

**“TO DEVELOP METHODOLOGY FOR
PRIORITIZATION OF ROAD SAFETY
MEASURES.”**

CASE STUDY :DELHI NCT

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Code - 05049

Global scenario of Road Accidents



Together We can
Save millions
of lives.



**DECADE OF ACTION FOR
ROAD SAFETY 2011-2020**

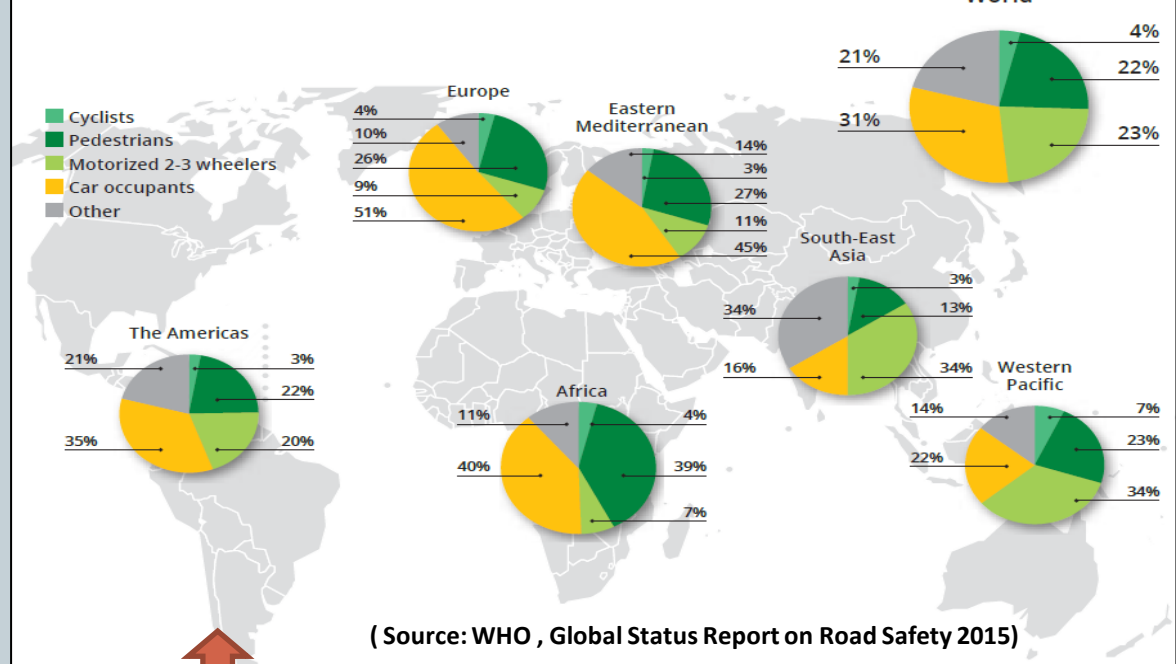
➤ The **"Decade of Action for Road Safety 2011-2020"** was officially proclaimed by the United Nations General Assembly in March 2010

➤ Globally, road traffic crashes is the main cause of death among those aged 15-29 years.

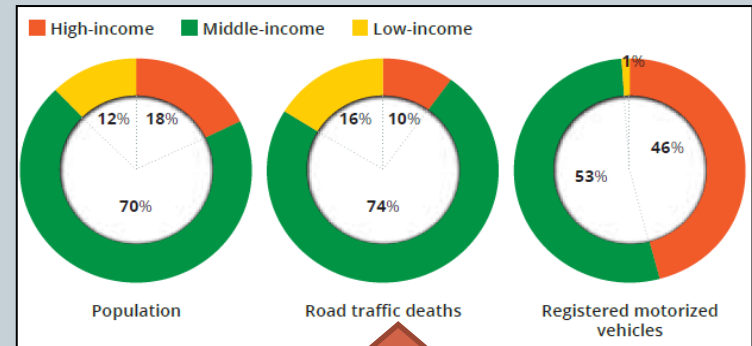
➤ Global Road Injury Mortality rate is 18 deaths per 1 lakh population and for India it is 18.9 with no. of **global deaths 1.25 Million per year**

➤ Middle-income countries have the highest annual road fatality rates, at 20.1 per 1 lakh population, **74 % of road traffic deaths occur in middle-income countries**, which account for 70% of the world's population, but only 53% of the world's registered vehicles.

Road traffic deaths by type of road user, by WHO region



It can be noted that Worldwide, Motorcyclists and Pedestrian deaths account for 45% of Road deaths



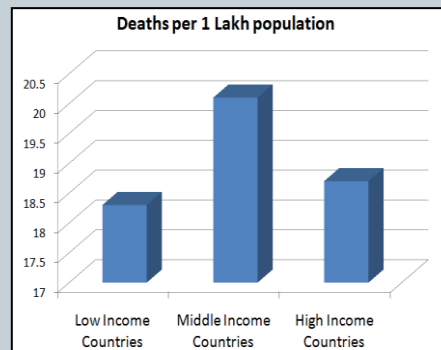
Population, road traffic deaths, and registered motorized vehicles of Countries (income wise)

"Road Accidents is a major BUT Neglected public health issue worldwide !"



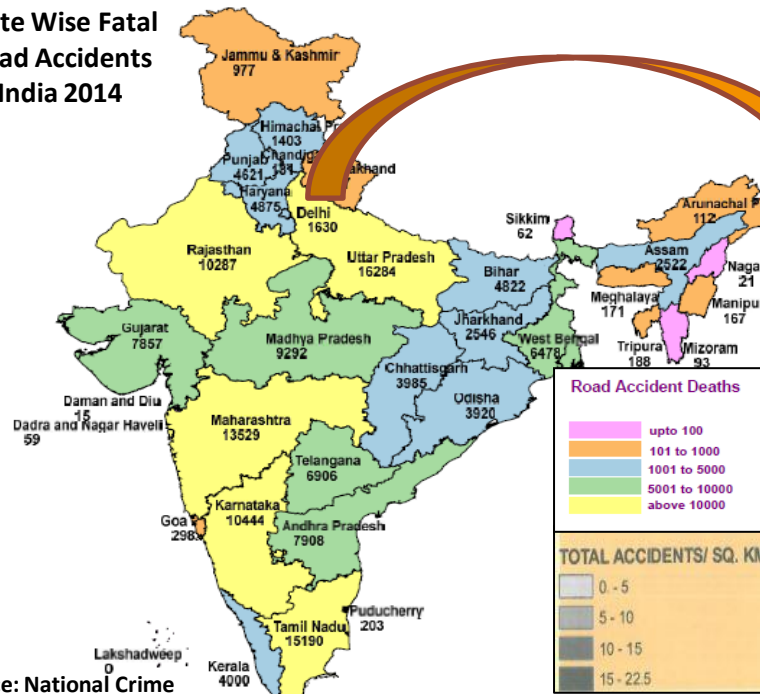
Source: WHO , Global Status Report on Road Safety 2015

Type of Country	Deaths per 1 Lakh population	Proportion out of Global traffic related trends
Low Income Countries	18.3	10%
Middle Income Countries	20.1	74%
High Income Countries	18.7	16%

