Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Powered Two-wheeler management in metropolitan areas of developing nations: Case city of Delhi

Sanjay Gupta[a], Sairam Dasari*

[a] *Professor of Transport Planning,School of Planning and Architecture, New Delhi, India*
[*] *Assitant professo (in contract), School of Planning and Architecture , New Delhi, India*

Abstract

The motorized two-wheeler market has been expanding rapidly, particularly in the urbanized areas of Asia. About 80 percent of the 300 million two-wheelers worldwide are in Asia, as are 90 percent of world two-wheeler sale. India has the second largest motorized two-wheeler market in the world, behind China (ICRA 2011). In 2012-13 close to 14 million two-wheelers were sold, more than five times the number of cars sold during the same year (SIAM 2013). India has the second largest motorized two-wheeler market in the world, behind China (ICRA 2011) .A study carried out by the Ministry of Urban Development, GOI in 2006 observed that the share of personalized modes has grown by leaps and bounds in the past couple of decades, especially two-wheelers at 12 percent per annum. Two-wheelers play an important role in motorized transport in Indian cities of all sizes, with the highest modal shares of about 30 percent in small to mid-sized cities.

The present study aims to propose various policy initiatives to manage two wheelers in case Indian cities. The purpose of this study is to collate evidence-based information about the travel behavior of two wheelers collated from various secondary sources that the government could use to refine its policies and practices. The focus of the study is on two wheelers ownership and use, its travel behavior and the potential for a shift from two wheelers to public transport.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: Urbanization, Rapid growth

* Corresponding author. Tel.: +91 9650203176
E-mail address: sairamdasari@mail.com

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY

1. Introduction

This rapid growth of population in urban areas is directly impacting the increase in growth of motorized vehicles. In 2015, the country reported 210.00 million registered motor vehicles, a motorization rate of 167 vehicles per 1000 population and two wheelers rate of 107 vehicles per 1000 population (Road Transport Yearbook, 2015). From 1999 to 2009, number of vehicles per 1000 people in metropolitan cities has increased more than two-fold from 132 to 286 (Figure 1).

The rapid rise of two wheelers in India poses a challenge to planning authorities and policy makers. The increasing dependence on two-wheelers has implications for the ridership and use of public transport that loses mode share .There is a need to better position the role of the two wheelers in providing urban mobility and its integration with other modes in Indian cities. This is especially the case considering potential changes to public transport options and the effect of rising incomes and car ownership. While there have been some attempts to understand the behaviour of two wheelers users in some of the developing countries very little is understood about the mobility patterns of two wheelers and the responses of two wheelers users to policy instruments available to government to better manage the mode in India. This absence of research on two wheelers in Indian cities is an impediment to planning and appraisal of policy initiatives in order to reduce the adverse effects of two wheelers. Hence there is a need to study the travel behaviour of two wheelers in context of Indian cities through reported literature and identify various policy instruments for management of its use in an effective manner

This paper aims to propose various policy initiatives to manage two wheelers in case Indian cities. The purpose is to collate evidence-based information about the travel behaviour of two wheelers collated from various secondary sources that the government could use to refine its policies and practices. The focus of the research is on two wheelers ownership and use, its travel behaviour and the potential for a shift from two wheelers to public transport.

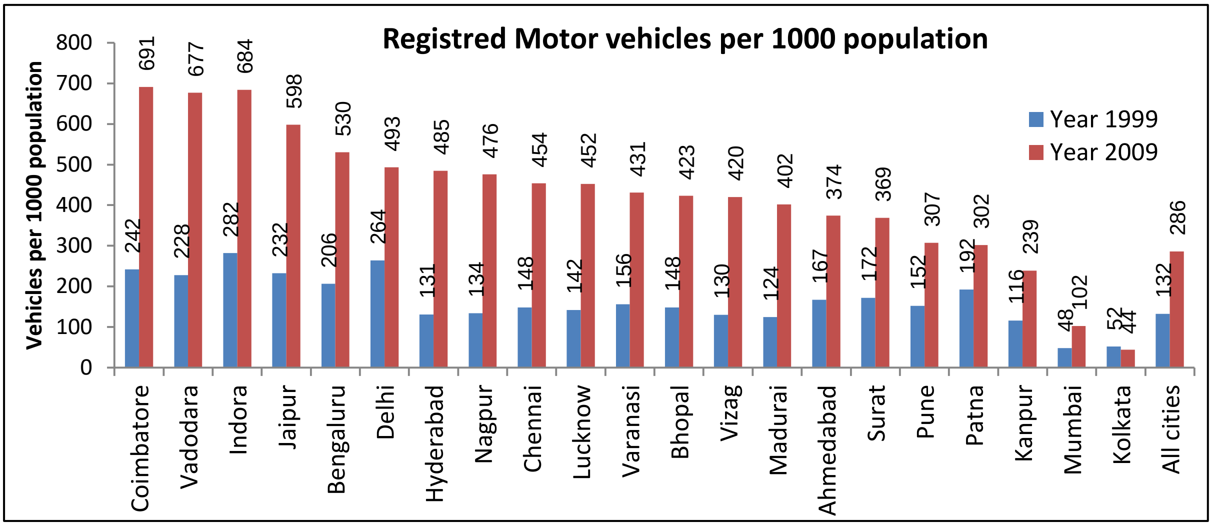


Figure 1 Registered Motor vehicles per 1000 population

2. Global trends of powered two wheelers

Several studies have been conducted from time to time to assess the rise in registration of vehicles in a country. In one such study by the Ministry of Road Transport and Highways, Government of India it was estimated that in India, there are 96 two wheelers for every 1000 persons (as indicated in Table 1).

In the temporal analysis across these countries, it was found that from 2003 to 2010, India experienced a rapid increase in the growth of two-wheelers surpassing Malaysia, Italy and Sri Lanka.

Table 1Population of two wheelers across select countries in relation to their population, gross national income per capita and number of two wheelers per 1,000 population - 2010

Country	Two Wheelers	Population (2010)	GNI per capita 2010 (US $)	Two Wheelers per 1,000 Persons
India	115,419,175	1,208,116,000	1,260	96
China	100,563,646	1,337,825,000	4,270	75
Brazil	14,688,678	194,946,470	9,540	75
Malaysia	9,441,907	28,401,017	7,760	332
U.S.A.	8,212,267	309,349,689	47,350	27
Italy	6,525,820	60,483,385	35,530	108
Germany	3,827,894	81,776,930	42,970	47
Japan	3,501,615	127,450,459	42,050	27
Philippines	3,482,149	93,260,798	2,060	37
Spain	2,707,482	46,070,971	31,460	59
Sri Lanka	2,630,375	20,653,000	6,200	127
Korea, Rep.	1,825,474	49,410,000	19,720	37
U. K.	1,234,000	62,231,336	38,140	20
Mexico	1,156,873	113,423,047	8,930	10
Portugal	544,602	10,637,346	21,830	51
South Africa	327,275	49,991,300	6,090	7

Source: https://data.gov.in/catalog/total-number-registered-motor-vehicles-india [Accessed on 12/11/2016]

3. Growth trends and mobility patterns of powered two wheelers in India

India has the second largest motorized two-wheeler market in the world next to china (ICRA 2011) and there is a chance to increase the market share continues to grow as the India continues to urbanize rapidly. From the below Tables it can be observed that the vehicle growth of two wheeler was rapidly increase in the share of registered motor vehicles between the period of 1981 to 2001 as it reports there is an increase from 48.6% to 70.1% respectively.

