“Buses Before Old Cars Bans - Expand Public Transport to Make Clean Air Equitable”

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“Smart Urban Design Can Cool Cities and Cut Emissions”

Intro: India is choking with pollution. Cities are heating up. Roads are jammed with polluting vehicles. Buses are few, and clean ones even fewer. Trucks run on old diesel engines, spewing toxic air. Meanwhile, electric vehicle adoption crawls, especially in freight. People protest age-based bans. Policymakers face a tough choice—clean air or public comfort? Can we afford green transport? Can we afford not to? In this urgent and powerful, statistical conversation this week on **Socio-Economic Voices**, transport expert and economist **Dr. Rahul Chakraborty** breaks it all down—costs, choices, climate and courage. He asks: Are we truly planning for the future or just reacting to the present? An exclusive at **Indiastat** with senior journalist **Mahima Sharma**. Take a read...

MS: How should city governments evaluate the cost vs. environmental benefit of deploying large-scale e-buses? What modeling metrics (e.g. emissions per passenger-km, reduction in veh-km) are most meaningful?

Dr. RC: An affordable, efficient and reliable public transport is the backbone of any city. Under the growing concerns of pollution and vehicular emissions plaguing Indian cities and the ensuing health emergencies, it is imperative that the city transportation system is sustainable as well. As per the Ministry of Road Transport and Highways, there were about 2.2 million registered buses in India in 2020 of which a meagre below 8 percent were under public sector. This translates roughly to 1.7 buses for every 1,000 individuals, which is considerably lower than that in many countries including China, USA, Thailand, among others. **There is a dire need to increase the availability of buses in India, especially in densely populated cities**, to provide citizens better access within the city and reduce their transport poverty.

Most of the city-level bus fleets in India till date consist largely of diesel or CNG buses, though recently, e-bus adoption has seen some traction. But even then, despite several initiatives such as the erstwhile FAME II scheme, e-buses accounted for less than 4 percent of bus sales in 2024-25. Many city administrations have been actively procuring e-buses. Delhi, for example, has mandated an e-bus only policy for its procurements. These are indeed welcome steps to reduce tailpipe emissions in Indian cities. However, a key consideration for such large-scale procurements of these newer vehicles is the costs. **A careful consideration of costs (capital costs, operation and maintenance costs, infrastructure costs and end-of-life costs) and benefits (zero tailpipe emissions, reduction in levels of pollutants and health benefits for citizens) is imperative for taking such procurement decisions**. West Bengal government, for example, has recently decided to not incorporate any new e-bus in its public transport fleet owing to higher costs (upfront as well as the battery replacement costs) and drastic fall in the cruising range on a full charge within few fears of procurement and instead plans to procure CNG buses in future. The social benefit of e-buses is undeniable, but given the fiscal landscape of city governments, financial viability remains a challenge. Furthermore, technological advancements are necessary to make batteries lightweight, heavy-density and cheaper. **The role of appropriate business models is extremely important** in introducing e-buses for intracity operations.

Emissions intensity of passenger operations can be measured either at vehicle km travelled (VKM) level or at passenger km (PKM) level. Each has its own applicability. It is best to measure GHG emissions in well-to-wheel (WTW) CO2 (or in CO2 equivalent, depending upon availability of emission factors) terms (linked to the fuel-type) as it captures the emissions on account of extraction of fuel, its transmission to the fuel-tank (battery) of a vehicle, to its final use (energy use in the vehicle). EVs do not produce tailpipe emissions, but at India's current energy-mix (50 percent of installed capacity sourced from non-fossil fuels), only the WTW method reflects their 'green-ness'. If the primary focus of city planners is on reducing overall emissions from transportation and congestion, it is better to estimate emission intensity w.r.t. VKT, as it captures use of more fuel-efficient vehicles. However, if the intention is to assess the efficiency and utilisation of passenger transport, it is better to measure emission intensity w.r.t PKM, as it indicates how well-utilised the transport infrastructures are.

Consider the following two situations of ferrying 44 passengers over a distance of 1 km.