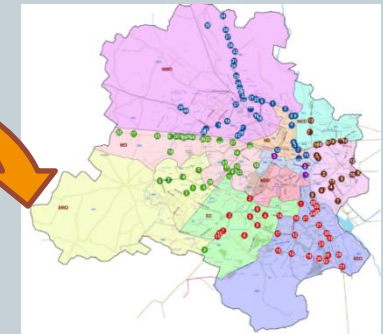


Road Accident scenario in India

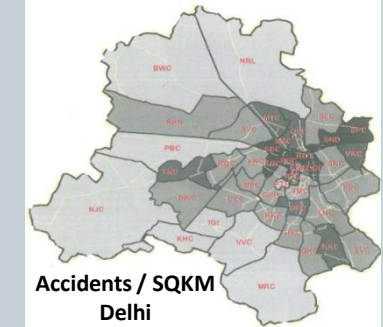
State Wise Fatal Road Accidents India 2014



Source: National Crime Records Bureau



137 Black Spots identified by Delhi Police



Accidents / SQKM Delhi

Road Accident Trend in Delhi

Year	Non Fatal Accidents	Fatal Accident	Persons Injured	Persons Killed
2008	6058	2015	7343	2093
2009	5113	2272	6936	2325
2010	5093	2104	7108	2153
2011	5162	2047	6975	2110
2012	5000	1822	6639	1866
2013	5619	1778	7098	1820
2014	6785	1630	8283	1671
2015	6343	1582	8258	1622
Total	45173	15249	58640	15660

Source: "Road Accidents in Delhi" Booklet by Accident Research Cell, Delhi Police

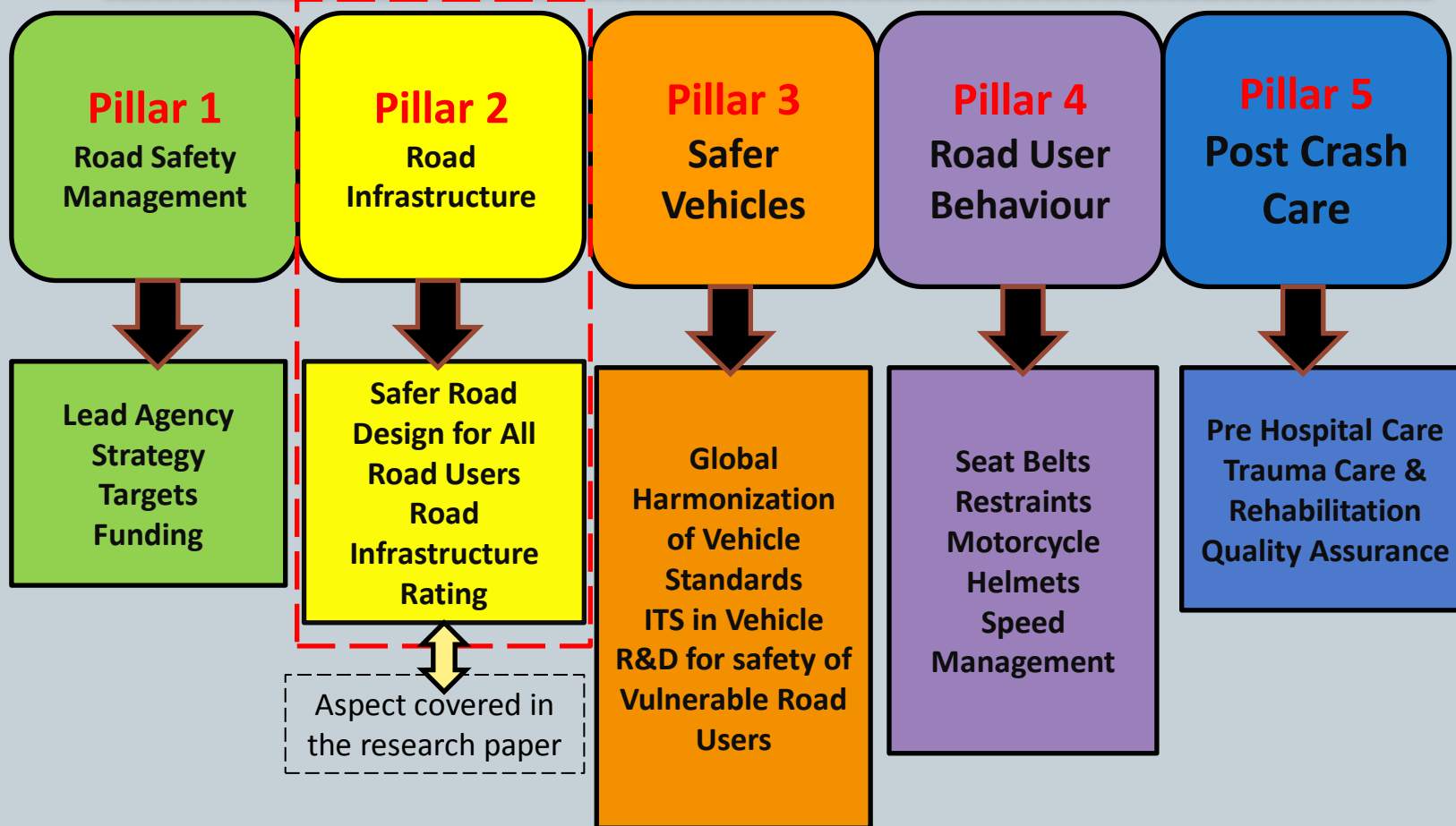
As per Delhi Police an accident black spot has been defined as a place where 3 or more fatal accidents or 10 or more non fatal accidents have taken place in a year

Statistical Facts

- Road crashes cost up to 3% of the country's GDP.
- The total number of road accidents increased by 2.5% from 4,89,400 in 2014 to 5,01,423 in 2015.
- The total number of persons killed increased by 4.6% from 1,39,671 in 2014 to 1,46,133 in 2015
- Road accident injuries have also increased by 1.4% from 4,93,474 in 2014 to 5,00,279 in 2015.
- Accident severity (number of persons killed per 100 accidents) has gone up from 28.5 in 2014 to 29.1 in 2015
- For the year 2015, 1374 accidents and 400 deaths take place every day on Indian roads
- Road accidents have injured more than 58000 people in Delhi in last 8 years
- Road accidents have led to death of 15660 people in last 8 years in Delhi.

