Urban Mass Transit Company Limited

Low-carbon Comprehensive Mobility Plan for Udaipur

Workshop on Sharing Experience in Preparation of Low-carbon Comprehensive Mobility Plans (LCMP) in Indian Cities

22nd and 23rd August , 2013

Presentation Outline

- Study Area
- Development of 4 Stage Transport Model
- Planning Parameters
- Urban Design-Public Transport Intervention
- Outcomes

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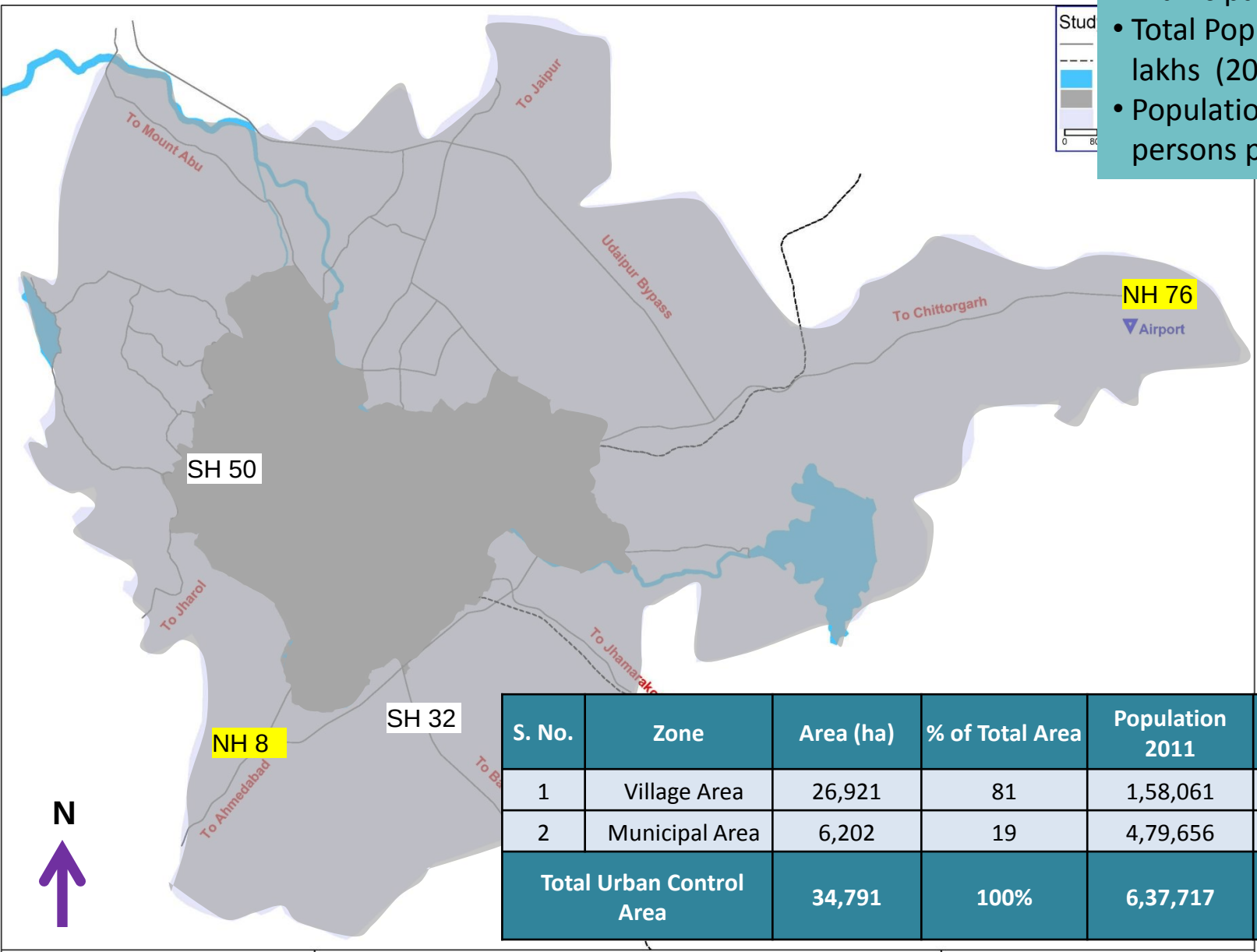
Study Area

Study Area- Udaipur Urban Control Area

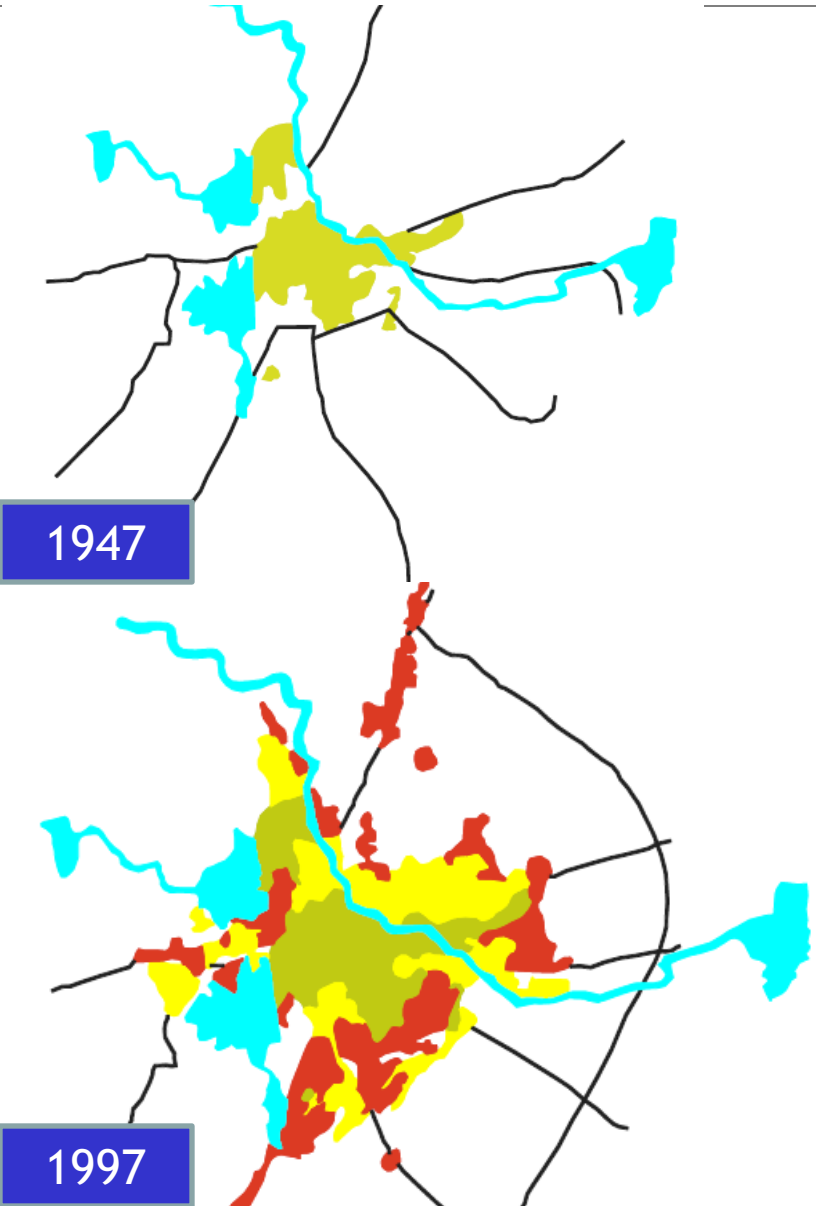
Study Area

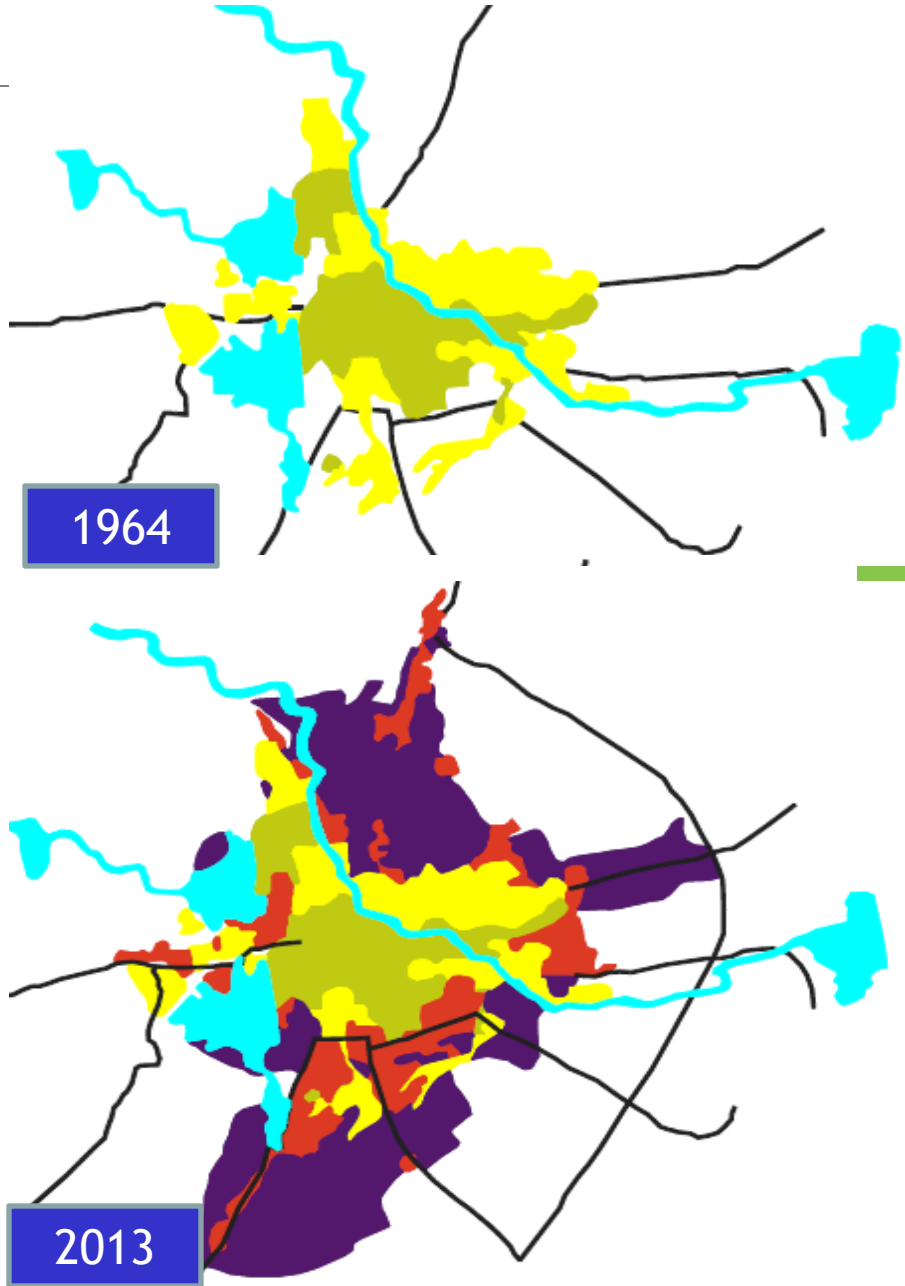
- Udaipur Urban Control Area – 34,791Ha
- Municipal area- 6,410 Ha
- Total Population -6.37 lakhs (2011 census)
- Population density- 19 persons per Ha (2011)



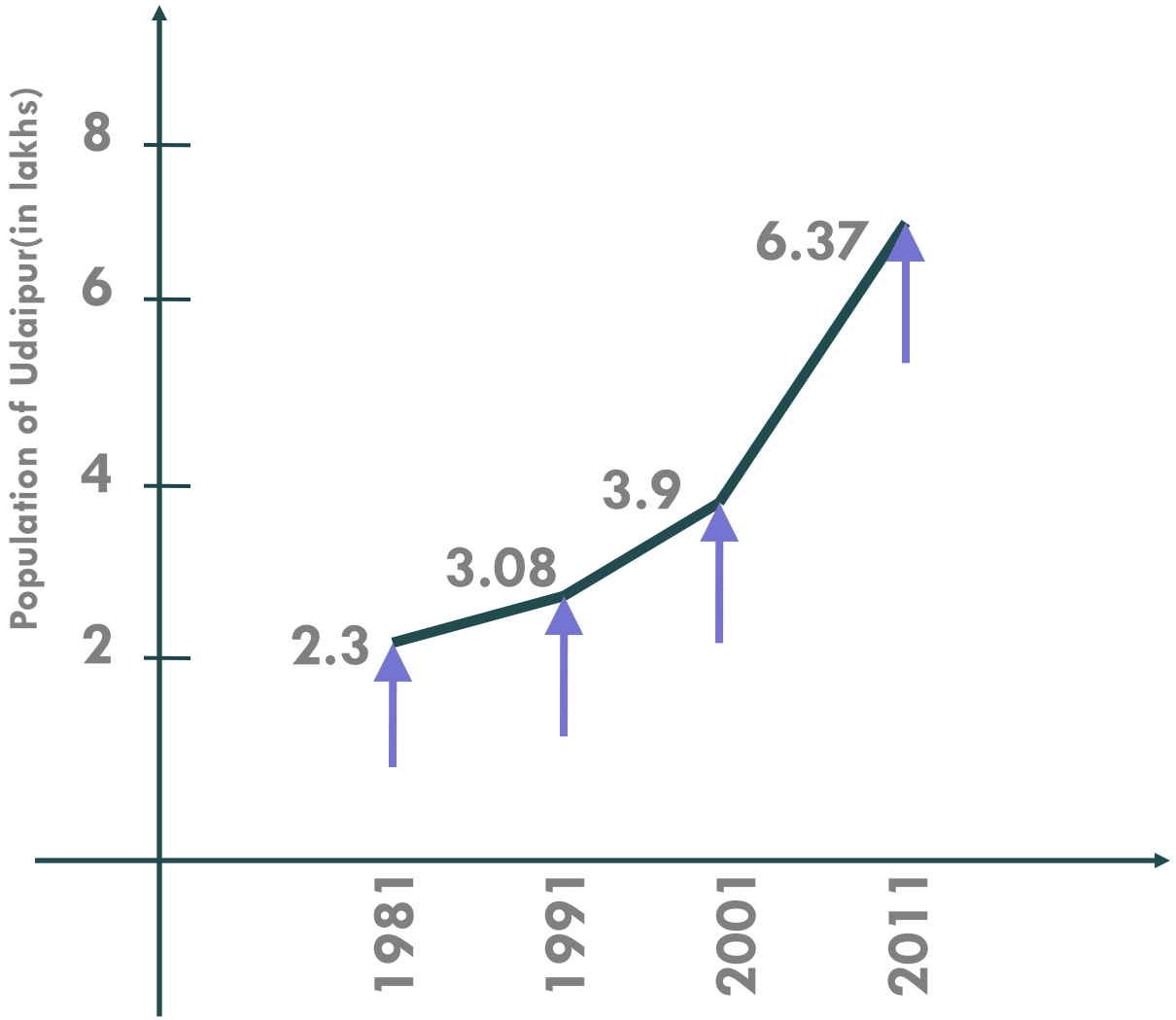
S. No.	Zone	Area (ha)	% of Total Area	Population 2011	% of Total Population	Density per ha.
1	Village Area	26,921	81	1,58,061	25%	6
2	Municipal Area	6,202	19	4,79,656	75%	77
Total Urban Control Area		**34,791**	**100%**	**6,37,717**	**100%**	**19**

Growth of Udaipur





Population growth



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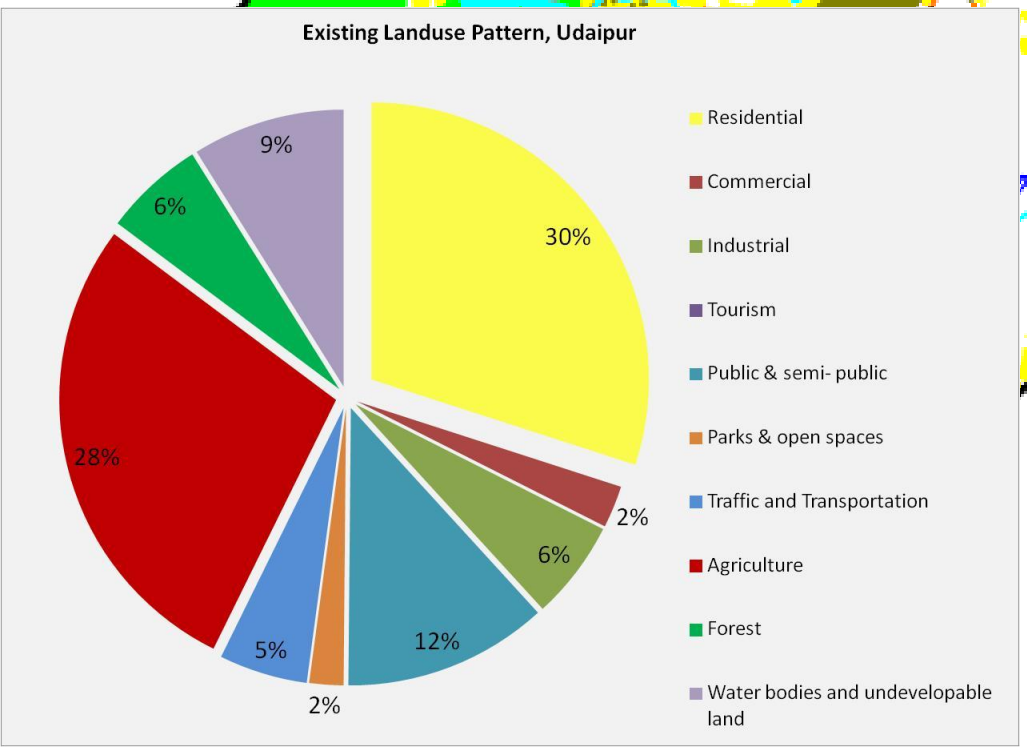
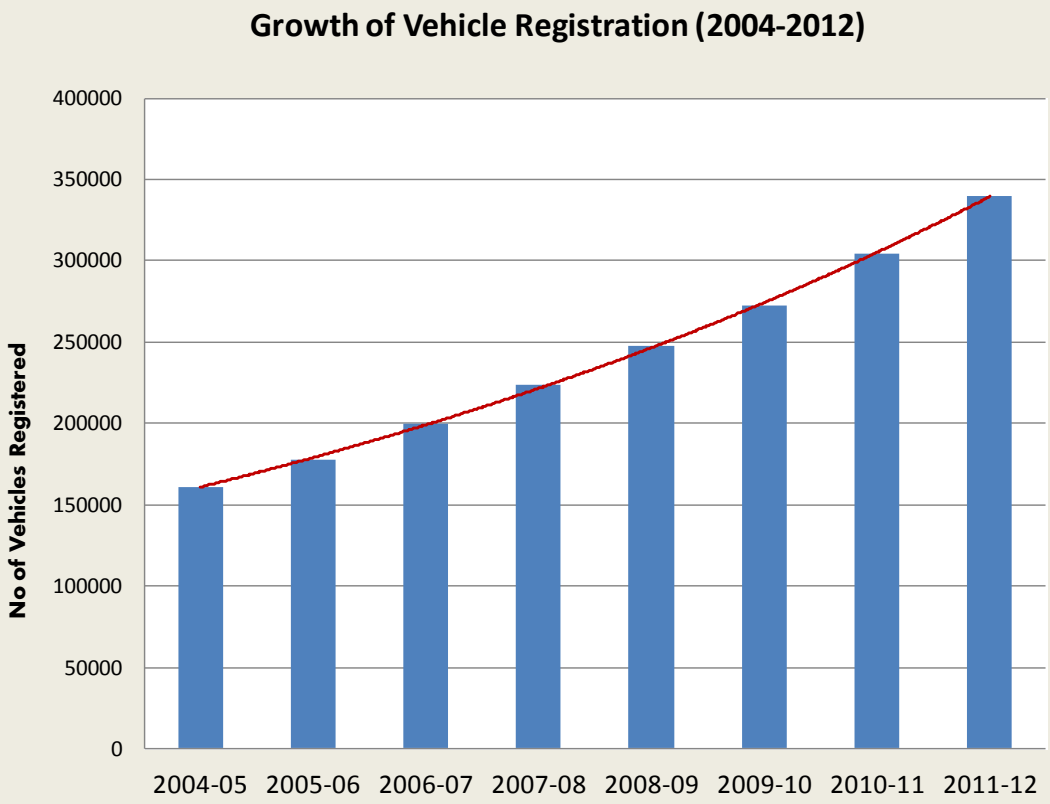
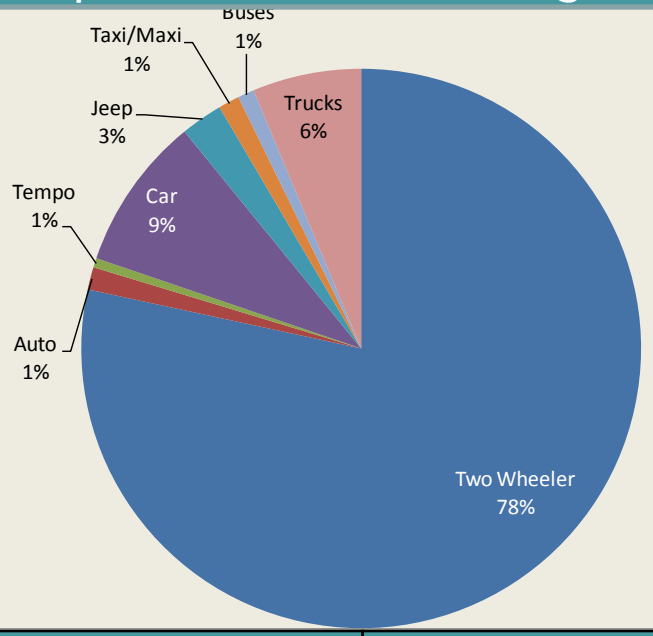
Land Use Plan (2013)



