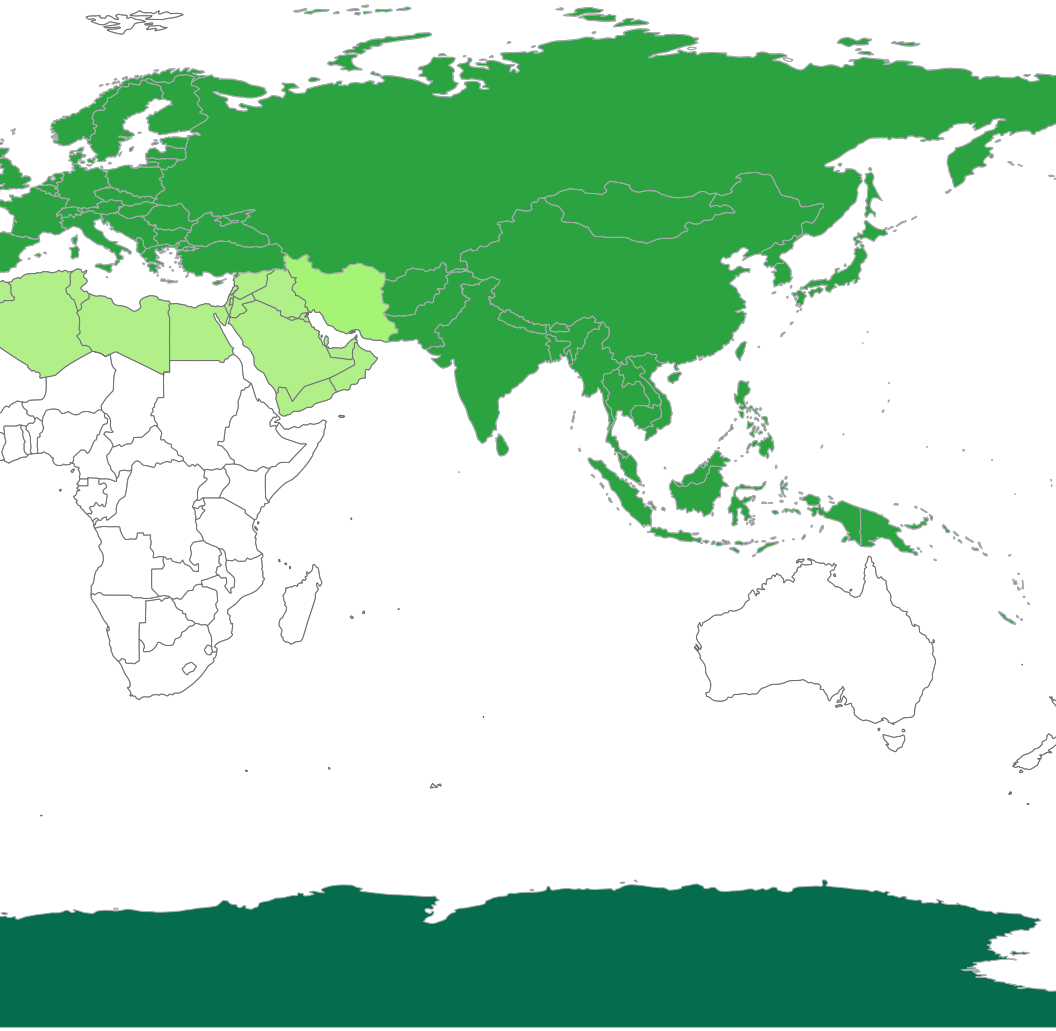
SUSTAINABLE TRANSPORTATION

AN INTERNATIONAL PERSPECTIVE



A NOTE OF THANKS Editorship is an adventurous journey. I learned a lot and enjoyed it – and it could not have been possible without my mentors and supporters. First, I would like to thank Larry Vale, my faculty advisor, for his support, his guidance and practical advice throughout the process of bringing this *Projections* volume to life. I am also grateful to Ezra Glenn for pushing forward this volume and the journal's future.

I would like to thank the authors, who contributed through their knowledge to this volume, iterated patiently through several revisions, and showed tremendous passion for their fields of expertise. I also would like to thank the editors for giving advice that improved this *Projections* volume significantly.

The former managing editors of Projections were very open in sharing advice - thank you Anna Brand, Isabelle Anguelovski and Rachel Healy. I hope you will enjoy the layout of this volume, and would like to thank Marissa for designing and improving the graphic design with her ideas. - EVA KASSENS, 2009

PROJECTIONS *volume 9*

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SUSTAINABLE TRANSPORTATION
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COVER IMAGE Map courtesy of Eva Kassens; data courtesy of World Resources Institute, 2005. This map shows CO_2 emissions by transport as a percentage of emissions. The more grey the continent, the higher the CO_2 transport emissions in relation to total emission of that continent; the more greeen the continent, the lower the CO_2 transport emissions in relation to total emission of that continent.

