Bicycles- an integral part of urban transport system in South Asian cities

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Summary

Bicycles and pedestrians are an integral element of urban transport in South Asian cities. These cities are characterised by heterogeneous traffic (mix of non-motorised and motorised modes) and mixed land use patterns. In addition to bicycles, non-motorised *rickshas* are used for delivery of goods like furniture, refrigerators, washing machines etc. Semi-skilled workers, carpenters, masons, plumbers, postmen, and courier services use bicycles. Therefore, the demand for bicycles and *rickshas* exists in large numbers at present and is likely to exist in the future also. This situation is not explicitly recognised in policy documents and very little attention is given to improving the facilities for non-motorised modes.

Since primarily bicycles and other NMVs use the left most lane of the road, buses are unable to use the designated bus lanes and are forced to stop in the middle lane at bus stops. This disrupts the smooth flow of traffic in all lanes and makes bicycling more hazardous. It is also obvious that in the absence of segregated NMV lanes on arterial roads, it is not possible to provide designated lanes for buses.

The paper presents details from a case study of a corridor in Delhi to illustrate how existing arterial roads can be replanned to provide for safer and more convenient bicycling and at the same time improve efficiency of bus transport system.

1. Urban Poverty and Transport Link in South Asian cities

Urban areas in developing countries experience such extremes of wealth and poverty that they can be characterized as having dual economies. One economy serves the needs of the affluent and features modern technologies, formal markets, and outward appearance of developed countries. The other serves disadvantaged groups and is marked by traditional technologies, informal markets, and moderate to severe levels of economic and political deprivation.

Nearly 60% of world population lives in developing regions (Africa, Asia and South America). These regions are characterised by dominance of large cities- more than 60% of the urban population resides in million plus cities. 62 cities out of largest 100 cities are in this region. A large proportion of the population residing in these cities lives below the poverty line (29-60%).

The urban poor, typically housed in slums and squatter settlements, often have to contend with over crowding, bad sanitation and contaminated water. The sites are often illegal and dangerous forcible eviction, floods and landslides and chemical pollution are instant threats.

Urban poverty characterized by unemployment, dependence on the informal sector, low wages and insecure jobs has a direct bearing on travel and transport demand of a large segment of the population residing in urban areas. Their dependence on transport which enables them access to job markets becomes essential for survival. This need is more critical for them than for those with high income and secure jobs.

An estimated 30% of the world population living in urban poverty in developing country cities is also transport poor. Even a subsidized public transport remains cost prohibitive for many of them. For this segment of the population it is harder for individuals and households to save and to build up some assets, to reduce their vulnerability to sudden changes in income or loss of income due to illness. Low incomes also make it difficult to for households to 'invest' in social assets such as education that can help reduce their vulnerability in the future. Therefore, access to affordable transport is necessary for survival. A sustainable transport system must meet the demand of this captive ridership of non-motorised transport existing in the cities of the South.

2. How do city residents travel in developing countries?

Most developing country cities have been classified as "Low Cost Strategy" cities[i]. In comparison to the cities in the West, these cities consume less transport energy. High densities, mixed land use, short trip distances, and high share of walking and nonmotorised transport characterize these urban centers[ii].

Mixed traffic in developing country cities

Developing country cities are characterised by heterogenous traffic (mix of non-motorised and motorised modes) and mixed land use patterns. Non-motorised vehicles are owned and used by a large section of the population .Car ownership rates in Asian countries are low compared to North America and OECD countries. In 1993 car ownership was 29 cars per 1000 residents in East Asian countries compared to 561 cars per 1000 residents in North America, 366 in OECD countries[iii]. Although the greatest growth rate in the number of motor vehicles is expected in many Asian countries, most of these increases in absolute numbers of the vehicle fleets will result from increases in the numbers of increases in the numbers of MTWs and three wheelers[iv]. In Thailand, Malaysia, Indonesia and Taiwan, two and three-wheelers make up more than 50 percent of all motor vehicles.

Non-motorised transport (NMT) constitutes a significant share of the total traffic in many Asian cities. Shanghai, Hanoi, Kanpur and Tokyo all have a relatively high rate of bicycle ownership and a high proportion of bicycle traffic . In Indian cities, share of NMT at peak hour varies from 30-70%. The proportion of trips undertaken by bicycles range between 15 and 35 percent, the share tending to be higher in medium and small size cities. The patterns of NMT use change with growth in the city size. In most NMT dependent low income cities, bicycles are used for the entire trip (e.g., commuting, shopping). In a high-income city like Tokyo, bicycles are increasingly used as a feeder mode to rail stations as well as for shopping and other purposes[v]. Every motorised public transport trip involves access trips by NMT at each end. Thus, NMT including walking continues to play a very important role in meeting the travel demand in developing country cities.

