Who pollutes and guzzles more from urban commute?

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Centre for Science and Environment
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The convergence: Climate Change, Clean Air and Urban Agenda
Public health challenge

More than 18 million healthy life years lost due to air pollution.

Exposure to toxic emissions from vehicles a serious public health concern.
Climate change is for real....
Toxic Air
More cities in grip of critical level of PM10

Source: Centre for Science and Environment of CPCB air quality data submitted to Rajya Sabha for 44 cities
Mixed and worrying trends across cities

PM10 concentration in six mega cities—way above the standard

PM10 concentration in metropolitan cities

*Data available since 2011

Source: Computed by CSE from CPCB air quality data submitted to Rajya Sabha for 44 cities and CPCB the ENVIS centre
Mixed and worrying trends across cities

NO2 concentration in six mega cities

NO2 concentration in six metropolitan cities

Source: Computed by CSE from CPCB air quality data submitted to Rajya Sabha for 44 cities and CPCB the ENVIS centre
Energy Insecurity
Over 40% of oil and oil products in India go into running of vehicles

Trends in primary oil consumption in India—present (2000–13) and projected (2013–40)

Till 2040, the transport sector in India will continue to record the highest growth rate in energy consumption—as much as 7 per cent—followed by industry at 6.4 per cent and the building sector at 2.4 per cent.
Personal vehicles and heavy duty trucks drive the consumption

- **2013**: light-duty vehicles used up 13% of overall energy consumption by the transport sector;
- **2040**: This share to increase to 27%
- Share of heavy-duty trucks to increase from 23% in 2013 to 34%

Vehicles threaten energy security

Kolkata:
-- Cars and two wheelers together use up about 40% of total transport energy consumption.
-- Transport oil consumption will triple by 2030 with largest increase expected from four wheelers.
Trends in total vehicle registrations in India (1951–2015)

Total vehicle registrations—the number has increased 700 times

Source: Road Transport Yearbook, MoRTH, 2016
All cities are sprawling today...........

Cities have grown about twice as fast in area as they grew in population, -- declining average city population densities and increasing sprawl.

Faster population growth on the peripheries of major cities.

For the 12 largest Indian cities, satellite imagery shows that:

--- Proportion of built-up area outside a city’s official boundaries exceeds that within its boundaries

--- Also exceeds the proportion of population, -- low density sprawl.

(World Bank 2015)
What have we tried to do?

Assess toxic and warming emissions and energy guzzling only from urban commute in cities.... From the way we travel in our cities.........
Who pollutes and guzzles more from urban commute?

Cities under scanner

Megacities-- Delhi, Mumbai, Kolkata, Chennai, Bengaluru Hyderabad

Metropolitan cities: - Ahmedabad, Pune, Jaipur, Lucknow, Kochi, Bhopal, Vijaywada Chandigarh

How are cities coping to reduce emissions and energy use from urban commute?

• Particulate matter
• Nitrogen oxides
• Heat-trapping carbon dioxide
• Energy consumption
What parameters influence energy use and emissions from urban commute?

Parameters that require policy focus

- Population – Planning for number of people
- Per person trip generation and volume of daily travel trips
- Average trip length by modes of transport
- Share of different modes in all motorised trips
- Average distances that modes cover and total kilometers they travel
- Level of vehicle technology and fuel quality

Challenges of such assessment

- Lack of official data base
- Mobility plans, Census of 2011, project reports, research studies
- Better data may modify ranking but the overall message from ranking will not change
Cities have been ranked based on two approaches:

i) **Ranking based on overall aggregated emissions and energy use from urban commute:** Based on combined score for all parameters – establishes the overall position of all cities

ii) **Ranking based on per trip emissions in cities:** A smaller city may have lower overall pollution but may have high emissions per trip due to a polluting mode. Emission is influenced by the mode of travel for a trip we make and the level of its technology and fuel quality. This is a better indicator to plan remedial measure

• **Where are our cities in this race?**
Comprehensive Ranking of the Cities (All Modes)

Based on overall emissions and energy consumption

- Bhopal
- Chandigarh
- Kochi
- Jaipur
- Ahmedabad
- Pune
- Mumbai
- Hyderabad
- Chennai
- Delhi
- Kolkata

Based on per travel trip emissions and energy consumption

- Kolkata
- Bhopal
- Ahmedabad
- Lucknow
- Vijayawada
- Pune
- Chennai
- Bengaluru
- Kochi
- Chandigarh
- Hyderabad

Source: CSE analysis
Mega Cities Ranking

Based on overall emissions and energy consumption

Based on per travel trip emissions and energy consumption
Mega Cities Ranking

Kolkata wins among mega cities

Based on overall emissions and energy consumption

Based on per travel trip emissions and energy consumption
The rider ..............