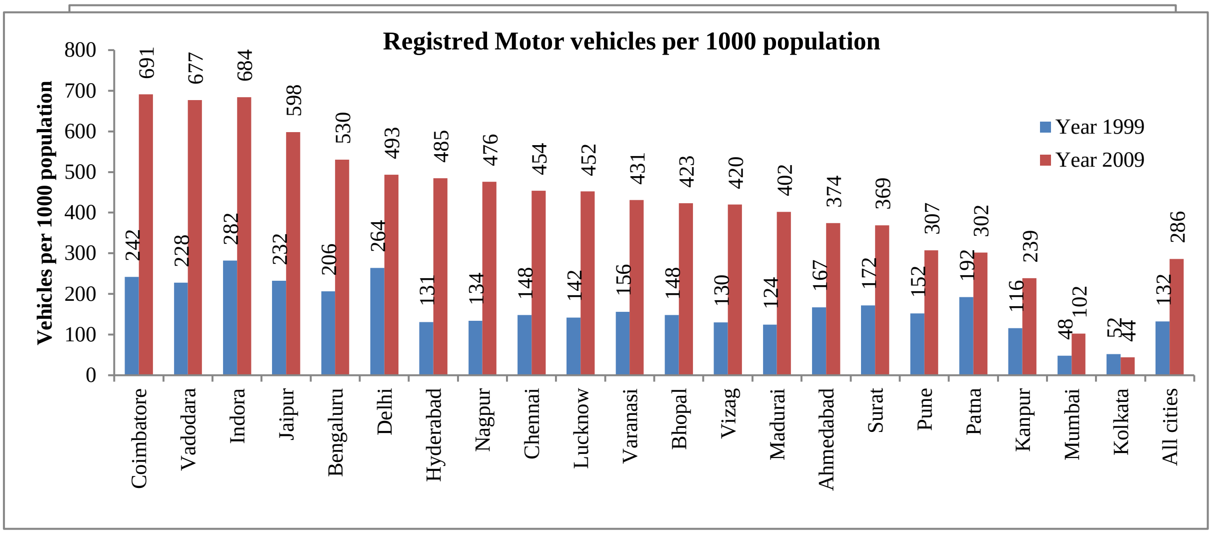


Figure 2 Mode wise Vehicle growth in India

Two-wheelers account for over 73.5% of the total registered vehicle population. Growth of two wheelers is more in urban areas and their percentage share of two wheelers vary from various metropolitan cities. They account for at least 90% of total vehicles in Ahmedabad, Bhopal, Coimbatore, Delhi, Kanpur, Lucknow, Nagpur, Vadodara, Varanasi, and Vishakhapatnam. Two-wheelers alone account for more than 80% of the total vehicles in number of metropolitan cities. For example, during the year 2009, in Nagpur (84%), Varanasi (84%), Surat (83%), Coimbatore (83%), Madurai (82%), Bhopal (81%), Kanpur (81%), Vadodara (81%), Vishakhapatnam (81%), and Lucknow (80%), two-wheelers accounted for at least 80% of the total vehicles. **Table** shows the growth rate of two wheelers from 2000 to 2009.

In India, across all the cities the percentage of two wheelers share is more with comparing to other personalized, public and share modes. As the cost of the vehicle is cheap with comparing to other private modes and it is convenient for middle class and low class income group. Two-wheelers cater to the needs of low and middle income users and help fill the gaps when public transport systems are inefficient, not integrated, or non-existent (PCFV 2010). The reality is that many Indian cities lack substantial and efficient public transport systems. As incomes rise, users of public transport and people limited by their lack of mobility are looking to private modes of transportation to meet their mobility needs. While car ownership may be on the rise, it is two-wheelers that are leading the process of mass motorization as millions of people in India's growing middle class are able to afford an entry-level two-wheeler

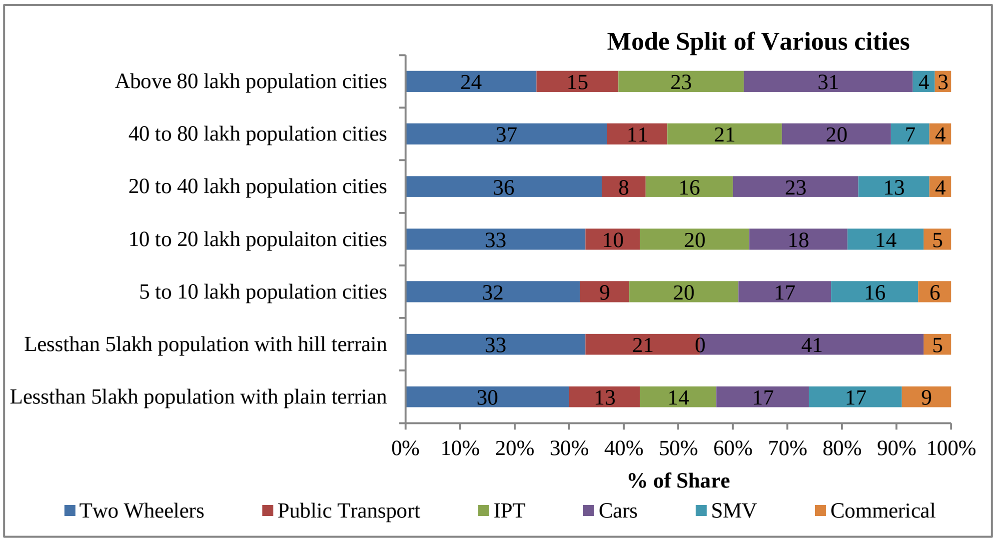


Figure 3 Mode split of various cities

Several cities and countries have notified policies and regulations to improve and restrict the operations of two wheelers in the city. Tables summaries the policies of various nations.