Existing Transport Scenario



Composition of Vehicles Registered



Fuel Type Used	% of Vehicles
Petrol	75.29%
Diesel	24.34%
LPG	0.02%
CNG	0%
Batery/Electric	0.14%
LPG & Petrol	0.22%

- Total Registered Vehicles- 2,66,197 (2013)

  Average Trip Length-5.09 Km
- Four wheelers constitute 13% of total registered vehicles, with 4% of total trips
- Two wheelers constitute 78% of total registered vehicles, with 48% of total trips
- Public Transport (Bus) - accounts for only 1% of total registered vehicles and contribute 3% of total trips

Socio- Economic Profile and Travel Characteristics

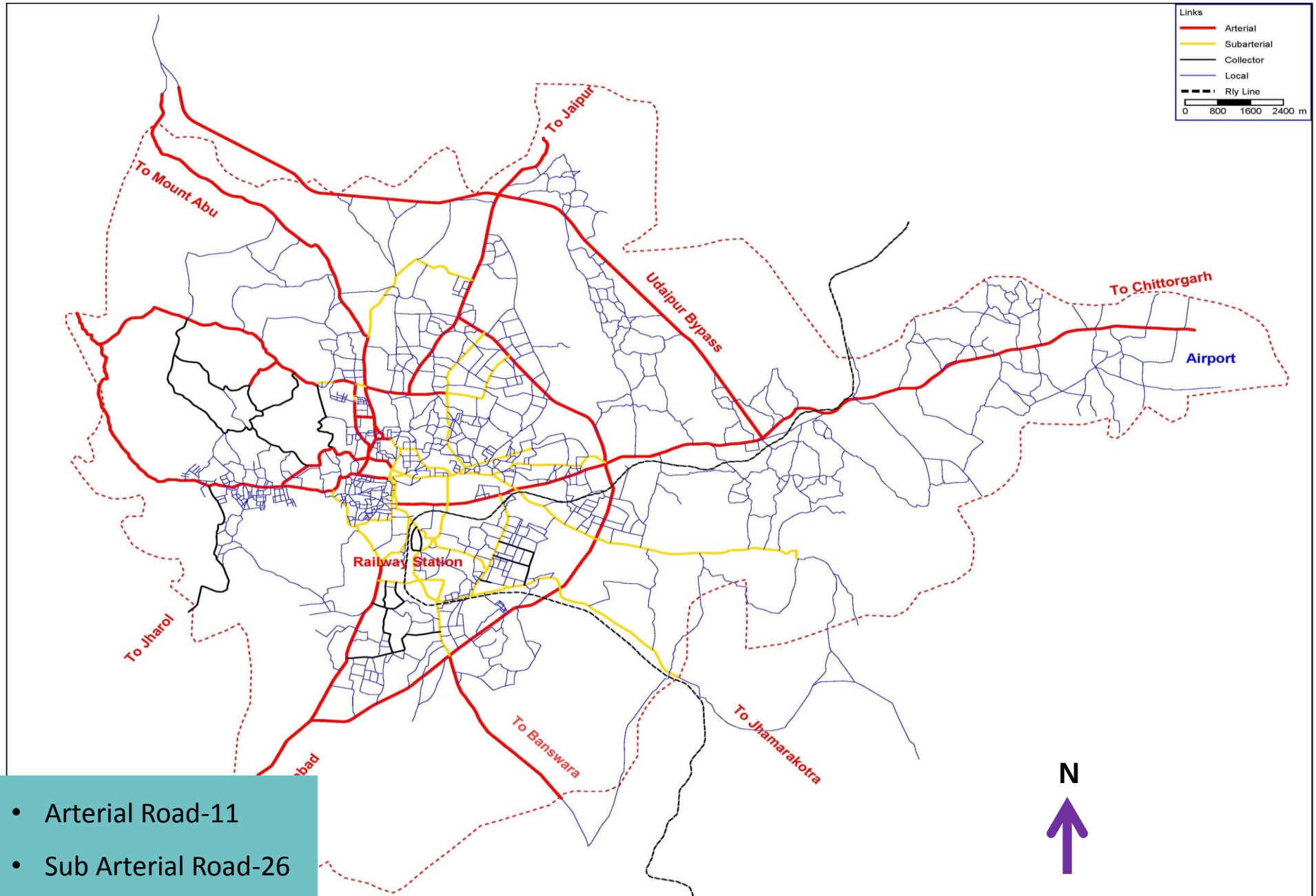
Income Group / Gender	Trip Rate With Walk Mode	Trip Rate Without Walk Mode
High Income Group (HIG)	**1.2**	**0.96**
Female	0.75	0.48
Male	1.57	1.34
Medium Income Group (MIG)	**1.17**	**0.82**
Female	0.71	0.34
Male	1.55	1.21
Low Income Group (LIG)	**0.96**	**0.43**
Female	0.61	0.19
Male	1.28	0.65
City Average	**1.12**	**0.73**

- Average Occupancy for Car-2.5
- Average Occupancy for Tourist Taxi -4.25
- Average Occupancy for Two Wheeler-1.6
- Average Occupancy for Bus-38

- Average HH size- 5
- Average HH income –Rs. 18,000 per month
- HIG-13%, MIG-61%, LIG-27%
- Student population constitute 19%
- Average expenditure on transport – 12.5% of total monthly income (HIG-10%, MIG-26.5% and LIG-.96%)

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Walk	48%	80%	25%
Cycle	2%	2%	3%
Two Wheeler	34%	14%	48%
Car	3%	1%	4%
IPT	11%	3%	18%
Other Buses	3%	0%	3%

Road Network Characteristics

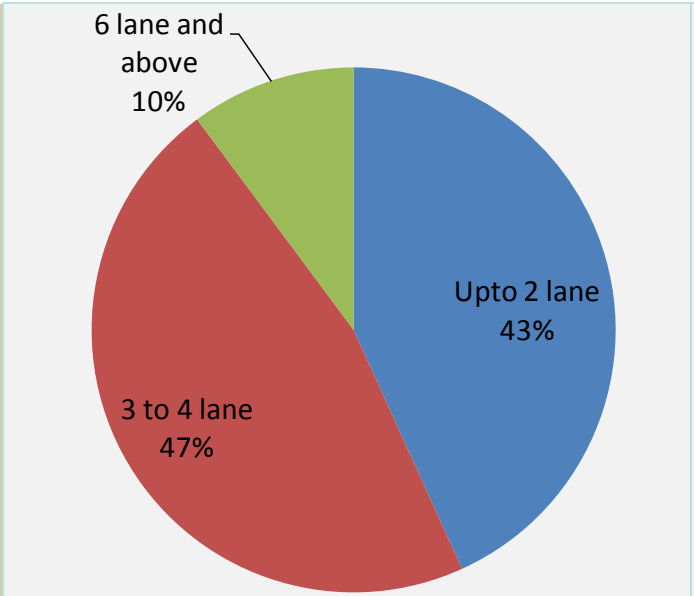


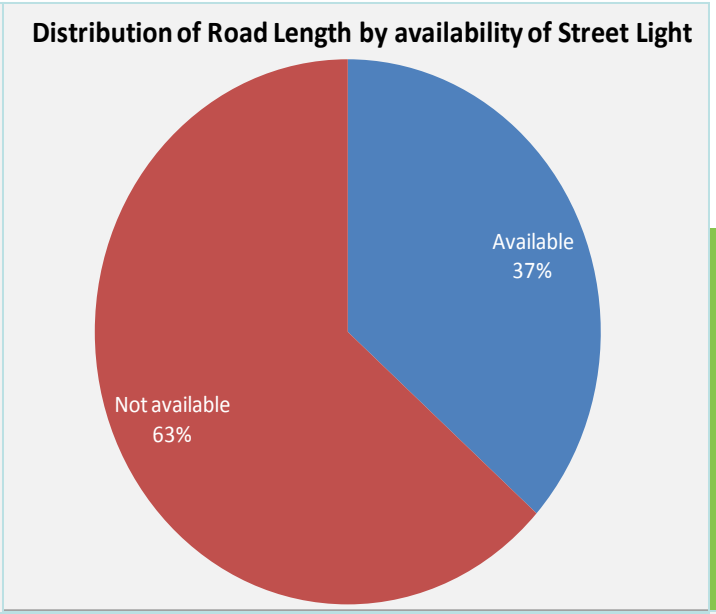
- Arterial Road-11
- Sub Arterial Road-26

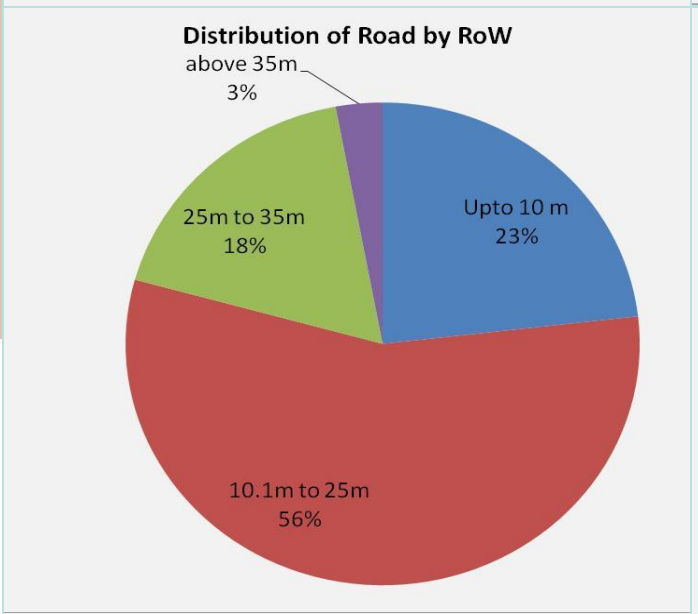
Road Network Characteristics

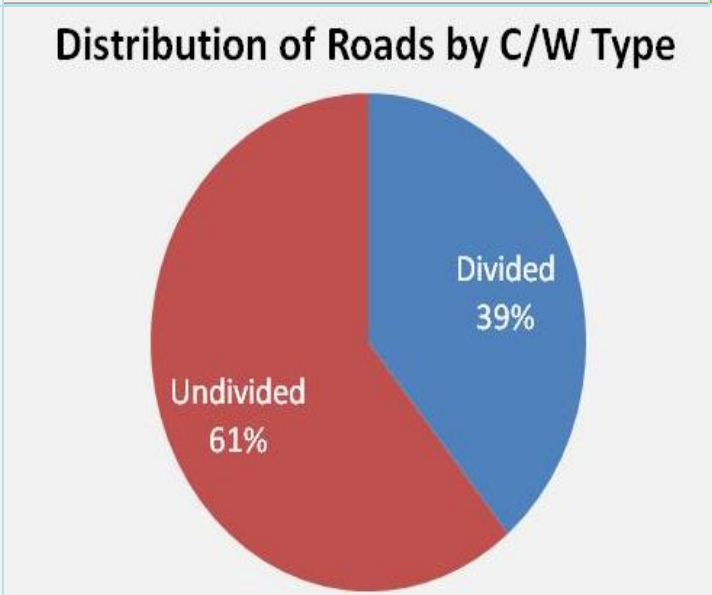
Road Network

- Area under circulation-5%
- Average Journey Speed- 38 Kmph
- Journey speed as low as 10 Kmph in bottleneck points, e.g., Old Cty area, Bapu Bazaar, Ashwani Market, Pratap Nagar etc.
- Only 4% of the road network has footpath
- 37% of the road network within study area has street lighting facility.









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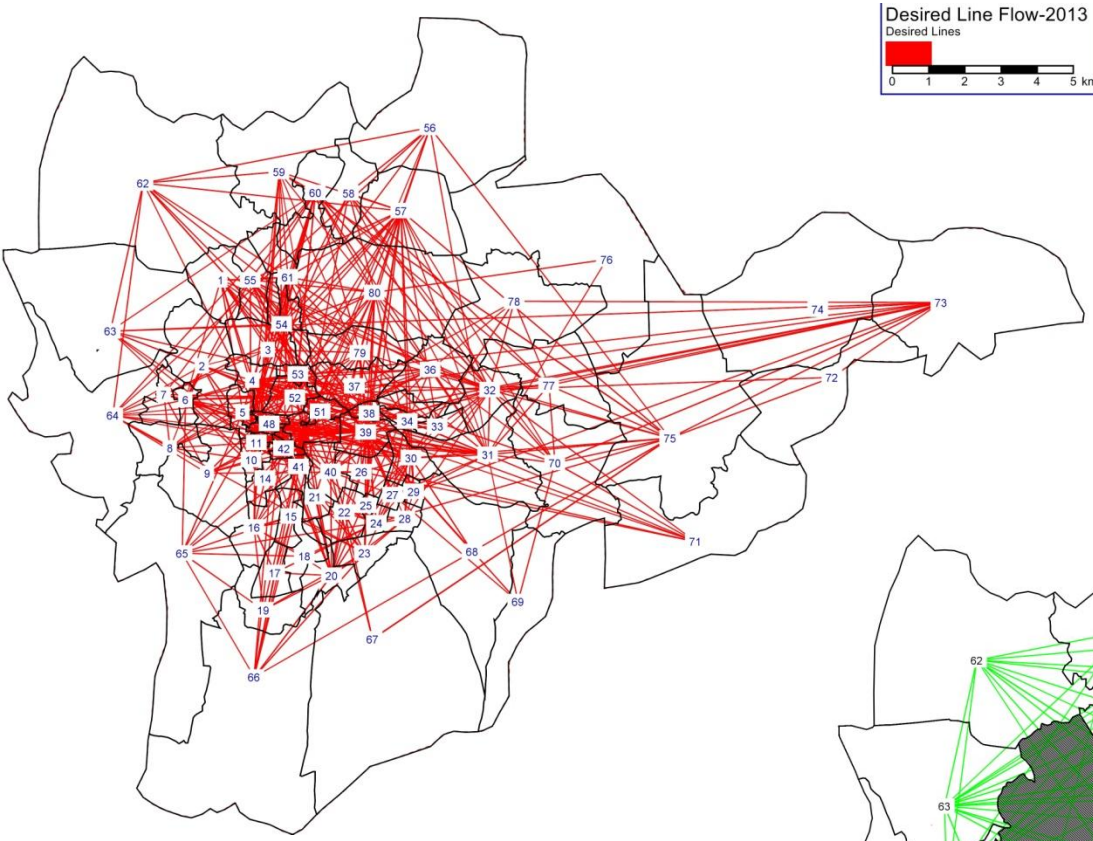
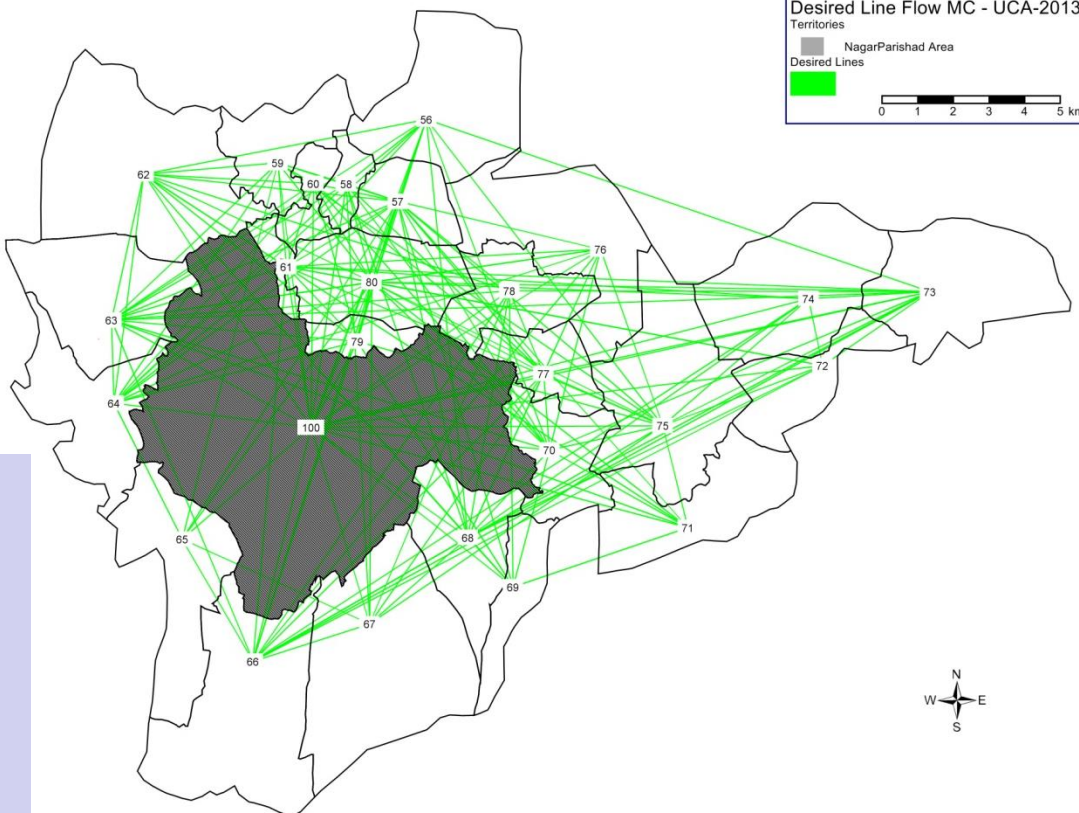
Desire line Diagram





1. Heritage centers or tourist centers
2. Commercial centers
3. Industrial centers
4. Educational centers
5. Transport terminals

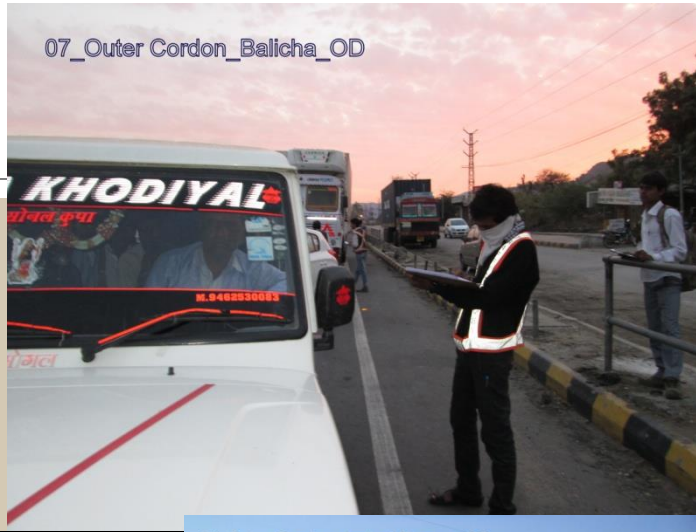
Traffic Volume Count

Code	Name	Total Traffic		Morning Peak		Evening Peak	
		Vehicles	PCUs	PCUs	% of Total Traffic	PCUs	% of Total Traffic
01	Fatehpura Chowk	46,094	39,788	3,588	9.0%	3,551	8.9%
02	Syphon Circle	26,610	21,501	2,187	10.2%	2,080	9.7%
03	Bhuwana Circle	31,467	36,853	2,642	7.2%	4,191	11.4%
04	Sukhadia Circle	24,106	22,263	1,834	8.2%	1,942	8.7%
05	Chetak Circle	71,109	59,229	4,567	7.7%	4,900	8.3%
06	Panchwati Circle	34,510	29,029	2,327	8.0%	2,294	7.9%
07	Court Circle	63,721	53,444	4,223	7.9%	4,346	8.1%
08	Shastri Circle	62,157	49,217	4,025	8.2%	4,169	8.5%
09	Delhi Gate	79,025	63,495	5,067	8.0%	5,367	8.5%
10	Hathipol	46,678	32,461	2,784	8.6%	2,775	8.5%
11	Udiapol	60,075	49,230	3,909	7.9%	4,109	8.3%
12	Pratap Nagar Chowk	48,414	64,260	5,019	7.8%	5,447	8.5%
13	Surajpol	100,578	90,528	8,352	9.2%	7,577	8.4%
14	UIT Circle	27,734	21,909	1,673	7.6%	2,137	9.8%
15	Ayyad Puliya	52,456	40,159	3,542	8.8%	3,383	8.4%
16	Sewashram Circle	68,889	54,322	5,436	10.0%	4,916	9.0%
17	Malla Talai Chowk	35,060	26,455	2,227	8.4%	2,426	9.2%
18	Patel Circle	41,395	36,387	2,651	7.3%	3,304	9.1%
19	Subji Mandi	33,488	30,512	2,827	9.3%	2,601	8.5%