Source: "Road Accidents in India-2015" Annual Report by MoRTH

Literature Study: 5 Pillars of Road safety- Decade Action Plan United Nations

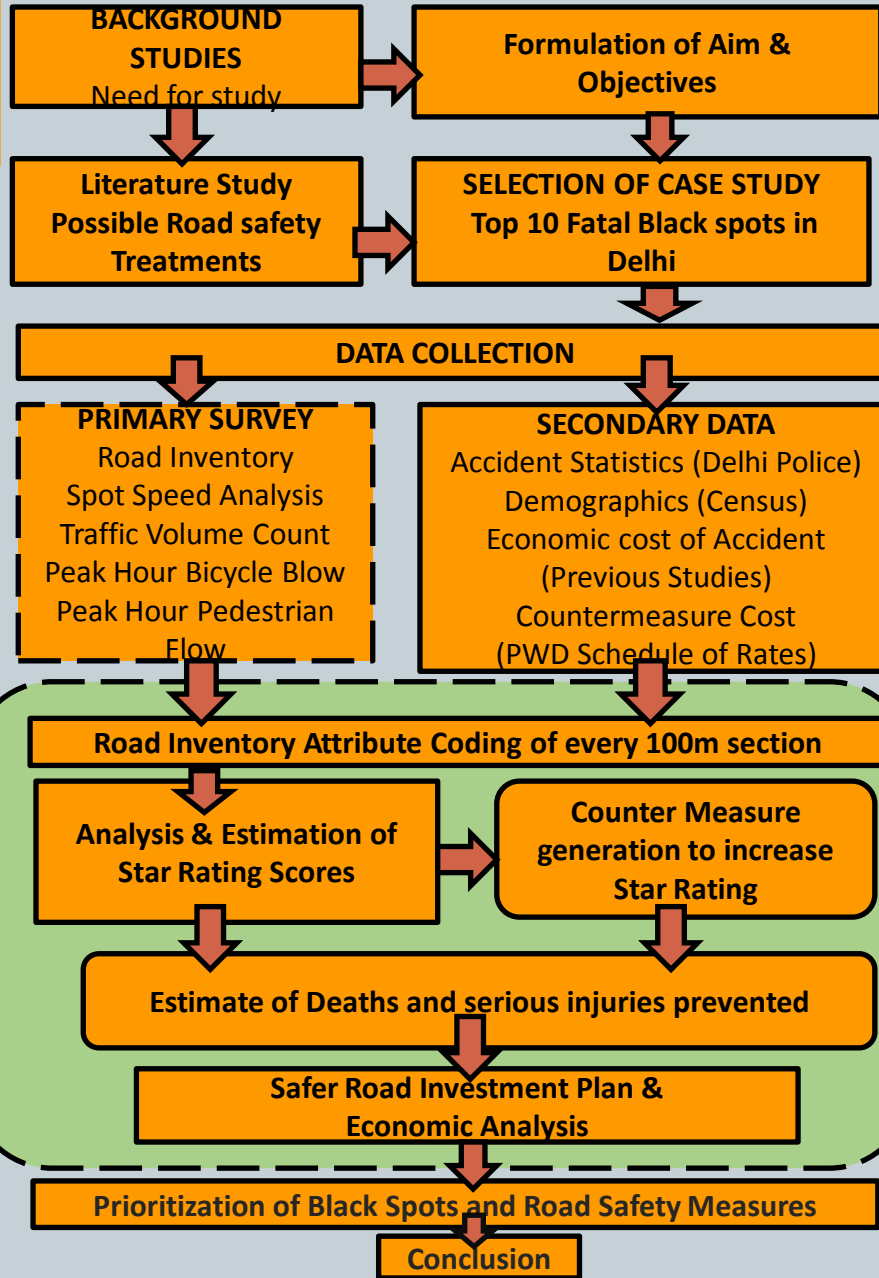


3 Basic Principles for Road Safety

- “Positive Guidance” to Road User through Road Markings & Traffic Signage
- Fulfilling “Driver Expectancy” by removal of Ambiguity in Road Environment so that he gets a visual clue about road ahead
- Geometric Design “Consistency” as any such inconsistency will violate Driver expectancy

Aim Objectives & Methodology

METHODOLOGY



AIM - To develop methodology for prioritization of Road Safety Measures

OBJECTIVES

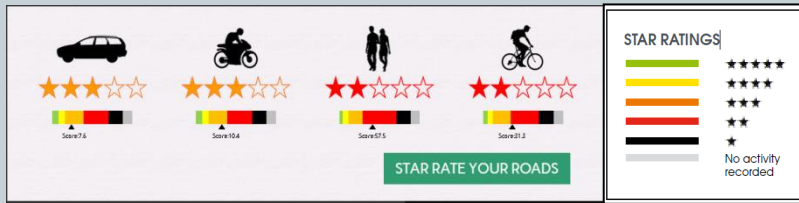
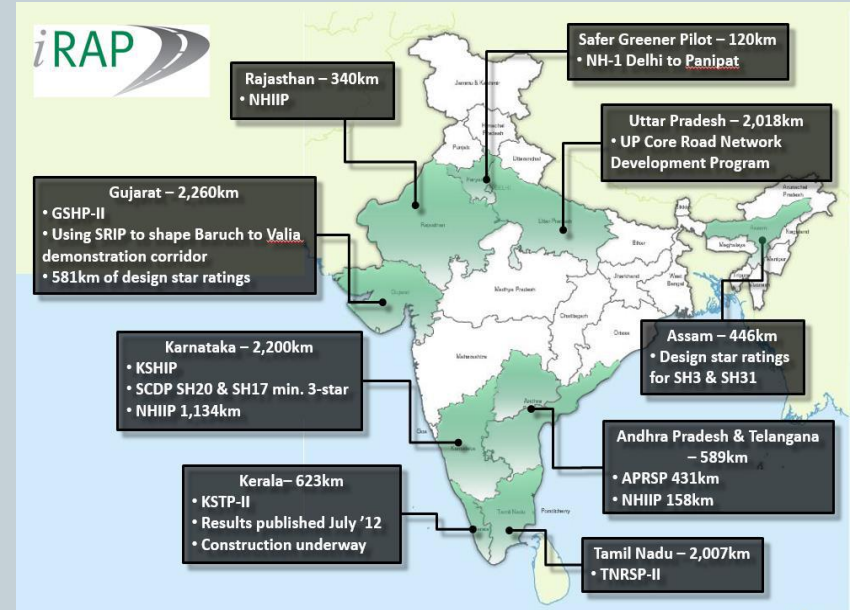
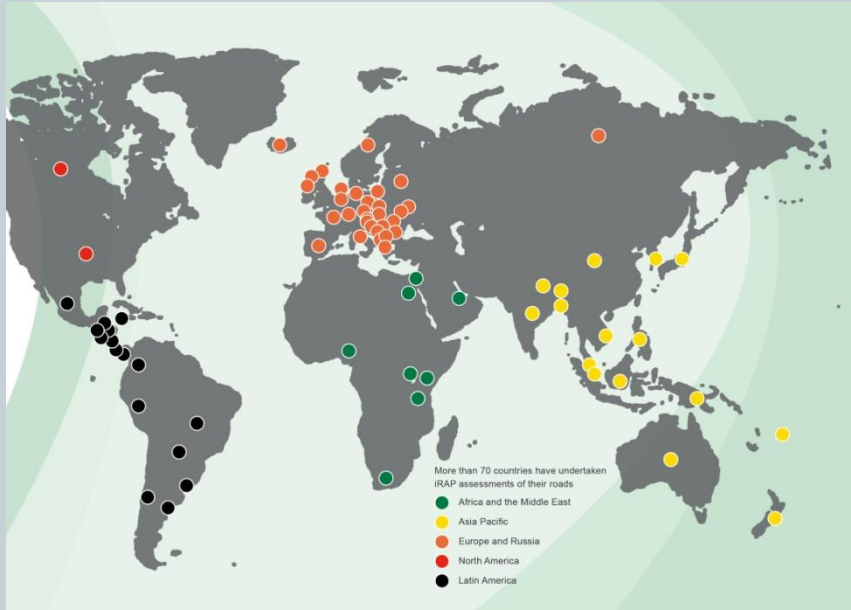
1. To identify the Accident Black spots based on past accidental data from Police records
2. To determine Star Rating & score of Road stretches along the identified Black Spots.
3. To analyze & suggest Countermeasures for enhancement of Road safety on Black spots
4. To determine the economic benefits of suggested Road safety measures.
5. Prioritization of Road safety measures & Black Spots based on Economic Benefits