Table 2 Policies/ Regulations of various nations

Sr.no	**Policies/Regulations**	**City / Country**
1	Exclusive Lanes	Taipei, China, Bangalore
2	Banning on certain streets	Metro Manila, Beijing, Xiamen, Mumbai, Hyderabad
3	Capping the number of vehicles	New Delhi, Metro Manila, Mumbai, Jakarta
4	Modal Targets	Guangzhou
5	Road Pricing	Singapore, Taipei, China
6	Road Tolls	Manila, Bangalore
7	Revolving fund for emission reduction	Manila, Kolkatta
8	Hefty charges on plate registration	Yuxi, Quijing, Singapore
9	Banning based on technology	Kathmandu, Colombo, Wuhan, Xianfan, Dhaka, New Delhi
10	Set up two stage left turn regulation	Taipei, China

Table 3 Policies/ Regulations of various nations

Policies/Regulations	City / Country
Ban on Two and 3 wheelers	1.If a city or part of a city is not in compliance with an international or national ambient air quality or noise standard, then the cities are justified in banning or restricting any vehicle in the area 2. Banning motorcycles to reduce traffic congestion will not be successful. To mitigate congestion, restrict access by private, single occupancy, 4 wheeled moto vehicles and taxis to specific lanes 3. Banning bicycles, cycle rickshaws, motorcycles from specific streets because of frequent illegal behaviour by some operators
Restricting number of 2 and 3 wheelers	1. Restricting the number of commercial two and three wheelers, where and whether allowed to cruise for passengers, and where and whether they are allowed to park, is necessary to protect the public interest, but these specific restrictions are a better alternative than outright ban on specific streets or in specific zones 2. Setting Modal targets without placing any restrictions on the growth of private 4 wheelers, is impossible to justify from a traffic congestion mitigation point of view
Providing exclusive lanes for 2 and 3 wheelers	1. Providing exclusive lanes for roads where motorcycles and three wheelers constitute over 50% of the vehicle modal split is not recommended 2. A segregated motorbikes lane may be called for if there are more than 1,000 motorbikes per hour and the traffic composition is greater than 10% and less than 60% motorcycles

4. Profile of case city of Delhi

As per 2011 Census, NCTD had a population of 16.75 million. Delhi is highly urbanized with 93.18% of its population living in urban areas as against the national average of 27.81%. The decadal growth of population for Delhi has declined from 51.45% in 1981-91 to 47.02% in 1991-2001 to 21.92 in 2001-2011 (fig 1). The average annual exponential growth rate of population of Delhi during 2001-2011 has been recorded as 1.92%. The overall population density of Delhi has increased from 9340 persons per sq.km. in 2001 to 11297 persons per sq.km. in 2011 which is highest as compare to All India and other States/UTs.

The existing transport network in Delhi is "Ring and radial' in nature. The transportation network in Delhi is predominantly road based with 1284 km of road per 100Sq.km. The total road length (km. lane) which was 14,316 km in 1981 which increased to 28,508 km in 2001 and 31,373 km in 2009 respectively.

Delhi had a registered vehicle population of 7.45 million in 2011 having increased from 5.21 million in 1981 at a CAGR of 1.20%. Two-wheelers (63%) followed by passenger cars (32%) have major share in the fleet. Table shows the growth trend of registered vehicles in Delhi.

4.1 Per Capita Trip Rate (PCTR)

The per capita trip rate (excluding walk trips) in the city has increased from 0.72 in 1981 to 0.87 in 2001. Per capita trip rate is increasing at the CAGR 1.8% per annum. The table below shows the PCTR details

Table4: Change in PCTR of Delhi, 1981-2007

Purpose	1969	1981	1986	2001	2007
Work	0.29	0.31	0.65	-	
Education	0.08	0.22	0.29	-	
Others	0.12	0.19	0.14	-	
All	0.49	0.72	1.08	0.87	0.70

Source: RITES 1994; RITES, Planning for Mass Transit System for Delhi 1989; Transport Demand Forecast Study and Development of an Integrated Road cum Multi-Modal Public Transport Network for NCT of Delhi – RITES. 2010.

4.2 Average Trip Length (ATL)

In Delhi observed average trip lengths of bus and car in the city in were 10.7 km and 11.3 km respectively. Table below shows the ATL for motorized vehicles for 1969, 1994 and 2007.

Table5: Average Trip Length (ATL) of Delhi – (1969 – 2007)

Year	Overall	Motorised Mode
1969	-	5.4
1994	4.88	7.87
2007	-	10.2

Source: Report of the Working Group On Urban Transport. Ministry of Urban Affairs and Employment, Government of India, New Delhi, February 1996; Wilburg Smith report 2008; RITES 1994.

4.3 Motorized trips

An estimated 15.1 million motorised trips were performed in the city by 2007 of which the share of public transport was 54.7% while two wheelers and cars accounted for 25.5 % and 15.5 % share respectively. The intra-city motorized person trips are increased from 10.8 million in 2001 to 15.1 million in 2007. Table below shows motorised trips trend in Delhi.

Table6: Motorized trip rate of Delhi – (1994 – 2007)

Year	1994	2001	2007
Motorised trips	7.57	10.8	15.1

Source: RITES 1994; RITES, Planning for Mass Transit System for Delhi 1989.

4.3 Modal Shares of Trips

In 2001 about 33% trips were estimated to be walk trips. Among the vehicular trips, the maximum (60%) trips were being performed by buses while the personalized modes of transport were carrying about 27% of vehicular trips in the study area. The modal split in favour of public transport has increased from 41 % in 1969 to 52.5% in 2007

Table7: Modal Share of Trips in Delhi (1969-2007)

Year	1969	1981	1986	1994	2001	2007
Public transport	41	62	62	62	60.5	52.5
Private	59	38	38	38	39.5	47.5

Source: Wilbur Smith report 2008; RITES 1994; RITES, Planning for Mass Transit System for Delhi 1989; Transport Demand Forecast Study and Development of an Integrated Road cum Multi-Modal Public Transport Network for NCT of Delhi – RITES.

5. Powered two-wheeler user characteristics in case city area: Delhi

5.1 Socio-economic profile of powered two-wheeler users

5.1.1 Gender

For this study, 200 samples were collected at various locations and it was observed that the males are using it more with comparing to females. Below Figure shows the share of male and female using two-wheelers as a commuting mode. In past, two wheelers are designed for the male user group as it can be observed from design of the mode. But from the past few years the share of female is increased due to the change in technology and design as it can be observed from the past five years sales of scooter in the market. Below Table shows the last five year sales for two wheelers by typology

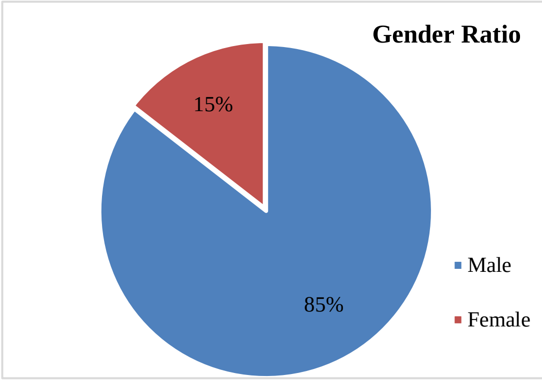


Figure 4 Percentage shares of male & female users using powered two-wheeler

Table 8: Modal Share of Trips in Delhi (1969-2007)

