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IMPACT OF TRANSPORT TECHNOLOGIES IN SHAPING FUTURE CITIES TOWARDS SUSTAINABILITY

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UP METRO

12th Urban Mobility India Conference & Expo 2019

INSTITUTE OF URBAN TRANSPORT (INDIA)

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Aim and Objectives

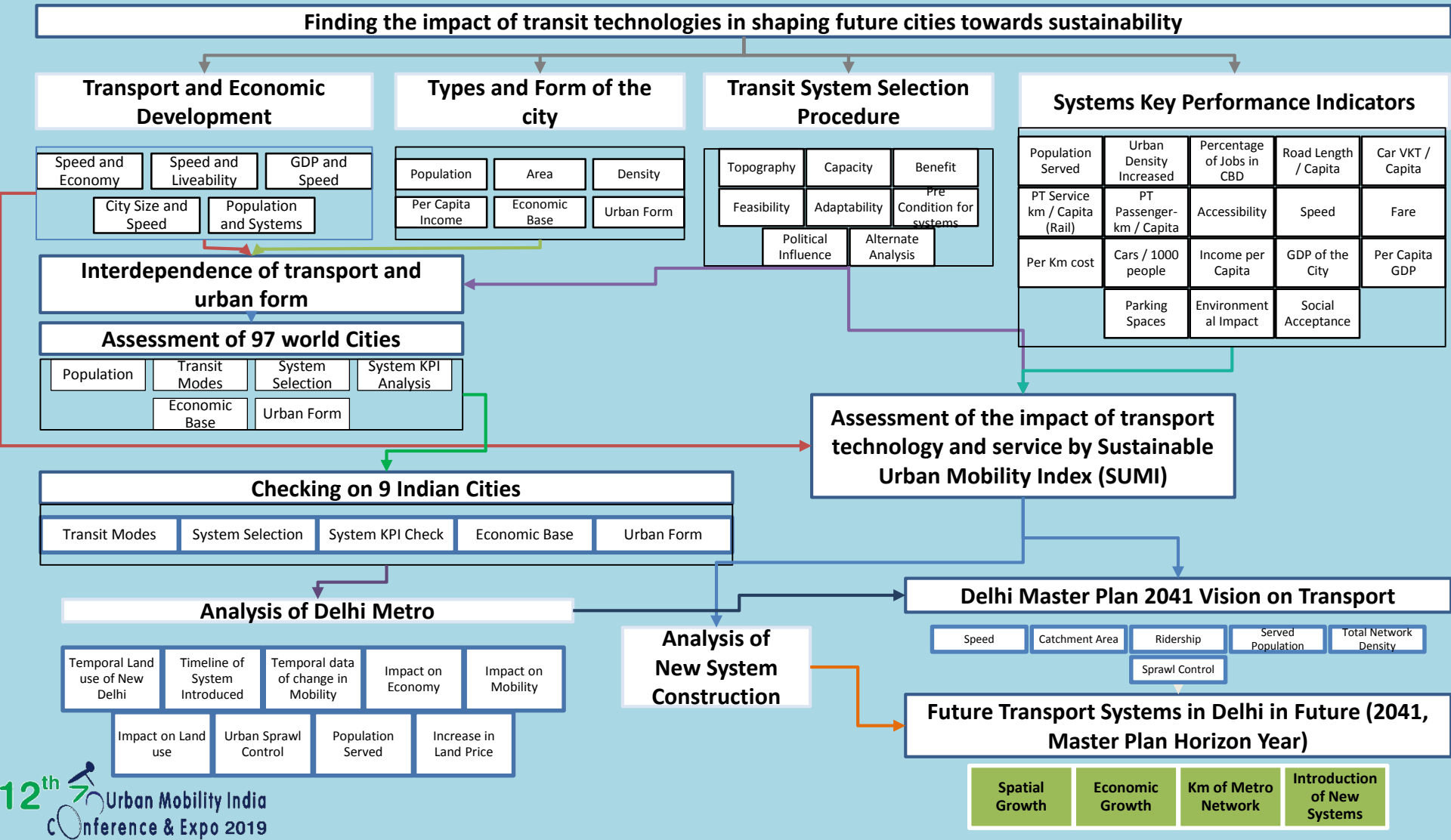
Aim

- Finding the impact of transit technologies in shaping future cities towards sustainability

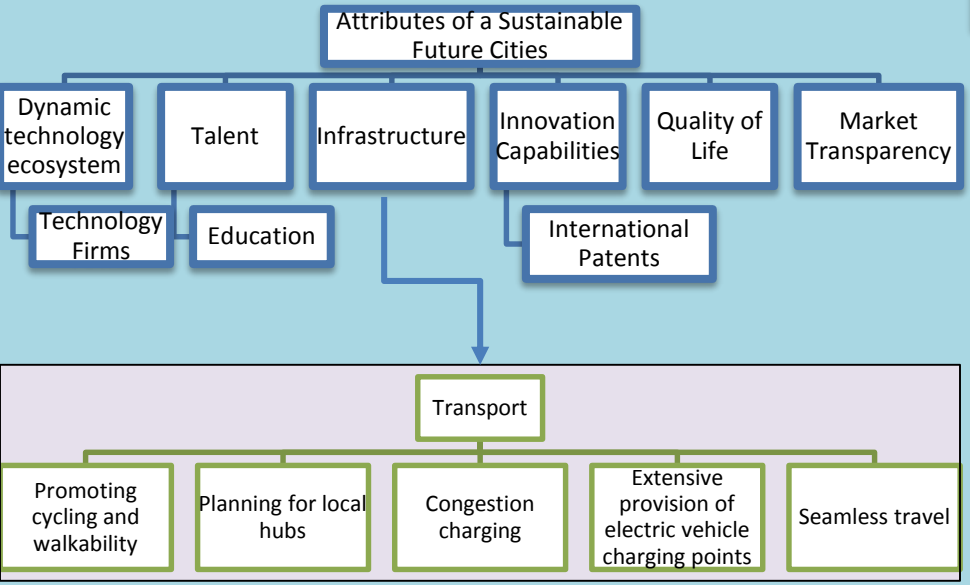
Objectives:

- To review through literature interdependence of Transit and urban growth in sustainable cities.
- To develop a relationship between transit supply and ridership, per Km ridership, Economic, Social and Environmental development
- To develop a Sustainable Urban Mobility Index for evaluating the Impact of Transit Systems in City
- To assess the impact of metro in Delhi on physical, economical, social and environmental Development.
- To evaluate the alternate transit development strategies on case study area of Delhi for growing towards sustainable mobility

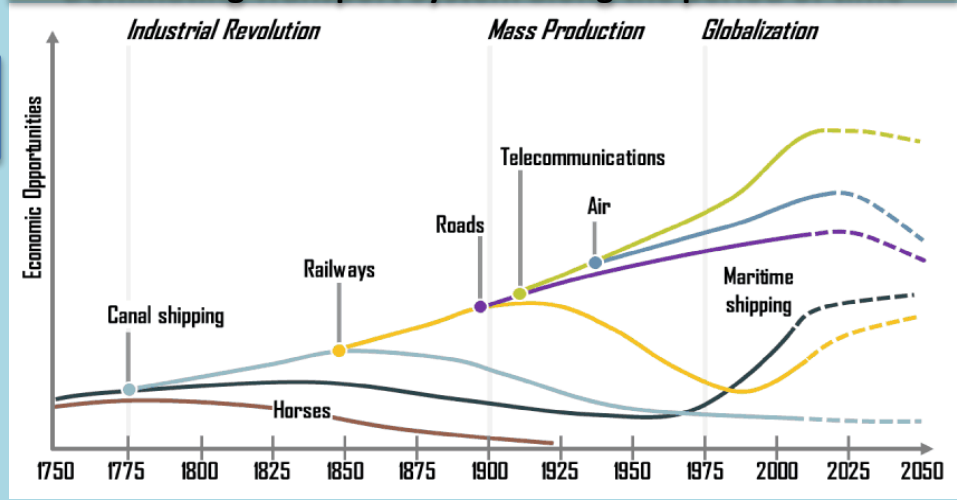
Methodology



Sustainable Cities: Definition and Concept



Dominating Transport System along the period of time



Urban Railway is the most dominating mode for the next half of a century along with Telecommunication

Comparison with World Cities

Presense of Modes

	Bus	Tram	LRT	BRT	Metro	Maglev
India	100%	14%	0%	29%	100%	0%
Rest of the World	100%	38%	38%	22%	97%	6%

- Indian cities are predominantly moving on Bus and Metro in available for cities with more than **5 million population.**
- Medium capacity transit systems such as tram, Monorail are absent except for Calcutta and Bombay

Mass Transit Technologies: Selection Procedure

Factors In Choosing a Type of Public Transport Technology

COST

1) CAPITAL COSTS (Infrastructure and Property costs) 2) OPERATING COSTS 3) PLANNING COSTS