	Mileage (kmpl)	Passenger	Distance (VKT)	Emission factor (kgs of CO_2e/l)	Emission (kgs of CO_2e)	Emission (gms of CO_2e)/ VKT	Emission/ PKM
Situation 1							
Bus1	4	40	1	3.24	0.810	810	20.25
Car1	16.6	2	1	3.24	0.195	195	97.59
Car2		2	1	3.24	0.195	195	97.59
Total		44	3		**1.200**	**1200**	**27.28**
Situation 2							
Bus1	4	22	1	3.24	0.810	810	36.82
Bus2	4	22	1	3.24	0.810	810	36.82
Total		44	2		**1.620**	**1620**	**36.82**

Note: Emission factor is sourced from **DIN EN 16258:2013-03**

We see that in the second situation the VKT has dropped on account of the same number of passengers. But, emissions have increased at the aggregate level as well as at per VKT. This is purely linked to the fact that a less fuel efficient vehicle (bus) has replaced more fuel efficient vehicles (cars). At the same time, emissions per PKM has worsened too, indicating that the buses are underutilised (sub-optimal loading). If Bus1 under both the situations is compared, the underutilisation of it (22 passengers vs. 44) in situation 2 has made the journey for each passenger more emission intensive.

MS: In July 2025, Delhi rolled back the ban on aged vehicles under protest from the common man - that is struggling with inflation. How should policymakers balance the urgency of emissions reduction with equity and public acceptance? Would a phased fitness-based certification approach work better than age-based bans? Please share practical steps ahead.

Dr. RC: The National Capital Region (NCR) of India has consistently been one of the most polluted regions around the world with consistently high levels of PM2.5 and PM10, almost throughout the year. Vehicular and other pollution have led to severe health crisis among the residents. In 2015, the National Green Tribunal (NGT) imposed a ban on petrol vehicles aged 15 years or more and diesel vehicles aged 10 years or more, from plying within the NCR. Later, the Supreme Court ratified this order in 2018 (M. C Mehta vs. UOI). These set the legal precedent for a ban on

end-of-life (EOL) vehicles in the NCR. **However, loopholes remained in proper implementation, which has resulted in a large number of EOL vehicles still plying within the NCR with 10.6 millions of such vehicles yet to be deregistered.**

In a move that would perhaps reinforce the ban, the Commission for Air Quality Management (CAQM) in its directive issued in April mandated a complete denial of fuel to the EOL vehicles from 1st July. However, CAQM put it on hold till 31st October (in NCT of Delhi and 6 adjoining high vehicle density districts), the main reasons being - lack of preparedness to introduce the complex identification and monitoring procedures at state levels, unjustified logic in linking EOL solely with the age of a vehicle irrespective of having a valid Pollution Under Control (PUC) certificate and the strain it may put on the middle-class. It presents a crucial dilemma for the policymakers- balancing between social welfare- reduced pollution and improved health outcomes vs. individual hardship emotional values attached to vehicles, financial burden for lower and middle-income class and feasibility of retrofitting.

The NCR faces an environmental and health crisis owing to not just vehicular pollution but also due to high industrial pollution, construction activities and open waste burnings (Guttikunda et al., 2023). It has further resulted in a reduced life expectancy in this region (Balakrishnan et al., 2019). **It is imperative that a "desperate time calls for desperate measures". However, such measures need to be well formulated.** To combat vehicular emissions and pollutions, a ban on relatively more polluting vehicles is a sine qua non, eventually paving the way for zero-tailpipe emission vehicles (ZEV) in future. However, given the demographics of NCR, a hasty implementation of the ban may create a transport crisis in the region. It has to be done in steps and measures:

1. As an immediate strategy to incentivise scrapping of EOL vehicles, the government may increase the awareness about vehicle scrappage, **scrapping incentives or incentivise through income tax rebate.** The incentive can vary based on the fitness of the vehicle.
2. Further, for the lower- or middle-income class, to smoothen their transition to newer vehicles, **priority loans and lower interest on car-loans** can be considered.
3. **A formal and regulated electric-kit retrofitting market** with suitable financial incentive mechanisms can persuade the owners of 'fit' EOL vehicles to continue using their vehicles for a few more years.
4. Concurrently, the respective governments in the NCR should aggressively **increase the size of the bus fleet (public)**, to cater to the growing demand owing to a transitional lag between scrapping of banned vehicles and purchase of new ones.
5. **The Delhi government is aggressively deploying e-buses**. Other cities in the NCR may follow suit for a 'greener transportation'. An expanding and efficient public transport (including the metro rail network and RRTS) in this region may for good reduce the need for personal vehicle ownership or the need for taxi services and help the region in a similar way like for Beijing. Unfortunately, 'emotions' should play a minimal role during a health crisis.