FY	Scooter	GR %	Motorcycle	GR %	Total Two wheeler	GR %
FY 12	2558981	19%	10073303	12%	13409150	14%
FY 13	2923424	21%	10085000	0%	13797185	3%
FY 14	3602743	21%	10481115	4%	14806778	7%
FY 15	4500920	28%	10726013	2%	15975561	8%
FY 16	5021678	31%	10700466	0%	16455911	3%

5.1.2 Age profile of the users

80% of the users are under the age group of 18 to 35 within that males are about 60% and females are 20%. Young and working age group are the most users

Male	Age group	Female
2%	Lessthan18	0%
18%	18 to 25	68%
56%	25 to 35	25%
22%	35 to 50	7%
1%	50 to 60	0%

Figure 5 Age & Gender pyramid

5.1.3 Age profile of the vehicle

From the interview based survey, it is observed that there are very less percentage of people using two wheelers which are above 5 years old. All Most 60% of the user's vehicle age is less than 3 years and almost all user education levels are up to under graduation. At the time survey most of the users stated that, till there income levels reaches to afford a car till they use or till they got a family because of lower occupancy levels.

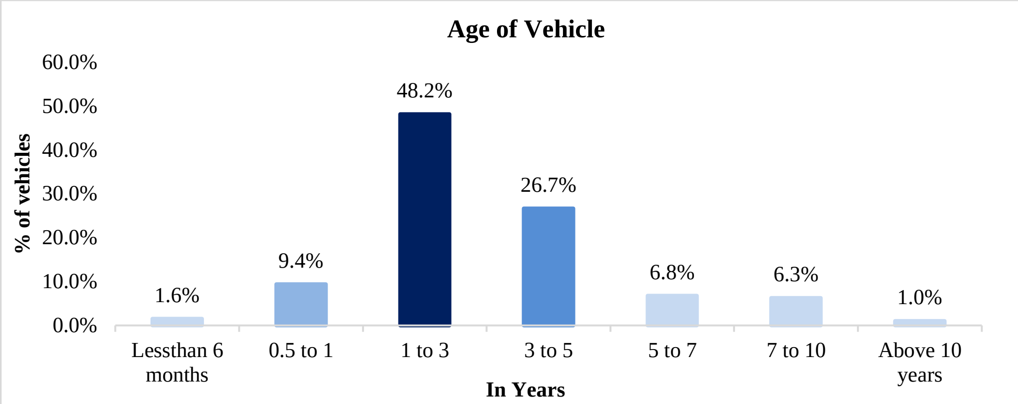


Figure 6 Age profile of vehicles

5.1.4 Occupation of the users

Two wheelers are mostly using by the daily commuters such as office employee with 39.4%, business persons with 31.6% and students with 18.7% share in the total surveyed users. Below figure shows the percentage distribution of users with respective to their occupation levels.

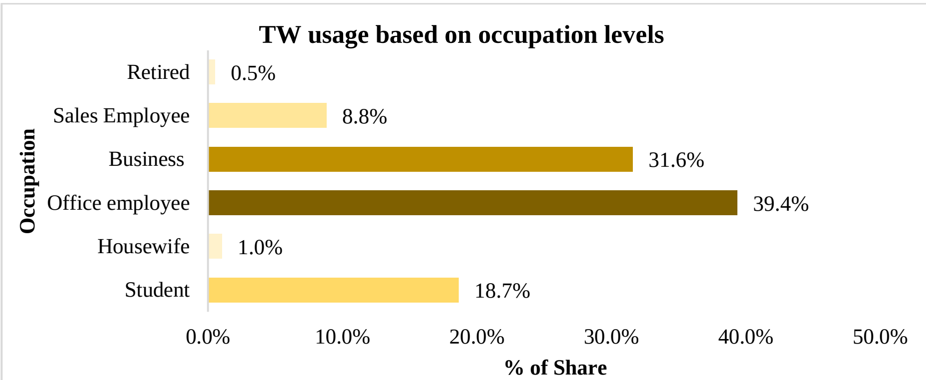
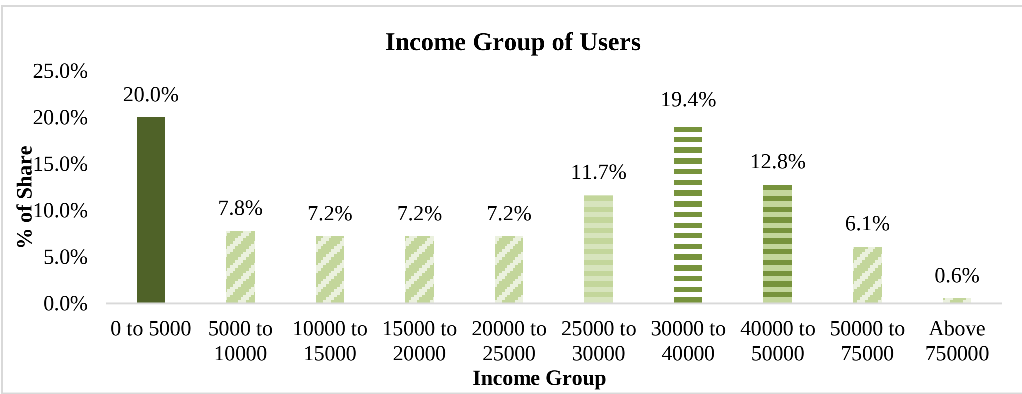


Figure 7 Two-wheeler users occupation levels

5.1.4 Income levels of the user

Form this it is clearly indicated that two wheeler is using by the low and middle class group income levels. Only 18.5% users with income greater than 50000 Rs. per month are using two wheeler and about 20% of the user's income is less than 5000 Rs. per month. Below figure presents the percentage share of users based on their income levels



5.2 Mobility Characteristics of powered two-wheeler users

5.2.1 Monthly total distance travel using powered two-wheelers

About 58% of the users travel distance lies between 750 to 1500Km distance as it used as daily commuting mode. In the short distance travel bands students % is more and in the longer distance travel bands office employee share is more with comparing to other users. The below Figure shows the distribution trips based on the monthly travel and Figure shows the monthly travel based on the occupation levels.

