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MINISTRY OF HOUSING AND URBAN AFFAIRS
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Climate Change Mitigation in Urban Transport Sector

A Case Study of Gurugram-Manesar Urban Complex (GMUC), Haryana

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Background

Climate Change has emerged as a **major global challenges** and **Greenhouse Gas (GHG) Emissions** from **Transport Sector** are a key contributor.

Worldwide

Transport Sector accounts for about **23%** Global Energy-related **Greenhouse Gas (GHG) Emissions**.

Source: IPCC, 2014

Developing Countries

- Growing demand for **fossil fuel-based energy** and **lack of viable alternative** fuel sources
- Increasing of GHG emissions.

Source: ADB, 2009

Urban Areas

About **40%** of the overall transport dependent GHG emissions are generated in **cities**.

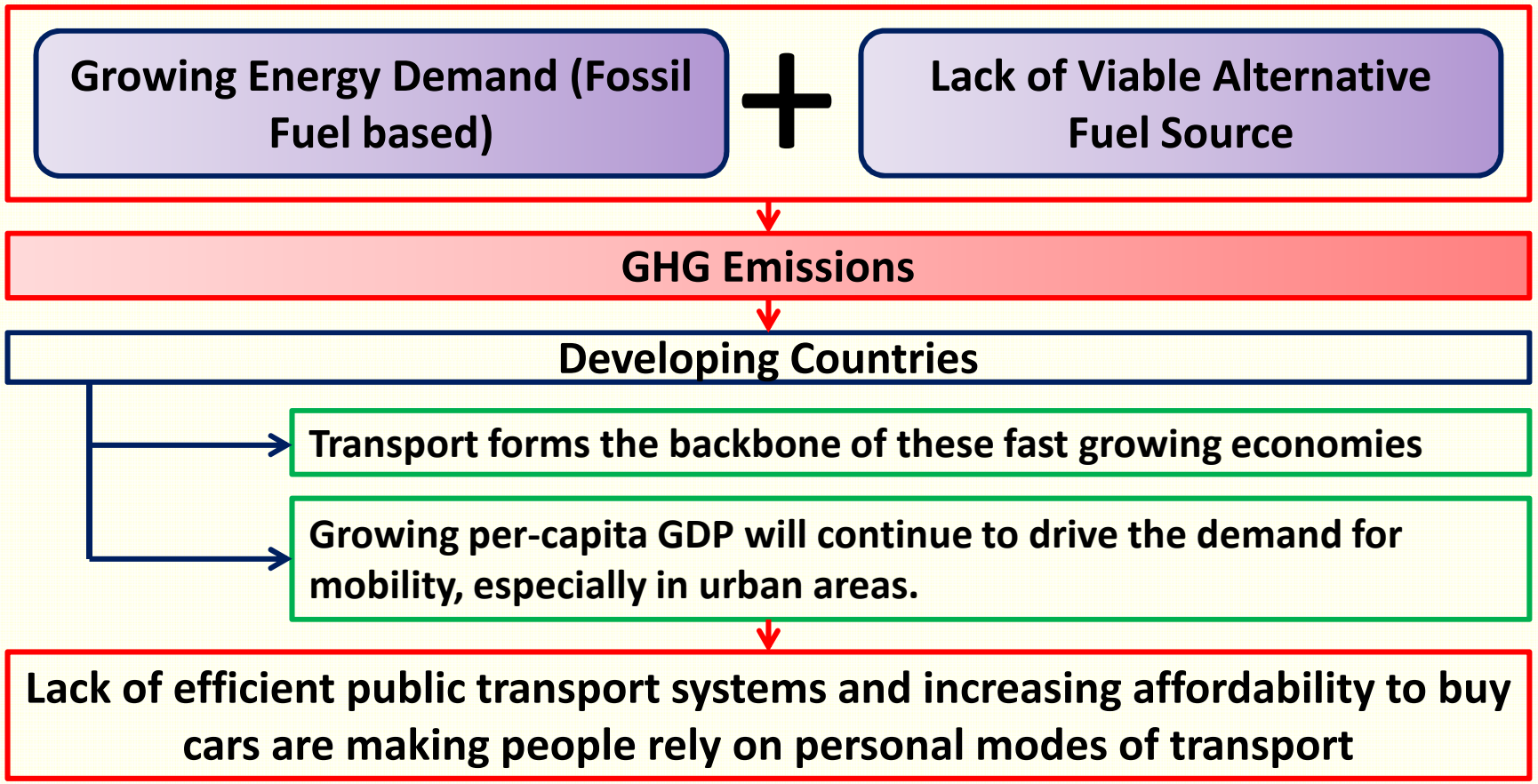
Source: IPCC, 2014

Indian Cities

- Growing % of private vehicles & high dependence on fossil fuels
- High concentration vehicles in some areas

Source: GIZ, 2012

Research Need



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Research Need

At Present — Per-capita urban transportation emissions in developing countries is many folds lower than developed country cities.

In Future — If the present trend continues, it will be very significant and major contributors of GHG emissions on the planet (*IPCC, 2014*).

There is now a growing international consensus that **future targets for CO_2** reductions in the **post-2012 Climate Policy Framework** will not be achieved unless CO_2 contribution from the **transport sector in developing countries** is appropriately addressed.

(ADB, 2009)

Research Objectives

1. To understand the concept of **climate change** with reference to **Transport Sector** and identify Transport issues affecting the climate.
2. To review methods for **estimating transport dependent GHG emissions** and **identify best practices** on climate change mitigation in Urban Transport.
3. To assess the **urbanization and motorization patterns** in terms of **transport demand and supply** across cities in India and its impact on **transport dependent GHG emissions**.
4. To assess the **Urban Transport characteristics** of **Gurgaon-Manesar Urban Complex (GMUC)** in terms of urbanization patterns, transport demand-supply and management.
5. To estimate the **transport dependent GHG emissions** in Gurgaon-Manesar Urban Complex.
6. To **evolve** and **evaluate** alternate climate change **mitigation policies**.

Stages of the Research

Stage 1

- Study of the concepts of **Climate Change** along with Role and Contributions of **Transport Sector**.
- **Best practices** and **methods** for **estimation** and **mitigation** of transport dependent GHG Emissions.

Stage 2

- Study of **Transport Demand** & **Emission Patterns** in Indian Cities.

Stage 3

Baseline Study of Transport Demand & Emission in GMUC

- Identification of **Primary** and **Secondary Data**
- **Data Collection** and **Surveys**
- **Four-Stage Modelling** and **Estimation of Emission**

Stage 4

Forecasting and **Study** of **Horizon Year Emission Scenarios** in GMUC

Stage 5

Recommendations and **Evaluation** of Mitigation Strategies.

Literature Review

Principal GHGs & GWP

Gas	GWP (20 yrs)
Carbon Dioxide	1
Methane	56
Nitrous Oxide	280

Source: IPCC Report, 1990

Approaches for GHG Estimation

1 Top-Down Approach

Total fuel / energy consumption (*liter*) x Specific CO_2 Conversion Factor (kg CO_2 e / liter) = GHG Emission (kg CO_2 e)

