Creating Innovative Solutions for a Sustainable Future

High Speed Rail in India

Selection of corridors and Impacts on energy and emissions*

Sarbojit Pal

International Transport Forum Roundtable on the Economics of investments in HSR

December 18-19th, 2013

*Emissions throughout this presentation refer to CO_2 emissions from operations only

Ever increasing demand for mobility

GROWTH IN PASSENGER TRANSPORT

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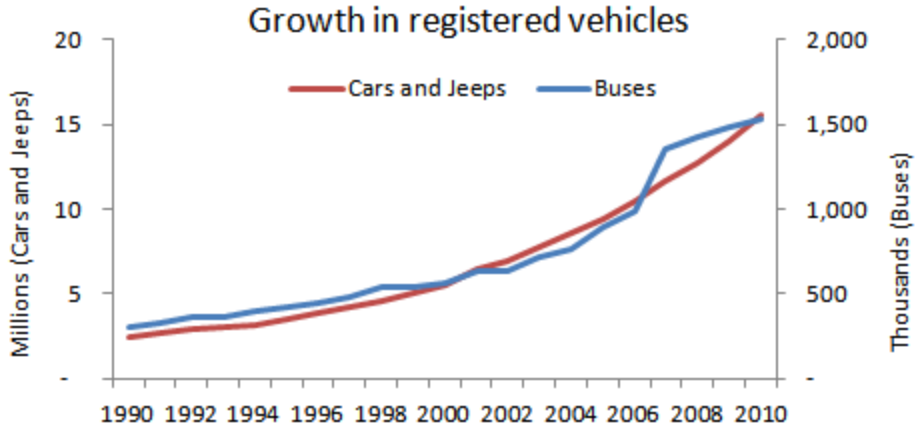
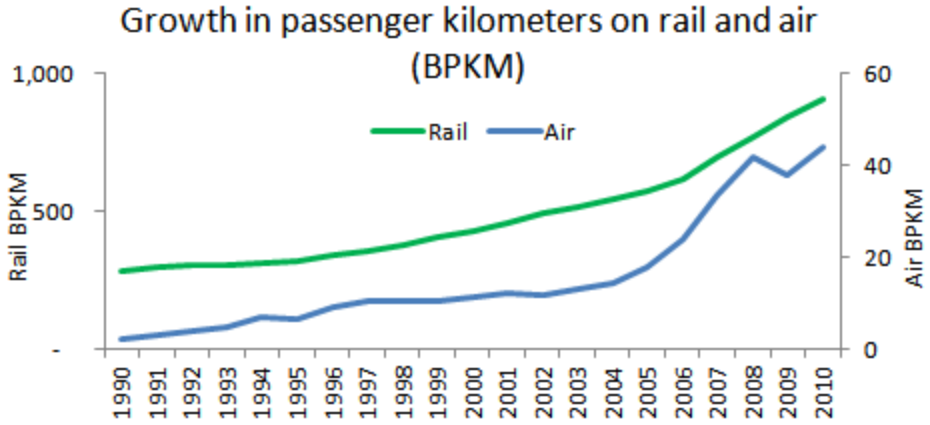
- Very fast growth in passenger transport activity

2.5 Mil. Cars (1990) → 15.5 Mil. Cars * (2010)



- Growth drivers: population, economy, urbanization, motorization

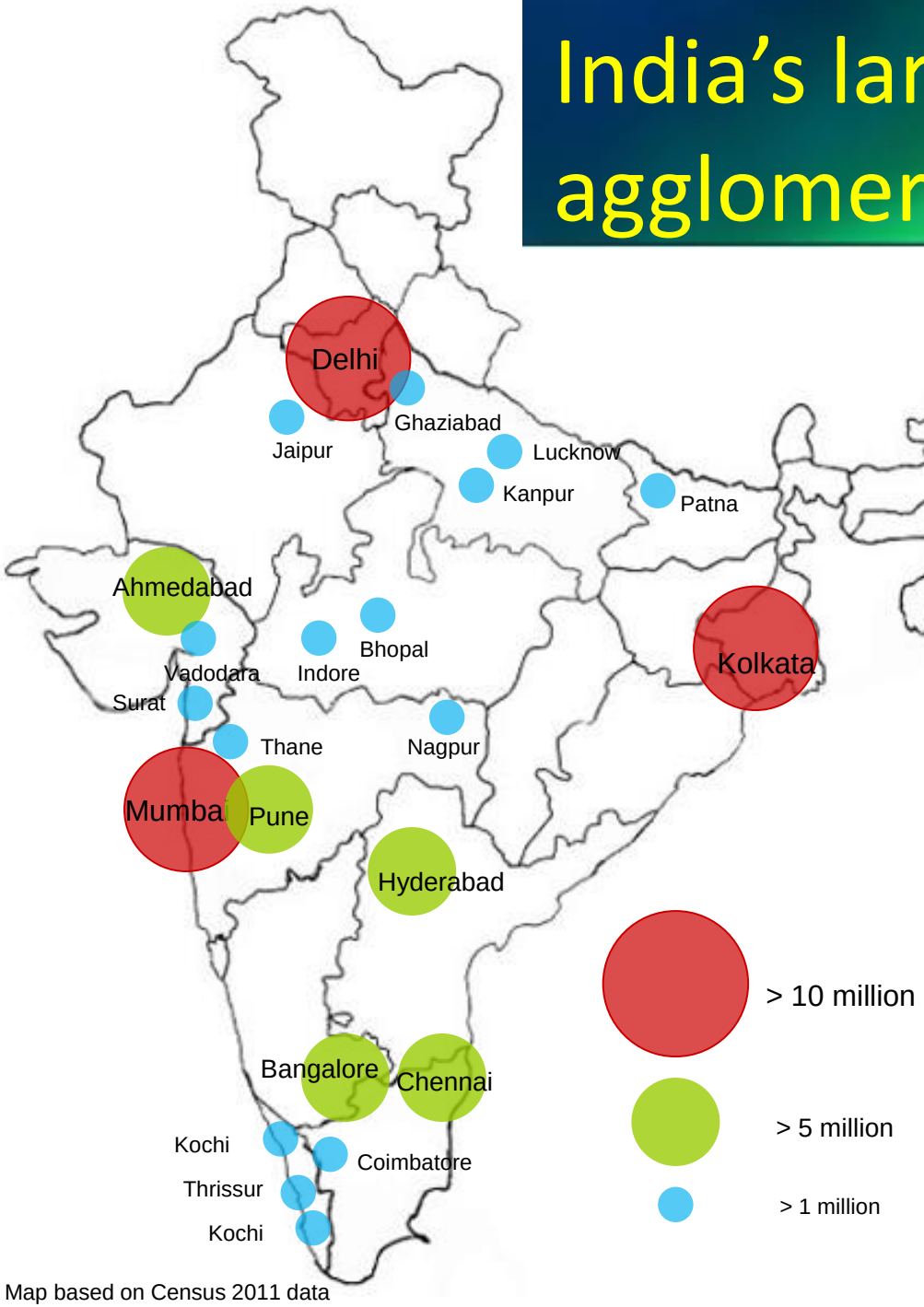
286 Rail BPKM (1990) → 1,046 Rail BPKM (2012) **



* Total number of registered cars and jeeps in India; source: Basic Road Statistics, MoRTH; ** Data from the IR

The absolute growth in mobility has been very rapid specifically in the last decade

India's large urban agglomerations

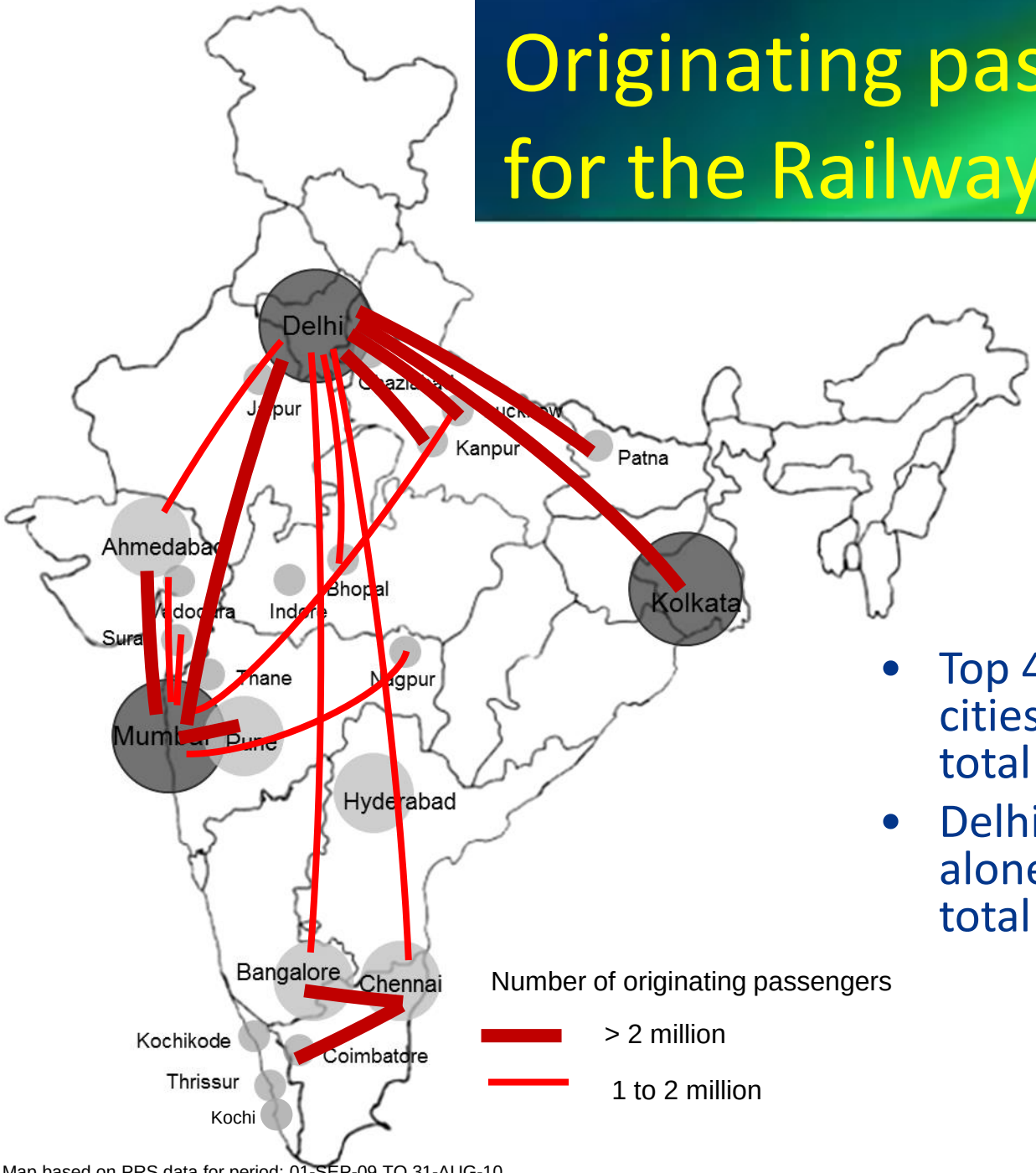


Map based on Census 2011 data

- Already 8 urban centers have populations greater than 5 million people
- By 2030
  - At least 6 ten million plus cities
  - 6 to 11 five million plus cities