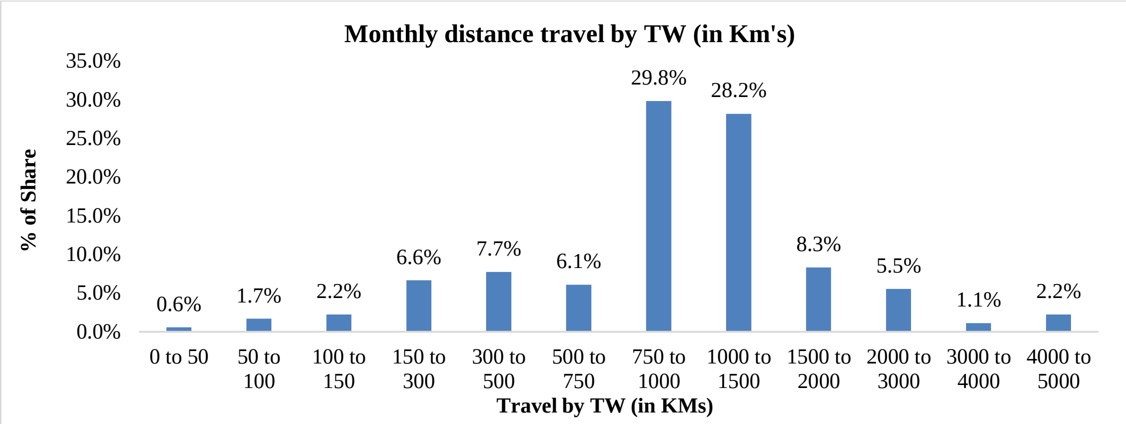


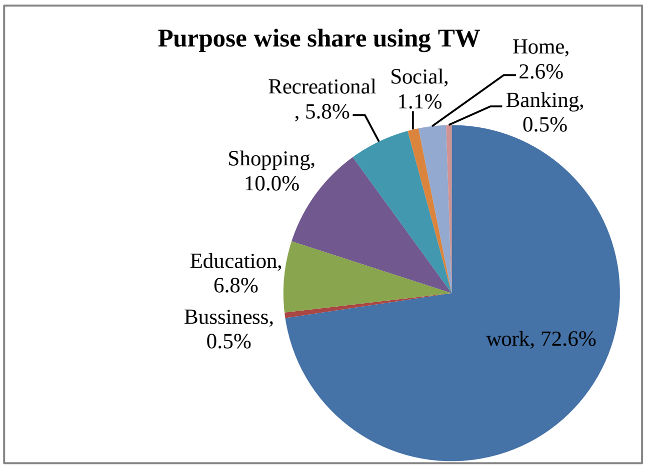
Figure 8 Trip length frequency distribution of powered two-wheeler users (Monthly)

Table 9: Average Distance Travelled & ATL of powered two-wheeler users

Occupation Levels	**Average distance travelled (per month in KM)**	**Average distance travelled (per Day in KM)**	**Average Trip Length (in KM)**
Student	833	28	9.2
Housewife	550	19	7.5
Office employee	1385	46	9.7
Business	1193	40	9.5
Sales Employee	1668	56	8.6
Overall	1126	38	9.1

5.2.2 Share of two wheeler usage based on purpose

From the sample survey it is observed that almost 72.6% of the users are using two wheeler for work purpose and 10% for shopping purpose. As the office employees and business users are more the usage under work purpose share is more with comparing to other purposes. Below Figure shows the purpose wise share of using two wheeler as a commuting mode.



5.2.3 Parking fee distribution

81% of users are paying Rs.5/- as parking fee even at the major commercial place where parking supply is low the congestion levels are more. The parking cost is which very low with comparing other modes, as car users parking fee is twice or thrice to the two-wheeler parking price.

5.3 Powered Two-wheeler users behaviour analysis

5.3.1 Attitudinal response towards using two-wheeler

Reasons for not using Two-wheeler

51% of the users are using two-wheeler as it offers cheap travel for short distance trips and they take less time to reach their distance. 30.6% of users stated that it is very convenient and they find easy parking at the destination. Only 8.4% people stated because of absence of reliable and cheap alternative mode they are using the existing mode.

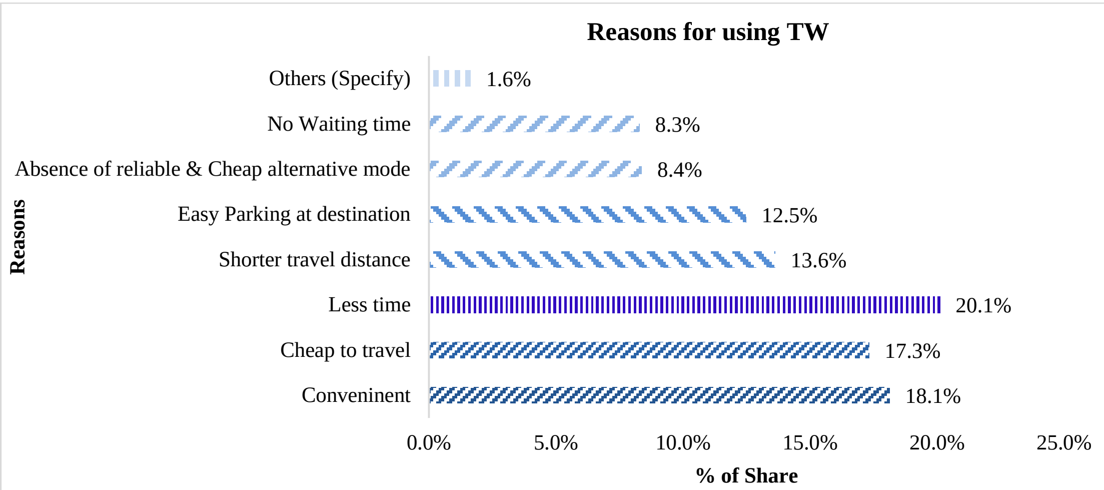


Figure 9 Reasons for not using Two-wheeler

Reasons for Using TW	Weighted Score	Preference
Less time	6.5	1
Convenient	5.9	2
Cheap to travel	5.6	3
Shorter travel distance	4.6	4
Easy Parking at destination	4.2	5
Absence of reliable & Cheap alternative	2.9	6
No Waiting time	2.8	7
Other Reasons	0.6	8

Conditions for not using two-wheelers

At the time of interview based survey, lists of conditions were observed when the users are not willing to use the two-wheeler. 56.1% users stated that when they are travelling with family and for social trips they are less likely to use the two-wheeler, as its passenger occupancy level is very low. 23.1% users are not using the two-wheeler during the night time and 18.6% users are rejecting two-wheeler as a travel mode in winter months.

Reasons for not using TW	% of Share
Summer Months	2.3%
Winter Months	18.6%
Night Time	23.1%
Travelling with family	31.2%
Recreation/ Social trips	24.9%

Response on hazardous of using two-wheeler

43.4% users are responded on exposure to extreme weather conditions and 32.0% users respond to exposure to hazard traffic conditions.