A ZEV-only mandate in NCR at present is neither feasible nor practical, given the house ownership structure and the technical challenges associated with widespread charging infrastructure. But, in the medium- to long-run, with proper urban planning and recycling ecosystem, the NCR can be the pioneer for a ZEV-only mandate.

MS: Considering rebound effects (e.g., 17% increased travel after fuel savings) and feebate limitations, what mix of policies (road pricing, parking reform, digital platforms) yield net emissions gains?

Dr. RC: A carbon rebound effect (CRE) is well-documented (Özsoy, 2024) in case of technological advancements in the transport sector owing to better fuel economy, leading to a behavioural shift towards more driving, increasing emissions (Bansal and Dua, 2022). CAFÉ Norm precisely tries to improve fuel-efficiency of M1-category vehicles (passenger cars) by periodically setting stringent benchmarks for vehicles and penalising the vehicle manufacturers for non-compliance. **India does not have any feebate mechanism in place but the central government**

experimented with purchase subsidies to promote adoption of electric vehicles (EVs) under FAME I and II schemes (selectively targeting specific segments). This was also complemented by some of the state governments (for example Delhi).

A feebate mechanism is complex to design as it needs to be revenue neutral, as well as has its limitations as it fails to address the CRE, ignores modal-shift and fails to address the existing vehicle stock. **Road pricing is an attractive policy** in terms of its impact on reducing the CRE, but it is regressive in nature until it is carefully linked to GPS-based live vehicle tracking and a certain 'acceptable threshold' is designed. **Parking reform (by increasing parking fee) and congestion taxes** can dissuade vehicle purchase and increased usage of vehicles, but its effects are largely limited to cities. Intercity leisure travel contributing to the CRE will largely remain unaffected. As plausible complements to increasingly stringent CAFÉ Norm and other emission-saving measures (like purchase incentives for EVs), **India needs to focus mainly on providing efficient, reliable public transport for both intracity and intercity travels**, by expanding bus-fleet, increasing capacity of the rail network to operate more passenger trains (providing comfort) and reviving/improving the suburban rail system across different urban agglomerations. Moreover, **an integrated transport network (at least at the city level) based on digital platforms** can help commuters plan their travel, provide easier access to public and shared mobility options and actively nudge commuters towards environmentally friendly travel choices by real-time carbon tracking and providing discounted fares for not taking 'unnecessary trips'. **An efficient, optimally utilised public transport system** (through modal shift) can offer net-gain in terms of emissions even if it fails to address the rebound effect. Work-from-home arrangements and 'walkable cities' concept can also be explored to reduce travel.

MS: Road freight carries 97% of 4.6 billion tonne-freight, emits ~53% of particulates, yet makes up only ~3% of vehicles. It contributes ~34% of road transport emissions, but electrification is still minimal. With studies projecting up to 70% CO_2 cuts by 2050 through heavy vehicle electrification, what infrastructural and behavioral barriers hinder progress - and how can policy overcome them?

Dr. RC: Road freight segment is the laggard in EV adoption in India and cumulative registration of EVs account for a meagre 0.1 percent of all goods vehicles registered. Light goods vehicles (with gross vehicle weight up to 7.5 tonnes) accounting for 60 percent of all goods vehicles registered, perform relatively better but still the electrification hovers around 0.2 percent of vehicle stock. **In 2024-25 FY, out of 9 lakh newly registered goods vehicles only 5,357 (0.6 percent) were electric vehicles**. Such low adoption of EVs in the goods vehicle segment pose significant challenges to freight decarbonisation efforts.

