Transport and Communications Bulletin for Asia and the Pacific

No. 85

Sustainable and Inclusive Urban Transport

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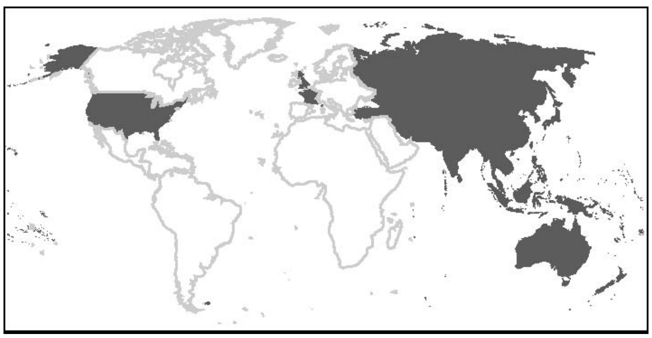

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Editorial statement

The *Transport and Communications Bulletin for Asia and the Pacific* is a peer-reviewed journal published once a year by the Transport Division of the Economic and Social Commission for Asia and the Pacific (ESCAP). The main objectives of the *Bulletin* are to provide a medium for the sharing of knowledge, experience, ideas, policy options and information on the development of transport infrastructure and services in the Asia-Pacific region; to stimulate policy-oriented research; and to increase awareness of transport policy issues and responses. It is hoped that the *Bulletin* will help to widen and deepen debate on issues of interest and concern related to the transport sector.

Increased urbanization and subsequent growth of city populations stresses urban transport systems and infrastructure. This in turn increases car usage in cities, translating into increased consumption of fossil fuels, increased emissions, air pollution and traffic congestion and more accidents. The knock-on effects are seen in the loss of productivity and health. Tackling these issues can positively impact mobility and improve economic opportunities and quality of life.

The issue in this region extends beyond megacities and also includes mid-sized cities that are home to between 500,000 and 5 million people and which account for 38 per cent of the urban populations in the region. Given the focus on larger cities, these mid-sized cities can be ignored in terms of financing and other aspects, thus stunting their development, which can have serious implications in the long run.

Given the increased demand for urban mobility due to rapid urbanization and rural-urban migration, Asian countries need to make a significant investment in improving urban transport infrastructure and systems. There is a need for evidence-based policies and sustainable and inclusive plans for the urban public transport systems that tackle these pressing issues. In this *Bulletin* these issues are explored with a focus on countries in the Asia-Pacific region.

The negative implications of increased urbanization and motorization suggest a need to learn from best practices and similar experiences in the region in integrated transport planning, intermodal transport, emerging public mass transit systems (mass rapid transit, light rapid transit, bus rapid transit), technological advances, non-motorized transport and road safety. In addition, growth in the region also suggests a need for greater regional connectivity for trade flows and better mobility for commuters. There are some good practices in sustainable transport systems in Asia; for example, Ahmedabad, India, has an integrated bus rapid transit system, Seoul, a City Master Plan for Green Growth, and Japanese and Chinese cities are advanced technologically.

The importance of the transport sector and of the commitment of countries is further highlighted by the inclusion of transport-related targets in the Sustainable Development Goals adopted by the General Assembly of the United Nations in September 2015. The framework includes 17 Goals and 169 targets, and 5 of the targets under Goals 3, 7, 9, 11 and 12 are directly related to transport. This places further emphasis on the work of countries and transport communities towards achieving transport-related goals and targets through the implementation of focused sustainable transport policies, strategies and action plans and the improvement of institutional mechanisms.

There are clear reasons for the urgency for sustainable transport and urban transport initiatives: statistics show that 25 per cent of global CO_2 emissions come from the transport sector. Of this, road transport contributes 73 per cent. While road transport results in noise and water pollution and land degradation as well as other impacts, air pollution is by far the most significant issue. Advances in shifting to modes of transport that produce significantly less air pollution by utilizing high-efficiency external combustion engines and anti-pollution devices have been made, and, when combined with an increased reliance on public transport institutionally, pollution levels can be significantly improved. However, when pushing for increased usage of public transport, it is important to consider the implications for commuters and infrastructure. The four papers in this bulletin attempt to shed light on the pertinent questions that arise when moving towards increased usage of public transport.

The first paper, entitled “Impact of bus rapid transit on urban air pollution: commuter’s exposure to $PM_{2.5}$ in Ahmedabad”, by Shivanand Swamy, Madhav Pai and Shelly Kulshrestha, focuses the discussion on monitoring commuter’s exposure to $PM_{2.5}$, a key pollutant recognized for causing adverse health impacts. The paper includes an examination of how a commuter's choice of transport, timing (time and season) and the location they choose to travel can affect their exposure to this pollutant in Ahmedabad. Using the urban transport environment, the key factors contributing to exposure are examined in order to facilitate policy initiatives to reduce exposure. The study was conducted on a 10 km stretch in the city of Ahmedabad, using Bus Rapid Transit System (BRTS) buses, city buses and other motorized and non-motorized modes. The study gives a comparative overview of real-time exposure to $PM_{2.5}$ across nine transport modes. In-vehicle exposure in air-conditioned BRTS buses showed the lowest $PM_{2.5}$ concentration levels, 25 per cent less exposure compared to air-conditioned car use and 76 per cent less exposure compared to non-air-conditioned modes of transport. Another finding was that the highest exposure levels were during peak hours, which can also affect the optimal time to travel. Another important finding was that exposure was closer to the ground, signaling that the impact on children may be higher. These findings can significantly reduce commuters' exposure to pollutants if deliberately factored into policy initiatives.

Beyond the commuter's exposure to pollutants, another policy focus is the mode of transport. This is a key concern as economic and social factors affect the types of transport chosen, which in turn can impact how sustainable and equitable the system is.

Public transport as a percentage of urban transport is decreasing in many Asian cities. Therefore push and pull policies are required to keep or increase the share of public transport and non-motorized transport modes. Understanding their differing effects is important for policy initiatives because factors that affect buses are very different to what affects two-wheelers. Efficient and effective policies need to include a consideration of the transport mix in order to have the maximum impact on commuters.

The second paper, entitled "Sustainable and equitable transport system in Delhi: issues and policy direction", by Absar Alam, focuses on the urban transport system in Delhi, India, and on mode share by highlighting both the benefits of developing the non-motorized transport sector infrastructure and the need to integrate the Delhi Metro and Urban Bus services physically and operationally. The author also highlights the need to regulate transport-related services, as a significant share of commuters access these services in the form of mini-buses and two- and three-wheelers. Highlighting the Delhi Master Plan – 2021, the author shows the need to develop the non-motorized transport infrastructure, as it not only supports the existing public transport system as a connector but is also an alternative form of transport for short distances. Also highlighted in the paper is the emergence of new forms of supporting transport services, such as the e-rickshaw, and the need for a regulatory framework and infrastructure support for these forms of transport.

It is clearly documented that public transport systems can improve the efficiency and sustainability, economically and environmentally, of urban transport systems. A key measure of this is quantity and frequency of ridership.[1] For example, if a bus lane is freed of other road traffic, it can carry up to 73 per cent more commuters and transport 35,000 commuters per hour, one way. While this is a significant number, it is also important to consider the individual cultural landscape and applicability in developing systems and policy initiatives.

With examples from the cities of Islamabad and Rawalpindi, the third paper, entitled "Towards an inclusive public transport system in Pakistan", by Muhammad Adeel, Anthony G.O Yeh and Zhang Feng, includes a discussion of regulatory, spatial and demand-related constraints and ways to minimize them through a number of initiatives, including integration of modes, improvements to the quality of service and condition of vehicles, and the facilitation of the mobility of women and non-motorized travelers. Specifically in Pakistan, mobility is a gendered phenomenon, and women are less mobile which results in decreased access to health care and education. Other vulnerable populations are students and unemployed, disabled, elderly and young people. All these disadvantaged social groups, when combined, form a majority of the country's overall population; only a handful of the population can be considered non-disadvantaged. Using data related to the public transport network and operations management, the paper includes an examination of the factors that need to be considered to make public transport more accessible and inclusive.

[1] MACKETT/EDWARDS, New Urban Public Transport Systems, p. 236; MORRIS, Save the environment, Freakonomics article

The fourth and last paper, entitled “The institutional environment for sustainable transport development”, by Abdul Quium, is another entry in this dialogue on the planning and development of sustainable transport infrastructure and public transport systems. In the article, the multiple ministries, government departments and agencies at different levels of government that are involved in planning and implementation of transport projects are highlighted, and the need for coordination between these industries and related sectors, in order to make transport sustainable and inclusive, is explored. The paper includes a discussion of the institutional environment and issues that policy makers need to focus on. Also explored are important institutional barriers, such as transport sector governance, legal and resource constraints, the absence of integrated policies reflecting the multisectoral nature of transport and a programmatic approach to development, the inherent weaknesses of current transport planning practices (national or urban), the de-linkage between planning and financing, the decentralization of powers and responsibilities, and institutional capacity to handle complex transport issues, especially in a multisectoral environment. The inherent inefficiency in fragmenting the decision-making process and planning is also highlighted. One of the main conclusions is that in planning and designing a sustainable transport system there is a need to conceptually reframe transport issues, planning and policy formulation methodologies, as well as institutional arrangements, and to bridge these issues with institutional reforms, capacity-building and streamlining of overall procedures in planning, policy formulation and implementation.

The papers collected in the *Bulletin* address important policy issues related to sustainable urban transport development that can contribute towards a sustainable, efficient and effective public transport system. These papers can be a catalyst for further debate, and in so doing increase awareness of the policy implications and the responses to sustainable transport development in countries of the region. It is also hoped that as a result, policymakers will be encouraged to learn from good practices in other countries and to take action.

The *Bulletin* welcomes analytical articles on topics that are at the forefront of transport development in the region, as well as articles on policy analysis and best practices. Articles should be based on original research and should have analytical depth. Empirically based articles should emphasize policy implications emerging from the analysis. Book reviews are also welcome. See the inside back cover for guidelines on contributing articles.

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CONTENTS

IMPACT OF BUS RAPID TRANSIT ON URBAN AIR POLLUTION: COMMUTER'S EXPOSURE TO $PM_{2.5}$ IN AHMEDABAD

Shivanand Swamy[1] , Madhav Pai[2] and Shelly Kulshrestha[3]

Abstract

There is a growing concern about the health impacts of transportation leading to curiosity among commuters about their exposure to air pollutants during transit. The paper examines a critical pollutant, Particulate Matter ($PM_{2.5}$) and explores road based transport modes with an objective to minimize risk of exposure to pollutants. The study is conducted on a 10 km stretch in the city of Ahmedabad, India using Bus Rapid Transit System (BRTS) buses, city buses and other motorized and non-motorized modes. It defines variation in $PM_{2.5}$ concentration levels while commuting in different modes, during various seasons (winter, summer and monsoon), location as well as varying time of the day.

The study gives a comparative overview of real time exposure to $PM_{2.5}$ across nine transport modes. In-vehicle exposure in air conditioned (AC) BRTS buses showed lowest $PM_{2.5}$ concentration levels. Factors such as segregation, elevated height of exposure and the presence of air-conditioning were seen to favor lower exposure levels. In all the modes, the mean concentration level of $PM_{2.5}$ was highest during winter (M=390µg/m^3, SD=187) and lowest during the monsoon period (M=115 µg/m^3, SD=107). Another consistent observation during the day was lowest $PM_{2.5}$ levels during the afternoon and highest during the evening trips. This has relevance for commuters with respiratory problems in scheduling their travel plan. While walking, internal street trip recorded lower $PM_{2.5}$ levels as compared to the main road with traffic. Real time information to commuters would increase their awareness for choosing the mode with lower exposure levels. The paper provides a platform to influence policy decisions for promoting segregated public transport considering the health perspective of commuters.

INTRODUCTION

Ahmedabad, with a population of 5.5 million and an area of 466 sq. km (180 sq. miles) is the 7th largest city in India and a major industrial and commercial hub. The city has grown by 144 per cent (in area) and 58 per cent (in population) since 2006. Vehicular growth has also been tremendous. The annual growth rate of motorized vehicles registered in the city is about five times higher than that of the city population (24 per cent vs 4.7 per cent). In 2011-2012, 206,749 vehicles were added to the existing vehicle population of 1.96 million. 71 per cent of the newly registered vehicles were two-wheelers, followed by four-wheelers (25 per cent), autorickshaws (2 per cent) and buses/ trucks (0.1 per cent). Ahmedabad has been grappling with issues of congestion, pollution and an increasing floating population. With the launch of a national city modernisation scheme-Jawaharlal National Urban Renewal Mission (JnNURM) in 2006, the city has fast tracked the urban development process with key interventions in the transportation sector. These initiatives included restructuring of the road network, conversion of autorickshaws and buses to Compressed Natural Gas (CNG), augmenting public transit facilities like increased bus fleet under Ahmedabad Municipal Transport Service (AMTS) and introduction of Bus Rapid Transit System (BRTS).

This study focuses on monitoring commuter's exposure to $PM_{2.5}$, one of the key pollutants recognized for causing adverse health impact. Mode choice, time of travel or other travel pattern is seldom based on pollution studies. The study assesses in-vehicle $PM_{2.5}$ concentration levels in nine road-based transport modes, which are being commonly used by Ahmedabad citizens. The paper

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gives a comparative overview of the $PM_{2.5}$ levels and explores key factors which contribute to commuters' exposure in the urban transport microenvironment. It attempts to support policies for fostering transport modes and practices which minimize the risk of particulate exposure during transit.

1. LITERATURE REVIEW

1.1 Exposure to $PM_{2.5}$ - A Concern for Commuters

Exposure to $PM_{2.5}$ is of concern as particles smaller than or equal to 2.5 micrograms easily enter the respiratory tract reaching the alveoli. There is substantial literature which suggests that continued or even short term exposure to elevated levels of $PM_{2.5}$ leads to adverse respiratory (allergies, asthma, bronchitis, coughing, shortness of breath, decreased lung functions, lung cancer etc.) and cardiovascular health impacts (Brook, et al., 2010); Pope III & Dockery, 2006; Laden et al., 2006). It is of critical concern for susceptible individuals like people with heart and lung disease, children and the elderly as even short- term exposure can lead to adverse health impacts (Dominici, et al., 2006; Bell, Ebisu, & Belanger, 2007).

Particulate pollution on the road is mainly from sources like fuel combustion, wear and tear of vehicle body (brake lining, tyres), re-suspension of road dust, chemical reaction etc. The level of $PM_{2.5}$ concentration in motorized modes can vary depending on the infiltration from the ambient environment and self-pollution of the vehicle, dominant source of self-pollution being the tailpipe and the engine crankcase (Hill, Zimmerman, & Gooch, 2005). Multiple factors influence commuter's exposure levels including vehicle design, vehicle age, fuel type, position on the road, vehicle upholstery, passenger capacity, speed, acceleration activities, ventilation, etc. Other aspects like exposure height (position of breathing zone), meteorological factors (wind-speed and direction, humidity and temperature), time of the day, seasons, number of intersections, location (route/path followed by individuals) and pollution sources also influence exposure levels (Wohrnschimmel, et al., 2008; Adams et al., 2001; Kaur et al., 2007).

1.2 Assessment of Exposure to PM2.5 in the Transport Environment

Though average trip length in Ahmedabad is about 5 kms, which is comparatively shorter than other metro cities (CoE, 2013), exposure to elevated $PM_{2.5}$ levels and other pollutants is critical especially for the sensitive group. Exposure studies are useful when monitoring happens in close proximity to the commuters allowing them to identify those critical moments when the pollutant level exceeds the limit, even for a short duration. As most of the pollution data at the city level is generated through fixed monitoring stations (where the instruments are placed at a particular height or on rooftops), it has limited applicability for assessing an individual's exposure level. Fixed monitoring stations underestimate the pollution concentration level experienced by commuters (Adams et al., 2001; Kaur et al., 2007). This study preferred carrying out real time monitoring using portable monitors. As the pollutant concentration level is seen to vary with transport related micro-environment, multiple road based modes were selected for spatial real-time monitoring (Wang & Gao, 2010; Sabapathy, Ragavan, & Saksena, 2012).

2. MATERIAL AND METHODS

2.1 Modes and transit facilities

The study covered all dominant road-based modes including BRTS buses (AC and non-AC), city buses, private four-wheelers (AC and non-AC), three-wheelers, two-wheelers, cycles and pedestrians. Public transit facilities like bus stations were also included for monitoring to account for $PM_{2.5}$ exposure during the waiting period. To understand the usage of modes in the city, information was gathered through a few recent transport studies. Given below is an overview of the modes and bus stations in Ahmedabad.

Public Transport

The public transport in Ahmedabad consists of the city bus service and BRTS. It accounts for only 10 per cent of the total trips in the city (*10*). The city bus service is operated by AMTS and consists of 827 buses (174 routes, 1,688 bus stops). The total network is 550 km long and has a ridership of 600,000 passengers per day. It covers about 92 per cent of the total developed municipal area.

BRTS is operated by Ahmedabad Janmarg Limited. Started in 2009, it currently covers 86 kms (131 bus stations). The system functions with segregated bus lanes, median bus stations, level boarding and alighting, high frequency (2-5 minutes), low fares and a real-time passenger information system. It has a ridership of 125,000 passengers per day.

Private Transport

Ahmedabad has a substantially high number of private vehicles (cars and two-wheelers) constituting around 90 per cent of the total registered vehicles in the city. Private vehicle population is about 1.7 million (0.2 million cars and 1.5 million two-wheelers). Both the modes are growing at 8 per cent per annum and four-wheelers have more than doubled during the last decade (*10*). Two-wheelers are the most popular mode accounting for a third of the total trips in the city

Intermediate Public Transport (IPT)

Three-wheelers including auto-rickshaws and shared rickshaws are the main IPT modes operating in the city. There are 112,515 auto-rickshaws operating in the city, accounting for 9 per cent of the total trips. Their population is growing at 11 per cent per annum (*10*). Three-wheelers pose stiff competition to buses due to their easy availability and affordability. While auto-rickshaws operate in all parts of the city, shared autos are common in the eastern part.

Non-Motorized Transport (NMT)

Walking and cycling are the prevalent means of commuting in Ahmedabad. They account for 34 per cent of the total trips. Studies show that 50 per cent of the BRTS commuters prefer to walk for access and egress. Average walk trips are about 2 km and bicycle trips are about 3 km length in Ahmedabad (CoE, 2013).

