GOVERNMENT OF INDIA
MINISTRY OF HOUSING AND URBAN AFFAIRS

Vehicular Emission Modelling at Toll Plazas under Mixed Traffic Conditions

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Brief Outline

1. Introduction
2. Literature Review
3. Research Gaps
4. Objectives
5. Methodology
6. Data Collection
7. Data Analysis
8. Results and Conclusions
9. References

Facts about India

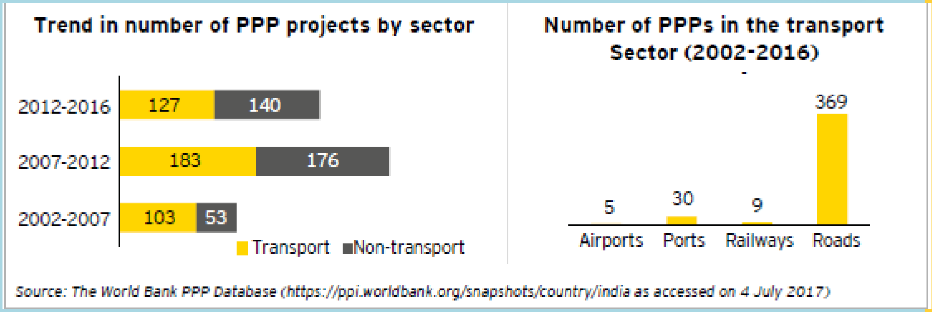
2nd Largest Road Network

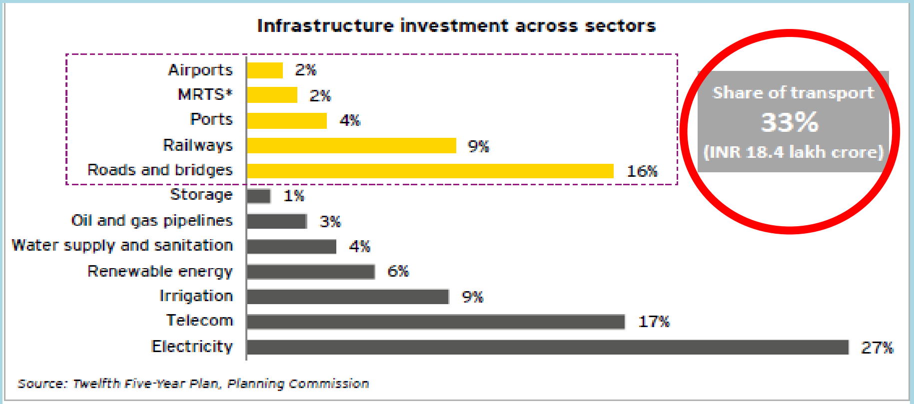
Vehicular Growth Rate - 9.9 % (2018)

1% in Worlds Vehicular Population

1.7 % of NH carries 40% of traffic

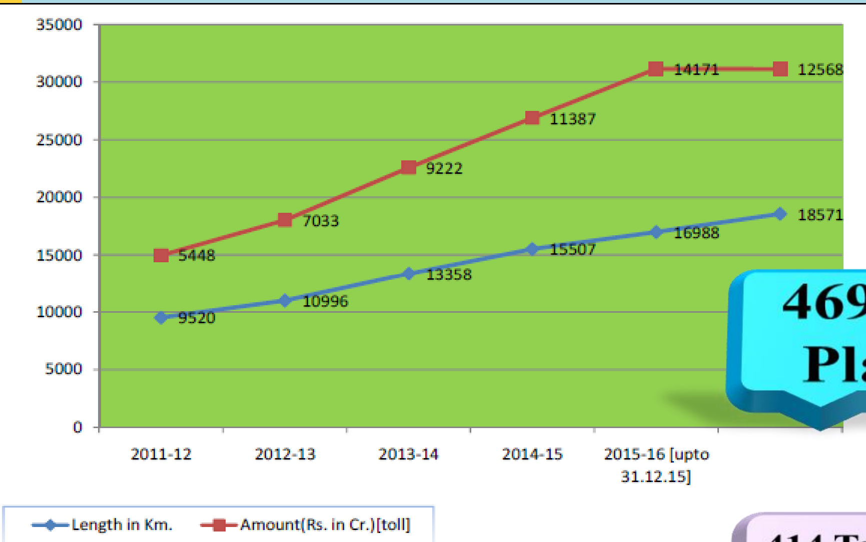
Infrastructure (Road Growth Rate-5.87%)





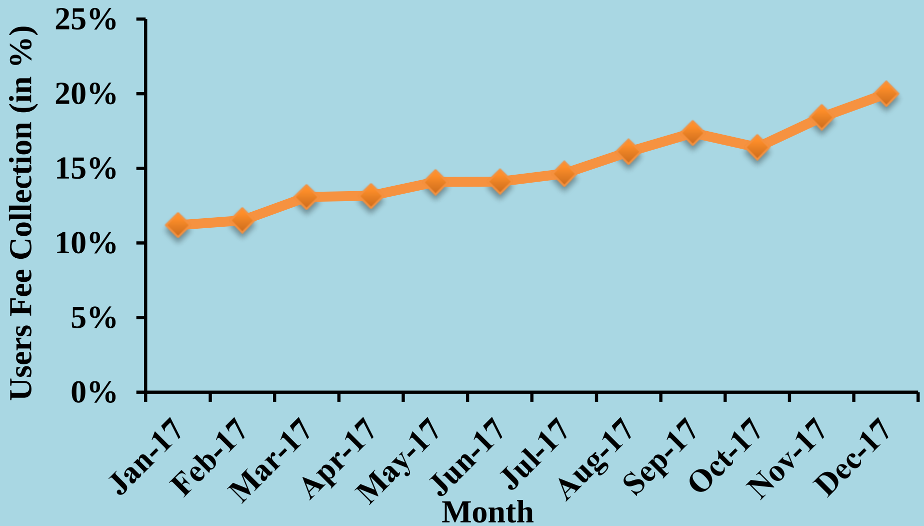
(Source: www.morth.nic.in)