From a public policy stand-point, it is important to recognize that the difference between cities in terms of emissions of toxic and warming gases and transport energy use, is not a matter of chance.

It is a matter of choice—a result of conscious decision-making and prioritization related to sustainable modes, compact urban form and road design, and transportation planning, that influence commuting choices of the masses.
Population and population densities (2017) of the selected 14 cities

Source: UN Population Projections, 2017
More people in city, higher trip generation

(Per capita travel trip rate) 2017

- Population size, gender and work profile influence trip generation and travel demand
- Megacities with very high population are at the top
- Mumbai in the lead, followed by Chennai, Kolkata and Delhi.
- Bhopal, Pune, Vijayawada, Lucknow, Kochi and Jaipur are placed in that order.

Note: *For Hyderabad, the trip rate is for Greater Hyderabad Municipal Corporation area which was constituted in 2007 and thus exhibits a non-uniform level of urban development within its boundary, possibly leading to a rather lower trip rate.

Source: Base figures from multiple transport studies; projections using factors given in “Review of Urban Transport” prepared by CSTEP and IUT
What is the average trip length of cars, two-wheelers and taxis/autos in cities

- Mumbai, Chennai, Delhi, Hyderabad: -- high average trip length.
- Metropolitan cities of Kochi and Vijayawada: on the higher side (e.g. twin cities of Kochi–Ernakulam)
- Kolkata, - a megacity, but with smallest average trip length among 14 cities.

Source: Base figures from multiple transport studies; projections using factors given in “Review of Urban Transport” prepared by CSTEP and IUT
**Share of different modes of transport in motorized trips**

<table>
<thead>
<tr>
<th>City</th>
<th>Public transport</th>
<th>IPT</th>
<th>Two-wheelers</th>
<th>Cars</th>
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<tbody>
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<td>Lahor</td>
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<td>Mumbai</td>
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- **Mega cities**: Public transport share higher; has the highest personal vehicle dependence for work trips-- Hyderabad, Bengaluru, Chennai and Delhi, with Mumbai and Kolkata bucking the trend.

- **Metropolitan cities**: Share of personal vehicle usage high -- Close to 80 per cent in Chandigarh; Lucknow, Ahmedabad and Jaipur at 70, 65 and 60 per cent respectively.

- Two-wheeler usage very high.
Share of private and public transport in motorized trips

- **Mumbai and Kolkata**: Highest share of public transport trips followed by Delhi and Chennai.
- **Bengaluru**: at lower level
- **Metropolitan cities**: High share of personal vehicle trips

**Source**: Base figures from multiple transport studies, projections using factors given in “Review of Urban Transport” prepared by CSTEP and IUT
Average distance travelled by different modes of transport

Personal vehicles dominate the daily distance travelled in all the cities.

- Two-wheelers travel the maximum, -- in Delhi, Chennai, Hyderabad and Bengaluru.
- Kolkata and Mumbai, -- lowest share of personal vehicle trips in terms of total kilometres travelled.
- Metropolitan cities -- personal vehicles dominate

Source: CSE analysis
Levels Of Motorization in Different Cities

Trend in total registered vehicles and average annual growth rate in the 14 cities (2006–16)

- Mega cities have very high vehicle stock
- Metropolitan cities with smaller base have recorded very high growth rate

Source: MoRTH statistics
Total particulate emission load from urban commuting in the 14 cities (kg per day)

Particulate load from urban commuting in Bhopal is 11 times lower than Delhi.