Type of Accident	Economic Cost of Accidents (average)
Fatal	24.34 Lakh
Serious	334500
Major Injury	20627

Note : The economic cost of different types of accidents for Delhi was taken from a previous study done by Arvind Manickam, (2014) Thesis SPA Delhi

IRAP Software
(VIDA)

Application of Star Rating For Road Safety using iRAP



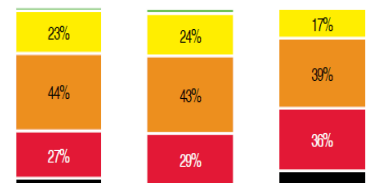
❖IRAP (International Road Assessment Program) is a registered Charity which Inspect roads and develop Star Ratings

❖Star Ratings is a measure of the level of safety of different Road Users

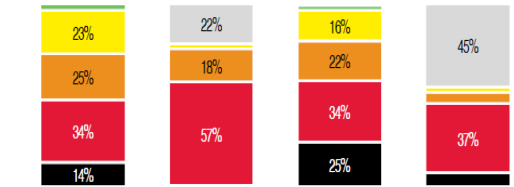
❖Five-star roads are the safest while one-star roads are the least safe.

❖iRAP considers more than 90 proven road improvement options to generate economically sound Safer Road Investment Plans (SRIP) that improve a Star Ratings.

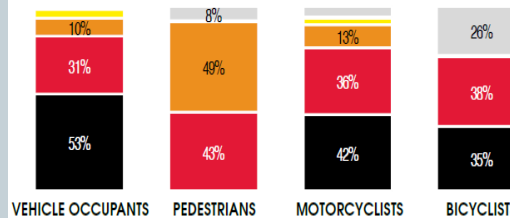
Latin America and the Caribbean (19,900km assessed)



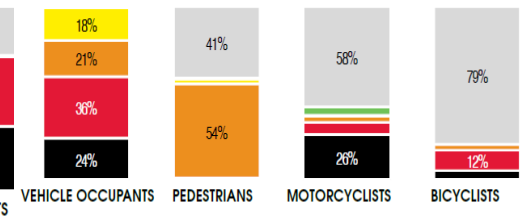
Asia Pacific (15,300km assessed)



Africa (10,100km assessed)



CIS States/Eastern Europe (6,800km assessed)



Star Rating Demonstration

Ankelshwar to Sagbara (21.1km)
Vehicles: ☆

- 80 km/hr
- Lane width >= 3.5m
- Fixed Objects (0-5m)
- Undivided Road
- Unsignalized Intersection
- Narrow Sealed Shoulder
- No Rumble Strips
- Poor Delineation

Ankelshwar to Sagbara (42.5km)
Pedestrians: ☆☆

- 80 Km/Hr
- No Crossing Facilities
- No Sidewalk Provision
- No Paved Shoulder
- 1 Lane in each Direction
- Unpaved Shoulder
- No Physical Median

Harij to Radhanpur (1.7km)
Vehicles: ☆☆☆

- 80 Km/Hr
- Undivided Road
- Fixed Objects (5-10m)
- No Intersection/Access
- Straight/Gentle Curve
- Wide Lane Widths
- Medium Paved Shoulder
- Adequate Delineation
- Good Road Surface

Patan to Shaniaji (10.0km)
Pedestrians: ☆☆☆

- 80 Km/Hr
- No Intersection /Access
- No Sidewalk Provision
- No Physical Median
- 1 Lane in each Direction
- paved Shoulder

Motorway 40 (46.1km)
Vehicles: ☆☆☆☆

- 100 Km/Hr
- No Intersection
- Safety Barrier
- Divided Median
- Rumble Strips
- Sealed Shoulder
- Adequate Delineation
- 2 Wide Lanes
- Good Pavement Condition

Sayala to Surendranagar (32.3km)
Pedestrians: ☆☆☆

- 50 Km/Hr
- No Pedestrian Crossing
- Low Crossing Demand
- No Physical Median
- Low Roadside activity
- Footpath Both sides
- Raised Kerb

Star Ratings are determined by assigning Star Rating Scores (SRS) to the bands as shown in the table below.

- Motorised road user scores are based on head-on, run-off road and intersection crashes;
- Pedestrian scores are based walking along and across the road crashes;
- Bicyclist scores are based on riding along the road and intersections crashes.

Star Rating	Vehicle & Motorcyclist	Pedestrian	Bicyclists
5	0-2.5	0-5	0-5
4	2.5-5	5-15	5-10
3	5-12.5	15-40	10-30
2	12.5-22.5	40-100	30-60
1	22.5 & above	100 & above	60 & Above

$SRS = \sum \text{Crash Type Scores}$

Crash Type Scores = Likelihood x Severity x Operating speed x External flow influence x Median traversability

Road Safety Treatments

Source: <http://toolkit.irap.org/>
Austrroads (2002-07) Road Safety
Risk Assessment Project