2 Bottom-Up Approach

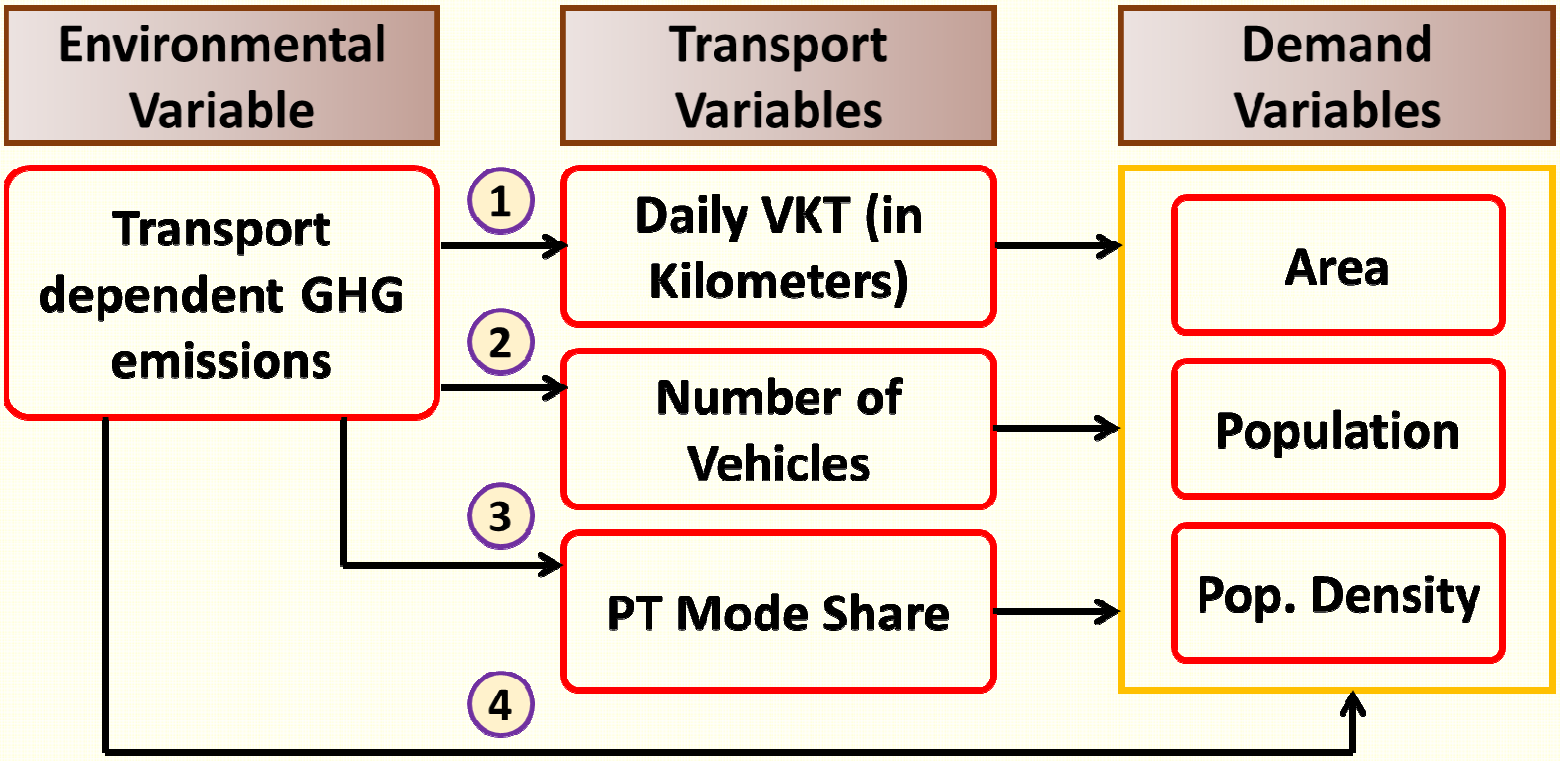
Transport Activity (VKT) X GHG Emission Factor (g CO2-e / km) = GHG Emission (kg CO_2 e)

Source: GIZ, 2012

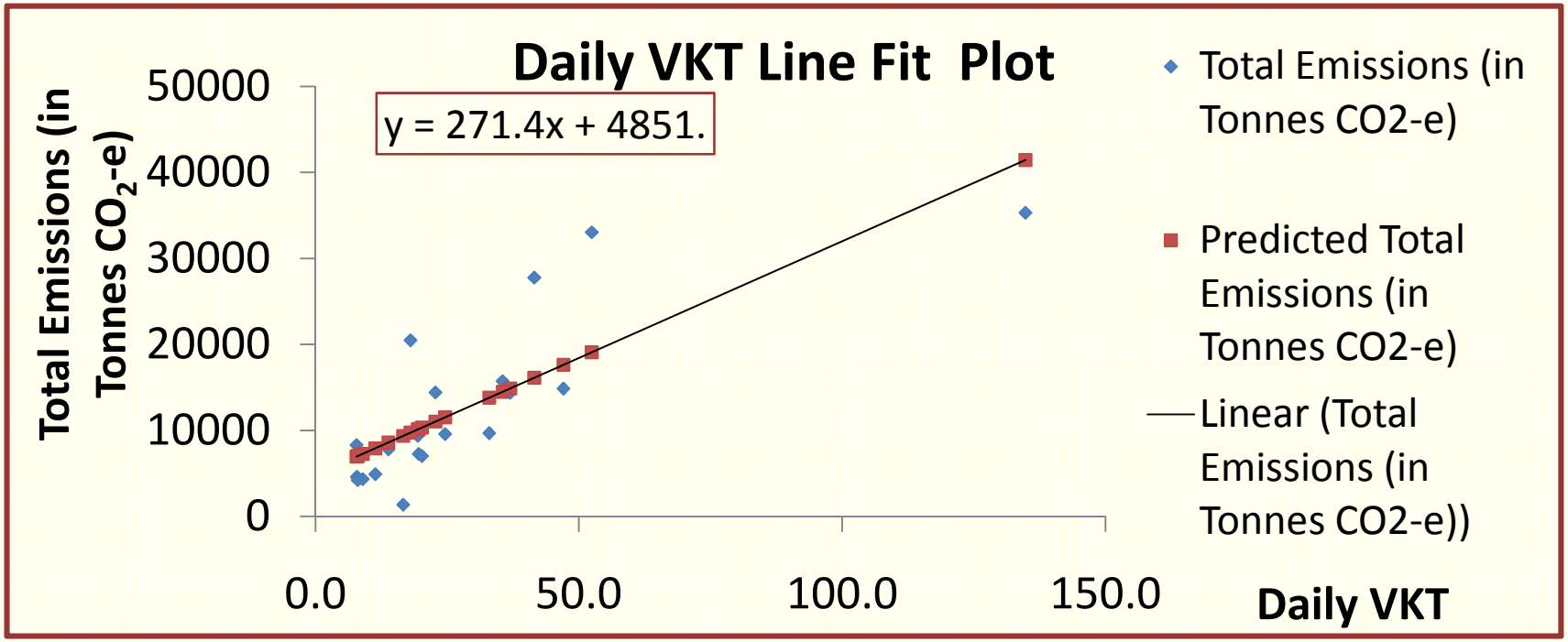
Climate Change Mitigation Instruments & Measures

Instrument	Mitigation Measures
Planning	• Integrated Land Use & Transport • Public Transport • NMT infrastructure provisions • Pedestrian Facilities
Management	• Travel Demand Management (TDM) • Flexible work hours • Shared Mobility
Economic	• Fuel Taxes, Road Pricing • Public Transport Subsidies
Technology	• High performance engines • Electric Vehicles

Transport Demand & Emission Patterns in Indian Cities



Transport Demand & Emission Patterns in Indian Cities

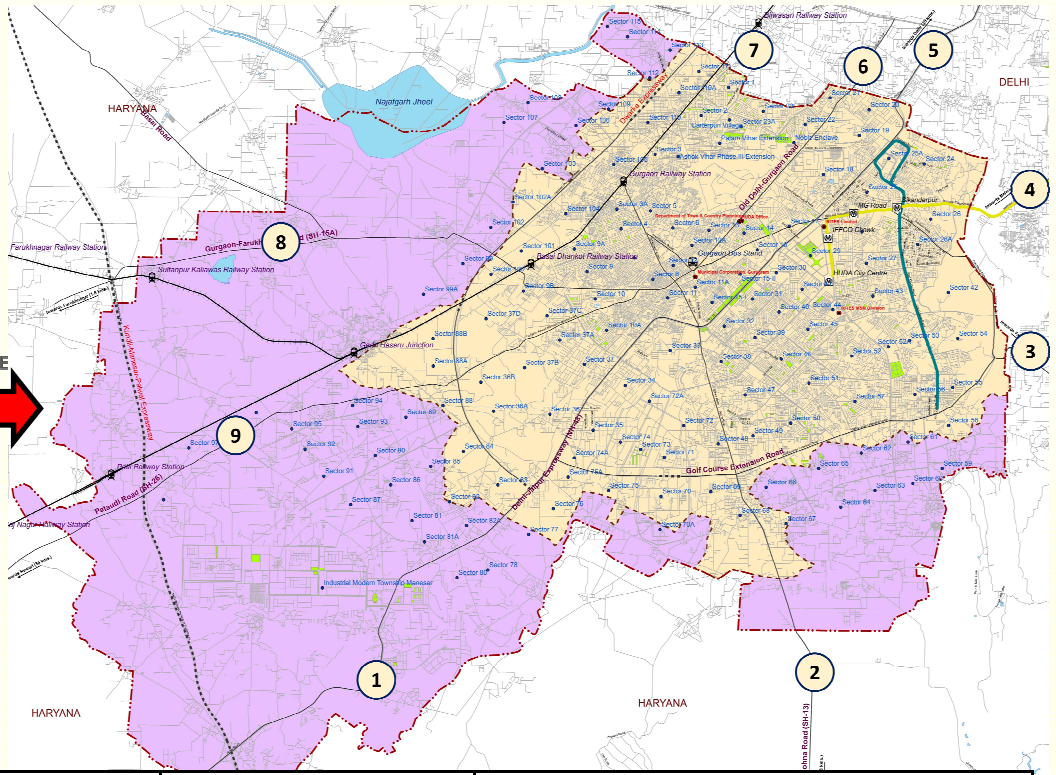


1. Daily VKT	$R^2 = 0.6$	P-value = 2.56×10^{-5}	T-stat = 5.6
2. Number of Private Vehicles	$R^2 = 0.7$	P-value = 5.68×10^{-7}	T-stat = 7.5
3. Public Transport Share	$R^2 = 0.5$	P-value = 0.0009	T-stat = 4.1