Large passenger mobility can be seen between such large cities across the country

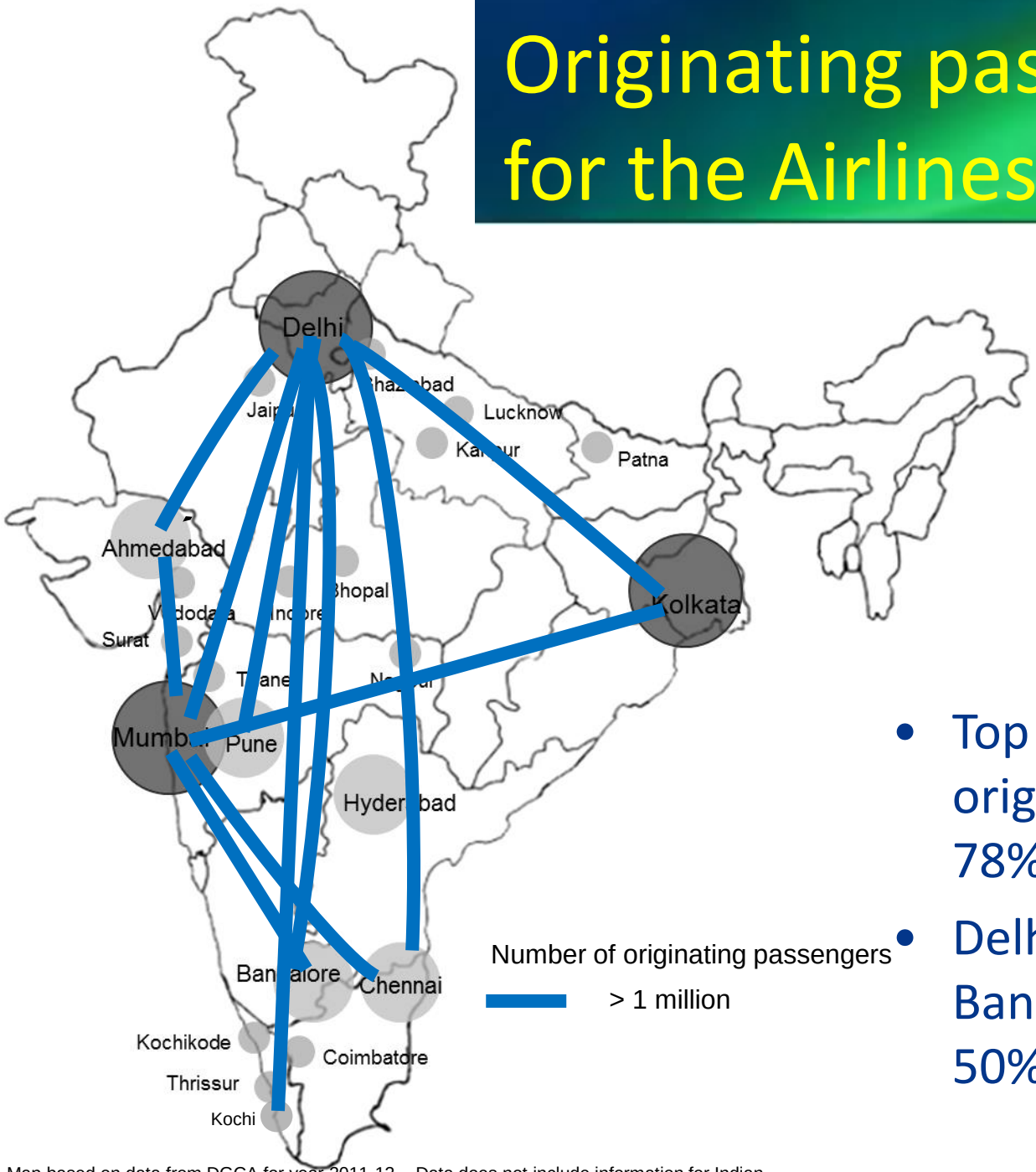
Originating passengers for the Railways



- Top 40 passenger originating cities generate 51% of the total non-suburban traffic
- Delhi, Mumbai and Kolkata alone generate 20% of the total traffic

Map based on PRS data for period: 01-SEP-09 TO 31-AUG-10

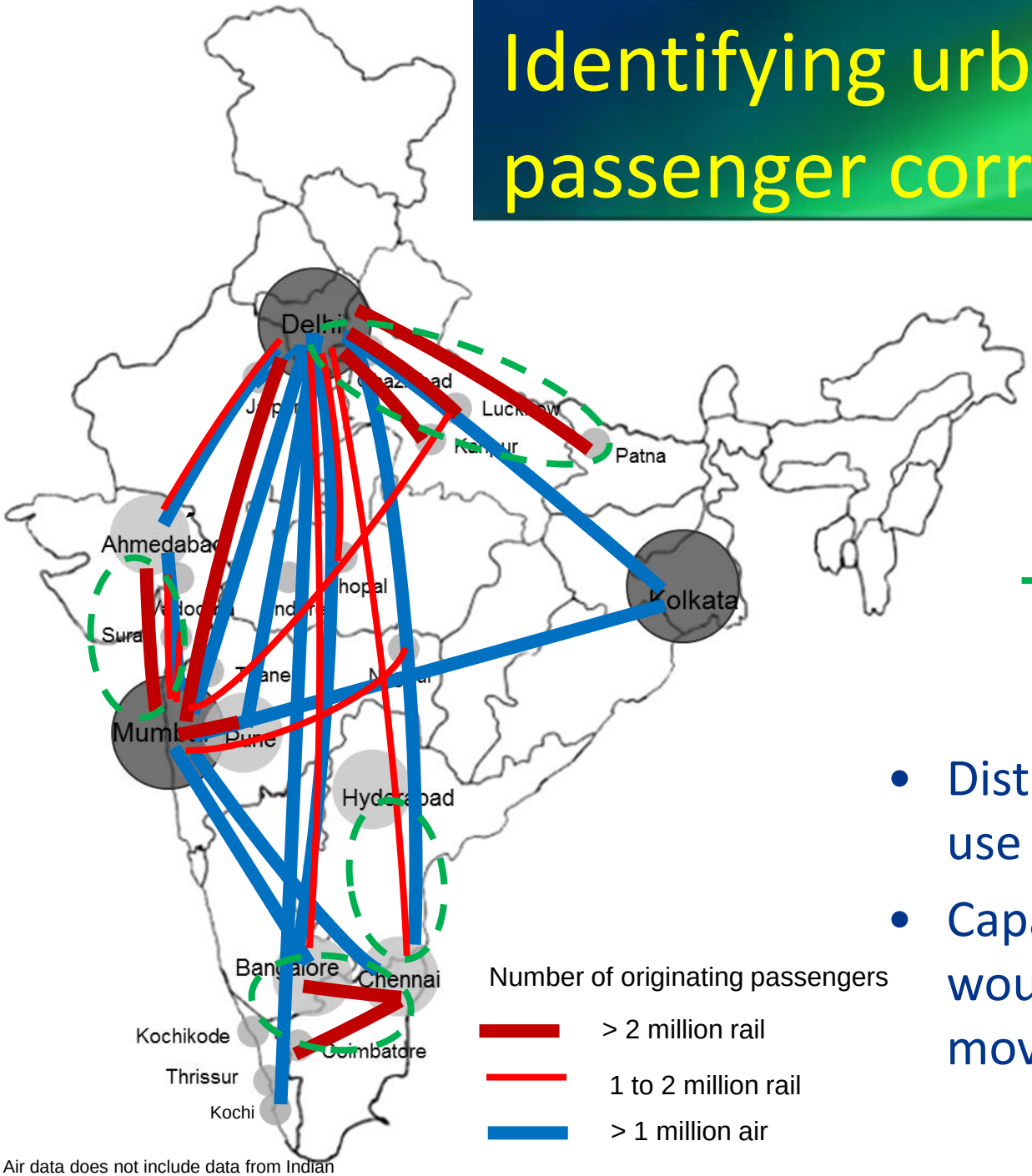
Originating passengers for the Airlines



- Top 10 passenger originating cities generate 78% of the total traffic
- Delhi, Mumbai and Bangalore generate about 50% of the total traffic

Map based on data from DGCA for year 2011-12 – Data does not include information for Indian

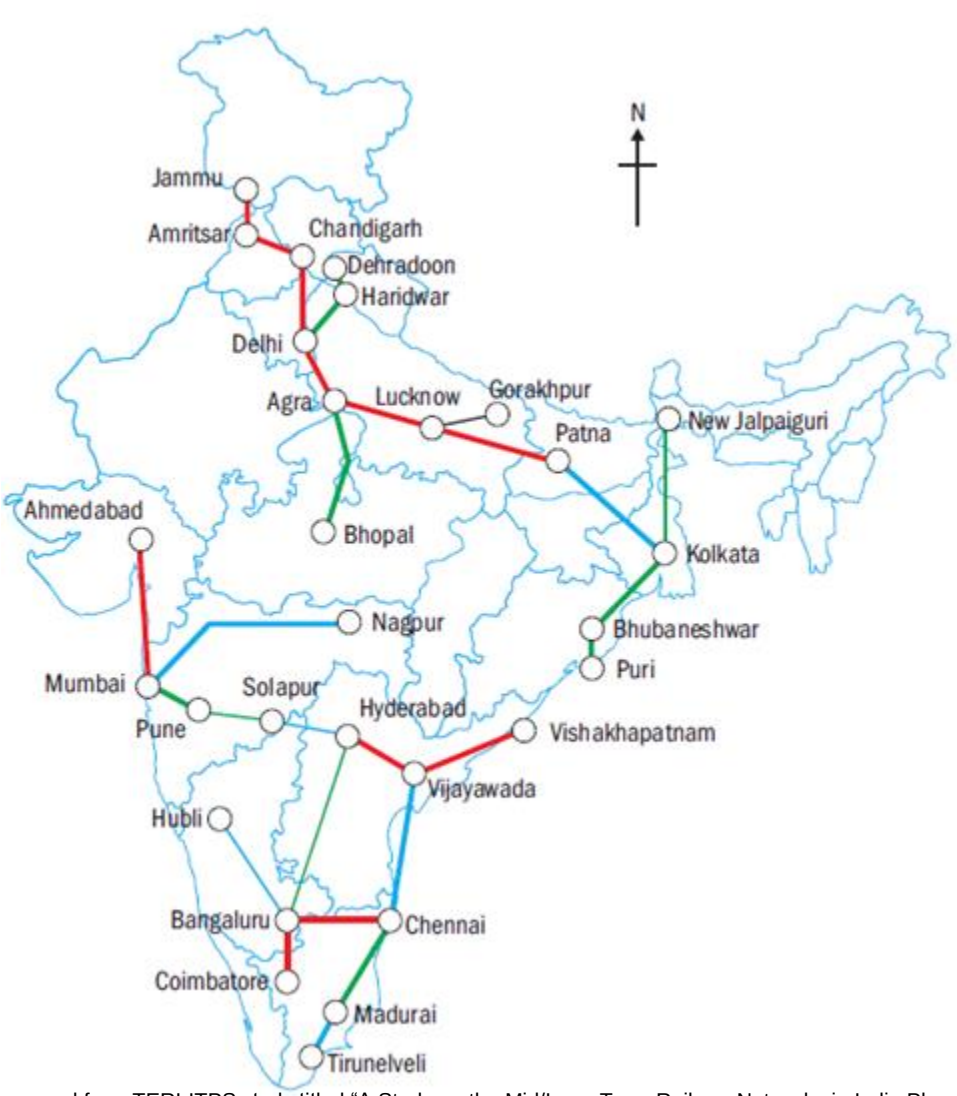
Identifying urban passenger corridors



- Distinct heavy passenger use corridors emerge
- Capacity constraint of rail would mean traffic will move to air and road

Air data does not include data from Indian

Identification of potential HSR corridors in India



Economic & social parameters	Corridor specific
Per capita GDP	Corridor length/time
Population densities	Number of cities on corridor
Population growth rates	Intercity OD traffic volume
Historic connectedness	Capacity along the corridor

- TERI-ITPS study tried to determine the potential corridors for HSR in India
- There were several overlapping corridors with the Govt. links
- Detailed study on two corridors:
  - **Western Corridor**
    - Ahmedabad – Mumbai – Pune
  - **Southern Corridor**
    - Chennai – Bangalore - Coimbatore

Map sourced from TERI-ITPS study titled “A Study on the Mid/Long-Term Railway Networks in India Phase II”.