Volume Count Characteristics

- Surajpol Intersection experiences highest traffic (90,528 PCUs) followed by Pratapnagar Chowk (64,260 PCUs) and lowest traffic was observed Syphon Circle (21,501 PCUs)

Outer Cordon Traffic Volume Count

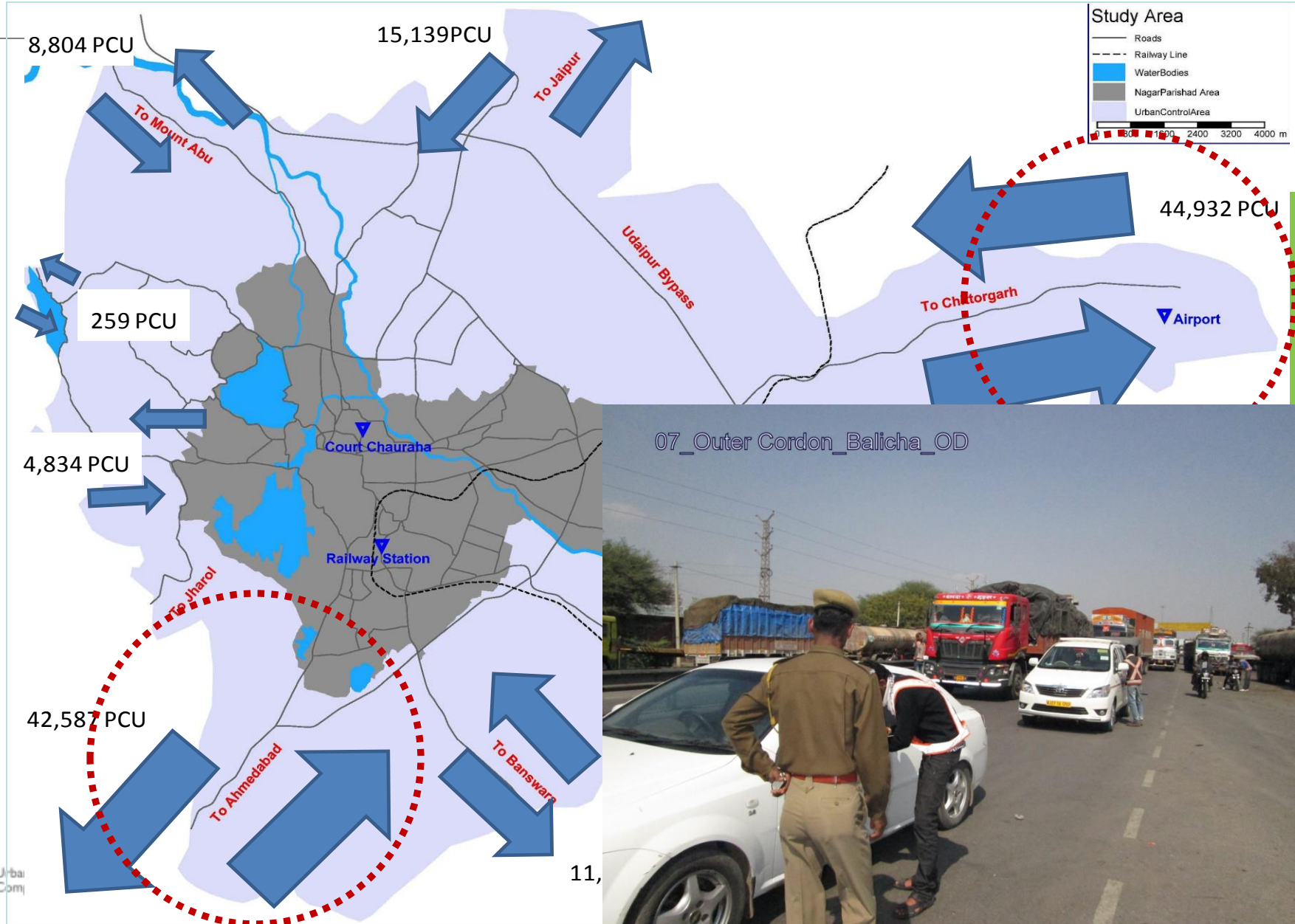


Traffic Characteristics

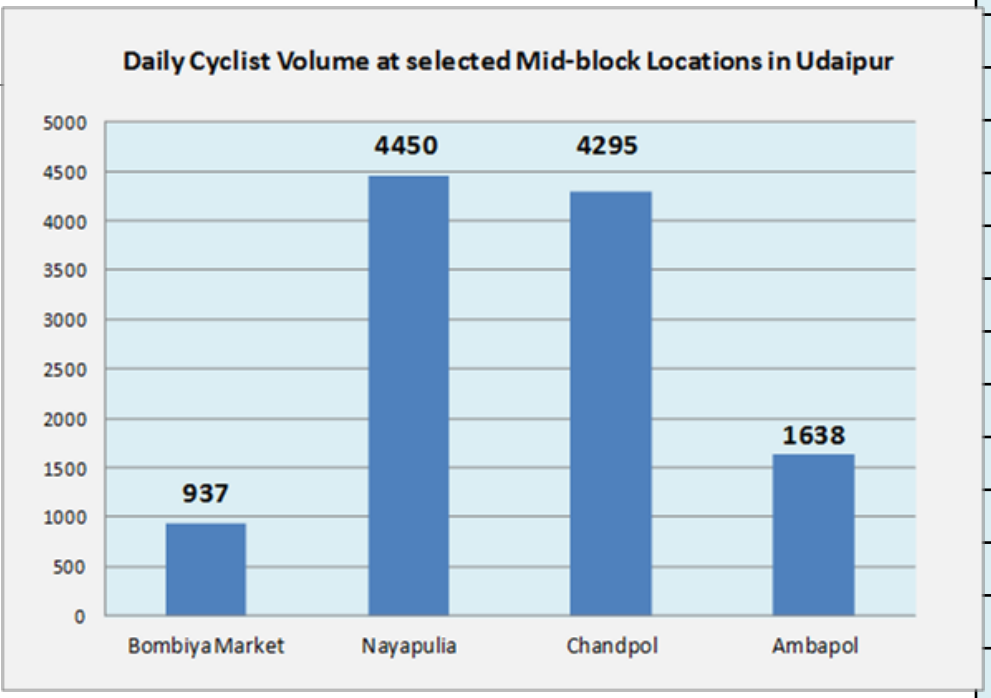
- Maximum traffic along Chittorgarh Road (Airport Road) 44,932 PCUs
- On the average 12.6% passenger vehicles at OC locations are bypassable traffic (E-E) maximum (28%) being at OC-7
- On the average 36% goods traffic at OC locations are bypassable traffic (E-E), maximum (79%) being at OC-7

Code	Name of the intersection	Total Traffic		Morning Peak		Evening Peak	
		Vehicles	PCUs	PCUs	% of Total Traffic	PCUs	% of Total Traffic
1	Abu Road	6,873	8,804	696	7.9%	705	8.0%
2	Amberi Bypass	9,696	15,139	903	6.0%	1,053	7.0%
3	Debari Bypass	27,306	44,932	3,269	7.3%	3,274	7.3%
4	Madri	13,089	10,749	978	9.1%	838	7.8%
5	Eklingpura	10,225	11,411	892	7.8%	1,158	10.1%
6	Banswara Road	11,230	11,745	1,027	8.7%	1,100	9.4%
7	Balicha Bypass	19,022	42,587	3,119	7.3%	2,657	6.2%
8	Rampura Chuaraha	5,466	4,834	444	9.2%	376	7.8%
9	Badi Lake	358	259	27	10.4%	19	7.4%

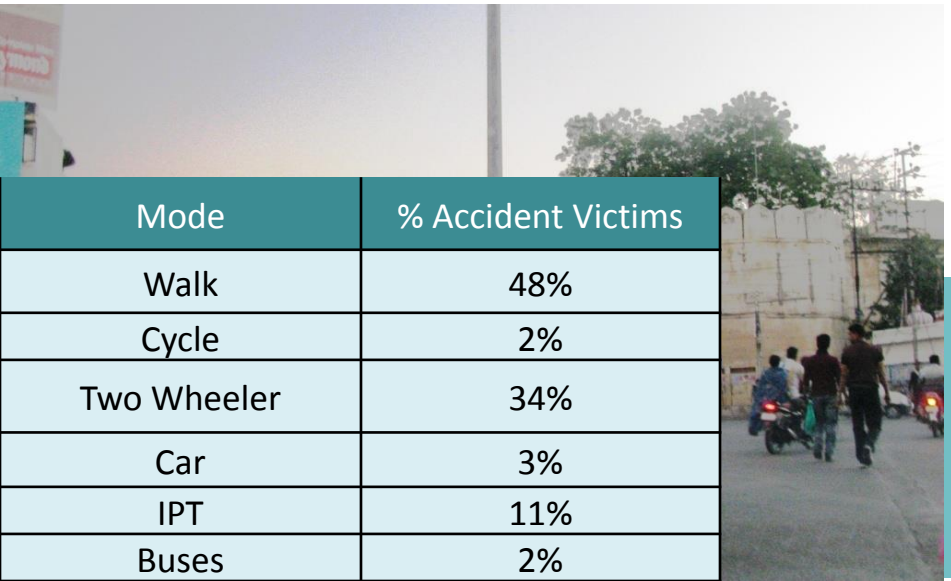
Outer Cordon Traffic Volume Count



NMT Movement Pattern



SL No	Name of Location	Daily Pedestrian Volume
1	Fatehpura Chauraha	14,077
2	Syphon Chauraha	5,963
3	Bhuwana	9,615
4	Sukhadia Circle	3,772
5	Chetak Circle	22,776
6	Panchawati Circle	7,609
7	Court Chauraha	16,003
8	Shastri Circle	18,530
9	Delhi Gate Chauraha	41,173
10	Hathipol Chauraha	18,035
11	Udiapol Chauraha	40,202
12	Pratap Nagar Chauraha	24,494
13	Surajpol Chauraha	53,338
14	UIT Circle	4,601
15	Ayad Puliya	8,855
16	Shewasram Chauraha	17,188
17	Mallah Talai Chauraha	18,576
18	Patel Circle	7,783
19	Subji Mandi Chauraha	10,915



Mode	% Accident Victims
Walk	48%
Cycle	2%
Two Wheeler	34%
Car	3%
IPT	11%
Buses	2%

Pedestrian Characteristics

- Maximum flow of pedestrian of 53,338 at Surajpol Chauraha, followed by Delhi gate Chauraha and Udiapol Chauraha and minimum of 4,601 at UIT circle to maximum
- Out of 19 major intersections at 15 locations the conflict of vehicular and pedestrian conflict is critical

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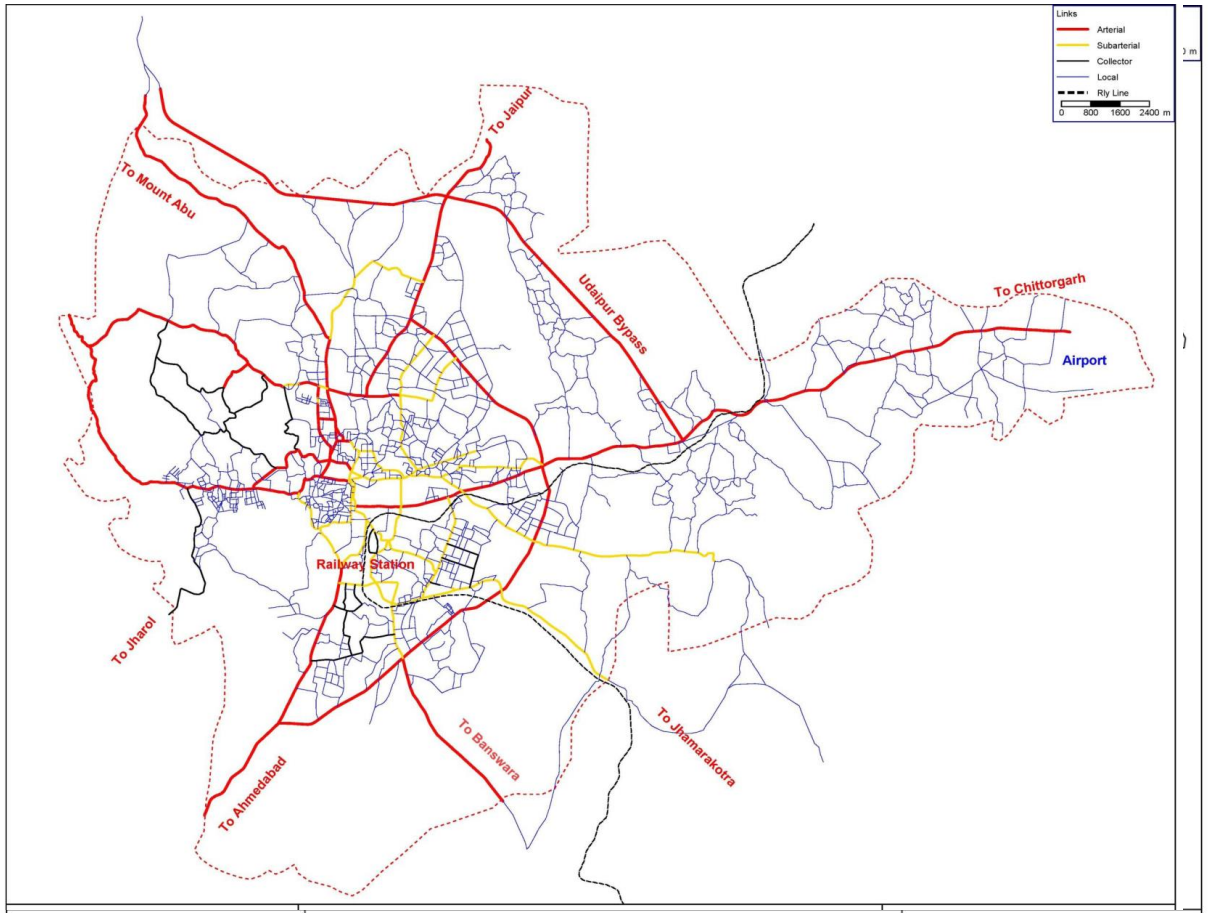
Development of 4 Stage Transport Model

Study Area Zoning



KEY FEATURES

- Detailed Zoning:
  - 80 Internal Zones
  - 4 Terminal Zones
  - 8 External Zones
- Detailed network coding
- Junction coding, including signal phasing
- *Separate network coded for NMVs*
- *4-Stage modelling adopted*

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Trip Generation Calibration

I. Home Based Work, Home Based Education & Home Based Other purposes

II. Multiple linear regression method

III. Variables available for trip end models

- Population
- No. of cars
- No. of two wheelers
- Total Vehicles
- Zone wise number of households
- No of High Income group workers residing in the zone
- No of medium Income group workers residing in the zone
- No of Low Income group workers residing in the zone
- No. of High Income group students residing in the zone
- No. of Medium Income group students residing in the zone
- No. of Low Income group students residing in the zone
- Employment
- Student Enrolment

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Trip Generation Models developed (**By Categories**)

Home Base Work Productions	R Square	t-stat
Work Productions = -416 + 1.8754 * No. of High & Medium Group Workers Residing + 1.5047* No. of Low Income Workers Residing	0.65	8.35(HIG & MIG workers) 3.93 (LIG workers)
Home Base Work Attractions	**R Square**	**t-stat**
Work Attractions = 996 + 1.3808 * Employment	0.80	17.49
Home Base Education Productions	**R Square**	**t-stat**
Education Productions = 200 + 1.3345 * No. of High & Medium Group Students Residing + 1.694* No. of Low Income Group Students Residing	0.71	9.28 (HIG & MIG students) 4.19 (LIG students)
Home Base Education Attractions	**R Square**	**t-stat**
Education Attractions = -539 + 1.7939* Student Enrollment	0.85	21.19
Home Base Other Productions	**R Square**	**t-stat**
Other Productions = -2960 + 0.4155 * Population	0.54	7.57
Home Base Other Attractions	**R Square**	**t-stat**
Other Attractions = -35 + 0.2892* Employment	0.65	11.82

Trip Distribution – Gravity Model formulation

$$f(d_{ij}) = a * d_{ij}^{\ b} * e^{c(d_{ij})}$$

Where,

dij: distance in shortest path from zone i to j.

a,b,c : calibrated parameters

Parameters/Purpose	HBW	HBE	HBO
a	0.335	0.910	0.739
b	-0.742	-0.065	-1.582
c	-0.157	-0.410	-0.215

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Mode Choice Model

- Multi-Nomial Logit Model with Generalized Cost as variable

Generalized Cost = (Value of Time* Travel time) + Travel Cost

- ***4 different sets*** of models developed for
    I. Households with no access to vehicles,
    II. Households with access to cycles
    III. Households with access to two wheelers
    IV. Households with access to cars
- Higher order vehicle owners have access to lower order vehicles
- Mutually exclusive mode choices.

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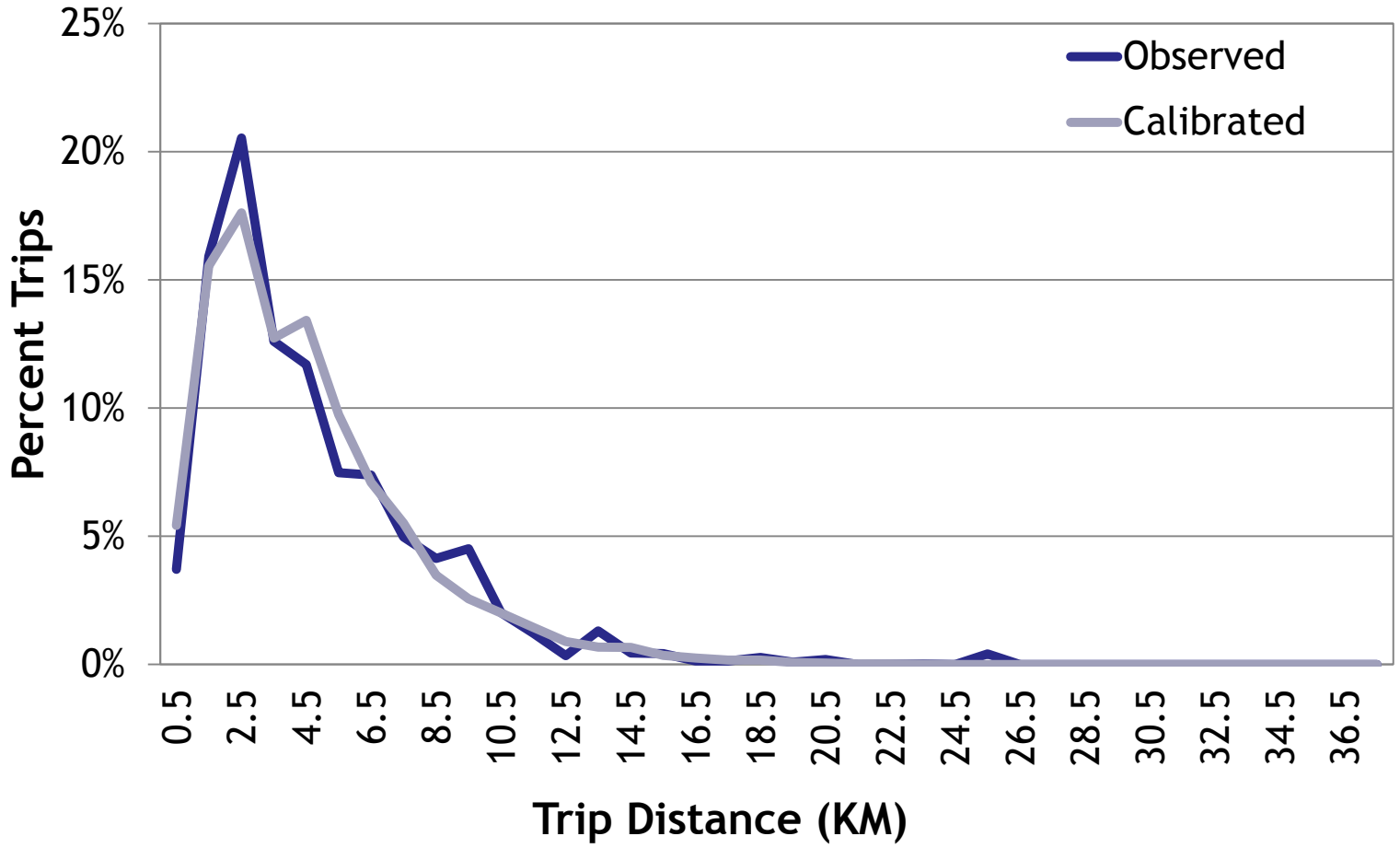
Estimated Utility Equations