8A

Case City Profile - GMUC

Location in NCR



Location	Population* (2017)	Area** (Ha)	Density (Persons per Ha)
GMC	1097733	14299	76.8
Manesar	28827	3250	8.9
Villages	488990	16177	30.2
GMUC	**1616662**	**33726**	**47.9**

Extrapolated using Census of India Data (1991-2011)

**GIS Data from Gurugram Municipal Corporation*

8B

Case City Profile - GMUC

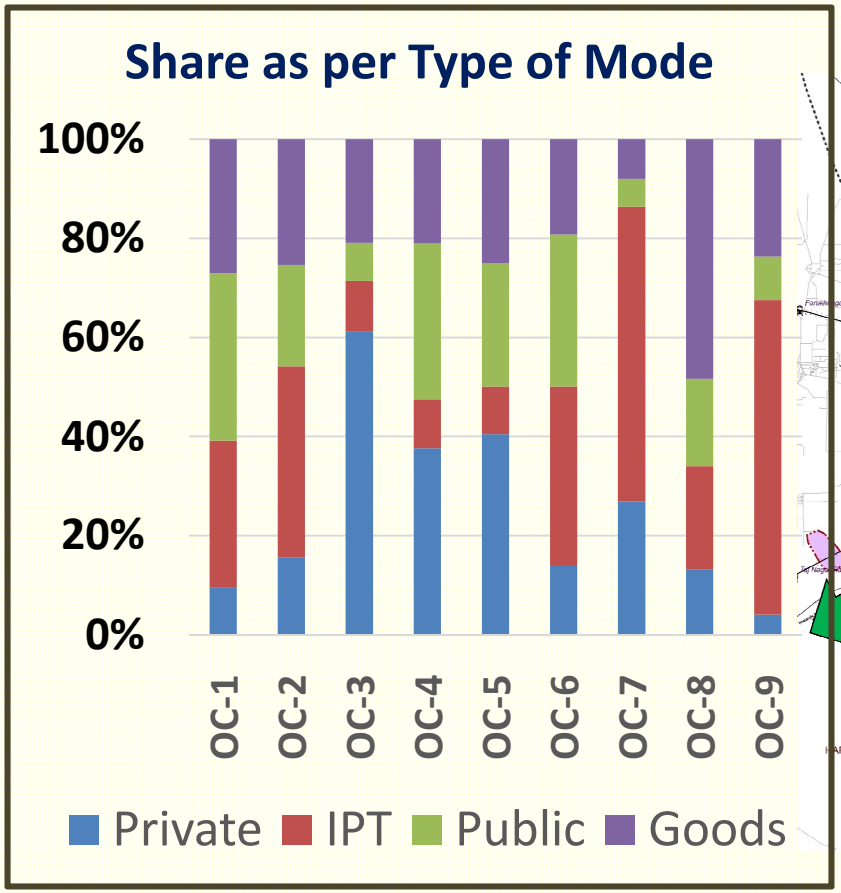
Transport Systems

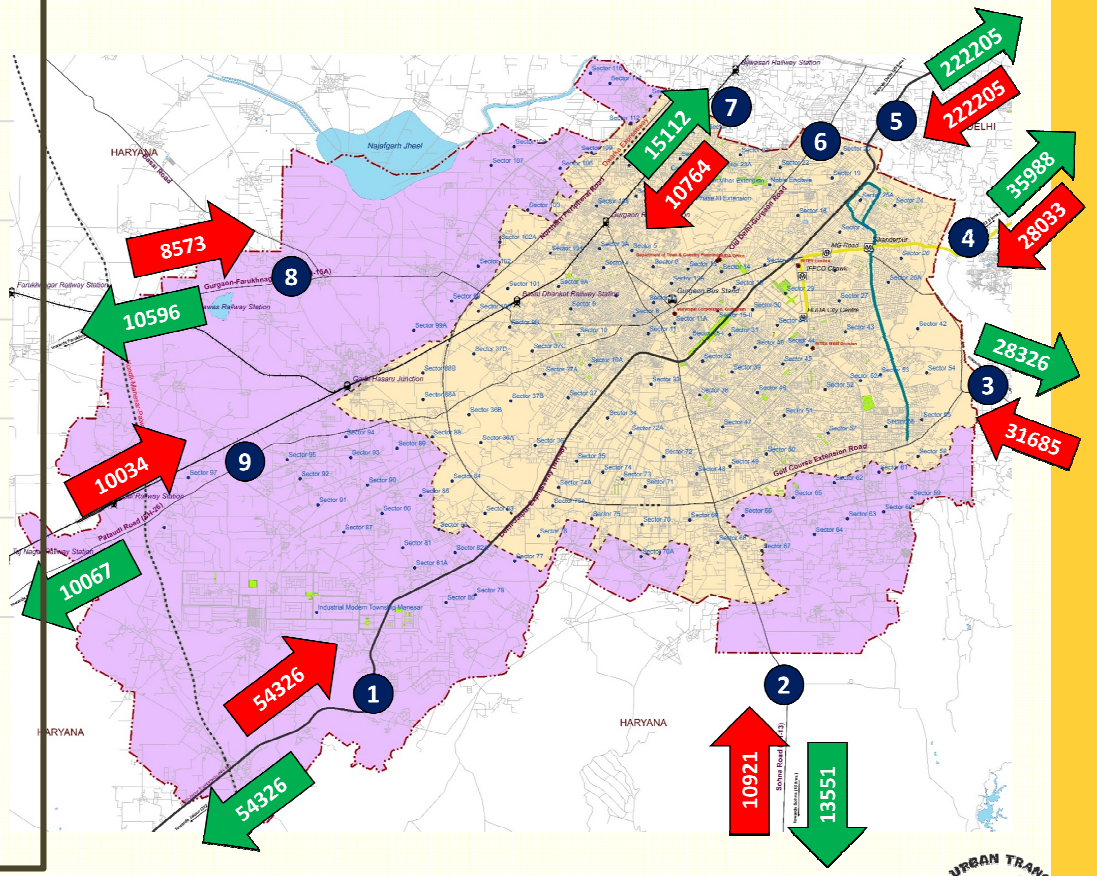
Transport System	Modes
1 Personalized Travel	2-Wheelers, Cars, Hired Taxi, App-based Taxi
2 Shared Mobility	App-based Carpool Taxi
3 IPT	Hired Auto, Shared Auto
4 Public Transport	Mini Bus, Bus
5 Mass Transit	Metro
6 Goods Movement	LCV, MAV, Trucks, Tractor