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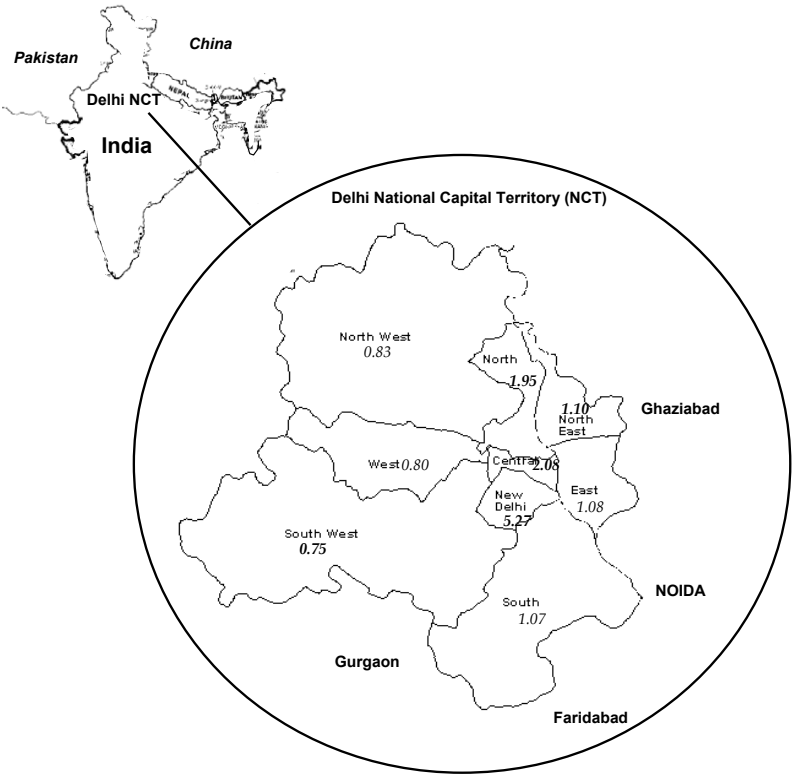
Associate Professor Piyushimita Thakuriah

TRANSPORTATION AND EMPLOYMENT ACCESSIBILITY IN A CHANGING CONTEXT OF METROPOLITAN GROWTH : THE CASE OF DELHI, INDIA



ABSTRACT

Phenomenal increases in personal mobility has led to rapid increases in urban raffic congestion worldwide and difficulties in spatial access to economic opportunities. This paper examines the factors that act as drivers of these great increases in the demand for personal transportation by examining the case of the Delhi metropolitan area in India. The Delhi metro area has increased significantly in size due to outward movement of the built-up areas as a result of both planned and unplanned factors since the 1960's. General economic policies to increase motor car production, availability of easier credit to purchase cars, construction of expensive public transportation but lack of concurrent policy to price personal auto travel has greatly facilitated the demand for personal vehicles and increased mismatch between locations of jobs and residential location of workers. The equity aspects of these phenomena have been significant including slum resettlement to inaccessible parts of the metro area with little economic opportunities, large rates of fatalities among non-motorized transportation users who are mostly poor and negative air pollution impacts among roadside dwellers.

While traditional measures of spatial job accessibility measurement are useful in the Indian context, the paper shows that marginal workers, recent migrants, street hawkers, slum dwellers and workers in the transportation sectors, all of whom are low-income, have different job accessibility needs. A new framework is needed for measuring job accessibility, given the data limitations that exist and the multi-pronged nature of the problem, to assist policy-making towards sustainable urban systems and equitable spatial access to economic opportunities.

INTRODUCTION

India's recent economic growth has received a lot of attention in the media and global commerce. These basic economic factors, together with unprecedented urbanization of Indian cities, rapid increases in urban decenbtralization and growth in demand for personal (motorized) mobility, have essentially led to a situation of explosive growth in traffic congestion. These trends are similar to those in other Asian mega-cities (Shen, 1997 in the case of Shanghai and Bowen, 2006 in the context of South-East Asia's three large mega-cities: Bangkok, Manila and Jakarta.

The consequences of these trends on accessibility to jobs and other locations with social and economic potential by the urban workforce should be paramount, but are often ignored in transportation planning. However, recent strategies have stressed the importance of the social equity aspects of transportation, including the equitable access to jobs and other meaningful opportunities by all segments of the population (for example, the World Bank, 1996; U. S. Executive Order 12989, 1994). Although there is no universally acknowledged definition of accessibility, the concept relates to "an individual's freedom to participate in activities" (Weibull, 1980). Many countries and development programs have now started to respond to the transportation needs of the poor, socially excluded and disadvantaged populations, but there is a need for much better understanding of how different urban processes lead to spatial variations in job accessibility. For example, an extensive literature in the U.S. has examined the link between the economic and social needs of the urban poor to their residential and locational conditions (Kain and Persky, 1969; Wilson, 1987, 1996; Ihlanfeldt, 1999). Others have investigated the connection between job accessibility and labor market outcomes such as employment status, wages earned and related indicators (Bederman and Adams, 1974; Thakuriah and Metaxatos, 2000; Raphael, 1998). Although evidence connecting job accessibility to acquiring and sustaining employment in good quality jobs by low-skilled workers is mixed, the importance of the concept as a performance measure in transportation planning cannot be over-emphasized for the purposes of sustainable development and is rightfully achieving a foothold in the evaluation of transportation projects, along with traditional mobility-based measures (such as changes in average speeds or Vehicle Miles Traveled).

In the developing world, investments in transportation infrastructure have been used as a strategy to alleviate poverty and to connect the poor to jobs and markets; however, the literature linking investments to labor market outcomes is more limited (Boarnet, 2006). In addition, the complex dynamics of urban population growth, race and ethnicity of the workforce and the interactions among land-use, housing, labor markets, transportation and economic development and ways in which these affect job accessibility, is not well understood in developing cities. While job accessibility is important for all segments of the urban labor force, it is particularly important to understand in the case of the urban poor. As a group, poor members of the urban workforce find it the hardest to overcome spatial barriers to job destinations because existing

public transportation links can be expensive, too time-consuming or simply non-existent, while walking or bicycling is unsafe in mixed-mode traffic or not an alternative at all, given large distances between home locations and job locations in increasingly decentralizing urban areas. The means to purchase and operate personal vehicles (cars or motorized two-wheeled scooters or motorcycles) or the ability to relocate to housing (including informal housing) in job-rich areas, is also likely to be beyond their means.