Bus Stations

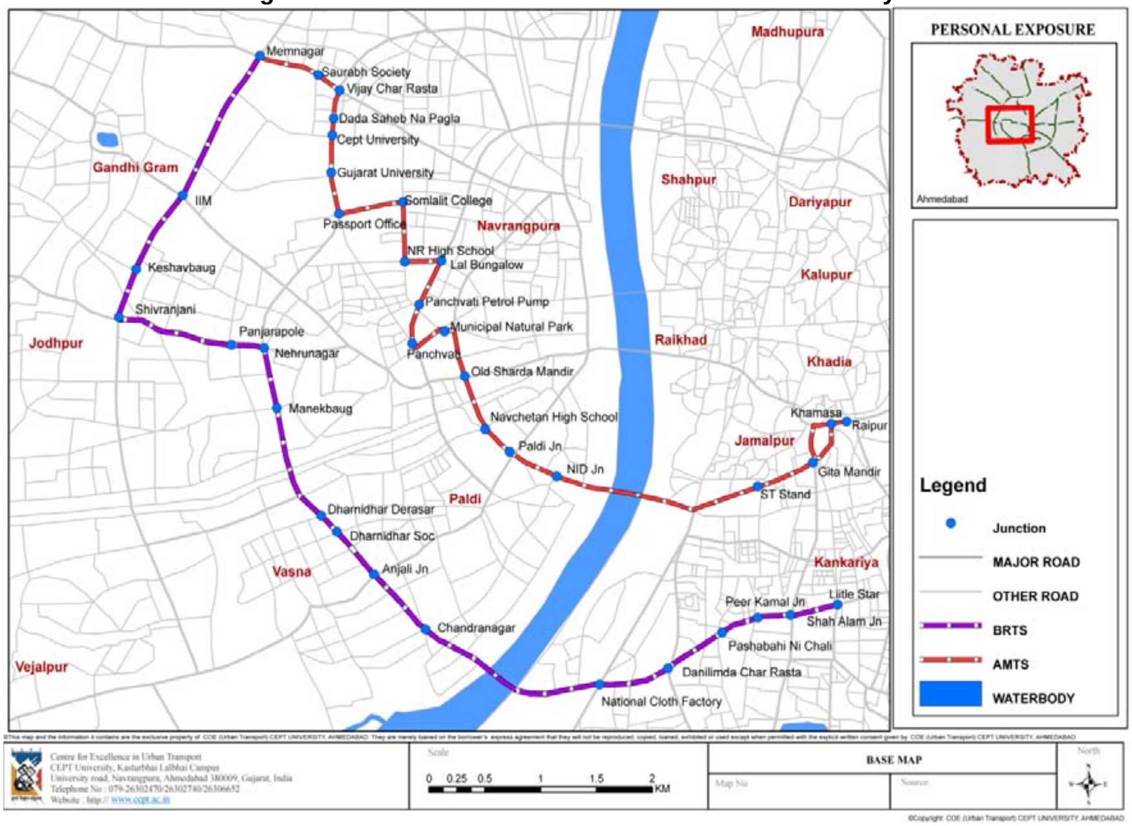
Ahmedabad's public transport system has two types of bus stations- median and curb side. BRTS stations have median location, high plinth (900 mm), at-grade approach, off-board ticketing facilities and tensile wires defining its exterior. Most of these stations are located near the junction with synchronized signal phasing for pedestrians. AMTS bus stops are located on the curbside of the road. They are a mixture of signposts and temporary structures.

2.2 Study Corridor

The study corridor was finalized after conducting trial runs using AMTS and BRTS buses. The selection criteria considered coverage of both eastern and western parts of the city defined by Sabarmati River; mix of land-use and income groups; completed corridors without any major ongoing civil work activities (construction, road-widening etc.) and inclusion of continuous routes for both modes.

The BRTS corridor extended from Memnagar to Kankaria Telephone Exchange covering a length of 10.56 km and 16 stations (Figure 1). A parallel corridor with similar Right of Way (RoW) was selected for monitoring exposure levels on an AMTS route. It extended from Memnagar to Raipur Darwaza covering a length of 9.6 km with 28 stops.

Figure 1 BRTS and AMTS routes selected for the study.



2.3 Sampling Design

The measurements were done in three phases (December 2011-January 2012; April 2012-May 2012 and June 2012-July 2012) representing winter, summer and the monsoon period. In each phase, a similar monitoring schedule was maintained covering all modes and sample bus stops. All modes were surveyed for three time slots in a day comprising of the morning peak (8:30 AM-11 AM), the afternoon off-peak (1:30 PM-4:00 PM) and the evening peak (6:30 PM-9:30 PM).

Monitoring was also conducted at bus stations during the waiting period. Additional surveys included measurement of $PM_{2.5}$ levels while walking on the main and internal roads, across road cross-section and with variation in elevation levels. 20-minute recordings were done at each point including footpaths, cycle tracks (where available), mixed lanes, railings/ edge of the BRTS lane and the center of the BRTS lane.

In all, the study consisted of 45 days of survey spread over three seasons. It summed up to 254 hours of in-vehicle monitoring involving 30-36 one-way trips in each of the nine modes (except walk trips, which were 26 one-way trips). In addition, the survey included 70 hours of monitoring at the bus stations during the peak and off-peak hours.

2.4 Monitoring Equipment

Two handheld photometric instruments-“Dust Track TM 8532” were used in the study for recording realtime $PM_{2.5}$ concentrations. Along with this, GPS instruments-“Garmin eTrex” and “Temperature–Relative Humidity Recorder (RH Temp101A)” helped to assign the location track point and the MET condition.

The Dust Track (DT) instruments (4.9x4.75x12.45 inches/ 12.4x12.1x31.1 cm) recorded the $PM_{2.5}$ concentrations at 5-second intervals and provided data on average, minimum and maximum readings in $\mu g/m^3$ during the trip. The DT instrument is based on technology using a light scattering sensor wherein a beam of laser light measures the particles in air. It uses an equation to convert the observed light deflection into an estimate of mass concentration in real time. DT instruments can measure particles in the range of 0.001 to 150 mg/m^3. Data logger (RH Temp101A) recorded temperature and relative humidity.

The DT instruments were operated as per the manual guidelines by a trained team of four people. The instruments were zero calibrated and the impactor plate was cleaned after every round trip. The display time in all instruments was synchronized daily. While monitoring, the DT instruments were kept close to the inhalation level. During each trip, the team recorded information related to waiting time, occupancy levels (in case of public transport), traffic condition and the surrounding polluting activity.

DT instruments were adjusted to record at 10-second intervals. The average number of samples recorded for one-way trips ranged from 100-300 in motorized modes and increased up to 1000 in non-motorized modes. After each trip, the $PM_{2.5}$ readings were checked for errors. Resurveys had to be done for six trips. A master sheet was developed after linking mode-wise DT data with its corresponding GPS, temperature and relative humidity data.

2.5 Field Checks for DT Calibration

Dust Track instrument's conversion process of light intensity to mass concentration of particles depends on various factors like the size distribution, refractive index, shape and density of the particle as well as the absorbed humidity (DUSTTRAK™, 2008). Studies show that DT instruments have good precision; however, they record higher concentrations in comparison to the established reference gravimetric method. Thus, calibration is required (Huang, 2007; Joshua et. al, 2011; Kim et al., 2004.). The "Dust Track TM 8532" instruments are factory calibrated for Arizona Test Dust (ISO 12103-1), so a secondary calibration would enhance accuracy for Ahmedabad road dust conditions.

During each phase of the study, the DT instruments were calibrated by placing them together with the Gravimetric Samplers and conducting field checks at bus stations for 8 hours and 24-hour period. The correction factor (obtained by dividing the DT reading with the Gravimetric readings) showed slight variations (1 per cent- 4 per cent) for the two instruments. The average calibration factors (1.19 for instrument 1 and 1.25 for instrument 2) were applied to the readings of the corresponding DT.

2.6 Data Processing and Analysis

The data from DT, Temp-RH logger and GPS instruments was downloaded and inspected after each round trip. Any error or missing information was highlighted in the data. Repeat surveys had to be carried out in the few instances where instrument errors were detected. A detailed master sheet was prepared by trip-wise information showing exposure levels while commuting in all the nine modes and while waiting for public transport at the bus stops. The mastersheet included fields showing details of travel mode, date, time, peak, $PM_{2.5}$ recorded, $PM_{2.5}$ corrected, speeds, RH-Temp, segment and junction name. Even though the absolute values of $PM_{2.5}$ have been defined, focus was on comparing values among different modes.

Descriptive statistics were used for comparative analysis. Mean and standard deviation values have been used to describe the variation in $PM_{2.5}$ concentration levels. The findings are mostly represented graphically as "box plot" to bring out the simultaneous comparison and data variation. It shows the lowest and the highest recorded $PM_{2.5}$ values besides the first and the third quartile. $PM_{2.5}$ concentration levels are compared in terms of M and SD, wherein M represents the mean $PM_{2.5}$ concentration level and SD represents the standard deviation of the value. Statistical significance was established using the f-test and the t-test.

3. DISCUSSION OF RESULTS

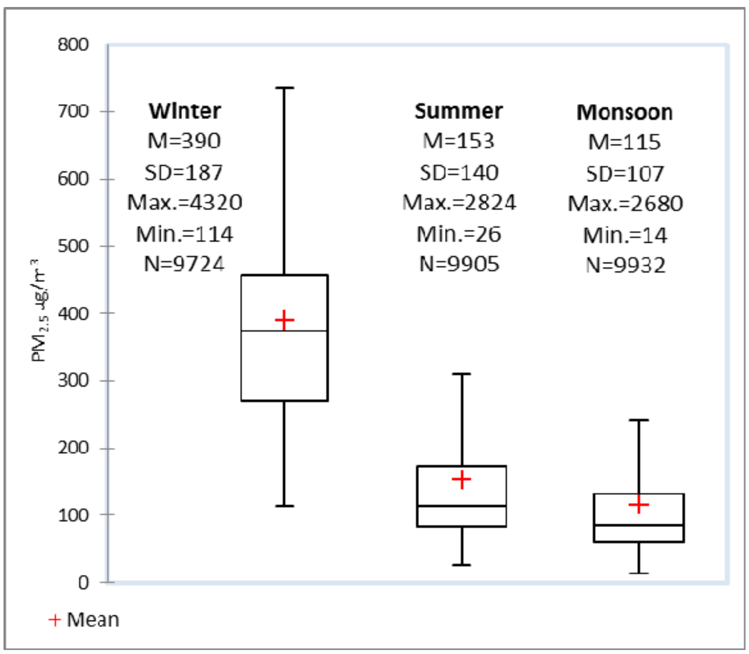
3.1 Seasonal Variation

$PM_{2.5}$ concentration levels were found to decrease from the winter (December-January) to the monsoon period (June-July). There was a marked reduction of 61 per cent for in-vehicle mean concentrations from winter to summer (April-May) (M=390 µg/m3, SD=187 in winter and M=153 µg/m3, SD=140 in summer) and then again a reduction of 25 per cent from summer to monsoon (M=115 µg/m3, SD=107) in non-AC modes (Figure 2). Statistical results using f and t-tests showed significant differences in the mean $PM_{2.5}$ levels between winter and summer (t-test, p=0) and between summer and monsoon (t-test, $p < 0.00001$) at the 95 per cent significance.

The trend was similar for bus stations, where we observed reduction of 34 per cent from winter to summer (M=267 µg/m3, SD=132 in winter; M=175 µg/m3, SD=162 in summer) and 32 per cent from summer to monsoon (M=119 µg/m3, SD= 92 in monsoon). Seasonal variation in $PM_{2.5}$ levels suggests meteorological impacts like reduced ventilation coefficient (determined as a function of average mixing height and average wind speed) during winter as compared to summer and monsoon. Low mixing heights are observed in India during the winter and monsoon, however stronger wind speeds and rains help to reduce ground level pollutant concentration in monsoon (Krishnan & Kunhikrishnan, 2004; Iyer & Raj).

Correlation results of in-vehicle $PM_{2.5}$ concentration with temperature and relative humidity showed a weak negative correlation with temperature (-0.332, P< 0.0001, R2=0.11) and a weak positive correlation with relative humidity (0.47, P<0.0001, R2=0.22). Temperature and RH gave a strong negative correlation (-0.94, P<0.0001, R2=0.88) with each other. Further research would be required to establish the meteorological impact on in-vehicle exposure.

Figure 2. Box plot representing commuter's exposure to $PM_{2.5}$ during winter, summer and monsoon trips in non-AC modes. (*The seasonal results include one-day trips conducted in each of the seven Non-AC modes (including 2 peaks and 1 off-peak hour trip/day).



3.2 Exposure to PM2.5 in Different Modes

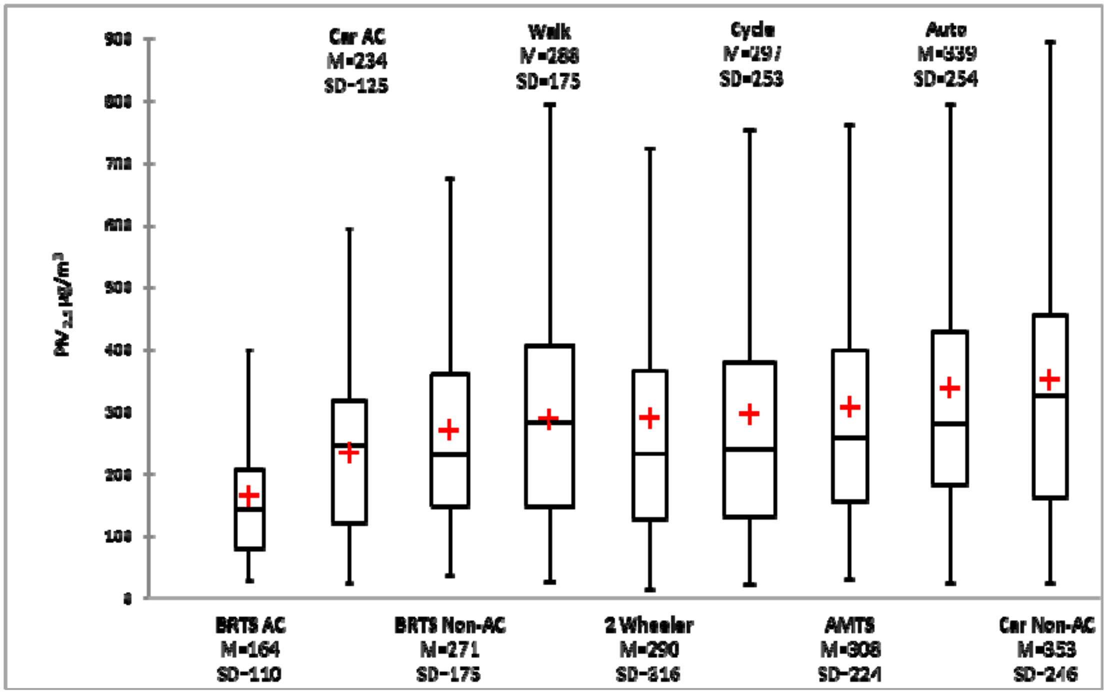
The in-vehicle concentration levels varied significantly between different modes. However, the pattern remained almost similar during each season as well as most of the trips. The $PM_{2.5}$ readings observed for all trips during December 2011 to July 2012 is summed up in table 1 and represented as box-plot diagrams in figure 3. The first (25th percentile) and third quartile (75th percentile) of the concentrations are represented as the lower and upper parts of the box. The inter-quartile range as well as the outliers were minimum in AC BRTS buses followed by AC-cars and non-AC BRTS buses. While the median value and the inter-quartile range of open modes like walk, cycle and two-wheeler remained similar to non-AC BRTS, the numbers of outliers were very high in the open modes. Except BRTS (AC and non-AC) and AC-cars, all the other modes had a high number of outliers reaching beyond 2000 µg/m3. This shows strong influence of ambient and other factors (self-pollution etc.) for in-vehicle exposure. Summer and monsoon trips showed a similar sequence of mean exposure levels -AC BRTS (least) followed by AC car, walk, BRTS, cycle, two-wheeler, city-bus, non-AC car and then three-wheeler with highest levels. Winter sequence varied slightly with non-AC BRTS (M=325, SD=169) having a lower mean than walk (M=347, SD=150) and three-wheelers (M= 385, SD=248) slightly lower than non-AC car (M=414, SD=242).

Table 1. Descriptive statistics for all in-vehicle $PM_{2.5}$ exposures

Mode	Season	Mean (µg/m³)	Std. Error	Median (µg/m³)	Mode (µg/m³)	Std. D. (µg/m³)	Range (µg/m³)	Min. (µg/m³)	Max. (µg/m³)	Count
Closed/ Partially open modes										
BRTS Non-AC	W	325	2.0	264.4	236.8	168.7	1289	103.2	1392	6944
	S	139	2.4	117.6	92	75.7	616	51.2	667.2	974
	M	109	2.1	81.6	67.2	82.2	661	36.8	697.6	1535
AMTS	W	367	2.8	310.4	256.8	228.2	3587	84.8	3672	6733
	S	168	3.0	138.4	92.8	107.6	962	30.4	992	1294
	M	122	2.1	99.2	63.2	71.1	752	38.4	790.4	1174
Car Non-AC	W	414	3.1	383.2	432	242.1	2539	44.8	2584	6036
	S	180	4.2	134.4	104.8	135.2	938	29.6	968	1038
	M	123	3.4	99.2	93.6	99.2	1031	24.8	1056	846
Auto	W	385	2.9	328	260	247.8	4219	100.8	4320	7083
	S	206	7.1	140	76.8	229.9	2770	53.6	2824	1038
	M	134	4.9	92	70.4	148.3	1968	24	1992	919
Open modes										
2 W	W	359	4.7	300	317.6	346.8	7149	75.2	7224	5557
	S	165	4.6	126.4	96	139.8	1454	25.6	1480	939
	M	114	3.4	82.4	34.4	129.7	2666	14.4	2680	1485
NMT	W	347	1.3	315.2	288	214.4	5217	39.2	5256	27183
	S	132	1.9	100.8	91.2	127.9	2794	30.4	2824	4617
	M	110	1.7	78.4	52	104.6	1449	23.2	1472	3968
Air-conditioned modes										
CAR AC	W	292	1.3	280.8	274.4	95.0	1451	100.8	1552	5093
	S	116	2.0	93.6	89.6	61.5	337	24	360.8	920
	M	83	1.9	68	60	66.0	643	29.6	672.8	1202
BRTS AC	W	226	1.9	193.6	188.8	104.7	503	72	575.2	3124
	S	100	1.3	90.4	84	41.5	225	33.6	258.4	978
	M	67	0.7	64	43.2	27.4	384	28.8	412.8	1347

W=winter, S=summer, M=monsoon

Figure 3. In-vehicle $PM_{2.5}$ exposure pattern for all three seasons combined.



AC BRTS buses had lower exposure to $PM_{2.5}$ in comparison to other vehicles in any given season (P<0.00001). The mean $PM_{2.5}$ levels inside the AC BRTS bus (M=164 µg/m3, SD=110) was about 76 per cent lower than the mean exposure in all other modes combined ((M=289 µg/m3, SD=224). It was 57 per cent, 49 per cent and 67 per cent reduction in mean $PM_{2.5}$ levels against all other modes during winter, summer and monsoon respectively. Statistical results using t-tests show significant difference in the mean $PM_{2.5}$ levels between AC BRTS buses and all the other modes (t-test, P=0) at 95 per cent significance .