The western corridor - a quick snapshot

The Western Corridor
Ahmedabad – Vadodara – Surat – Mumbai – Pune

Road

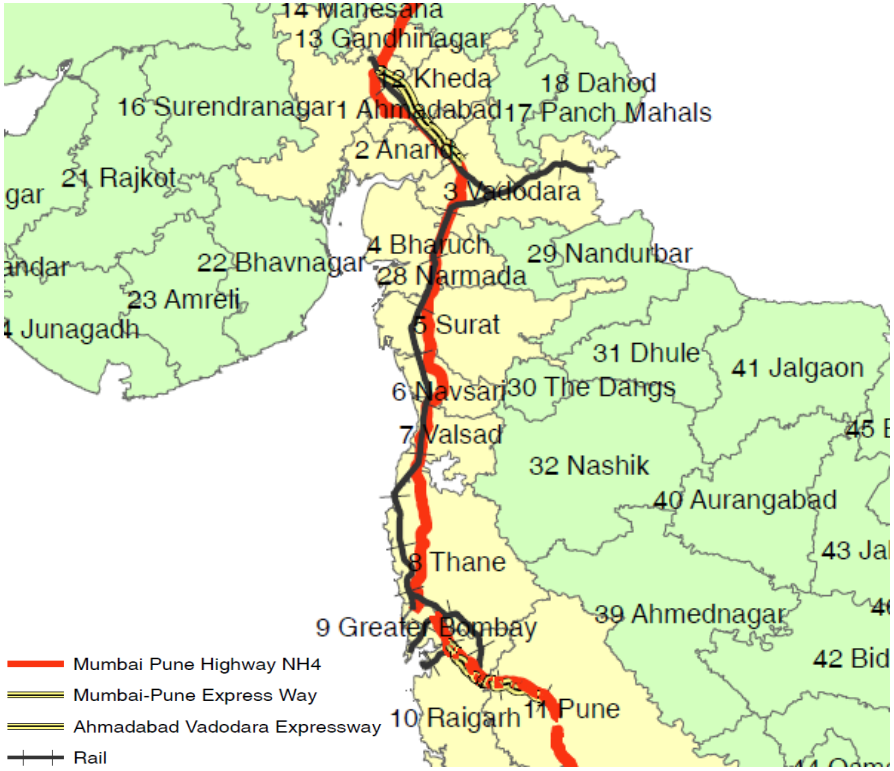
- 95 km Ahmedabad-Vadodara Expressway (1.5 hours)
- 93 km Mumbai-Pune Expressway (2 hrs)
- Ahmedabad - Pune corridor coming up connecting Vadodara, Surat and Mumbai

Rail

- Ahmedabad, Vadodara, Surat, Bharuch, Valsad, Borivali, Dadar, Mumbai Central & Pune
- 30 trains runs along the Ahm to Mum, 15 - superfast, 11 - Express, 4 Rajdhani, Shatabdi & Duronto

Air

- All the cities along the corridor are connected by air with center at Mumbai



Section 1: Ahmedabad to Mumbai

Section 2: Mumbai to Pune

The southern corridor - a quick snapshot

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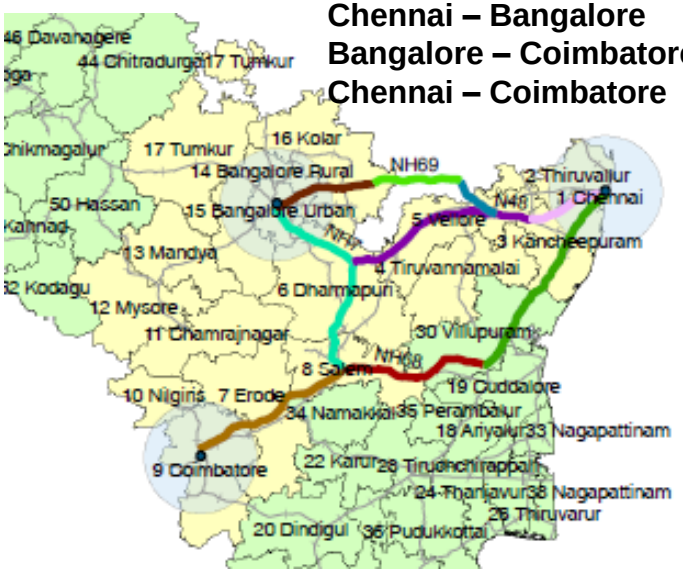
The Southern Corridor
Chennai – Bangalore - Coimbatore

Road

- High density passenger network on roads – SRTUs and private operators
- NHAI is expanding the road from 4 to 6 lanes between Chennai and Bangalore – DPR is ready
- Expressway being planned independently between Chennai – Bangalore and Chennai – Coimbatore

Air

- There are about 9 flights daily between Chennai-Bangalore and 3 between Bangalore and Coimbatore
- Since Bangalore airport is 40 km away from the city center it takes approximately the same time between the cities on air as it takes on the road



Chennai – Bangalore 327.6 km
Bangalore – Coimbatore 372.0 km
Chennai – Coimbatore 530.0 km

Rail

- 17 trains between Chennai and Bangalore and 13 trains between Bangalore – Coimbatore (no Shatabdi)

Section 3: Chennai-Bangalore Section 4: Bangalore-Coimbatore

Section 5: Coimbatore-Chennai

THE AHMEDABAD-MUMBAI SECTION

Ahmedabad-Mumbai Section

NATURE OF TRAFFIC, ENERGY AND EMISSIONS

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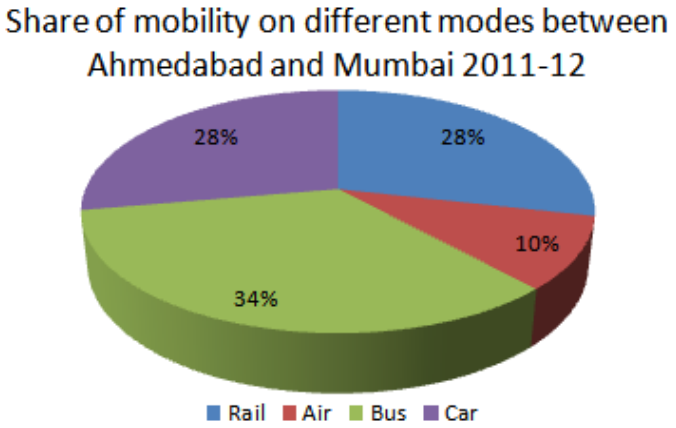
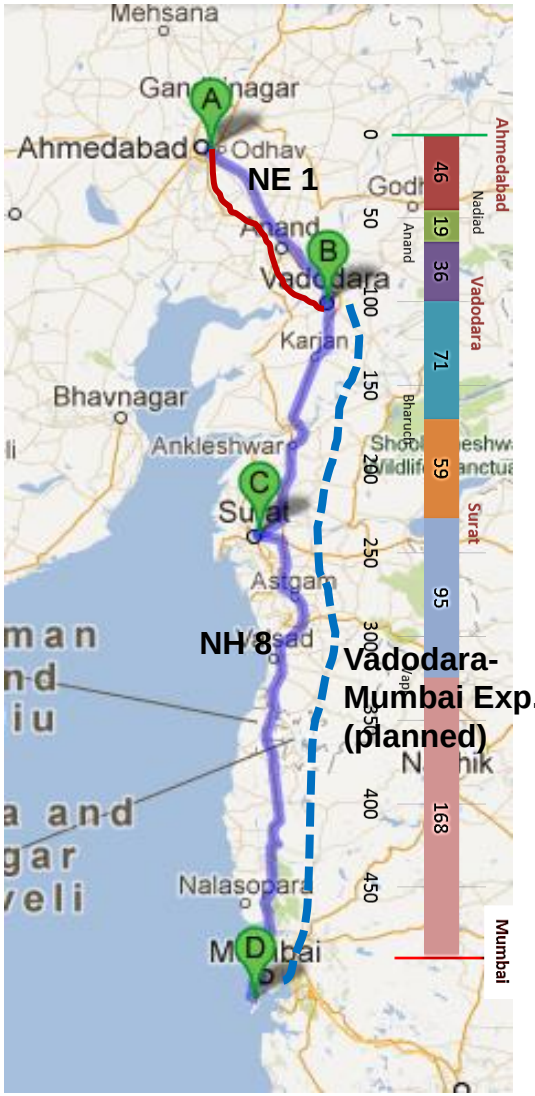
Ahmedabad-Mumbai

7.94 BPKM in 2011-12



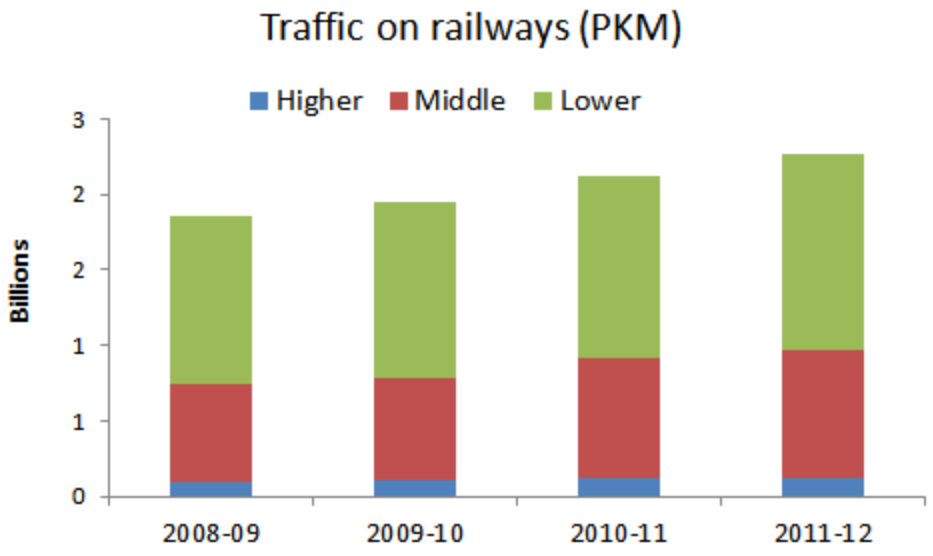


- 58% of the traffic moves on the roads
- Aviation grew at almost 37% (CAGR) between 2008/09 and 2011/12
- Traffic on cars and jeeps have almost caught up with that on the railways