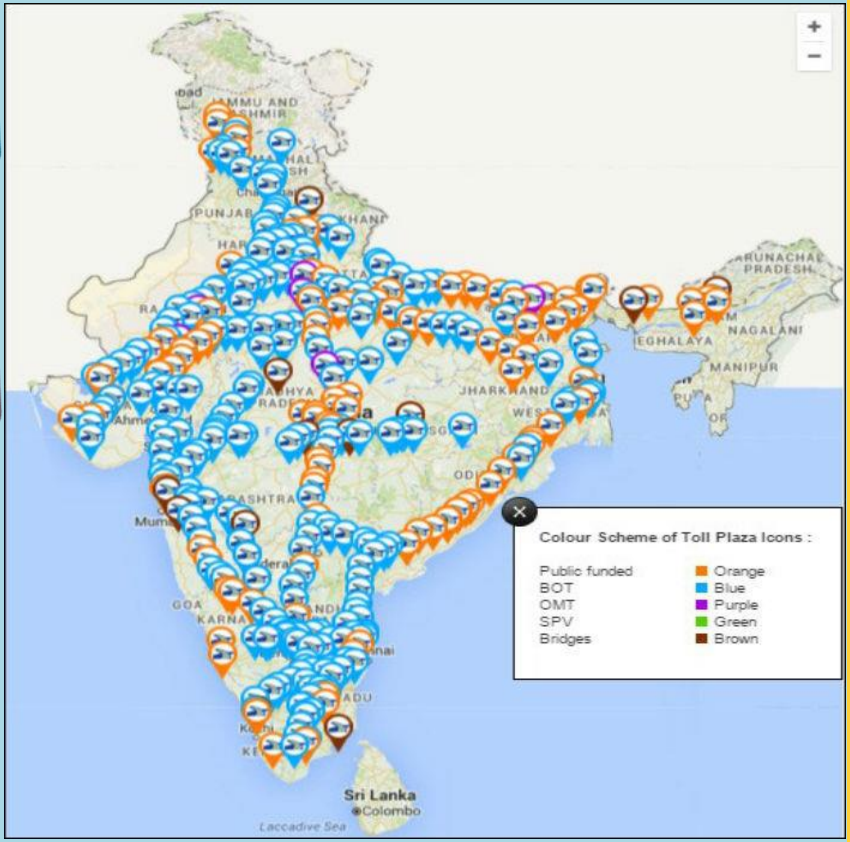
Overview of Indian Toll System



469 Toll Plazas

414 Toll Plazas with one lane Fast-Tag





Location of Toll Plazas in India

Source: www.nhai.in

Loss of 870 billions
per
(The Hindu,2014)

Residents may move court to get Kherki Daula toll shifted

Say Dust & Air Pollution Pose Serious Risks To Health

Ipsita.Pati@timesgroup.com

Gurgaon: After three years of the government dragging its feet on the Kherki Daula toll plaza shift, residents of new sectors along the Dwarka Expressway have decided to move high court.

"We have been holding protests seeking its removal since 2016. Yet, we continue to suffer. Now, we will take the matter to the Punjab and Haryana high court," said Satish Yadav, a member of Toll Hatao Samiti, at a press conference.

The toll plaza is a major choke point on the Delhi-Gurgaon Expressway. The traffic congestion aside, emissions from vehicles that wait in long lines affect air quality, residents claim. Besides, uneven roads in the vicinity are almost always dusty. All of this, residents of areas along the Dwarka Expressway have been saying, has turned into a persistent health hazard.

"Children and old people are suffering because of the air pollution," Yadav added.

'SEEKING REMOVAL SINCE 2016'

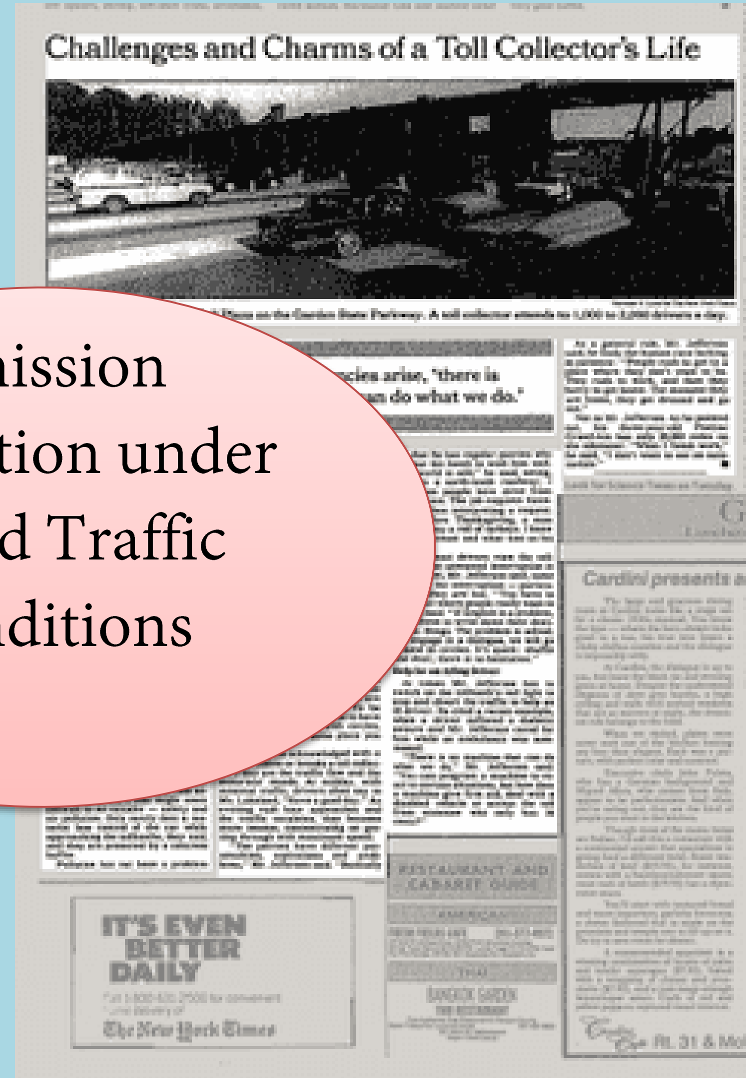
75,000-80,000 vehicles cross the toll plaza every day

₹800 crore Estimated cost of shifting

Residents have complained that emissions from vehicles waiting at the toll plaza are adding to air pollution in the area. They have been staging protests since 2016

What would also help, residents said, is completion of the Dwarka Expressway stretch from National Highway-8 to the airport, easing some of the congestion.

Last year, the toll operator — Millennium City Expressway Private Limited (MCPEL) — had opposed the proposal to move the toll plaza on the grounds that it would suffer massive revenue losses. "We had filed an RTI, seeking information ... the collection of funds at ... toll plaza. The response to our RTI revealed that the Delhi-Gurgaon Expressway cost Rs 550 crore, while expenditure on change of scope was Rs 113 crore — which was in addition to the earlier cost ... We found out that the toll operator, MCPEL, has already recovered the money," RTI activist Harinder Dhingra said. In fact, since the project was awarded, ...