Delineation

Chevron Markings,
Line markings,
Guide posts, Retro
reflective markers



Cost- Low
Life 1-5 Years
Effectiveness 10-25%



Grade-Separated Pedestrian Facility



Cost – High , Life- 20 Years , Effectiveness 60%

Pedestrian Fencing

Cost- Low
Life 10-20 Years
Effectiveness 25-40%



Signalized Pedestrian Crossings

Cost- Medium
Life 10-20 Years
Effectiveness 25-40%



Pedestrian Refuge Island



Cost – Low
Life 5-10 Years
Effectiveness 25-40%

Bicycle Lanes



Cost- Medium
Life 10-20 Years
Effectiveness -25-40%

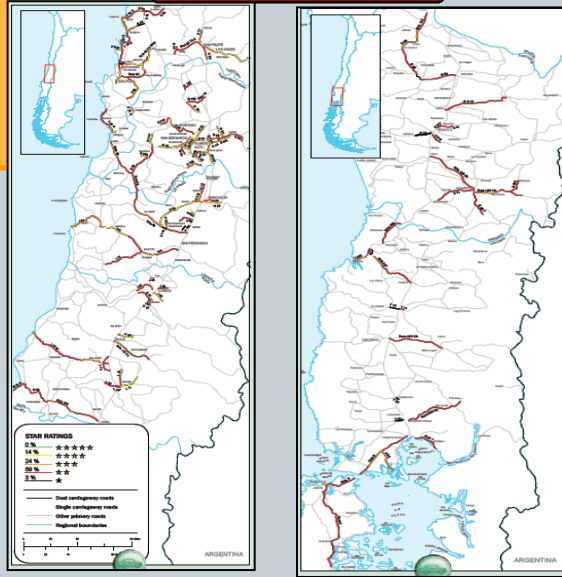
Shoulder Sealing & Rumble Strips



Cost –Medium
Life- 5-10 Years
Effectiveness 25-40%

International Case Studies

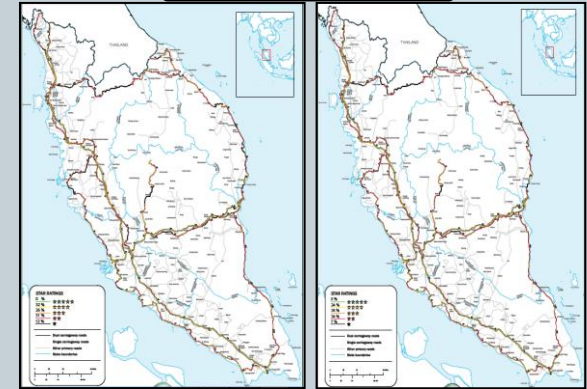
CHILE



EGYPT



MALAYSIA



Star Rating	Vehicle Occupant	MotorCycle	Pedestrian	Bicycle
	% Length	% Length	% Length	% Length
5 Star	0%	0%	0%	0%
4 Star	6%	0%	1%	0%
3 Star	40%	23%	1%	1%
2 Star	36%	45%	3%	6%
1 Star	18%	32%	11%	12%

Star Rating	Vehicle Occupant	Motor Cycle	Pedestrian	Bicycle
	% Length	% Length	% Length	% Length
5 Star	0%	0%	0%	0%
4 Star	32%	24%	0%	2%
3 Star	26%	35%	48%	16%
2 Star	31%	34%	51%	65%
1 Star	12%	7%	1%	17%

Length of Road Surveyed	3273 km
Estimated initial cost of construction EGP currency	1809315588
Total Present Value of Safety Benefits	7130347379
FSI Saved (20 Years)	37.030
Benefit Cost Ratio	4

Length of Road Surveyed	3700 km
Estimated initial cost of construction	556 Million
Estimated Maintenance Cost (20Years) Malaysian Currency	578 Million
FSI Saved (20 Years)	31800
Value of Safety Benefit (20 Years)	9.3 bn
Benefit Cost Ratio	16

Star Rating	Vehicle Occupant	Pedestrian	Bicycle
	% Length	% Length	% Length
5 Star	0%	3%	0%
4 Star	14%	16%	3%
3 Star	24%	81%	15%
2 Star	59%	0%	63%
1 Star	3%	0%	19%

Length of Road Surveyed	2541 km
Estimated initial cost of construction \$ (CLP)	30 bn
Estimated Maintenance Cost (20Years) \$ (CLP)	32 bn
FSI Saved (20 Years)	19400
Benefit Cost Ratio	32

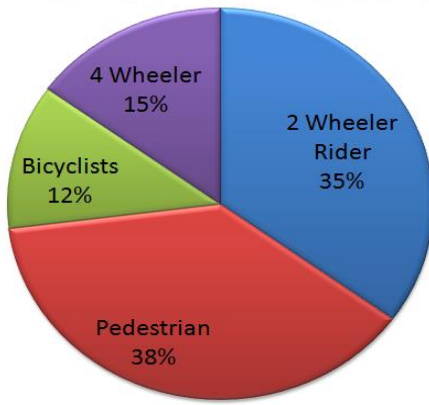
Case Study : Delhi (Top 10 Black Spots)



Top 10 Black Spot in Delhi	Non-Fatal	Fatal	Total	Road Name
Sarai Kale Khan	36	9	45	Ring Road
ISBT K. Gate	22	7	29	Ring Road
Mahipalpur Flyover	20	7	27	Nh-8
Dr Bhabha Marg Crossing	17	8	25	56 No Road
Kashmiri Gate Chowk	16	9	25	Boulevard Road
Shani Mandir	16	7	23	Gtk Road
Nigam Bodh Ghat	12	9	21	Ring Road
Shahadra Flyover	11	7	18	G.T.Road
Mukhand Pur Chowk	9	9	18	Outer Ring Road
Punjabi Bagh Chowk	6	8	14	Ring Road
Total	165	80	245	

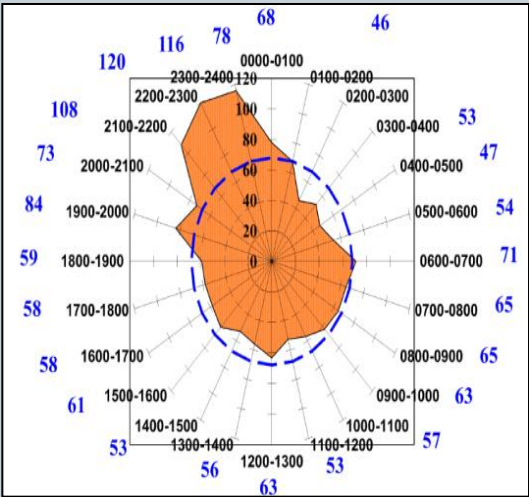
It can be noted that maximum no. of accidents occur b/w 7pm-12am.

Victims of Fatal Accidents



Inferences from Secondary Data

- 50% of total victims were pedestrian and cyclists, then comes the motorcycle riders with 35% of the total victims
- Heavy vehicles (38%) were among the top offenders and then cars 15%
- 35% of fatal accidents were hit and run cases
- Sarai Kale Khan has a highest no. of fatal and non fatal accidents in 2014 followed by ISBT Kashmiri Gate

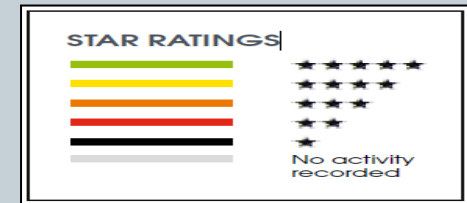
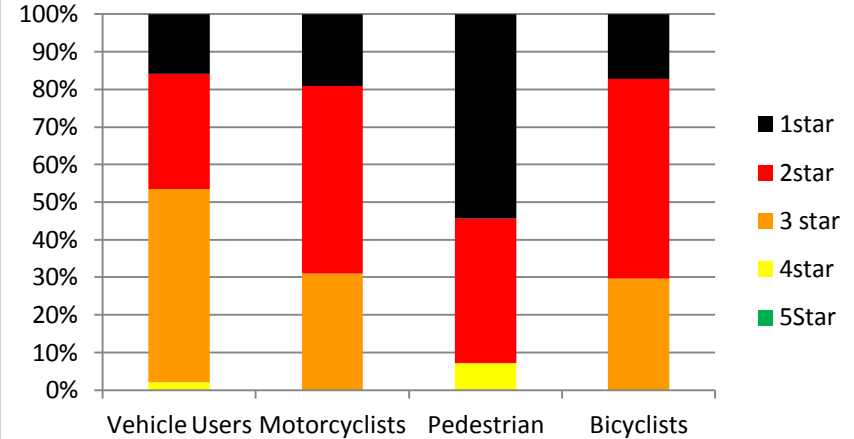