Amongst the non-AC vehicles, BRTS travelers were exposed to lower $PM_{2.5}$ concentrations. A comparison with the cumulative readings of all non-AC modes shows about 12 per cent reduction for non-AC BRTS commuters during both winter and summer and about 6 per cent reduction during monsoon (mode-wise reduction ranges from 19 per cent in the autos, 27 per cent in non-AC car and 13 per cent in AMTS during winter; 49 per cent in the autos, 30 per cent in non-AC cars and 21 per cent in AMTS during summer; 22 per cent in the autos to 12 per cent in non-AC cars and AMTS during monsoon). Statistical results using t-test show that, except NMT modes (walk and cycle) during summer and monsoon and two-wheelers during monsoon, all other modes have significantly higher exposure levels (P<0.00001) as compared to non-AC BRTS buses). The following reasons may explain low exposure in non-AC BRTS buses:

Segregation
BRTS plies in a 7.5-meter wide corridor in the center of the road defined with plantations in many areas.

Self-pollution
BRTS buses have Euro III and IV compliant engines

Height of Exposure
BRTS buses have 900 mm floor height

The modes can be broadly grouped as “Open” and “Closed” with AC/non-AC and segregated/mixed lane traffic option. Comparative results show distinct character for closed modes moving in mixed traffic lane. For e.g., AMTS buses moving in mixed traffic experience lower exposure than non-AC cars and three-wheelers probably due to the exposure height and air dispersal (number of windows). Non-AC cars and three-wheelers observed higher levels of $PM_{2.5}$ than most of the modes. It implies that factors like window openings, vehicle volume and exposure height from the ground have significant influence over the concentration levels.

Open modes like two-wheelers, walk and cycle observed a similar exposure pattern marked by sudden and frequent peaks of $PM_{2.5}$. Though air dispersion is quicker in open modes, spot exposure is sometimes higher due to localized pollution sources (tail pipe emissions from surrounding vehicles, road construction etc.). Pedestrians and bicyclists use footpaths and side lanes of the carriageway. As these are not in line with the tail pipes direction of vehicles, the concentration levels are relatively lower. Placing bicycle lanes and utility lanes (parking) appear to lower $PM_{2.5}$ exposure levels for commuters. It was observed that closed modes with air conditioning and segregation have reduced exposure levels.

3.3 PM2.5 Exposure Before and After BRTS Impementation

Systems from around the world have demonstrated the impact of BRTS on travel. A further benefit of the reduction in travel times is the reduction in exposure to $PM_{2.5.}$ Savings in travel time established through the BRTS in Ahmedbad result in lower $PM_{2.5}$ counts. On average, an AMTS bus travels 18 km/hr, bringing the average travel time to approximately 18 minutes per trip. With a modal shift of 50 per cent AMTS users shifting to BRTS, a significant decrease in average travel time to 13 minutes can indicate a significant reduction in the time exposed to $PM_{2.5}$. The lower $PM_{2.5}$ exposure associated with BRTS (as shown in Table 1) means shifting from any mode to an air-conditioned service will have considerable effects on the exposure levels. Table 2 shows a simple calculation conducted to estimate the percentage variation in exposure levels. The calculation uses mode share and per capita trip rate data to estimate the number of users and level of exposure based on their mode. This illustrates the before-BRTS scenario. Post-implementation of the BRTS, a similar calculation using mode shift data was used to show the number of users now being exposed to lower levels of $PM_{2.5}$. As a result, the variations between the before and after BRTS current scenario (based on modal shift) is 0.30 per cent (winter), 0.24 per cent (summer), and 0.14 per cent (monsoon). Ideally, the methodology should use travel data collected from the same corridor as the $PM_{2.5}$ count data, to establish more accurate results. In this case, the calculation is used to indicate a variation in pre and post implementation of the BRTS and to indicate the need for further assessment for more accuracy. The travel time savings of over 25,000 hours also suggests another potentially beneficial method to limit the exposure to fine particulate matter. This assessment demonstrates that BRT systems can potentially be a system that significantly lowers exposure levels for. A deeper assessment of exposure and concentration data could strengthen the case for BRT systems as a way to manage negative externalities associated with daily travel. Studies suggest that the most significant benefits are usually from the reduction in airborne fine particulate matter or $PM_{2.5}$. Additionally, with the health benefits assocaited with reduced exposure and multiplied by the vulnerable user groups there is strong potential for input into policy mandates. A scale-up strategy for BRTS ridership could significantly multiply the health benefits attained from lower exposure, benefitting users and others affected.

Table 2. Estimate the percentage variation in exposure levels

Modes	Season	Travel Time (mins)	$PM_{2.5}$ Count	Exposure Level	Modal Shift (per cent)	Travel Time Savings (mins)	$PM_{2.5}$ Count	Exposure Level
2W	W	41580000	5557	2.311E+11	14	217239.8	3124	2.30367E+11
	S		939	3.904E+10			974	39023406825
	M		1485	6.175E+10			1535	61713170932
IPT	W	10692000	7083	7.573E+10	30	465513.8	3124	73438843817
	S		1038	1.11E+10			974	11002611746
	M		919	9.826E+09			1535	10054367177
Car	W	3564000	5093	1.815E+10	2	31034.26	3124	18068792259
	S		920	3.279E+09			974	3276662461
	M		1202	4.284E+09			1535	4289175611
AMTS	W	21780000	6733	1.466E+11	50	775856.4	3124	1.41813E+11
	S		1294	2.818E+10			974	27544617770
	M		1174	2.557E+10			1535	25495582611
NMT	W	209088000	27183	5.684E+12	4	62068.51	3124	5.67329E+12
	S		4617	9.654E+11			974	9.63629E+11
	M		3968	8.297E+11			1535	8.28217E+11

3.4 Exposure Variation while Walking on Arterial and Internal Roads

As an extension to the survey, variation in $PM_{2.5}$ concentration was observed while walking on the main and internal streets. Results showed a reduction of 35 per cent-40 per cent in the mean levels monitored on the internal streets (M=91, SD=36) as compared to the arterial road (M=137, SD= 91). The peaks were frequent on the main road with elevated levels near the junctions mainly contributed by the vehicle emission due to the waiting traffic.

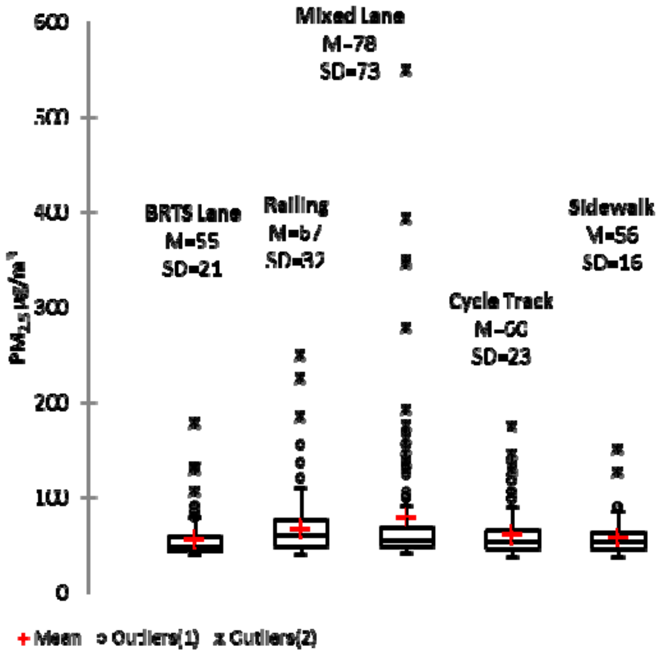
The results draw attention to factors like segregation, ventilation, enclosure and height of exposure. Though these form only a part of the large spectrum of variables that influence $PM_{2.5}$ concentrations, it helps to evaluate segregation and prioritization of public transport from the planning perspective.

3.5 Exposure Variation across Road Cross Section and with Altitude (in the Ambient Environment)

A typical 40 m cross section of the BRTS corridor includes a centrally segregated lane 7.5 m wide with three lanes of mixed traffic adjacent to it and NMT facilities at the edge. Monitoring across the road cross-section helped to observe the exposure variations at different points like the footpath, cycle track (where available), mixed lane, railing/ edge of the BRTS lane and the center of the BRTS lane. The $PM_{2.5}$ concentration levels were lowest on the footpath and increased as one moved into the mixed corridor. In a few cases, maximum level was observed at the right side of the mixed corridor, probably due to the presence of vehicle tail-pipes towards that side. The levels again came down in the BRTS corridor. A significant difference (t-test, p=0.002) was observed with about 30 per cent reduction in the mean $PM_{2.5}$ exposure inside the segregated BRTS lane as compared to the mixed lane (figure 4). This establishes the positive impact of segregation in case of BRTS.

In a follow-up survey to observe variation with height, recordings were done for 20-minute periods at three points closest to the ground at 300 mm, 900 mm and 1800 mm. Mean $PM_{2.5}$ concentrations were found to increase by 44 per cent near the ground level as compared to the reading at 1800mm from the ground - Height=300 mm (M=71, SD=24); Height=~900 mm (M=56, SD=19); Height=~1800 mm (M=49, SD=15). Proximity to the ground elevates exposure levels probably due to direct tail pipe emissions and re-suspension of road dust. This is significant as children with lower height of inhalation get more frequently exposed to elevated $PM_{2.5}$ concentration as compared to the adults.

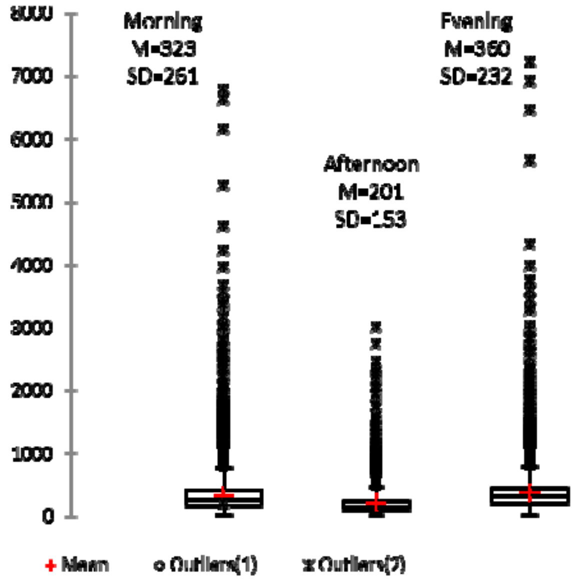
Figure 4. Variation of $PM_{2.5}$ exposure across the road, monitored at ~900 mm on 18 April 2012.



3.6 Exposure Variation during the Day

Diurnal assessment of the $PM_{2.5}$ exposure pattern shows low levels during the afternoon trips (1:30 PM- 4:00 PM) and elevated levels during the evening peak hour trips (6:30 PM-9:30 PM). A similar pattern was observed in all seasons for in-vehicle as well as bus station monitoring. The diurnal variation pattern was analyzed separately for the Non-AC and the AC Modes. The mean $PM_{2.5}$ levels during the evening non-AC trips were observed to be 44 per cent higher than the afternoon levels for all non-AC trips combined (Figure 5). The morning and evening variation ranged from 5 per cent in winter to about 34 per cent in summer and monsoon. Elevated $PM_{2.5}$ concentrations during the evening may be attributed to meteorological conditions (lower mixing height determined by various factors like temperature, relative humidity, wind speed, cloud cover, etc.) and also urban factors like traffic conditions. Evenings observed a heavy traffic flow with work and social trips occurring in the same period. In addition, the evening peak extends over a longer duration than the morning peak. There is lower diurnal variation in terms of mean $PM_{2.5}$ levels of AC modes during morning (M=185, SD=107); afternoon (M=148, SD=78) and evening (M=256, SD=138). Further research would be required to establish the exact reason for the diurnal $PM_{2.5}$ variation.

Figure 5. $PM_{2.5}$ diurnal variation in all the Non-AC in-vehicle trips (with outliers).



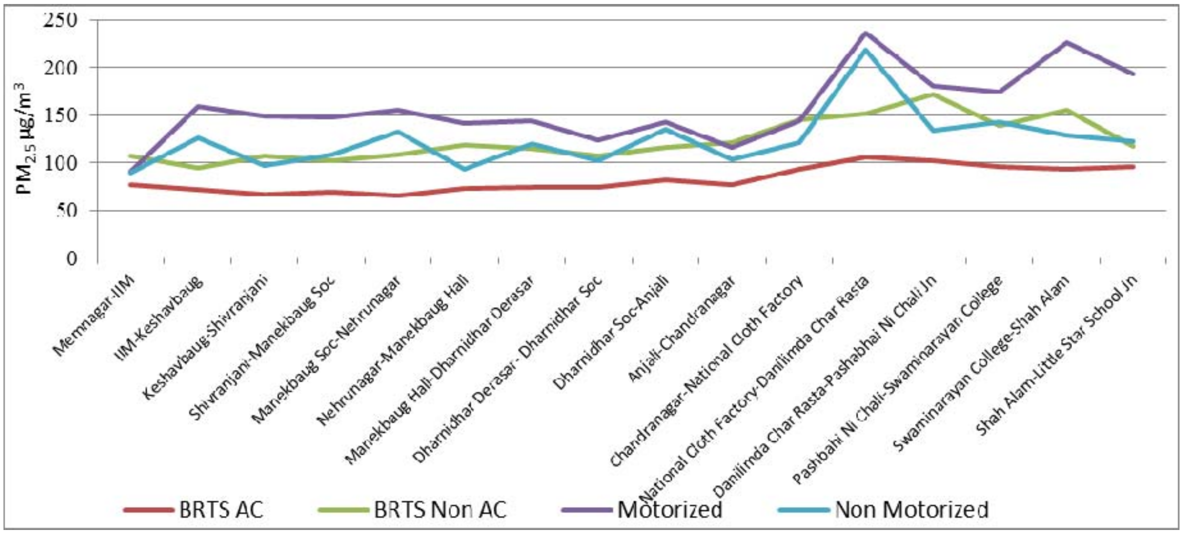
3.7 Variation with Location

In terms of location, few stretches in the eastern part of the corridor showed a consistent increase in $PM_{2.5}$ exposure levels. It includes the stretch from the *National Cloth Factory to Shah Alam*, which is industrial and mixed land-use development with informal settlements. In addition, there is heavy movement of freight vehicles like trucks on that corridor. Elevated readings were observed in this part during most of the in-vehicle trips. Ambient environment and heavy vehicle traffic movement appears to have a high influence on the in-vehicle $PM_{2.5}$ exposure levels. The western part of the corridor, *IIM* to *Keshavbagh,* showed elevated levels, especially in the evening trips for all the closed mixed traffic modes (non-AC Car, three-wheeler, two-wheeler), except non-AC BRTS. This may be due to traffic congestion at the *Keshavbagh* junction.

Stretches mainly in the western corridor, like *Keshavbagh to Shivranjani*, *Nehrunagar to Manekbaug hall*, *Dharnidhar Derasar- Dharnidhar Society and Anjali to Chandranagar* observed lower levels in almost all the modes. These are mainly residential areas with mixed-use development along the road.

The mean $PM_{2.5}$ levels were 17 per cent lower in the western segments of the corridor for all modes which increased to 23 per cent in AC BRTS buses (AC BRTS - West: M=149, SD= 110; East: M=193, SD= 105); (non-AC BRTS- West: M=260, SD=170; East: M=293, SD=182). Figure 6 shows location-wise variation in AC BRTS, non-AC BRTS, motorized and non-motorized modes along the corridor.

Figure 6. In-vehicle exposure variation for all modes - segment wise (cumulative results of April to July 2012)



3.8 BRT Bus Stations

A 20-minute dust tracking survey conducted at 16 BRTS stations during the three peak periods showed a similar pattern as in-vehicle exposure with respect to the seasonal and diurnal variation. The seasonal drop was 34 per cent from winter to summer and 32 per cent from summer to monsoon. The diurnal levels dropped by 38 per cent from morning (M=241 µg/m3, SD=139) to afternoon (M=150 µg/m3, SD=83) and then increased by about 80 per cent in the evening (M=268 µg/m3, SD=181) from the noon levels. Overall, the $PM_{2.5}$ levels in the western side BRT stations were 22 per cent lower than the eastern side stations ($P<0.001$). In many cases, BRTS stations nearer to the junction with traffic congestion recorded higher levels of concentrations (for example *Andhjan Mandal* and *Shivranjani* BRTS Stations which are less than 100 meters away from the junction). Further research is required to analyze the role of orientation, design and other factors in influencing the exposure levels inside the stations as established from literature review (Moore, Figliozzi, & Monsere, 2012).

4. CONCLUSIONS

The study suggests that mode type, location, seasonal as well as temporal variations due to meteorological conditions impacts the exposure of commuters to $PM_{2.5}$. It was observed that closed modes with air conditioning and segregation have reduced exposure levels than open modes like two-wheeler, walk and cycle. Partially closed modes in mixed traffic lanes such as non-AC city bus, three-wheeler and non-AC car experience maximum $PM_{2.5}$ pollution. The survey results show, AC BRTS commuters experienced minimum $PM_{2.5}$ concentration levels irrespective of season and time of the day. There is about 25 per cent reduction in mean $PM_{2.5}$ levels of AC BRTS as compared to the AC car users and about 76 per cent reduction with respect to other non-AC modes. Movement in segregated lanes, height and its volume seem to play a significant role in minimizing the concentration levels in BRTS buses. The reduction of travel time by around 25,000 hours suggests that the time exposed to higher $PM_{2.5}$ counts can be minimised through BRTS, while ensuring better health benefits. It can be concluded that policy decisions for maximizing the BRTS fleet of AC buses will significantly reduce commuter's exposure to $PM_{2.5}$. There is an increase in cities which are developing BRTS, thus similar studies will be useful in verifying the particle pollution exposure results.

The results showed that $PM_{2.5}$ concentrations varied significantly over the year with lowest levels during the monsoon and maximum during winters. The mean levels reduced by 61 per cent from winter to summer and then again by 25 per cent from summer to monsoon. Diurnal assessment of $PM_{2.5}$ levels across modes indicated lowest levels in the afternoon and highest during the evening peak hours. This is relevant for commuters, especially in the sensitive group for avoiding travel during peak hours, as it increases their chances of exposure to elevated $PM_{2.5}$ levels. Also, higher $PM_{2.5}$ levels as one gets closer to the ground is an important observation from the design and planning perspective. Children with lower inhalation height are likely to be exposed frequently to elevated $PM_{2.5}$ levels. For pedestrians and cyclists, commuting on internal streets (with lower traffic and source pollution) rather than a busy arterial road can be favorable from the health perspective. The findings also suggest that cyclists and walkers commuting on un-segregated lanes for long hours pose increased vulnerability to elevated exposure levels.