The Ahmedabad-Mumbai corridor

RAIL TRAFFIC

- 6.2 million passengers travelled on reserved rail categories in 2011-12
- Growth of passenger kilometers on various classes (CAGR: 2008/9-2010/11)
  - **Higher - 7.62%**
  - **Middle - 6.79%**
  - **Lower - 3.85%**
- Higher journey classes have higher leads (404km-373km-348km)



Class types combined:
Higher: 1A, 2A, EC; **Middle**: 3A, 3E, CC; **Lower**: SL, 2S

Fastest end to end travel time on railways: 6h 25min

The Ahmedabad-Mumbai corridor

RAIL – GLIMPSE AT PASSENGER PROFILES

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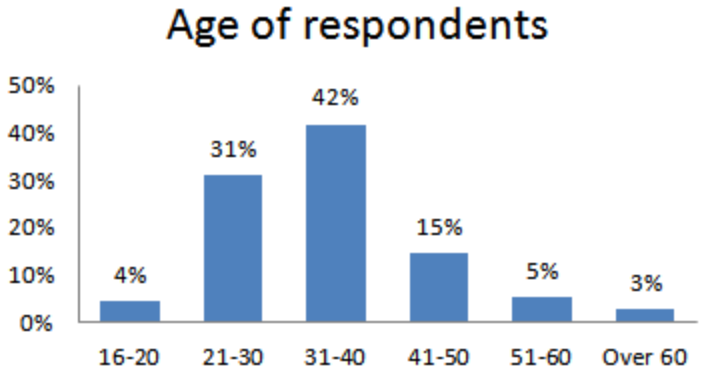
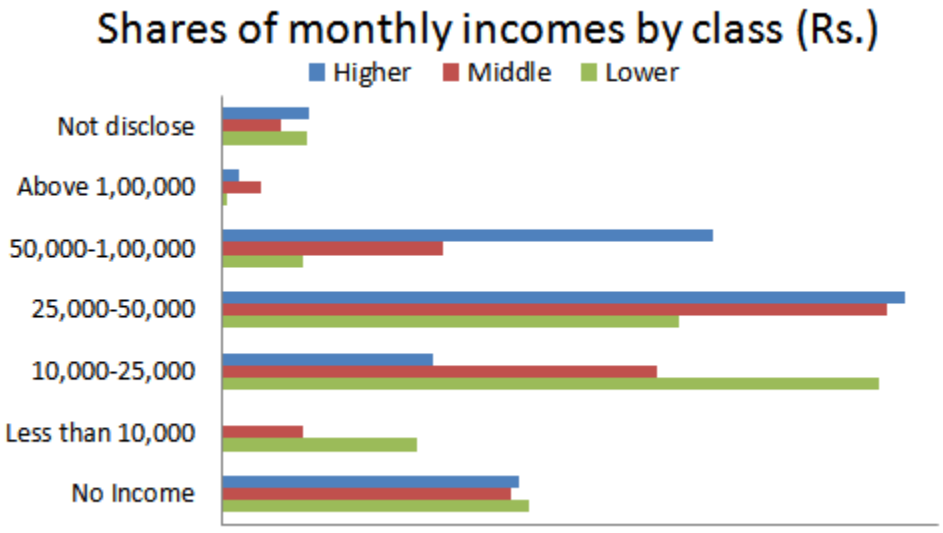
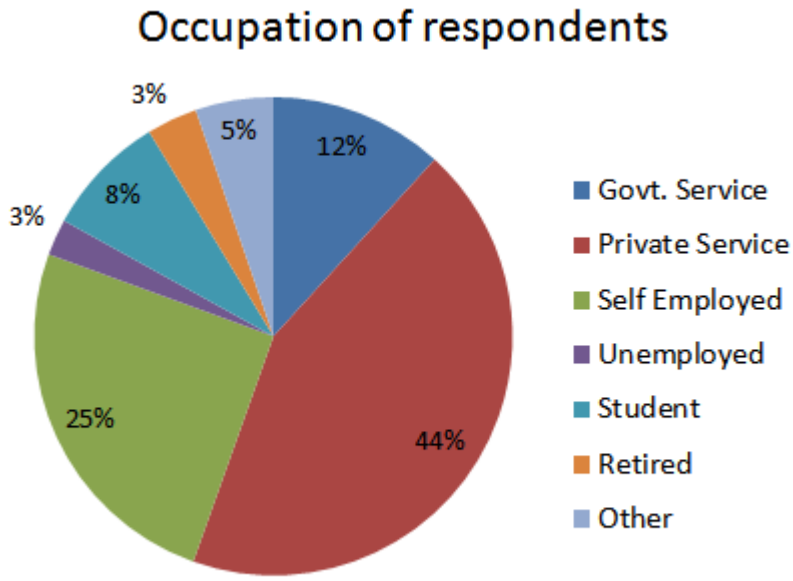
- Conducted a primary face to face passenger survey on-board trains
- 73% of the respondents were in the ages between 21 and 40 years
- Largely in private services (44%) or self employed (25%)
- Highest share of total respondents in the income band of Rs. 25-50,000







Primary surveys were conducted on day passenger superfast trains that started and terminated between Ahmedabad and Mumbai Central. Sample size: 1461

The Ahmedabad-Mumbai corridor

RAIL – GLIMPSE AT PASSENGER PROFILES

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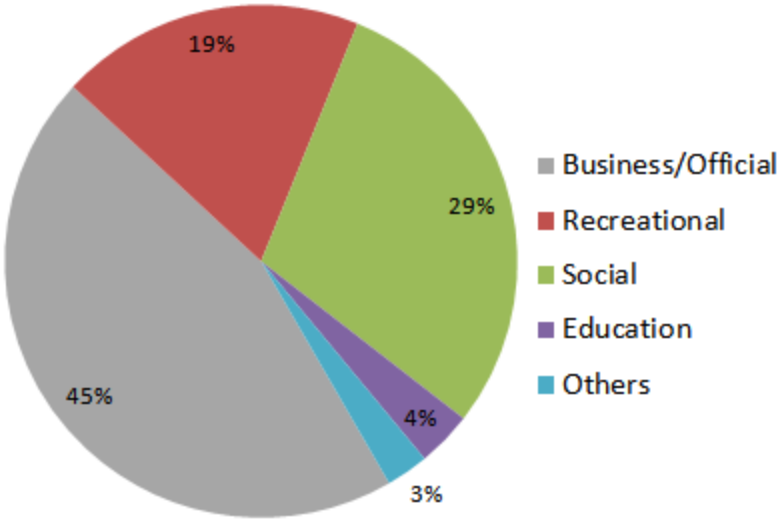
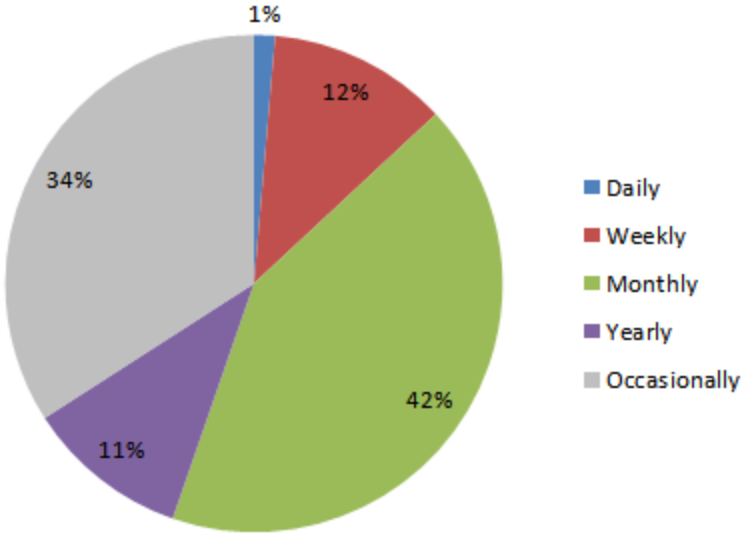
Purpose of travel by respondents



Frequency of travel



- 45% of the respondents were traveling for business or official purposes
- A large number of people were also traveling for social reasons

Large share of rail passengers surveyed were making this journey on a monthly basis and most of them were traveling on work

The Ahmedabad-Mumbai corridor

BUS TRAFFIC – PASSENGER PROFILES

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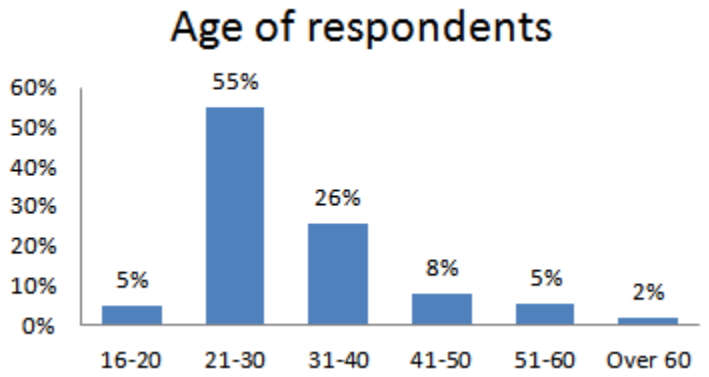
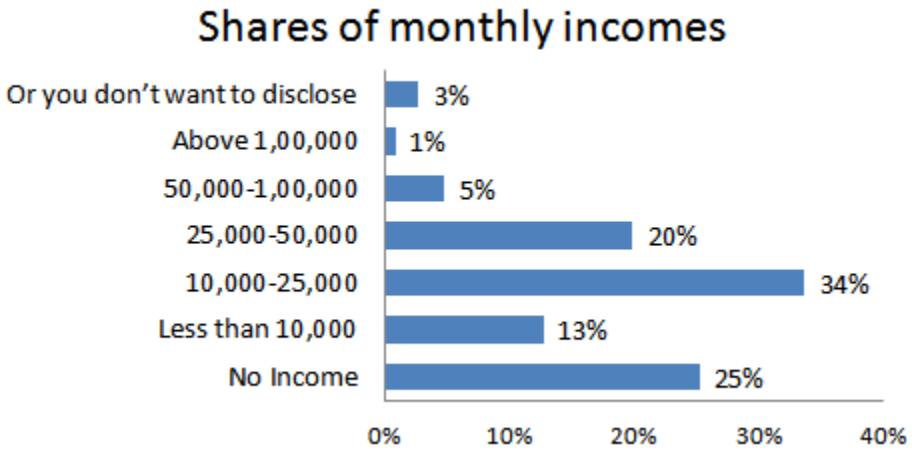
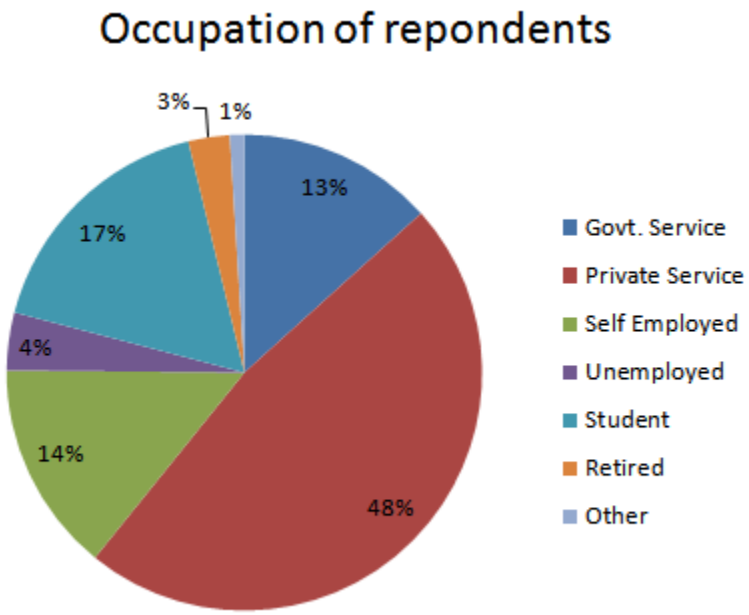
- About 12 million people travel on intercity buses along this corridor (2011-12)
- Mostly young travelers - 55% respondents between 21 and 30 years
- Greater percentage of respondents were students as compared to the railways
- Respondents had on average, lower incomes than those on the railways