Indian cities have been undergoing significant changes in urban form and in the spatial distribution of population and economic activity. Several authors have discussed the transportation needs of the urban poor in the larger Indian cities. For example, Tiwari (2002) discusses the case of Delhi, the capital city, where the existing urban transportation infrastructure does not meet the needs of a large number of city residents, who remain outside the formal planning process, and are almost exclusively dependent on non-motorized transportation. Badami et al. (2004) describe how low-income groups are affected by various transportation impacts, and discuss the travel characteristics and the urban transportation needs and priorities of these groups. Srinivasan (2004) describes access to jobs, shopping and social services by low-income households in the City of Chennai in southern India, while Baker et al. (2005) identified the demands for transportation services by the poor in Mumbai, based on a large-scale survey. These authors also discuss the extent to which urban transportation policy and planning have only marginally responded to the needs of the urban poor.

This paper attempts to add to the discussion on the importance of considering job accessibility in sustainable transportation planning in developing cities, by examining the case of Delhi, India. The paper undertakes an exploratory review of the trends in land-use, housing, economic development and transportation patterns over time in the Delhi metro area and examines how these processes have affected the spatial distribution of workers and jobs, which are the building blocks of job accessibility. The data to estimate detailed accessibility measures are not available in the case of Delhi and while the emphasis of the paper is not to estimate accessibility measures per se, the discussion makes use of an aggregate, zone-based accessibility measure (a jobs-to-worker by district index). The paper begins with a review of urban labor patterns and current mobilty and accessibility trends in the Delhi metro area. Spatial variations in job accessibility are explained in terms of an interacting set of urban processes and public policies and an attempt is made to break down the job accessibility needs of different subsets of the low-income workforce. The paper concludes with a set of multi-pronged recommendations about strategies to improve low-income worker accessibility to jobs in developing cities, with the goal of improving sustainable transportation systems.

STUDY AREA

The National Capital Territory (NCT) of India, which includes the capital city of New Delhi, is

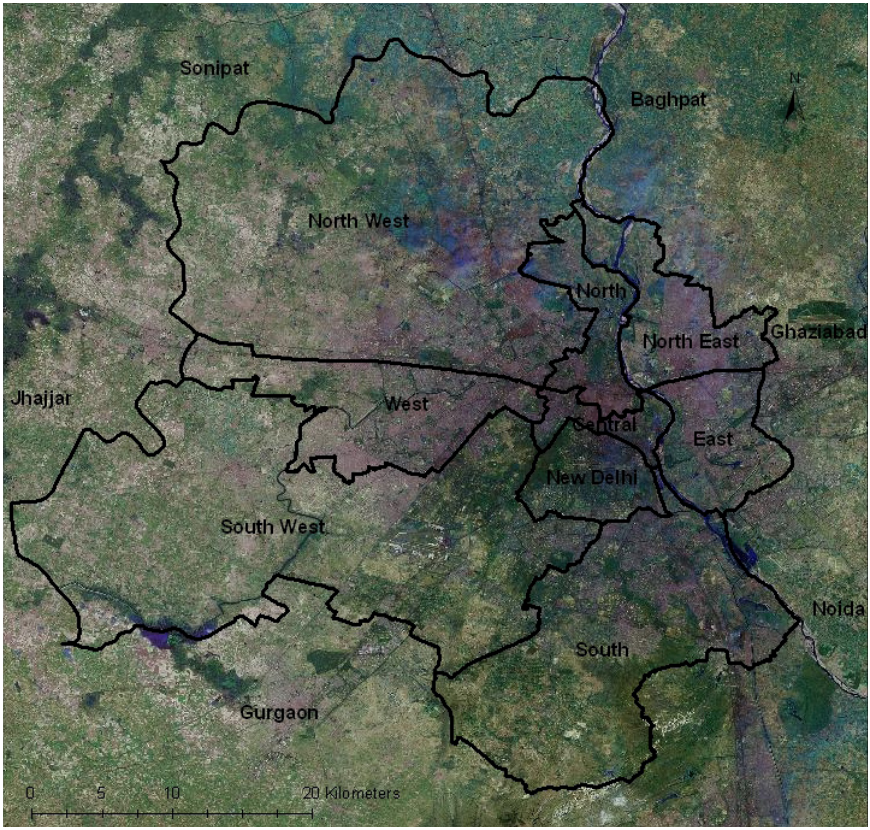


FIGURE 1. Nine districts of the National Capital Territory of India, including the capital city of New Delhi.

TABLE 1. District-Wise Area, Population And Economic Statistics In National Capital Territory.