The study provides a platform to influence policy decisions for promoting segregated public transport as well as non-motorized transport considering the health perspective. It can be scaled up to promote awareness about real time exposure to pollutants, thus creating awareness for healthier modes of transport.

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SUSTAINABLE AND EQUITABLE TRANSPORT SYSTEM IN DELHI: ISSUES AND POLICY DIRECTION

M. Absar Alam[1]

Abstract

The paper highlights the current scenario of transport related, policies and planning and existing transport infrastructure and services in Delhi. It presents a critical analysis of transport planning and practices as per the proposed master plan through transport related expenditures on various components of transport. It suggests that development of NMT infrastructure, operational and physical integration of public transport systems viz. Delhi Metro and Urban Bus services are required for better mobility linked with adequate pathways for NMT. Transport related services are also important and needs examination in detail. The paper provides an outline of transport related services in Delhi and suggestions for proper guidelines and standards to be formulated for operators such as mini bus operators, shared auto and E-Rickshaw.

INTRODUCTION

The transport sector plays a crucial role in the development process of a country. It has a direct impact on living standards both in terms of economic as well as social well-being. Demand for transportation related services is generally a derived demand for other economic and social activities such as activities related to health, education, employment, etc. Transport infrastructure needs are assessed based on the demand scenario of such activities which form the potential market for transport infrastructure and services. It is in this context, that the provision of transport related infrastructure and services varies in accordance with its market potential. Accordingly, characteristics of the mobility needs of the people form the basis of the types of infrastructural needs and characteristics of the required transportation services.

During recent times, mobility needs of the people, due to increasing economic activities, have been insatiably increasing across the globe in general and across the developing world in particular (Acharya, 2005). This phenomenon is ubiquitous in megacities in Asia. Modern mechanization of transportation systems further fueled this phenomenon and heavy motorization is evident in these cities. Thus, motorized transport is fulfilling these insatiable transport needs. In turn, transport systems have become environmentally unsustainable and are now one of the major contributors of greenhouse gas emissions worldwide. Thus, a sustainable and equitable transport system is one that provides mobility related facilities and services while minimizing emissions both at local and global level and also serve as safe, reliable and economical means of mobility for all the sections of society including elderly, women and disabled persons (Black, 2010).

In addition, the absence of mass transit systems and the domination of privately owned vehicles on the roads results in the state of poorer and prohibited usage of the public infrastructure which creates inequitable transport system. This coupled with negative externalities like rise in accidents and increasing level of pollution caused by such transport systems negatively affecting both users and non-users of the existing transport system. This phenomenon is equally true in Delhi. Despite the major improvements in public transport systems, India's capital city, Delhi is still suffering from these ills affecting both the provision of infrastructure and its related services.

Delhi is a hub for personal motorized vehicles in India. Total motorized vehicles in Delhi comprised of more than 4.6 per cent of the total at national level in 2012 whereas in the case of cars and two wheelers, Delhi accounted for more than 12 per cent of total cars and 22 per cent of total two wheelers in the country respectively in 2012 (Ministry of Road Transport, 2013). Within Delhi, car and jeeps accounted for more than 30 per cent of the total registered mortised vehicles in the city

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(Government of Delhi, 2014, pp. 201). Given the concentration of motorized vehicles, traffic congestion and declining air quality is evident in Delhi. As per the recent survey by the Centre for Science and Environment (CSE), air pollution levels are not only increasing but also adversely affecting those who are contributing in reducing the pollution, in this case the users of non-motorized transport (CSE, 2015). Delhi Master Plan, 2021 also states that this situation of increasing motorization is likely to worsen due to increasing economic activities and the pressures of population growth, likely to be at 2.9 per cent annually during 2016-21 (DDA, 2007).

To tackle an insatiable demand for transport, strategies have been developed by the master plan for the development of the city which also includes small steps as demand side management like rationalization of parking charges. Major steps such as demand side management measures are still on the policy discourse. Facilitating environmental friendly transport modes like non-motorized transport (NMT) is an alternate approach to the same at least for shorter distances which has also been included in the priority areas of the master plan. However, as a result of low levels of investments in NMT, last mile connectivity and less capital intensive public transport systems, passenger mobility is less eco-friendly and the use of NMT is unsafe. Moreover, transportation systems in the city are disintegrated at both physical and operational levels. For example, Delhi's public transport like bus and metro rail clearly present a state of disintegrated systems. Physical integration implies combining the infrastructure of the two facilities. At present there is a lack of space for bus stations to be connected with the metro rail through suitable pathways. At the operational level, the commuters of both metro rail and public buses are compelled to use separate tickets, passes to travel in the city. The separation manifests also at the management of the operational of these two services which could lead to diseconomies in the scale of operation leading to financial losses to both consumers and the economy as a whole. Those most significantly affected are the poor in society who are using public transport, non-motorized transport and who have a smaller propensity to spend on travel. Therefore, transportation planning and policy needs to be revisited in terms of both sustainability of the system and equity in services in Delhi (DDA, 2007).

The objective of this paper is to analyze these very important aspects of Delhi's transportation systems. The paper presents a critical analysis of transport planning and practices for the given state of transport demand in the city. It examines the state of transportation infrastructure in Delhi with a view to derive conclusions about its sustainability and equity in the approach of transport development. Finally, it presents recommendations to frame appropriate policies for developing equitable reliable, safe and environmentally sustainable city transportation system.

1. STATE OF TRANSPORT DEMAND IN DELHI

As stated earlier, transport is a derived demand. It has close linkages with other economic and social activities. At the macro level, overall economic performance also determines the level of transport demand in the city. Delhi's economy has grown at more than 9 per cent average annual growth rate during 2005-15 (Economic Survey of Delhi, 2014-15). The expansion of economic activities resulted in increase in the population from migration. Table 1 shows that during 1980 to 1990, the population increase in Delhi was about 2.8 million (Government of NCT of Delhi, 2014). During the 1990s, this increase mounted to 4.2 million. However, this trend has been found to be slower between 2000 and 2011. The total increase in the population was estimated to be 3.3 million, lower than the increase during previous decade. Delhi's gross population was 6.2 million in 1980 which rose to 16.7 million in 2011- a more than two and half times increase in the size of the population of Delhi during the last 20 years. The increase in the size of the economy was estimated to be about nine-fold during the same period. Per capita income of Delhi increased by more than 20-fold during 1980-2011 (Government of NCT of Delhi, 2014).

This change is catalyzing Delhi's transport planning as well. Per capita income of Delhi was increasing at a 7 per cent average annual growth rate during 2005-11. In 1980, per capita income in Delhi was US$ 92.6 which increased to US$ 2562.2 in 2011, an almost 28 times increase in the per capita income (Government of NCT of Delhi, 2014).

Table 1. Macroeconomic Indicators

Indicators	1980	1985	1990	1995	2000	2005	2010	2011
Population in million	6.2	7.3	9	9.1	13.2	15	16.5	16.7
Population density (persons/sq km)	4180.7	4922.5	6068.8	6136.2	8900.9	10114.6	11126.1	11297.0
GDP growth (per cent change on YoY)	N.A	4.7	10.2	11.1	4.1	11.6	14.8	19.2
Per capita income (US$)	92.6	127.2	225.3	437.9	740.8	1101.3	2171.3	2562.2

Source: Estimated from various sources like Economic Survey of Delhi, Population data of CSO, Labour Department, and Government of Delhi (Statistical Handbook). The estimates are based on data in Rs. The estimates assume $ 1 = Rs. 58

Note: The growth rate and per capita income is at current price and Years are the financial year in Indian context with 31 March ending month.

It is also recognized that rise in per capita income leads to increases in the size of household holdings of personalized vehicles if other things remain constant. This is reflected in the trend of in the size of personalized vehicles and changing composition of motorized vehicles in Delhi (Table 2). An unprecedented increase in demand for urban mobility was noted by Master Plan-2021. The city's ownership of cars increased in absolute number from 400,000 in 1990 to 870,000 in 2000 (Government of NCT of Delhi, 2014). This further increased to 2173,000 in 2011 (Government of NCT of Delhi, 2014). In terms of cars per 1000 persons, the number has also increased from 64.3 in 1990 to 134.1 in 2011. The same is also noted in the case of motorcycle per 1000 persons from 197 in 1990 to 288 in 2011 (table 2). Alternatively, total number of buses, the backbone of Delhi's public transport, has not increased in the same proportion when compared to private vehicles. Delhi's urban transportation has been moving towards domination by private vehicles during the last three decades.

Table 2. Trend of Motorized Vehicles in Delhi

Motorised Vehicles	1990	1995	2000	2005	2010	2011
Total Vehicles (in 000)	1810	2430	3350	4470	7230	7350
Truck (in 000)	100	130	160	120	240	130
Passenger Car (in 000)	400	580	870	1431	2013	2173
Motorcycle (in 000)	1220	1620	2180	2840	4400	4342
Others (in 000)	90	110	140	150	390	390
Population (in million)	6.2	7.3	9	9.1	15.9	16.2
Cars per 1000 persons	64.3	78.9	96.6	149.4	138.1	134.1
Motorcycle per 1000 persons	196.9	221.6	242.7	312.1	276.4	287.8
No. of Buses*	4392	2770	1932	3469	6204	5884
No. of Non-AC Buses*	4392	2770	1932	3469	4954	4609

Source: Various Issues of Economic Survey of Delhi, Government of Delhi and Ministry of Road Transport and Highways, Government of India.
*buses are owned by Delhi Transport Corporation (a public sector unit) only
Note: Years are the financial year in Indian context with 31 March ending month.

Master plans were developed to guide the futuristic expansion path for towns in Delhi. This started with the Delhi Development Act, 1957 and later Master Plan of Delhi in 1962 (DDA, 2007).[2] The Master plan was revised in 1990 to focus on developing urban spatial structure. The revised master plan had ten year perspective planning. This later revised in 2007 as Master Plan-2021.

In addition to the perspective planning for urban development, these master plans also focused on transport related policies. As per Master Plan- 2001, 14 million passenger trips daily was assessed to be originating and it was hoped that public transport would cater to the majority of these

[2] Delhi Master Plan-2021, The Perspective for Year 2021, http://delhi-masterplan.com/, accessed on 25 May 2015

trips. The expected number of trips is likely to be more than 28 million by the year 2021. This projection also includes 2.3 million non-motorized trips.[3] The notable difference between these two plans is the recognition of the importance of NMT. Master Plan 2021 suggests that 7.4 per cent of the projected daily passenger trips would be trips generated by NMT (table 3).

Table 3. Modal Split as Envisaged in Delhi Master Plans (per cent)

Modes	2001	2021
Rail	8.57	0.5
Bus/Tram/Light Rail	65.97	46.3
Personalised Fast modes	12.26	36.7
Hired Fast Modes	3.27	
Hired Slow modes	0.65	4.1
Bicycle	9.28	5.0
Other NMT		7.4

Source: Delhi Master Plan and RITES, 2010

As per the assessment of Delhi Master Plan-2021, daily transport demand is likely to increase from 13.9 million passenger trips in 2001 to 27.9 million passenger trips in 2021. Based on the projected demand scenario of transport, it is also estimated that, 55000 km road infrastructure would be needed against the availability of 28000 km roads by 2021. In view of this, it would be important to see that how the basic infrastructure is being built for reliable, safe and environmentally sustainable transport system in the city. This is examined in the next section in terms of investment in transportation sector in Delhi.

2. INVESTMENT IN TRANSPORT INFRASTRUCTURE

As noted earlier, by 2021 about 28 million passenger trips is expected to be originated on a daily basis. Of these, the majority of the trips are envisaged to be catered for by public transport which includes bus and metro services in Delhi. This makes the case for improving the infrastructure of public transport in Delhi. In this direction, successful construction and operation of metro rail, as a mass transit, has been initiated. In addition, the experiment for bus rapid transit corridor was also undertaken by the government and different modalities of the same are under examination but no progress has been reported and no provision of expenditure has been made in the budget for the year 2015-16 of the Delhi Government.

Table 4. Annual Plan Expenditure in Delhi (per cent share)

Sectors	2002-03	2003-04	2004-05	2005-06	2006-07
Ports & Light Houses	0.0	0.0	0.0	0.0	0.0
Civil Aviation	0.0	0.0	0.0	0.0	0.0
Roads and Bridges	40.4	44.5	55.0	60.5	66.2
Road Transport	59.6	2.8	11.2	1.8	4.2
Inland Water Transport	0.0	0.0	0.0	0.0	0.0
Other Transport Services	0.0	52.6	33.8	37.6	29.6
Sectors	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
Ports & Light Houses	0.0	0.0	0.0	0.0	0.0
Civil Aviation	0.0	0.0	0.0	0.0	0.0
Roads and Bridges	39.2	52.2	61.8	52.9	46.5
Road Transport	27.5	16.0	0.0	46.5	23.3
Inland Water Transport	0.0	0.0	0.0	0.0	0.0
Other Transport Services	33.4	31.8	38.2	0.6	30.2

Source: Planning Commission, Government of India, 2011-12 is approved outlay

[3] ibid.

In case of NMT, which is envisaged to play critical role in the future as a link to public transit systems, as outlined in Delhi Master Plan -2021 it also needs critical attention. This would need expenditure in improving NMT infrastructure. It is also important that major infrastructure for NMT is provided at municipal level; however, a city level outlay dedicated to NMT is also required due to India's planning characteristics which follows top down models. Transport related expenditure of the government indicates a low level of expenditure made in the area of NMT. During 2002-07 (10th Five Year Plan) and 2007-12 (11th Five Year Plan), expenditure on roads and bridges dominated (table 4). Expenditure on roads and bridges includes outlay on construction of roads and construction of bridges. Expenditure on road transport includes expenditure incurred by the transport department primarily in strengthening the transport related institutions. Expenditure under the head of other forms of transport, expenditure on street lights, construction of infrastructure for NMT, foot-over bridges, etc. is included. During 2002-07, maximum expenditure was estimated on account of roads and bridges. A similar trend is noted in during 2007-12. To understand the actual position of NMT in these expenditures, it would be important to examine the agency wise expenditure.

In 2002-07, a large investment was envisaged by various departments. Transport department of the Government of Delhi estimated an outlay of US$ 506.7 million, of which 49 per cent was likely to be devoted for the mass rapid transit system. Total outlay was envisaged to be US$ 939.1 million of which 54 per cent was likely to be expended by the transport department. Local authorities that are supposed to facilitate transport infrastructure for non-motorized vehicles accounted for only 11 per cent of the total outlay approved (DDA, 2007). During 2002-07, major targets were the rapid bus transit system, road expansion and Metro Rail Transit System (MRTS). In this context, the approved expenditure for the different agencies was US$ 27.6 million for PWD (28.7 per cent of the total outlay), US$ 12.9 million for Municipal Corporation of Delhi (MCD) (13.6 per cent of the total outlay) and US$ 53.5 million to the transport department (57.1 per cent). The rest of the allocation was approved for New Delhi Municipal Corporation (NDMC) (Government of NCT of Delhi, 2013).[4] Expenditure on account of Public Works Department (PWD) was limited to projects like development of parking, Transport Nagar (an area exclusively dedicated to transporters with transport related facilities like parking, transporter's offices, repair and maintenance facilities, etc.), construction of road under bridges, etc. Limited expenditure was planned for strengthening of pedestrian and NMT infrastructure.[5] US$ 17,241 was approved for the period 2002-07 for this cause. This is about 0.02 per cent of the total outlay approved for transport sector.[6]

Similar trends are seen during the 2007-12. The approved outlay for the transport sector during the period was Rs. US$ 3,202 million of which US$ 1,341.3 billion was approved for transport department wherein major expenditure was approved for restructuring of the DTC. In addition, expenditure was approved for rapid transit corridors and development of the metro rail in Delhi. 0.06 per cent of the approved outlay under the transport department was meant for encouragement of pedestrian and NMT vehicles. PWD accounted for 47 per cent of the approved expenditure under the transport head during 2007-12. Of these approved outlays, major projects were related to the construction of bridges and development of roads. Such a small allocation for NMT in the planned expenditure suggests a slower pace of the development of NMT infrastructure from top in the State Government's allocation and which is negligible at the municipal level. While an increase in the planned expenditure on urban transit system and related infrastructure is essential for better and faster passenger mobility, it is also essential that adequate NMT infrastructure be developed to link these systems for reliable and safe mobility of passenger which is also economical to them.

3. STATE OF NMT INFRASTRUCTURE

In Delhi, the present state of NMT infrastructure needs a thorough investigation with respect to the proposed accessibility plan. Planning of transportation infrastructure is guided by this principle as outlined in Delhi Master Plan-2001. As envisaged, the transport requirement for the future would be designed with the goal to provide accessibility to social infrastructure that includes education, health, market and other facilities. As per the proposed accessibility plan, the people of Delhi should

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[4]Government of Delhi, Plan Documents, Available on
http://www.delhi.gov.in/wps/wcm/connect/DoIT_Planning/planning/plan+documents/scheme-wise+write-up+v1/transport
(Note: US$ 1= Rs. 58 as conversion factor)
[5] Ibid.
[6] Ibid. pp. 361

enjoy easy, safe and reliable access to major services relating to health and education located within walking distances (table 5). However, such facilities are usually located at distances demanding for the use of motorized transport. Therefore, an alternative is to make such facilities easily accessible by public transport to ensure having easy and safe access. This could be done through the provision of a reliable and safe urban transport that is adequately connected with NMT infrastructure at closer distances. These were two of the priorities of the Delhi Master Plan-2001.

In both the scenarios, revamping of the transport infrastructure and services would be required in Delhi due to the fact that development of NMT infrastructure is still to be taken up in the city as a mandate. Although, NMT serves for shorter distance travel, yet it has important role in providing last mile connectivity to major public transport in Delhi such as Metro and Buses and has the potential to improve the connectivity of passenger trips originating at the city level.

Table 5. Proposed Accessibility Plan

Proposed Accessibility Plan	Master Plan-2001	
	Distance Km	Approx Walking Time (minutes)
Crèche/Nursery School (Nearest)	0.3	5
Primary School	0.5-0.8	10
Higher Secondary School	1-1.5	20
Tot Lot	0.20-0.30	5
Park	0.5-0.8	10
Play Area	1	20
Bus Stop	0.5-0.8	10

Source: Delhi Master Plan, 2001

It is notable that the proposed plan for accessibility indicates that some of the social infrastructure would be planned within the reach of non-motorized transport like walking and cycling. Therefore, the phase of planning for transportation during 1990-2001 and after 2001 was required to be in this direction in addition to infrastructure relating to transit systems. This aspect is not reflected in the expenditure during the planned period after 2001. During this period, expenditure on the transport sector reflects that the lions share went to road infrastructure and bridges. A little was spent on other transport services and improvement of NMT infrastructure which was equally important for better accessibility to public transport running on these roads. For the development of an environmentally sustainable transport infrastructure a balanced expenditure would be required on both transit oriented transport facilities and also on NMT infrastructure to ensure the level of development of both are comparable and achieves the stated objectives.