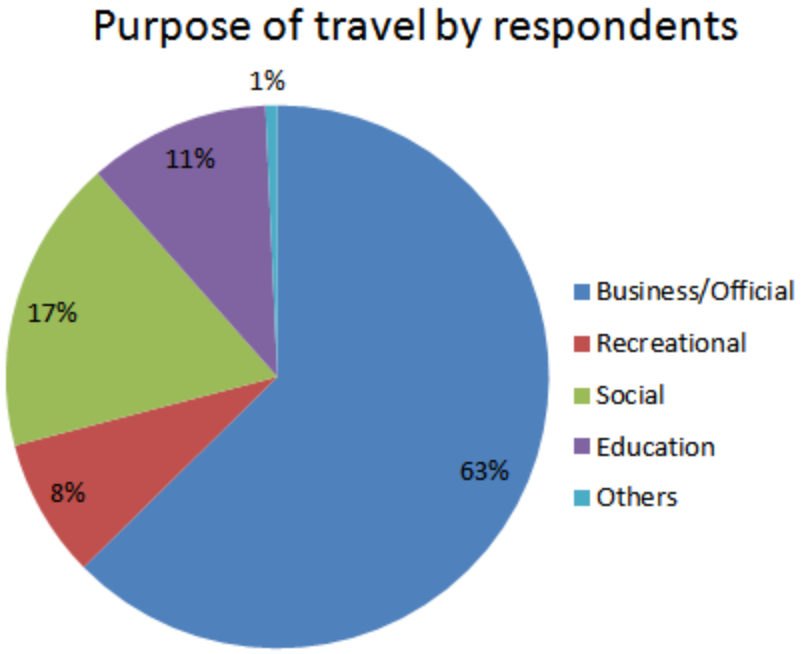


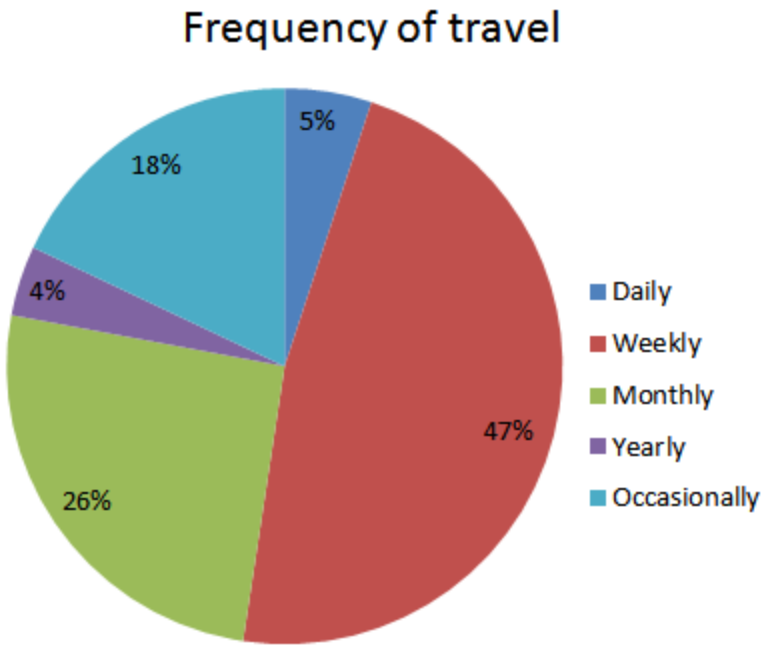
Primary surveys were conducted at bus terminals in Ahmedabad, Vadodara, Surat and Mumbai. Sample size: 712

The Ahmedabad-Mumbai corridor

BUS TRAFFIC – PASSENGER PROFILES

Creating Innovative Solutions for a Sustainable Future





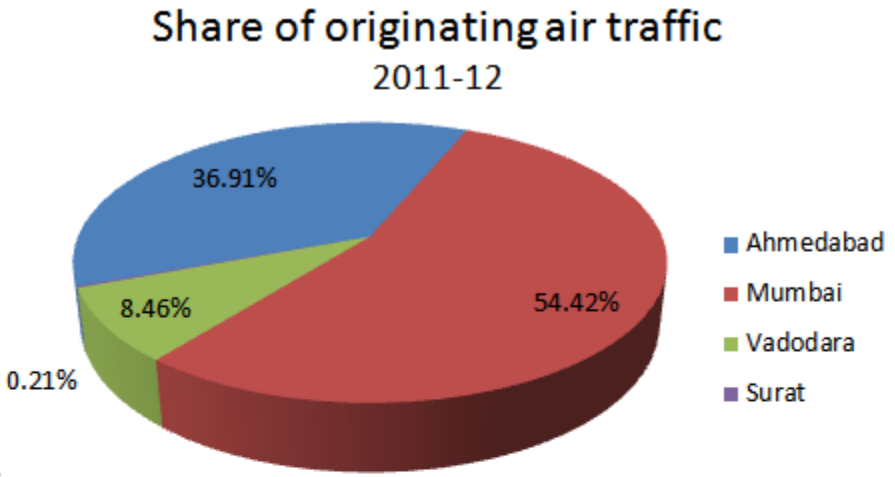
- 63% of the respondents were traveling for business or official purposes
- Most of these respondents made trips along this corridor once a week

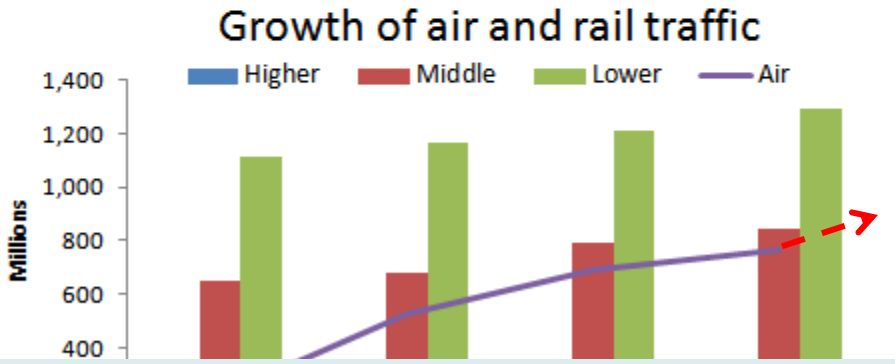
High share of bus passengers surveyed along this corridor were young and booked their tickets at the time of journey

The Ahmedabad-Mumbai corridor

AIR TRAFFIC

- 1.76 mn passengers travelled by air in 2011-12
- Mumbai-Ahmedabad accounts for 80% of the traffic
- Rapid growth of aviation passengers
- New airports in the anvil
- At this rate the mobility on air would exceed the mobility on medium classes of the railways by 2012-13





This growth of passenger traffic driven by growth in air and road traffic is unsustainable in the long run

Ahmedabad-Mumbai corridor

MODAL SHIFT TO HSR

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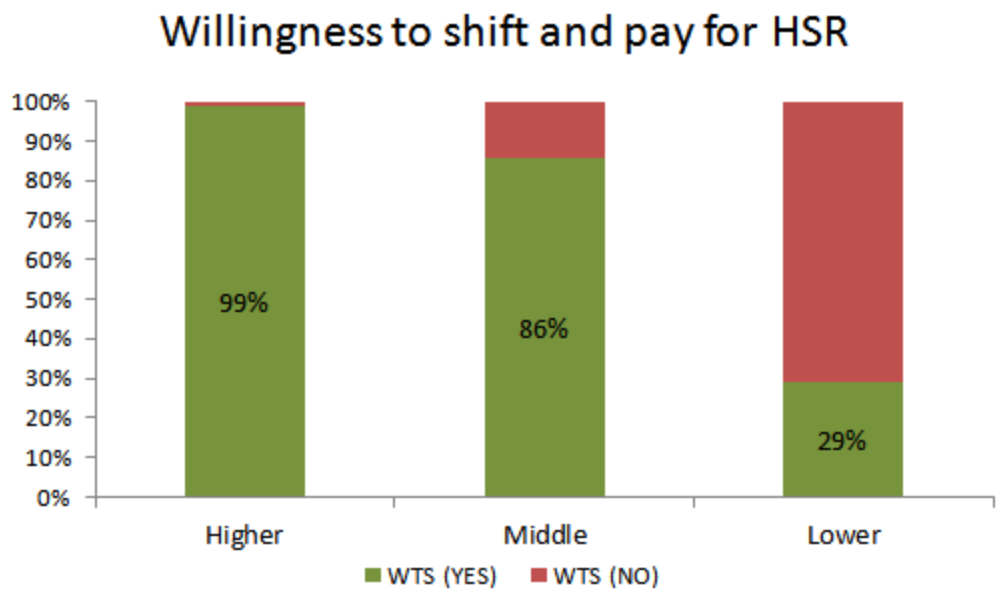
Rail

- Conducted primary surveys on board trains and on platforms to understand willingness of current passengers to shift to HSR if introduced
- About 98% passengers said that they would be willing to shift to HSR
- But smaller percentage were willing to pay for HSR services