Challenges and Charms of a Toll Collector's Life

Emission Estimation under Mixed Traffic Conditions

Need of the Study

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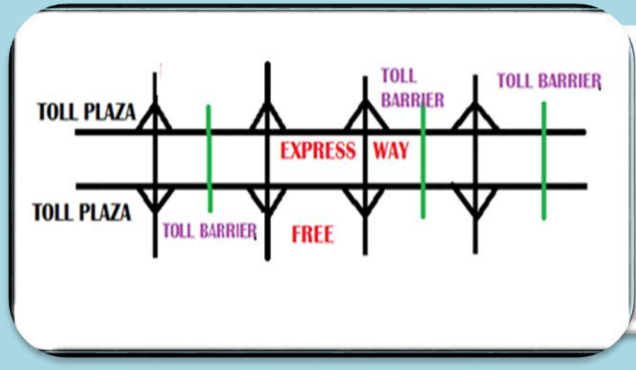
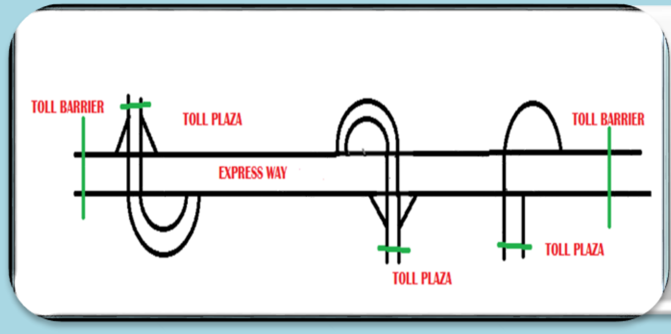
Toll Road Classification



Open Toll System



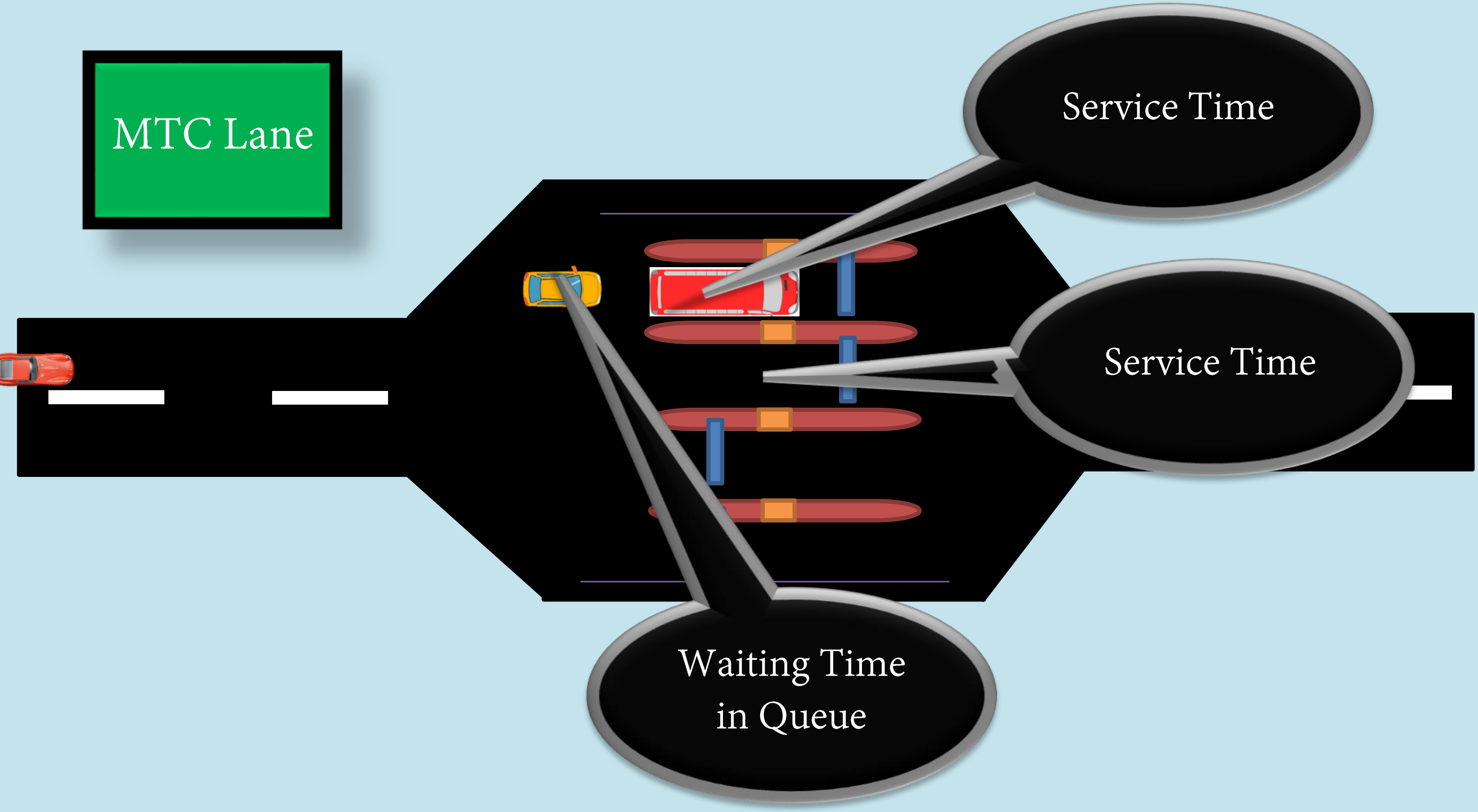
Closed Toll System

Methods of Toll Collection

Manual Toll Collection (MTC)

Automatic Coin Machine (ACM)

Electronic Toll Collection (ETC)


MTC Lane
Service Time
Service Time
Waiting Time
in Queue

1 Literature review on zone of influence

Literature Review

2 Literature review on emissions

01

Literature review on zone of influence

Reported Zone of Influence by Different Researchers

Researcher	Facility	Country	Zone of Influence (ZOI)
Saka et al. (2001)	Toll Plaza (ETC)	United States of America (USA)	610 m
Mousa (2002)	Signalized Intersection	Oman	330 m
Venigalla and Krimmer (2006)	Toll Plaza (ETC)	New York	610 m
El-Shawarby et al. (2007)	Signalized intersection (deceleration)	Virginia	93.1 m
Song et al. (2008)	Toll Plaza (MTC and ETC)	China	400 m
Song et al. (2010)	Acceleration lane	China	518 m
Song et al. (2010)	Deceleration lane	China	288 m
Weng et al. (2015)	Toll Plaza (ETC)	China	240 m
Weng et al. (2015)	Toll Plaza (MTC)	China	300 m
Yang et al. (2016)	Ramps	California, USA	152 m
Bokare and Maurya (2017)	Signalized intersection	India	837 m
Chung et al. (2017)	Toll Plaza (MTC and ETC)	Korea	870 m