At present, the presence of discontinued footpaths discourages pedestrian usage. It is found that major obstacles other than discontinued footpaths are "*potholes, open manholes, poor maintenance of paver blocks, trees, parked vehicles, street furniture like light poles, electric wires, and discontinuity due to driveways*" (Goel and Tiwari, 2014). No uniform design standards are also followed for footpaths resulting in the creation of obstacles for the disabled to use for travel. These problems for pedestrians are further escalated by the presence of long foot-over bridges. There is no uniform design standards followed for the construction of foot-over bridges in Delhi. This leads to the creation of unsafe and non-reliable walking for people including the elderly, children and the handicapped. This results in avoidable accidents most of the time.

An alternate way is to examine the trend of transport related assets assessed by the household survey. As per the census report of Delhi, 2011 a high proportion of households possess a cycle (non-motorized transport vehicle). On average 33.6 per cent of total households have a cycle in Delhi. Relative to this, private car ownership by the households surveyed was reported to be 19.56 per cent. Ownership of a two-wheeler was relatively high at 39.26 per cent. Table 6 presents this scenario in various districts of Delhi. In all the districts two-wheeler is dominating in households. However, in districts like East Delhi, New Delhi, North East Delhi, North West Delhi, West Delhi and

South West Delhi they have a high proportion of households possessing non-motorized transport vehicles.

When we compare the results of the household survey of 2011 with the survey of 2001, it is found that there is significant decrease in number of households having bicycles between 2001 and 2011. It simply outlines the fact that less has been done for the development of NMT infrastructure. At the Delhi level, 37.6 per cent of total households surveyed in 2001 had a bicycle which reduced to 30.6 per cent in 2011. Similarly, during these two periods, the number of household which are using two wheelers had increased. In 2001 28 per cent of the households that had two wheelers rose to 38.90 per cent in 2011. Such an increase is also experienced in case of cars from 13 per cent to 20.7 per cent between the two survey periods (Government of NCT of Delhi, 2015). This trend is alarming and needs to be tackled urgently. It may be construed that if public transport is not attractive in Delhi, the scenario after ten years would be worse. This trend is happening even in the situation when a large scale of expenditure is made in public transport and roads.

Table 6. Transport Related Assets Possessed by Households (in per cent)

District	Bicycle	Two-Wheeler	Four-Wheeler
Central	15.76	31.89	20.31
East	28.17	45.32	26.78
New Delhi	37.25	32.96	24.86
North	25.18	34.13	15.07
North East	35.06	40.09	10.78
North West	37.08	38.24	16.77
South	28.88	36.61	23.65
South West	41.94	42.98	18.69
West	31.09	41.78	24.91

Source: Census, 2011

As we have already noted that cars and two-wheelers together carry a major portion of daily passenger trips. Walking and cycling even for shorter distances remain negligible. This scenario is a result of the lack of availability of infrastructure for NMT in these districts. Non-availability of NMT infrastructure has two fundamental consequences. Firstly, the city is not able to utilize the available potential of cycling which has characteristics of sustainability and if adequately linked with public transport systems then it also possess the potential characteristics of inclusivity. The second consequence is limited growth in the potential of NMT as well. In fact, it has experienced negative growth between the household census of 2001 and 2011. Limited data is available on mobility patterns in Delhi. This is an important area for further investigation in how mobility pattern are affected by the changing composition of transport related assets.

The majority of populations in Delhi are dependent on motorized transport for their daily commute. It has been estimated that about 4.5 million daily passenger trips was originated by bicycles in 2006 in which 74.7 per cent was the trips for below 5 km of distances (Arora, 2011). In another study, major cyclists are found to be factory workers accounting for 21 per cent of cyclists. Furthermore, travel distances were up to 10 km for cyclists (Tiwari and Jain, 2008). However, NMT infrastructure for factory workers is severely neglected. The reason behind this neglect is the spatial characteristics of industrial and residential locations of industrial workers. Industrial areas are located along main highways; the residential areas are located in slums (Arora, 2011). This is one of the reasons that the average travel distance of factory workers are too high, up to 10 km daily. In addition to the long travel, cyclists used to travel on major arterial routes on which speeds are usually high. Moreover, poor management of corridor traffic flow and traffic systems do not provide smooth passages to pedestrian and cyclists wherein all road users share same carriageway. These result in fatalities due to accidents on roads (Tiwari, 1999). In addition to this problem, most of the time, the carriageway is also shared by street vendors. A clear separation of pedestrian ways from motorized urban roads would be essential in order to accommodate street vendors at a stretch other than urban roads. Some step was undertaken earlier in this direction but failed to achieve major breakthrough. Bicycle Master Plan (BMP) was developed for Delhi with the objective to develop a network of cycle corridors. However, the progress in this direction remains negligible. An attempt was made to develop a separate cycle track along the Bus Rapid Transit Corridor in 2008.

4. STATE OF PUBLIC TRANSPORT INFRASTRUCTURE

Public transport has two major components viz. bus transport and metro rail. These two major transport systems are playing a vital role in facilitating public transport in Delhi. In fact, both the systems are the lifeline of the people of Delhi. At present, the average ridership of Delhi metro is reported to be 2.4 million per day (Government of Delhi, 2015, pp. 174). Ridership on Metro Rail is further expected to increase up to 4.0 million per day after completion of the final stage of construction of DMRC. On average, daily ridership on DTC is 3.8 million passengers (Government of Delhi, 2015, pp. 181). RITES (2010) points out that there is a need to integrate the two major public transportation systems in the capital.

Table 7. State of Transport Facilities in Delhi

Items	Units	2000	2005	2006	2007	2008	2009	2010	2011
General roads investment	Mil $/year	102.4	115.9	170.2	235.6	327.6	448.5	591.4	427.1
Road network length (Total length)	Km	28508	31183	30923	30985	31199	31229	31183	31969
MCD Road Network	Km	24885	27139	27139	27139	27139	27139	27139	26459
Bus Rapid Transit route length	Km					5.8	5.8	14.5	14.5
Buses	No.	1932	3469	3444	3537	3809	4726	6204	5884
Non-AC Buses	No.	1932	3469	3444	3537	3284	3726	4954	4609
AC Buses	No.	-	-	-	-	525	1000	1250	1275
Release of fund Delhi Metro (end of march)	Mil $/year			69.8	63.1	117.5	153.0	144.8	219.4
Share of equity in Metro funds (per cent)				85.8	84.1	67.0	82.4	98.2	
Cumulative Length of Delhi Metro	Km	0	-	33	65	68	75	156	162

Source: Government of Delhi, Planned expenditure on road transport and roads, ASRTU Statistical Abstracts and Economic Survey of Delhi, Various Issues
bridges (Rs. 58 = US$ 1)

Table 7 presents that general expenditure on roads increased by more than four-fold during 2000-11. Road networks have increased both in case of total road networks and roads managed by municipal corporations in Delhi. A gradual improvement in the capacity of city buses may also be seen which has now more than 5,000 buses plying the roads in Delhi. In case of Delhi Metro, rapid expansion is noted in terms of its length and final phase of the construction of metro rail network is underway.

The presence of public transport infrastructure is quite encouraging in Delhi. However, the basic flaw is the disintegration in the management of public transport systems. Both Delhi Metro and Delhi Bus services are not integrated with each other at the physical and operational levels. For successful public transport in Delhi, there is an urgent need for vertical and horizontal integration of these two transport systems. A recent survey of passengers using Delhi Metro indicates that major portion of the user walk from home (Goel and Tiwari, 2014). When asked about mode of choice after reaching destinations, a higher number of users replied that they were using non-motorized transport (in this case walking). Limited number of users of Metro use cycling for the last mile connectivity. On the other hand, bus and auto constitute more that 30 per cent of the users of metro for last mile connectivity.[7]

There are two major conclusions that can be construed from this outcome of the survey. The first and foremost is the provision of adequate walking and NMT infrastructure for the users of metro

[7] *Ibid.*

rail in Delhi and the second one is integration of bus transport with metro for the users of bus and auto.

There exist several models for integrated multimodal transportation in case of urban mobility. For example, operational integration in terms of a single ticketing system for more than two modes is in operation in cities like Adelaide, Auckland, Singapore and Greater Stockholm. In case of physical integration, a suitable example for Delhi is Singapore. However, it is argued that prior to the operational integration, it would be better to create a physical infrastructure in order to achieve the motive of physical integration between two modes of transport. At present, physical integration between metro and buses merely exist in improper ways. Operational characteristics of bus rapid transit systems other than the physical infrastructure indicate that operational integration between metro and buses may be persuaded prior to the creation of infrastructure for physical integration.

5. PROVISION OF TRANSPORT RELATED SERVICES

Provision of transport infrastructure defines the quality of transport services as well. Non-integrated public transport systems provide space for other players in providing transport related services to users. Major service-providers other than bus and metro rail are auto rickshaw, electric vehicles, mini bus operators and private cab operators. These operators provide both last mile connectivity as well as door to door transport. These players work as both feeders to public transport and also as alternate to the same. Cabs and auto rickshaws play a major role as alternative means of transport. In the case of operators like mini buses and shared auto rickshaws, service standards are not defined and are not being governed by any mobility standards. Presence of such operators in the domain of public transport makes public transport uncomfortable for travel. In addition, a new player is added in this category i.e. electric rickshaw (popularly known as E-Rickshaw) which also needs to be regulated with proper service and operational standards.

Service quality has a critical role in attracting users of private and personalized vehicles and other modes for intra-city travel on public transport. Services include proper schedules, good bus stations, bus stops friendly to users even in the case of disabled users, safety measures for women, reducing congestion on roads by eco driving measures and easy ticketing services, etc.

DTC which manages bus transport in Delhi publishes its time table for various bus routes on its website. These information need to be published on bus stations providing information for bus services to the specific routes at which the station is situated. This may further be augmented to time to time audit of buses for its schedule adherence. Alternatively, geographical information systems may also be developed using intelligent transport system for timely and reliable bus transport in Delhi. Some progress has been made and GPS enabled tracking system is now used in DTC buses. Operational services of public buses in Delhi require a major overhaul in its transport management. DTC is still running a loss and does not have the resources for augmentation in such services. In its budget for the year 2015-16, the Government of Delhi proposed about 20 per cent of the total outlay to the transport sector. This allocation is the second largest allocation after allocation of 24 per cent of total outlay in education. Major priority areas for upgrading the public transport are to improve service quality including high priority for women’s safety and adding more buses to DTC.

6. THE WAY AHEAD

In order to make reliable, safe, environmentally sustainable and economical transport system, Delhi as a capital city needs a policy directions towards developing NMT infrastructure as a support to the existing public transport systems and integration of operation between bus transport and metro rail.

In case of NMT, there is a need for planned expenditure in this direction. NMT infrastructure is required to be viewed not only as a support infrastructure for urban transit but also as a separate and alternate mode for travel for shorter distances. It would mostly be managed and developed by municipalities in Delhi which would require funding from State and Central Governments as well. It is recommended that the governments could set up an institution for developing NMT infrastructure which needs to be funded by both central and state governments.

Addressing the issue of public transport, it was noted that metro rail is carrying 2.4 million passengers daily. Similarly, 3.8 million passengers are daily travellers of DTC buses. A survey report suggests that only 11.2 per cent of bus users ride the metro. A clear indication is the operational and physical integration of the two institutions. The two corporations, DMRC and DTC would require working in this direction. It would be useful for establishing a special purpose vehicle in order to perform integrated operation of metro and bus services with larger equity participation from Metro Rail. This may be taken up after completion of the third phase of the construction of metro rail in Delhi which is likely to be completed in December, 2016.

Finally, it is important to define the service standards of other transport providers such as shared auto and mini buses. Proper infrastructure facilities are also required for such operators. These operators play a vital role in facilitating linkages to the nearest transit oriented public transport such as metro and urban bus services under DTC. More recently, electric rickshaw has also been introduced in Delhi to provide services for last mile connectivity. Such facilities are also required regulation and infrastructure support which needs to be taken up in policies and planning related to transport in Delhi.

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TOWARDS AN INCLUSIVE PUBLIC TRANSPORT SYSTEM IN PAKISTAN[1]

Muhammad Adeel, Anthony G.O Yeh and Zhang Feng[2]

Abstract

Urban transport in Pakistan is characterized by the coexistence of formal and informal transit services. While urban transport is deregulated and - somehow – multimodal in the country, the transport service providers often compete with each other within their particular constrains and their equilibrium defines the overall landscape of urban accessibility. With examples from the cities of Islamabad and Rawalpindi, the paper discusses three broad constraints on the urban modes of transportation, namely regulatory, spatial and demand related constraints, using a number of important system characteristics. Results show that the overall level of constraints remains 'Very High' on the newly constructed BRT, followed by 'High' constraints on the informal paratransit mode, 'Qinqui'. Whereas the Suzuki and Wagon modes coverage remains maximum and they carry relatively lower level of constraints. In this context, an inclusive urban mobility largely depends on a proactive approach by management authorities to minimize these constraints through a number of initiatives including integration of modes, improvements of the quality of service and condition of vehicle, and by facilitating the mobility of women and non-motorized travellers.

Keywords: *Transport, accessibility, Pakistan, BRT, Qingqi*

1. BACKGROUND

Population explosion and rapid urbanization in Asian countries have brought complex mobility challenges for a vast majority of their people who also face issues of poverty, inequality and limited access to basic services (Gakenheimer, 1999). While the average distances between activities are increasing with time, so are the issues of mobility and accessibility. Lack of access to public transport, poor quality of transportation infrastructure, rising levels of personal automobile ownership and a persistent disregard of traffic regulations pose further issues to the already challenging mobility environment (Dimitriou and Gakenheimer, 2011). These issues affect the majority of Asian population, including poor, unemployed, young, elderly and most of the women. In this context, provision of an inclusive transport system has been a top priority of the national as well as local governmental and non-governmental organizations. Often the aim is to provide an inclusive public transport system that moves the masses at a financially affordable, socially acceptable and environmentally sustainable manner and also helps increasing local economic growth in the area. However, the on-ground public transport system regularly fails to provide the minimum acceptable level of mobility that suits the sociocultural and financial needs of its users (Vasconcellos, 2014).

With the example from the cities of Islamabad and Rawalpindi, this paper elaborates three broad constraints on the urban public transport system in Pakistan, namely regulatory, spatial and demand related constraints, which have consequential effects on the landscape of accessibility and inclusiveness of the transportation system in the country. The next two sections provide a background of public transport system and sociocultural context of mobility in the country. Section 4 and 5 explains the salient characteristics of public transportation in the case study cities and the data and methods. Section 6 defines and examines the salient characteristics of the three constraints on public transport system. Lastly, section 7 concludes with some recommendations for addressing these constraints and the way forward towards an inclusive urban transport environment in the country.

2. PUBLIC TRANSPORT SYSTEM IN PAKISTAN

Nearly half of the Pakistan's total 190 million population resides in urban areas, which makes it the most urbanized country in Asia Pacific (Planning Commission, 2014). Around two thirds of its

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[1] A part of this paper, related to public transport accessibility, was presented in the International Conference on Town Planning and Urban Management 2014 (ICTPUM14), held in Engineering University Lahore, Pakistan during 29-30 September 2014.

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urban population is concentrated in 10 large cities. Continuous changes in the organizational and functional characteristics of urban areas are making them a tougher place to live and survive. The traditional high density, walkable and prosperous urban localities are becoming overcrowded, deficient in local service provision with rising levels of urban poverty. A lower average income means that only the well-off Pakistanis can afford private cars at home. As a result, and nearly half of the work or job related trips depend on the fragile public transport system of the country (Adeel et al., 2014a).

Public transport system in Pakistan was deregulated in early 1980s. Since then, private operators provide the urban transport services and the government plays a role in fare control and route licensing. These individual transport operators prefer low cost, small size transport vehicles in order to maximize the profits. Transport authorities consistently fail to supervise the quality and efficiency of the public transport system due to lack of institutional capacity to supervise these solo transport operators (Imran, 2010).

3. SOCIOCULTURAL CONTEXT OF MOBILITY IN PAKISTAN

Mobility is largely a gender phenomenon in the country. Women are considered private and family honor. This particular sociocultural context makes female mobility through public transport a sensitive subject as it may affect their privacy and personal safety. As a result, women become less mobile, travel mostly for important purposes and that also after permission from the family head, after veiling their bodies or with escort from a male family member.

In this context, women and their families prefer a transport facility that is highly accessible, comfortable and more importantly which helps preserving their honour and privacy. Lack of access to personal automobiles means that majority of population, including women, largely depend on the existing public transportation system for their daily mobility. However, the transport system in its current form, rarely suits their mobility needs as it fails to provide door to door accessibility, comfortable and female-reserved seating, privacy from male travellers and a hassle free travel. Walking access to public transport remains the most important and defining aspect of urban public transportation system in the country. Studies have shown that the lack of access to transportation system and a suitable mobility environment significantly decrease female access to basic services such as healthcare and education (NIPS, 2008).

Other than women, lack of access to transportation system greatly affects the lives of vulnerable population including the student, unemployed, disabled, elderly and the young. All these disadvantaged social groups, when combined, form a majority of country’s overall population and only a handful of population comes out to be non-disadvantaged for their daily accessibility and mobility in Pakistani society.

4. DESCRIPTION OF THE STUDY AREA

Cities of Rawalpindi and Islamabad forms the third largest metropolitan in Pakistan, called Rawalpindi Islamabad Metropolitan Area (RIMA). It houses approximately 1.8 million populations on 278 km^2 land (NTRC, 2006, RDA, 2013).