MNL Results for Households with no access to individual vehicles		
Parameter	**Estimate**	**t-stat**
Log (Generalized Cost)	-1.9532	-4.42
Constant (walk)	-3.7708	-8.18
MNL Results for Households with access to cycles		
Log (Generalized Cost)	-0.7239	-2.20
Constant (Cycle)	-1.3982	-2.64
Constant (walk)	-1.3899	-3.85
MNL Results for Households with access to two wheelers		
Log (Generalized Cost)	0.70272	9.55
Constant (walk)	-1.43384	-11.35
Constant (cycle)	-4.04398	-12.27
Constant (two wheeler)	0.04798	1.28
Constant (Other buses)	-3.32918	-26.33
MNL Results for Households with access to cars		
Log (Generalized Cost)	-0.4867	-2.18
Constant (walk)	-2.0672	-5.89
Constant (cycle)	-3.1461	-5.61
Constant (two wheeler)	-0.2398	-1.27
Constant (car)	2.3256	7.54
Constant (Other buses)	-0.1711	-0.64

Model Validation- Trip Distribution (Work Purpose)



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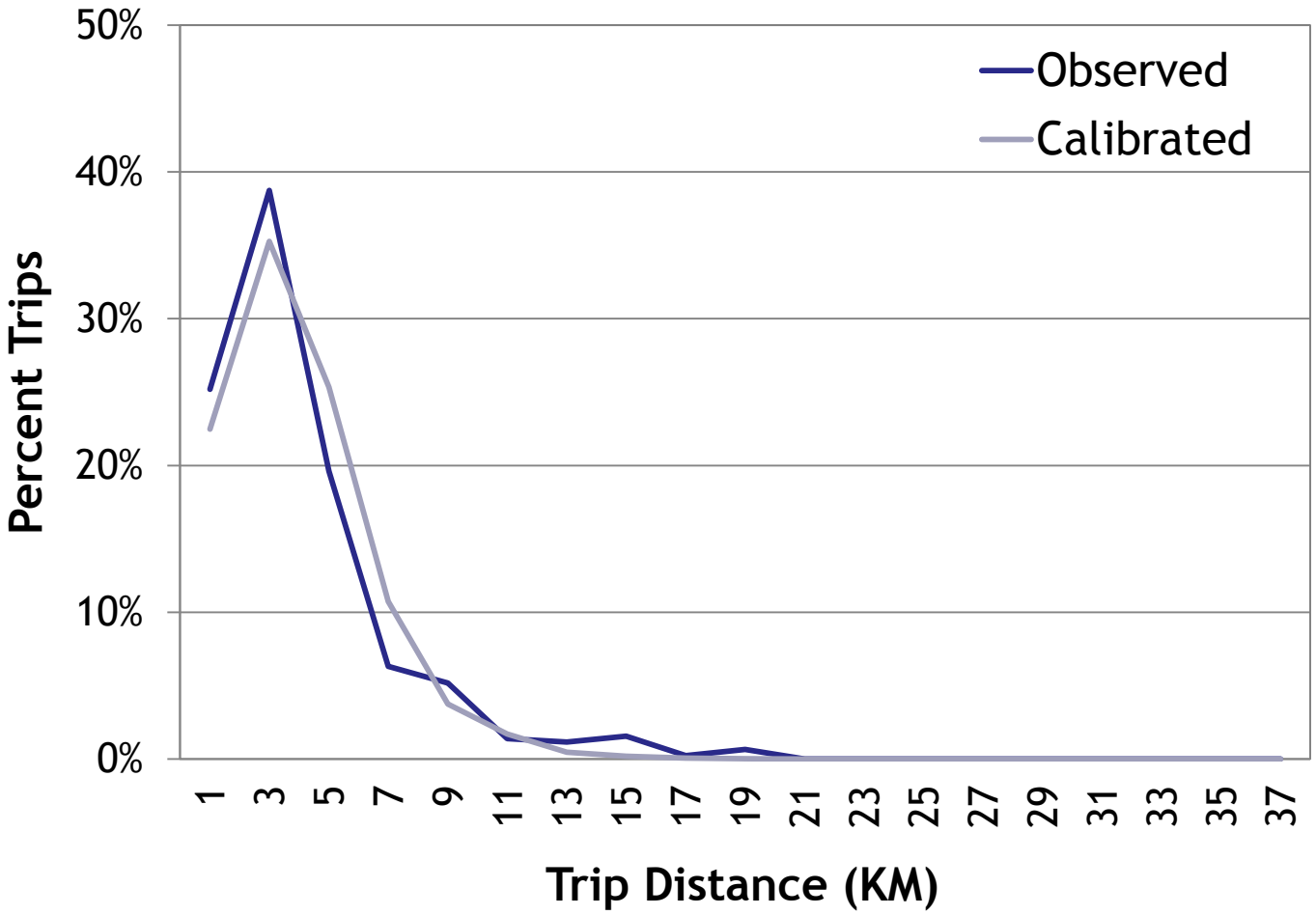
Model Validation- Trip Distribution (Education Purpose)



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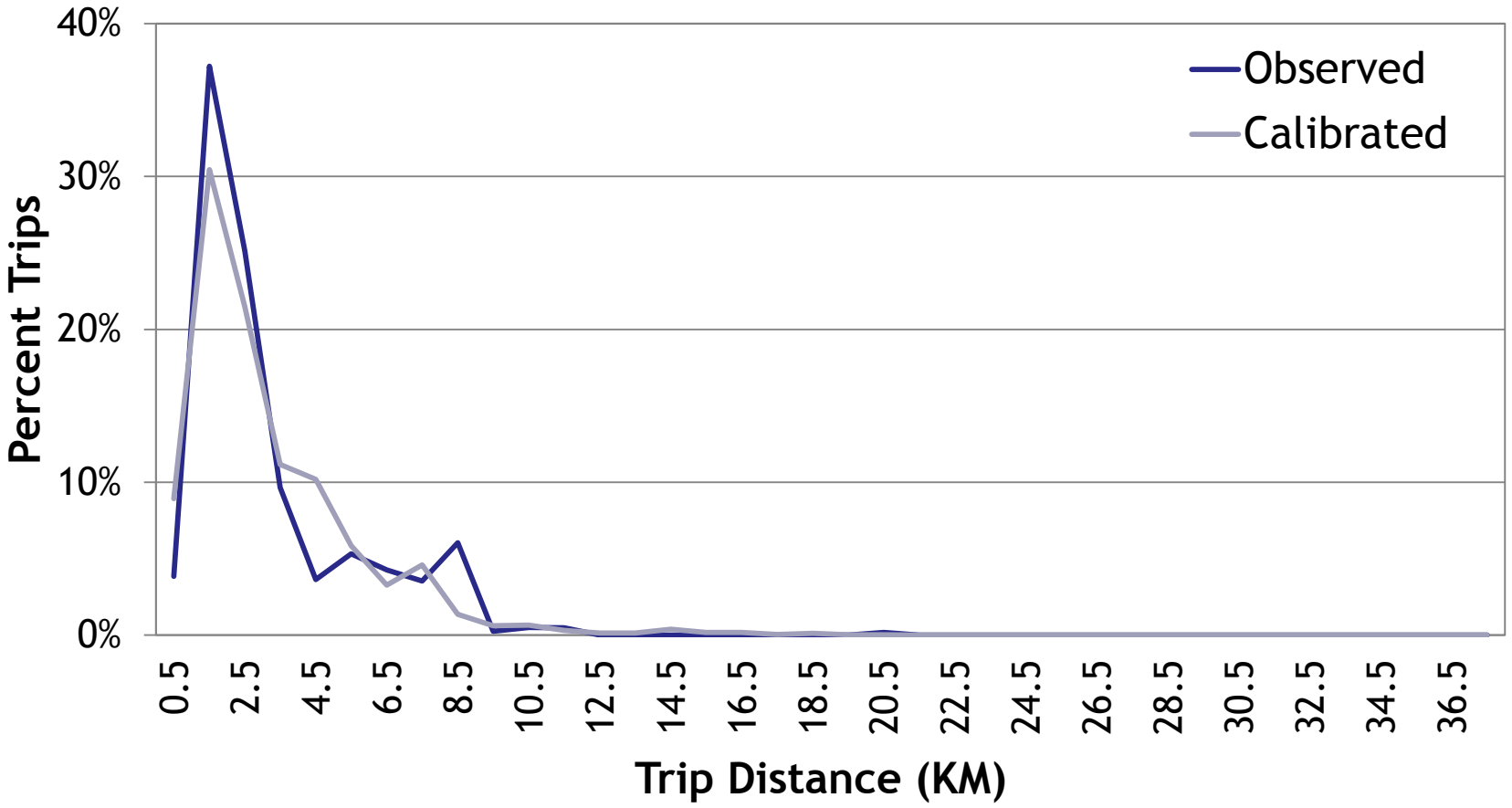
Model Validation- Trip Distribution (Other Purpose)



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Trip Assignment

- A very high level of network model accuracy targeted to accurately represent the transport conditions in Udaipur
- Necessary to predict the movement pattern, on links ***and*** turns, as well a the time taken on key corridors to undertake air quality analysis accurately.
- The Design Manual for Roads and Bridges (DMRB) standards for trip assignment validation used
- Comparison of assigned and observed volumes using **GEH statistic**
- TFlowFuzzy matrix correction tool used in VISUM.

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Application of GEH

- GEH statistic compares observed and modelled flows on turns and links
- Methodology for validation well known and well established

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

Where

M is the Modelled flow and

C is the ground count

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Model Validation- Trip Assignment

Mode	Comparison	GEH<5%	GEH>10%
Cycle	Link Volumes	82%	1%
	Turn Volumes	81%	2%
Two Wheeler	Link Volumes	84%	5%
	Turn Volumes	80%	5%
Other Buses	Link Volumes	84%	2%
	Turn Volumes	83%	2%
Cars	Link Volumes	81%	2%
	Turn Volumes	80%	3%
Goods	Link Volumes	81%	3%
	Turn Volumes	83%	3%
IPT	Boarding	83%	8%
	Alighting	92%	0%

Journey Time Validation

S. No.	Corridor Name	Direction	Observed journey time (s)	Modeled Journey time (s)	Difference (s)	% Difference
1	Airport to Suraj Pol	E - W	1566	1590	24	2%
	Suraj Pol to Airport	W - E	1523	1499	24	2%
2	Govardhan Vilas Park to Dehli Gate	S - N	791	773	18	2%
	Dehli Gate to Govardhan Vilas Park	N - S	830	809	21	3%
3	Court circle to Udaipol via University Road and Bypass	Clockwise	1571	1553	18	1%
	Udaipol to Court Circle via University Road and Bypass	Anti Clockwise	1663	1675	12	1%

As per DMRB, over 85% of routes should have a modelled time within 15%, or 1-minute, of the observed

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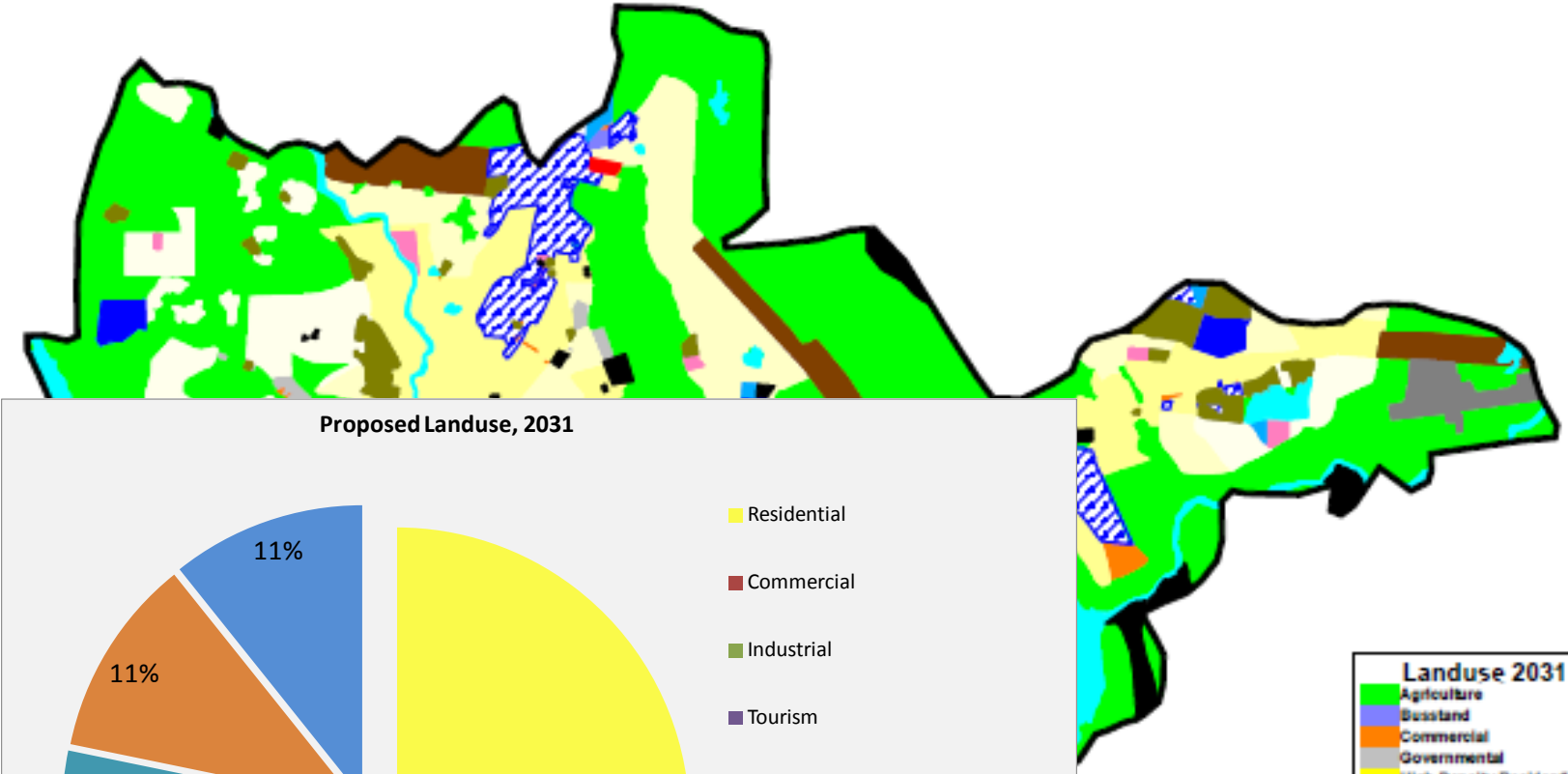
Planning Parameters

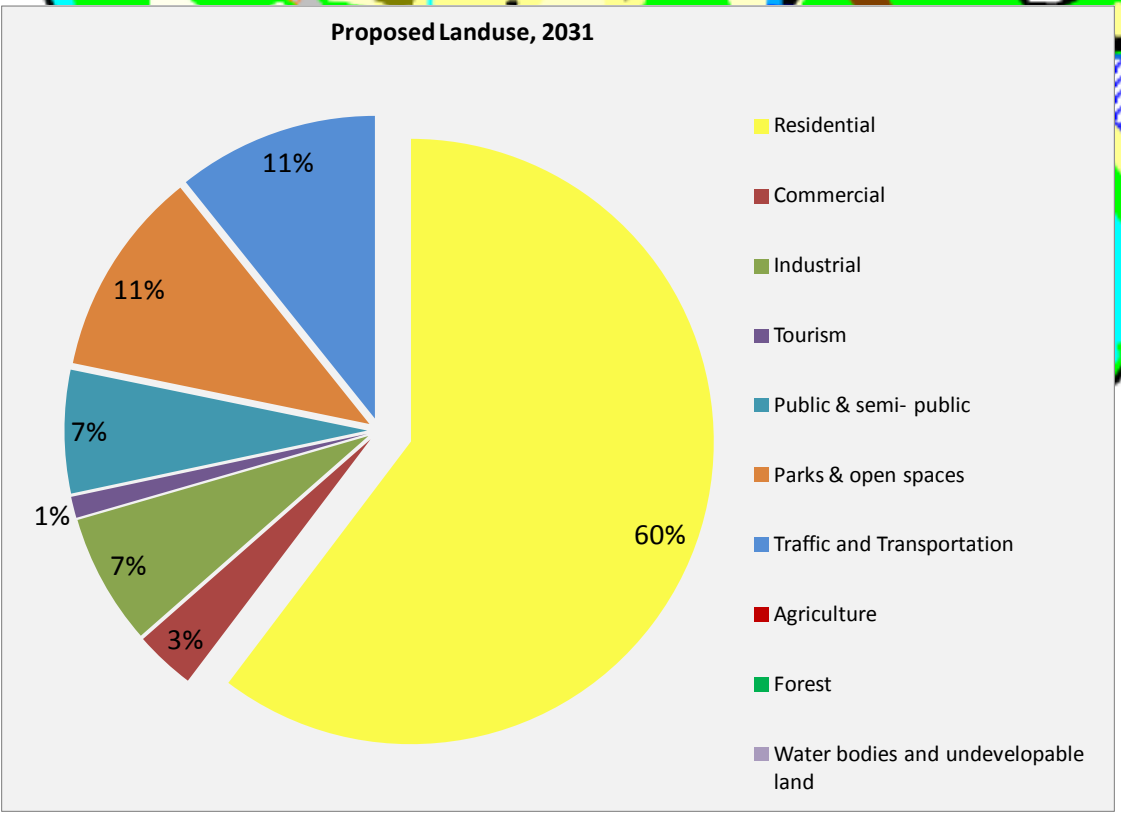
Planning Parameters

Year	Population
2021	759,000
2031	1,002,000
2041	1,580,354

- Population Projection
  - Current Trend
  - Master Plan Growth Rate
  - Testing of Different Growth Patterns (Exponential Growth Pattern)
- Landuse in Horizon Year
  - Master Plan
- Employment Projection
  - Current District Trend
  - Current State Trend
- Workers Projection
  - Current Trend
  - Master Plan Growth Rate
- Student Enrolment Projections
  - Current District Trend
  - Master Plan Growth Rate
- Ratio of different Income Groups (Assumptions based on State level Statistics)
- Projection of Tourist Traffic
  - Current Trend
  - Master Plan Growth Rate
- Projection of Freight Traffic
  - NH Growth Factor (MoRST)

Land Use Plan (2041)





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Public Transport Intervention

Concept

ONE LANE (people per hr):

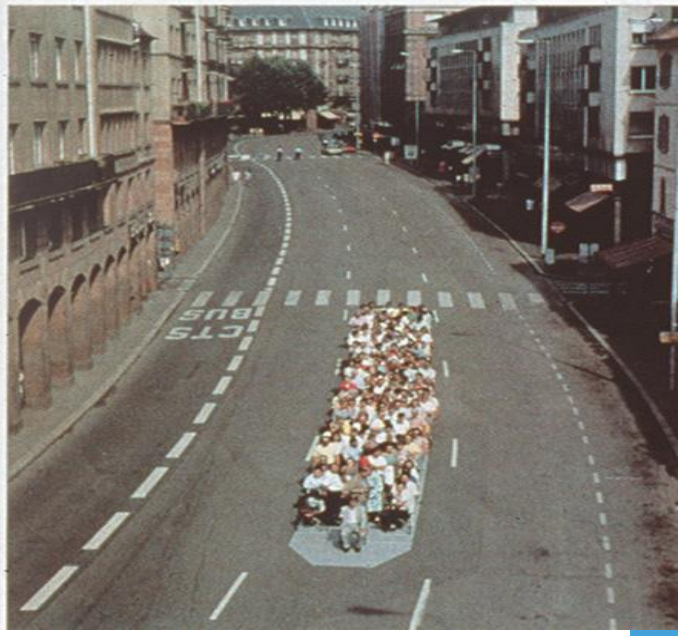
- Freeway: 2,500
- Busway: 5000
- LRT: 10-20,000
- Train: 50,000

240 Persons travel to work:

-- in 177 Cars

-- in 3 Busses

-- in 1 Tram



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Source: Newman P., Presentation "Indian Cities in Global Context and the Potential Role of Value Capture and Multi Modal Interchanges", 2013, Nagpur

- Transport is one of the key contributors to the increasing emission into the environment.
- Low carbon strategies are now a global approach to address the issues.
- A huge opportunity for addressing issues related to quality of life and economic prosperity for the cities [1]
- ***AN ALL WIN SITUATION***

1: Low Carbon Transport: A Greener Future, a key component of The UK Low Carbon Transition Plan, July 2009, Department for Transport, UK

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Public Transport Strategy

- Phase wise matching the Demand Vs Supply
- Heads for developing strategy:
  - Modal Choice Solutions (wider availability over greater catchment)
  - Technology Solutions