02

Literature review on Emission

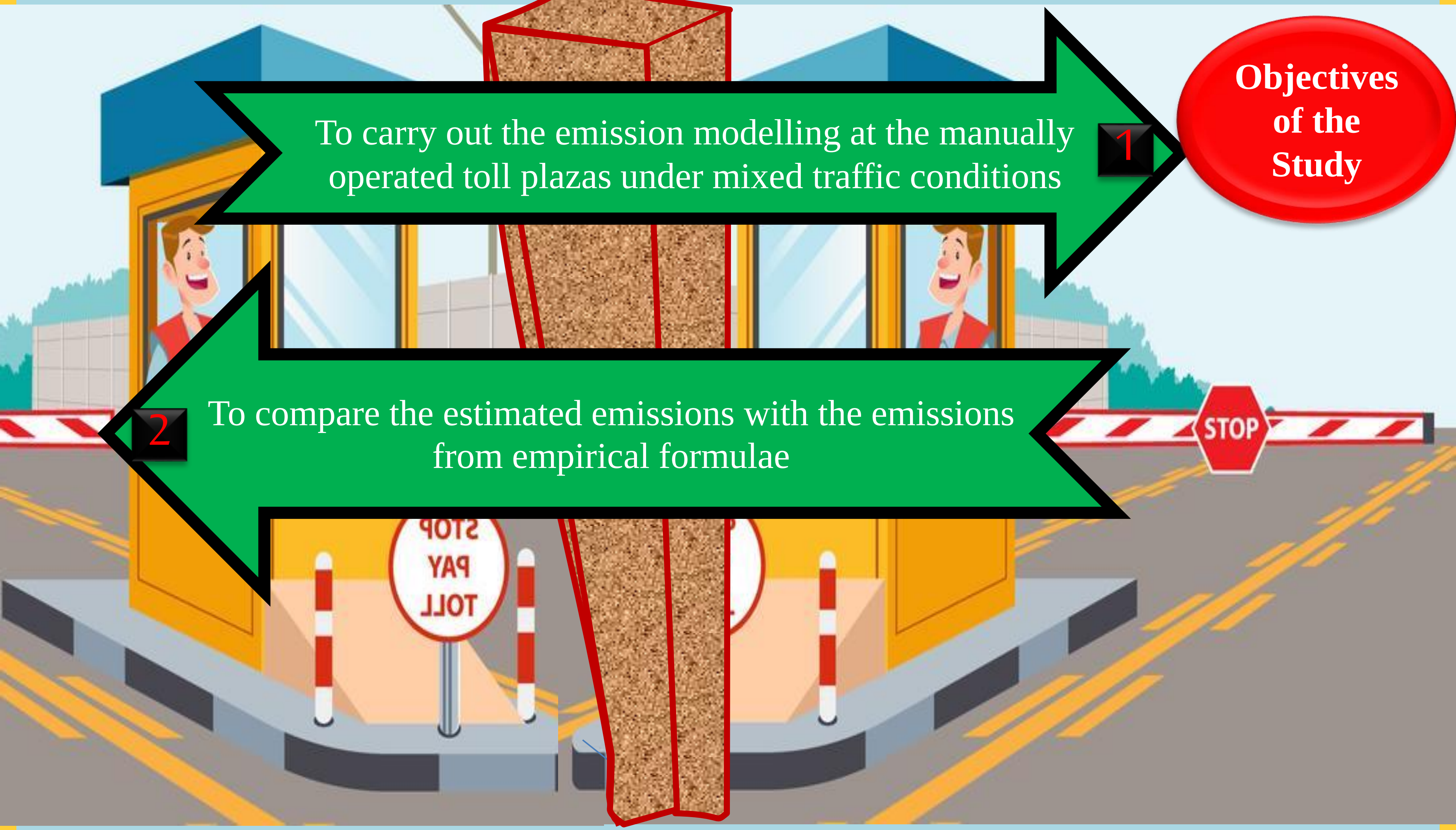
Reported Methods of Emission Estimation

Researcher	Country	Method	Facility
Saka et al. (2001)	Baltimore Metropolitan area	MOBILE 5b and Simulation	ETC, MTC lane
Feng and Cheng (2002)	Chongqing	Mobile5	Urban Freeway
Ahn et al. (2002)	Oak Ridge National Laboratory (ORNL	Regression Method	Freeway
Rakha and Ding (2003)	Phoenix	Floating car Method and PEMS	Freeway
Coelho et al. (2005)	Portugal	Microwave Doppler sensor	ETC, MTC lane
Venigalla and Krimmer (2006)	New York	Speed Profile Discretization (SPD)	ETC, MTC lane
Nesamani and Subramanian (2006)	India	International Vehicle Emission (IVE)	Urban road
Song et al. (2012)	China	Floating car Method and PEMS	Freeway