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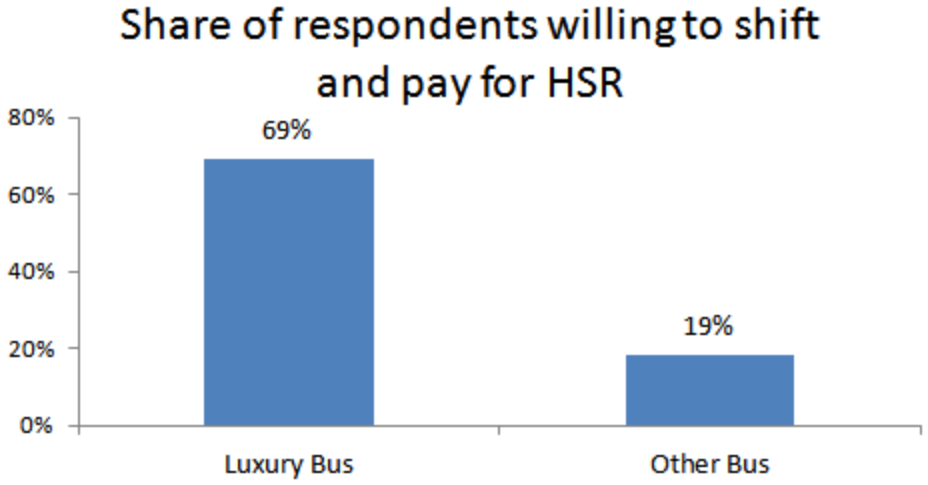
The Ahmedabad-Mumbai corridor

MODAL SHIFT TO HSR

Creating Innovative Solutions for a Sustainable Future

Road

- Conducted primary surveys at bus terminals to understand willingness of current passengers to shift to HSR if introduced
- About 69% passengers traveling on luxury bus classes said they would shift to HSR and pay
- From the Japanese experience of the Shinkansen, about 15% of car users was assumed to shift to HSR



Primary surveys were conducted at intercity bus terminals in Ahmedabad, Vadodara, Surat and Mumbai. Sample size: 712

The Ahmedabad-Mumbai corridor

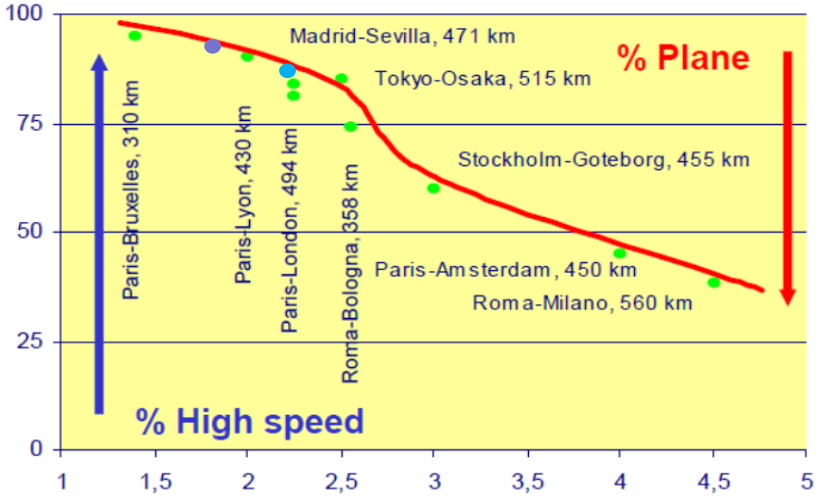
MODAL SHIFT TO HSR

Creating Innovative Solutions for a Sustainable Future

Air

- International experience show HSR passengers prefer to travel by HSR for journeys with travel time less than 3 hours

Relationship between rail speed and market share



Source: UIC-High Speed Presentation by Jean-Pierre LOUBINOUX 2009

- About 80% of the passengers between Ahmedabad and Mumbai can be expected to shift to HSR

Based on these assumptions an alternate scenario was built to evaluate the impact of HSR along this corridor

The Ahmedabad-Mumbai corridor

TRAFFIC TRENDS WITH INTRODUCTION OF HSR

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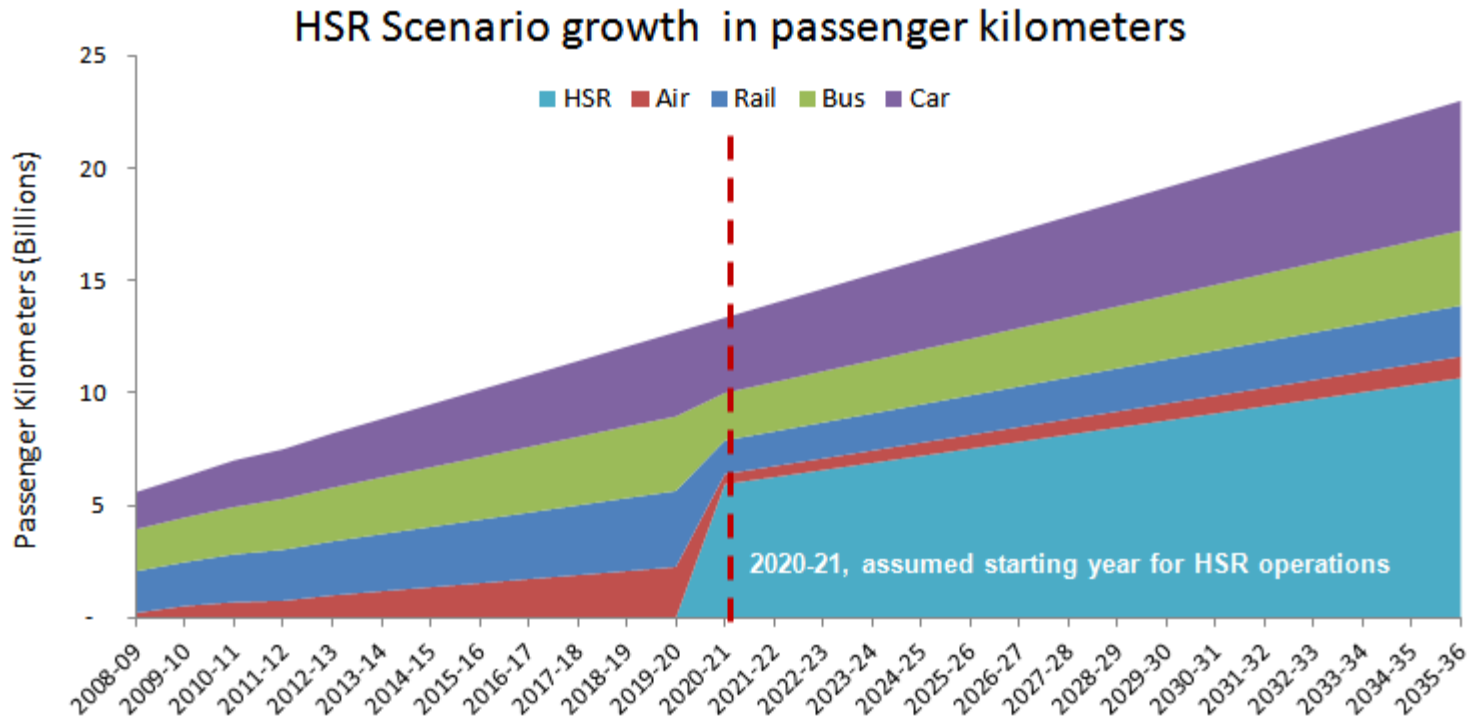

- After 15 year of operations likely shares of traffic on this corridor would be
  - 46% on HSR
  - 40% on roads (car: 24%, bus: 16%)
  - 4% on air and 10% on conventional rail

The Ahmedabad-Mumbai corridor

ENERGY TRENDS WITH INTRODUCTION OF HSR

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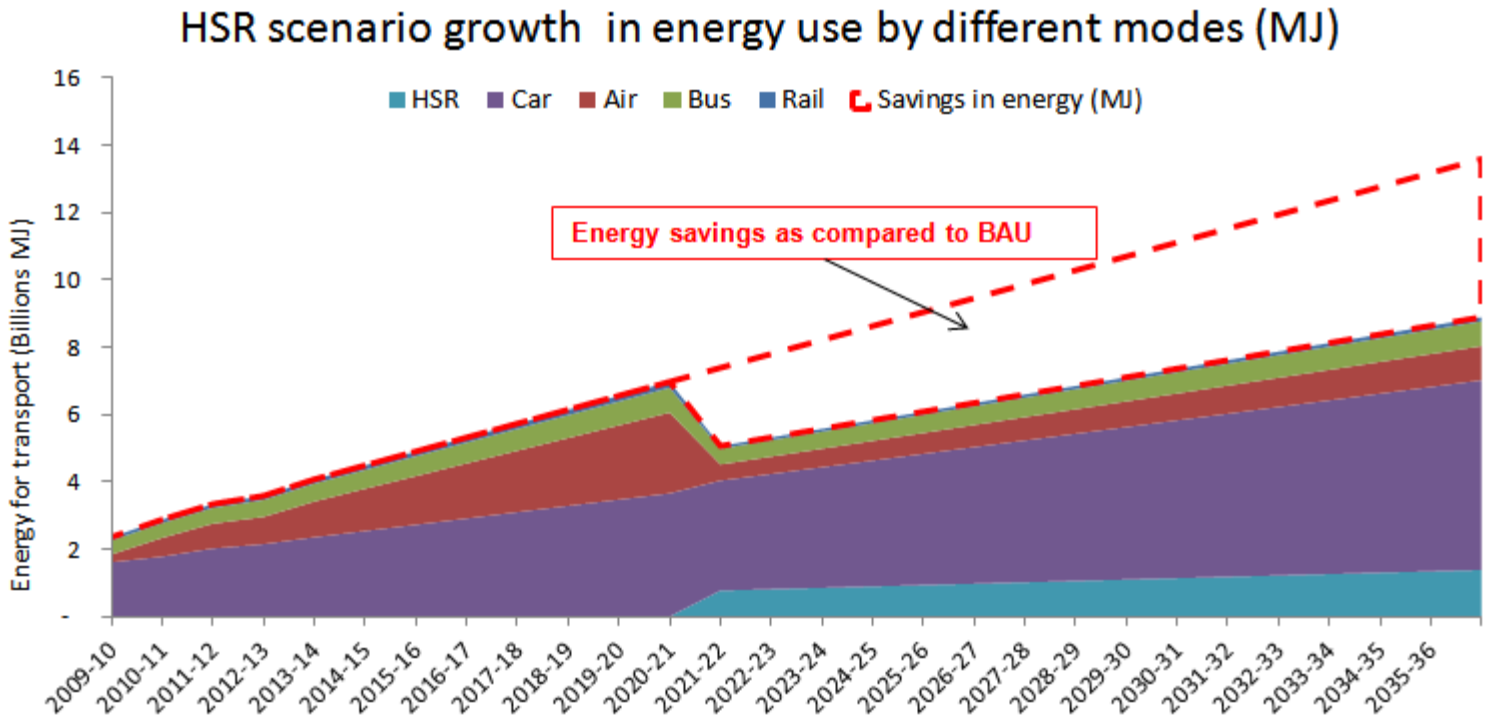
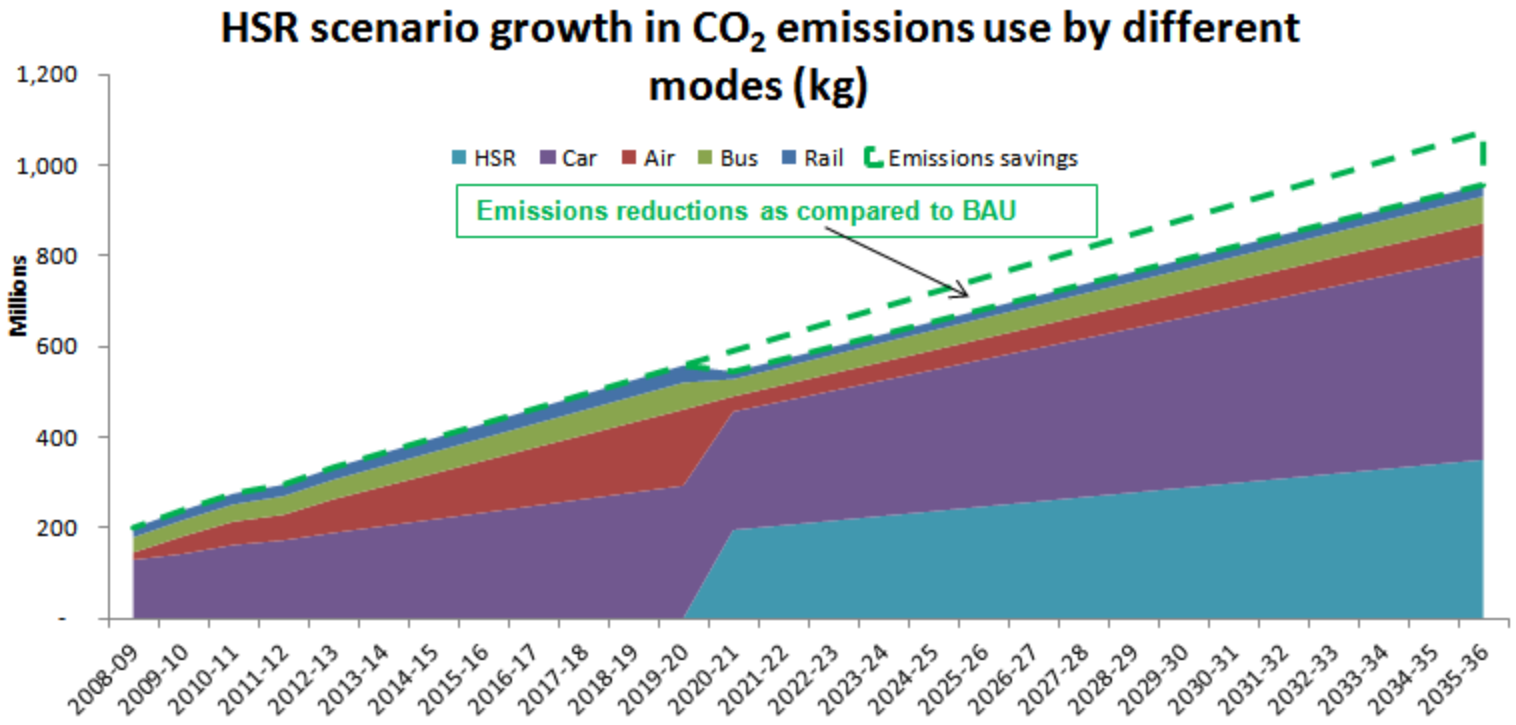