District	Area (km^2)	Percent Share of Population	Population Density (per km^2)	Percent Decadal Population Growth	Percent of Total Business Enterprises
North-West	440	20.65	6,471	+60.12	17.33
South	250	16.37	9,033	+50.27	14.16
West	129	15.37	16,431	+47.81	13.39
North-East	60	12.77	29,395	+62.52	12.02
South-West	420	12.67	4,165	+61.29	8.26
East	64	10.57	22,637	+41.61	12.22
North	60	5.64	12,996	+13.30	10.56
Central	25	4.67	25,760	-1.91	10.29
New Delhi	35	1.29	4,909	+2.47	1.73
NCT Delhi	1,483	100.00	9,294	+46.31	100.00

SOURCE ECONOMIC SURVEY OF DELHI 2003-04

approximately 1,483 square kilometers and has a population of 12.9 million (Census of India, 2001). Administratively, the territory has nine districts, shown in Figure 1. Table 1 gives basic information on the Delhi Metro Area at the district level. The North-West district is the largest in land area, has the greatest share of NCT population and enterprises and has witnessed the third-highest rate of decadel growth in the NCT region. The North-East district, on the other hand is the most densely populated and has witnessed the greatest share of decadel growth.

FIGURE 2. Annual Growth in Motorized and Man-Animal Driven Vehicles in Delhi (1991-2006)

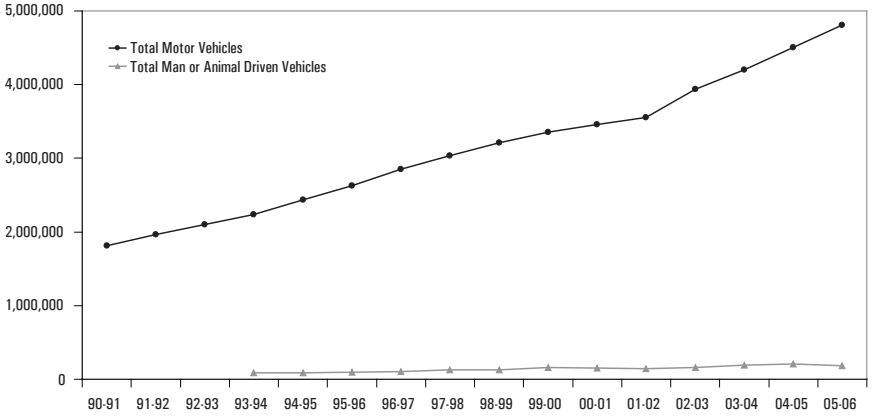


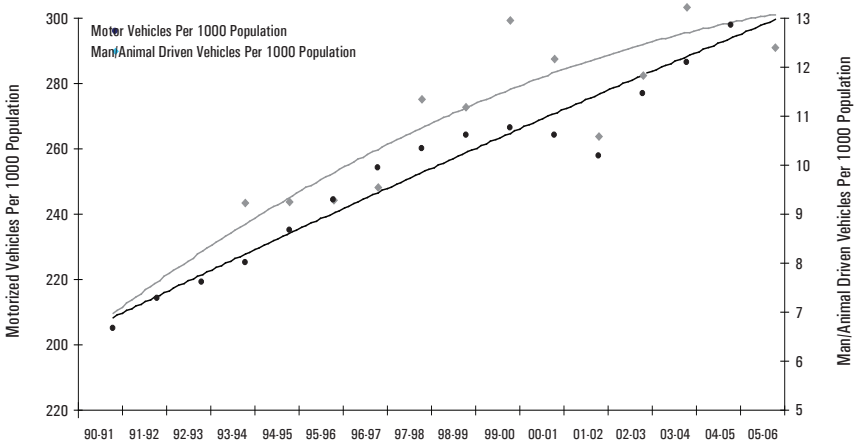
Figure 2 shows the growth in motorized and non-motorized vehicles in the Delhi metro area during the period 1991 through 2005. In contrast to motorized transportation, which exhibits a strong upward trend, non-motorized transportation has remained more or less constant over time. A variety of factors have contributed to the increases in personal motorized vehicle ownership.

Personal Motorized Transportation

Ingram and Liu (1997) estimated that saturation levels for the market penetration of cars and total motor vehicles are at 770 cars and 1,180 total motor vehicles per 1,000 population. Figure 3 shows the smoothed trends in motorized and man-animal driven vehicles per 1,000 population in Delhi. In 2005-2006, motorized vehicle penetration per 1,000 population was an estimated 250. The largest share of motorized transportation is composed of two-wheeled transport such as scooters and motorcycles. Although it would seem that Delhi is far away from reaching the predicted saturation point, the factors described below are likely to continue to boost these trends in the future.

- *Changes in Economic Policy*: Despite high gas prices, the Indian market for motorized transportation, especially the car market, is booming. Sales of passenger vehicles crossed the million-figure mark (1,044,597 units) in 2004, making India the fastest-growing in this segment (Basu, 2005). In terms of affordability of cars to a bigger segment of the total market,

FIGURE 3. Smoothed Annual Growth in Motorized* and Man-Animal Driven Vehicles** Per 1000 Population in Delhi (1991-2006)



perhaps no other phenomenon is more likely to foster greatly increased car ownership than a new generation of ultra-cheap cars, which are intended to be "introductory" cars and will quite possibly attract two-wheelers into the car market. India produces 1.3 million cars a year. With the market growing at 10% to 12% per year, this could reach 3 million within a decade. In terms of changes in governmental policies, steps to make auto manufacturing competitive by creating export promotion zones, expanding infrastructure such as power, roads and ports, bringing down transaction costs, developing industry-specific clusters and freeing industries from excessive regulations are cited to be important auto ownership boosters (Basu, 2005).

- *Great Increases in Personal Wealth and Disposable Incomes*: In constant (1993-1994) prices, the per capita income growth in Delhi between 1993-1994 and 2004-2005 was 4.29% while that of the rest of India was 3.97% (Economic Census of Delhi, 2005-2006). The number of double-income families has gone up, with resultant increases in disposable income. These changing lifestyles have led to greater preferences for personal mobility. In addition, the percentage of households below poverty in Delhi decreased more steeply during 1974-2004 period, compared to the rest of India (Economic Census of Delhi, 2005-2006), leading to increases in purchasing power, on the aggregate, for personal cars.

