mobility plans develop a travel demand model which provides the analytical foundation for developing, evaluating, and implementing comprehensive mobility plans that enhance accessibility, efficiency, and sustainability in urban areas.

- Mobility plans typically focus on catering to travel demand, without always having a clear view of the outcomes. There are multiple ways to service travel demand along any given corridor. The typical response to addressing a congestion point is to smoothen traffic flows by widening roads or building flyovers. However, such approaches encourage private vehicle usage as opposed to public transport and are therefore not desirable.

- CMP will define clear outcome goals based on the GRIDS framework, which will inform decisions on urban mobility investments and initiatives in CMA. CMP will establish overall targets for indicators such as transport sector greenhouse gas emissions in CMA. The impact of individual projects and initiatives on such outcome indicators will be systematically modeled, to decide the mix of investments and

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initiatives which will drive towards these targets. Doing so will steer the city towards reducing greenhouse gas emissions, and enhancing climate resilience, inclusion, and road safety.

- Lessons from the Compendium can be used to decide the mix of initiatives to be included in CMP. The Compendium is built upon several analytical studies on the full range of urban mobility and spatial development topics, and therefore represents the tip of the iceberg. The studies are being used as an input for CMP and will inform decisions on what to do and when to improve urban mobility in CMA.

Translating plans into reality requires strong implementation and financing roadmaps. The lesson from the Second Master Plan which was explored in the first topic was the lack of clarity on how to finance and implement master plan initiatives. An analysis of financing and funding for urban transport in Chennai revealed that government expenditures in urban mobility are sizable but can be better balanced for impact.[1]

- **The city could invest more in buses and non-motorized transport which is already happening to some degree as explored in topics two and four.** Chennai's annual average spending in urban mobility amounted to about 1.9 percent of the Gross Domestic Product (GDP) over FY16 to 2020 or USD 808 million.[2] Metro rail dominated capital expenditures (64 percent) and bus transport dominated operational expenditures (60 percent). Revenue from users amounted to 22 percent of total expenditure. The operating deficit of city agencies is widening partly due to a decline in the public transport share of motorized trips. Grant support per passenger varied considerably with support per metro passenger (USD 3.3) equivalent to 30 times that for bus passengers (USD 0.1) in 2019, owing to the low utilization of metro services. Allocation to NMT amounted to about 6 percent of the capex allocation for roads over FY16-20, or less than US$10 million annually.
- **There is a need for a coordinated sectoral funding allocation which is a role that CUMTA could play in the future.** A multiplicity of institutions leads to constraints in developing a coherent and integrated view of the financing and funding of mobility services in CMA. There is limited coordination of allocations based on objectives across mobility options, a role which CUMTA would eventually play. Investment planning for agencies (except CMRL) is largely driven by annual budgets, and the lack of funds earmarked for investment projects constrains their implementation. Where funds are available, the focus is on discrete infrastructure asset creation instead of the impact on urban livability or service delivery performance measured in terms of coverage, quality, sustainability, and resilience. Institutions also lack sustainable financing frameworks, with low own-source revenue generation, high reliance on the state government for input-based budget allocations and operating subsidies, few incentives for cost-effective service delivery and private sector participation. The Public Transport Service Contract for bus services is a step in the right direction towards improving accountability for service delivery.
- **CMP could provide useful guidance on long-term investment planning.** Innovative financing frameworks, including private capital mobilization and maximizing revenue generation are critical for establishing a sustainable financial footing.

Endnotes

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