The primary reason against EV adoption in this segment has been:

- The **upfront cost and lack of clear total cost of ownership (TCO) advantage over traditional internal combustion engine (ICE) vehicles** at present technological and operational context in India. This proves to be extremely challenging for an unorganised trucking landscape like India, where more than 60 percent of trucks are owned by small-owners (owning less than 5 trucks).
- Moreover, there has been a **lack of available models to choose from- unlike the matured ICE segment, very few EV models exist**, restricting the choice set for vehicle purchasers (individual owners or fleet operators).
- **Another important hindrance is the heavy battery penalty in terms of reduced carrying capacity**- compared to ICE fuel tanks, batteries for e-trucks weigh significantly more, thus it reduces the payload capacity for trucks of similar GVW classes.
- **Charging infrastructure is an issue** while considering EV purchase and India's charging network is still growing.

Given the driving pattern of truckers in India (over 400 km/day, 13 hours/day), it is of paramount importance to address the range issue with e-trucks without imposing considerable battery penalties.

How to deal with the situation?

1. Governments may **identify priority corridors and circuitous goods movements** (mines to industry clusters or industry clusters to ports and goodsheds) for mandating e-truck operations, as these follow a predictable pattern.
2. Charging or battery swapping infrastructure can be **set up on priority** basis around these tracks.
3. **A hub-spoke mechanism of goods transport network** across the country can be established where the major transport hubs will be identified, the roads linking these would be prioritised for setting charging and swapping infrastructure at 'reasonable' distance.
4. One issue plaguing the Indian trucking sector is the high empty-run (underutilisation). Thus, battery penalty may not be a major issue if **efficient logistic practices** such as freight aggregation can be adopted.
5. Under the **EU CBAM Mechanism**, the exporters would be required to reduce emissions to avoid carbon tariff while exporting their products to the EU. This can have a spillover effect for domestic goods transport as well.
6. Moreover, **a Clean Freight Programme** can be developed and linked to the Indian Carbon Market, where the shippers would trade carbon credits based on the Scope 3 emissions avoided. These can induce shifts towards cleaner transport options such as EVs or in future hydrogen-ICE trucks.
7. Another important aspect that needs to be addressed is **affordable financing of vehicles**. Small-owners in particular need affordable financing options to offset the significantly higher upfront cost of electric trucks. **The financing landscape needs to mature along with technological advancements** that would reduce the long-term costs associated with electric truck ownership. Battery-as-a-service (BaaS) has recently been launched by one of the leading EV car manufacturers and accounts for about a fifth of their EV sales. **Truck manufacturers need to diversify their portfolio of trucks and may consider similar business models** to delink the cost of battery from the truck itself.

Often overlooked in this discourse of electrification of goods movement, the Railways, with almost 100 percent broad-gauge track electrification provides an existing 'green' option. However, it is grappling with challenges such as high turnaround time, detention of trains, lack of wagons, uncompetitive and rigid freight pricing policies, poor terminal infrastructure, etc. **The Dedicated Freight Corridors and The PM GatiShakti National Master Plan** aims to address some of these issues to divert more traffic from road to rail.

MS: Studies show EV truck fleets can reduce freight emissions by up to 35-70% by 2050; scrappage policies yield only 6-11% emission cuts. Given this, how should policymakers balance investment between scrappage programs and infrastructure for electric freight?

Dr. RC: Scrappage programmes tend to provide short-run solutions to transport emissions, whereas, alternative policies like investment in electric freight infrastructure yield long-run gains. The average age of the trucks operating in India has been growing and is over 10 years. More than 80 percent of goods vehicles in India use diesel as fuel and average age of over 10 years. Further, more than half of the registered heavy-duty trucks fall under legacy BS I, II and III norms. This is a matter of concern from an emission reduction perspective. **These indicate the need for a robust scrappage policy that incentivises scrapping through subsidies.** Over 60 percent of truck operators in India are marginal (small-owners) and operating under unorganised setup. Without a comprehensive scrappage incentive, it would be difficult to persuade them from operating polluting aging vehicles. Though India introduced an age-based Voluntary Vehicle-Fleet Modernisation Program (V-VMP) in 2021, it was amended to a fitness-based criteria in 2024. Vehicles of older vintages, irrespective of their fitness, are more polluting than vehicles of newer emission norms. As an immediate short-run target to reduce emissions from EOL or close-to-EOL vehicles, an efficient and credible scrappage programme is imperative. **The present vehicle scrappage policy has seen lacklustre response from owners (often attributed to lack of awareness and sufficient incentives) and have resulted in mounting losses for the Registered Vehicle Scrapping Facilities (RVSFs) across the country.**

Investments in charging and swapping infrastructure can significantly induce electric truck uptake in the long-run. Presently, the e-truck adoption is insignificant for various reasons, some of which are linked to lack of ecosystem to support wide-scale adoption. However, it presents a chicken-egg situation. Unless other policies (as discussed in last question) are adopted to promote **e-truck purchase, large-scale investment in infrastructure alone may generate captive assets** that remain underutilised in near future.