PLANNING AND MANAGEMENT

1) PLANNING AND IMPLEMENTATION TIME 2) MANAGEMENT AND ADMINISTRATION

DESIGN

1) SCALABILITY HOMOGENEITY 2) FLEXIBILITY 3) DIVERSITY VERSUS

PERFORMANCE

1) CAPACITY 2) TRAVEL TIME/SPEED 3) SERVICE FREQUENCY

4) RELIABILITY 5) COMFORT AND SAFETY 6) CUSTOMER SERVICE

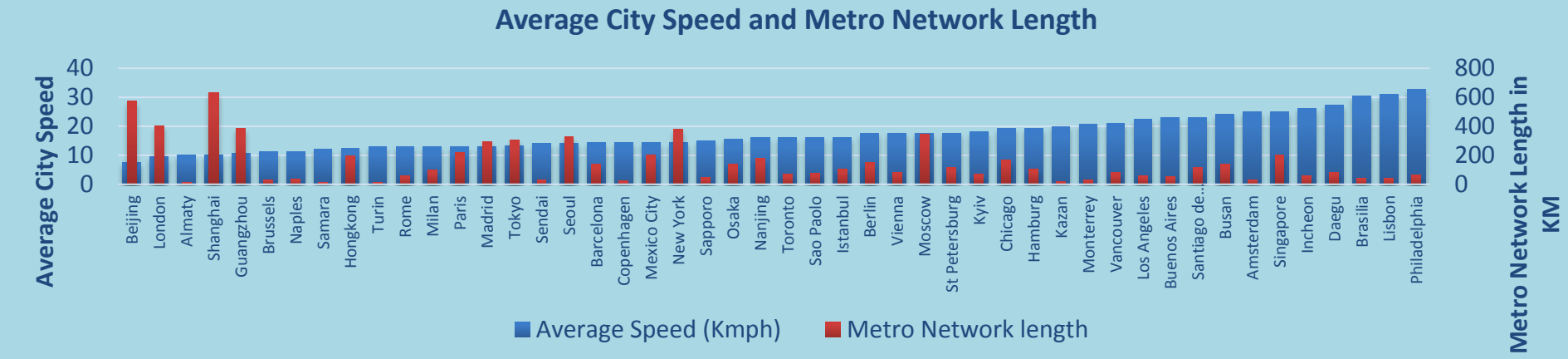
7) IMAGE AND PERCEPTION

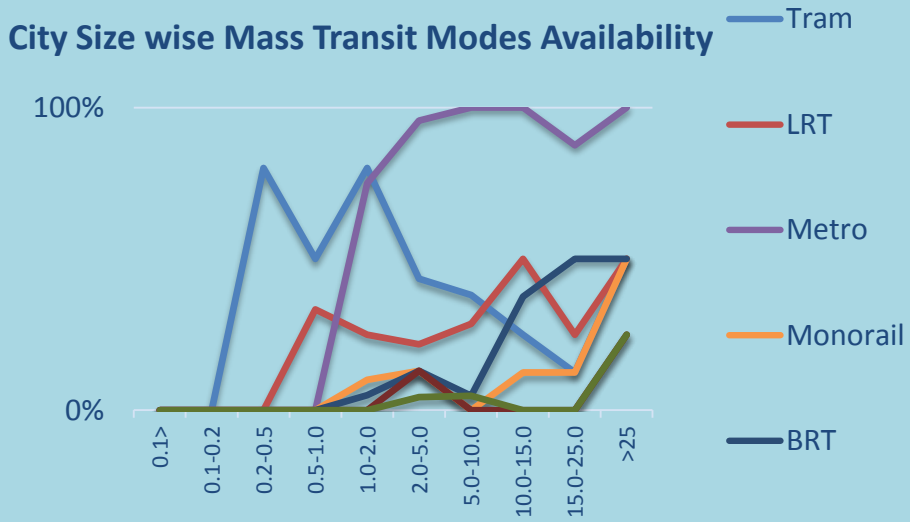
IMPACTS