- *Liberalization of Credit and Lending Mechanisms*: The availability of credit is another major booster of car ownership (Thakuriah and Liao, 2006). It is estimated that about 80% of cars currently sold in India are financed through the credit system (Basu, 2005) in contrast to earlier decades, where cars would be purchased by well-off households by means of up-front payment of the entire cost. Interest rates on car loans have witnessed a surge of at least 3% points since December 2005 (Venkatakrishnan, 2006), but motor vehicle sales

have nevertheless remained buoyant. The chief reasons attributed to this trend are the sales incentives and discounts offered by vehicle manufacturers, which are operating in a highly competitive market. These financial strategies add a layer of complexity to car ownership growth rates in India, beyond what simple income-based measures would predict.

Road Infrastructure and Public Transportation

Inspite of booming car ownership rates, public transportation continues to be the choice for the majority of trips in Delhi. Close to 34% of trips are made by bus, followed by bicycles, motorized two-wheelers and then private cars. The total length of the road network in Delhi has increased from a mere 652 kms in 1981 to 1,122 kms in 2001. The trip length by private car and bus was 11.28 km and 10.66 km in 1993 respectively and forecasted to be 17.74 km and 14.58 km in 2021 (DUEIIP, 2001) .

In response to these motorizing trends, the government has undertaken several large-scale transportation infrastructure projects, including limited access expressways, road-widening, flyover construction and Intelligent Transportation Systems projects, as well as an extensive rapid transit system project, the Mass Rapid Transport System (MRTS). However, considerations regarding the urban poor are either weak or entirely missing in these projects. While the construction of a high-speed, high-capacity public transportation system is commendable, rail forecasts in general have been significantly optimistic compared to reality. Actual ridership is usually lower than forecast, and actual costs are higher (Shoup, 2006); other authors have raised similar concerns (Pickrell, 1992; Richmond, 2005). In the case of the Delhi MRTS, while some reviews regarding its congestion mitigation and air quality improvement potential have been positive (Murty, et al., 2006), others have critized its low ridership levels, enormous levels of subsidy and its unresponsiveness to the needs of poor commuters (Mohan, 2006; Advani and Tiwari, 2005). The other major initiative is a Bus Rapid Transit (BRT) system; at the time of writing this paper, an initial demonstration of such a system had been made. Irrespective of governmental interventions of this type, the fundamental job accessibility considerations for workers remain open, as these were not a factor in the planning process in the first place.

Job Accessibility in the Delhi Metro Area: Jobs-to-Worker Ratio by District

Although there is no universally acknowledged definition of accessibility, researchers have proposed various indicators of accessibility (Ingram, 1971; Weibull, 1976; Morris et al., 1978; Handy and Niemeier, 1997; Miller, 1999; Harris, 2001), which range from simple counts of jobs within commuting distances of residential origins, to more complex measures based on spatial interaction models and random utility models. Baradan and Ramjeri (2001) summarize the literature on classification of accessibility measures. One way to classify accessibility measures is zone-based versus individual measures. Zone-based measures try to capture the overall accessibility for a zone, while individual measures try to capture the accessibility of

individuals based on detailed characteristics of space, available time, and means to overcome space (Berglund, 2001).

Several considerations enter into adequately estimating zone-based job accessibility measures for low-income workers: First, low-wage or "entry-level" jobs that are appropriate for the skill-levels of low-income workers should be identified, from the total pool of jobs in a zone (as in Sen et al, 1999). Second, in order to estimate "potential" or "opportunities" for low-income workers, it is not the total number of entry-level jobs per se that is important, but rather job openings (also in Sen et al, 1999). The second point warrants further discussion and is relevant due to recent U.S.-based research based on the "job chain" approach (Persky and Felsenstein, 2006). Specifically, the results of a simulation model used to estimate non-user benefits of a federally-funded U.S. transit program targeted to connecting workers from low-income residential locations to job-rich areas – the Job Access and Reverse Commute program – shows that when such services link low-wage workers to job locations where the existing jobs are already filled by workers with similar skills and there are no net new jobs (created as a result of, say, an economic development program), the consequence can be job loss by the existing workers, deflation of wages and other movements down the job chain, as the new workers serve as substitutes for the existing workers (Thakuriah, et al, 2008). Third, data on commuting flows by mode and precise estimates of travel costs or impedances between zonal pairs by mode (which might be available from travel demand models) are necessary.

In terms of measuring job accessibility rigorously in Delhi according to these requirements, a number of problems arise:

- *Extreme Levels of Mixed Land Use*: As in many developing cities, Delhi has a high level of mixed land uses, with no clear-cut concentric zones of different activities (Tiwari, 2002). While there are several core areas with high levels of commercial development, such development patterns can co-exist with high concentrations of housing. Further, income levels at residential origins tend to be mixed because high-income housing may co-exist in the same zone with squatter dwellings. Thus, the location of low-income workers and areas where appropriate economic opportunities exist for them, are somewhat ubiquitous over the urban space.

- *Data Limitations including Spatial Resolution of Information on Labor Market, Travel Demand and Commuting Costs*: Most data on the labor market aspects of the analysis (number of jobs, type of jobs etc.) are available only at the district level, which can be fairly large. Recent origin-destination travel demand and commuting cost data such as travel times or out-of-pocket costs between zones are not known at a small enough spatial resolution to be meaningful to estimate accessibility measures.