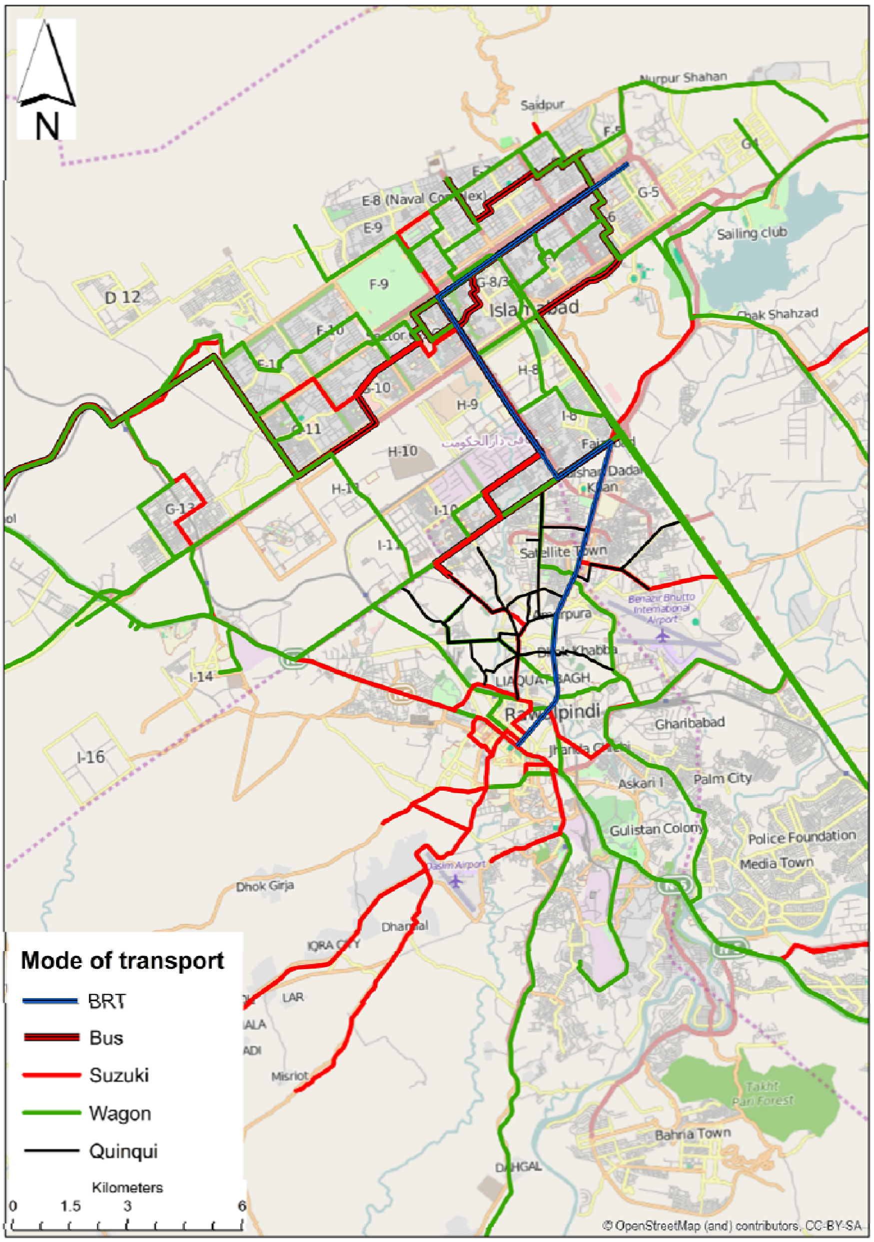
According to recent estimates by the authors, the city of Rawalpindi houses 61 per cent of RIMA’s total population at just 9 per cent area, with estimated density of 6600 persons/km^2 (Adeel et al., 2014b). The city of Rawalpindi is a typical example of mix use, high-density Asian cities. Existing facilities and services in the city remain inadequate and overused (Government of Punjab, 2008). It seems that accessibility to goods and services is further deteriorating with its continuous densification and outward spatial expansion. The city also exhibits an above average unemployment rate as compared to its Punjab province (4.0 vs. 5.5, see Government of Punjab (2008)). Similarly, about half of its population can be categorized as urban poor (Asian Development Bank, 2005). As a result, majority of Rawalpindi’s residents find it hard to pay for their daily mobility needs (NTRC, 2006).

Built in the early 1960s, Islamabad is the only master planned city in the country and the seat of the Federal government. The city houses 39 per cent of the RIMA population at 91 per cent area with estimated densities of approximately 2800 persons/km^2 (Adeel et al., 2014b). Approximately one third of Islamabad’s population resides in squatter settlements (CDA, 2013). As a whole, issues of affordability and accessibility put at least 40 per cent of the capital's residents in various transport related disadvantages (Adeel et al. 2014b).

Public transport is controlled and regulated by two different government entities in RIMA. District Regional Transport Authority - Rawalpindi (RTA) is responsible for managing the public transport affairs in Rawalpindi while Islamabad Transport Authority (ITA) does the same work for Islamabad.

RIMA is often seen as one urban agglomeration, especially for the provision of the public transport system. Approximately, 70,000 workers and students commute daily between the twin cities over a distance of 30 km long job-housing axis along Murree road and Islamabad highway (CDA, 2012). Many of the current transport routes in RIMA have been approved by any of these two authorities however they provide service to both cities e.g. Wagon route no 1, approved by RTA, originates from Saddar Rawalpindi and ends in Pakistan Secretariat stop in Islamabad.

Figure 1. Public transport network in the Rawalpindi Islamabad Metropolitan Area



The public transport system in the study area comprises of both formal (authorized) and an informal modes of transportation. Formal public transport modes are: 12 seater Suzuki (similar to Jeepnys in Manila), 20 seater Wagon (Similar to Matatus in Nairobi, Kenya) and 30-40 seater Buses or Minibuses (Figure 2). Recently the government has initiated a new Bus Rapid Transit (BRT) network along Rawalpindi's Murre road and Islamabad's 9th Aveneue and central business district (Blue Area). The BRT network is approximately 23 km long and has a bus station at every one-kilometre road length. Qingqi rickshaw is the informal or unauthorized public transport service in the study area.

Figure 2. Public transport modes in the study area (not to scale)

Up to 95 per cent of RIMA's current public transport fleet is made of Suzuki and Wagon modes that are run by individual operators. People cannot stand inside both transport modes and they are particularly less suitable for women, children, disabled and elderly (Scandiaconsult and Contrans AB, 1995).

5. DATA AND METHODS

The paper is based on the primary and secondary data related to public transport network and the management of public transport operations in the study area. The primary data on public transport route network was collected through GPS based field surveys in December 2013. The field data was overlaid on the online street map freely available through ESRI's ArcGIS for GIS based buffer analysis. As there was no updated public transport network map of the study area, the data and its results provide a wealth of information on public transport accessibility in the study area.

For examining and commenting on the public transport governance and its specific constraints in the study area, we have largely relied on the most recent available official communication, updates and reports by the ITA and RTA. This data was collected by the first author through a number of visits to these organizations. Discussion with the office staff and personal experience as a resident of the area was also useful in organizing and elaborating the information presented in this paper.

6. THREE CONSTRAINTS ON PUBLIC TRANSPORT SYSTEM IN THE STUDY AREA

6.1. Regulatory Constraints

RIMA's transport route network was delineated in the early 1980s, potentially without any scientific analysis, and even today retains its original alignment. Lack of revision in transport network has created pockets of underserved residential areas in the city. Newly constructed suburban neighbourhoods also face a shortage of transport due to lack of new transport routes. Other than this, up to 40 per cent of public transport routes are inactive because transporters do not see financial incentive in these routes (Adeel et al., 2014b).

Two different authorities, RTA and ITA, manage RIMA's transport system. Due to lack of coordination between them, there are no uniform standards of route approval or enforcement in the area. Regulatory constraints on public transport are usually stricter in Islamabad and in commercial or institutional areas than in Rawalpindi or in residential areas. As a result, residential areas are more likely to suffer from oversupply or undersupply of public transport. The lack of coordination between authorities results in poor enforcement of service standards. If the transport authority in one city tries to enforce stricter regulations, such as setting a maximum permissible age of transport vehicle, their operators get registered with the authority in other city and still keep serving the metropolitan area without following the stricter service standards. Transport fares are not regularly updated with the change in fuel prices. This often becomes a source of contention between government, transporters and the passengers. Lack of enforcement in Rawalpindi often results in frequent overcharging by transport operators and complains about non-availability of service during off peak hours. Passengers also complain that transporters often refuse to complete their route and sell their passengers to other vehicles for their convenience.

Figure 3: Newly constructed overhead bridge for Bus Rapid Transit network in Rawalpindi

The operators of Bus, Suzuki and Wagon vehicles need a route permit for running their service. Their route permit requires them to operate along authorized transport routes only. However, Qingqi service, being the unrecognized transport mode, is operated without any permit. Authorities tend to prohibit Qingqi from serving along the existing transport route network. As a result, their network exists in the service gap areas that were previously operated by the defunct horse driven *'Tonga'* service. As they are not allowed to operate in Islamabad, the service gap areas in the capital city remain unnerved due to the regulatory constraints. However, our spatial analysis indicates that Qingqi covers more than 90 per cent of population in Rawalpindi. Although this paratransit service remains an important part of urban mobility, it has got the least priority in the urban transport system of study area due to regulatory issues with this mode.

Table 1. Regulatory constraints on public transport system in the cities of Rawalpindi and Islamabad, Pakistan

Transport modes	Bus / minibus	Suzuki / wagon	BRT	Qingqi
Status	Legal	Legal	Legal	Unauthorized
Role of government	Regulator	Regulator	Promotional	Prohibitive
Route structure	Fixed	Fixed	Fixed	Flexible
Working in both cities	Yes	Yes	Yes	No - banned in Islamabad
Priority in public transport system	Normal	Normal	High	Least
Fare subsidy	Yes	No	No	No
Overall – regulatory constraints	***Low***	***Low***	***Very low***	***High***

The limited network of BRT has obtained highest priority in RIMA's public transport system evident from the newly constructed bus bays, exclusive bus-only roads and overhead bridges. As a whole, it seems that the regulatory constraints remain very low in BRT (due to extensive support by the government), low in case of bus, Suzuki and wagon (as they provide most of the transportation services in the area), and high for Qingqi (due to strong opposition by government and transport operators).

6.2. Spatial Constraints

Overall, it can be observed that each mode of transport carries its specific spatial constraints due to its size, seating capacity, ease of operation and the area of service. Buses and BRT service exhibit the highest level of spatial constraints, followed by Suzuki/ Wagon network while the paratransit service of Qingqi is the least, yet significantly, affected by these constraints (Table 2).

Table 2. Spatial constraints on public transport system in the cities of Rawalpindi and Islamabad

Transport modes	Bus / minibus	Suzuki / wagon	BRT	Qingqi
Share of population covered	Minimum	Highest	Medium	Restricted due to legal issues
Service locations	Suburban	Main city roads	Main corridors	Inner city; service gap areas
Movability in congestion	Least	Lower	Highest	Higher
Overall - spatial constraints	***High***	***Low***	***High***	***High***

Table 3 below presents the result of spatial analysis that estimates the share of population within given walking distance buffer. At the metropolitan level, public transport accessibility remains quite low and nearly three quarters residents live beyond convenient walking distance from public transport network. Estimates show that, around 41, 61 and 81 per cent population can access any mode of transportation within 5, 10 and 20 minute walk from their residence, respectively. Wide differences exist at modal level and buses provide the minimum level of coverage in the studied area. Buses and Suzuki cover only 45 per cent, within 20 minutes' walk, each while the newly constructed BRT covers just 22 per cent of metropolitan residents. On the other hand, wagons cover much greater share of 80 per cent population within this threshold distance. As a large share of urban residents remains un-served, the lack of accessibility to public transport increases the demand for intermediate mode of transportation. However, the paratransit service of Qingqi, which runs in the service gap area, covers only 13 per cent of the metropolitan population highlighting an unfulfilled demand for public transport in the area.

Wagons cover the largest share of the metropolitan population and nearly one third of the population resides within 400 meters while 54 per cent could reach them within 10 minute walk. Still 22 per cent residents cannot find wagons within 20 minutes walking distance from home. Suzuki service is available to only 10 and 20 per cent residents within 5 and 10 minutes' walk from home, respectively. Around 61 per cent population of the capital city cannot access it within 20 minutes walking distance. Surprisingly, the proposed BRT network covers only a handful of city's population. Only 8 per cent population of Islamabad resides within 10 minutes' walk from the BRT while around 83 per cent of city's population resides more than 20 minutes' walk form BRT network.

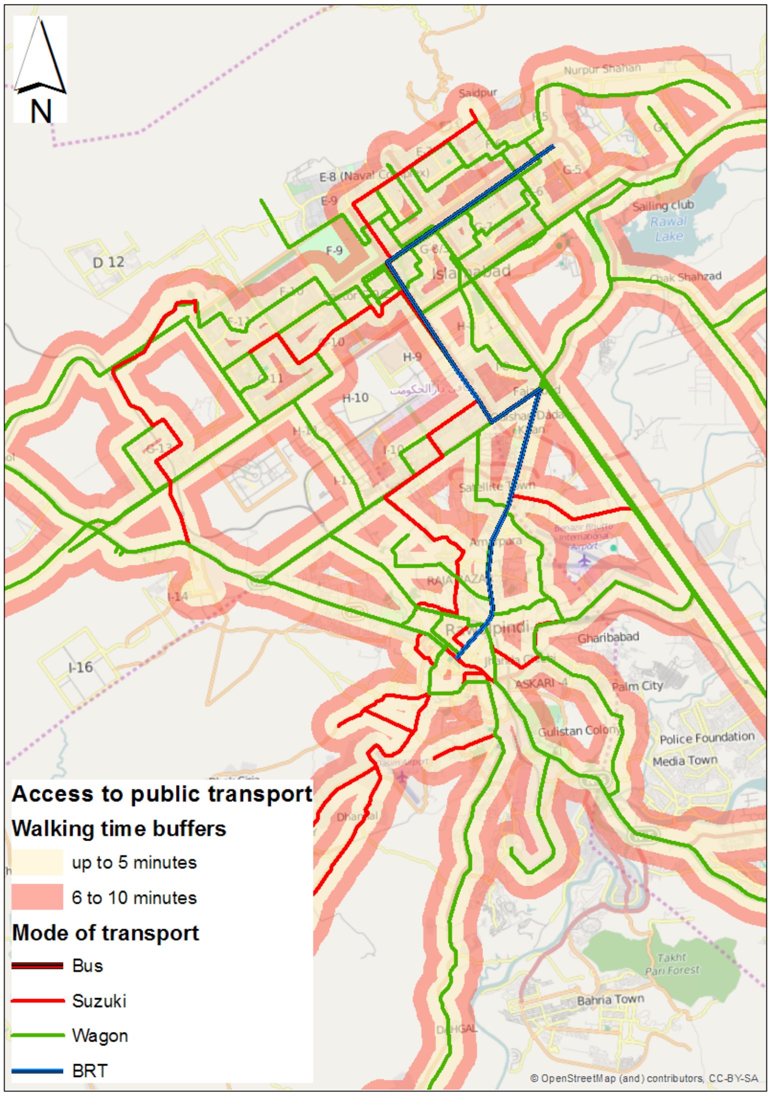
Table 3. Public transport accessibility in the cities of Rawalpindi and Islamabad

City	Transport Mode	< 5 minute	10 minute	15 minute	20 minute	> 20	All
Islamabad	1. Bus, Minibus	16	28	37	45	54	100
	2. Wagon	34	54	68	78	22	100
	3. Suzuki	10	20	30	39	61	100
	4. Qingqi	0	1	2	3	96	100
	5. BRT	3	8	12	16	83	100
	Any of 1-3 modes	***38***	***57***	***70***	***79***	***21***	***100***
Rawalpindi	1. Bus, Minibus	10	21	33	43	56	100
	2. Wagon	57	88	98	100	0	100
	3. Suzuki	38	66	88	99	2	100
	4. Qingqi	63	85	93	97	3	100
	5. BRT	15	38	56	71	28	100
	Any of 1-3 modes	***70***	***96***	***99***	***99***	***0***	***100***
RIMA (both cities)	1. Bus, Minibus	15	27	37	45	55	100
	2. Wagon	36	57	71	80	20	100
	3. Suzuki	13	25	36	45	55	100
	4. Qingqi	6	9	11	13	87	100
	5. BRT	4	11	17	22	78	100
	Any of 1-3 modes	***41***	***61***	***73***	***81***	***19***	***100***

Note: 5 minutes walk = 400 meter, 10 minutes walk = 800 meter and so on
Source: GIS buffer analysis on the primary data collected by the first author

When the results are disaggregated at city level, we see that the coverage of public transport coverage is significantly better in Rawalpindi than that of Islamabad. Nearly all of Rawalpindi's residents could find any mode of authorized public transport within 15 minutes walking distance as compared to only 70 per cent residents from Islamabad. While the BRT network is accessible to only a handful of population within convenient walking distances in both cities, it serves nearly 56 per cent of Rawalpindi residents within 15 minutes' walk as compared to only 12 per cent Islamabad residents.

Figure 4. Portion of RIMA within and outside 10 minutes walking buffers from public transport network



Source: Primary data collected by the first author

Wagon and Suzuki compete with each other for maximum coverage in Rawalpindi. However, wagon clearly serves greater population in Islamabad. This is probably linked with the fact that the Islamabad's transport authority, ITA, prefers wagons due to their better quality of service and physical outlook. However, in Rawalpindi, Suzuki becomes the preferred choice for suburban transport routes due to its lower seating capacity and relatively smaller size.

6.3. Demand constraints

The concept of demand constraints points out to the extent to which a particular mode of transportation is desirable from user perspective. Buses and minibuses are often used by employed and student travellers, who commute to the institutions located in the administrative neighbourhoods of the metropolitan. However, these modes of transport run at a relatively lower average speed due to traffic congestion. As compared to Suzuki and wagon service, buses are more gender friendly due to more comfortable seating and ability to accommodate standing travellers. Initial investment is high and so a majority of buses are very old. There is relatively fewer number of buses on road which means that they have a lower service frequency and poor availability in off peak hours. Overall, demand constraints for buses remain high.

Suzuki and wagon modes generally serve the residential neighbourhoods and commercial areas of the metropolitan. They are mostly used by the low-income population who travel to work in the central business district or reside in the inner city or suburban areas. These vehicles can be very old, poorly maintained, with congested seating and their operators often exhibiting risky driving behaviour in the picking of passengers, often pushing them forcefully in and out of the vehicle. During low ridership periods, they may refuse to complete the route and sell their passenger to the other vehicles. Despite their poor service, due to their extensive coverage they somehow have a monopoly in this passenger market.

BRT service is specifically designed to quickly transport intuitional workers and students along the main commuting axis of the metropolitan area. Its serves a special corridor with an exclusive bus way and bus stops. A better operation management means better service frequency, less accident risk and a courteous attitude towards women travellers. The expansive construction of network means that the government heavily subsidizes its fare and it might not cover the project costs in the near future. As a result of limited network coverage and numerous financial and operational issues, demand related constraints on this system remain ‘High’.