However, a low-hanging fruit is the urban logistics which has a significant contribution to overall logistics operations in India and is poised to grow in future. Investments in setting up urban logistic hubs and charging infrastructure within urban agglomerations need to be prioritised to provide e-truck push in the urban areas. **A balance needs to be struck in incentivising scrapping of EOL vehicles (being considerate about the truck ownership pattern in India) for short-run emission reduction and investments in infrastructure** (specially in urban areas to begin with) coupled with other policy measures for long-run 'green transport' goals. Hasty decisions for short-run gains may prove to be inflationary and increase the logistic costs manyfold.

MS: With cities warming nearly 2× faster than rural areas and 600 million urban dwellers projected by 2036, how can behavioral nudges and urban design (like transit-oriented development and non-motorised transport) be embedded into emission-focused transport models to tackle urban heat and vehicle emissions?

Dr. RC: There are generally two types of transport models- bottom-up and top-down (Loo and Li, 2012). The bottom-up approach is the most-widely used to forecast transport demand and emissions. There are four major components of these bottom-up models- transport activity [passenger-km (PKM), tonne-km (TKM) and vehicle km travelled (VKT)], modal-split, energy intensity of modes and emissions factors (Schipper and Marie-Lilliu, 1999).

Models developed by some of the organisations like TERI (TERI, 2024) explicitly incorporate rural (intercity) and urban (intracity) transport operations. Under such distinctions, the role of behavioural nudges and urban designs play an important role in quantifying the impacts of such policies on transport emissions.

Behavioural nudges in transportation largely try to induce modal-shift, reduced travel and/or responsible consumption (reduced freight demand). These may also promote aggregation of delivery services. Transit-oriented development (TOD) integrates the concepts of 'walkable cities', accessible and efficient public transport, non-motorised transport (NMT) infrastructure, for making the cities sustainable. Both of these directly impact transport activity and utilisation of alternative modes, by reducing PKM and TKM and restructuring of PKM and TKM (shifting from personal vehicles to public transport and NMT or by shifting to larger delivery vehicles that are better utilised with reduced empty-return ratio). These can be incorporated within these transport models.

However the main challenge in incorporating these is to quantify their impacts as most of these are still hypothetical concepts (particularly, in case of India). **Identifying the exact extent of reduction in transport activity or modal-shift** on account of specific behavioural nudges and TOD policies is extremely challenging and may require large-scale experimentation before being integrated with the models. **Unfortunately, the transport models do not measure the heating impact of the transportation sector** as their main focus remains on GHG emissions and energy usage. The VKT data along with modal-shares can be fed to urban heat island models to assess the impact of the behavioural nudges and urban designs.

MS: Delhi's Metro removed ~500,000 vehicles daily in 2021, reducing CO2 by ~24 g/km. How can such metrics be scaled and institutionalised into planning for accountability?

Dr. RC: DMRC has been doing a remarkable job in 'greening' the transport sector in Delhi, by offloading passengers from roads, thus reducing per passenger carbon footprint (and associated congestion and pollution impacts) and also through increased sourcing of power from renewable sources (from solar plant in Rewa, Madhya Pradesh). **In 2023, DMRC launched the CarbonLite Metro Travel initiative to make commuters (purchasing QR tickets) aware of the**

CO2 avoided for their trip by metro rail, which apparently is a large-scale behavioural nudge at a regional level. Such measurements of avoided emissions (and pollution) and periodic reporting can be made mandatory while sanctioning major transport projects.