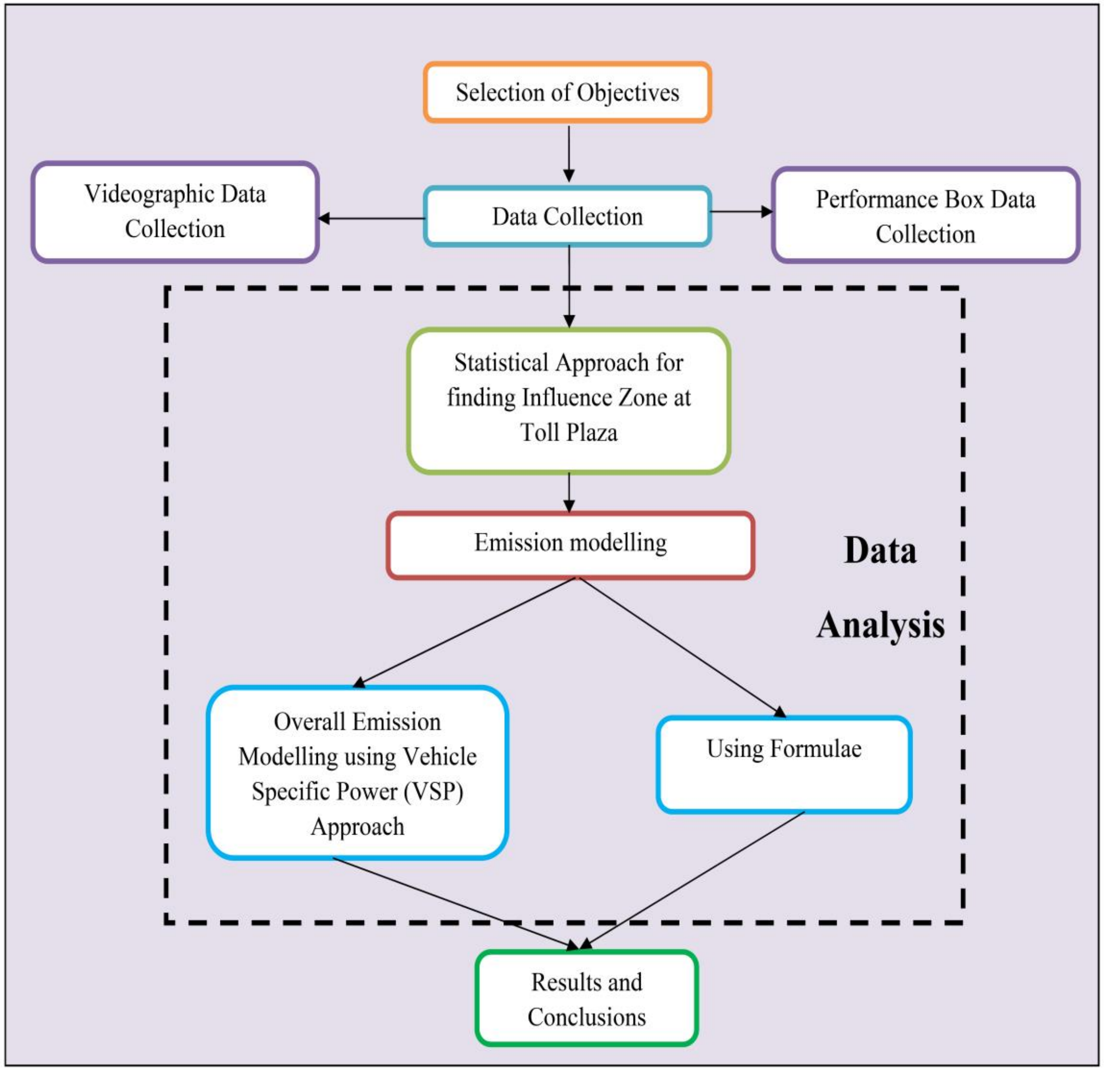
Objectives of the Study

1. To carry out the emission modelling at the manually operated toll plazas under mixed traffic conditions

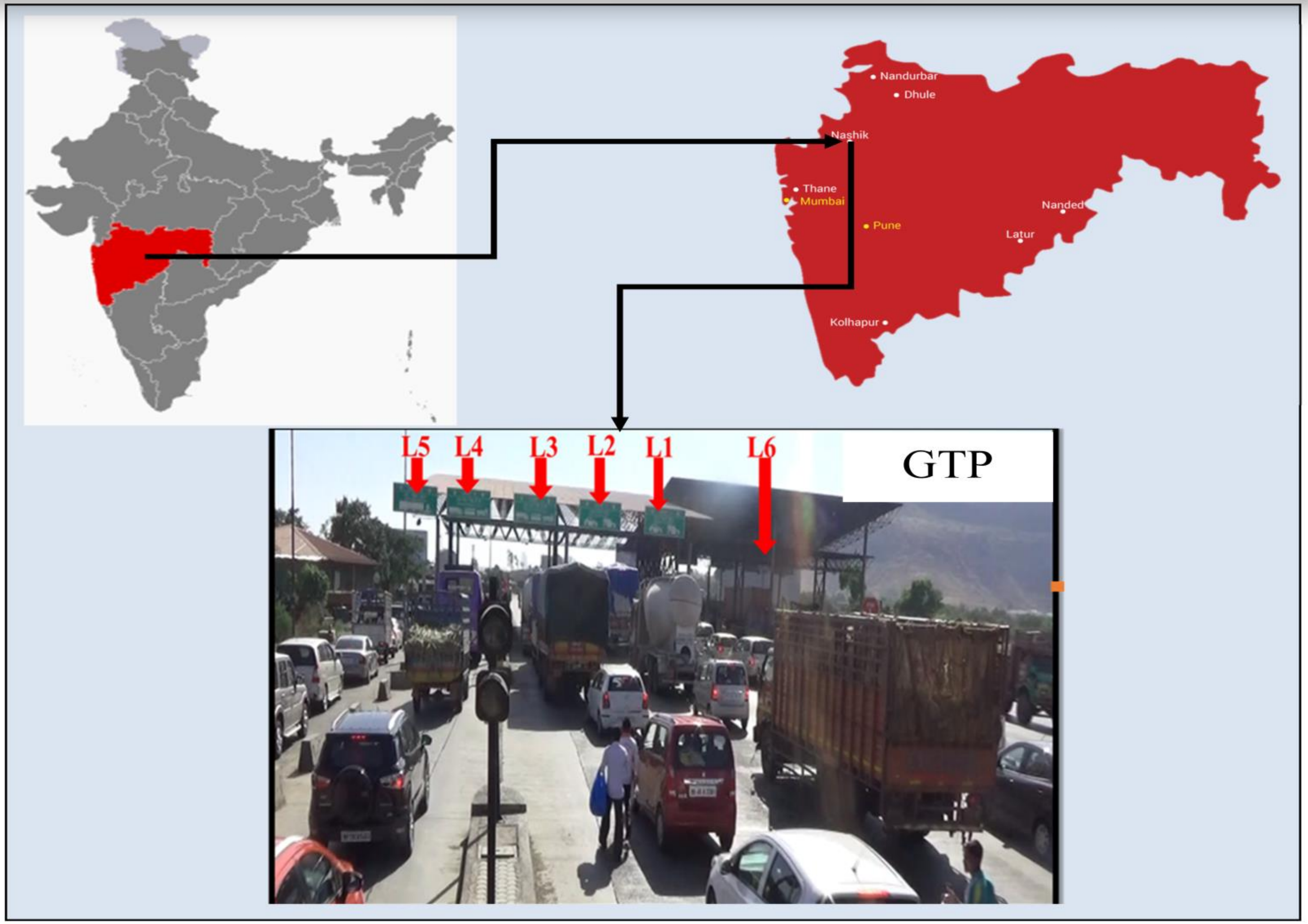
2. To compare the estimated emissions with the emissions from empirical formulae