Source – Primary Survey

Traffic Characteristics in GMUC in Base Year (2017)- Outer Cordon

Average Daily Traffic at Outer Cordon Locations	7,99,229 Vehicles

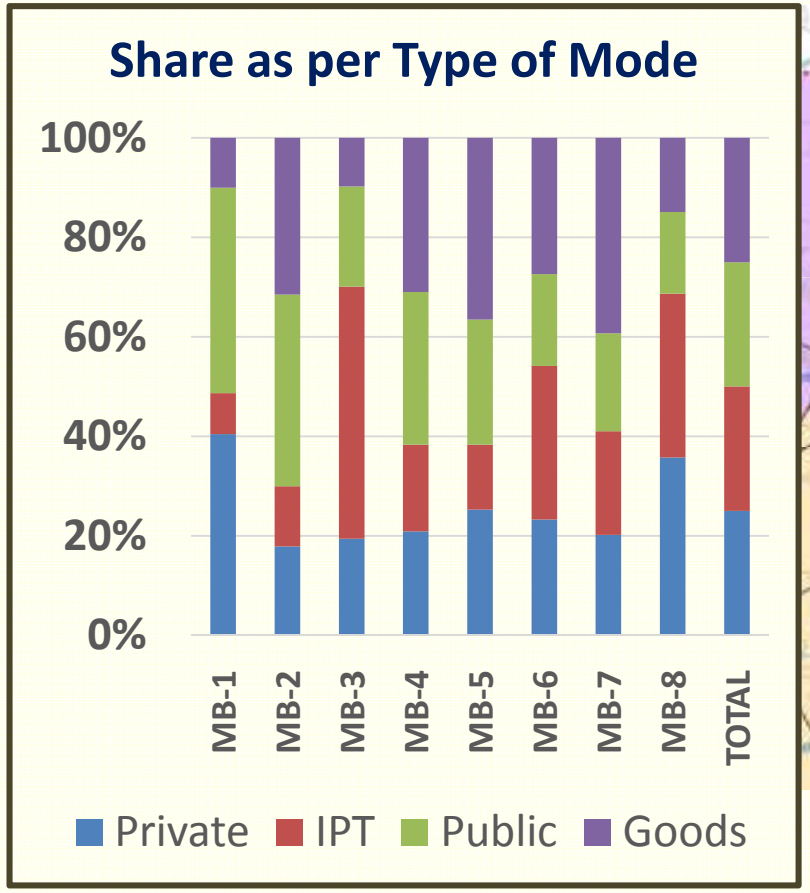


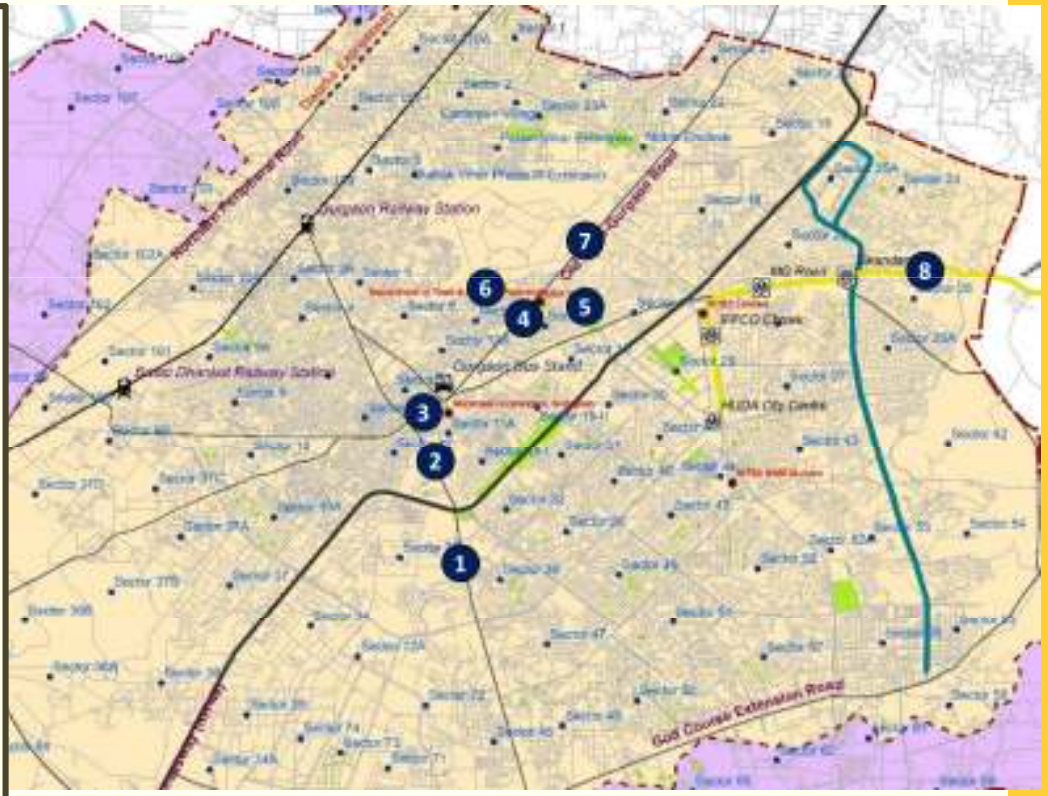


Source – Primary Survey

Traffic Characteristics in GMUC in Base Year (2017)- Mid Block

Average Daily Traffic at Mid-block Locations	2,58,265 Vehicles





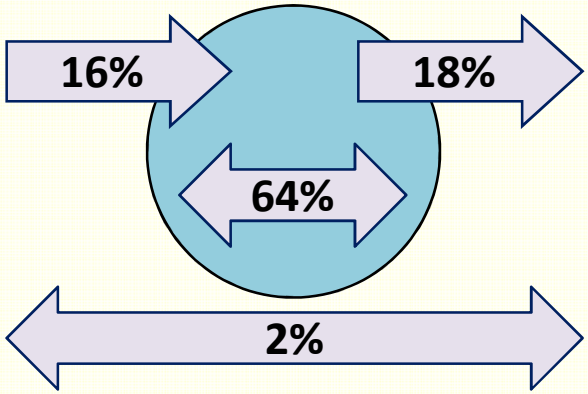
Source – Primary Survey

Travel Characteristics in GMUC in Base Year (2017)

Passenger Vehicle Trips

Trip Type	Number of Trips
E - E	48,555
E - I	3,20,378
I - E	3,68,847
I - I	13,00,994
TOTAL	**20,38,774**

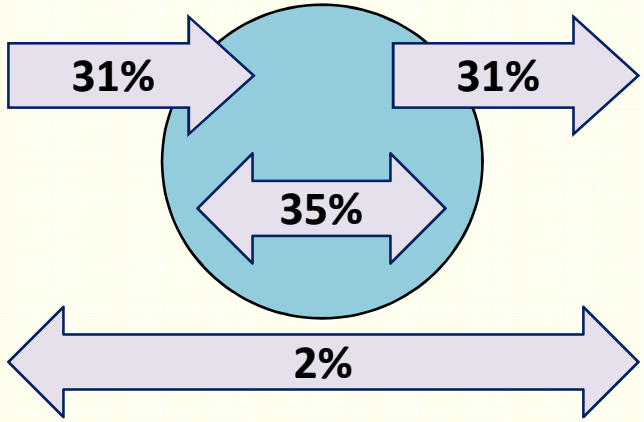
Source – Primary Survey (Passenger Origin-Destination Survey at OC & Midblock locations



Goods Vehicle Trips

Trip Type	Number of Trips
E - E	2,938
E - I	42,610
I - E	42,337
I - I	47,750
TOTAL	**1,35,635**

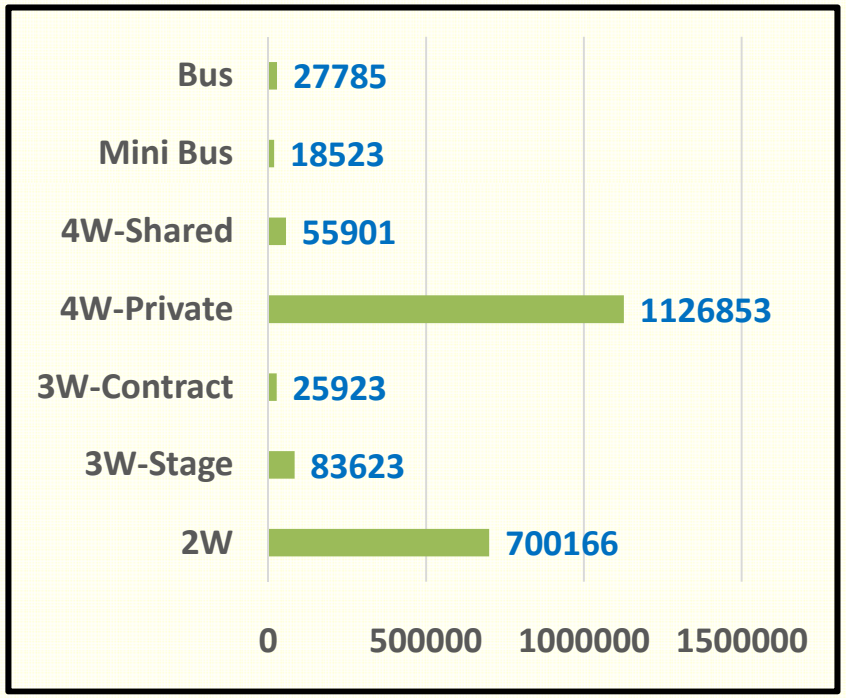
Source – Primary Survey (Goods Origin-Destination Survey at OC & Midblock locations