In Kenya, despite several constraints, the NMT including walking are still the most prevalent modes that provide more than 45 percent of all the personal transport in the urban centres.

Due to socio-economic compulsions significant proportion of the population living in unauthorised settlements close to place of work also results in short trip lengths. 57% of the total trips are less than 5 km in Delhi. This means 4.5 million daily trips are less than 5 km. Thirty percent of bus trips, 44% of scooter/motorcycle trips and 60% of all three wheeler taxi trips are less than 5 km. Changing modal shares in Delhi show decline in cycle and walking trips (Table 1) however, a large number of people continue to use bicycles and bus for daily commuting. Table 2 highlights the difference between commuting patterns of low income and high income people residing in Delhi. Since nearly 50-60% of the city population resides in unauthorised slum settlements having an average income of Rs.2000/month, bicycles, buses and walking continue to be important modes of transport. Similar patterns exist in other megacities of the South.

Table1: Changing Modal Share in Delhi 1957-1994

Mode	1957	1969	1981	1994	1994*
Cycle	36.00	28.01	17.00	6.61	*4.51*
Bus	22.40	39.57	59.74	62.00	*42*
Car	10.10	15.54	5.53	6.94	4.74
SC/MC	1.00	8.42	11.07	17.59	*12*
Auto	7.80	3.88	0.77	2.80	*1.91*
Taxi	4.40	1.16	0.23	0.06	
Rail	0.40	1.23	1.56	.38	.26
Others	17.90	2.19	4.10	3.62	2.47
Walk					31.77
Total	100.00	100.00	100.00	100.00	

Source: Household Travel Surveys in Delhi, 1994 ORG.

** including walk trips*

Table 2: Commuting patterns of high and low income households in Delhi(1999)

	High Income Households*	low Income households**
Cycle	*2.75*	***38.8***
Bus	*36.2*	***31.43***
Car	*28.35*	***0***
SC/MC	*29.29*	***2.48***
Auto	*1.74*	***.96***
Taxi	.04	***0***
Rail		***1.79***
Others		***2.34***
Walk	1.62	***22.12***
Total	100.00	100.00

** IIT survey of high and middle income households (average income Rs.7000/month)

***IIT survey of low income households(average income Rs.2000/month)

3. Development/ transport infrastructure improvement priorities

Sustainable transportation options rely heavily on promotion of public transport and non-motorised modes. However, the actual policies promoted do not recognise the conflicts inherent in some of the measures suggested. In the name of development or city improvement plans , a type of brutalisation of the habitat takes place that sends the already marginalised segment of the population further away to even more remote areas. Investments in transport improvement plans continues to focus projects which benefit car users, at the cost of environment friendly modes- NMTs and pedestrians.

The Government of India in 1997 prepared a *White Paper* on pollution in Delhi.[vi] Subsequently an Environmental Pollution Control Authority was set up for the city. Some of the measures suggested for reducing vehicular pollution are given below:

- Construction of expressways and grade separated intersections.
- Introduction of one way streets and introduction of synchronised signals and area traffic control systems.
- Construction of a metro rail transport system.
- Phasing out of older buses and increase in number of buses.

Effect of expressways, wide roads and grade separated junctions

Construction of expressways through or around cities and grade separated junctions encourage higher speeds, greater use of private vehicles and longer trip lengths. Higher speeds always result in an increase in the incidence and severity of accidents unless very special countermeasures are put in place for control of injuries. The probability of death starts increasing dramatically at speeds greater than 30 km/h and flattens out at levels above 95% at 60 km/h. A similar relationship would be true for bicyclists and motorcyclists.

Recent studies show that in impacts with heavy vehicles severe injuries can be sustained even at velocities lower than 30 km/h.[vii] Thus very small increases in speeds can result in large increases in deaths and injuries. This increase in risk has the maximum effect on pedestrians and bicyclists resulting in lower use rates of public transport services.

Wide roads and expressways (especially elevated sections) and grade separated junctions also divide the urban landscape into separate zones. It becomes very difficult for people to cross these arteries on foot or using other non-motorised modes. As explained above, this has the effect of discouraging public transport use, as all commuters using buses have to cross the road at least two times for every round trip at the origin or the destination. Elevated roads also reduce the attractiveness of business and entertainment activity in their vicinity.

Grade separated junctions have a similar effect. The area occupied by grade separated intersections is much greater than ordinary intersections. The location of bus stops at grade separated intersections is such that commuters have to walk greater distances for changing bus routes. This can discourage those who own private means of motorised transport from using public transportation modes. In addition, because of the increase in walking distance and road widths, pedestrians and commuters would be exposed to higher accident risks. This would further discourage use of public transportation by children, disabled persons and other vulnerable road users.