Standardised metrics such as avoided VKT, reduction in emission/PKM, net fuel saving and health co-benefits can aid in assessing the viability of alternative projects at the time of planning. These can then be linked to **project approval, funding and appraisal processes to promote sustainable transportation** in the cities. Digital infrastructure can be utilised to **make citizens aware of data pertaining to the emission impact of their mode-choices** (like in case of DMRC) as well as city level performance. For example, cities like **Calgary** (Climate & Environment Dashboard), **Singapore** (LTA DataMall), **London** (Transport for London), **Stockholm** (Miljöbarometern) maintain records on emissions and other metrics and publish environmental facts about these cities via dashboards and annual reports. Moreover, urban masterplans, especially in newer cities, **should clearly set a vision to reduce carbon footprint on account of transportation and promote TOD**. Without vision or with myopic visions we may end up proposing longer elevated roads or tunnel roads instead of costly but much sustainable mass-transit like metro or light rails (Hebbal-Silk Board tunnel road in Bengaluru is a classic example of misplaced priorities).

In a nutshell, **mandatory reporting** is imperative for accountability of ongoing or functional projects. Standardisation of measurement metrics and approval tied to social benefits can incentivise sustainable transport projects. **Public dashboards or dissemination of city performance** through annual reports and other platforms are crucial for transparency, accountability of the administration and public engagement. Masterplan targets help in integrating sustainability of transport projects with the city vision itself. A balance needs to be maintained between **immediate short-run objectives and long-run net-zero** or other goals for the cities.

MS: In light of India's EV push amid energy security concerns and climate commitments, how can the transport sector balance decarbonisation, affordability and ethical sustainability to truly support both environmental and social equity goals?

Dr. RC: In India's pursuit towards net-zero by 2070, it is imperative to address the energy trilemma- energy equity, energy security and environmental sustainability. At the COP 29 in 2024, the developed countries upped their pledge to contribute USD 300 million annually by 2035, which fell significantly short of the demand for USD 1.3 trillion (by the developing countries) in light of differentiated responsibilities. This poses severe threats to achieving the climate goals set by the developing countries as well as the primary goal of the Paris Agreement. This may lead to serious obstacles in financing the transition in developing countries.

The transport sector contributes almost 13 percent of India's CO2 emissions and contributes significantly to the pollution crisis in urban centres. **The government adopted the FAME scheme in two phases to promote electric vehicle adoption. It has seen some success but has largely remained muted in the freight segment owing to exclusion of the segment from subsidies.** The recently launched PM E-Drive scheme has introduced much needed incentives for goods vehicles for the first time, however limited in its extent in terms of number of vehicles to be supported. India is a signatory of the EV30@30 campaign that envisions 30 percent of newly registered vehicles to be electric by 2030. But, at the present rate of adoption, EV penetration seems to fall short of that target.

India has been aggressively promoting indigenisation of vehicle manufacturing through the PLI scheme, with special focus on EVs. **However, the concentration of critical minerals in specific geographical locations and control over such minerals by few countries seem to pose a bottleneck in EV manufacturing.** Moreover, the extraction process associated with some of the critical inputs required for EVs, have been notorious in terms of labour right violations, poor working conditions, as well as impact on ground-water toxicity. The question lies ahead for the policymakers in India is how to promote sustainable mobility without being held hostage by geo-politics, at the same time being ethical in choice of technologies.

- India needs to **diversify its sources of raw materials, rare-earth magnets and develop indigenous battery manufacturing capabilities** to withstand any geo-political shock that can cripple an EV-focused transport system in future.
- The path towards transport decarbonisation should also take an **ethical approach to responsibly source the inputs from suppliers** adopting ethical mining practices. A developing country that has witnessed years of subjugation and colonisation by invaders cannot take the advantage of poorer people in sub-Saharan Africa and other regions in the world, **through the supply-chain that is blind to the unethical practices at source.**
- A balance needs to be struck between use of transition fuels in the short-run, followed by a meticulously orchestrated shift to 'greener technologies' as the **R&D, manufacturing, infrastructure and recycling ecosystems mature. The cost of transition should not create an inflationary impact on the masses.**
- 'Massification' of efficient and comfortable public transport (electric buses, light rails, trams, metro rails) can be a core strategy that can reduce vehicle dependence by modal-shift, hence the stress on input requirements.
- **Railways can play a 'pivotal' role** in India's transport decarbonisation endeavour, without much of the pitfalls of electrifying the road transport.

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