- *Porous Labor Markets*: In order to estimate job accessibility by district, what we ideally need is an origin-destination matrix, where the origins are home locations and destinations are job locations. The cells of the matrix would give the commuting flows for each O-D pair. In the case of Delhi, unlike many U.S. metro areas, the labor market borders are very porous, i.e., workers from neighboring states commute to Delhi, thus creating an ill-defined labor shed and further complicating accessibility-based analysis.

For these reasons, this paper considers a preliminary zone-based measure of job accessibility in the case of Delhi. The measure is a jobs-to-worker ratio by district, ie, [(total number of jobs in a district)/(total number of workers residing in that district)]. A surplus of jobs per worker may be indicative of in-bound commuting flows to a district and would potentially call for improvements in transportation connections; a deficit of jobs per worker in a district potentially indicates out-bound commuting flows from that zone, thus calling for economic development or job-creation programs in those areas or perhaps even the relocation of the low-income workers residing in those areas, to areas with greater economic opportunities.

TABLE 2. District-Wise Employment Statistics in National Capital Territory

District	Total Jobs	Total Workers by Residence	Total Jobs to Worker Ratio	Number of Persons Usually Working	Main Workers by Residence	Persons usually Working to Main Workers
North-West	768,560	919,483	0.83	585,635	872,278	0.67
South	836,554	778,495	1.07	685,596	739,276	0.92
West	582,463	720,848	0.80	463,510	686,572	0.67
North-East	554,362	500,361	1.10	432,019	471,011	0.91
South-West	452,764	602,505	0.75	377,713	569,861	0.66
East	516,153	475,371	1.08	405,069	456,198	0.88
North	501,702	256,574	1.95	395,125	244,851	1.61
Central	467,062	223,843	2.08	389,495	213,307	1.82
New Delhi	356,779	67,596	5.27	45,871	64,426	5.36

SOURCE Economic Survey of Delhi 2003-04

Table 2 gives district-wise employment information that is relevant to the current discussion. The total number of persons usually working is 4,080,024 (Directorate of Economics and Statistics, 2005). Out of the total number of workers, over 76% were hired workers and the rest were household or informal workers. About 41% of the informal sector workers are in retail trade followed by about 11% in the transport sector and 10.5% in manufacturing and trade. Details on the spatial distribution of these jobs and the estimated jobs-to-worker ratio are as follows (note that these overall remarks are about all types of jobs and workers, and not just the low-income sector; the case of low-income workers is considered later on in the paper):

- *District-Wise Share of Jobs*: The district-wise share of jobs (given in column 2 of Table 2) gives the total number of jobs that the Census collects from establishments (the share of establishments or enterprises is given in Table 1). This figure includes both the number of hired persons usually working as well as the number of non-hired persons usually working (workers who typically work in households or in non-enterprise premises). The total number of workers by residence (Column 3) gives all workers (main workers as well as marginal workers; main worker is a person who has worked a major part of the year, i.e. for 183 days or six months or more, whereas marginal worker is a person who might have worked any time during the previous year, but not for the major part of the year).

- *Jobs-to-Worker Ratio and Surpluses, Deficits and Commuting Needs:* The ratio of all jobs per district to all workers per district is given in column 4. From these numbers, it is possible to get a rough idea of potential commuting patterns. We see that the New Delhi, Central, North, North-East, East and South districts have a surplus of jobs per worker, meaning that it is most likely that workers from other areas are commuting into those areas. The North-West, South-West and Western districts, in that order, have the greatest deficit between total jobs and total workers, potentially resulting in the need of the residents in these districts to commute to other districts.

  If we consider the case of jobs where persons are defined to be usually working (all jobs where the person is hired to work in all types of enterprises, perennial or non-perennial) as a proxy for formal sector jobs and main workers as formal sector labor, we see that the New Delhi, Central and North districts have the highest ratios for persons usually working to main workers. The districts with the greatest difference between the number of formal sector jobs and workers are the North-West, West, South-West and Eastern districts. This indicates that formal sector workers in these locations are more likely to have to compete for appropriate jobs with others like them in their district or potentially face long commutes to areas where the formal sector jobs to workers ratios are more advantageous.

Indirect Drivers of Demand for Transportation

Job accessibility is the both the cause and the result of a myriad set of interwoven urban processes relating to demographic, land-use, social and economic changes over time. These factors in the Delhi NCT have contributed to variations in job accessibility as currently observed and have led to the development of a large, multi-nucleated city. While natural increases in population and the workforce have played a major role, a number of previous planning activities that had a basis in India's former socialist, state-driven planning paradigm, appear to have contributed significantly to the decentralization of urban population and economic activities away from the central core, towards outlying areas of the metro area. In this section, the reasons underlying the spatial variability in job accessibility are explored.

Changes in Urban Growth and Structure: Phenomenal urban growth trends in the Delhi metro area (with over 46% growth from 1991 to 2001, more than double the national rate) have contributed significantly to the demand for motorized transportation and variations in job accessibility. DuPont (2003) estimated that natural increase in population contributed to 35% of the total population growth, net in-migration from rural and urban areas surrounding the NCT (as well as from states that are located far away) about 40% and the reclassification of the urban-rural population, an additiona 25%. Women are also entering the workforce in greater numbers. While the total number of women in formal sector jobs in India remain small, the number of female main workers increased 40% since 1981, compared to an increase in male main workers of 23% (Dunlop and Velkoff, 1999). Moreover, the average household size has decreased marginally from 5.5 persons to 5.4 persons during the 1990's (United Nations, Department of Economic and Social Affairs, 2001); in urban and rural NCT combined, the average family size is 5.1 whereas in urban Delhi, over 45 percent of families were composed of 4 or fewer persons. This phenomenon has also lead to increased demand for independent incomes (jobs) and housing. As a result of these factors, the sheer size of the workforce which contributes to travel demand today is much greater than what it was 10 years ago.