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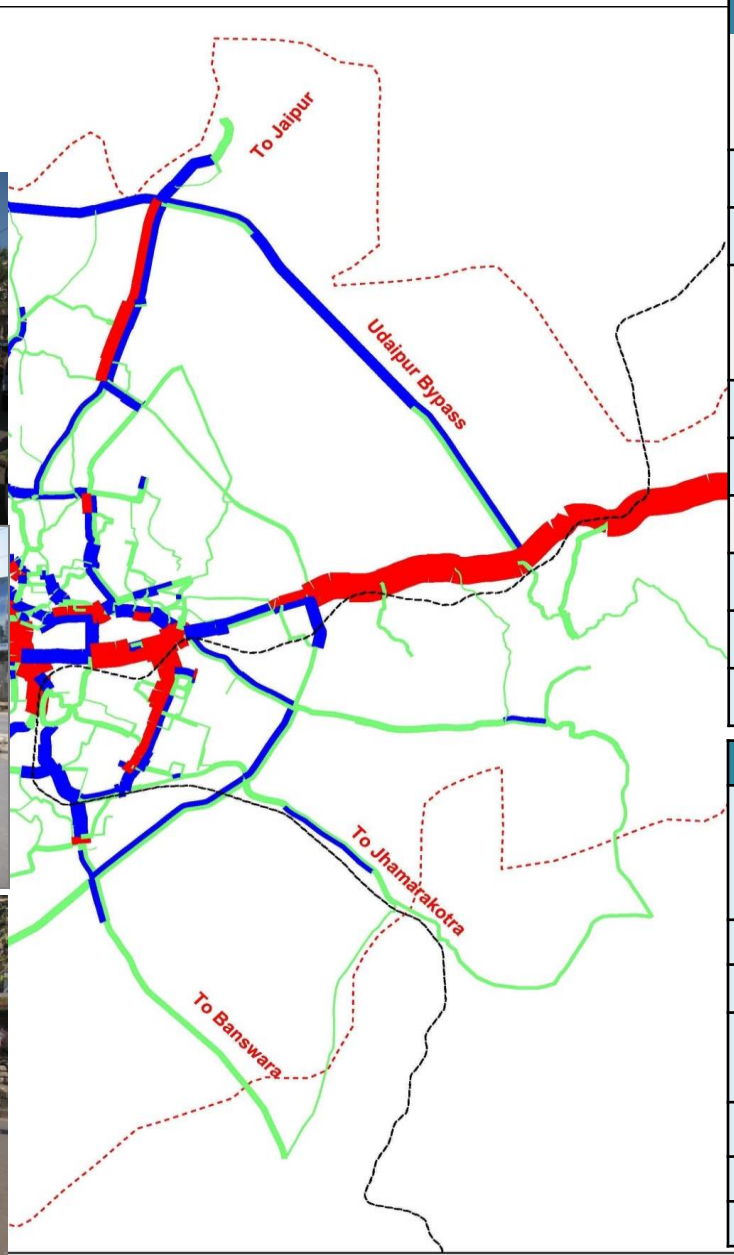
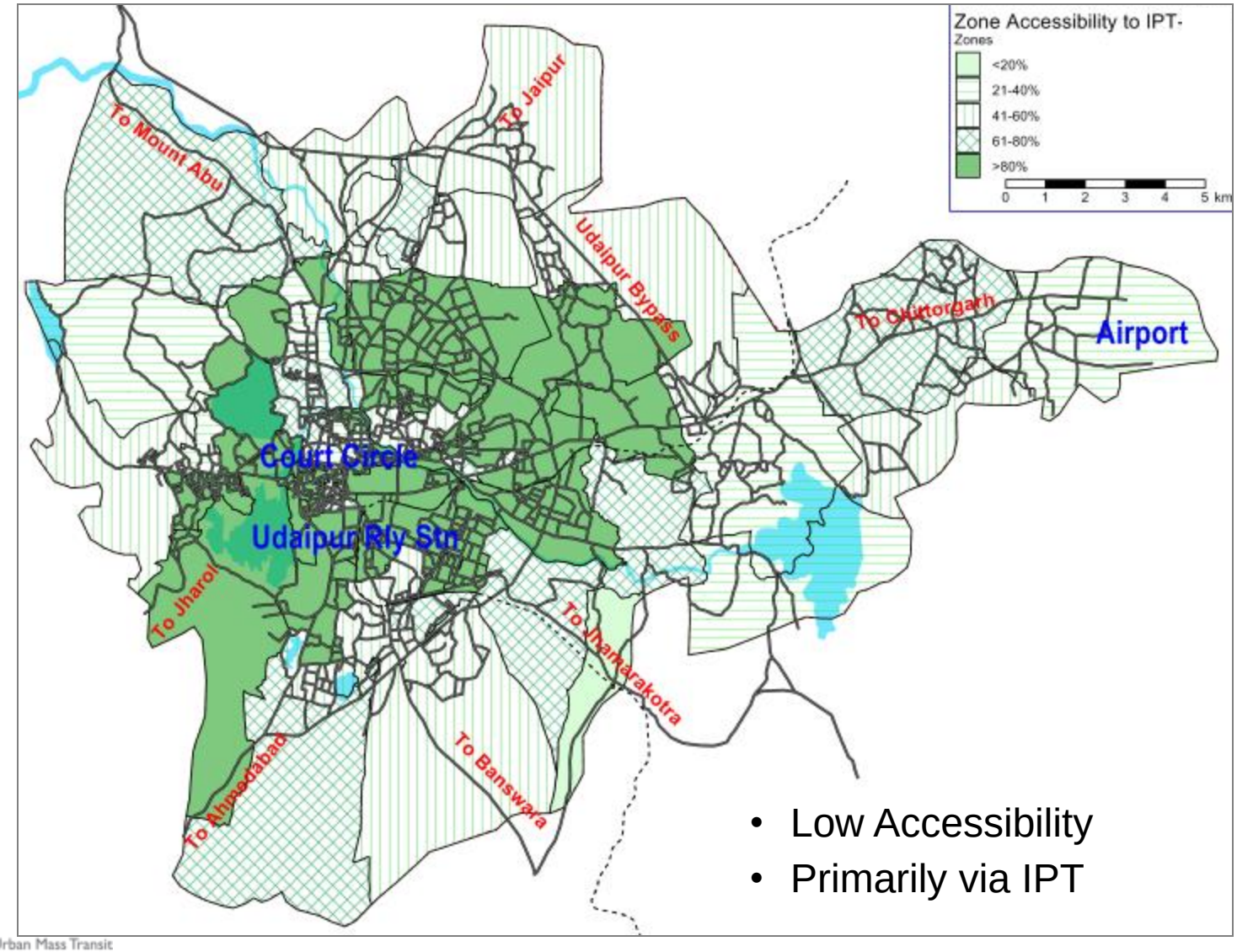
Relevance of Public Transport Inter



Income Group / Gender	Trip Rate With Walk Mode	Trip Rate Without Walk Mode
High Income Group (HIG)	**1.2**	**0.96**
Female	0.75	0.48
Male	1.57	1.34
Medium Income Group (MIG)	**1.17**	**0.82**
Female	0.71	0.34
Male	1.55	1.21
Low Income Group (LIG)	**0.96**	**0.43**
Female	0.61	0.19
Male	1.28	0.65
City Average	**1.12**	**0.73**

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Walk	48%	80%	25%
Cycle	2%	2%	3%
Two Wheeler	34%	14%	48%
Car	3%	1%	4%
IPT	11%	3%	18%
Other Buses	3%	0%	3%

Public Transport Accessibility – BAU (2041)



- Low Accessibility
- Primarily via IPT

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Focus of Strategy

- Availability
- Accessibility (safety, multimodal integration, etc.)
- Reliability
- Affordability

Essential for public transport to be promoted as a ***Mode of Choice***

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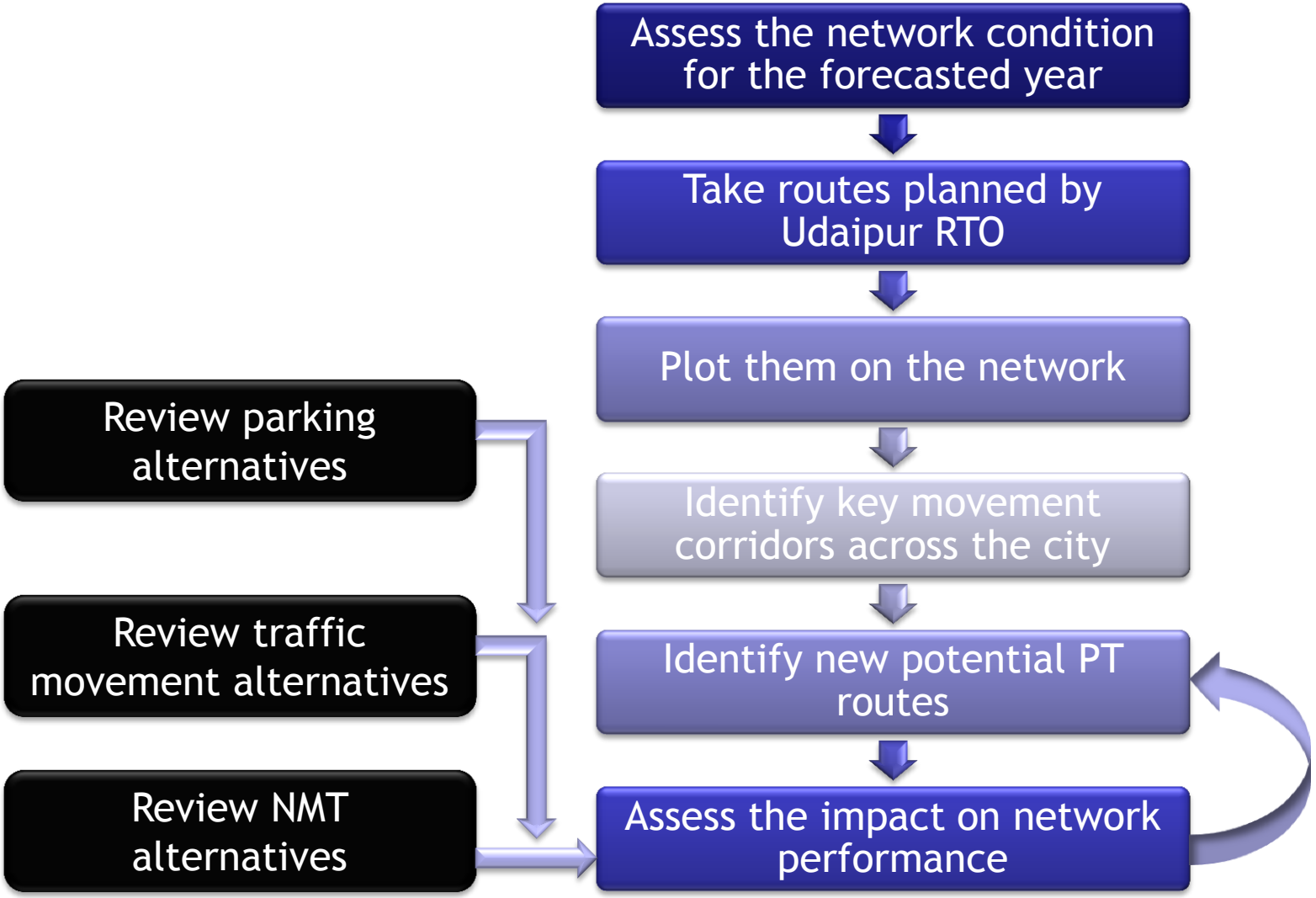
Availability Strategies – Provision of Buses



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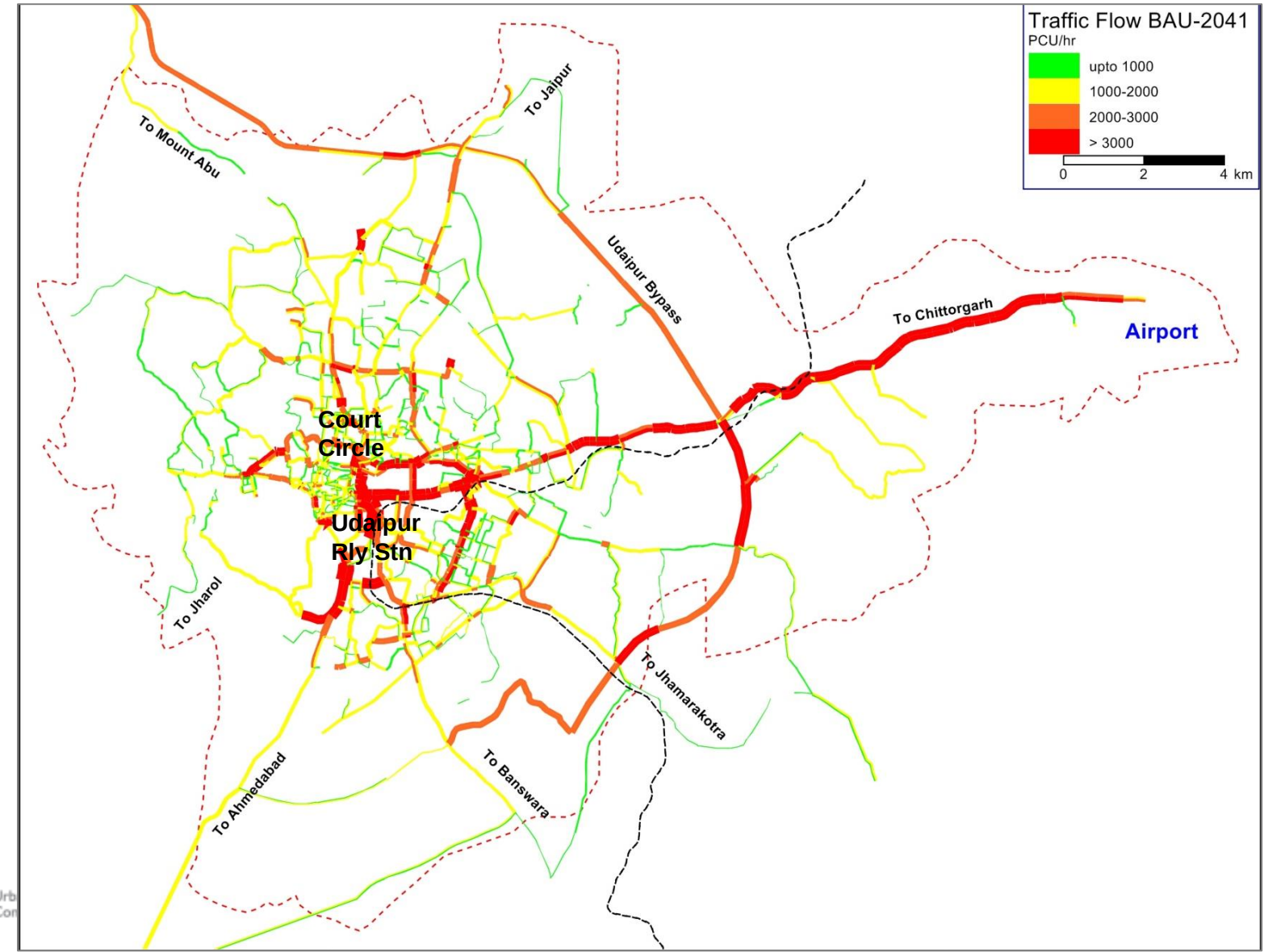
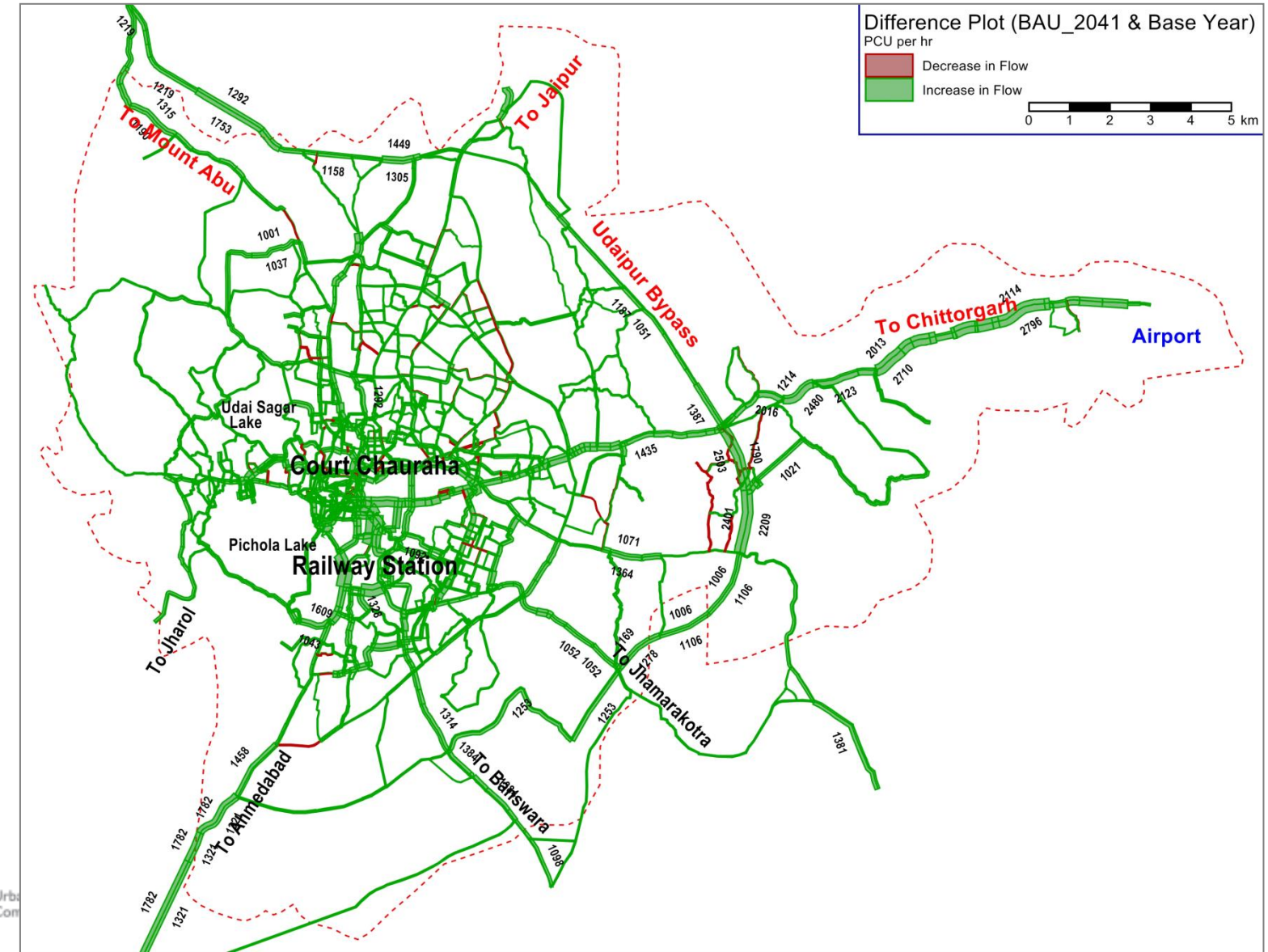
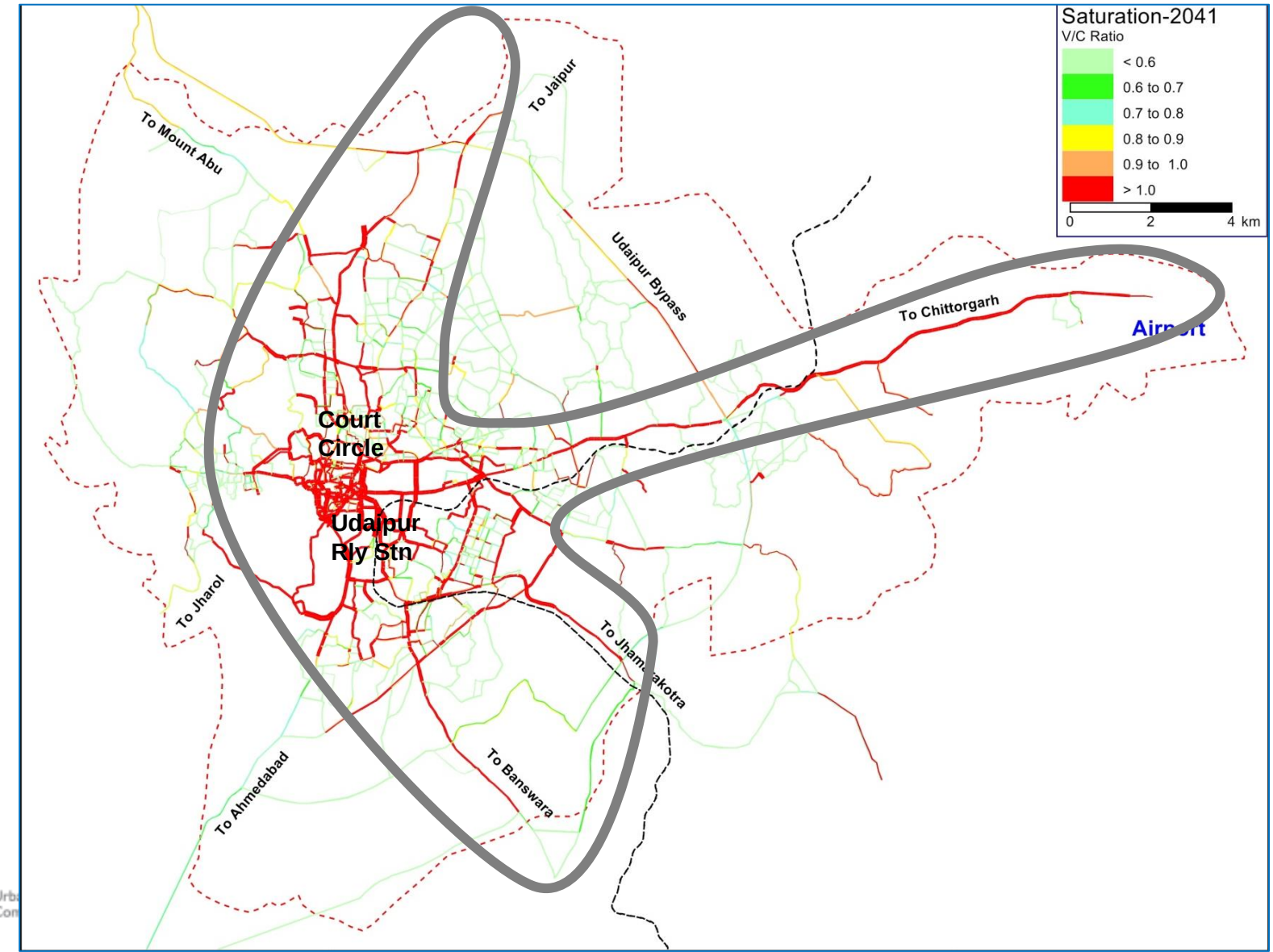
Network Flow - 2041



