Shifting Focus from Supply to Demand—The Changing Face of Transportation Towards Sustainability

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Abstract Urban form and transport system have an enormous impact on the way people travel. With rapid growing economies and population typically seen in developing countries, there is an increasing trend of expansion of urban sprawl and auto-based mobilization. This has a direct effect on the level and form of transport demand and pattern. In the absence of the implementation of proper policy measures, like parking charges, congestion charging, fare revisions, pedestrianization, it also leads to an increased additional cost for transportation infrastructure and its operation, while at the same time, creating many environmental, economic and social problems. Sustainable transport systems are those which aim to reduce emissions, fossil fuel consumption and the consumption of natural land, while providing easy access to people. This chapter throws light on various issues and challenges related to achieving sustainable urban transportation solutions in Indian cities and how the fundamental focus has shifted from traditional supply centric approaches to demand centric approaches. A case study of steel flyover project in Bangalore, India, is also presented to emphasize this point.

Keywords Sustainability · Transportation · Demand · Supply · India

1 Introduction

Ability of both persons and goods to move, safely and quickly, from one place to the other, i.e. mobility, is the basic need for the well being and prosperity of any individual, society, or a nation and nobody can argue on this basic requirement. However, the larger question to answer in present local and global context is what is good for us, is it just mobility or 'sustainable' mobility? 'Sustainable Mobility'

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means improving our ability to move faster and safer in such a way that it does not compromise the ability of our children to do so in future. For any sensible person, the answer will definitely be 'sustainable' mobility. But it is important to think and answer, whether we are really choosing or tending towards sustainable mobility or not? Unfortunately, looking at the present state of transport infrastructure development and policy making in majority of Indian cities and also cities from many other developing economies like BRICS, the answer is no, to a large extent.

This is evident from the road infrastructure-based projects dominating the cities in the present times as a solution to address the transport-related externalities; the question is while such projects are one possible solution to solve mobility problems but is it a sustainable solution? In other words, as also observed with many such past road-based infrastructure projects, the effectiveness of such measures has proved to be for a very short time (sometimes just a year or couple or even less). From past experience, if has been observed that flyovers and underpasses (no matter of short or long length) does not solve the congestion problem but only shift the point of congestion from one place to the other. If we look around our cities, we can identify many examples of such unsustainable measures. Unfortunately, such measures are often perceived by the political class as 'populist' measures that can fetch votes for them during elections. To a large extent, citizens are also responsible for the same, after all 'populist' is all about what is popular and acceptable among the masses. This is also due to the aspirational aspects of large Indian middle class to own and use a car.

Ironically, many Indian cities are currently trapped in the 'Vicious Circle of Congestion' as shown in Fig. 1. It started with the economic boom in the country that began in early 1990s and which resulted in exponential growth of car ownership, particularly since car is largely seen as 'The' symbol of wealth in the Indian society (from small cars to SUV/MUVs now and to luxury cars in future). This resulted in more congestion and delay while travelling on our city roads and which then started the vicious circle of congestion with public pressure to increase road capacity, which resulted in adding of new flyovers/underpasses, road widening, etc., because of which movements by car become more easy and fast, which further favoured urban sprawl as people can travel longer distances with car in the same time, which then lead to further increase in number and average length of trips, eventually getting us back to square one, i.e. more congestion and delay on the roads and further forcing us into the same loop again. The ongoing predominance of road-based infrastructure development will do nothing but add fuel to this already existing fire and trap our cities deeper into this vicious circle of congestion.