Decentralization of the Delhi Metro Area: Dupont (2003) noted three spatial factors between 1991 and 2001 that are symptomatic of urban decentralization: (i) absolute decrease in population, indicating net outward movement, that has occurred in the historical core called the Old City, (ii) decrease in population in some parts of New Delhi, which is the capital city with mostly government buildings, government-provided housing and some commercial activity and (iii) great increases in population (over 10%) in neighborhoods in the outskirts; although the outskirts do not have the low-density patterns of U.S. cities, they are still far less densely populated than the inner, core areas. Some of the key drivers of the Delhi metro area decentralization are:

- *Planned Development of Outlying Areas:* The population increases in the peripheral areas are the result of both governmental policy and private action. DuPont (2003) notes that since the 1960's, there was deliberate planning to develop townships in the periphery of Delhi to accommodate urban growth; eventually these areas grew faster than the central agglomeration of Delhi. Eventually, transportation connections (roads and rail) propelled the outward movement of population from the urban core to these peripheral towns, leading to the development of one very large, multinodal urban area. In addition, the local governmenal acquired large amounts of agricutural land in the peripheral areas from the 1960's for the purpose of constructing apartment buildings, leasing of land to private households and cooperative group housing, as well as land for resettling evicted slum dwellers.

  The economic base of these peripheral areas was strengthened in an attempt to improve jobs-housing balance with the development of industrial centers and parks in these areas.

Over time, households relocated close to these areas, further adding to the decentralization process. These industrial areas were developed in the 1970s and over the years have deteriorated considerably in terms of physical infrastructure (IF&LS Ecosmart Ltd., 2006). In the case of New Okhla Industrial Development Area (NOIDA), a peripheral area just east of the South district, about one-fourth of its working inhabitants now commute daily to work outside their town of residence (DuPont, 2003). It is most likely that commuters in this area are employed in the surplus jobs in the South, New Delhi, Central and East districts; however, almost 98 percent of the workers living in the slums in NOIDA work in or close to NOIDA, due to dependencies on non-motorized modes of transportation.

Private Development of Outlying Areas: The private development of outlying areas has also greatly facilitated the deconcentration of urban population and employment opportunities. A classic example is that of Gurgaon, south of the city, in the adjoining state of Haryana. Because of its close proximity to Delhi, Gurgaon has become one of the most important corporate and industrial hubs of India and is home to several auto manufacturing plants, IT companies and Call Centers. The Government of India has embarked on an economic development policy of creating Special Economic Zones (SEZ's), which are intended to be engines for economic growth by attracting larger foreign investments to India. Eight of the 154 SEZ's identified in 2005 will be in Gurgaon, leading to an increase in the number of jobs and attraction of international capital and service jobs associated with such investment. One survey found that about half of the employed inhabitants surveyed in DLF Qutab Enclave, a residential area within Gurgaon, worked in the city of Delhi (DuPont, 2003). It is likely that these commuters are filling the surplus jobs in the South, New Delhi and Central districts. Virtually all these trips are undertaken by private motorized transportation, given the lack of adequate public transportation such as bus or charter bus and the image issues often associated with public transportation by the affluent.

Consequences on Job Accessibility for the Urban Poor

The above motorization, congestion and commuting trends potentially have the following major effects on the accessibility of poor urban labor in Delhi:

- Exposure to high rates of traffic fatalities in the increasingly mixed-mode streets (where the affluent are in cars or buses and the poorer inhabitants in non-motorized modes);
- Exposure to very high pollution intensities, which affect the poor disproportionately, because these inhabitants are more likely to live and work road-side, where air pollution levels are typically higher than farther away (Badami, 2004);
- Reduction of employment opportunities and dampening effect on wages, due to lack of adequate access to job sites that are located far away from home locations and are not accessible by non-motorized modes or inexpensive public transportation;

- Housing in slum dwellings close to temporary or seasonal jobs, which are often lacking in basic amenities.

While the above points apply broadly, the urban poor are not homogeneous and can be divided into the following groups, based on the type of occupation they work in and their residential location:

- Low-income labor with salaried positions who work in the formal sector and who live in low-rent (permanent) housing;
- Marginal but full-time workers in the informal economy many of whom are migrant workers or are slum dwellers and reside in slum housing;
- Abject poor, who are homeless and out-of-work or are transient labor.

The transportation needs of these three groups might be quite different. The author synthesized the following remarks from published writings, because a formal analysis of the differences among the groups would be possible only on the basis of a large-scale travel behavior survey and accompanying labor market information.