Impact of Proposed PT on Network Flow – 2041 (BAU)

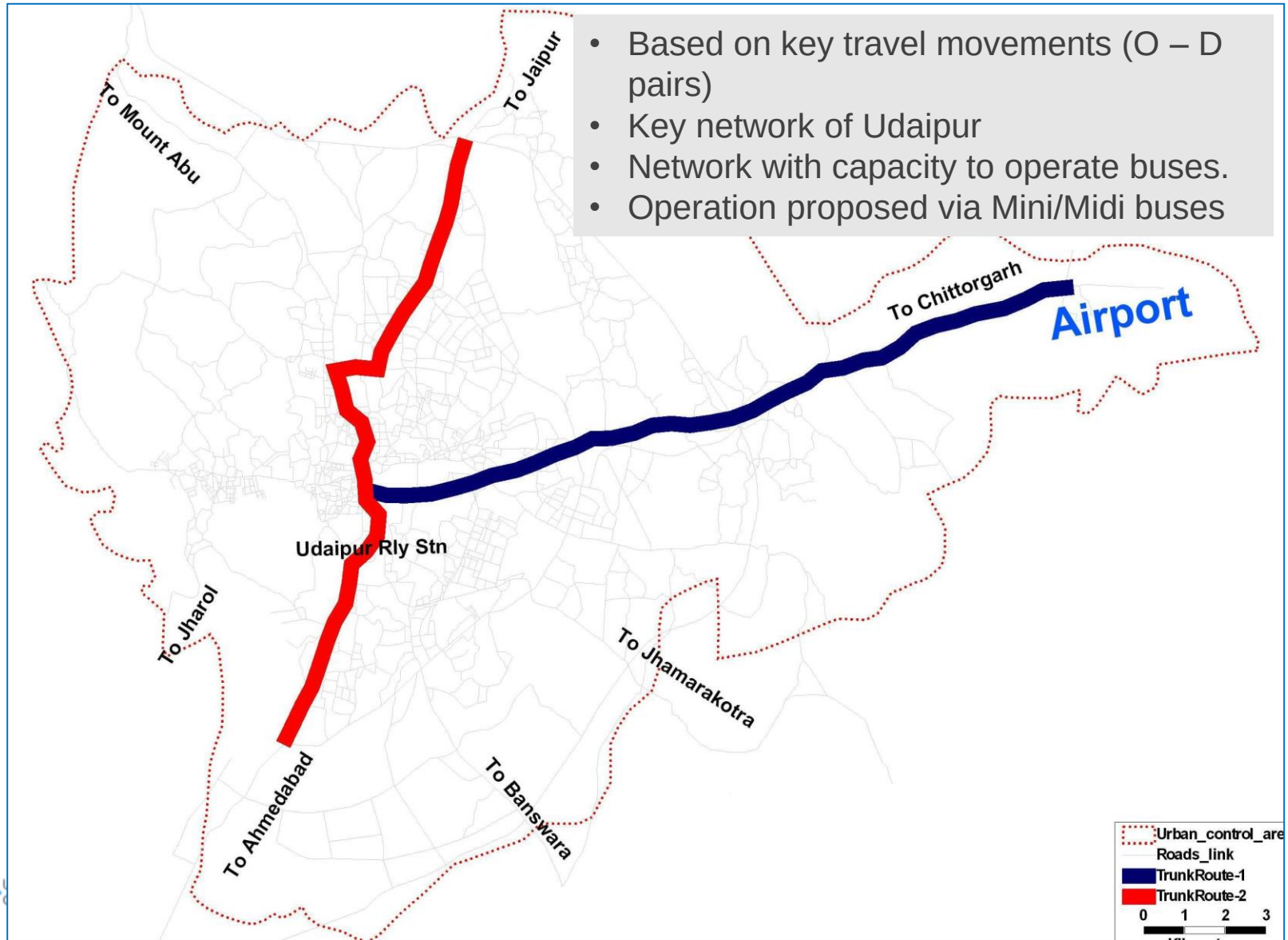


Network Saturation – 2041 (BAU)

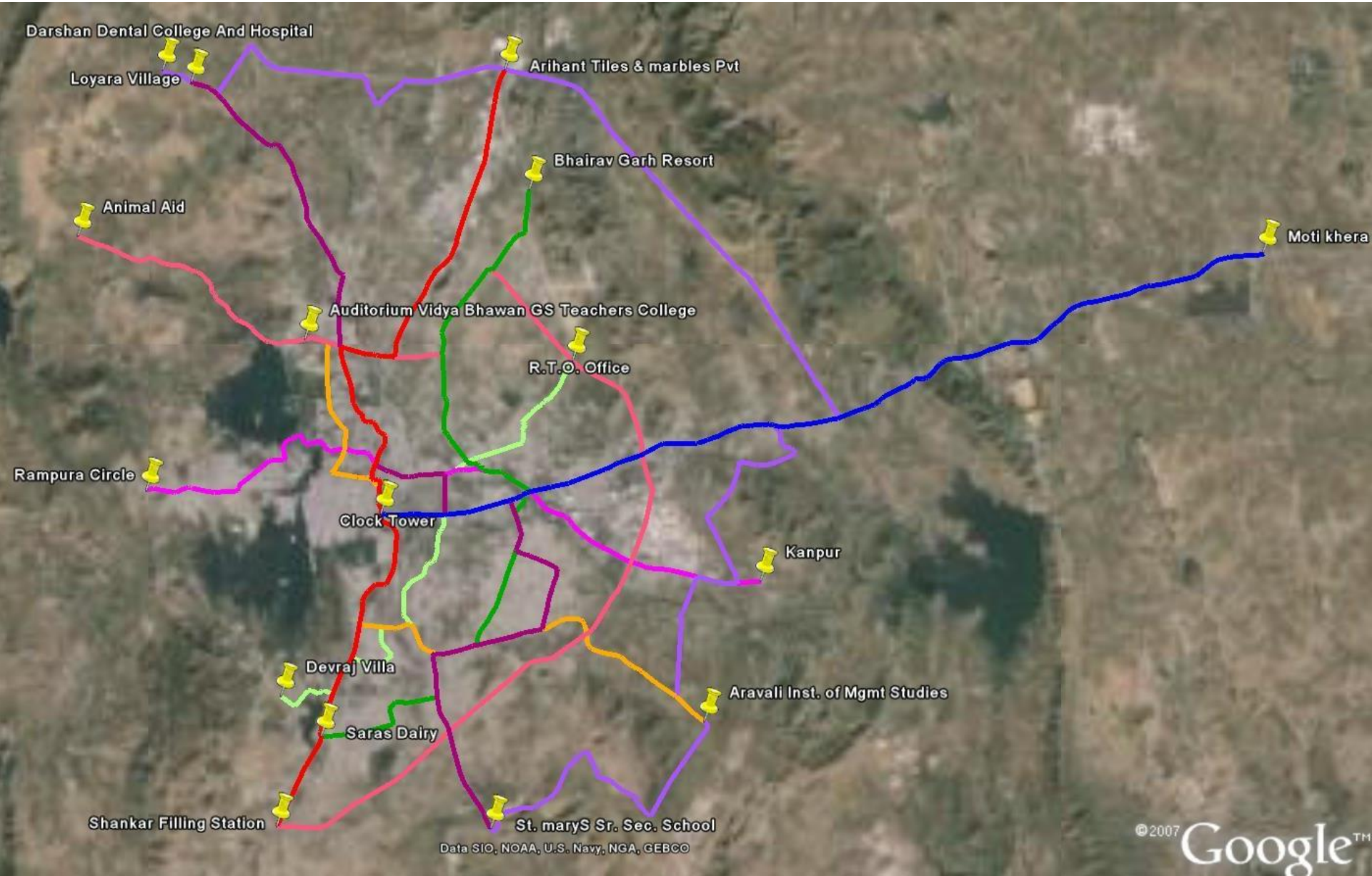


Proposed Main PT Corridors

- Based on key travel movements (O – D pairs)
- Key network of Udaipur
- Network with capacity to operate buses.
- Operation proposed via Mini/Midi buses



Public Transport Routes



Model Outputs from Public Transport Strategy

Inputs

- Introduction of Public Transport routes-178 kms
- Introduction of Organized IPT
- Trunk Route-45 Kms
- Feeder Routes-133
- Trunk Route Headway -5 minutes
- Feeder Route Headway-15 iminutes

Outputs

- Increase in intra-zonal shorter trips by 53%
- Increase in NMT share by 30%
- Decrease in Travel length by 20%
- Decrease in VKT by 16%

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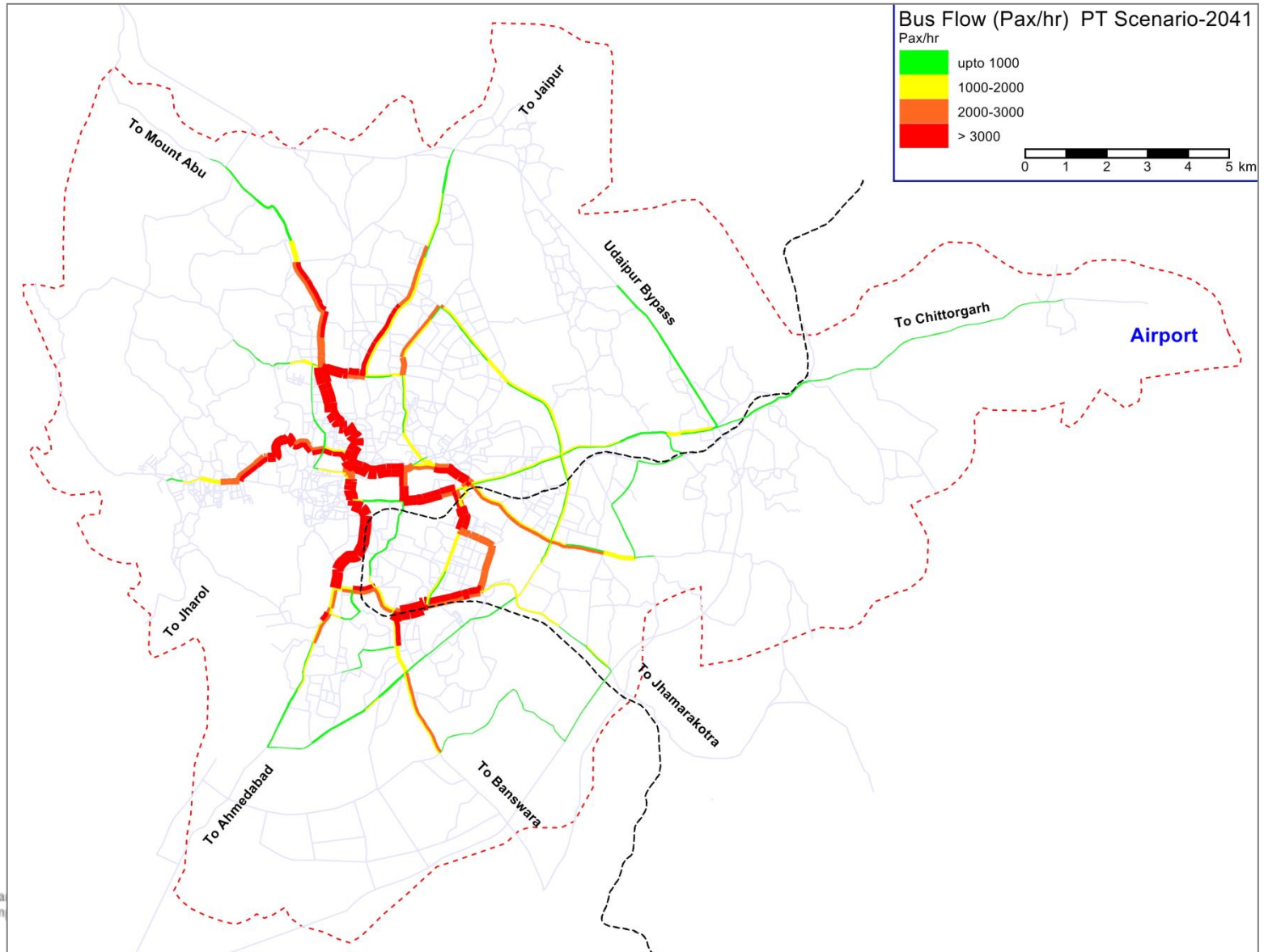
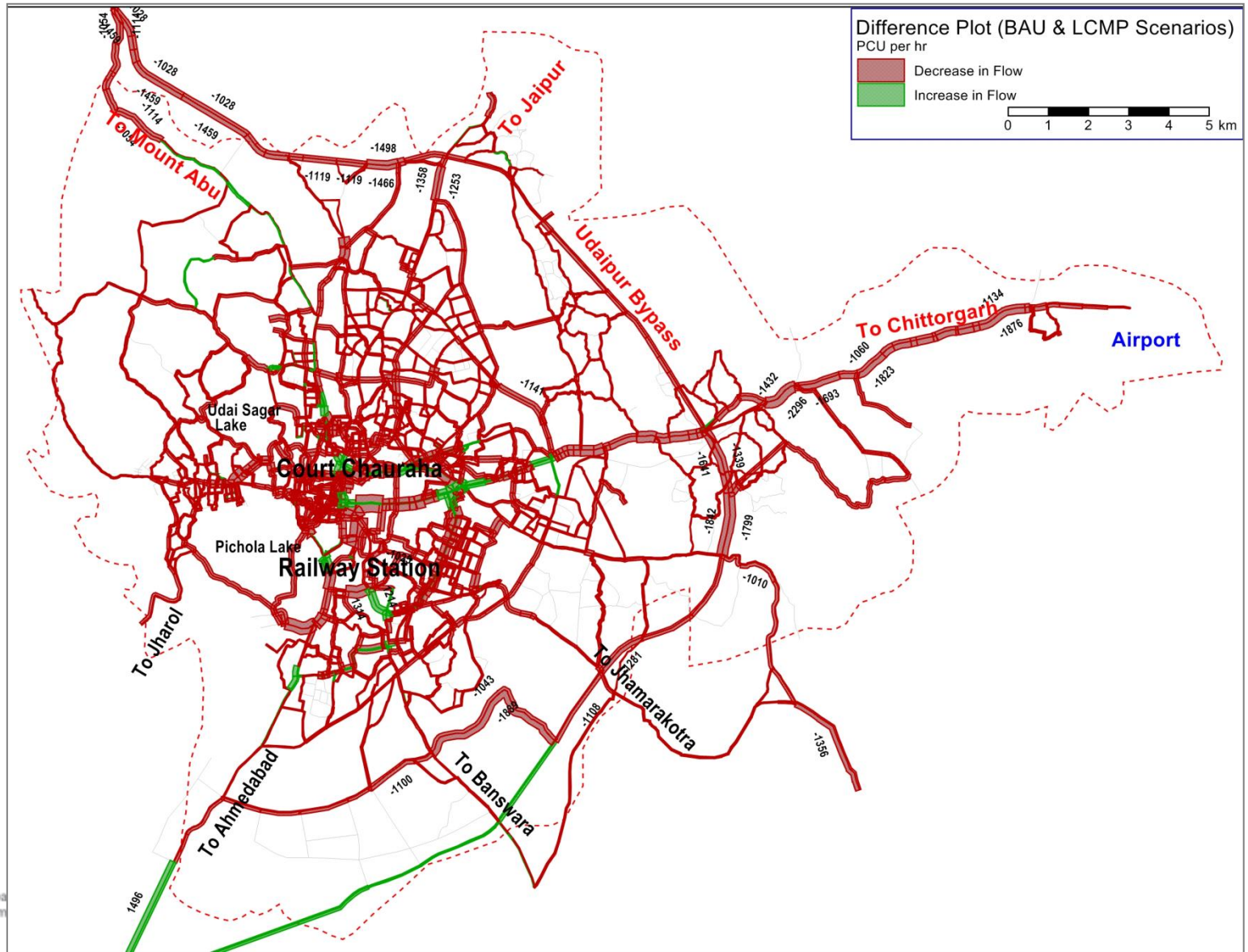
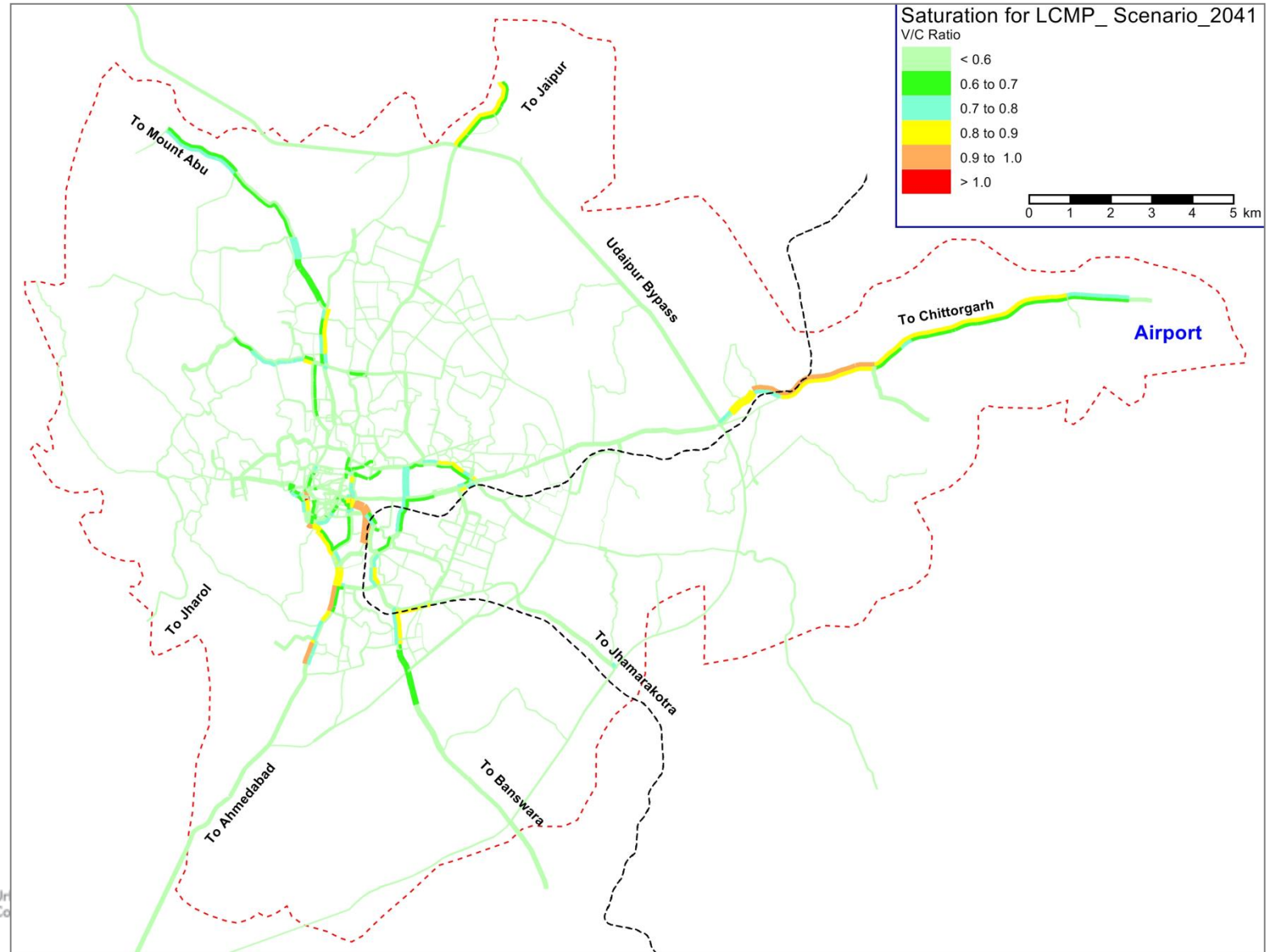
PT Ridership - 2041