Travel Characteristics in GMUC in Base Year (2017)

Passenger Vehicle Trips

Mode-wise Number of Daily Passenger Vehicular Trips



Goods Vehicle Trips

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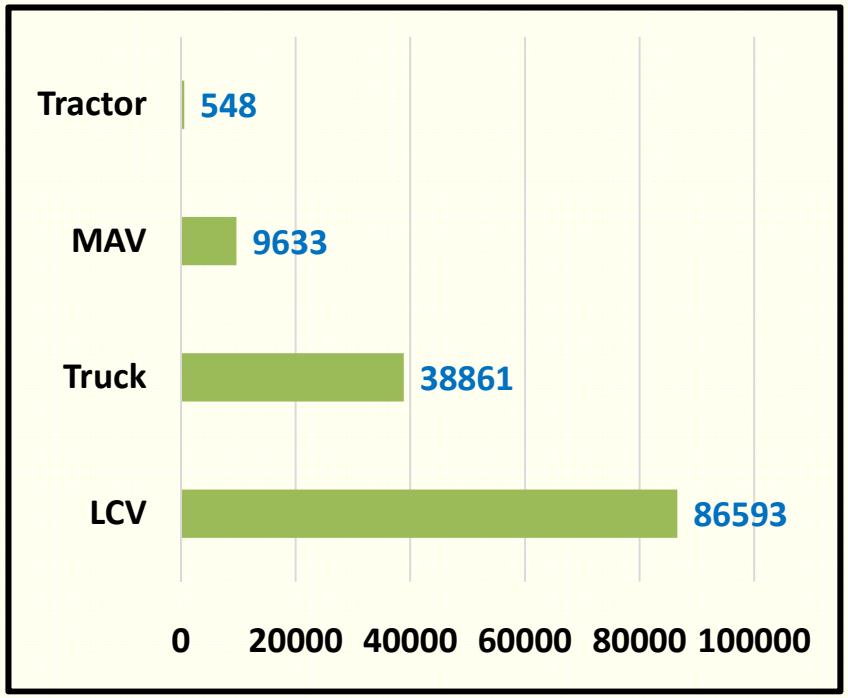
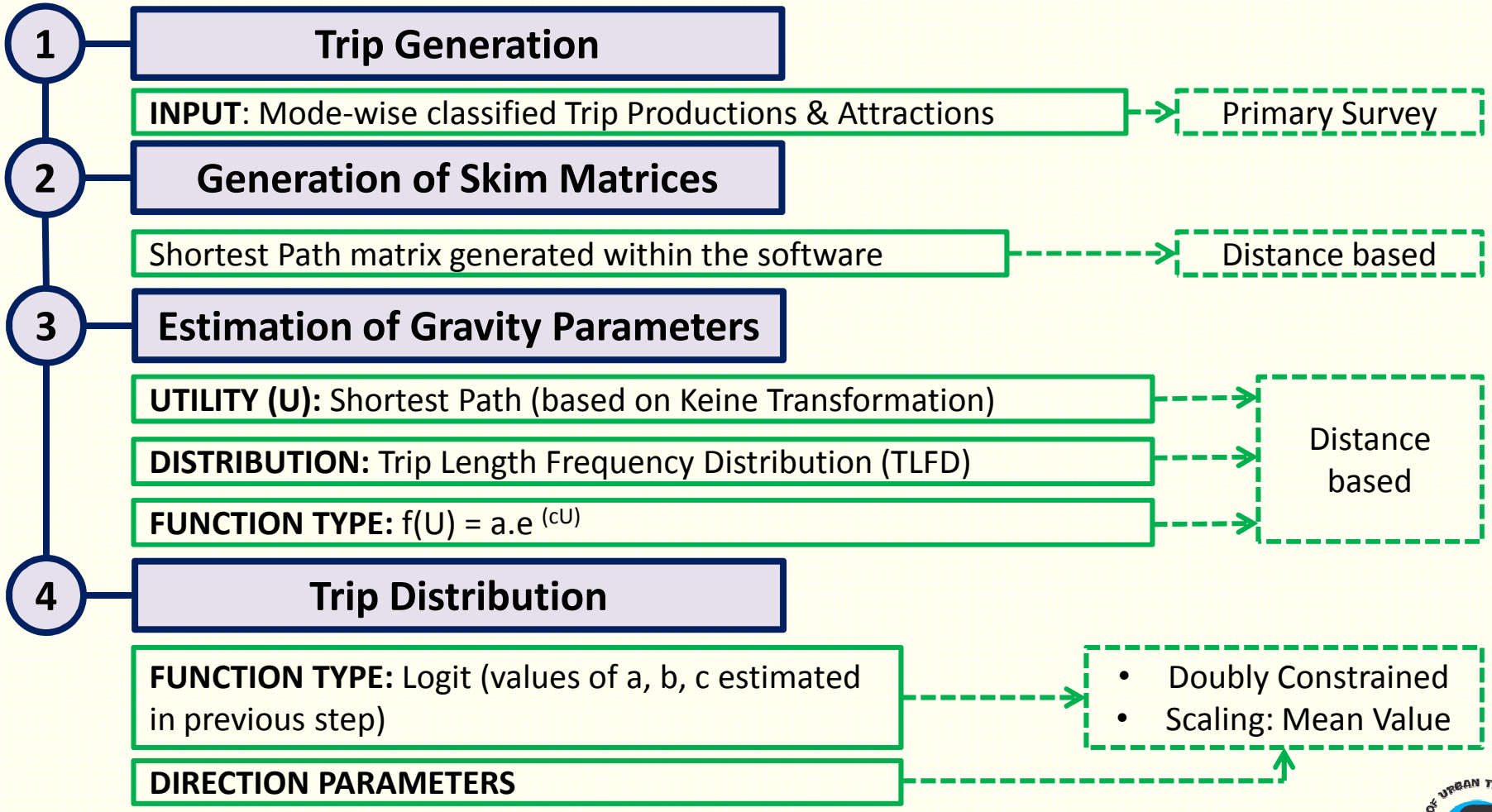


Metro (I-I)	1,33,885 **(5%)**	**Non-Metro (I-I)**	25,92,789 **(95%)**

Source – Primary Survey

Travel Demand Modelling & GHG Estimations for Base Year (2017)



Travel Demand Modelling & GHG Estimations for Base Year (2017)

5 Traffic Assignment

Incremental Assignment: 33% -> 33% -> 34% → Software Default

6 Matrix Calibration

TFlow Fuzzy: For calibration using ground count at survey locations → Corrected Matrix

7 Traffic Assignment & Validation

Corrected Matrix is Re-assigned using Incremental Assignment & variations are observed at OC. → Corrected Matrix