Diurnal Variation of Accidents

Source: Road Accident in Delhi 2015 Booklet, Accident Research Cell, Delhi Police

Analysis of Black Spot – Sarai kale khan

Star Rating	Vehicle Occupant		MotorCycle		Pedestrian		Bicycle	
	Length	%	Length	%	Length	%	Length	%
5 Star	0	0	0	0	0	0	0	0
4 Star	0.5	2	0	0	1.54	5	0	0
3 Star	15.64	52	9.44	31	0.0	0	5.74	19
2 Star	9.40	31	15.10	50	8.3	27	10.2	34
1 Star	4.70	16	5.70	19	11.5	38	3.40	11



Countermeasure	Length / Sites	FSIs saved	PV of safety benefit	Estimated Cost	Cost per FSI saved	Program BCR
pedestrian fencing	0.30 km	79	15,582,099	67,814	854	230
Footpath provision passanger side (>3m)	2.60 km	1,471	288,693,655	9,530,625	6,478	30
Traffic calming	2.60 km	515	101,041,440	6,719,590	13,050	15
Signalized crossing	2 sites	200	39,300,669	2,631,708	13,140	15
Protected Turn Provision 4 Leg	2 sites	224	43,858,250	4,781,247	21,392	9
clear roadside hazards passanger side	2.30 km	72	14,159,542	4,496,500	62,314	3
Clear roadside hazards road side	0.30 km	6	1,089,435	586,500	105,640	2
side road grade seperated pedestrian crossing	2 sites	123	24,170,782	21,993,750	178,554	1
Upgrade pedestrian facility quality	1 sites	3	633,139	436,127	135,168	1
		2,693	528,529,010	51,243,861	19,025	10

Inference

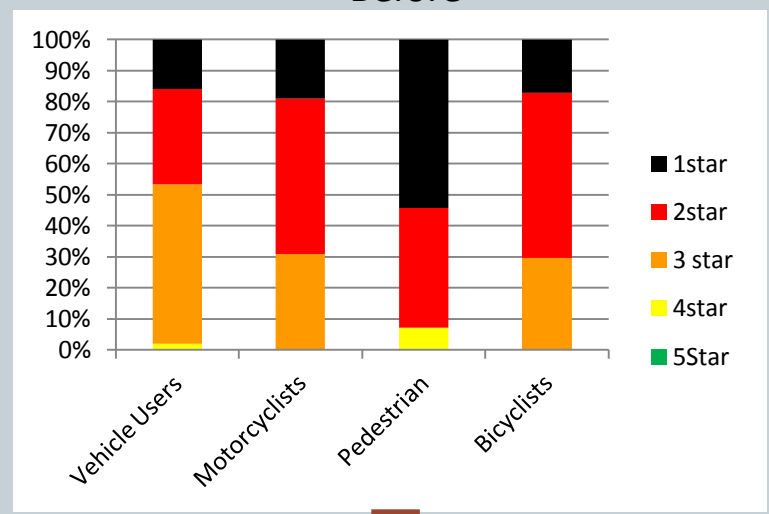
An investment of 5.12 Corers on this Black spot can save 2693 Fatal and serious injuries in coming 20 years with an economic benefits of 52.8 Crores and a Benefit/Cost ratio of 10

Transformation Sarai Kale Khan after Counter measures

Before

Star Rating	Vehicle Occupant		MotorCyclist		Pedestrian		Bicyclist	
	Length	%	Length	%	Length	%	Length	%
5 Star	0	0	0	0	0	0	0	0
4 Star	0.5	2	0	0	1.54	5	0	0
3 Star	15.64	52	9.44	31	0.0	0	5.74	19
2 Star	9.40	31	15.10	50	8.3	27	10.2	34
1 Star	4.70	16	5.70	19	11.5	38	3.40	11

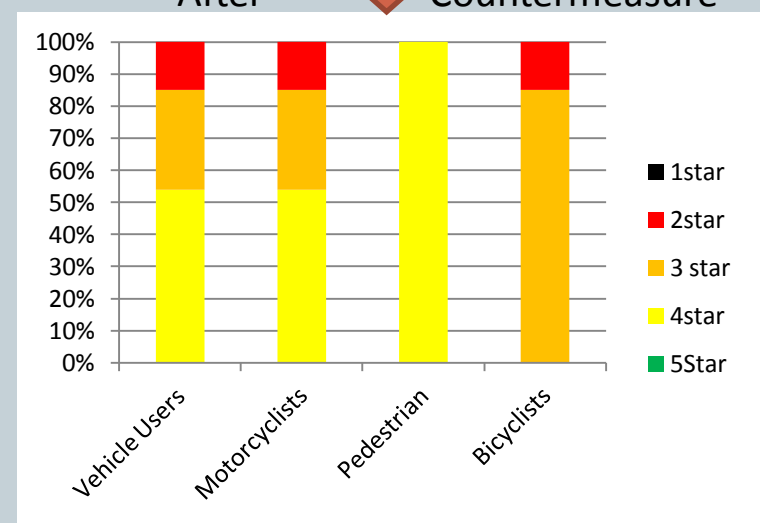
Before



After Countermeasure

Star Rating	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
	Length (kms)	%	Length (kms)	%	Length (kms)	%	Length (kms)	%
5 Stars	0	0%	0	0%	0	0%	0	0%
4 Stars	1.4	54%	1.4	54%	2.6	100%	0	0%
3 Stars	0.8	31%	0.8	31%	0	0%	2.2	85%
2 Stars	0.4	15%	0.4	15%	0	0%	0.4	15%
1 Star	0	0%	0	0%	0	0%	0	0%
Totals	2.6	100%	2.6	100%	2.6	100%	2.6	100

After Countermeasure



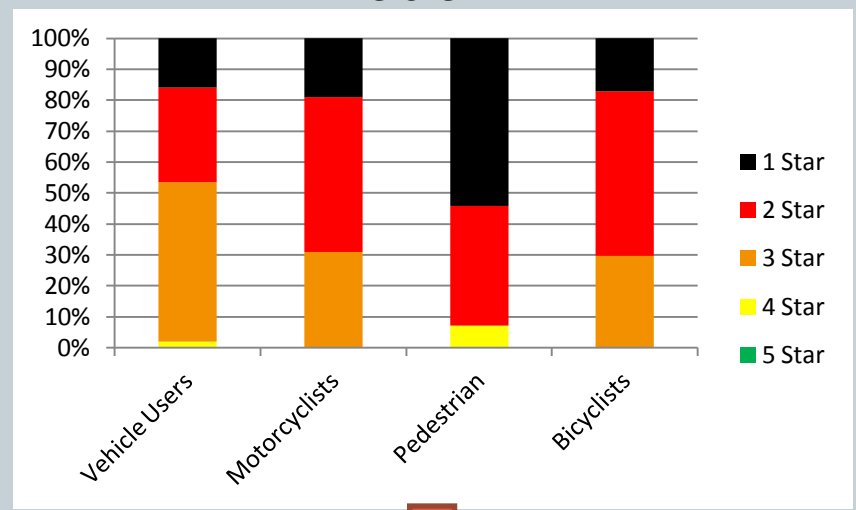
INFERENCE : Pedestrian Safety can be enhanced considerably from 1 and 2 star rating to 3 star rating