- This scenario results in an annual average savings of about 3.5 PJ over a 15 year period
- By 2035-36, HSR services would carry about 46% of the total traffic by consuming only 16% of the energy
- Road transport would still continue to consume the largest share of energy

The Ahmedabad-Mumbai corridor

EMISSIONS TRENDS WITH INTRODUCTION OF HSR



- A 10% reduction of emissions per annum over BAU
- Annual average emissions reduction of about 81,040 tCO_2 over a 15 year period
- Impact on emissions due to HSR is dampened due to heavy coal based energy generation – need to move towards non-fossil fuel energy sources

HOW DO THESE IMPACTS VARY ACROSS OTHER SECTIONS?

Traffic shares

VARIOUS SECTIONS in 2011-12

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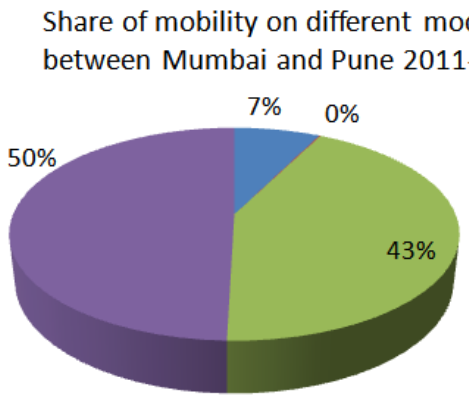
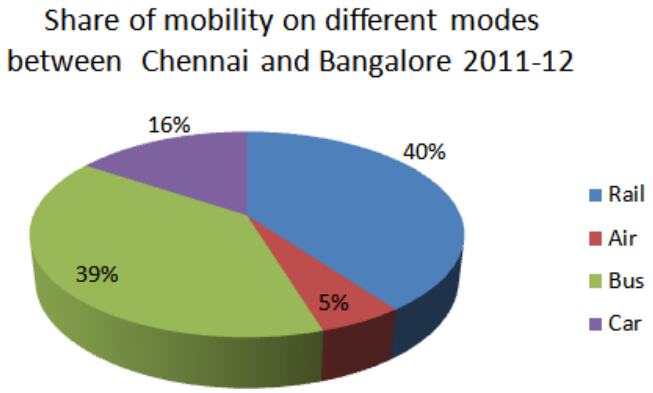
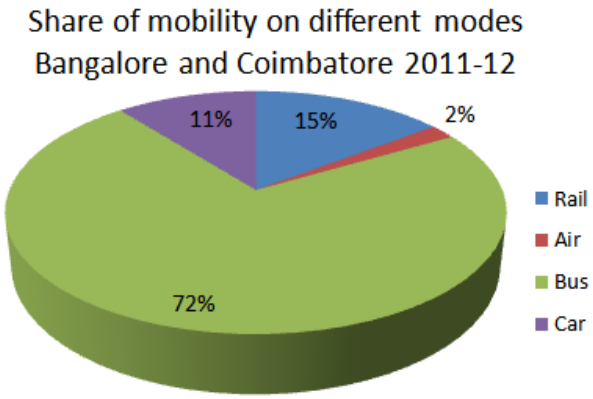


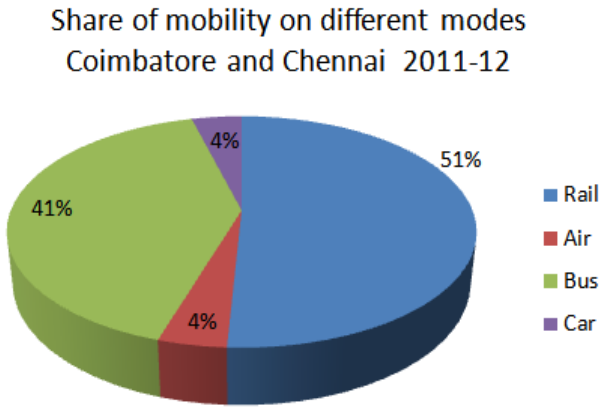
Mumbai-Pune: 6.41 BPKM



Chennai-Bangalore: 3.99 BPKM



Bangalore-Coimbatore: 1.35 BPKM



Coimbatore-Chennai: 4.57 BPKM

Changing shares of traffic

COMPARING DIFFENRENT SECTIONS

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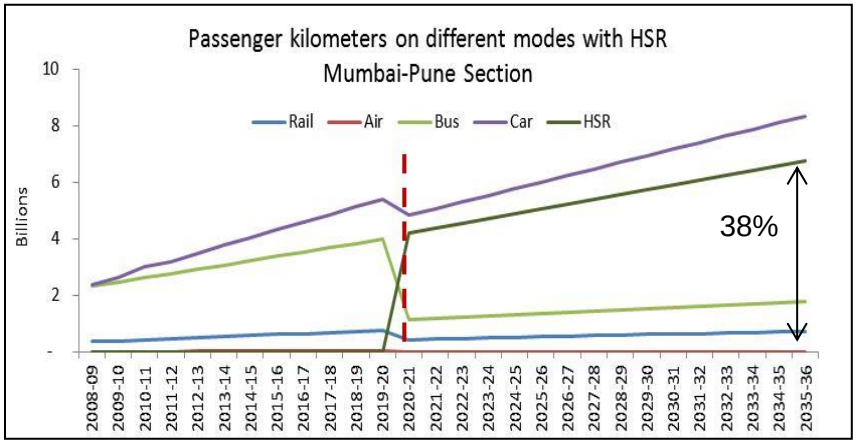
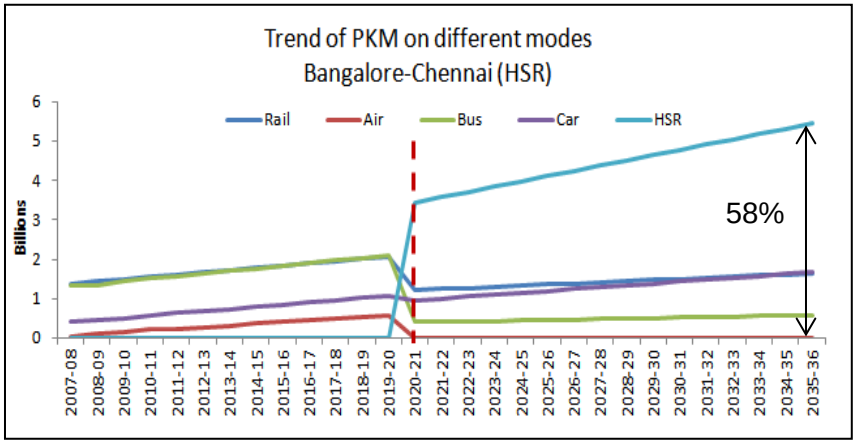
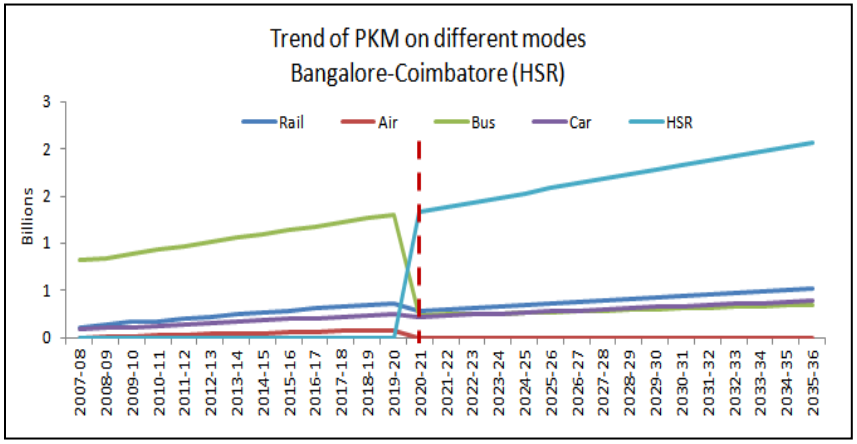