Variation within the range of 15% is desirable

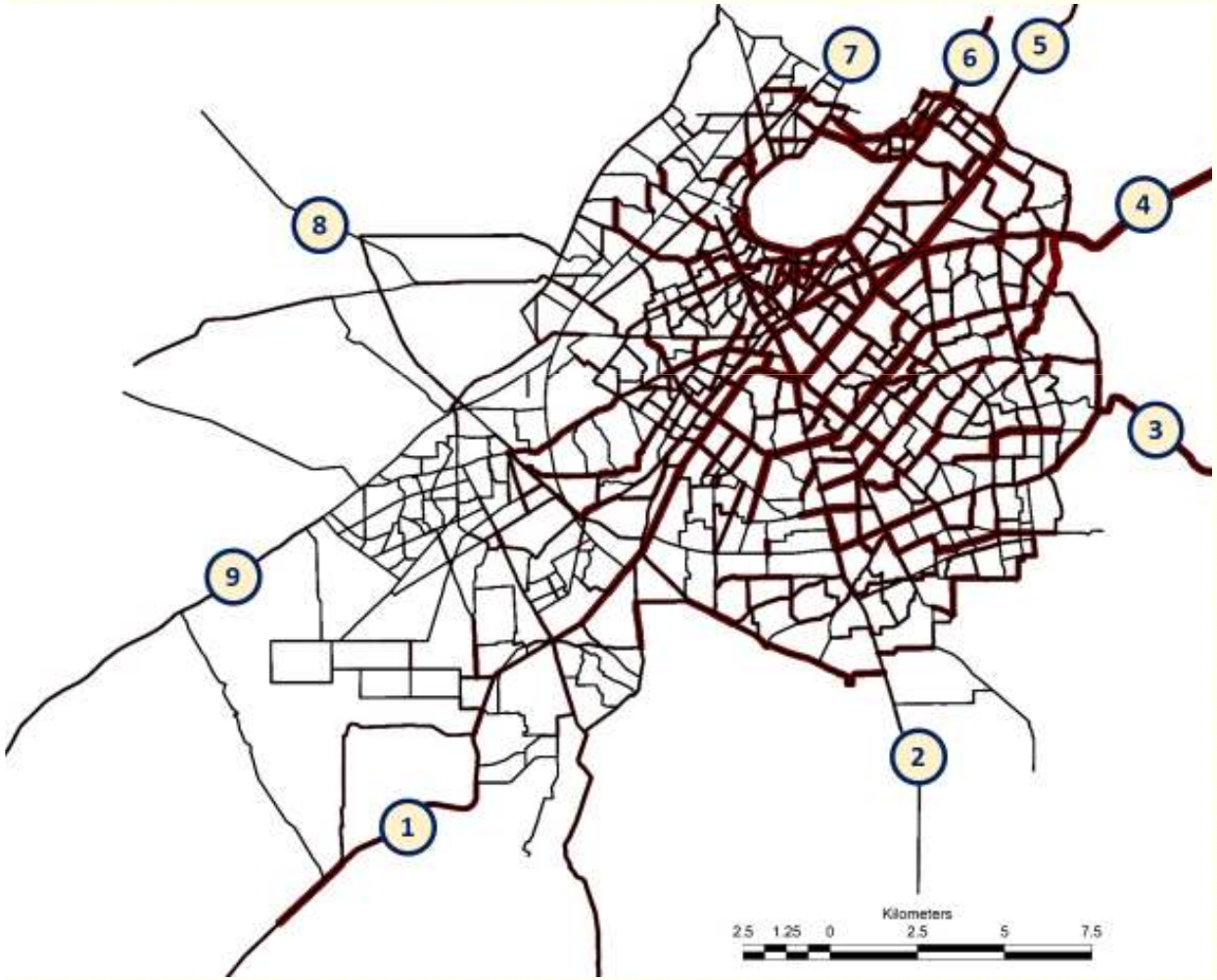
8 Calculation of GHG Emissions

(Length of Link) X (Assigned Volume) = **Vehicle Kilometers Travelled**

Multiply with

Emission Factors (from IPCCs Emission Factor Database (EFDB)) → Transport dependent GHG emissions

Travel Demand Modelling & GHG Estimations for Base Year (2017)



Traffic Assignment on the Network

↓

Assignment not validated at 4 locations (1, 5, 7 & 8)

↓

Matrix Correction using Ground Counts

↓

Traffic Assignment on the Network

↓

Validation (Average variation of ± 10%)

Travel Demand Modelling & GHG Estimations for Base Year (2017)

Daily Peak Hour Vehicle Kilometres Travelled (VKT)	19 lakh Kms.

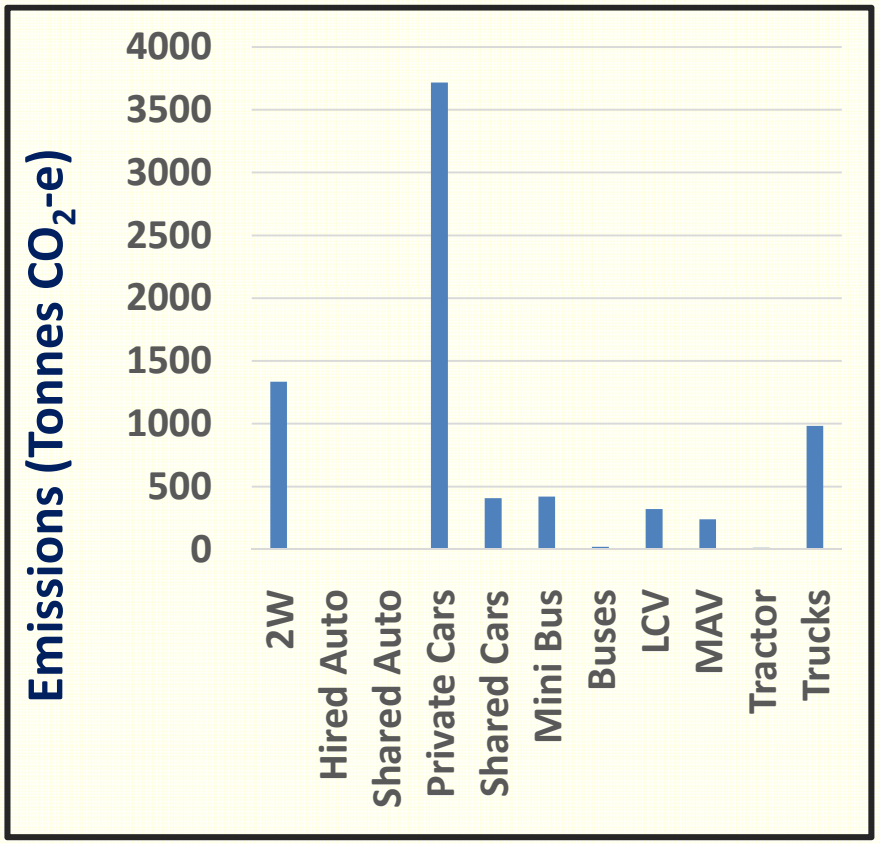
Peak Hour Emissions

GHG	Emission (Tonnes)	Emission (Tonnes CO_2-e)	% Share
CO_2	406.39	406	5%
CH_4	126.09	7061	95%
N_2O	0.008575	2.4	0.03%
TOTAL		**7470**	**100%**

Peak Hour Emissions = 9.8% of Daily Emissions in GMUC

Source: Primary Survey

Daily Emissions → **73,206 T CO_2-e**



Projection for Planning Parameters for Horizon Year (2027)

Population Projection

Year	GMUC Population Estimation by -		Variation
	Master Plan (CAGR Method)	Present Study	
2017	14,13,998	16,16,662	**14%**
2018	14,75,790	17,23,033	**17%**
2027	21,68,731	29,60,766	**37%**

Land Use Projection

S. No.	Land Use	Area (Ha) - 2027
1.	Commercial	1336.8
2.	Industrial	3960.2
3.	Public / Semi-Public	1688.4

Projection of Trip Ends for Horizon Year (2027)

Horizon Year	Trip Productions	Trip Attractions
2022	22,00,000	22,00,000
2027	30,00,000	30,00,000

Trip Type	Value of Trip Ends	
	2022	**2027**
E - E	83,993	1,14,535
E - I	5,92,087	8,07,391
I - E	6,70,702	9,14,593
I - I	22,00,000	30,00,000
TOTAL	**35,46,781**	**48,36,520**
Round Off	**36,00,000**	**49,00,000**

Business-As-Usual Scenario for Horizon Year (2027)

Aspect	Consideration
Bus Transport	**Trend Based** • Low Mode Share: **5%**
Metro (peak hour)	**Existing (Delhi Metro + Rapid Metro)** • Ridership: **18,900** **Delhi Metro Phase 4 (Yellow Line)** • Estimated Ridership: **30,000** **Rapid Metro Phase 3** • Estimated Ridership: **6,900**
Shared Mobility	**Trend Based** (Source: NITI Ayog - 2017) • Estimated Share: **3.6%**
Electric Mobility	**Trend Based** (Source: McKinsey & Company - 2017) • Estimated Share: **18%**
New Engine Technology (From 2020)	**BS-VI Compliance (Euro-VI)** • Emission Standards