Analysis All 10 Black spots

Before

Before

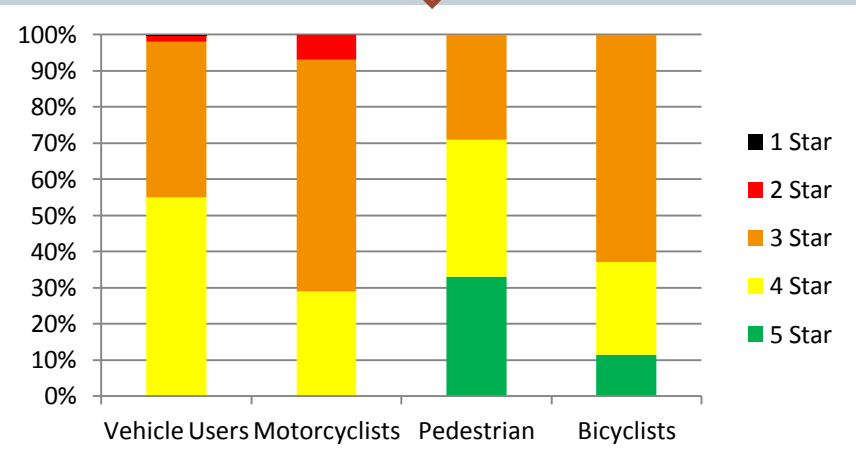
Star Rating	Vehicle Occupant		MotorCycle		Pedestrian		Bicycle	
	Length	%	Length	%	Length	%	Length	%
5 Star	0	0	0	0	0	0	0	0
4 Star	0.5	2	0	0	1.54	5	0	0
3 Star	15.64	52	9.44	31	0.0	0	5.74	19
2 Star	9.40	31	15.10	50	8.3	27	10.2	34
1 Star	4.70	16	5.70	19	11.5	38	3.40	11



After Countermeasure

After Countermeasure

Star Rating	Vehicle Occupant		Motor Cycle		Pedestrian		Bicycle	
	Length	%	Length	%	Length	%	Length	%
5 Star	0	0	0	0	6.369	33	2.2	11.4
4 Star	16.74	55	8.84	29	7.22	38	4.96	25.7
3 Star	13.10	43	19.3	64	5.79	8	12.14	62.9
2 Star	0.4	1	2.10	7	0	0	0	0
1 Star	0.10	0	0	0	0	1	0.70	2



Road User wise Road Star Rating

Star Rating Charts

Total Length of Stretches along 10 Black Spots – 30.24 Km



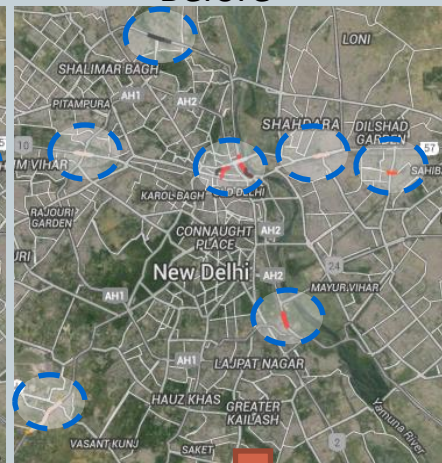
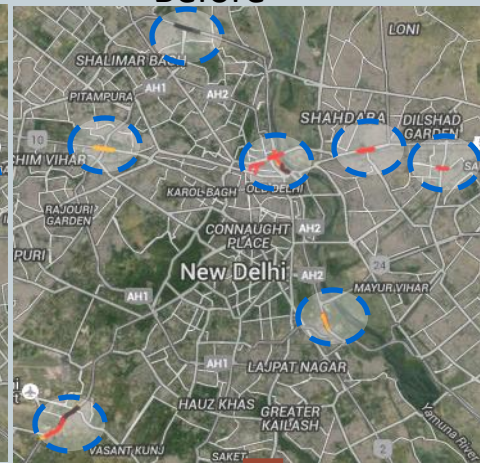
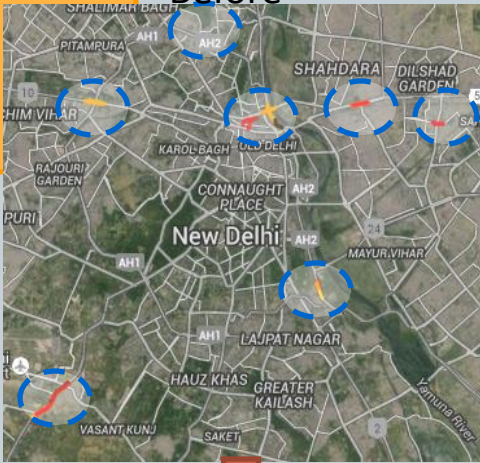
Analysis results for all 10 Black Spots

Before

Before

Before

Before

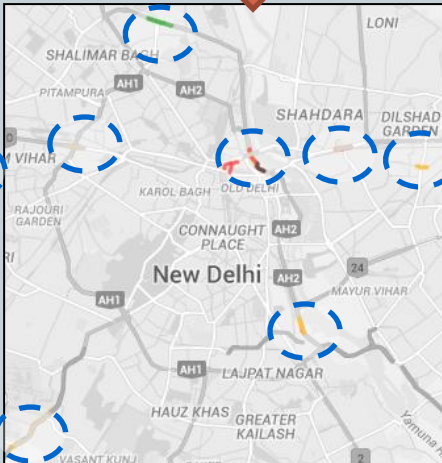
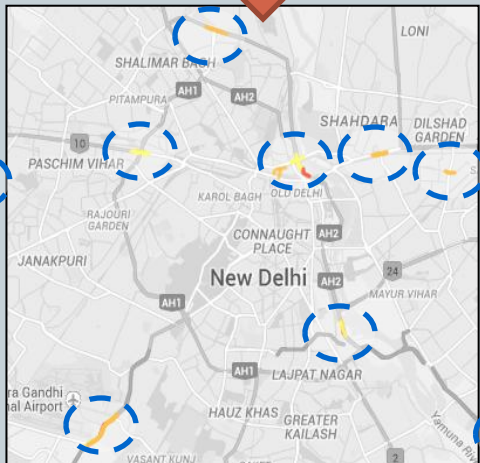
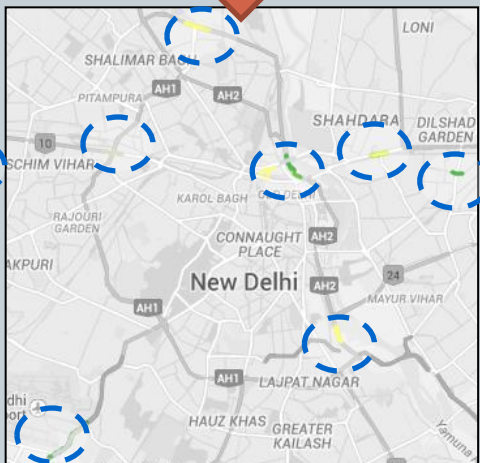
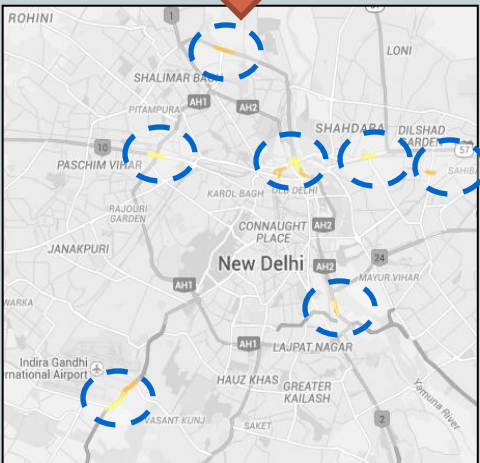