Hazards of using TW	% of Share
Exposure to Hazard traffic condition	32.0%
Exposure to extreme weather (Rain, Winter, Summer)	43.4%
Glazing of lights in night	23.7%
Other Reasons	0.9%

5.4 Modelling willingness to shift of two-wheeler users

5.4.1 Introduction

The purpose of this study is to estimate a model to determine the factors which influence the two wheeler trips in the case study area. The economic theory behind the analysis can be summarized by the following conceptual model:

Two wheeler trips = f (Travel time, Travel cost (incl. fuel cost & parking fare), distance of travel)

The willingness to shift from two wheeler trips is expected to be inversely related with the travel cost and travel time of the trips.

5.4.2 Methods

The analysis is conducted with data collected from the survey. The variables used in the empirical analysis are described in Table 1. The descriptive statistics are presented in the below Table.

The dependent variable which measures the willingness to shift from existing mode to alternate mode trips at different costs and travel time is YES. YES is equal to 1 if the respondent would shift from existing mode to alternate mode if the travel cost and travel time savings are higher, where cost and travel time is a randomly varied amount, and 0 otherwise. Since the dependent variable is discrete, the ordinary least squares regression can be used to fit a linear probability (LP) model. However, the linear probability model is heteroskedastic and may predict probability values beyond the (0, 1) range, the binary logistic regression model is used to estimate the factors which influence mode-shift behaviour (Stynes and Peterson, 1984; Greene, 1997).

From the stated preference survey it is observed that among all alternative modes, considerable users respond to shift towards metro and city bus and very negligible percentage is recorded shifts towards shared mode, based on the variables. For this study, alternate mode is considered as public transport (Metro and city bus) as there savings in travel time and travel cost is higher with compare to shared modes. The table below shows the willingness to shift results with respective to alternate modes.

Willingness to shift (mode)	Yes	NO	Total
Two Wheeler to Share Auto	0.6%	99.4%	100.0%
Two Wheeler to Share Taxi	1.0%	99.0%	100.0%
Two Wheeler to City Bus	7.3%	92.7%	100.0%
Two Wheeler to Metro	20.2%	79.8%	100.0%

5.4.3 Results

Binary Logistic regression results are presented in Table 3 and Table 4. Two models are presented, the dependent variable in each is whether the two wheeler users would from the existing mode if the savings in time and cost of the trips were to increase (YES=1 if they would shift to alternate modes, 0 otherwise). Each model includes different blocks of independent variables.

A Test of Rational Choice Theory

The most parsimonious model includes only the randomly assigned variables which specify the savings in travel cost and travel time. The results from Model 1 indicate that two wheeler users behave according to economic theory. As the savings in travel costs and travel time s increase, they are less likely to be willing to continue in the existing mode. The block chi-square statistic is significant at the .01 level (critical value = 9.21 [df=2]), The model predicts 91.1% of the responses correctly. The McFadden's R2 is almost 100% (Amemiya, 1981). The coefficients of the model variable are statistically significant at the .05 to .10 levels.

Additional Tests of Distance Theory

Model 2 includes one additional theoretically important independent variable: Distance band. According to the block chi-square statistic, Model 2 is superior to Model 1 in terms of overall model fit. Increasing in distance bandwidth is associated with increased likelihood of exhibiting shift to city bus services and Metro. Total seven distance band widths worked out based on the trips frequency based on travel distance. These seven distance band widths are considered in the second level model as a disaggregated level. The average block chi-square statistic is significant at the .01 level (critical value = 9.21 [df=2]), the average percentage of correct predictions at seven bandwidths is 91.1% with a minimum 89% and maximum of 93.4% and the McFadden's-R2 value is almost 100% larger. The coefficients on the distance variable are statistically significant at the .05 to .10 levels.

The users most likely to shift from the existing mode to city buses at the distance bandwidths of 9 to 18kms where the percentage of shift is 1.58 times more with comparing to other distance bandwidths in the two wheeler to city bus service and metro model. It is observed, for the short length trips is associated with increased likelihood shift from two wheeler to metro case.

5.4.4 Conclusions

The purpose of this study was to estimate a model to determine the factors which influence two wheeler users in the case study area. The empirical results indicate distance theory is supported: two wheeler users are responding rationally to increases in savings of trip cost and travel time. Also, the travel distance (distance band widths) has important effects on the willingness to shift.

Table10: Variables

Variable	**Variable Description**
Yes	Response to the question: if the distance of X if you could save Y cost and Z time then you will shift to city bus? Yes 1 or No 0
Travel Time	Increase Savings in travel time (Enhance the public transport service)
Travel cost	Increase Savings in travel cost (Increase the parking price & Fuel price)
Distance band widths	Distance bandwidths developed based on the frequency of trips on each bandwidth

Table11: Descriptive statistics for YES (“1”) (Tw to City bus)

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Savings in Travel Time (in mins)	294	10	49	29	10.69
Savings in Travel cost (in Rs)	294	11	90	51	22.49
Distance (in Km)	294	3	20	12	6.26

Table12: Descriptive statistics for YES (“1”) (Tw to Metro)

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Savings in Travel Time (in mins)	294	8	12	10	5.73
Savings in Travel cost (in Rs)	294	8	12	10	20.05
Distance (in Km)	294	3	20	12	1.41

Table13: Logistic Regression Results (Tw to city bus)

Model No	Distance	Variable	ASC**	Travel Time	Travel Cost	Model Chi-Square [df]	% Correct Predictions	Nagelkerke R Square
Model 1	Overall	Coefficient	-2.302	-0.017	-0.008	0.752[2]	91.1	0.001
		t-stat	259.074	0.668	0.747			
Model 2	0 to 3 kms	Coefficient	-0.619	-0.248	-0.087	0.35[2]	89.0	0.001
		t-stat	0.056	0.260	0.287			
	3 to 6 Kms	Coefficient	-2.395	-0.131	-0.069	0.284[2]	93.4	0.001
		t-stat	4.833	0.185	0.218			
	6 to 9 Kms	Coefficient	-2.718	-0.032	-0.021			
		t-stat	7.305	0.021	0.056	0.424[2]	92.8	0.002
	9 to 12 Kms	Coefficient	-2.064	-0.079	-0.032	0.376[2]	91.1	0.002
		t-stat	14.476	0.255	0.194			
	12 to 15 Kms	Coefficient	-1.232	-0.243	-0.093	3.302[2]	89.7	0.013
		t-stat	3.241	3.250	3.152			
	15 to 18 Kms	Coefficient	-1.905	-0.119	-0.054	1.316[2]	90.7	0.006
		t-stat	7.946	1.261	1.294			
	Above 18 Kms	Coefficient	-0.484	-0.105	-0.034	2.481[2]	90.7	0.01
		t-stat	0.184	1.611	0.936			

Note: The Wald statistics are distributed chi-square with 1 degree of freedom.

The coefficient is statistically significant at, at least, the .10 level.