Source: CSE analysis
Particulate emission load per trip from private and public modes of transport (in g per year)

Source: CSE analysis
Total NO2 emission load from urban commuting in the 14 cities (kg per day)

- Source: CSE analysis
Nitrogen oxide emission load per trip from private and public modes of transport (in g per year)

Source: CSE analysis
Heat Trapping Gases increase Climate Risk in Cities

CO2 emission load from urban commuting in the 14 cities (in tonnes per day)

- Bhopal
- Vijayawada
- Chandigarh
- Lucknow
- Kochi
- Jaipur
- Kolkata
- Ahmedabad
- Pune
- Mumbai
- Hyderabad
- Bengaluru
- Chennai
- Delhi

Source: CSE analysis
Heat Trapping Gases increase Climate Risk in Cities

CO2 emission load from different modes of transport (in tonnes per day)  
Per trip CO2 emission load in cities (kg)

Source: CSE analysis
Energy consumption for urban commuting in the 14 cities (in MJoules per day)

Source: CSE analysis
Maximum Energy guzzler-- Cars and two-wheelers

Mode-wise distribution of energy consumption (in MJoules per day)

Per trip energy consumption in cities (in MJoules per year)

Source: CSE analysis
Lessons from cities.............
Bhopal ranks best among all
Advantage of early action

Advantage
-- Lower population
-- Personal transport usage is higher, but average trip length of different modes is second lowest; average distance travelled by different modes also lowest
-- Vehicle numbers among lowest. Less vehicle miles travelled
-- Lowest particulate, nitrogen oxide load and CO$_2$ load

-- **Early action** to build bus and bicycle programme with enhanced bus fleet, bus rapid transit system and public bike sharing schemes. Modal share of public transport -- 23%

-- Transit-oriented development policy has progressed here.
Kolkata wins among mega cities

-- Sixth among all 14; -- Wins among six mega cities
-- Third highest volume of trips due to large population,
-- Lowest average trip length for all different modes
-- Average distance travelled by different modes lowest among all mega cities.
-- Lowest vehicle stock; second highest share of public transport.
-- Early investment in diverse and connected public transport and physical restraints
-- Public transport culture, compact city design, high street density, short travel distances restricted availability of land for roads and parking -- good practices.

-- Most diverse public transport systems buses (now upgrading to electric buses), metro, trams, suburban rail, para-transit and waterways. -- Public transport and IPT trips 88 per cent.

-- Proves - only high population, high travel volume and economic growth need not necessarily lead to higher automobile dependency.
Mumbai stays ahead with public transport spine

-- Ranks 10th

-- Ahead of all mega cities except Kolkata.

-- Highest volume of trip generation.

-- Average trip length of all modes second highest.

-- Average distances of different modes are comparatively smaller than six other cities. -

-- Vehicle stock higher than Kolkata; but much lower than other mega cities.

-- Winning streak -- public transport spine –suburban rail system. Public transport and para transit -- 89 per cent of all motorized trips.

-- Highest trip length for personal vehicles ; Yet overall guzzling and emissions are lower

-- Despite having highest trip generation and volume of travel Mumbai could reduce impacts by adopting public transport strategy.

-- Even with highest per capita GDP among the six megacities and highest volume of trip generation use of personal modes is lowest in Mumbai.
Delhi’s dilemma
Ahead and yet a loser

The paradox of Delhi

-- **Total volume of trip generation is lower** than Kolkata, Mumbai, Chennai, and Bengaluru.

-- **Average trip length for different modes is lower** than Chennai, Mumbai, Bengaluru, Vijayawada, Kochi, and Hyderabad.

-- **Delhi’s public transport share is the third best among all cities.** Delhi is 7th in per-trip pollution generation.

-- **Despite these relatively better overall positions why is Delhi at the bottom rank?**

**Reason**

-- Higher population than other megacities. Highest vehicle stock
-- Volume of trips, even with lower trip rate, are very high
-- Per day around 20-30 million more trips are generated than Kolkata, Chennai, Hyderabad and Bangalore.
-- Total vehicle kilometres generated far exceeds that of any other megacity.

-- **Eclipsed benefits of CNG, and better travel parameters than other cities**
-- Requires much more ambitious and harsh measures to bend the curve
How does Delhi’s paradox look like?