It is interesting to note that Indian cities are not experiencing anything new that cities in other countries have never experienced. In fact, we are only reinventing the wheel, as many cities in developed economies have experienced the same vicious circle of congestion earlier, and some of which have been able to break this vicious circle through strong political/people's will and policies and planning that took them on the path of sustainable mobility. For example, Netherland was largely in

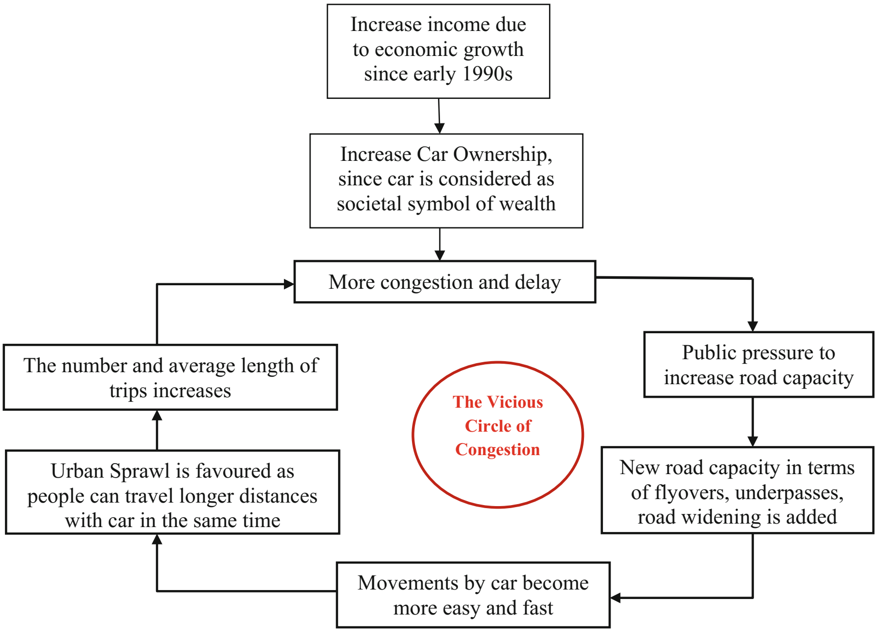

Fig. 1 Vicious circle of congestion in which many Indian cities are trapped

the same mess of congestion about 40 years before, but they chose a sustainable mobility path and today almost 60% commute trips daily are made by cycle in their cities like Amsterdam (Verma et al. 2016). Historically, if we compare the mobility development in India with that of USA and Europe, we will realize that there is a time lag of almost 50–60 years with respect to USA and 40–50 years with respect to Europe (Ecola et al. 2014). This is specifically in terms of saturation levels of motorization rates and infrastructure development which happened much earlier in USA, Europe and many other developing economies as compared to India where it is still at a very low level. However, it is interesting to understand that when infrastructure development, particularly of roads, happened in these countries, it was totally untouched from any global concern related to energy, climate change, carbon emissions, etc. The terms like climate change, carbon footprint and their possible consequences were hardly known to people at that time. Unfortunately, these global issues are much more prominent, known, and pressing in today's context, which means that India and other fast developing economies of BRICS, unfortunately, does not have the luxury of being untouched from these issues as compared to USA and Europe. This then leads us to think, whether India and other BRICS countries should follow the same path of infrastructure, particularly highway and other road-based development, that matured economies of USA, Europe, Australia, etc., followed historically or should India and other BRICS countries leap frog in terms of infrastructure development that is much more sustainable than the matured economies. More importantly, do we really have a choice today to leap frog? The answer is yes, only if Indian cities stop following the Western way of Highway or in other words only if we stop the race of constructing/expanding more and more roads, flyovers, elevated roads, etc. Unfortunately, this is happening in spite of clear message from our National Urban Transport Policy that says 'focus on moving people rather than vehicles' (MOUD 2006).