*ASC** indicates the Alternative specific constant*

Table14: Logistic Regression Results (Tw to Metro)

Sr. No	Distance	Variable	ASC**	Travel Time	Travel Cost	Model Chi-Square [df]	% Correct Predictions	Nagelkerke R Square
Model 1	Overall	Coefficient	-1.886	-0.076	-0.013	173.723[2]	79.4	0.074
		t-stat	418.626	90.576	34.868			
Model 2	0 to 3 kms	Coefficient	-0.886	-0.131	-0.034	1.995[2]	73.4	0.006
		t-stat	4.623	1.551	0.769			
	3 to 6 Kms	Coefficient	-2.378	-0.059	-0.037	2.834[2]	90.3	0.012
		t-stat	62.026	0.0521	0.621			
	6 to 9 Kms	Coefficient	-2.548	-0.050	-0.019	1.528	89.5	0.006
		t-stat	49.554	0.038	0.359			
	9 to 12 Kms	Coefficient	-3.094	-0.010	-0.041	19.217[2]	84.9	0.064
		t-stat	35.782	0.002	1.983			
	12 to 15 Kms	Coefficient	-2.161	-0.098	-0.014	0.884[2]	83.9	0.003
		t-stat	10.316	0.210	0.501			
	15 to 18 Kms	Coefficient	-3.439	-0.052	-0.034	19.398[2]	83.5	0.062
		t-stat	2.799	0.041	2.139			

Note: The Wald statistics are distributed chi-square with 1 degree of freedom.

The coefficient is statistically significant at, at least, the .10 level.

*ASC** indicates the Alternative specific constant*

6. Policy Interventions

According to World Health Organization (WHO), Delhi tops the list of most polluted cities. Among the world's 20 most polluted cities in the world, 13 are in India. India is in the group of countries that has the highest particulate matter (PM) levels. Its cities have the highest levels of PM10 and PM2.5 (particles with diameter of 10 microns and 2.5 microns). At the level of more than 150 micrograms, Delhi has the highest level of airborne particulate matter

PM2.5, considered most harmful. In this chapter, various policies were tested to manage the two – wheeler in the case cities area and their impact on user's mode selection.

Board level polices has been tested, to study the impact on mode selection of the two wheeler users based on the travel cost and travel time. Polices are developed which has a benefits in travel cost, travel time and combination of two factors.

6.1 Increase in fuel prices

Two-wheeler travel cost is very low (1.8rs/- per Km.) with comparing to other alternate mode. At present fuel price is 66.0rs/- per liter. It is proposed to increase the fuel price to 20% of the existing fuel price. In future petrol prices will be 79/-rs. Per liter. As the fuel price of two -wheeler increase the shorter trips length trips cost will increase so it has greater shift towards with comparing to other distance bandwidths and same for the long trip length as the transit fares for long trip length trips cost is low. Below tables shows the mode shift analysis of two-wheelers to alternative transit modes at various bandwidths.

Table15: Model results of Increase in fuel prices

Distance (in KM)	% Tw to Metro	% Tw to Bus
0 to 3	19.30%	2.30%
3 to 6	9.80%	2.20%
6 to 9	8.30%	5.00%
9 to 12	10.80%	3.70%
12 to 15	12.50%	0.40%
15 to 18	11.00%	1.90%
Above 18		2.80%
Overall	15.50%	7.30%

6.2 Decrease in wait time of public transport modes

Choice of public transit is majorly depends on the users access/ dispersal time and wait time at the transit stop. If this time is increases the users preference to personalized modes in their economic level will increase which leads to congestion and emission levels in the city. Providing public transport with less wait time and access & egress time, users will shift towards the transit time. Existing wait time in the study area is 7mins for the bus system and 4mins for the metro system. As a part of the study wait time of the transit were reduced to 50% of the existing wait time. The proposed wait time for the bus system is 3.5mins and for metro 2mins and it is observed that there is an increase of mode is happened with comparing to the fuel price at overall level. At the long trip length distance the probability of shift towards the transit is higher with comparing to other distance band widths as the give more benefit to the users in terms of travel cost and travel time. Below table represents the mode shift analysis of two-wheelers to alternative transit modes at various bandwidths.

Table16: Model result of Decrease in wait time of public transport

Distance (in KM)	% Tw to Metro	% Tw to Bus
0 to 3	27.80%	8.50%
3 to 6	11.10%	3.90%
6 to 9	9.30%	5.60%
9 to 12	9.20%	5.00%
12 to 15	16.20%	1.00%
15 to 18	10.30%	2.50%
Above 18		3.70%
Overall	18.80%	7.70%

6.3 Increase in parking fee and decrease in wait time of transit modes

For this study, two policies are combined one with benefit in travel cost and the other one with benefit in travel time. So increase in parking cost and decrease in travel time are combined to see the combine effect of user's mode choice selection as it gives higher benefit in travel time and travel cost from all the polices and it is observed there is a huge impact on short trip lengths and long distance trip lengths as there benefits in travel time and cost are higher. Below table shows the shift analysis at various distance bandwidths towards transit system.

Table17: Model result of combine increase in parking price and decrease in wait time of Public transport

Distance (in KM)	% Tw to Metro	% Tw to Bus
0 to 3	43.20%	34.60%
3 to 6	20.70%	14.00%
6 to 9	15.40%	10.00%
9 to 12	25.80%	12.10%
12 to 15	25.20%	29.90%
15 to 18	31.00%	18.40%
Above 18		13.00%
Overall	25.80%	9.70%

6.4 Summary of policies impact on mode selection

A comparative analysis has been done to understand the benefit of each polices and it is observed the combination of increase in parking fee and decrease in wait time gives more benefit in the shift analysis as they offer benefits in travel and travel cost. Below table and figure shows the all police scenarios at various distance bandwidths and at overall level.

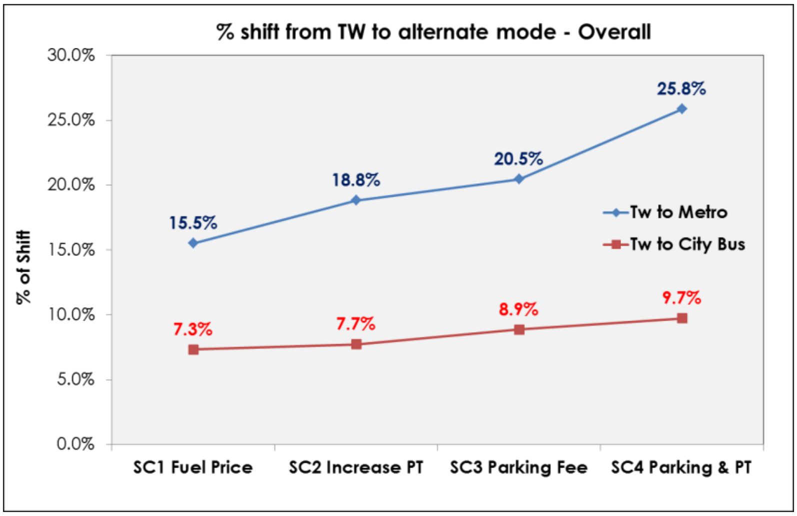


Table18: % shift from Two-Wheeler to Metro at various scenarios

Distance (in KM)	SC1 Fuel Price	SC2 Increase PT	SC3 Parking Fee	SC4 Parking & PT
0 to 3	19.30%	27.80%	31.00%	43.20%
3 to 6	9.80%	11.10%	17.10%	20.70%
6 to 9	8.30%	9.30%	13.00%	15.40%
9 to 12	10.80%	9.20%	25.00%	25.80%
12 to 15	12.50%	16.20%	18.60%	25.20%
15 to 18	11.00%	10.30%	26.70%	31.00%
Overall	**15.50%**	**18.80%**	**20.50%**	**25.80%**