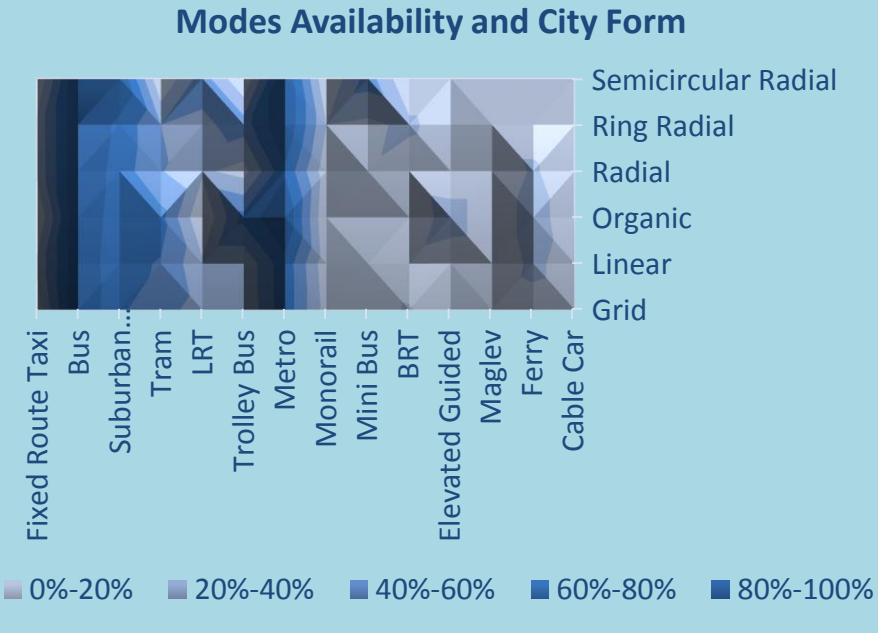
1) ECONOMIC IMPACTS 2) SOCIAL IMPACTS

3) ENVIRONMENTAL IMPACTS 4) URBAN IMPACTS

Transit technologies and Sustainable Cities







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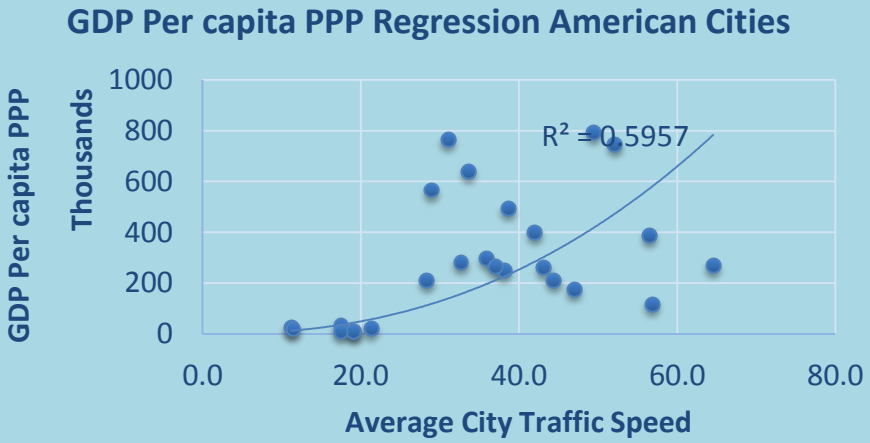
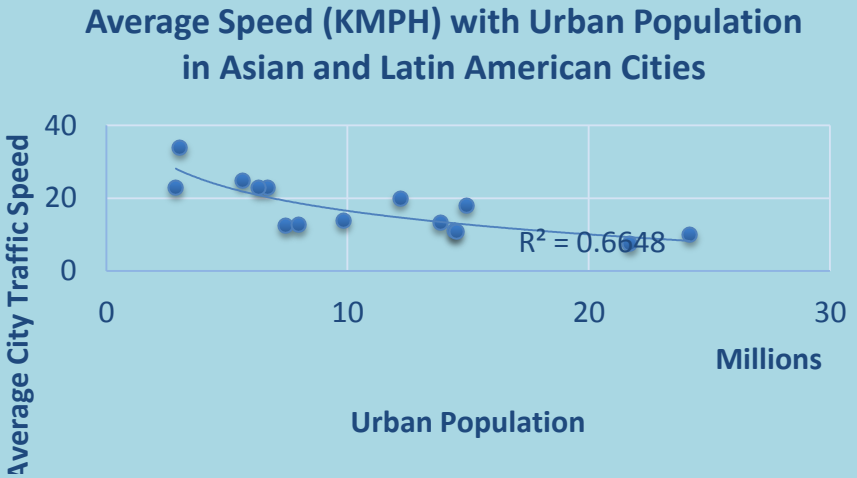
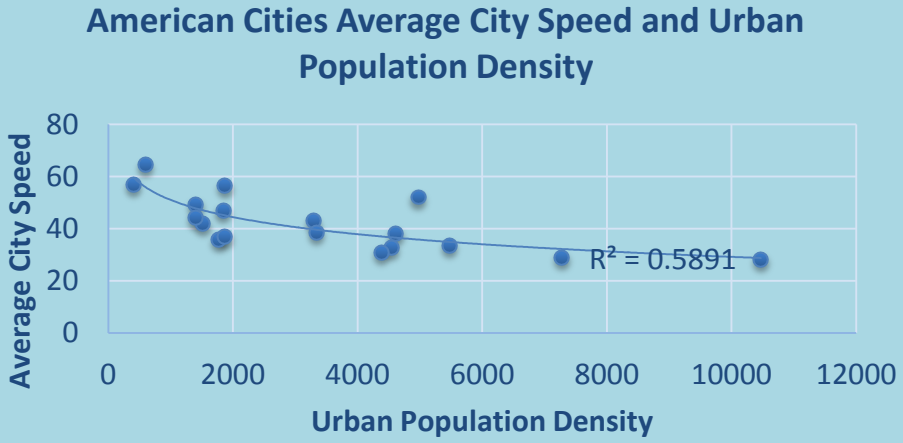
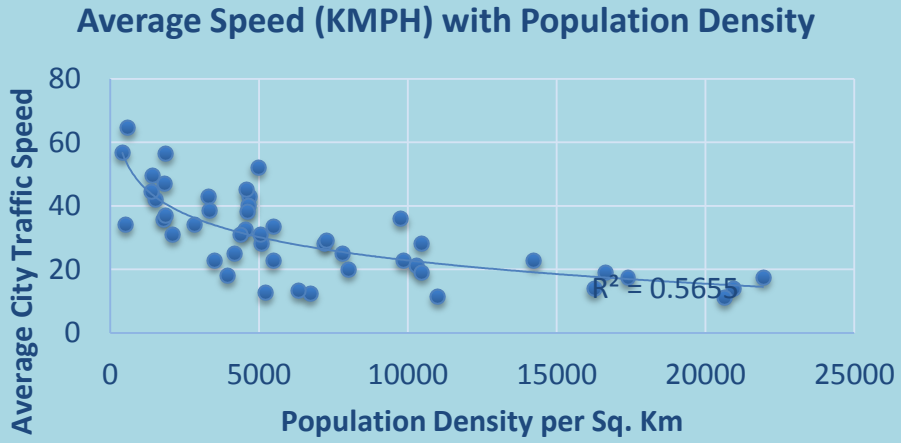
Global Cities: Transit and Economy