Impact of Proposed PT on Network Flow - 2041



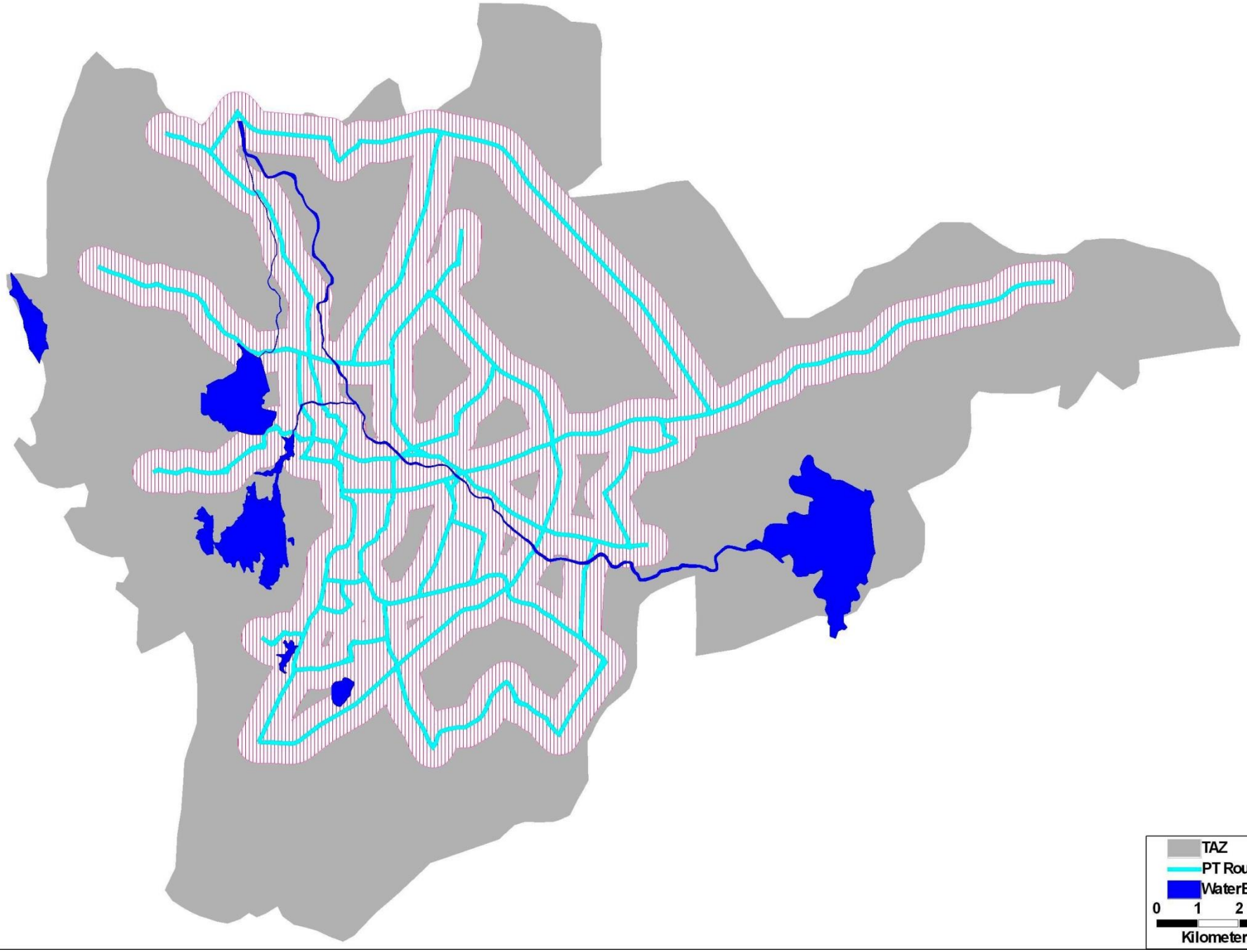
Impact of Proposed PT on Saturation - 2041



Accessibility

- Design Intervention
  - Disable friendly design of access footpaths and bus stops – adequate national guidelines available
  - Safety features such as Pedestrian friendly street lights and well lit bus stops

- Feeder and Multi Modal Connectivity
  - Connectivity from bus stops via pedestrian routes, NMT routes


TAZ
PT Route
WaterBody
0 1 2 3
Kilometers

Reliability

- Technology Aided
  - PIS system
  - Bus information through the internet and smartphone applications

- Demand Management Options at Micro-Level
  - Bus priority routes
  - Private vehicle movement restrictions
  - Parking management

Affordability

- Average HH income –Rs. 18,000 per month
- HIG-13%, MIG-61%, LIG-27%
- Average expenditure on transport – 12.5% of total monthly income
  - Average expenditure on transport by HIG– 10% of total monthly income
  - Average expenditure on transport by MIG– 26.5% of total monthly income
  - Average expenditure on transport by LIG– .96% of total monthly income

Provision of Public Good (Improvement of Urban Transport-Promotion of PT, NMT etc.) requires state interventions and policy changes

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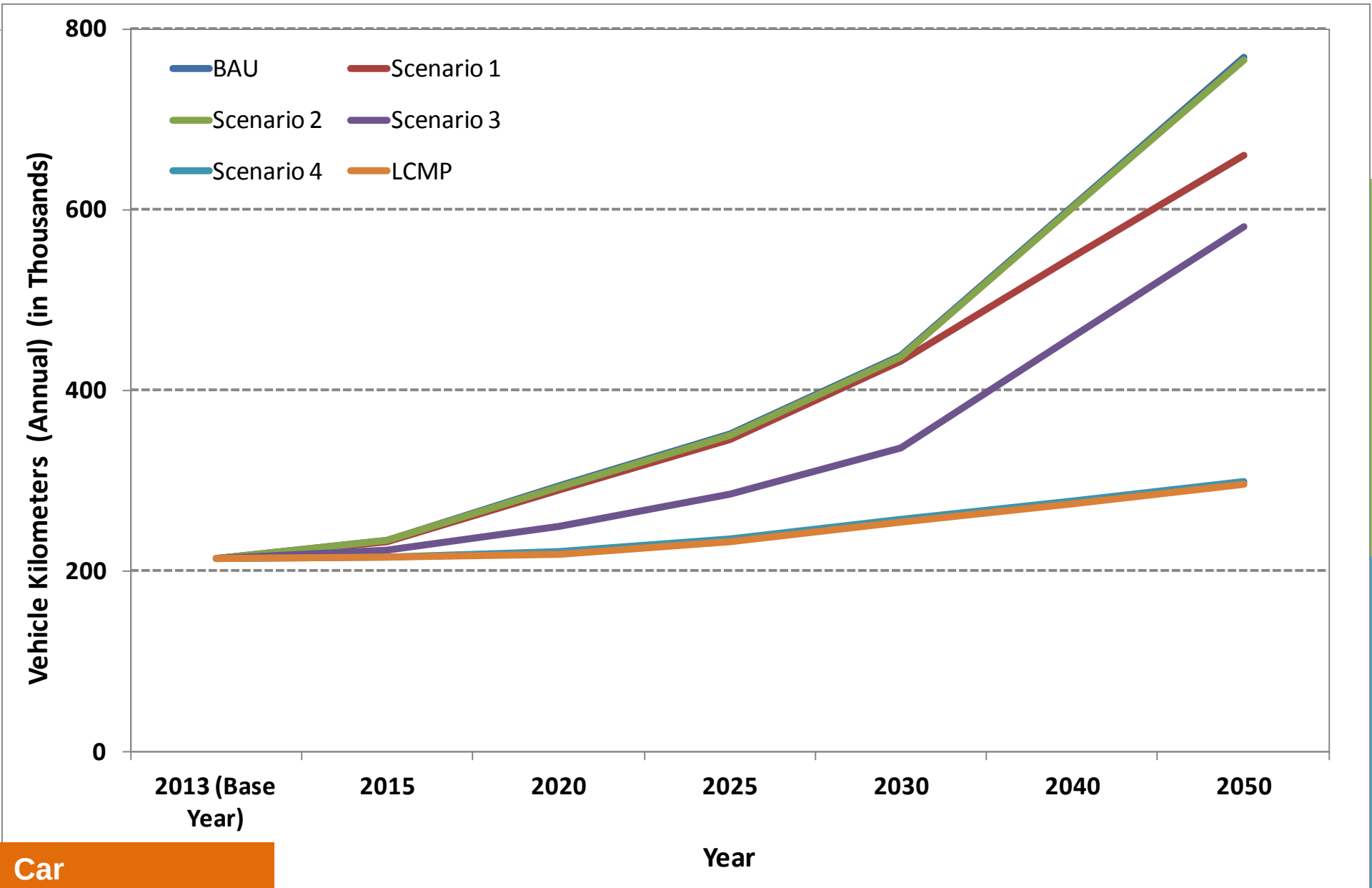
Outcomes

Indicator/Values	Base Year (2013)	BAU (2041)	Landuse Intervention Scenario (2041)	NMT Intervention Scenario (2041)	Public Transport Intervention Scenario (2041)	Combined Landuse, PT and NMT Intervention Scenario (2041)
Mobility and Accessibility						
Modal Share in %						
Modal Share of Walk	25%	20%	29%	38%	27%	28%
Modal Share of Cycle	3%	2%	6%	9%	9%	9%
Modal Share of Two Wheeler	48%	51%	41%	31%	21%	20%
Modal Share of IPT	18%	22%	18%	15%	12%	10%
Modal Share of Car	3%	3%	2%	2%	1%	1%
Modal Share of PT	3%	2%	4%	5%	30%	32%
Trip Length (KM)						
Walk	1.18	2.06	1.62	3.31	1.78	1.89
Cycle	2.37	3.65	3.13	4.08	3.35	3.09
Two Wheeler	5.54	5.92	5.56	6.3	5.63	5.13
IPT	4.52	5.55	5.24	5.51	4.98	5.32
Car	7.06	7.51	6.98	7.68	7.77	6.56
PT	-	5	5	5	5.75	5.65

Outcomes

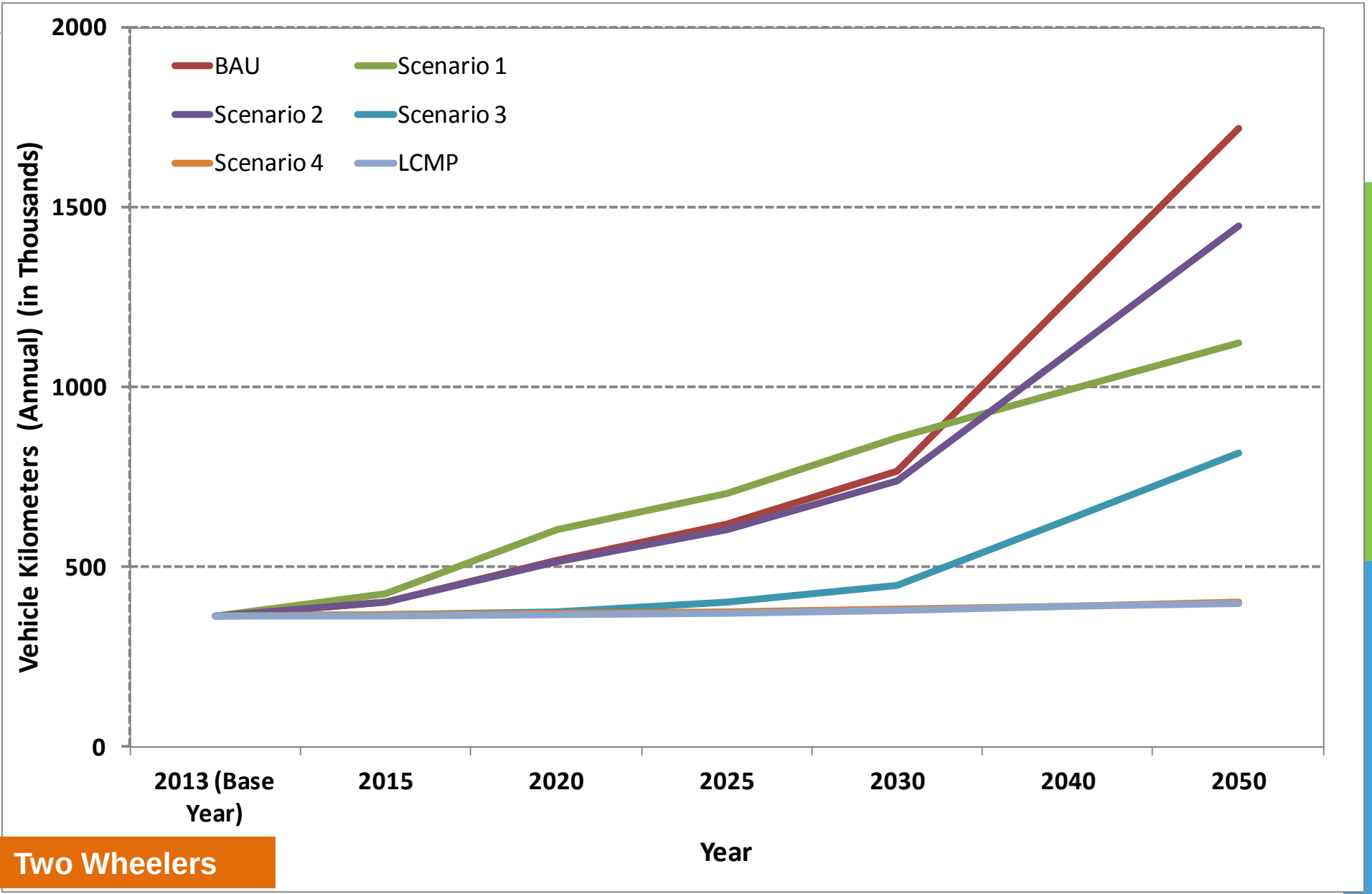
Indicator/Values	Base Year (2013)	BAU (2041)	Landuse Intervention Scenario (2041)	NMT Intervention Scenario (2041)	Public Transport Intervention Scenario (2041)	Combined Landuse, PT and NMT Intervention Scenario (2041)
Accessibility						
% of HH within 10 minitues of walking to access PT (IPT for Base Year)	69%	60%	80%	78%	83%	83%
LOS of PT facilities as per MoUD SLB Handbook	4	4	3	2	2	2
Landuse Mix Intensity						
Increase in the % of Intra-Zonal Trips as compared to Base Year (Base year value is 19%)	-	16%	68%	16%	16%	68%
Safety to use NMT						
Walk	7.5%	7.5%	78%	83%	-	83%
Cycle	7%	7%	70%	80%	-	80%
Total Motorised Vehicle Kilometers (Thousand Kms)	88,0489	25,59,907	21,59,624	23,41,289	16,91,624	13,35210
LOS of NMT facilities as per MoUD SLB Handbook	4	4	3	2	-	2
Congestion Level						
Road Length (KM) with value of V/C ratio is equal to 1 or more	-	26%	14%	16%	10%	5%

Vehicle Kilometres (VKT)



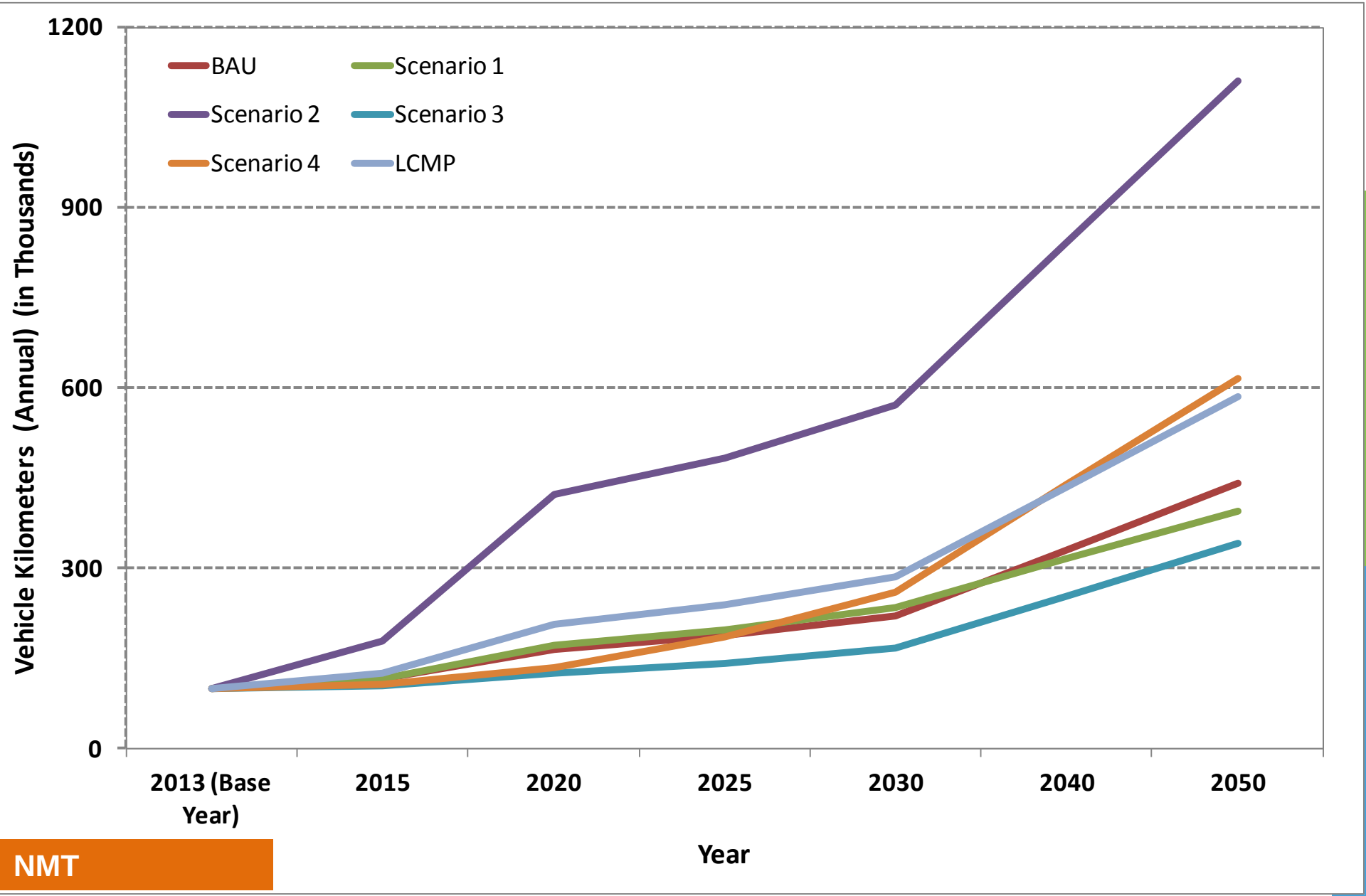
Car

Vehicle Kilometres (VKT)