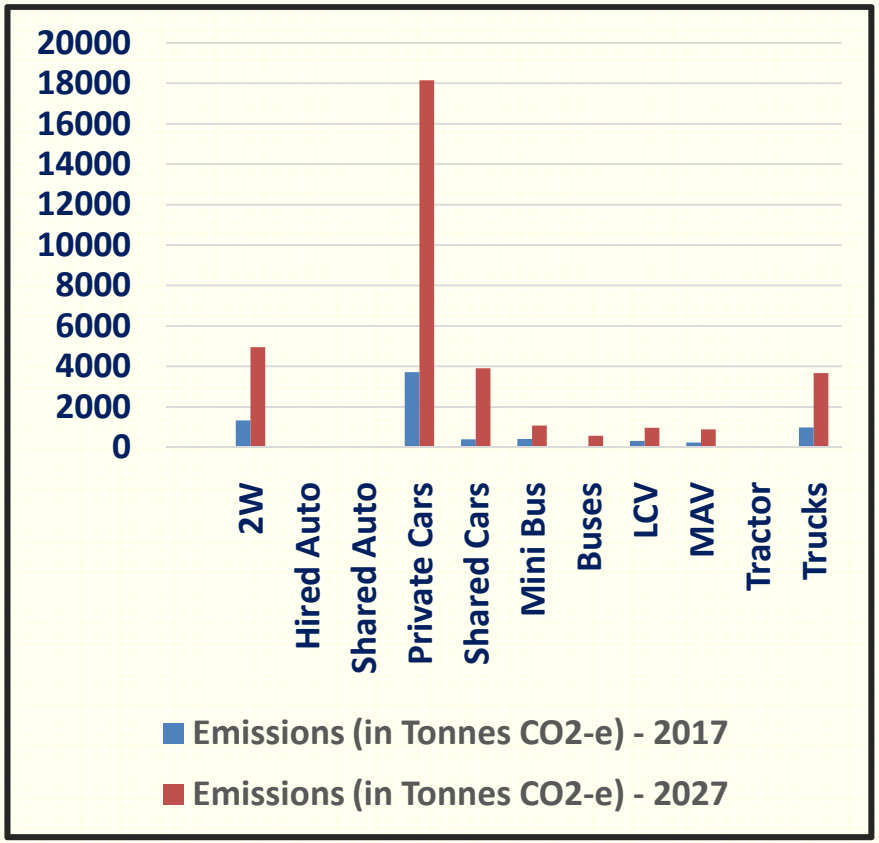
Business-As-Usual Scenario for Horizon Year (2027)

Daily Peak Hour Vehicle Kilometres Travelled (VKT)	88 lakh Kms.

Peak Hour Emissions

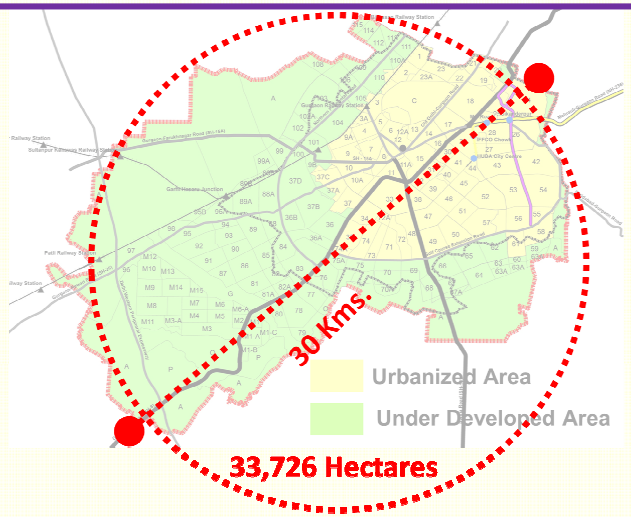
GHG	Emissions (Tonnes CO_2-e)	
	Base Year (2017)	BAU (2027)
CO_2	406	1,857
CH_4	7,061	32,440
N_2O	2.4	10
TOTAL	**7,470**	**34,307**

Daily Emissions → 3.5 lakhs T CO_2-e



Issues in GMUC

1. Huge Spatial spread of GMUC



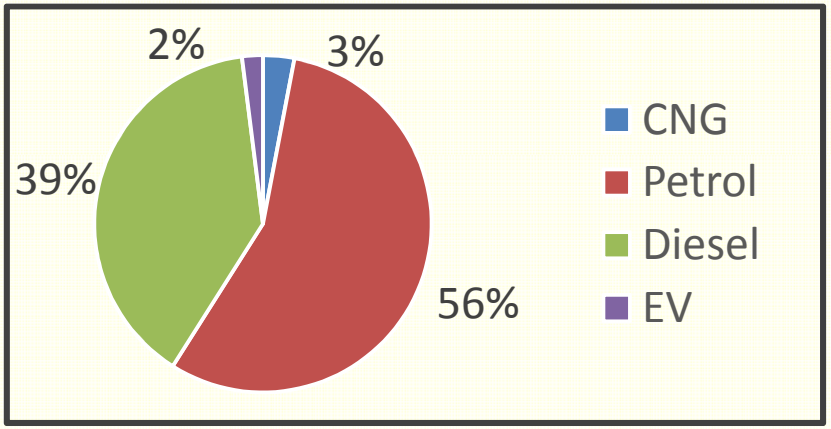
2. Lack of Compactness

3. Lack of Public Transport

4. Affordability & High Vehicular Ownership

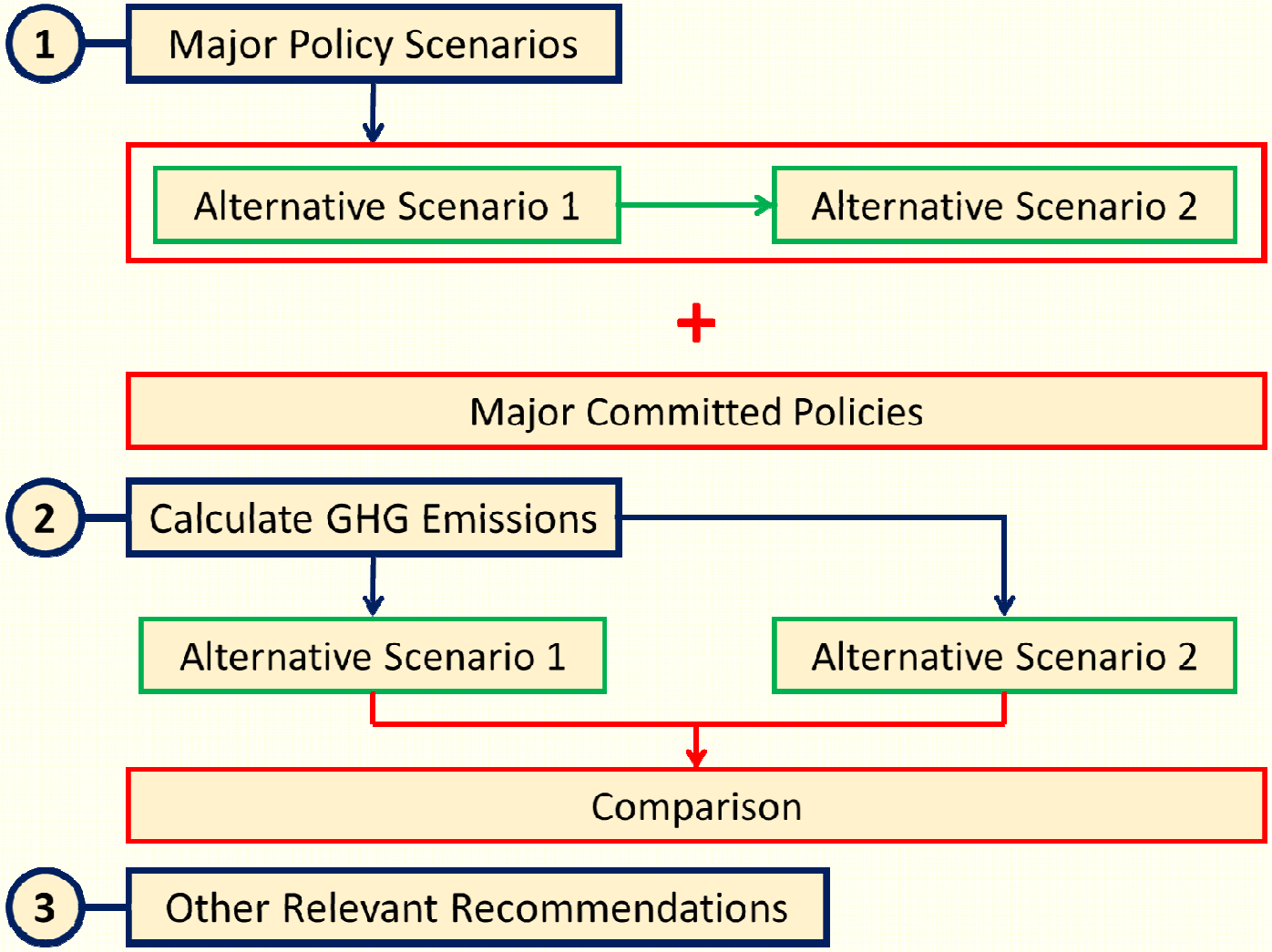
5. Congestion

6. High share of Fossil Fuel based Personalized Trips



7. Lesser shift to New-Age Mobility Trends

Development of Alternative Scenarios for Horizon Year (2027)