A grade separated intersection inside the city speeds up traffic at that junction and the arrival rate of vehicles at the next light controlled junction increases. This causes greater delays at junctions on both sides, especially during rush hours. Therefore, it is not clear whether such junctions serve a useful function over a network in terms of travel time or reduction in pollution. At grade separated junctions noise and exhaust is produced at a greater height and spreads over a wider area. This makes this area unsuitable for living and other community functions.

This is very well illustrated by the environmental impact assessment done for the construction of the inner ring road in Guangzhou, China.[viii] This inner ring road is a "modern high-speed road running around the centre of the city" with a total length of 26.7 km. Elevated sections account for 75.8% of the length with design speed of 60km/h. The funds invested for construction were loaned by the World Bank. A detailed environmental protection and monitoring plan has been worked out for this project. Some of the important guidelines are outlined below:

- Increase distances between residential houses, sensitive areas and the ring road.
- Minimum distance between road and buildings 20 m.
- First row of buildings not suitable for schools, hospitals etc. These should not be within 100m of the road.
- Buildings sensitive to vibrations not to be within 40m of the road.

- Strict controls of heavy vehicle use at night to prevent noise pollution.
- Strict control of speeding by all vehicles to limit noise.
- Elevated roads should be reduced as far as possible, and double-layer or mutli-layer roads should not be adopted.

This shows that any high capacity road inside a city influences land use around it and makes it less people friendly. Owners of residential houses also tend to shift away from such locations. The experience of large cities in China shows that construction of such high capacity roads has not even improved traffic congestion levels:

> *Guangzhou*: Has an orbital expressway and inner ring road and a large number of interchanges. The total number of vehicles is 1 million. However, the average speed on north-south and east-west main roads for 12 hrs in daytime is 18-21 km/h.[12]
> *Beijing*: Has constructed two ring roads and the third ring road is in the process of completion. The city has already constructed 119 flyovers and 202 overpasses. The total number of vehicles is 1.2 million. However, the rush hour average speed on trunk roads is still 13-19 km/h.[ix]
> *Shanghai*: The road area in Shanghai has been increased by 42% between 1991 and 1997 and 400 roads have been designated as one-way streets. The total number of vehicles is 1.3 million. The average vehicular speeds inside the inner ring road during rush hours are 16 km/h.[x]
> *Shenzhen*: The city has completed construction of 139 km of highways, the total number of vehicles is 250,000, but the rush hour average speed on main roads is 20 km/h.[xi]

It is probably this experience of developments in Chinese cities that prompts Wu (Ministry of Construction) and Li (China Academy of Urban Planning and Design) to comment that "In the past five years, the input to road infrastructure in the large cities has been doubled. Almost all the large city authorities believe that the situation of traffic congestion may be alleviated through road construction.…But to date, we are still short of rational study which verifies the relationship between road infrastructure and traffic volume or the ownership of motor vehicles.…The traffic volume introduced with road construction may again increase vehicle emission and cause new traffic congestion, multiplying all the pollutants. So there would be no direct cause-and-effect relationship among infrastructure construction, pollution prevention and environmental protection" (emphasis added).[xii]

Wu and Li's data show that though the number of public transit vehicles increased in all of the 12 large cities studied in China between 1993 and 1997, the total number of passengers using public transport decreased in 8 of them. Bicycle use has also reduced in cities like Beijing, Shanghai, Shenzhen, Zhuhai, Xiamen and Guangzhou. This could be because bicycle use is being restricted on the major roads in some of these cities in order to promote "smoother" motor-vehicle movement. This decrease in public transport use can be the unintended effect of the building of high capacity roads in the city which increase risk to pedestrians and bicycle users and encourage private motor vehicle use.

A study on relationships between road capacity and induced vehicle travel by Noland concludes that induced travel demand is a likely outcome of capacity expansion and that over time, the induced demand effect becomes somewhat more important, relative to other factors affecting growth. [xiii] This is particularly true for urban areas. Similar views are expressed in a report from UK prepared by the Standing Advisory Committee on Trunk Road Assessment (SACTRA).[xiv] The Committee found that "induced traffic can and does occur, probably quite extensively, though its size and significance is likely to vary widely in different circumstances." The SACTRA report found that induced traffic is of 'greatest importance' under certain circumstances. These include "where trips are suppressed by congestion and then released when the network is improved". The report clarified that "in urban areas where there are many alternative destinations, modes and activities, induced traffic may be an appreciable consequence of major road building schemes… It will simply not be possible to cater for future, unrestrained demand for travel by private vehicles. Demand management measures and public transport policies are likely to form part of an overall transport strategy aimed at containing the demand for travel by road within the capacity of the road system."