Today the road length per unit population or per unit area in Indian cities is much lower compared to the cities in developed world and so as the motorization levels, at the same time the length of reserved/priority public transport and cycle tracks per unit population is also very less in Indian cities as compared to many cities in European countries (Verma et al. 2016). If, as a policy, we decide today that we will not reach the levels of road indicators as high as what they are in Western world today and instead focus on increasing the density of sustainable modes then we certainly have the opportunity to leap frog. As a first step to leap frog, the government should think ways to decouple economic growth from the motorization rate and decide a desired modal share of trips for our cities and country overall that each type of mode/infrastructure should carry, by considering sustainability as the prime criteria. Based on this, the governments at national and state level, as well as civic bodies should allocate funds in such a manner that we achieve this desired modal share. On the other side, it is equally important to be aware that no commuter will adopt sustainable modes like public transport, walking, bicycling unless they are attractive travel options for them as compared to their personal vehicles. In other words, the question is; do we have high-quality public transport for us to travel safely and comfortably from our point of origin to point of final destination; do we have well connected and complete network of high-quality walking and bicycling infrastructure (also well integrated with public transport) that provides us safe end-to-end connectivity; do we have right kind of land-use transport planning in place that naturally encourages usage of sustainable modes? Unfortunately, the answer is no. So, to achieve this level of sustainable infrastructure, a complimentary set of policies, like congestion charging, parking restrictions, priority for public transport, pedestrianization of city core, various incentive schemes to promote usage of sustainable modes, etc., are required along with funding infrastructure development for sustainable modes.

In fact, this is the Western way of 'sustainable' mobility that many European countries like, Netherlands, Germany, Switzerland, etc., have adopted and which we should actually follow rather than the Western way of highway. This will also make the Indian population much healthier and will reduce the health expenditure of the country.

2 Case Study—Proposed Steel Flyover Project in Bangalore, India

This section presents a case study from Bangalore, India, of a recent road-based infrastructure project, namely the 'Steel Flyover Project' that was proposed by the state government of Indian state Karnataka as a measure to solve problem of congestion on a major corridor of Bangalore city (about 11 km) leading to the Bangalore airport and passing through some major road junctions that are major bottlenecks for the traffic moving on this corridor (Fig. 2). This section evaluates the sustainability of proposed solution particularly in terms of longevity of proposed solution to alleviate traffic congestion on this corridor. As a guiding principle, transportation planning for a city is done based on technical parameter called as 'Level of Service' (LOS), which is rated in six categories from A to F, and is based on the value of the ratio of traffic volume to capacity (V/C), expressed in passenger car units (PCUs) per hour (h), on individual links of the transport network. The level A (V/C tending to zero) corresponds to the best situation when vehicles move at free speed and level F (V/C tending to one or above) corresponds to the worst situation when the volume of traffic reaches or is above capacity, i.e. bumper-to-bumper traffic with only stop-and-go movement (in other words, complete traffic jam). The aim of transport planning is always to improve the transport system to bring down the LOS tending towards 'A' and as per Indian Roads Congress (IRC) guidelines, the design LOS is taken as 'C' which corresponds to V/C ratio of 0.7 (IRC 1990). In the context of the case study road corridor (airport road) leading to the Bangalore airport, it is important to note that some sections of the road (like, starting from Mekhri Circle towards Hebbal) are already operating at LOS 'F' (stop-and-go situation) during peak hour period based on the present traffic trends. While debating on merits of steel flyover or other proposed measures to reduce traffic congestion, the question really is: how; for how long; at what economic, financial and social cost; with what impact to the environment and ecology of the city we achieve the benefits of a proposed solution.

Below is a detailed technical analysis of the impact of added road capacity on airport road with steel flyover, in terms of LOS and 'Sustainability' criteria (development that not only serves today's needs but also serve the next generation in future). The aim of this technical analysis is to highlight the facts and figures which stress on the level of scientific and sustainable nature of the proposed steel flyover. Three scenarios have been considered to show the prevailing traffic situations in those conditions. The capacity of the roadway was obtained from IRC, 106: 'Guidelines for capacity of urban roads in plain areas' (IRC 1990). For the steel flyover, and for the at-grade road, the capacity is assumed as 2700 PCUs/h for three lanes (arterial category). The three scenarios are described below:

Scenario 1: Considering average vehicular growth rate of 4.75% as mentioned in the Detailed Project Report (DPR) prepared by STUP Consultants Pvt. Ltd. for steel flyover (*Source*: Bangalore Development Authority).