Table19: % shift from Two-Wheeler to City at various scenarios

Distance (in KM)	SC1 Fuel Price	SC2 Increase PT	SC3 Parking Fee	SC4 Parking & PT
0 to 3	2.30%	8.50%	10.70%	34.60%
3 to 6	2.20%	3.90%	6.90%	14.00%
6 to 9	5.00%	5.60%	8.40%	10.00%
9 to 12	3.70%	5.00%	7.90%	12.10%
12 to 15	0.40%	1.00%	9.00%	29.90%
15 to 18	1.90%	2.50%	9.90%	18.40%
Above 18	2.80%	3.70%	7.40%	13.00%
Overall	**7.30%**	**7.70%**	**8.90%**	**9.70%**

7. Conclusions

7.1 Findings from the case study

Finding from the study of the case city are as following:

- Motorised two wheelers are predominantly used for work purpose followed by shopping and education purposes.
- 75% of two wheeler users have trip length within 12 km for work purpose and 7 km for education purposes
- There is a potential of about one third of two wheeler users to shift to public transport systems like metro and bus system provided there is improvement in public transport system service delivery coupled with enhancement of parking fees for two wheelers.
- There is a larger shift towards metro expected from two wheeler riders in comparison to bus system possibly owing to unstable operating environment of city buses in comparison to guided mass systems like metro in Delhi.

7.2 7.4 Recommended Strategies for Management of motorized Two-wheelers

- Discourage parking for two wheelers particularly in areas which are well served by efficient public transport such as city centres, work zones, activity areas etc. through reduced parking supply and increased parking fees
- Provide adequate park and ride facilities for two wheelers at transit stations to encourage use of mass transit for long journeys
- Incentivise use of shared taxi cabs, car-pooling, public transport for motorised two wheeler users (discount vouchers, travel vouchers, etc.)
- Promote development of reliable, safe and good quality public transport on priority along major travel corridors served by good last mile connectivity
- Provide public information campaign to educate motorised two wheelers regarding safety and environment hazards of using motorised two wheelers and benefits of using mass transport system
- From transport planning perspective it is important to understand the two wheeler user attributes, his/her two wheeler usage pattern and the behaviour towards alternate modes which is vital toward evolving rationale motorized two-wheeler policies.
- Integrated land use – transport planning policies need to be adopted in cities of developing countries through restricting sprawl development and focus on compact urban form/structure which enable smart growth patterns and discourage use of personalised modes
- It is necessary to build in safety aspects of motorised two wheelers in urban transport planning and policy process and recommend transport infrastructure thereof.
- Safe Public transport provision for all should be viewed by urban local bodies as an obligatory function for city's economic growth and social equity
- Need for countries in developing world to undertake mobility behaviour studies of two wheelers and adopt policy measures for encouraging modal shift to public transport and enabling low carbon mobility environment.
- Countries need to provide the necessary statistical information on the safety and use of motorised TW
- Number of vehicles per type of motorised two wheelers and per standard age group,
- Kilometres per type of vehicle, per age group, and if possible per type of road,
- Numbers of accidents/injuries per type of vehicle, age group, and per type of road.
- There is a need to create repository of motorised two wheeler data base particularly for developing countries and develop tool kit for managing two wheeler traffic under varying operating environment

8. References

[1] Arora, R. (2016, June 4). Government all set to legalise two-wheeler taxis . *Economic Times* .

[2] EMBARQ. (2014). *Motorised Two Wheelers in Indian Cities: A Case Study of the City of Pune* . EMBARQ, India .

[3] Government of India . (2010). *Two Wheelers per 1,000 Persons of selected countries.* Retrieved from Open Government Data Platform India: https://data.gov.in/catalog/two-wheelers-1000-persons-selected-countries

[4] Government of India. (2010). *Total Number of Registered Vehicles in India.* Retrieved from Open Government Data Platform India: https://data.gov.in/catalog/total-number-registered-motor-vehicles-india

[5] HT Correspondent . (2013, March 13). Now a survey confirms it: Two-Wheelers rule Indore roads. *The Hindustan Times*.

[6] IANS. (2016, March 3). Two-wheeler taxi services uberMOTO, Ola Bike launched. *Business Standard*.

[7] J. Junior, M. F. (2002). The Brazilian Motorcycle Taxi Phenomenon. *Traffic and Transportation Studies*, 1566-1572.

[8] Jayaram, A. (2014, June 18). For Indians, two-wheelers are the vehicles of choice. *The Business Line*.

[9] Kaushiki, H. (2016, February 26). At 140% rise, two-wheelers take over Gujarat Roads . *The Times of India* .

[10] Mathur, A. (2011, November 4). More two-wheelers take to Delhi roads than cars. *Hindustan Times* .

[11] Mech Dara, M. B. (2013, July 16). Tuk-Tuk, Motorcycle-Taxi Drivers Get Lesson in Helmet Use. *THe Cambodia Daily*.

[12] Osava, M. (2016, November 14). TRANSPORT-BRAZIL: Helicopters, Motorcycles as Alternative Taxis. *IPS News Agency*.

[13] Ranjan, R. (2015, December 8). 55 lakh bikes are the biggest Delhi polluters. *India Today*.

[14] Ray, A. (2015, July 29). At 55 lakh, Bengaluru has most vehicles plying after Delhi. *The Times of India*.

[15] Sen, S. (2016, March 14). Experts alarmed as 2-wheeler count in Mumbai doubles in 10 years. *The Times of India*.

[16] The Hindu. (2013, September 27). Bangalore, A city of two-wheelers. *The Hindu*.

[17] UNEP. (n.d.). *Managing 2 & 3 wheelers in Asia.* Nairobi: United Nations Environment Programme. Retrieved November 14, 2016, from http://www.unep.org/transport/pcfv/pdf/23-Wheelers-in-Asia-Book.pdf