An analysis of the relationship between highway expansion and congestion in metropolitan areas based on the 15-Year Texas Transportation Institute (TTI) in the U.S.A. shows similar results. Analysis of TTI's data for 70 metro areas over 15 years, shows that metro areas that invested heavily in road capacity expansion fared no better in easing congestion than metro areas that did not. Trends in congestion show that areas that exhibited greater growth in lane capacity spent roughly $22 billion more on road construction than those that didn't, yet ended up with slightly higher congestion costs per person, wasted fuel, and travel delay.[xv]

These experiences from very different locations suggest that construction of more high capacity roads can have the unintended effect of reductions in public transport and bicycle use without increasing vehicle speeds or reducing congestion on city roads. Reductions in bus and bicycle use would result in higher pollution levels and possible increase in traffic congestion. No detailed studies have been done to understand the effect of these changes on road user behaviour in cities of low-income countries. It is possible that in these countries the construction of high capacity roads at the expense of facilities for public transport and non-motorised traffic may make things worse for every one. These effects could include higher incidence of congestion for motorised traffic, higher accident risk for non-motorised traffic and reductions in public transport and non-motorised traffic.

4. Socio-economic burden to urban poor

Urban poor comprise of almost 50-60% of the city population in megacities of the South. Since the formal plans have ignored their existence, they are forced to commute long distances, in hostile environment. In a recent survey in selected slums of Delhi the residents noted that commuting to work is the most dangerous aspect of their work. Also, low income households spend larger share of their income on transport thus affecting their other needs such as food, shelter and health. They are more vulnerable to events like traffic accidents because of no savings or any other social network. Often they have to give up their temporary job to get to the hospital to get their relatives treated. Economic and emotional cost of traffic accident to this group of people is enormous because there have been instances where families have been forced to sell their meagre assets, give up their temporary jobs and take loans which takes a life time to repay.

5. Avoided costs due to investments in bicycle/non-motorised mode friendly infrastructure

Providing a separate bicycle/NMV track would make more space available for motorized modes and make bicycling less hazardous. Our studies in Delhi show that on urban arterials the curbside lane (3.5 m) is used primarily by bicycle and other non motorized traffic. Because of the presence of bicycles and NMVs in the far-left lane, buses are unable to use this lane and are forced to stop in the middle lane at bus stops. Motorized traffic does not use the curbside lane even when bicycle/NMV densities are low. A segregated bicycle lane needs only 2.5 m and since most of the major arterials in Delhi as well other Indian cities where planned development has taken place after 1960s, have a service road, the existing road space is wide enough to accommodate a bicycle track. This would not require additional right of way for road. A detailed study completed in Delhi, India shows how existing roads can be redesigned within the given right of way to provide for an exclusive lane for NMT modes (bicycles and three wheeled rickshaws).[xvi]

Since majority of the bicyclists in Indian cities are daily commuters captive riders- people who use bicycles despite poor facilities for the same due to lack of any other options, the proposed network must enable direct and safe bicycle-travel within a coherent system. The proposed routes must guarantee a coherent network structure, minimize trip length (directness) and minimize the number of encounters between cyclists and motor vehicles (safety). The success of the bicycle/NMV route design depends upon meeting the requirement of convenience of bicycles and NMVs. Otherwise they are forced to share the road space with motorized vehicles resulting in sub-optimal conditions for all vehicles. Figure 1and 2 show these designs of arterial roads with integrated NMV lanes along with dedicated lanes for buses, pedestrian paths and service roads. These designs benefit all road users as discussed in the following section.

(Insert figure 1 and 2 here)

<u>Increased capacity</u> :If a separate segregated lane is constructed for bicycles, the curbside lane, which is currently used by bicyclists become available to motorised traffic. This relatively small investment in bicycle lanes can increase the road space for motorised traffic by 50 percent on 3 lane roads. Bicycle lanes also result in better space utilisation. For instance a 3.5m lane has a carrying capacity of 1,800 cars per hour whereas it can carry 5,400 bicycles per hour[xvii]. Average occupancy of a car is 1.15 persons [xviii]and bicycle carries one person. This implies that in order to move the same number of people we would need 2.6 times the road area that would be required for bicyclists. Given the fact that there is not much space available to expand existing roads, the future mobility

needs and projected trips can only be met by increasing the capacity of the existing road network. This can only be achieved by encouraging modes, which are more efficient in terms of space utilisation.