Methodology of the present study

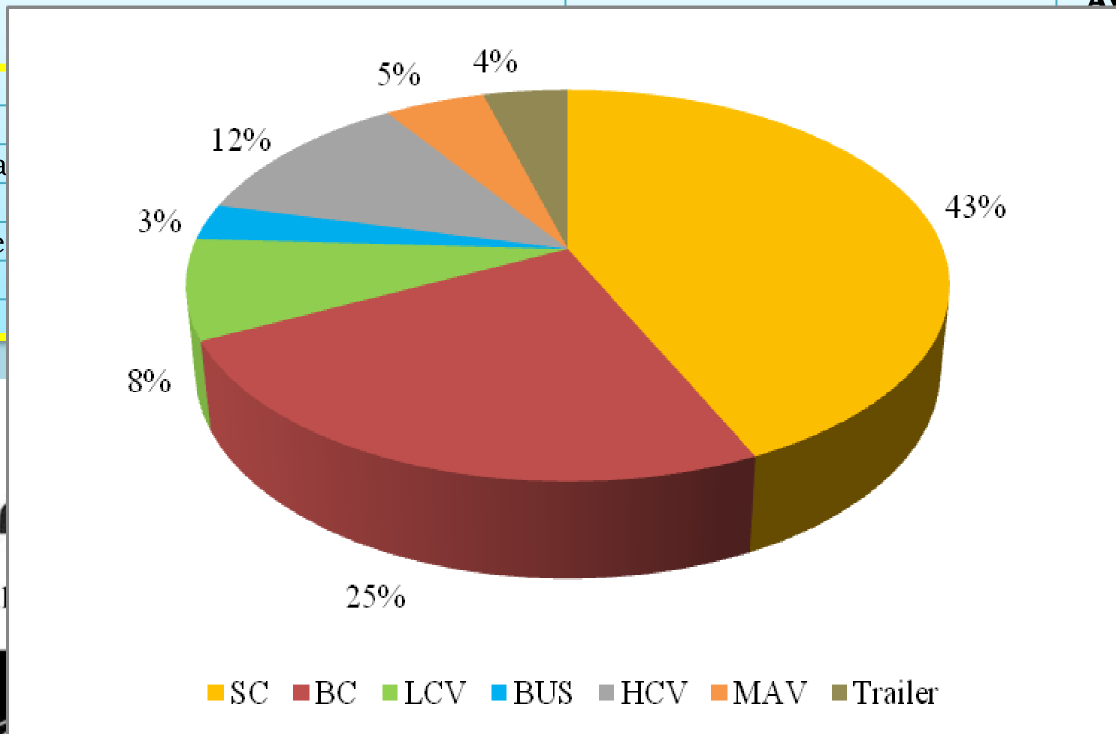


Data Collection



Vehicle Class for Study

Sr. No.			Average Length (m)
1			3.72
2			4.58
3	La		5.00
4			10.30
5	He		7.20
6			11.70
7			15.60

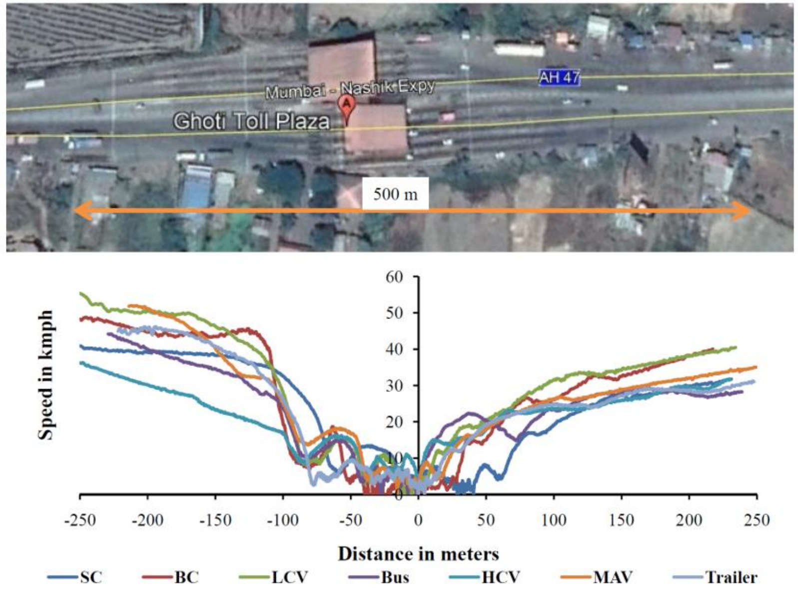


Small

Heavy Commercial Vehicle(7.20 m) Multi Axle Vehicle (11.70 m) Trailer (15.60 m)

Performance Box Analysis

Field Data Collection



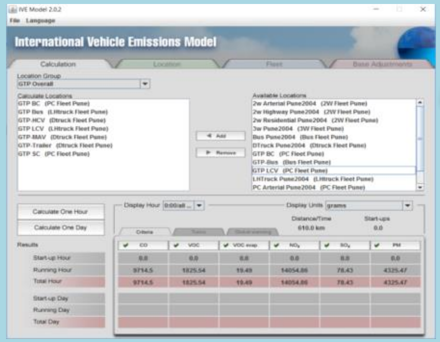
Extracted P-Box Data for Speed-Distance

P-Box

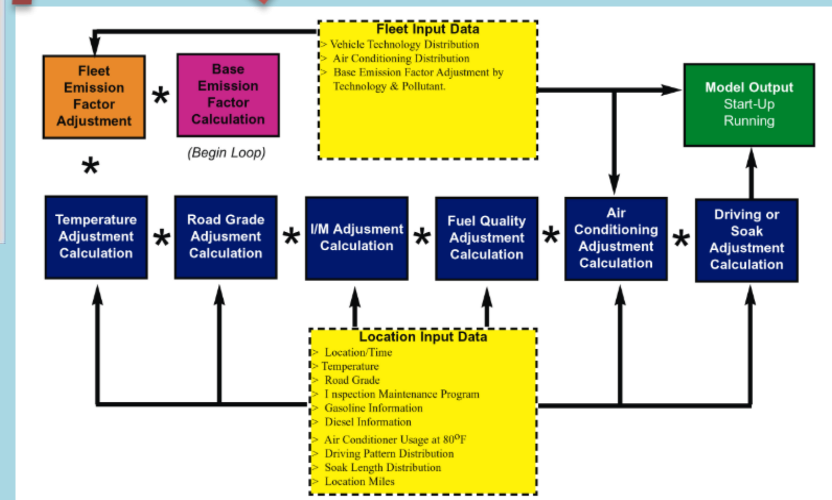
Descriptive Statistics for Zone of Influence (ZOI)

Vehicle class		SC	BC	LCV	Bus	HCV	MAV	Trailer
Number of observation		35	31	35	30	32	32	30
Distance before toll plaza	Minimum	60.00	50.00	100.00	40.00	100.00	40.00	143.80
	Maximum	160.00	240.00	206.50	220.00	208.00	180.00	200.00
	Average	90.00	130.00	167.00	175.00	161.80	143.20	175.40
	Standard Deviation	28.90	26.70	31.68	57.66	31.58	37.06	19.75
Distance after toll plaza	Minimum	60.00	60.00	40.00	120.00	120.00	60.00	100.00
	Maximum	140	180	240	230	240	240	240
	Average	85	126	185	206	212	192	195
	Standard Deviation	33.60	55.00	52.00	35.00	32.60	51.50	47.70