Table 4. Demand constraints on public transport system in the cities of Rawalpindi and Islamabad

Transport modes	Bus / minibus	Suzuki / wagon	BRT	Qingqi
Mostly used for	Work	Social and Work	Work and education	Social, educational, connecting trips
Travel speed	Medium	High	High	Low
Service frequency	Lower	High	High	Medium
Off peak hours availability	Extremely poor	Poor	Good	Poor
Initial investment	High	Medium	Highest	Minimum
Attitude towards women travelers	Somehow facilitating	Rigid and prohibitive	Facilitating	Facilitating
Route completion complaints	Yes	Yes	No	No
Risk of accidents	High	Higher	Least	Highest
Age of vehicle	Very old	Old	New	New
Overall - Demand related constraints	**Medium**	**Low**	**High**	**High**
Total level of constraints	**Medium**	**Low**	**Very high**	**High**

Qingqi service is used by both, the students and employed population alike, due to is strategic positioning in the service gap areas. They travel at lower speeds but are more risky due to poor vehicle design and often a lesser skilled driver. Qingqi operators are often more supportive to its travellers and generally do not refuse female travellers and ensure that they do not get touched by the male passengers. Due to their legal status and quality issues, demand constraints remain 'High'.

7. RECOMMENDATION FOR AN INCLUSIVE PUBLIC TRANSPORT SYSTEM

The previous section highlighted the nature and extent of regulatory, spatial and demand constraints on each of the transport modes in the study area. These constraints not only affect the functioning of a transport system, they create the overall landscape of accessibility and ease of mobility for their service population. As discussed at the start of this paper, an inclusive public transport system would enable the mobility of masses at a financially affordable, socially acceptable and environmentally sustainable manner. Other than providing an adequate mobility option and stemming the growth of private vehicles in the metropolitan area, an inclusive transport system would also facilitate local economic growth by facilitating the employment opportunities in the surrounding area.

Keeping in view the existing land use growth patterns as well as spatial, regulatory and demand related constraints on the urban transportation, this article recommends the following improvements for realizing a realizing an inclusive public transport system:

- **Enhancing public transport accessibility**

Existing transport route network is almost three decades old. City size and population has doubled over this period and is expected to further grow in future. Widening of road network and construction of new residential areas mean new transport nodes have developed over time. There is a need to re-examine the route network with a greater focus on bus based transportation system. Designing an integrated transport system with feeder routes is the answer to limit the growth of paratransit service and provide accessible public transport service to all the urban residents at convenient walking distance. Lack of availability of public transport has contributed to the growth of private vehicles in the cities of Rawalpindi and Islamabad. Strict enforcement of service levels in residential areas is required to provide an inclusive public transport system.

- **Improving affordability and quality of the service**

It is contended that the exiting public transport network need not be overlooked for improvement as it is still serves as the main mobility system in the area and provides livelihoods to thousands of individual operators. The existing transport service badly needs measures for improving affordability and quality of service. Provision of subsidized public transport for the unemployed, students and elderly is desirable as is an introduction of express bus routes that serve fewer stops, and a reduction in the maximum limit of passengers per vehicle. Again, as it will involve a trade-off with cost of travel, it is recommended to use multiple fare structure depending on the type and quality of service offered by the transport mode. Public transport should be made affordable for the urban poor by various means such as free service and concessionary fares, where applicable. Special considerations need to be given for safe and affordable mobility of students and women along with improvement in the behaviour of transporters. Student or female only busses can be a good option to start with.

- **Innovative use of ITS in traditional public transport**

Innovative use of ITS can go a long way in improving the quality of public transport system in the area, electronic fare collection and integration, bus schedule, ticketing and a feedback system are some of the important improvements needed in the existing system.

- **Gradual improvement in the of BRT**

An accessibility analysis of the BRT network presented in this study highlights that it serves only a minority of the urban population. Even within its coverage area, concerns remain over its suitability for the young, elderly and women because the passengers would need to walk up stairs to reach the overhead bus bays. Furthermore, BRT further needs to cover the previously un-served residential neighbourhoods particularly in Islamabad, and the gated communities

- **Integration of paratransit system**

Regularization and improvement of the organic Qingqi service can also facilitate mobility and accessibility in certain disadvantaged areas with reduced public transport coverage. While Qingqi is working without any binding service standards, they carry a considerable risk of safety during their journeys. If properly regulated, they can serve in the areas of low ridership as the feeder network for the main public transport system.

- **Active role of transport and planning agencies**

Lastly, urban management and planning has an important role to play in ensuring convenient access to activities in urban areas. The existing built environment and public transport service does not match with the needs of women, low income and those without a personal automobile, let alone the people facing physical mobility challenges. It seems that the current trend in urban planning has turned middle-income groups into a car-based society. Lack of coordination between suburban gated communities, transport providers and the development authorities has further forced people to turn towards personal automobiles. Appropriate connectivity between locations through walkways, traffic calming measures in residential areas and 'demand responsive' land use management can go a long way in reducing the automobile dependency of women, income less and elderly population. What remains to be seen is whether the urban and transportation officials have the will to do it and whether political decision makers would encourage management rather than construction practices.

Local transport and urban planning agencies need to promote public transport and non-motorized transportation through hard and soft measures. Hard measures include physical planning and facilitation of user-friendly mass transport system whereas soft measures include public awareness complains on the roads as well as in the electronic and print media.

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THE INSTITUTIONAL ENVIRONMENT FOR SUSTAINABLE TRANSPORT DEVELOPMENT

A.S.M. Abdul Quium[1]

Abstract

Many issues in sustainable transport development as well as their possible resolutions have a cross-sectoral dimension. Generally, multiple ministries, government departments and agencies at different levels of government are involved in transport development. Policies and plans across the sectors need to be consistent, and actions at all levels of government need to be coordinated to have the desired results. Furthermore, given that transport demand is a derived demand, complementary interventions in related sectors may be required in order to make transport development more inclusive and to realize its full potential to support the development process. These tasks can be rather challenging for various reasons, especially owing to deficiencies in the institutional environment comprising laws, regulations, rules, and governance institutions outlining how organizations function and conduct dealing with other organizations and stakeholders. Considering the importance of the institutional environment to sustainable transport development, this article focuses on institutional issues that need deliberation by elected officials, policy makers, experts and other stakeholders to find solutions, as needed. Otherwise, they may stand as barriers seriously limiting the progress on sustainable transport development.

Introduction to Sustainable Transport Development and Institutional Environment

The Brundtland Commission report, published in 1987, brought global attention to the concept of sustainable development. The report formalized the concept. Subsequently, the World Commission on Environment and Development adopted the concept of sustainable development at the first Rio Summit in 1992 and introduced sustainability into public discourse.[2]

During the 1990s, the concept was extended beyond the original environmental concerns. Three dimensions of sustainable development namely, environmental, economic and social are now generally recognized. The concept gained further prominence at the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002. At the Johannesburg Summit, governments agreed to support, among other things, an integrated approach to policymaking at all levels for transport services and systems to promote sustainable development in the sector.[3]

The Rio+20 Summit in 2012 renewed global commitment to sustainable development. The Rio+20 Outcome Document noted that transport and mobility were central to sustainable development. The Outcome Document recognized the importance of efficient movement of people and goods, and access to environmentally sound, safe and affordable transportation as a means to improve social equity, health, resilience of cities, urban-rural linkages and productivity of rural areas. (Paragraph 132)[4]

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[1] The author is a former staff member of the ESCAP secretariat. This article is based primarily on information from an unpublished report entitled "Sustainable Transport – Integrated planning, policy formulation and coordination" prepared for the Transport Division of UNESCAP by the author in 2014. Some new materials have been added, however. The findings, views and opinions expressed and arguments employed in the article are that of the author, and do not necessarily reflect the official views of the ESCAP secretariat or of the member States of ESCAP.

[2] The concept of sustainability is however much older. The concept broke into mainstream development discourse in the 1980s. The use of the term in the transport sector also dates back to that time. Before this the use of the term "sustainability" can be found in the fields of economics and natural resources. The Rio Summit is credited for bringing the issues in sustainable development in public discourse and for its subsequent inclusion in development agenda.

[3] Johannesburg Plan of Implementation, paragraph 21; available at http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf (accessed on 9 June 2014).

[4] The Rio+20 Outcome Document, paragraph 132, available at http://www.uncsd2012.org/content/documents/774futurewewant_english.pdf (accessed on 9 June 2014).

The outcome of these global and subsequent regional and national conferences have had a profound effect on the formulation of a national and international development agenda incorporating the concept of sustainable development in all areas of development especially in energy, environment, transport and other economic and social sectors. Now, efforts to apply the concept in all conceivable areas of development and at all levels can be seen.

As reflected in recent national plans and policies of many countries in Asia, governments have political commitments to sustainable transport development. Most developing countries, if not all, have considered various sustainable transport development initiatives or are in the process of doing so. However, most of these initiatives are ad-hoc and project-based in nature. As of 2014, only a handful of countries were known to be pursuing a programmatic approach to sustainable transport development at national and/or urban/metropolitan levels.

The most recent development would be in the inclusion of transport related targets in the Sustainable Development Goals (SDGs) adopted by the United Nations General Assembly in September 2015. Of the 17 SDGs with 169 targets, five targets related to goals 3, 7, 9, 11 and 12 are directly related to transport. Through this, more focused sustainable transport policies, strategies, action plans and improved institutional mechanisms can be formed by countries and transport communities.

Despite inclusion of sustainable transport development in national plans and policies and efforts made so far, the progress on the ground in most developing countries is far from satisfactory. Political commitments and the current level of efforts may not be sufficient for persistent sustainable transport development. One needs to revisit the challenges to sustainable development, consider the barriers and find ways to overcome those barriers.

A review of relevant documents on current practices, administrative arrangements and institutional issues in selected developing countries reveals that so far institutional issues in sustainable transport development have drawn much less attention. These issues are related to the institutional environment, comprising overall transport sector governance including planning, policy formulation, resource allocation, and coordination among multiple actors involved in transport development.[5] The governance issues appear to be a major factor behind the slow progress so far.

The institutional issues concerning sustainable transport development need greater attention. Many barriers to sustainable transport development are institutional in nature. Deficiencies in present institutions, particularly laws, regulations, rules, and governance institutions outlining how organizations function and conduct their dealings with other organizations and stakeholders can be barriers to sustainable development.

Fortunately, many governments now recognize the importance of the institutional issues and have initiated measures to address them. The primary objective of this article is to focus on such institutional issues with the aim that it would generate further debate among the policy makers, experts and other stakeholders, to increase awareness about the implications of these issues, and seek their possible resolutions.

In this paper, the institutional environment and its importance in sustainable transport development is first explored. Thereafter, the shared responsibility of transport development and the need for coordination of action is elaborated. The third section focuses on other institutional issues in sustainable transport development such as rapid economic development and urbanization, the fragmentation of authority between multiple agencies under different levels of government together with institutional, resource and capacity constraints. Next the paper provides a summary of the main observations on institutional arrangements highlighting the need for reforms in transport sector governance and finally some conclusions and recommendations are drawn.

[5] The importance of these issues has also been highlighted in the Rio+20 Outcome Document. For example, see paragraphs 75 and 76 of the Rio+20 outcome document.

1. THE INSTITUTIONAL ENVIRONMENT AND ITS IMPORTANCE IN SUSTAINABLE TRANSPORT DEVELOPMENT

Multiple ministries, government departments and agencies at different levels of government – national, provincial, metropolitan/urban and local as well as many international organizations and agencies are involved in transport development. Generally government departments and agencies are established under different laws or by decrees. Usually, their governance structure and mandates make them accountable only to their line ministries. In some cases, the laws may require the agencies to coordinate with other stakeholders but may not mention any definite means (institutional mechanism) for that purpose.[6] Because of their systemic and multi-sectoral nature, policies and plans across transport sub-sectors and the other related sectors need to be consistent and actions at all levels of government as well as those by international organizations and the private sector need to be coordinated to have the desired results.

In the absence of an institutional mechanism, typically transport development decisions, planning and policy formulation, and coordination of actions between responsible agencies are undertaken within a setting which is deficient to address the consistency of policies, plans and programmes and coordination of action by multiple actors.

The success of transport planning and policies depend greatly on the institutional environment within which they are prepared and implemented. An example is considered here. Public transport or transit oriented development (TOD) can be an effective strategy for guiding sustainable urban (transport) development. However, TOD is rarely adopted in urban planning and transportation planning practices in cities of developing countries. Effective TOD requires appropriate type of development control along the transit corridors and other complementary measures, which are generally administered by land use control authority. TOD and development control together with measures for land value capture along the transit corridor can support the development of an effective high-capacity transit system and also provide for its funding, at last in part. However, most cities fail to guide transit-oriented land use development or generate funds for public transport development due mainly to deficiencies in their institutional environment.

There are three main elements that comprise the institutional environment. These include:

a) Governance institutions that define the distribution of power and authority between levels of governments, organizations, and other actors. They also specify rules of business for organizations including how they conduct dealings with other organizations and actors;
b) The legal institutions that refer to statutes, constitutional provisions, laws, regulations and rules, and high level administrative orders governing the sector; and
c) Social and organizational culture within which the organizations and other stakeholders play their role. It also includes personal and group dynamic relationship between the organizations and the private sector, and various pressure groups that influence the decision environment and the allocation of resources.

However, according to Williamson (1994), there is another type of institution – the informal ones. Examples of informal institutions are deeply embedded social values, norms, practices, customs, and traditions. These are powerful conditioners of behaviour but they change very slowly. It is important to note that many deeply rooted informal institutions can be the basis for formal legal institutions at a later date.[7]

The institutional environment within which decisions are made or policies are developed is one of the key factors that influence the effectiveness of planning, policy formulation and implementation of projects. As has been observed by Meyer and Miller, the institutional environment can also be one of the major barriers or constraints that can limit innovation, change in current practices, as well as create institutional inertia to consider new initiatives. The institutional environment can guide the way countries, regions, cities and other jurisdictions implement or avoid implementing actions related to planning, policy formulation, coordination, infrastructure financing, the

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[6] The Basic Act on Transport Policy (Act No. 92 of 2013) of Japan is an example. Article 6 of the Act underscores the necessity of cooperation and collaboration among the State and local governments, transport operators and other undertakings but does not specify how that may be undertaken.

[7] Williamson, O.E. (1994) Institutions and economic organization – the governance perspective, Washington, D.C., World Bank.

role of markets, the role of the state, the role of governments at different levels, technology standards and technological change.[8] The institutions that define how these processes are carried out and roles are played determine greatly how a country, province or city develops its transport systems and how they are used and operated.

The deficiencies in existing legal institutions may become barriers to sustainable transport development and limit the actions of implementing agencies, while appropriate legal institutions can catalyze sustainable transport development in many ways. For example, the US Intermodal Surface Transport Efficiency Act (ISTEA) of 1991 placed a great influence and emphasis on incorporating intermodal connectivity issues into investment and planning decision-making, which has encouraged the development of intermodal transport development. There are similarly many other examples.

Cross-border transport is another area where the existing institutional environment may prove to be a major barrier. Efficient cross-border traffic flow requires, among other things, interoperability on both sides of the border. Interoperability includes common institutions such as driving and vehicle licenses, insurance and liabilities, waybills, customs/border control clearance procedures, information systems, safety standards, labour laws and practices, as well as matters related to technical specifications of vehicles (standards, permissive axle loading, etc.) and equipment. However, existing laws, rules and administrative arrangements can result in undue delays at borders, increases in costs and other adverse effects.

2. SHARED RESPONSIBILITY OF TRANSPORT DEVELOPMENT AND COORDINATION OF ACTION

The overall efficiency of a complex system such as transport depends much on the integration of shared responsibility between levels of government as well as coordinated action by multiple agencies. An integrated approach to transport planning is a positive way to influence the planning and provision of transport systems towards more sustainable patterns. Integrated transport planning can take into account major transport development issues such as intermodal transport, system interdependencies, interactions between transport and land use and accessibility, transport safety, traffic congestion, and transport demand management.

It is important to note here that policy formulation is more important and pertinent at higher levels while typical planning may be seen more important at lower levels. Responsibilities for planning and managing transport infrastructure and systems are shared across all tiers of government. National and provincial governments have important roles to play in planning, developing and managing national transport systems and establishing policy environments for lower levels of government.

Lower level government policies and strategies for transport development should therefore be based on strategic transport policy environments set by the national and/or provincial governments. Likewise, urban/metropolitan and local transport development should support the overall objectives of sustainable transport development at national and provincial levels.

The development of integrated intermodal transport (IIT) systems for both freight and passengers has the promise to significantly improve and make the transport processes more efficient in terms of cost, time, resource use, and reduction of adverse effects on society and environment. Governments' intentions to develop such intermodal systems are well reflected in many countries national transport plans.[9] The development of IIT systems requires close collaboration between multiple government departments, public and private sector transport operators, and other stakeholders. Often government departments involved in the process are under different ministries. In the absence of a formal institutional arrangement it is hard to ensure close collaboration between all such parties, which is essential for the purpose. As a result, although the necessity of IIT systems are recognized and outlined in national plans, their implementation badly suffers.

The development of urban transport, especially in large and metropolitan cities, involves actions by multiple agencies that are not always well coordinated. Very often, transport agencies

[8] Meyer, M.D. and Eric J Miller (2001). Urban Transportation Planning: A Decision-Oriented Approach, p.42, Singapore: McGraw-Hill.

[9] For example, Bangladesh, China, India, Malaysia, Nepal and Thailand.

responsible for various systems such as metros, light rail, bus rapid transit (BRT) and other urban and national transport modes develop such systems without much consideration of all such systems together. The absence of coordination in developing these systems may result in several issues including lack of integration among transport modes, costly and poor transport services, and the poor quality of urban environment.

The institutional environment of urban transport and land-use development in cities of most developing countries generally exhibit a mixture of multi-level national, regional and local government and semi-government development agencies and operators, as well as a host of private-sector transport operators and investors. With the fast-growing demand for urban transport in the region, transport organizations face a host of challenges including coordination of their efforts to develop a unified urban transport system. Another related issue is that such agencies are generally responsible to address formal sector transport concerns. Consequently, the informal and non-motorized transport (NMT) modes remain neglected in terms of the planning, resource allocation and management leaving them to care for themselves. This phenomenon occurs largely because these improvements while essential have low visibility and the marginal impact is low resulting in the tendency to focus on projects that have more fanfare and can thus hold more weight politically in terms of visible improvements made.

The rapid increase in motorization in Asia combined with limited attention to pedestrian, cycling and public transport facilities have resulted in a decrease in the overall non-motorized transport trip mode share. However, it needs to be highlighted that walking and cycling still provide mobility to a large percentage of people in many cities. Short distance non-motorized transport trips are very common in Asian cities which are characterized by very high population densities and mixed land-use development. But this trend is changing fast.

Rapid urbanization and migration of people is causing population growth in city areas with new developments being sprawled in the absence of more public and non-motorized transport modes, especially along massive ring road networks. This "steroid effect" results in higher trip lengths causing an increase in motorized trips. Due to the low visibility of NMT projects, planners and politicians usually go for large scale flyovers, metro or road projects which get high publicity.

Lack of priority and quality of NMT infrastructure such as footpaths and cycling tracks are not helpful for increasing the share of NMT mode and in reducing road crashes involving the Vulnerable Road Users (VRU). Authorities need to give priority to NMT and improve their quality. NMT infrastructures, footpaths and cycle tracks should be integrated with public transportation systems to facilitate mobility. Many Asian cities such as Chennai, India, Bangkok, and Kathmandu are improving their NMT infrastructure.