Motorised vehicles benefit because of improved capacity of the road and improvement in speeds. Capacity estimations of a typical arterial road in Delhi[xix] show improvement in corridor capacity by 19-23% by providing an exclusive cycle track. If the full capacity of the corridor is utilized, i.e, provision of a high capacity bus lane in the left most lane can lead to capacity improvement by 56-73%(present carrying capacity of 23000passengers/h to 45000passengers/h).

Improved speeds: Improvement in speeds of motorized vehicles will be experienced until the corridor is full to capacity due to realization of induced demand. Major beneficiaries of speed improvement are buses and two wheelers because curbside lane becomes available to them without interference from slow vehicles. Estimations of time savings experienced by bus commuters, car occupants and two wheeler commuters on a typical arterial corridor in Delhi[xx] show 48% reduction in time costs due to 50% improvement in bus speeds(from present 15km/h to 30 km/h) and 30% improvement in car and two wheelers.

Reduced congestion: Congestion has long been recognised as an environmental problem. Other than causing delay, it causes noise and fumes and increases health risks of road users and residents. Delhi as well as other Indian cities have invested in grade separated junctions and flyovers as one of the major congestion relief measure at an average cost of Rs. 100 million to 300 million for each intersection. However, detailed simulation of a major intersection in Delhi show that replanning the junction to include separate NMV lanes and bus priority lane can bring in 80% improvement over the present level of delays. Cost of this measure is 25 times less than the proposed gradeseparated junction.[xxi]

Increased safety:By creating segregated bicycle lanes and re-designing intersections, conflicts between motorised traffic and bicyclists can be reduced substantially leading to a sharp decrease in the number of accidents and fatalities for bicyclists and motorised two-wheelers. Safety benefits estimated for a typical arterial in Delhi show 46% reduction in accident costs. This is because segregated facility reduces injury accidents by 40% and fatalities by 50%.

Reduced pollution and energy consumption: Motor vehicles are reported to be the single largest source of air pollution causing 70% of the total air pollution in Delhi.[xxii] This is a serious concern to cyclists, pedestrians and motorists as air quality is worse in or near built up roads. Cyclists suffer the adverse affects of pollution because of heavier breathing whilst exercising close to the source of exhaust pollution. A dedicated infrastructure can reduce this problem to some extent. While motorised transport is one of the most polluting of all human activities, however, cycling is the least polluting mode of all. Cycling generates no noise pollution or toxic emissions. Therefore, there is a need to make cycling more popular than the existing levels. A better bicycle infrastructure can play an important role in increasing the modal share of bicycles and thus, reduce the air pollution and increasing adverse health affects of pollution.

Energy consumption and pollution also reduce because motorised vehicles have smoother driving and improved speed. Estimations for Delhi corridor show 28% reduction in fuel consumption and 29% reduction in health externalities related to air pollution.[xxiii]

Induced bicycle trips: There are approximately 1 million households in middle - high income category. If the average trip rate of these household is 2 per day, at least 10% of these trips specially by school going children and young adults could be new bicycle trips for recreation and school journeys. This group benefits by expanding their oppurtunity space to participate in different activities. It is difficut to express this number in money terms.

6. Vulnerable road users are the 'critical element' in the city transport fabric:

If the needs of VRUs are not met by the urban transport infrastructure, mobility of other modes gets affected adversely. Despite low level of vehicle ownership, high share of public transport and presence of NMVs, the concentrations of various pollutants exceed levels permitted by WHO standards for ambient air quality in many developing country cities.

It is evident that investments in projects which benefit only the car users have not been able to improve urban speeds. Congestion relief has been short lived due to the impact of latent travel demand. Construction of capital intensive systems like Metro (MRTS) has also not had lasting improvement on congestion and air pollution. In fact, some of the intended congestion relief measures (construction of flyovers, expressways) may have contributed to the increase in NMV and pedestrian fatalities due to increased speeds.

Urban transport system in developing country cities can become sustainable, providing mobility with minimal adverse effect on the environment, only if it provides safe and affordable transport for all sections of the population. Nearly fifty percent of the population in these cities needs to live close to place of employment. They need inexpensive modes of travel to work for survival. If the planned transport system does not provide for their travel needs, they are forced to operate under sub-optimal conditions. They continue to exist at places, which have not been planned for them. Consequently, landuse and transport plans are violated and all modes of transport operate under sub- optimal conditions. The experience of past decades of long term integrated landuse transport plan exercise suggests that the existence of informal sector and their travel needs must be recognised for preparing effective plans. This should encourage mixed landuse patterns and transport infrastructure especially designed for bicycles and other non-motorised modes.

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