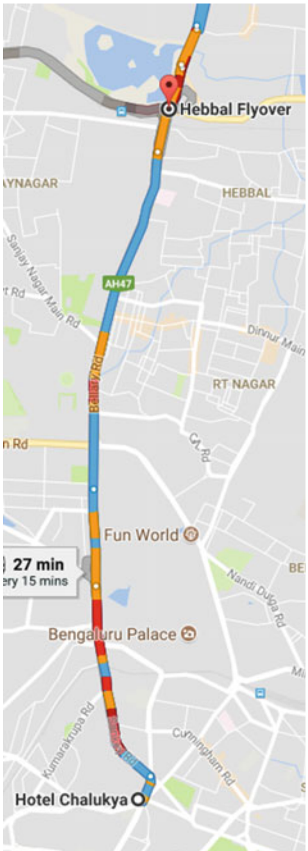

Fig. 2 Proposed steel flyover corridor in Bangalore. *Source* Google maps

Scenario 2: Considering average traffic growth rate of 10.6%, replicating the average annual growth rate in airline passenger traffic for Bangalore international airport in last 9 years (*Source*: Association of Private Airport Operators).
Scenario 3: Based on the coarse-grained assumption that car ownership (number of cars owned per 1000 population) in Bangalore has been doubling in every five years and so as the traffic (*Source*: Verma et al. 2013).

Also, since the amount of width (three-lane on each side) proposed for steel flyover and also on toll way road can easily accommodate two tracks in each direction of a hypothetical metro rail system on the same corridor, we have taken two scenarios of metro rail for analysis, which is with single metro rail track (ST) in each direction and with double metro rail tracks (DT) in each direction. This is further topped up with a scenario of only 50% people moving on the corridor shifting to metro, and a best case scenario when all are shifting to metro rail system.

These scenarios have been applied to two at-grade junctions along the proposed flyover namely; High Grounds Junction and Mekhri Circle. The traffic in consideration is the airport-bound traffic for which the capacity is 2700 PCUs/h each for the proposed flyover and at-grade roads. The traffic comparison (in PCUs) has been done for current and future stage (at the time of completion of project). Also, mode comparison is done to determine the saturation stage of existing traffic and a possible metro rail along this route. The capacity of a metro rail system is taken as 69,000 pphpd (persons per hour per direction); *Source*: (Verma and Dhingra 2001), and average car occupancy is taken as 1.5 persons per vehicle. Also, the peak hour traffic volume figures are taken from the DPR report of STUP Consultants for steel flyover (*Source*: Bangalore Development Authority).

2.1 Scenario 1: Growth Rate of 4.75%

High Grounds Junction

Time stage	2014	Current condition (2016)	Project completion (2018)
Traffic volume (PCUs)	6234	6840	7505
Capacity	2700	2700	2700 + 2700 = 5400
V/C	2.30	2.50	1.40

Mekhri Circle

Time stage	2014	Current condition (2016)	Project completion (2018)
Traffic volume (PCUs)	8884	9748	10,696
Capacity	2700	2700	2700 + 2700 = 5400
V/C	3.29	3.61	2.0

Summary: Though the growth rate is underestimated and undermines the realistic trends, the volume at Mekhri circle junction appears to be twice the capacity at the time of completion of steel flyover project, which means that it will only operate at LOS 'F' even on the first day of its operation. Even though, the total capacity of the existing at-grade road and grade-separated (flyover) comes up to 5400 (2700 + 2700), the current traffic has already overshot the combined capacities and situation only worsens by the time of completion of project (10,696 PCUs in 2018).
Metro in scenario 1: Now, evaluating the effectiveness of a possible metro from the High Grounds Junction for the same scenario (taking same growth factor of 4.75%) 2018 onwards.

Case 1: When all passengers switch to metro.