After Countermeasure

After Countermeasure

After Countermeasure

After Countermeasure



STAR RATINGS



Most of the existing black spots stretches with 1 star and 2 star rating can be made safe with countermeasures and rating can be enhanced to 3 or 4 stars

Prioritization of Road safety measures and Road investment Plan (20Years)

S.No	Road Safety Countermeasures (In decreasing order of Priority with regards to Benefit/Cost ratio of investment in the counter-measure)	Length / Sites	Fatal and serious injuries (FSI) saved	Present Value (PV) of safety benefit (Crores)	Estimated Cost (Crores)	Cost per FSI saved	Benefit Cost Ratio (BCR)
1	Pedestrian fencing (Highest Priority)	2.39 km	619	12.15	0.05	865	227
2	Improve curve delineation	1.40 km	312	6.12	0.04	1,361	144
3	Shoulder rumble strips	10.00 km	633	12.42	0.13	2,029	97
4	Footpath provision passenger side (with barrier)	3.20 km	2,252	44.2	1.19	5,275	37
5	Footpath provision passenger side	3.90 km	635	12.45	0.43	6,847	29
6	Improve Delineation	25.34 km	1,112	21.82	1.39	12,463	16
7	Traffic calming	18.39 km	3,300	64.76	4.75	14,402	14
8	Signalized crossing	13 sites	1,233	24.2	1.71	13,873	14
9	Upgrade pedestrian facility quality	6 sites	191	3.75	0.26	13,695	14
10	Footpath provision passenger side (>3m from road)	14.20 km	3,293	64.62	5.2	15,783	12
11	Bicycle Lane (off-road)	2.20 km	132	2.59	0.24	18,357	11
12	Delineation and signing (intersection)	18 sites	1,110	21.79	2.7	24,280	8
13	Motorcycle Lane (Segregated)	16.44 km	981	19.24	3.27	33,294	6
14	Grade separated pedestrian facility	3 sites	1,652	32.43	6.6	39,928	5
15	Roadside barriers- passenger side	16.90 km	1,236	24.25	4.45	35,984	5
16	Protected turn provision at existing signalized site (4-leg)	7 sites	348	6.82	1.62	46,643	4
17	Clear roadside hazards - passenger side	7.24 km	244	4.78	1.42	58,196	3
18	Signalize intersection (3-leg)	4 sites	178	3.49	1.21	68,051	3
19	Restrict/combine direct access points	3.80 km	158	3.09	0.98	62,302	3
20	Side road signalized pedestrian crossing	14 sites	542	10.64	6.84	126,167	2
21	Side road grade separated pedestrian facility	3 sites	325	6.38	3.3	101,432	2
22	Clear roadside hazards - driver side	0.30 km	6	0.11	0.06	105,640	2
23	Shoulder sealing driver side (>1m)	12.10 km	294	5.76	4.14	141,026	1
	Total		20,785	407.85	51.97	25,005	7.85

Inference –

- Pedestrian fencing has highest Benefit cost ratio of 227 thus has highest priority followed other measures
- An investment of 51.97 Crores can save 20783 Fatal and serious injuries on 10 black spots in coming 20years

Prioritization of Black Spots

Prioritization Hierarchy	Black Spot	FSI Saved	PV of FSI Saved	Estimated Cost	Cost per FSI Saved	BCR
1	Nigam Bodh Ghat	1,448	28,40,66,027	23,2,43,225	16,056	12
2	Sarai Kale Khan	2,693	52,85,29,010	51,2,43,861	19,025	10
3	ShaniMandir	974	19,11,33,322	20,0,05,266	20,539	10
4	Mukundpur Chowk	4,630	90,85,96,298	10,31,41,619	22,275	9
5	Kashmiri Gate	3,107	60,97,35,711	70,7,43,546	22,767	9
6	Sahadra Flyover	1,734	34,02,35,120	4,21,00,288	24,281	8
7	Mahipalpur	3,158	61,97,06,596	9,11,76,320	28,871	7
8	Mori Gate	1,471	28,85,60,003	4,58,97,946	31,212	6
9	Punjabi Bagh	562	11,02,93,923	2,14,66,284	38,191	5
10	Dr.BhabaMarg	1,026	20,12,50,367	5,12,01,087	49,923	4

Inference –

- Prioritization hierarchy with respect to Benefit cost ratio reveals that Nigam Bodh Ghat at highest priority with Fatal and Serious injuries saved in 20 years of 1448 , present value of economic benefits of FSI 28.4 Crore and investment on road safety countermeasure of 2.32 Crore thus a Benefit /Cost ratio of 12 and lowest Cost per FSI of Rs.16056 only.
- Highest No. of Fatal and serious injuries can be saved at Mukundpur chowk i.e.4630 in 20 Years by an investment of 10.3 Crores

CONCLUSION

- The 10 Black Spots in Delhi have 52% of road stretch with 3 star rating for Vehicles, 50 % of stretch has 2 star rating for Motorcyclists, 38 % has 1 star rating for pedestrians, 34 % has 2 star rating for Bicycles
- An investment of 51.97 Crores for Road safety Counter measures on 10 Black Spots in Delhi can save 20,785 fatal and serious injuries in 20 Years with Net Present Value(NPV) of economic benefits 407.85 Crores and Benefit-Cost Ratio (BCR) of 7.85.
- Prioritization of 10 Black Spots in Delhi suggests Nigam Bodh Ghat has highest priority with regard to FSI and BCR followed by others with cost per FSI saved Rs.16,056 & BCR 12
- The prioritization methodology adopted in this study can serve as a tool for comparative analysis of black spots globally as well as for comparison of road safety measures

WAY FORWARD

- Star Rating is not sensitive towards assessing potential impact of ITS. Research on impact of ITS in Infrastructure, Vehicles & enforcement measures can be done and integrated with Road infrastructure rating to further enhance Road safety.
- Diurnal Variation in Star rating of Road Infrastructure components and corresponding Countermeasures can further make roads more safe.