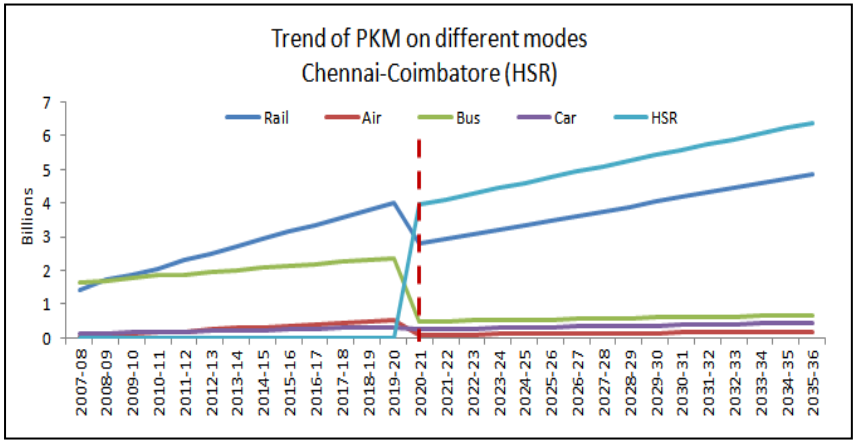
Not many car users are expected to shift, mostly bus users



Large shift from bus and conventional rail



Bus shares could go down from the present 72 per cent to as low as 10 per cent



HSR shares could grow to as high as 52 per cent on account of conventional railways

Energy use patterns

COMPARING DIFFENRENT SECTIONS

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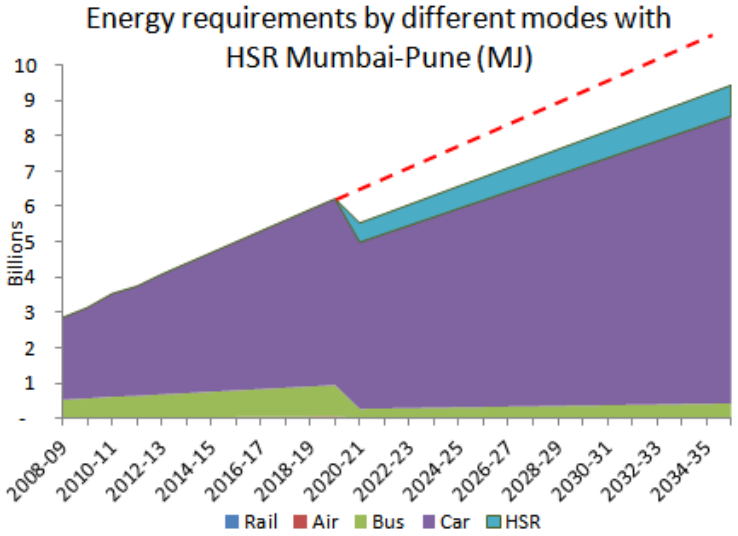
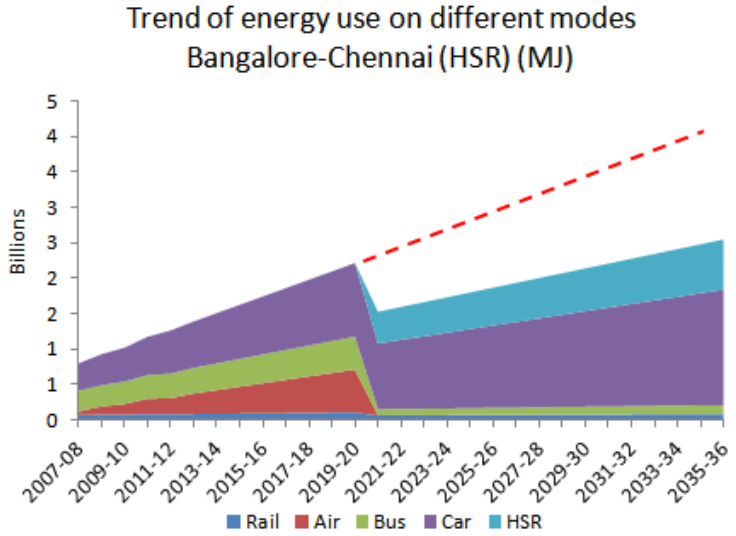
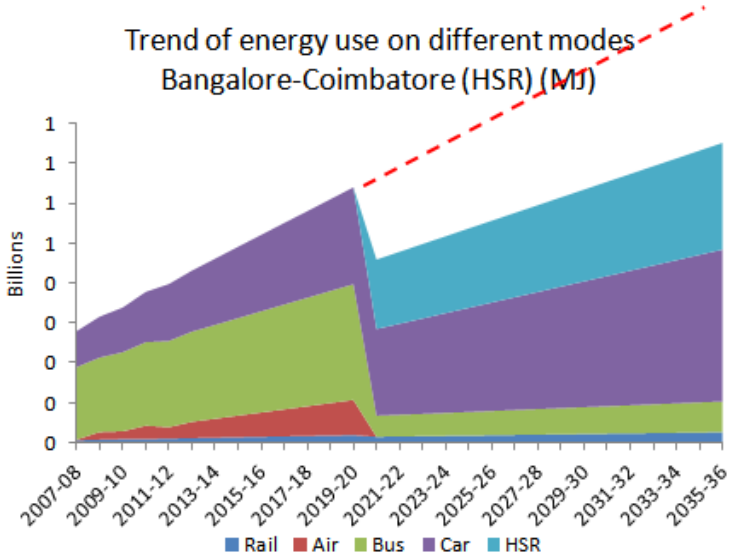
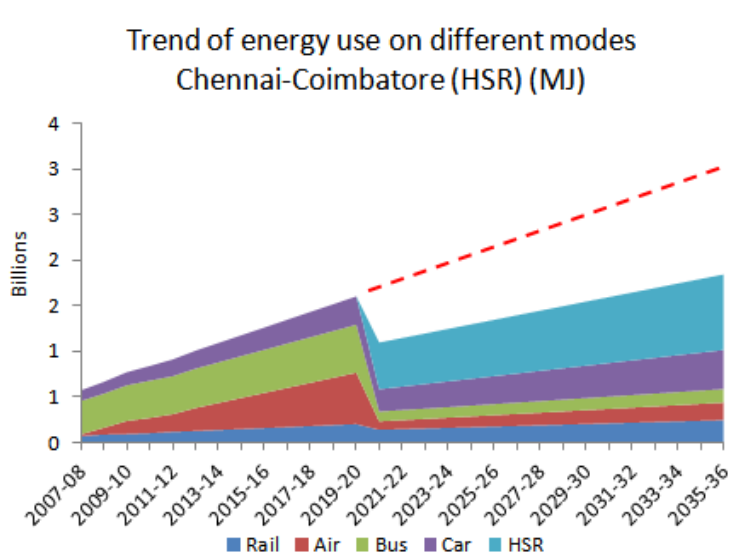






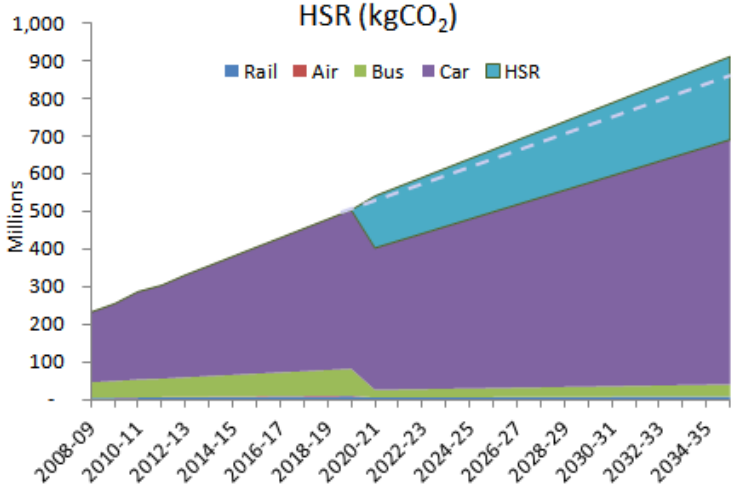


Emissions patterns

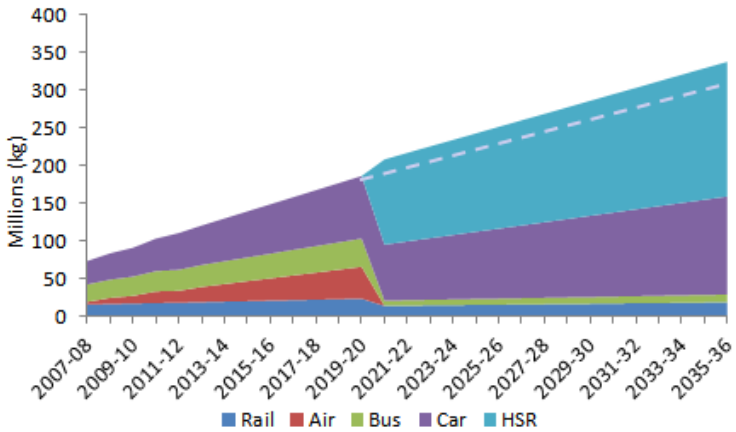
COMPARING DIFFENRENT SECTIONS

Creating Innovative Solutions for a Sustainable Future

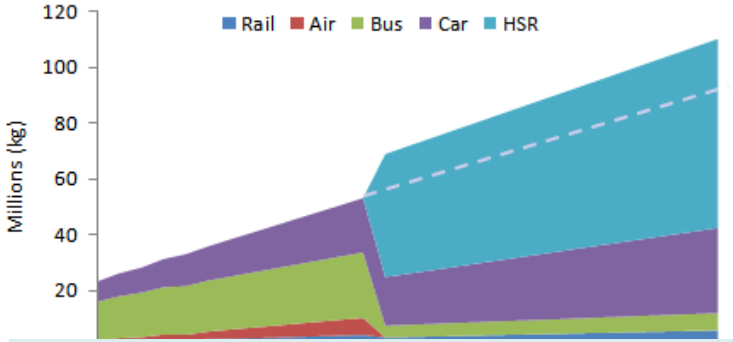
Emissions generated by different modes with HSR ($kgCO_2$)



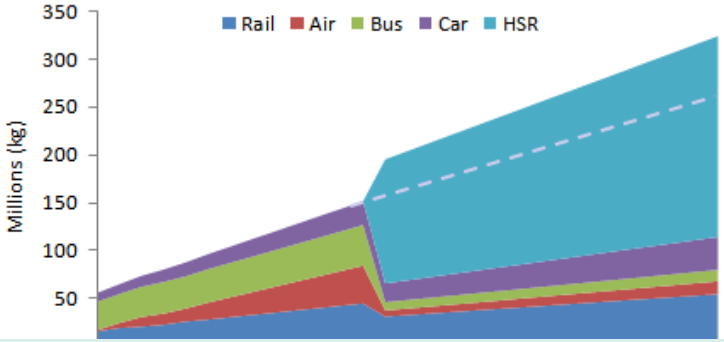
Trend of emissions on different modes Bangalore-Chennai (BAU)



Trend of emissions on different modes Bangalore-Coimbatore (HSR)



Trend of emissions on different modes Chennai-Coimbatore (HSR)



Where large shifts are expected from conventional rail and buses, there is a decline in the emissions benefits of HSR

Key takeaways

Creating Innovative Solutions for a Sustainable Future

1. High Speed Rail is one of the solutions to meet the rapidly increasing demands for mobility along these corridors
2. It will also help in achieving energy savings - however the level of savings would depend on the nature of modal shifts
3. Introduction of HSR may not result in decreased emissions in all cases
4. Electricity generation from dirty fuels like coal could reduce the overall benefits of HSR - need to move to renewables
5. The selection of HSR corridors should be done on a case by case basis after thoroughly understanding the traffic patterns along each section

THANK YOU