Ignoring the informal transport and NMTs could become a serious issue in urban transport management in the long run as demonstrated in Dhaka, Bangladesh and elsewhere.

Another important issue is that the lateral or horizontal links between relevant agencies – in functional as well as geographical terms – are typically poor compared to their vertical links.

In some respects, the institutional arrangements in Hong Kong, China and Singapore may be considered as good examples. Although the actual institutional arrangements in these two cities are different, both have been successful in dealing with the coordination issue in planning, development and management of urban transport. There are some commonalities in both the cases, however. One may argue that they have the advantage of being city states with a single tier government system, which automatically allows them to overcome many institutional issues. Nevertheless, some other factors may have contributed more significantly to their successes than the single-tier government system. As has been observed in a GTZ publication,[10] these factors include:

- Continuity of government policies – the basic policies related to transport development namely, development of integrated public transport system, restraint of private vehicles number and use, and investment in transport infrastructure have remain unchanged for decades

[10] GTZ (2004). Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities – Urban Institutions, Module 1b, revised edition in 2004, GTZ.

- Adequate professional expertise supplemented by external experts as needed, and availability of sufficient resources for transport development
- Effective regulatory and coordination mechanisms that subjugate all agencies and transport operators to basic policy objectives of the government.

It is being increasingly realized that the gap between planning and implementation by multiple agencies under different levels of government cannot be bridged without institutional reforms, capacity building and streamlining of the overall procedures in planning, policy formulation and implementation. In order to deal with this problem many governments have taken measures that include reforms in transport sector and urban governance, and creation of a unified special agency for metropolitan transport development and other matters related to traffic and transport management.[11] However, the successes of these unified specialized agencies at national or metropolitan levels are yet to be fully assessed.

3. SOME OTHER INSTITUTIONAL ISSUES IN SUSTAINABLE TRANSPORT DEVELOPMENT

Rapid economic development and urbanization in many developing countries in the region have led to unprecedented growth of demand for transport infrastructure and services. Often the growth of transport demand far exceeds the growth of the national economy. As a result, governments find it difficult to meet such high levels of demand based on a well thought out strategy for the overall long-term development of the sector. Often, a common response has been consideration of disjointed measures through implementation of a range of incoherent transport projects.

Fragmentation of authority between multiple agencies under different levels of government together with institutional, resource and capacity constraints has further compounded the problem. A literature review suggests the following are some of the major institutional issues in sustainable transport development:

- Formulation of integrated policies reflecting the multi-sectoral nature of transport and the necessity of vertical and horizontal coordination of actions
- Inherent weaknesses of the transport planning processes - national or urban (basically have remained “technical processes”)
- Integration of public transportation and land use
- Absence of a programmatic approach to development
- De-linkage between planning and financing
- Institutional capacity and incentives to translate good knowledge into effective actions
- Decentralization of powers and responsibilities

The following paragraphs summarize these issues and their possible general remedial measures.

The need for coordination within the governance structure

In most developing countries there is no formal mechanism to ensure policy consistency between different levels of government – national, provincial, urban/metropolitan and local. Often, due mainly to an organizational system of governments at different levels and their defined role and function in the national constitution, it is hard for the national government to ensure policy consistency at all levels. In order to circumvent such problems, especially at the urban/metropolitan level, some countries (for example, the United States of America) have enacted laws that require the governments at those levels to follow certain policy directions of the national/federal government. Some other countries (China and India, for example) have formulated national policy frameworks (including on urban/metropolitan transport) and made resource support from the national government conditional to adherence of the national policy framework.

[11] For instance, Dhaka Transport Coordination Authority or DTCA for Dhaka in Bangladesh; Metro Manila Development Authority or MMDA for Manila in the Philippines; and Urban Metropolitan Transport Authority or UMTA for many large cities of India have been created. In Thailand, a special agency under the Ministry of Transport called Office of Transport and Traffic Policy and Planning (OTP) coordinates the development of transport projects at both national and metropolitan levels.

Cities in the developing countries are rarely able to integrate public transportation and land use owing to the fragmented governance structure of public transportation systems, transport and land use planning in different departments under different ministries and levels of governments. Functional as opposed to jurisdictional issues can make it even more complex, especially in large metropolitan areas and conurbations. Reforms of the existing governing structure may be required to overcome this barrier.

Transport is a derived demand, meaning that the benefits from improved transport (for example, reduced time and cost for freight transportation) are passed through to prices for products and factors of production.[12] However, under imperfect market conditions and weak institutions, which is generally the case in most developing countries, additional policy and complementary interventions in related sectors are required to realize the full potentials of transport development. This suggests, transport development should follow a programmatic approach. This approach can also make transport development more inclusive in nature and create synergy between sectors. However, key to the programmatic approach to development is a governance structure that can ensure a comprehensive and integrated approach (also referred to as coordinated approach) to planning and policy development across the sub-sectors and other related sectors as well as coordination of actions by all actors as well as that of the private sector. The absence of such a governance structure is a major barrier to programmatic approach to development.

The importance of a strategic planning approach for long term development

It is recognized that a strategic planning approach is helpful to look into the longer term socio-economic and spatial development possibilities of an urban region. This planning approach can consider potential future development in a much broader context such as national development, regional integration (at sub-national level) and natural resource constraints. The strategic transport planning approach at the national level is also equally relevant to consider the possibilities of potential development in a similar broader perspective and longer term.

There are good examples of practicing this approach both at the national and metropolitan levels. The Netherlands government applied this approach in the formulation of the Second Transport Structure Plan (1987-1990). The Dutch approach was later adopted and applied by the "Group Transport 2000 Plus", established in December 1989 by the European Community to develop a European transport strategy. At the city/metropolitan level, the city of Guangzhou in China, for example, has adopted this approach by putting the future development in a much broader context of globalization, regional integration, and ecological preservation.[13]

The linkage between planning and resource allocation and its availability for infrastructure development is generally poor. The linkage between planning and financing, if any, is further weakened by the lack of sustainable financing mechanisms for transport infrastructure at both national and urban levels. In order to lessen the burden of financing on government, some countries such as China, India, Indonesia, the Philippines and Turkey have considered greater involvement of the private sector through public-private partnerships (PPP), and other innovative financing measures.[14] However, only a handful of countries have been able to pursue a programmatic approach to PPPs and/or considered other alternative financing measures. Consequently, in most countries, the burden of infrastructure development and financing has remained primarily on the government.

In most developing countries, transport infrastructure developments contained in the national transport plan or urban master plans are implemented on an ad-hoc basis as and when funding is secured for specific projects – often through unpredictable donor funding. The implementation process is further complicated when complimentary/component projects are to be implemented by multiple agencies under different funding arrangements. Usually, the national or urban transport plans are not prepared considering the expected development budget. Few countries or cities develop a

[12] It also means some demand for transport can be reduced by various measures including non-transport measures such as ICT applications.
[13] As mentioned in a World Bank publication China: Building Institutions for Sustainable Urban Transport, EASTR Working Paper No. 4, World Bank, 2006.
[14] These measures may include earmarked taxes and user fees, dedicated road/transport funds, tolls, indirect beneficiary payments, land readjustment, various types of debt financing instruments, carbon financing and private investment promotion funds.

Capital Improvement Plan—a common practice in developed countries. This approach can greatly enhance the pragmatism in transport planning and make it easier to implement.

The need to develop technical expertise in developing countries

An important common constraint for developing countries is the lack of technical capacity and practical experience in strategic planning. Another weakness of the current planning process is that planning is still very much a technocratic process - institutional arrangements for public/stakeholder participation in planning and decision making processes are rare. Wide participation increases the likelihood that actions taken or services provided by public agencies more adequately reflect the needs of people and that the benefits of development are more equitably shared, which is an important objective of sustainable development.

International knowledge and experience about many sustainable transport development measures is now widely available. Many international organizations have produced excellent manuals and guidebooks on sustainable transport development policies and specific measures. However, efforts to utilize the available knowledge and experience seem to be very limited.

The lack of interest in considering sustainable urban transport development measures probably has been much to do with institutional inertia, and absence of incentives and local initiatives to translate good knowledge into effective actions. In 2014, the ESCAP secretariat organized a series of national workshops and a regional workshop on sustainable transport development. It was observed that local leaders, such as many city mayors, were not fully aware of their leadership role that was necessary to considering bold initiatives to transform a city's transport system and make the city a more liveable place to work and prosper.

A related issue is the lack of technical and managerial capacity. Many agencies in developing countries are not able to recruit and/or retain qualified personnel to plan, implement and manage the complexity of transport projects. There is an urgent need to upgrade the capacity through training and professional development programmes in technical areas as well as for working in a multi-sectoral environment and inter-agency coordination.

Decentralization of powers and responsibilities has taken place in some countries (Indonesia and the Philippines, for example) with governments providing national planning guidance for local authorities and other agencies to use in determining their own priorities. However, such a flexible and supportive national environment has not been always very effective due mainly to limitations of internal capacities of local agencies and their power to mobilize local resources for project funding. The national government controls the revenue raising mechanisms and the means by which the funds are distributed. Such arrangement gives little incentive to innovate locally or to promote exemplary local leadership.

4. SUMMARY OF MAIN OBSERVATIONS ON INSTITUTIONAL ARRANGEMENT

Available national policies and the literature review reveal that the institutional environment in most developing countries is not conducive to promoting sustainable transport development. There are a number of important institutional barriers including the ones related to transport sector governance, legal and resource constraints. The other important barriers include: absence of integrated policies reflecting the multi-sectoral nature of transport and programmatic approach to development, inherent weaknesses of the current transport planning (national or urban) practices, de-linkage between planning and financing, decentralization of powers and responsibilities, and institutional capacity to handle complex transport issues especially in a multi-sectoral environment.

A wide range of transport sector governance structure exists in the Asia and the Pacific region. These structures often reflect a country's historical legacy and the political system of the government. The transport policy environment in most developing countries of the region is fragmented, with infrastructure planning, policy making, and financing strategies scattered across and within levels of government. In most countries, the present institutional environments to manage national and urban transport systems are quite fragmented and responsibilities are diffused. Effective institutional mechanisms for inter-agency cooperation and collaboration are either lacking or deficient. In the absence of an appropriate institutional environment for the development of integrated transport systems, agencies usually follow a sub-sectoral approach to transport development that results in inefficiencies in the transportation process in terms of cost, time, convenience, and capacity and resource utilization.

Cities in most developing countries have a fragmented institutional arrangement to deal with transport issues. Generally multiple government departments and agencies under different levels of government as well as local governments may be involved. In most cases, there is no institutional arrangement to coordinate their planning and development initiatives. In addition, often city governments do not have a framework on national urban transport objectives, policies and guidelines that they can follow to take development initiatives and implement them. In recent years, some countries have taken steps to address this issue.

Some governments have considered improvement of the institutional environment by creating a specialized umbrella agency for the metropolitan regions and other large cities (for example, in Bangladesh, the Philippines and Thailand). The literature review reveals that these agencies are yet to fulfil their mandates due mainly to legal and capacity constraints. It is also rather common to see the national government's transport related ministries deal extensively with transport issues in capital and large metropolitan cities. Such involvement of the transport and urban development agencies of the national government are mostly disjointed and ad-hoc in nature and can be a barrier to considering a well thought out strategy essential for planning, development, and operations and management of transport infrastructure and services. In addition, the city/metropolitan governments with limited capacity and mandates do not take an interest to develop their own capability.

Governments have also considered other measures including enactment of new law and/or amendment to the existing ones, mainstreaming of sustainable development issues in national transport policies and launching of national programmes on sustainable transport development.

Generally the institutional environment in most developing countries is weak. In view of this, the Johannesburg Plan of Implementation document considered strengthening institutional environments for sustainable development at the national level and suggested a number of measures.[15] It seems these considerations are still very much valid for most of the developing countries of the Asia-Pacific region.

5. THE NEED FOR REFORMS IN TRANSPORT SECTOR GOVERNANCE

Some major reforms of the transport sector governance institutions may be needed in most developing countries. It is not uncommon to see that the mandates of transport development agencies, as may be specified in their legal statutes or administrative orders, can be often contradictory as well as over- and under-lapping. The laws may require the agencies to coordinate with other relevant agencies but may not mention any definite means (institutional mechanism) for that purpose; or whatever mechanism is specified is not effective to deal with complex multi-sectoral issues handled by multiple agencies.

Reforms may also be needed in existing legal institutions. Many laws and rules can be obsolete or require changes in view of the changing environment; for example, regulatory standards on vehicle, fuel and emission control financial and other incentives for the promotion of sustainable development measures, and recognition of electronic documents to facilitate fast paperless transactions or payment of fees.

Many sustainable transport development policies and measures may need changes to existing laws and regulations, within or outside the realm of transport. Without such changes, the implementation of such development policies and measures may remain complicated by legal requirements or even made impossible due to legal barriers. A good example would be changes in development control regulations to facilitate TOD as well as funding of transit systems.

[15] Johannesburg Plan of Implementation, op. cit. p. 61, paragraphs 162-165. These measures include coherent and coordinated approaches to institutional frameworks at all levels, establishment or enhancement of sustainable development councils and/or coordination structures at the national and local levels, enhancement of the role and capacity of local authorities, and institutionalizing public participation, including access to information regarding legislation, regulations, activities, policies and programmes.

Cross-border transport is an area where considerable institutional reforms may be required. Efficient cross-border traffic flow may require many changes in the existing laws and practices related to matters such as recognition of driving and vehicle licenses from other countries, insurance and liabilities of goods in transit, waybills, customs/border control clearance procedures, information systems, safety standards, and labour laws and practices. Changes in laws may also be required for matters related to technical specifications of vehicles and other equipment to permit traffic from one country to another.

The existing organizations involved in transport development need to be reformed. The reform may include redefinition of their roles, and changes in organizational structure and operational practices to reflect the redefined role as well as accommodating operations in a multi-sectoral and multilateral environment (particularly for national transport). In order to assume the changing role of the public sector, revitalization of the existing organizations should focus on capacity building, developing a culture and institutional mechanisms for cross-sectoral policy formulation and collaboration between organizations, allocation of resources, and access to new technology (especially related to applications of ICT), etc.

The role of a national planning organization deserves special consideration here. As needed in many developing countries, consideration may be given to strengthen the role of the national planning organization. Besides allocation of socially optimal level of resources to different sectors, the organization should also assume the coordination function for cross-sectoral policy formulation by ministries and government departments.

In the context of globalization, often the effectiveness of national policies requires greater articulation of efforts by all national agencies within a multilateral framework. Since markets do not take into account the externalities, governments needs to consider such externalities through appropriate policy instruments at the national level, and in case of cross-border transport within the framework of multilateral agreements, which can ensure the sustainability of development in the sector. The national planning agency can take a lead role in this aspect. The national agency should also take the initiative to develop a vision and broad strategies for transport development as may be outlined by the political leaders.

Along with the reforms and revitalization of existing organizations, setting of new ones especially regulatory bodies, and reform of existing regulatory regimes may also be required to facilitate greater involvement of the private sector, public participation, competition, and to protect social interests at large.

Coordination between multiple agencies is a major issue in urban transport planning, development and management of transport services. However, the nature of coordination can be expected to change with time, owing to a country's overall level of development, institutional maturity and technical and social changes. As such, the institutional design for coordination needs to be flexible to accommodate such future changes. The overall structure of government and the governance culture vary by country. Because of such differences and changing needs, there is no universal institutional design that may serve the purpose of coordination for all countries and may also remain valid over the long-term. Any institutional framework will have to consider examination of the existing measures, assess the need of any additional measures and make changes as needed.

Lessons from developing and developed countries suggest that there is a strong case for developing cities to have a centralized transport supervising agency or authority, which already do not have one. The literature review reveals that the following are rationale for establishing dedicated transport authorities:

- To plan and mange public transport networks on a conurbation basis (that may overlap several local jurisdictions), with full network, fare and service integration between modes and operators; and
- The management of public funds to plan and develop infrastructure facilities, and procure transport services from transport operators.
- To overcome the typical administrative constraints of government departments for the above two functions namely, a legal basis, technical capacity, and financial resources.

The main purpose for such a supervising authority is to create an institutional arrangement to ensure necessary coordination between government departments and other agencies. It needs to be clarified here that a supervising authority does not necessarily require centralized decision-making. It may also be achieved through setting up of systems for information flow, and interactive dialogue between concerned organizations throughout the processes of planning and policy formulation, and programming and project development cycles. The related organizations should have clear obligations, responsibilities and financial and human resources to carry out their mandates. For this decentralized approach to work, it is necessary to develop an organizational culture and professional capacity to work in a multi-sectoral environment and in collaboration with other agencies.

6. CONCLUSIONS AND RECOMMENDATIONS

One of the main conclusions that may be drawn from the discussion presented in earlier sections is that planning and design for sustainable transport systems requires a fresh look at the conceptual level of understanding the transport issues, planning and policy formulation methodologies as well as institutional arrangements. Whatever planning methodology is followed, it is important to see whether it can consider the fundamental issues in sustainable transport development and satisfy the needs of decision makers and stakeholders.

The gap between planning and implementation by multiple agencies under different levels of government cannot be bridged without necessary institutional reforms, capacity building and streamlining of the overall procedures in planning, policy formulation and implementation.

A departure from the conventional planning, policy formulation and sub-sectoral approach to transport development practices is necessary. However, with the existing institutional weaknesses and governance problems in the sector, which are endemic in most developing countries, it is rather difficult to pursue a holistic approach in policy formulation, planning and coordinated action by multiple agencies.

The national government can play an important role in promoting sustainable transport development by creating an institutional environment for the implementation of national policy framework at all levels – national, provincial and local. The deficiencies in governance institutions defining the relationship between responsible agencies and other actors responsible for transport development are a major hindrance against their collaboration and cooperation to develop integrated transport systems. Without an effective solution to this problem, it would be hard to develop integrated transport systems that are key to sustainable transport. Also, an institutional mechanism such as the mandatory inclusion of national sustainable development policies in project/programme evaluation is needed to be in place to ensure implementation of national policies at all levels.

The political support of decision makers is very much essential, especially in countries where sustainable development has just started to take a root in national policies, planning, resource allocation and project development. It may be necessary to enhance their awareness about sustainable development and the commitments that their governments have made to sustainable development at international, regional and national levels. Where national policies exist, local decision makers need to be fully aware of such policies and how those may be implemented through local initiatives.

Concerned government agencies and local authorities may need advice and guidance in considering suitable projects, their financing and design as well as necessary technical assistance in project planning, design, financing and implementation. As part of creating a supportive environment, the national government may consider creating a national institute to provide such support. The institute, among other activities, may develop necessary resource materials, design guides, and train concerned officials according to their training needs.