Time stage	2018	2028	2038	Saturation ST (2057)	Saturation DT (2072)
Passenger volume (based on average car occupancy of 1.5)	11,257	17,904	28,478	68,774	137,955
Metro capacity (single track (ST))	69,000	69,000	69,000	69,000	–
V/C (single track)	0.16	0.25	0.41	0.99	–
Metro capacity (double track (DT))	138,000	138,000	138,000	138,000	138,000
V/C (double track)	0.08	0.13	0.20	0.49	0.99

Case 2: When half of the passengers switch to metro.

Time stage	2018	2028	2038	Saturation ST (2072)	Saturation DT (2087)
Passenger volume	5628	8951	14,237	68,971	138,350
Metro capacity (single track)	69,000	69,000	69,000	69,000	–
V/C (single track)	0.08	0.12	0.20	0.99	–
Metro capacity (double track)	138,000	138,000	138,000	138,000	138,000
V/C (double track)	0.04	0.06	0.10	0.49	1.0

Summary: Using the traffic growth rate of STUP Consultants, the metro rail system can serve the airport road corridor for another 70 years easily with even half of the passengers shifting to metro rail, which is sustainable solution by any definition.

2.2 Scenario 2: Growth Rate of 10.6%

High Grounds Junction

Time stage	2014 traffic	Current traffic (2016)	Project completion (2018)
Traffic volume (PCUs)	6234	7625	9327
Capacity	2700	2700	5400
V/C	2.30	2.8	1.7

Mekhri Circle

Time stage	2014 traffic	Current traffic (2016)	Project completion (2018)
Traffic volume (PCUs)	8884	10,867	13,292
Capacity	2700	2700	5400
V/C	3.3	4	2.5

Summary: The assumed traffic growth rate here is in compliance with the growth in passenger traffic at BIAL. While the LOS at High Grounds Junction may still seem hovering around C&D; the volume at Mekhri Circle is more than five times the capacity by 2018.
Metro in scenario 2: Now, evaluating the effectiveness of a possible metro from the High Grounds Junction for the same scenario (taking same growth factor of 10.6%) 2018 onwards.

Case 1: When all passengers switch to metro.

Time stage	2018	2028	2030	Saturation ST (2034)	Saturation DT (2041)
Passenger volume	13,990	38,315	46,868	70,130	141,966
Metro capacity single track	69,000	69,000	69,000	69,000	–
V/C single track	0.20	0.55	0.67	1.0	–
Metro capacity double track	138,000	138,000	138,000	138,000	138,000
V/C double track	0.10	0.27	0.33	0.50	1.02

Case 2: When half of the passengers switch to metro.

Time stage	2018	2028	2037	Saturation ST (2041)	Saturation DT (2048)
Passenger volume	6996	19,158	47,445	70,900	143,715
Metro capacity (single track)	69,000	69,000	69,000	69,000	–
V/C (single track)	0.13	0.38	0.94	1.0	–
Metro capacity (double track)	138,000	138,000	138,000	138,000	138,000
V/C (double track)	0.06	0.19	0.47	0.50	1.04

Summary: Using the 10.6% traffic growth rate, the metro rail system can serve the airport road corridor up to 2048 easily with even half of the passengers shifting to metro rail, which is sustainable solution by any definition.

2.3 Scenario 3: Double in 5 Years

High Grounds Junction

Time stage	2014 traffic	Project completion (2019)	(2024)
Traffic volume (PCUs)	6234	4192	8384
Capacity	2700	5400	5400
V/C	2.3	0.77	1.6

Mekhri Circle

Time stage	2014 traffic	Project completion (2019)	(2024)
Traffic volume (PCUs)	8884	17,768	35,536
Capacity	2700	5400	5400
V/C	3.29	3.29	6.6

Summary: For this scenario, the LOS at High Grounds Junction is already D at the beginning of the project (2019), and the LOS at Mekhri Circle show horrific results where the volume has reached three times the capacity.
Metro in scenario 3: Now, evaluating the effectiveness of a possible metro from the High Grounds Junction for the same scenario (doubling the passenger every 5 years) 2014 onwards.