Based on overall total emission load and energy use from urban commuting

**Total PM emissions:** • Delhi emits 5 times more than Kolkata, 3 times more than Mumbai, 13 times more than Bhopal, 9 times more than Chandigarh & 8 times more than Vijayawada

**Total CO2 emissions:** • Delhi emits 4 times higher than Kolkata, 2.3 times higher than Mumbai, 1.7 times higher than Hyderabad; 26 times more than Bhopal, 15 times more than Vijayawada and 11 times more than Chandigarh

**Total energy consumption:** • Delhi consumes 5 times more energy than Kolkata, 2.4 times more than Mumbai, and 2 times more than both Hyderabad and Bengaluru; 28.4 times more than Bhopal, and 15 and 13 times more than Vijayawada and Chandigarh respectively

BUT……….Delhi fares relatively better on per-trip emissions

**Based on per trip emissions:** Hyderabad & Kochi emit 3 times more PM than Delhi; Chandigarh & Hyderabad emit about two times higher CO2 than Delhi & twice more energy

Delhi’s comparatively higher public transport modal share, effect of CNG programme, in-use emissions management shows up in per trip emissions
Mega cities. Mega problems

Chennai, Bengaluru, Hyderabad – weighted down by growth and automobility

-- Chennai and Bengaluru with large population have high trip generation and volume of travel.

-- Average trip length for different modes especially cars among the highest; particularly in Chennai

--- Share of public transport ridership is lower than Mumbai, Kolkata and Delhi.

-- Average distances or total vehicle miles traveled by different modes are among the highest.

-- Signs of urban sprawl - increasing distances and dependence on personal vehicles

-- Even with lesser number of vehicles than Delhi, recorded highest annual average growth rate for vehicles among all mega cities.

-- Comparatively lower population than Delhi leading to overall lower number of trips and lesser kilometres travelled by vehicles.

--- Higher trip rate, trip length, low modal share of public transport have increased emissions per trip, -- worse than Delhi.

-- Hyderabad - average distance travelled by cars and two wheelers is among the highest. Its public transport ridership is lowest among all mega cities.
Cities at cross roads

Cities at crossroads can turn for the better or for worse:

Ahmedabad, Lucknow, Vijayawada, Pune and Jaipur at an inflection point

Their per-trip emissions are in the middle of the spectrum

Action has started – Bus fleet renewal, BRT, street design etc. but not enough

Depending on what direction their mobility policies go, their pollution levels may increase or decrease accordingly.

They need to take corrective measures now and avoid the fate of the megacities.
Mounting evidences of massive slide in public transport ridership in cities.

**Delhi bus services**: Share of public transport reduced from 64% in 2001 to 54% in 2010. Since 2013, DTC bus ridership is declining at an average rate of 8.88 per cent per annum. Overall, dropped by as much as 34%.

**Bangalore Metropolitan Transport Corporation (BMTC)**: Since 2009, the ridership increased by 9%. But now huge accumulated losses. Withdrawing buses from low-revenue-generating routes – creating service deficit. Have cut down full-day bus operations on 2,253 routes.

**Brihanmumbai Electric Supply and Transport (BEST)**: Daily ridership of BEST buses gone down to its lowest ever: -- a sharp fall of 40% in the past seven years.

**Ahmedabad**: BRT services – expanded network from 35-km corridor 125km but passenger traffic has not seen an upswing. - BRT passenger traffic stagnant

**Vijaywada**: Made an early transition to BRT at the early stages. But it has stopped operating the system

**No strategy to make public transport work in cities** – poor last mile connectivity for public transport, cheap or free parking, subsidised road taxes for cars, lack of integration, lack of operational reforms are big barriers
Message from Kolkata: Build compact and integrate with transit, walkability.....
Kolkata: Integrated modes

Most diverse public transit modes

MOVEMENT OF PASSENGERS
AVERAGE WEEKDAY PASSENGER VOLUME IN LAKHS

<table>
<thead>
<tr>
<th>MODES</th>
<th>2001</th>
<th>2025</th>
<th>% INCREASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBURBAN RAIL</td>
<td>32.5</td>
<td>46.0</td>
<td>41</td>
</tr>
<tr>
<td>METRO RAIL</td>
<td>2.0</td>
<td>13.0</td>
<td>550</td>
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<tr>
<td>CIRCULAR RAIL</td>
<td>0.2</td>
<td>4.0</td>
<td>1900</td>
</tr>
<tr>
<td>TRAM/LRT</td>
<td>2.0</td>
<td>10.0</td>
<td>400</td>
</tr>
<tr>
<td>BUS</td>
<td>113</td>
<td>175</td>
<td>55</td>
</tr>
<tr>
<td>PARA TRANSIT</td>
<td>35.0</td>
<td>67.0</td>
<td>91</td>
</tr>
<tr>
<td>INLAND WATER TRANSPORT (Ferry)</td>
<td>2.4</td>
<td>7.0</td>
<td>191</td>
</tr>
<tr>
<td>TOTAL</td>
<td>187.0</td>
<td>322.0</td>
<td>72</td>
</tr>
</tbody>
</table>
Kolkata sprawling …..
-- Development towards East and West more sprawled
-- Expansion towards south of the city is more dense and compact like the city core.
Rajarhat: Gated-community and inaccessible design. Wrong urban principle. Urban design make people captive users of car.
Is this paradigm sustainable?
Super blocks, opaque boundary walls, no street activity, limited access....