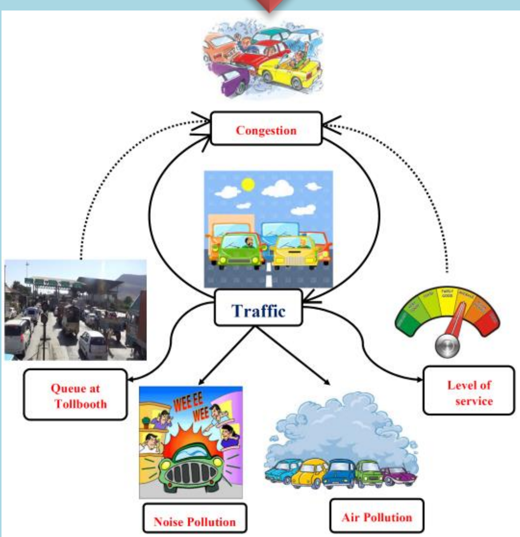
Emission Estimation



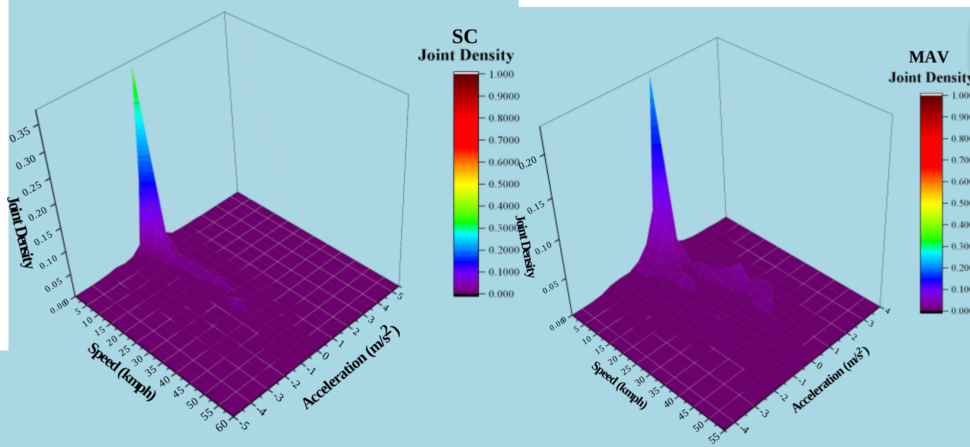
IVE Model



IVE Architecture



Inter Relation



Speed-Acceleration-Frequency Density (SAFD) Plots

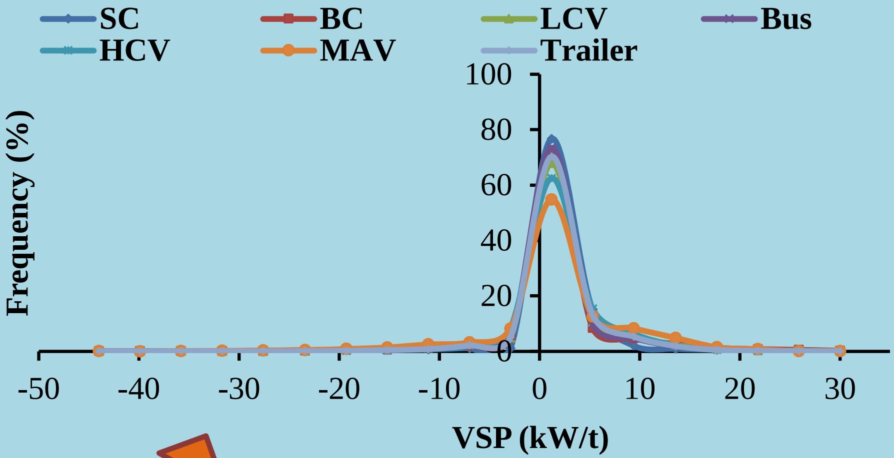
Vehicle Specific Power (VSP)

$$VSP = \frac{\frac{d}{dt}(\mathrm{KE+PE}) + F_{rolling} * v + F_{aerodynamic} * v}{m}$$

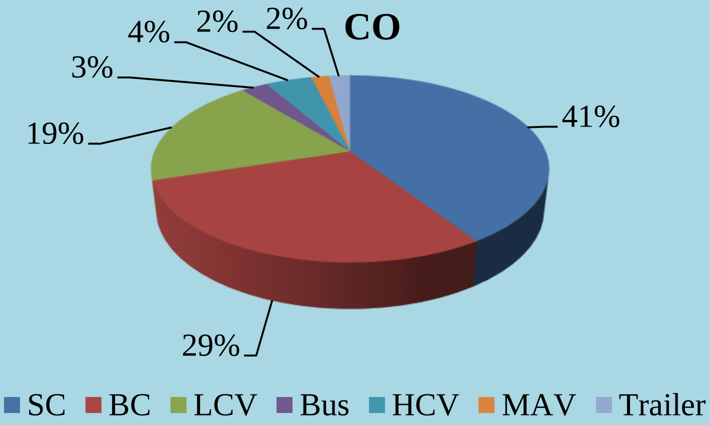
Jimenez-Palacios (1999)

$$VSP = \frac{v * [a * (1+\epsilon) + (g * grade) + (g * f)] + 0.5 * \rho * C_D * A * v^3}{m}$$

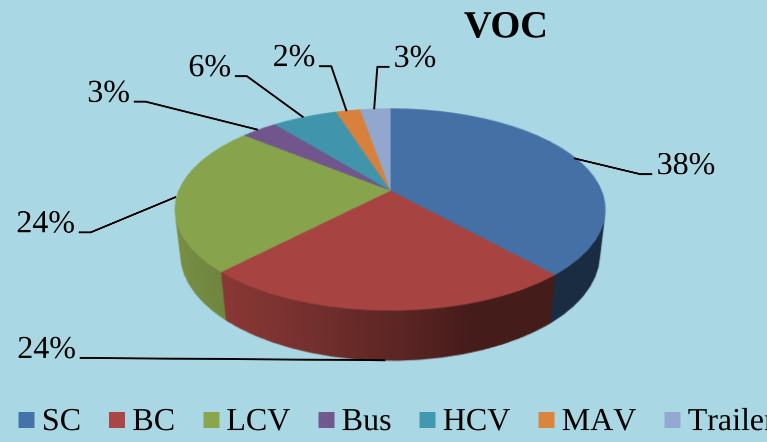
Song et al. (2012)