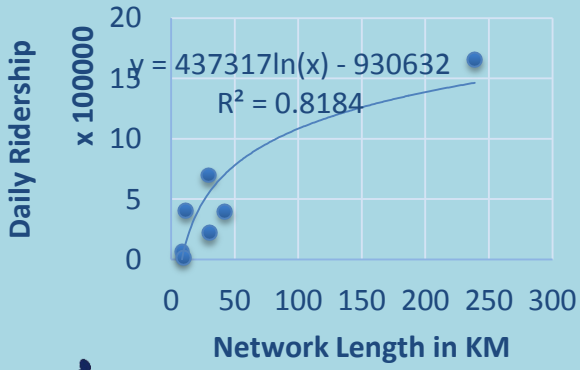


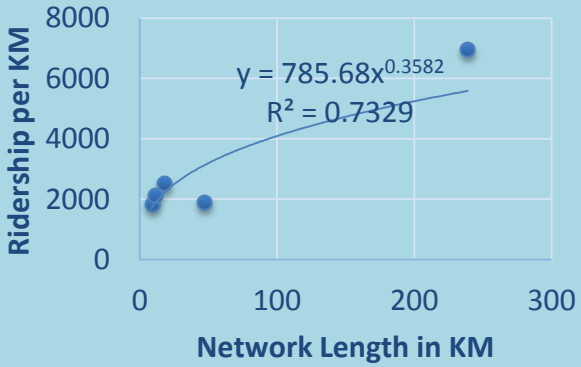
Systems in Indian Cities

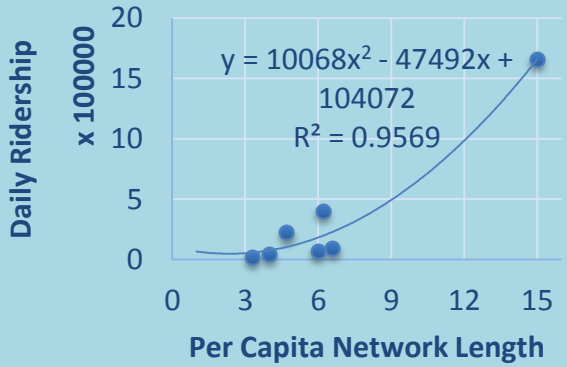
Metro System Efficiency Across India

Sl. No.	City	Population in Million	Opening	Network length	Stations	Lines	Avg. station distance (m)	Avg. line length (KM)	Stations per line	Daily ridership	Ridership per km	Length per resident in mm
1	Bangalore	10.60	15-Sep-11	42.3	40	2	1085	21.1	20.5	400000	9457	6.2
2	Bombay	21.00		11.4	73	6	2253	31.9	15.2	405107	35536	1
3	Calcutta	15.00	24-Oct-84	29.7	24	1	1291	29.7	24	700000	23570	2
4	Delhi	18.70	24-Dec-02	239	172	8	1366	29.9	22.9	2761000	11553	15
5	Hyderabad	6.80	28-Nov-17	29.8	24	2	1296	14.9	12.5	220000	7383	4.7
6	Jaipur	3.06	03-Jun-15	9.6	9	1	1200	9.6	9	17649	1839	3.3
7	Kochi	0.90	17-Jun-17	18	16	1	1200	18	16	45000	2500	
8	Lucknow	3.30	05-Sep-17	8.4	8	1	1200	8.4	8	67000	7977	
9	Madras	7.00	29-Jun-15	47.4	38	3	1317	15.8	13	90000	1899	6.6

Relationships in Indian Cities







Sustainable Urban Mobility Index

- **Sustainable Urban Mobility Index (SUMI)** is a is a framework of indicators for the assessment of urban transport systems and mobility and services in a city. The indicators and SUMI can help summarize, track and compare state of urban transport performance in a city. SUMI can serve as a useful tool for cities to assess the ability to move a city on a mass transit mode. It consists of **Population, Area, Population Density, GDP PPP, Per Capita GDP, Average Speed (Kmph), Network length, Stations, Lines, Avg. station distance, Avg. line length, Stations per line, Daily ridership, Ridership per km, Length per resident in mm, Usage, Stations per Lakh Population, Network Density.**
- **It is derived from Sustainable Urban Transport Index (SUTI)**
- **Methodology:** For SUMI both methods were tested using partly hypothetic yet realistic data. The test showed that the SUMI results (ranking of cities) in some cases could be affected by the choice of aggregation method. Based on the similar argument as for the HDI it was decided to apply the geometric mean for aggregation.
- **Index,** $I_i = \frac{(i_i - i_{min})}{(i_{max} - i_{min})}$ **, SUMI Base, General Index,** $J_i = \sqrt[n]{I_1 \times I_2 \times I_3 \times \ldots \times I_n}$ **, SUMI Base,** $K_i = \sqrt[8]{{J_1}^1 \times {J_2}^1 \times {J_3}^2 \times {J_4}^2 \times {J_5}^2}$
- $SUMI_i = \frac{K_i \times 100}{K_{max}}$

1. $I_i = \frac{(i_i - i_{min})}{(i_{max} - i_{min})}$
2. $I_{area} = \frac{(i_{area\_London} - i_{area\_min})}{(i_{area\_max} - i_{area\_min})}$ or $= \frac{(671-90)}{(8000-90)}$ or $= \frac{(581)}{(7910)}$ or $= 7.3$
3. $J_i = \sqrt[n]{I_1 \times I_2 \times I_3 \times \ldots \times I_n}$, or $J_{City} = \sqrt[3]{I_{area} \times I_{population} \times I_{population\ density}}$