Source: CSE
Car centric design

Poor walking access

Footpaths for beautification

No mid block crossings for pedestrians – Advantage to vehicles

Source: CSE
The TOD Building typology - in Kolkata:

- Roof of retail used as public space for residents.
- Zero Setbacks.
- Mixed Use (Commercial/Civic/Residential within same block)
- Privacy of residents ensured.
- Retail facing the street with homes overlooking, keeps pedestrians (women) safe.
Good practice in Kolkata: Mixed use development
Delhi setting norms for high density requirements

Delhi framing Transit Oriented Development Policy (DDA/UTTIPEC)

Density minimums as per the table below:

<table>
<thead>
<tr>
<th>Gross FAR (site)</th>
<th>Minimum permissible density (with ±10% variation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residential dominated project (Residential FAR ≥ 50%)</td>
</tr>
<tr>
<td>Below 1.0</td>
<td>Under-utilization of FAR (not permitted)</td>
</tr>
<tr>
<td>1.1 - 2.0</td>
<td>200- 400 du/ha</td>
</tr>
<tr>
<td>upto 3.0</td>
<td>400 - 600 du/ha</td>
</tr>
<tr>
<td>3.1 - 4.0</td>
<td>600 - 800 du/ha</td>
</tr>
</tbody>
</table>

* Site level FAR shall be based on Approved TOD Influence Zone Plan.

-- **Mixed land-use norms:** At least 30% residential and 20% Commercial & Institutional use of FAR is mandatory within the Influence Zone
Barcelona: High Density doesn't mean only high rise

Barcelona has density ranging between 200 dwellings per hectare to 500 dwellings per hectare. Highly accessible streets

Source: Mid-rise, high density. Until what extent does density matter? - Prof. Joaquim Sabaté
Kolkata have natural pedestrian precincts, by virtue of the sheer volume of pedestrians. This can be further built on to make pedestrian zones.
New look of footpath in Kolkata: A step forward
Where do you feel more safe to walk?

Why building setbacks and boundary walls?

Source: CSE
Accelerate action on vehicle technology and fuels to reduce on-road emissions and energy guzzling

**Action in Kolkata**

-- Phased out of old and polluting vehicles in 2009 with immediate impact on air quality

--- Introduced Bharat Stage-IV norms for vehicles with 50 ppm sulphur fuels in 2010. BS VI norms to be implemented in 2020.

-- Introduction of LPG-driven three wheelers. Two-stroke auto-rickshaws banned

-- Upgrading PUC emission testing centers. Need further action for compliance and quality control

-- Introduced remote sensing monitoring – can be scaled up. Integrate OBD testing

-- Implementing electric bus programme. Electric mobility is a way forward

-- Need next level of upscaling to control real world emissions

-- If combined with mobility strategy Kolkata can stay ahead of all
Step forward

Set time-bound targets for improving modal share of public transport, walking and cycling

Integrate urban planning with transportation planning and adopt transit oriented planning to reduce distances and motorized trip generation and improve access to sustainable modes

Promote compact urban form – small block sizes, density norms, mixed land use, mixed income neighbourhood, dense and permeable streets with active edges, etc

Need restraint measures for personal vehicle usage through parking policy, low emissions zones approach, tax measures and congestion pricing approaches.

Integrate urban mobility strategies with clean and fuel efficient vehicles, zero emissions technologies and clean fuels.

Need strong in-use emissions management and real world emissions control

Link funding strategies with reforms in public transport sector

Apply sustainability indicators for evaluating progress of programmes to ensure lowering of emissions and carbon and inducing modal shift towards sustainable modes.
Understand this problem  Modernise this paradigm
Thank You