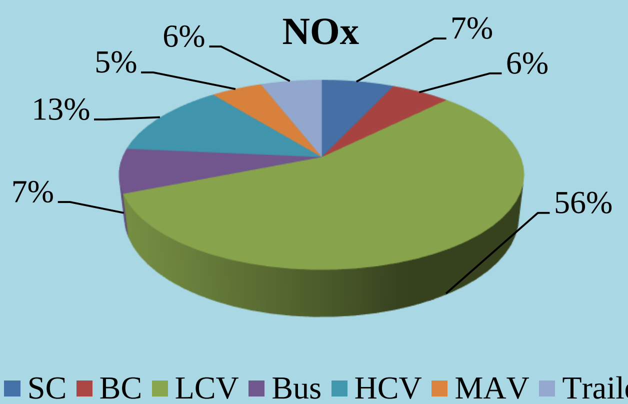


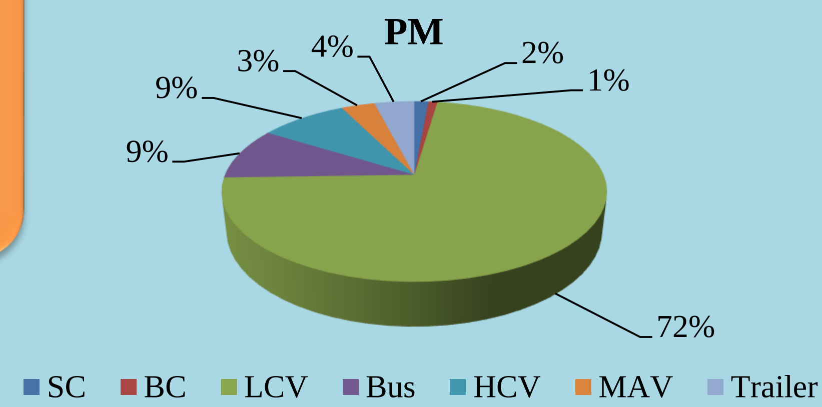
Parameter	SC	BC	LCV	Bus	HCV	MAV	Trailer
ϵ	0.10	0.10	0.10	0.10	0.10	0.10	0.10
$g(m/s^2)$	9.81	9.81	9.81	9.81	9.81	9.81	9.81
f	0.02	0.02	0.01	0.01	0.01	0.01	0.01
C_D	0.26	0.40	0.60	0.70	0.80	0.80	0.96
ρ (kg/m^3)	1.21	1.21	1.21	1.21	1.21	1.21	1.21
A	2.38	3.38	3.91	10.45	10.49	10.49	11.50
m(kg)	1570	1850	12000	16200	25000	31000	36600



Overall Emission Estimation







Emission by Formulae

- $E_i = \sum E_{ik}$

(He and Zhong, 2014)

- $E_{ik} = \dfrac{\sum EF_{ij} * V_i * L}{10^6}$

Vehicle Category	V_i	L (km)	EF_{ij}			E_{ij} kg/day		
			PM	CO	VOC	PM	CO	VOC
SC/BC	1000	0.5	0.055	4.564	1.183	0.028	2.282	0.592
LCV	120	0.5	0.168	0.870	0.357	0.010	0.052	0.021
Bus	44	0.5	0.694	5.139	1.965	0.015	0.113	0.043
HCV/MAV/ Trailer	310	0.5	1.268	12.028	1.589	0.197	1.864	0.246
					Calculated	0.249	4.312	0.903
					IVE	1.826	11.964	2.163
					Ratio	7.318	2.775	2.396

Conclusions

1. Zone of Influence (ZOI) was found to be total 500m (250m upstream and downstream)
2. Small car and Big cars are the highest emitter for CO
3. The percentage of NOx, VOC and PM were found to be highest from LCV and Bus
4. Empirical methods underestimate the emissions
5. Speed fluctuations should be decreased for better air quality

Recommendations

- The major contributor of NOx, VOC and PM was Bus and LCV, thus making strict measures of dedicated lanes for LCV and Bus will decrease idling cycle and thus helps to decrease the emission level.
- Use of high speed transaction methods such as FasTag will help to decrease emissions.

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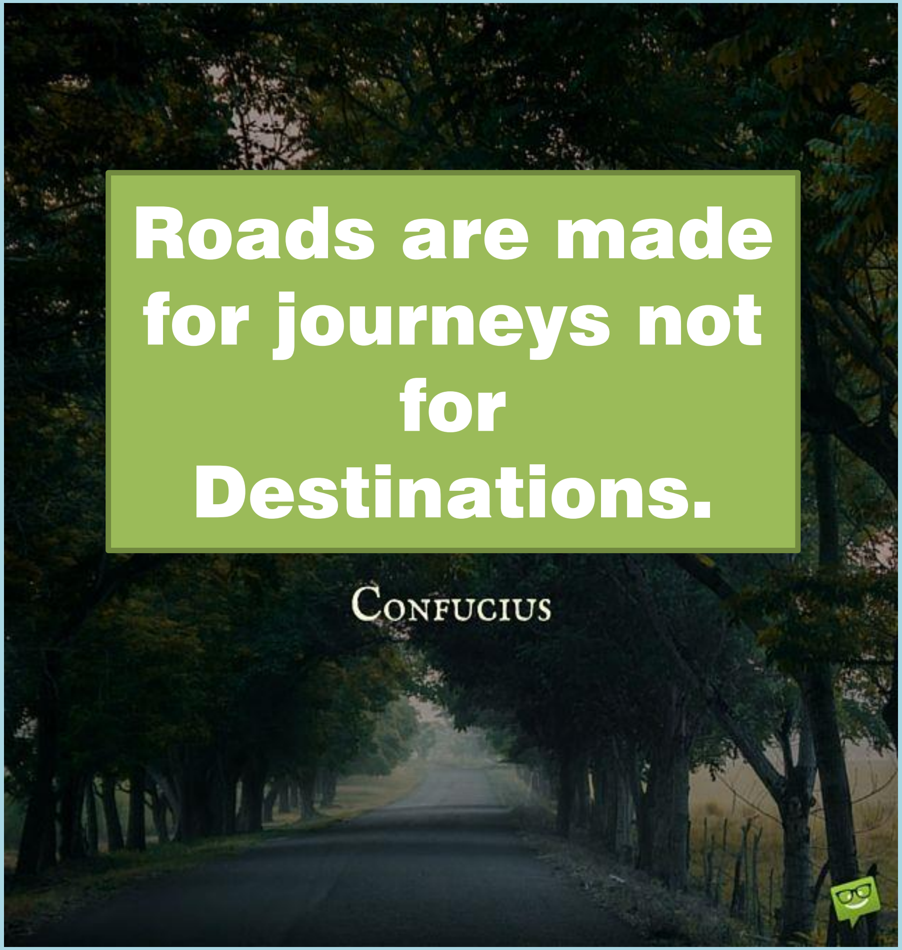
Roads are made for journeys not for Destinations.
Confucius


THANK YOU


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2
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