Development of Alternative Scenarios for Horizon Year (2027)

S. No.	Policy Scenario	Purpose
1.	Enhanced Public Transport with Master Plan Development Schemes	To improve the Public transport system of GMUC with consideration of proposed master plan and committed projects.
2.	Transit Oriented Development along stations	To introduce the concept of compact development through TOD and thus improve the overall transport system of GMUC

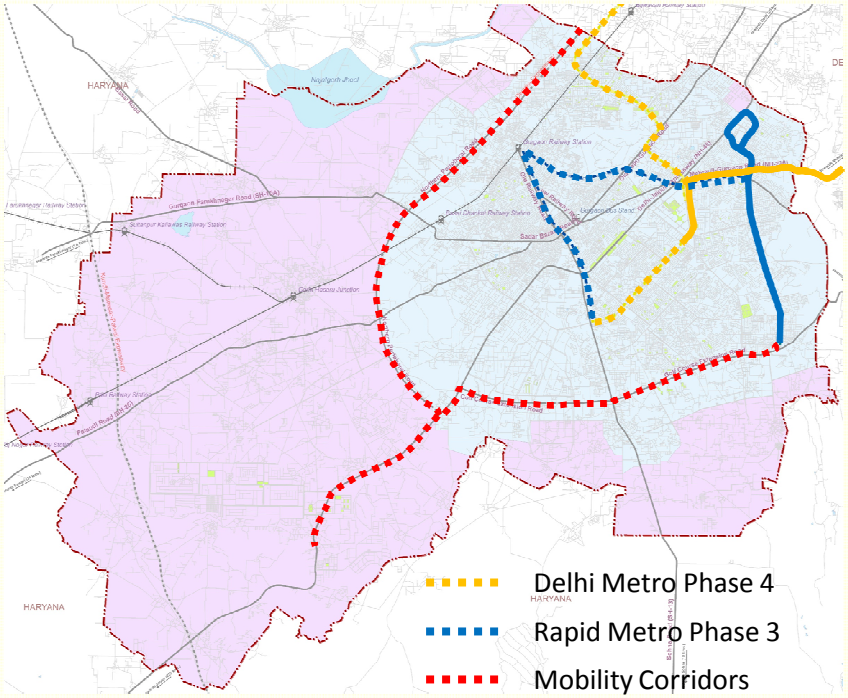
Other Consideration across Scenarios

S. No.	Instruments	Considered Policy
1.	Travel Demand Management	• Shared Mobility
2.	Technology	• Electric Mobility • BS-VI Compliant Engines

Alternative Scenario 1: Enhanced Public Transport

Aspect	Consideration
Bus Transport	**New Bus System** - CNG based Buses (Source: DIMTS - 2017) • Higher Mode Share: **31%**
Metro (Peak Hour)	**Existing** • Increase in Ridership: **18,900** **Delhi Metro Phase 4 (Yellow Line)** • Estimated Ridership: **30,000** **Rapid Metro Phase 3** • Estimated Ridership: **6,900** **Mobility Corridors along Northern & Southern Peripheral Roads** • Estimated Ridership: **90,000**
Shared Mobility	**Improved** • Estimated Share: **10%**
Electric Mobility	**Trend Based** • Estimated Share: **25%**
New Engine Technology (From 2020)	**BS-VI Compliance (Euro-VI)** • Emission Standards

Alternative Scenario 1: Enhanced Public Transport



Peak Hour Emissions

GHG	Emissions (Tonnes CO_2-e)	
	BAU (2027)	Alternative 1 (2027)
CO_2	1,857	1,647
CH_4	32,440	28,770
N_2O	10	9
TOTAL	**34,307**	**30,426**

Daily Emissions → **3.1 lakhs T CO_2-e**

Reduction in Transport Dependent GHG Emissions in 10 years (compared to BAU) → **11%**

Alternative Scenario 2:
Enhanced PT with Transit Oriented Development

Proposed Population Density around Stations

Predominant Character	Up to 500 Meters	Between 500 - 800 Meters
Purely Residential	1,500 PPH	1,000 PPH
Activity Centers	1,350 PPH	900 PPH

Source:
Rajesh Kaushik; Formulation of Corridor Level Plan For Southern Periphery Metro Transit Corridor – Gurgaon, Urban Mobility India

Alternative Scenario 2:
Enhanced PT with Transit Oriented Development

Proposed Population Density around Interchange

Predominant Character	Up to 1000 Meters	Between 1000 - 2000 Meters
Hub	1,000 PPH	830 PPH

Source: Kadkadooma TOD Project, UTTIPEC, Delhi Development Authority

Target Population

Aspect	Consideration
1. Maximum Population that can be Accommodated	22,20,261
2. Population to accommodate by 2027	13,44,104
3. Self contained Users (30%)	30%
4. Metro Users (70%)	9,40,873
5. Daily Metro Ridership	7,80,925
6. Peak Hour Metro Ridership	80,000 (approx.)

Alternative Scenario 2:
Enhanced PT with Transit Oriented Development

Aspect	Consideration
Bus Transport	**New Bus System** - CNG based Buses (Source: DIMTS Report - 2017) • Higher Mode Share: **31%**
Metro (Peak Hour)	**Existing (Delhi Metro + Rapid Metro Phase 1 and 2)** • Trend based Increase in Ridership: **18,900** **Delhi Metro Phase 4 (Yellow Line)** • Estimated Ridership: **30,000** **Rapid Metro Phase 3** • Estimated Ridership: **6,900** **Mobility Corridors along Northern & Southern Peripheral Roads** • Estimated Ridership: **90,000** • Impact of Transit Oriented Development: **80,000**
Shared Mobility	**Improved** • Estimated Share: **10%**
Electric Mobility	**Trend Based** • Estimated Share: **25%**
New Engine Technology	**BS-VI Compliance (Euro-VI)** • Emission Standards

Alternative Scenario 2:
Enhanced PT with Transit Oriented Development

Peak Hour Emissions in Tonnes CO_2-e for Horizon Year (2017)

GHG	BAU	Alternate 1	Alternate 2
CO_2	1,857	1,647	**1,337**
CH_4	32,440	28,770	**23,682**
N_2O	10	9	**7**
TOTAL	34,307	30,426	**25,026**

Daily Emissions → **2.5 lakhs T CO_2-e**

Reduction in Transport Dependent GHG Emissions in 10 years (compared to BAU) → **27%**

Conclusion & Recommendations

Conclusion

- Future targets for controlling the rate of Climate Change will not be achieved unless emissions from the urban transport sector in Developing countries is reduced.
- There is a strong relationship between Transport Factor (like Daily VKT in a city) and Gross Emissions from the Transport sector.
- As the size of city increases, emissions increase drastically in the absence of efficient Public Transport.
- Major Issues in GMUC –
  - Very high pace of Urbanization and Migration.
  - Very minimal share of passenger trips are made by Public Transport
  - Large emissions in the core area due to reduced travel speeds
  - Lack of connectivity in areas outside GMC which encourages personalized transport.
  - Huge dependence on the Fossil Fuel based vehicles and it is increasing at an exponential rate.
- If the present scenarios continues in GMUC, then in the coming 10 years, the total GHG emissions will increase by 359%.

Conclusion & Recommendations

Specific Recommendations

Alternate scenario 2 will result in the best possible results because TOD will create a compact type of development and support mass transit options.

Generic Recommendations

- Planning for Non-Motorized Transportation (NMT)
- Low Emission Zones (LEZs)
- Speed Restrictions
- Regulating Parking Supply
- Road Pricing
- Vehicle Taxation
- Intelligent Transport System

Thank You