or $J_{City} = \sqrt[3]{7.3 \times 18.6 \times 40.4}$

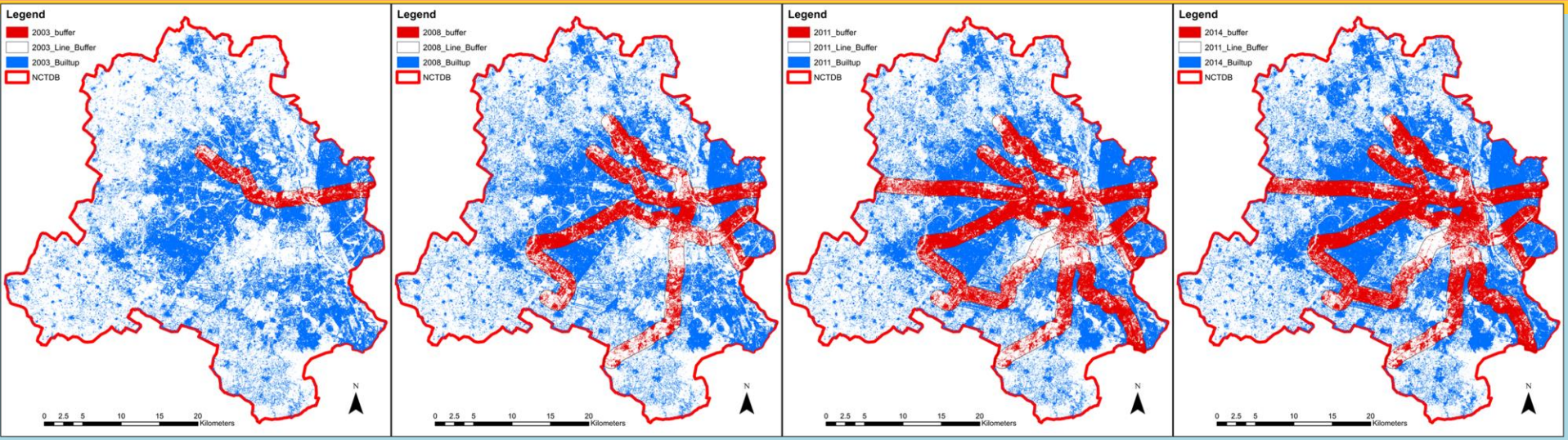
or $J_{City} = 17.7$

4. **SUMI Base,** $K_i = \sqrt[8]{{J_1}^1 \times {J_2}^1 \times {J_3}^2 \times {J_4}^2 \times {J_5}^2}$
5. $SUMI_i = \frac{K_i \times 100}{K_{max}}$

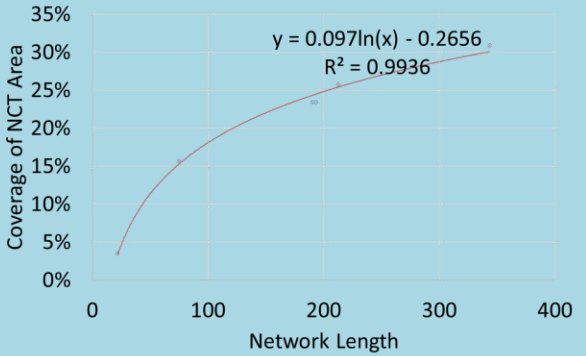
City Index (J_1)	Transit System Index (J_2)	Overall Transport Index (J_3)	Economic Index (J_4)	Environmental Index (J_5)
Area	Network length	Average Trip Length	GDP PPP	CO
Population	Lines	Motorised PCTR	Per Capita GDP	HC
Population Density	Avg. station distance	Average Speed (Kmph)		NO
	Avg. line length	Total VKT		PM10
	Daily ridership	PT Modal Split		
	Ridership per km	Private Modal Split		
	Length per resident in mm	Private VKT		
	Usage	Vehicle Hours Travelled		
	Stations per Lakh Population			
	Network Density			
SUMI Base				

Case Study: Delhi

2003 2008 2011 2014



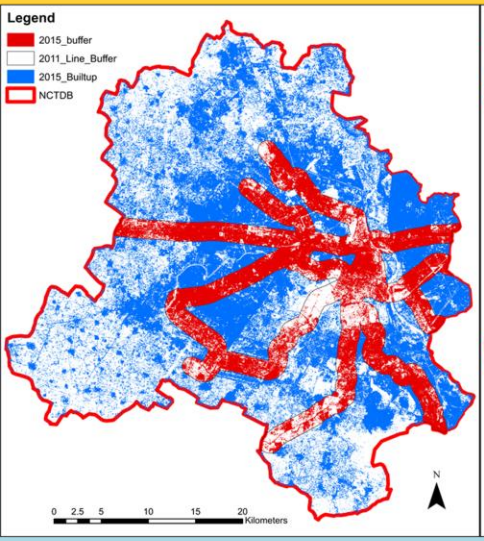
Physical							
Year	Delhi Metro in KM	Total Built-up Area of Delhi (Sq.KM)	Built-up area Percentage	Total Built-up within Present network coverage area	Built-up within 1km	coverage of NCT Area by Metro	Coverage of NCT Built-up Area
2000	0	456	30.87	220		0	0
2003	22	518	35.13	245	35	3.5	6.8
2008	74	617	41.79	268	139	15.7	22.6
2011	190	692	46.88	308	230	23.4	33.3
2014	193	757	51.26	330	247	23.4	32.7
2015	212	807	54.65	336	252	25.7	31.3
2016	212	830	56.26	339	254	25.7	30.6
2019	**343**	**867**	**58.71**	**363**	**363**	**30.9**	**41.9**



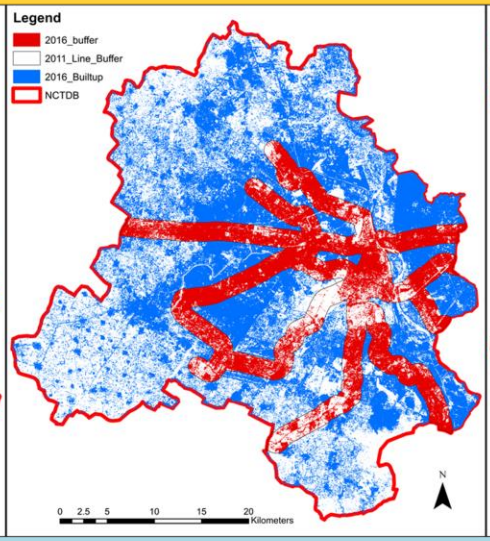
From 2011-12 to 2014-15 the extension of metro was stalled. Average growth of Delhi Metro Ridership was adjusted as 12.5 increase per year.