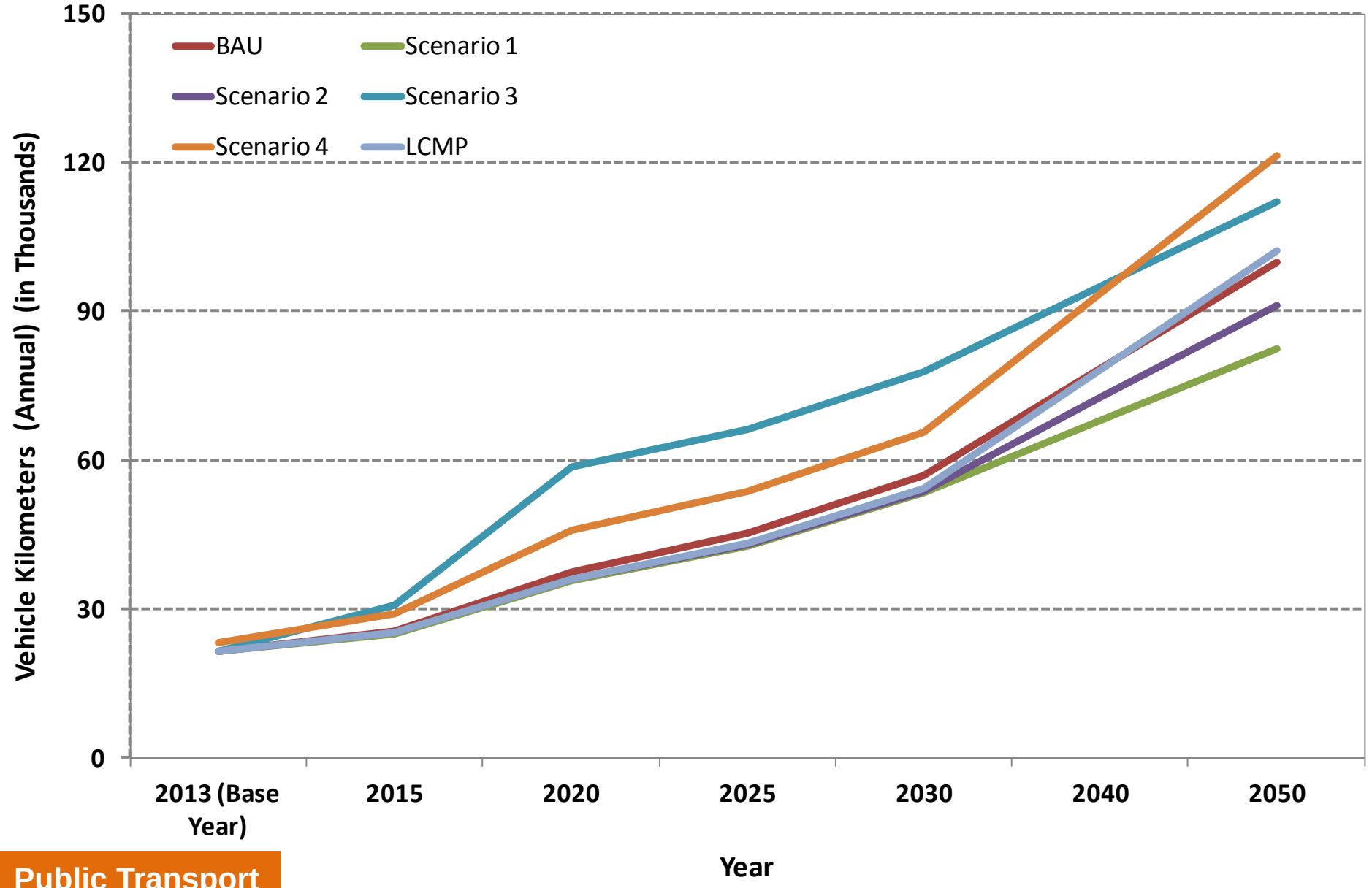


Two Wheelers

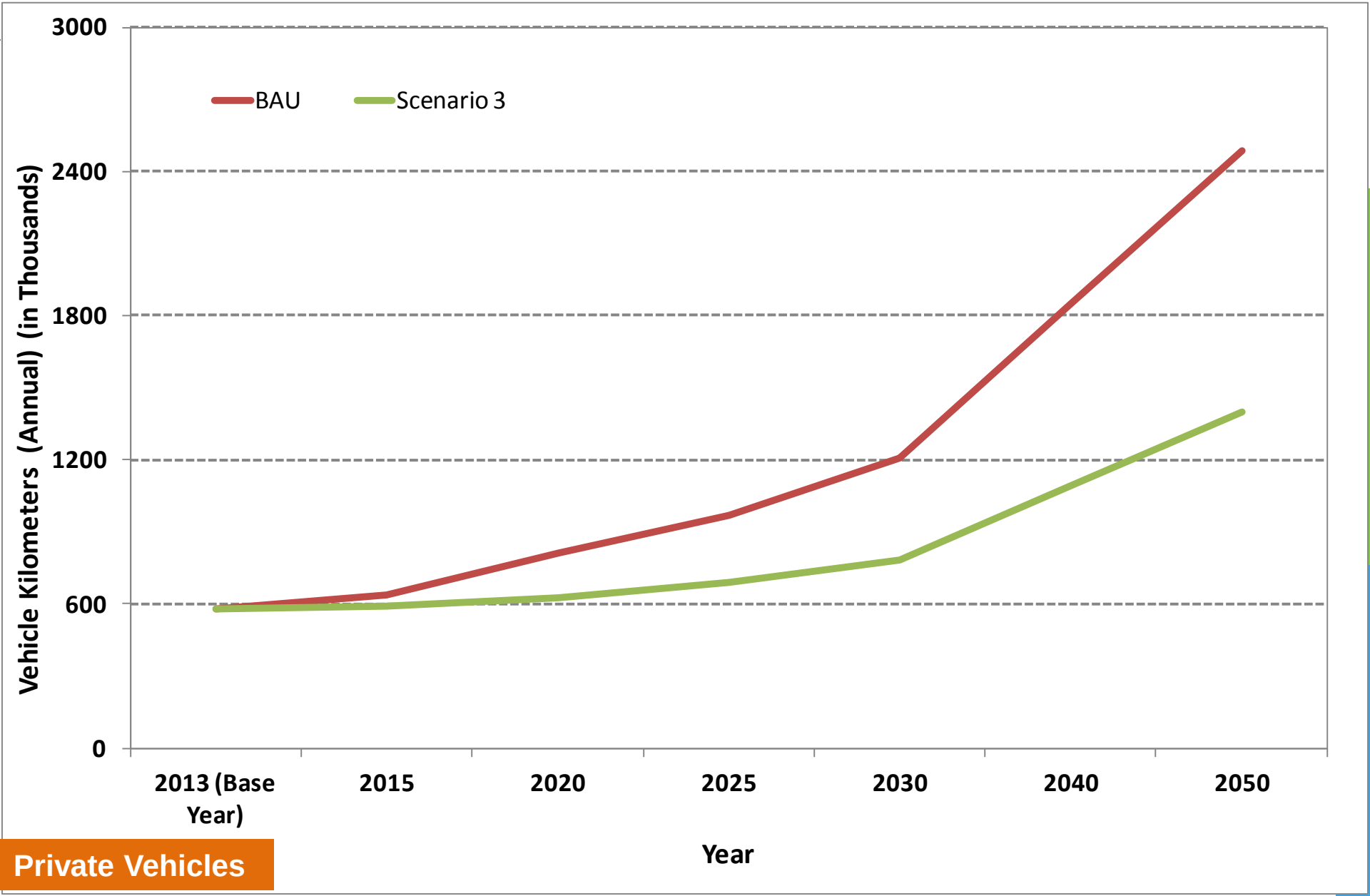
Vehicle Kilometres (VKT)



Vehicle Kilometres (VKT)

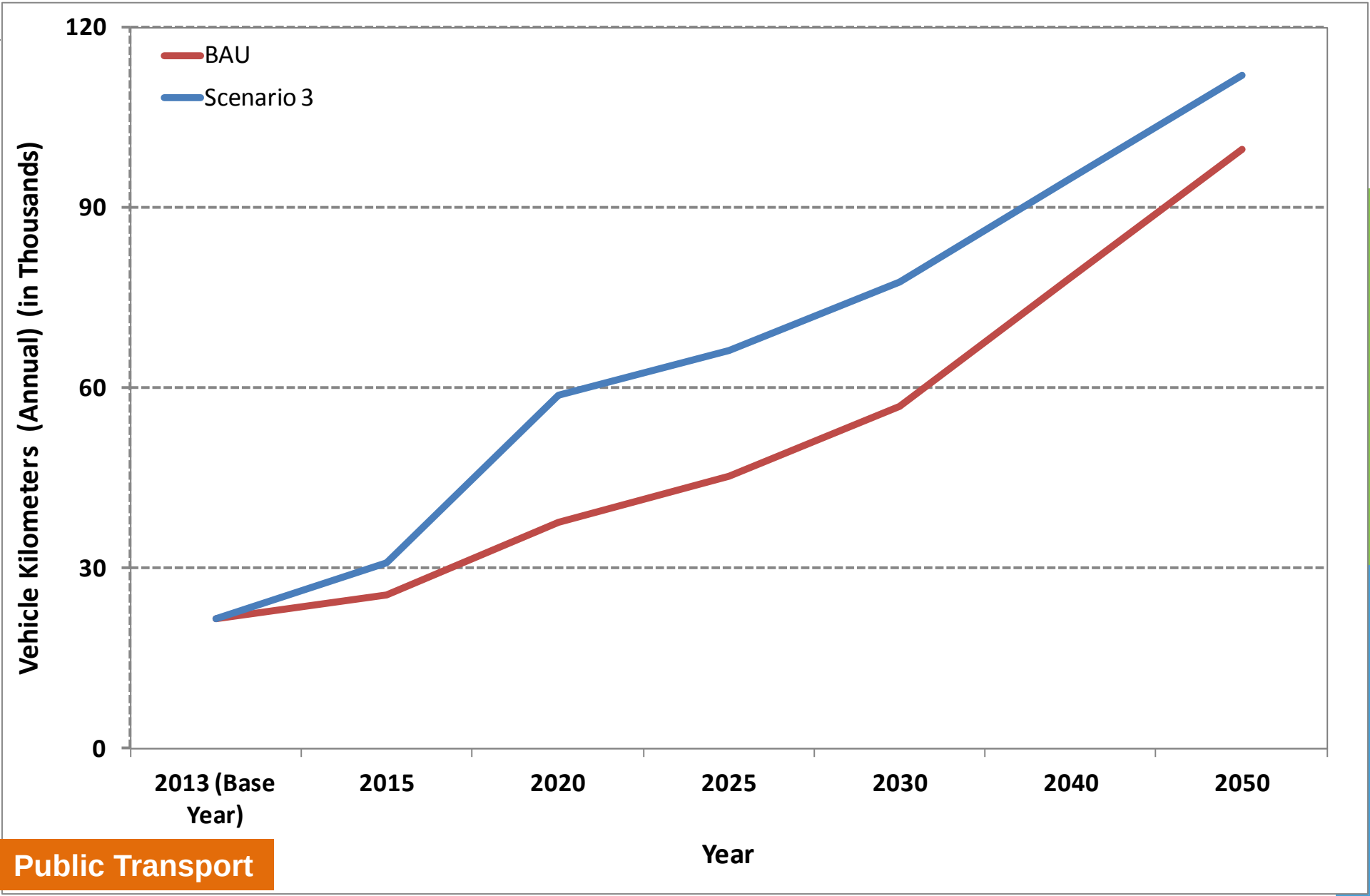


Vehicle Kilometres (VKT)



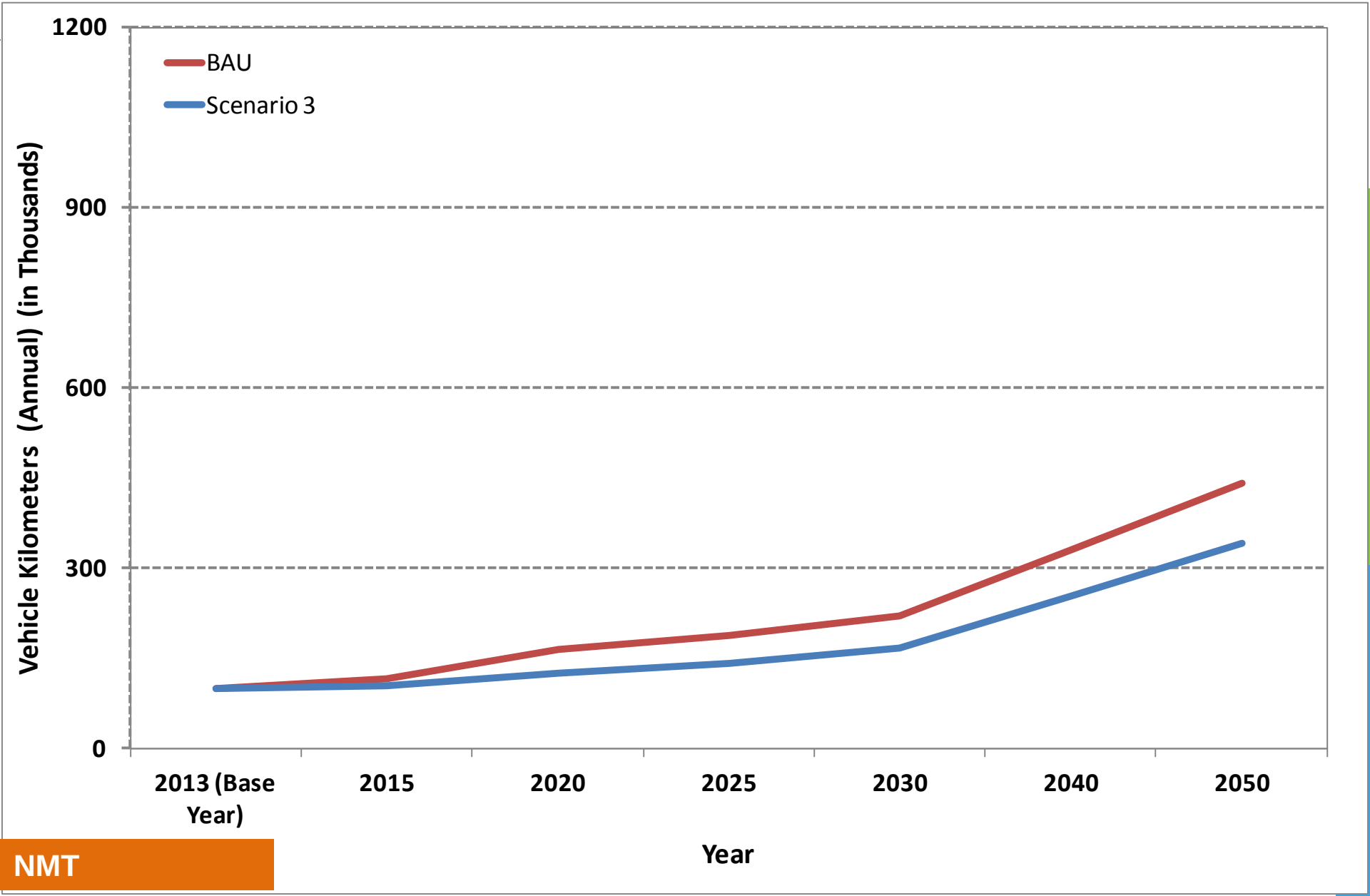
Private Vehicles

Vehicle Kilometres (VKT)



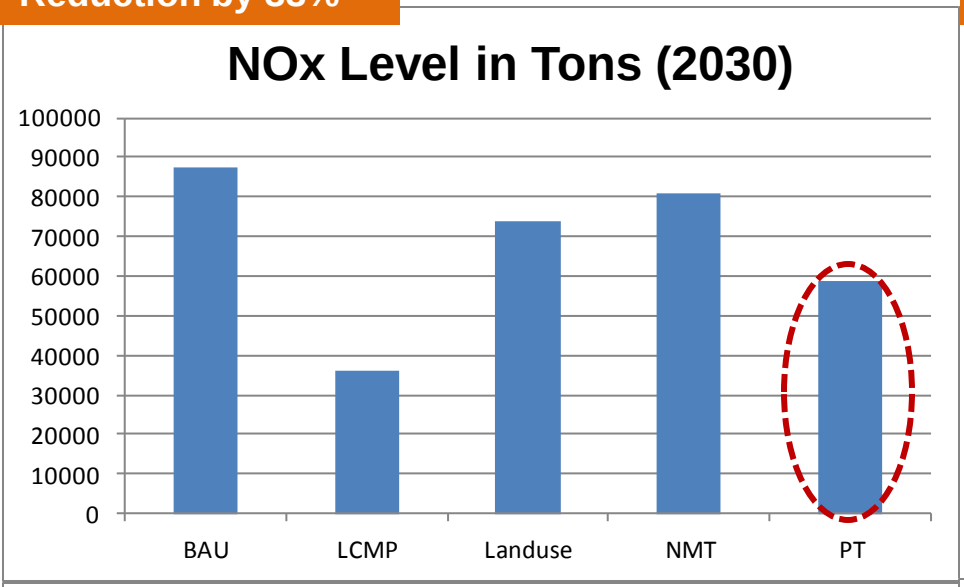
Public Transport

Vehicle Kilometres (VKT)

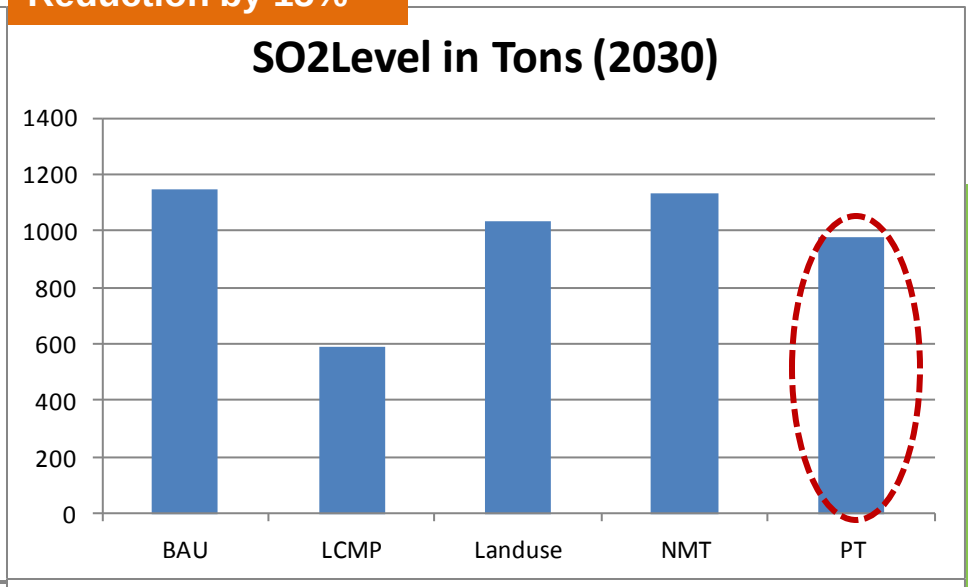


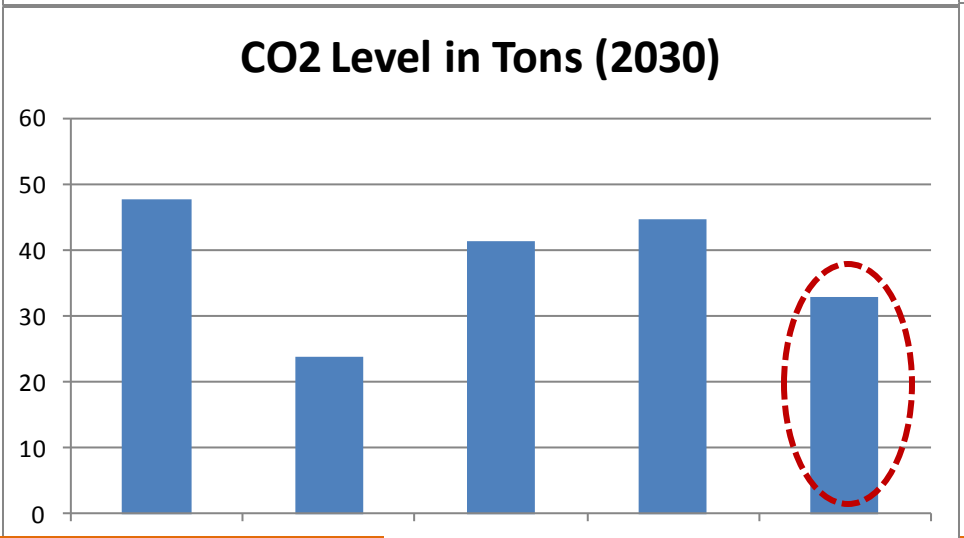
Emissions Level

Reduction by 33%

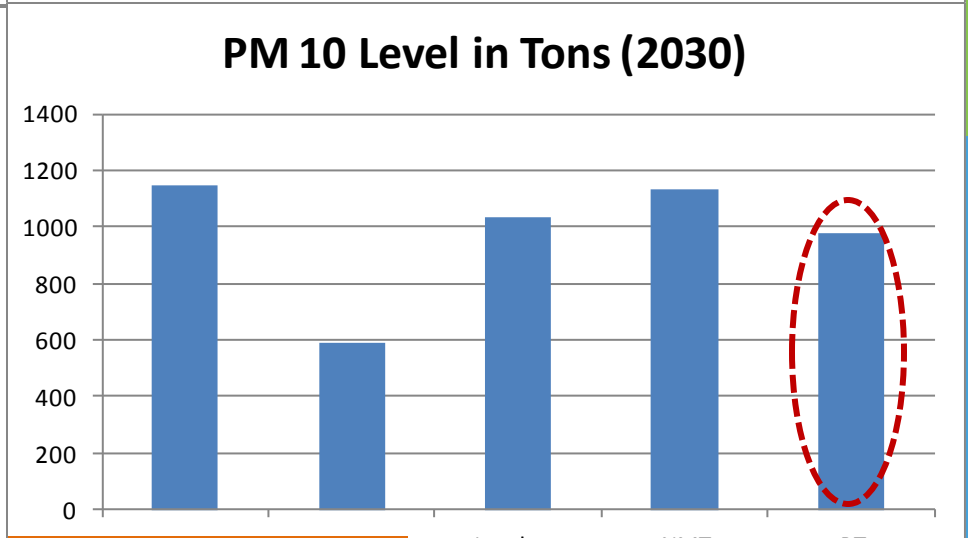


Reduction by 15%





Reduction by 31%



Reduction by 15%

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Thank You

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Tel No./Fax No.: 011 – 41606074/011 – 26410763