Case 1: When all passengers switch to metro.

Time stage	2019	2024	2029	Saturation ST (2034)	Saturation DT (2039)
Passenger volume	12,576	25,152	50,300	100,608	201,216
Metro capacity (single track)	69,000	69,000	69,000	69,000	–
V/C (single track)	0.18	0.36	0.72	1.45	–
Metro capacity (double track)	138,000	138,000	138,000	138,000	138,000
V/C (double track)	0.09	0.18	0.36	0.7	1.45

Case 2: When half of the passengers switch to metro.

Time stage	2019	2024	2029	2034	Saturation ST (2039)	Saturation DT (2044)
Passenger volume	6288	12,576	25,152	50300	100,600	201,216
Metro capacity (ST)	69,000	69,000	69,000	69,000	6900	–
V/C (ST)	0.09	0.18	0.36	0.72	1.45	–
Metro capacity (DT)	138,000	138,000	138,000	138,000	138,000	138,000
V/C (DT)	0.045	0.09	0.18	0.36	0.7	1.45

Summary: Even with a assumption of very high traffic growth rate, the metro rail system can serve the airport road corridor up to 2044 easily with even half of the passengers shifting to metro rail, which is again sustainable solution by any definition.

Further, with the growth in traffic on airport road in future and the high speed at which the vehicles will travel on the steel flyover and below, the air (from exhaust emission) and noise pollution can only increase adding further to the externalities due to transport.

So, if not steel flyover then what is the sustainable mobility solution for the airport road and also for the Bangalore city? From the analysis above, a metro rail system on the airport road corridor right up to the Bangalore airport and physically well integrated with airport terminal building itself may serve as an alternative solution which will also be sustainable on many grounds. This metro rail line to the airport should get connected and integrated at one or couple of transfer metro stations so that people can easily connect to the city network of metro rail system and then travel to any part of the Bangalore city. While doing so, the government should plan feeder bus systems for each metro rail station within 2–3 km influence zone on each side of metro station along with pedestrian/cycling-friendly infrastructure within 500–1000 m influence area around metro stations. On the metro stations in sub-urban locations of city, park-and-ride facility at metro station can be created and integrated so that people leave their car in park-and-ride and travel to the core area of city by metro. Further, buses and metro rail system being there for the same purpose of public transport, they can be operated under a single public transport agency rather than separate (BMTC and BMRCL), to eliminate redundancy of capacity and competition within public transport modes and to achieve the highest level of efficiency and network-wide connectivity. Worldwide, in cities which are very high on liveability index and have excellent and sustainable transport system, all public transport modes are operated by a single agency.

3 Summary and Recommendations

This chapter throws light on various issues and challenges related to achieving sustainable urban transportation solutions in Indian cities and how the fundamental focus has shifted from traditional supply centric approaches to demand centric approaches. A case study of steel flyover project from Bangalore, India, is also presented to emphasize this point. To conclude, the following questions should always be asked while deciding any transportation improvement in any Indian city:

- What is the amount of person capacity added per unit of investment made?
- What is the amount of person capacity added per unit of space width created?
- By what amount the fossil fuel consumption will change?
- By what amount the air and noise pollution will change?

If the above questions are answered in an unbiased manner than such transport improvements are likely to be sustainable. Following is the recommendation approach for road ahead in Indian cities:

- Development choices to decouple economic growth from private motorization growth.
- A multi-tier approach that includes comprehensive urban planning, improved policy making, effective economic instruments among others.

- Creating opportunities for cities to use existing transport infrastructure wisely, while generating funds to improve sustainable transport options.
- Developing cities such as from India have a challenging opportunity to build a system in which public transport and NMT become the first choice for mobility.
- Long run endeavour of 'Avoid-Shift-Improve' approach to build resilient and sustainable cities.

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