Case Study: Delhi

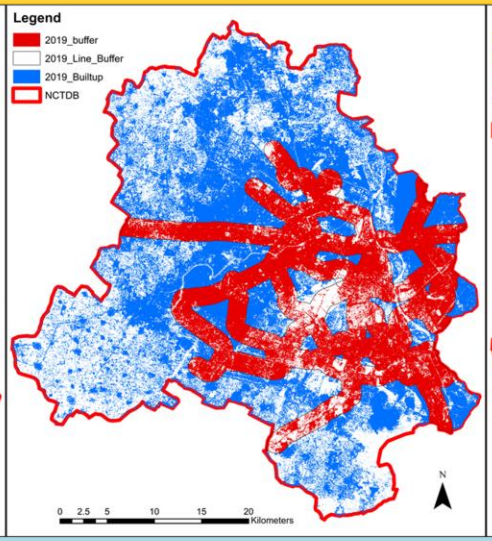
2015



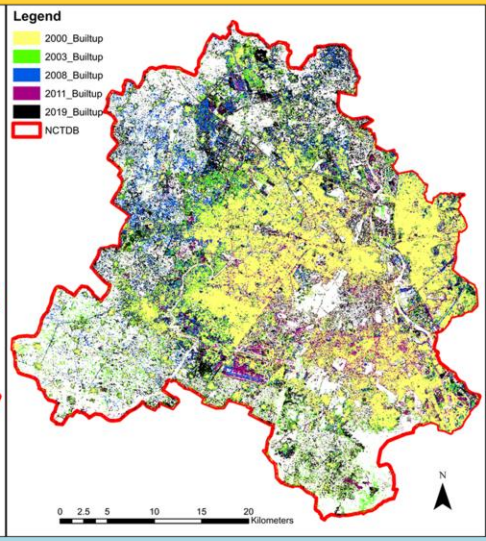
2016



2019

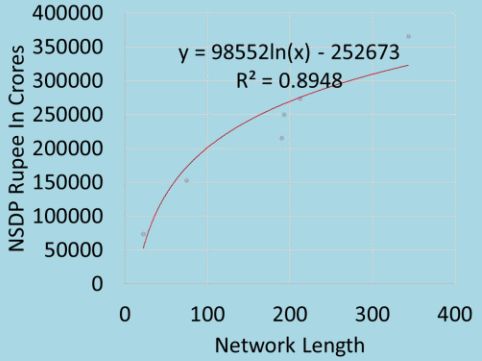


Growth Pattern



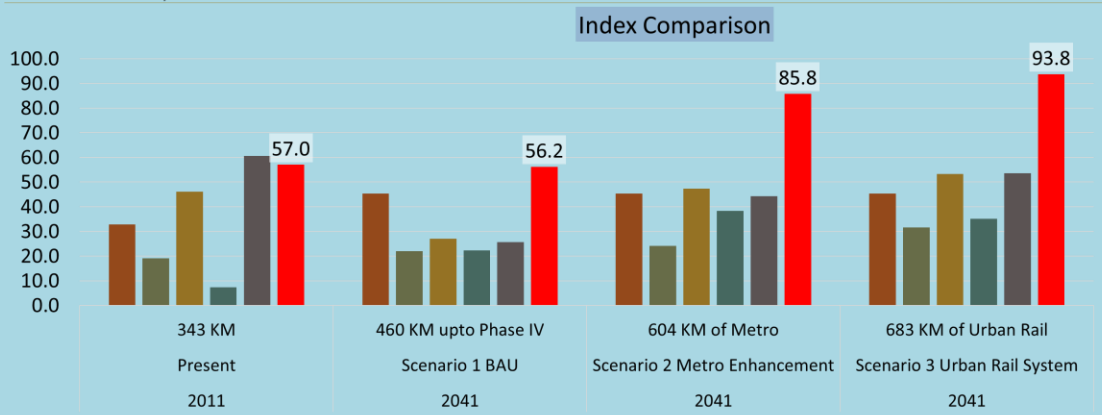
Economic DMRC Sustainability Report, 2013-14

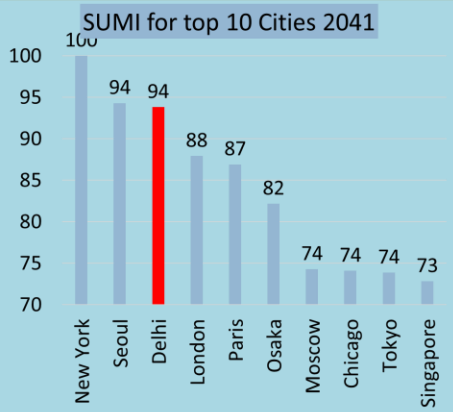
Adding up KMs of Network	Direct NSDP Rupee In Crores	Total Economic Benefit (Rupees in Crore)	Employment		Income		Total Employment	Total Income Rupee In Crores	Metro Network Building Cost Rupee In Crores	Cost Benefit Ratio (economic)	Multiplier Effect
			Direct	Indirect	Direct	Indirect					
10	2827	7568	425	3910	22	70	4335	93.33	3750	1.25	
20	5575	17429	850	7820	45	140	8670	186.66	7500	1.23	10.00
50	13388	44206	2125	19550	114	351	21675	466.65	18750	1.18	0.25
100	25173	86810	4250	39100	229	703	43350	933.3	37500	1.11	0.11
200	**45206**	**154257**	**8501**	**78209**	**459**	**1407**	**86710**	**1867**	**75000**	**10**	**0.10**

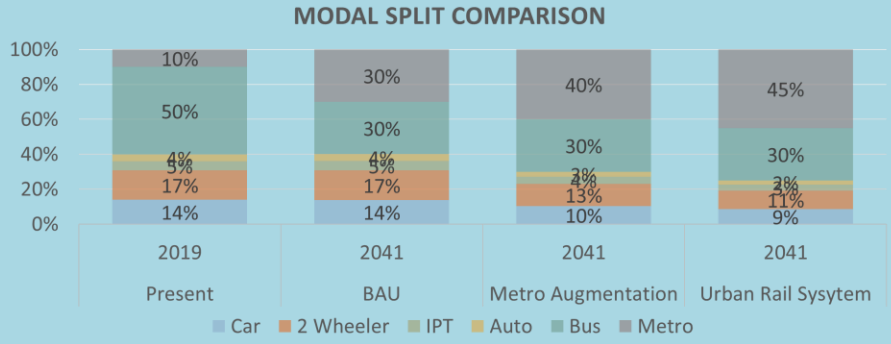


Case Study: Delhi

Year	Scenario	Options	Country	City	City Index	Transit System Index	Overall Transport Index	Econimical Index	Environmental Index	SUMI Base	SUMI	Percentage Development of SUMI from BAU
2019	Present	343 KM	India	Delhi	32.9	19.1	46.1	7.4	60.6	26.8	57.0	
2041	BAU	460 upto Phase IV	India	Delhi	45.3	21.9	27.1	22.3	25.7	26.4	56.2	0%
2041	Metro Enhancement	604 KM of Metro	India	Delhi	45.3	24.2	47.3	38.3	44.3	40.4	85.8	53%
2041	Urban Rail System	683 KM of Urban Rail	India	Delhi	45.3	31.6	53.2	35.1	53.6	44.1	93.8	67%







Scenario	Total Network Length	Cost in Crore Rupees	Per KM Cost in Crore Rupees	Increase in SUMI Index	Cost per SUMI Index Increase
BAU	460	46800	400	-0.8	**-58500**
Metro Augmentation	604	104400	400	28.8	**3625**
Urban Rail System	683	100320	295	36.8	**2726**

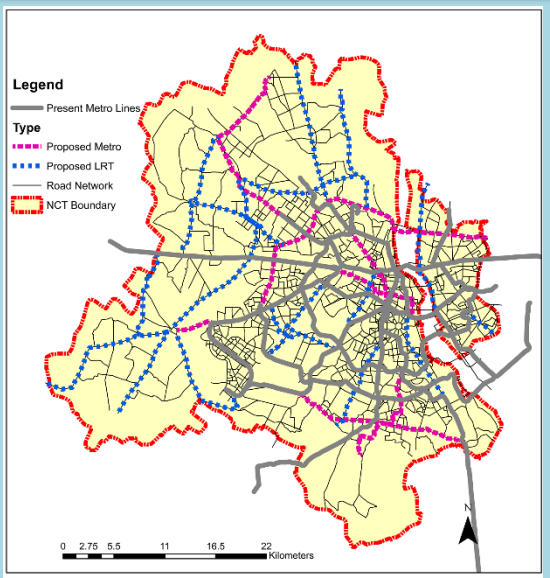
	Bus	Auto	Ola/Uber		Car	2 Wheeler		Metro
BAU								
Fleet Required	9660	57242	29239	Vehicle KM	162Lakh	328Lakh	KM Required	**456**
Modal Split	30%	5%	4%		14%	17%		**30%**
Users/Ridership	63Lakh	10.6Lakh	8.5Lakh		29Lakh	36Lakh		**63Lakh**
Metro Enhancement								
Fleet Required	9660	45793	21929	Vehicle KM	115Lakh	251Lakh	KM Required	**608**
Modal Split	30%	4%	3%		10%	13%		**40%**
Users/Ridership	63Lakh	8.5Lakh	6.3Lakh		21Lakh	27Lakh		**85Lakh**
Urban Rail System								
Fleet Required	9660	34344	14619	Vehicle KM	104Lakh	212Lakh	KM Required	**684**
Modal Split	30%	3%	2%		9%	11%		**45%**
Users/Ridership	63Lakh	6.3Lakh	4.3Lakh		19Lakh	23Lakh		**95Lakh**

Conclusion and Recommendation

Recommendation

- Urban Rail System needs to given the top priority in Large Cities like Delhi
- Rail based systems are essential to achieve sustainability in large cities as seen in the global sustainable cities as well as in India
- Rail based transport impacts the city in terms of physical extent, economic extent as well as social enhancement
- There is a straight relationship between per capita network length and usage of Systems
- As the Network Length Increases, the Ridership per KM increases
- The average speed of a city is directly impacting the Per Capita GDP of a City
- To increase ridership, a whole network has to be created, a single corridor
- Multimodality increases efficiency of each system
- Alternate scenarios to be developed and right system and network has to be implemented

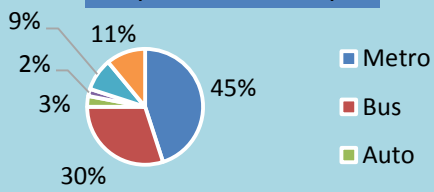
Proposal for 2041 Delhi



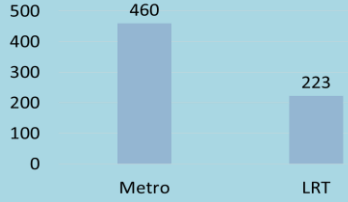
460 KM Metro Network was as considered upto Phase IV, plus **223 Kms LRT Network** according to BAU Traffic Assignments, PPHPDT over 20 thousands for New LRT

Target PT Modal Split 75%

Proposed Modal Split



Network Mix



Way Forward

- SUMI can be further developed
- Weightage (Power) of different criteria may be considered statistically
- Proper weightage of Metro, BUS, BRT, LRT and Trams has to be calculated. In this study capacity of the systems are considered as their weightage