- *Low-income labor with Salaried Positions in the Formal Sector:* The first group may have the need to access jobs in formal job premises at large distances away from where they reside. Table 3 gives the distributions of mode choice by income category. The mode used most often by higher-income households is bus, followed by two-wheelers and private car. In contrast, the mode used most often by low-income households is bicycle, followed by bus and walking. This is not surprising because low-income households are most likely to be in involved in low-

TABLE 3. Mode Shares by Low and Higher-Income Households in Delhi

Mode of Transportation	Low-Income Share	High-Income Share	Total
Private Car	0	28.35	14.175
Bus	31.43	36.2	33.815
Rail	1.79	0	0.895
Auto-rickshaw	0.96	1.74	1.35
Taxicab	0	0.04	0.02
Motorcycle & Scooter	2.48	29.29	15.885
Bicycle	38.8	2.75	20.775
Walked	22.12	1.62	11.87
Other	2.34	0	1.17
Total	**100**	**100**	**100**

SOURCE Tiwari, 2002)

wage, informal sector jobs close to their home location. Perhaps given better transportation connections, low-skilled workers might be able to travel farther away and obtain secure jobs with higher pay and better benefits.

Marginal or full-time workers in the informal economy: The second group is more likely to work close to where they are currently residing. The areas with the greatest number of marginal workers and adults out of the labor force are in the North-East, West, South-West and Southern districts of the NCT. Many of these workers are slum dwellers. As a result of prior policy, slum dwellers were evicted from the city to the periphery but at the present time, informal housing clusters are scattered over many parts of the city and attempts to relocate slum-dwellers continue. Slum inhabitants tend to work in the service sectors, which includes occupations such as domestic help, hawkers and vendors, low paid workers in the industrial, commercial and trade or business sectors etc. A large number of these housing settlements have no access from the arterial and sub-arterial roads in the city, making access to formal public transportation modes difficult. Some of these workers might be part-time workers in multiple jobs, calling for access for transportation that links them for the home-to-work, work-to-work and work-to-home trips.

Street hawkers and others in occupations that work by the streets would also fit into this category. The term "street vending" brings to mind two definite activities: that of the trader who walks around the city offering goods and services without a fixed place from which to operate, and that of the trader who sells merchandise or provides services from a fixed point on public thoroughfares (Aurora and Tagore, 2002). Both types of hawkers are vulnerable to increasing motorization; the first from the risk of street accidents and fatalities and the second from being dislocated from motorizing streets. Aurora and Tagore (2002) also note that street vendors are routinely beaten and driven out of public spaces. As a response to these atrocities, the Government of India has passed National Policy for Urban Street Vendors in 2004. The policy calls for a paradigm shift away from "prohibition" towards regulation. The metropolis must be divided into "green, amber and red" zones, signifying free access, fee-based access and prohibited access by hawkers, respectively. The division into the three categories may vary with the time of the day, the day of the week and the week of the month.

- *Transient Labor and the Abject Poor:* The travel patterns of the third group are unknown from previous studies. Where they live and ways in which they search for jobs or travel to work are the topics of much-needed research and newly collected primary data.

Recommendations to Improve Job Accessibility of the Urban Poor

In response to the various problems afflicting the urban poor, the Government of India has adopted an ambitious program, called the Jawaharlal Nehru National Urban Renewal Mission

(JNNURM) (IF&LS Ecosmart Ltd., 2006). Several transportation projects are eligible for funding under the JNNURM directorate for Basic Services to the Urban Poor. However, these policies are somewhat isolated from the larger workforce development, housing, land-use and economic growth trends that affect job accessibility. The following recommendations could be considered, in addition to the positive steps already taken, to improve job accessibility of the urban poor:

Transportation planning should be coordinated with real-estate developers, employer representatives, municipal governments and social service agencies: Much greater coordination is needed in integrating land development and social services, including human services, workforce development and job placement strategies, with transportation. The current pattern of fragmented policies can be alleviated only if the key stakeholders responsible for land-use, economic development and social policies are formally and actively a part of the process. Business leadership is indispensable in this phase of the city's growth since the great economic growth trends have significant implications for attraction of a larger workforce and the generation of freight transportation. Economic development and job creation strategies in neighboring satellite cities should be vigorously pursued to address the continuing rates of urbanization. Moreover, planned land development should be sustained over time, in contrast to previous planned activities that were started in the 1960's, in the periphery of the city.

Greater investment is needed in fundamental transportation infrastructure that supports the urban poor: It is clear that a complex urban area like Delhi will need a variety of solutions to address the fast-paced growths in personal mobility. The current investments in rail and BRT are a step in the right direction, but increased investments in feeder services to these systems and high-quality express bus should be a part of the strategy. Most importantly, investments are needed in safe pedestrian and bicycle facilities and in the physical coordination of such facilities with facilities for motorized transportation. Given the narrow roads, emphasis on BRT and the wide-spread practice of street parking, dedicated bike lanes have not received political support. However, given that close to 40 percent of low-income commuters use bicycles and rickshaws, a practice of rush-hour bike-only road segments might be instituted in secondary roads and supplemented by strict enforcement of no-parking in primary roads.

Employer participation, tax incentives and jobs-housing balance should be a part of the strategy: Many low-wage workers will simply not have the means to commute to jobs in far-away locations; hence a strategy needs to be in place to directly address job-housing balance and the financial needs of workers to afford public transportation. Key in this strategy will be the participation of employers (or groups of employers) in providing transportation to their employees, which can be increased by creating a system of corporate tax incentives for providing employment transportation and worker housing. In order to increase affordability of existing public transportation, a system of tax credits can also be created to subsidize commutes by low-

wage workers. The government should also attempt the dedication of land for informal housing near job-rich locations or near transportation hubs.

Incentives and information regarding informal, community-based transportation should be instituted: Informal, community-based transportation (called jitneys in some developed countries), paratransit services, ridesharing programs and self-organized vanpools should be actively pursued and incentives provided for participation in such transportation.

Information Technology should be leveraged in personal transportation: The idea of "New Mobility Hubs" (Zielinski, 2006), which connect a variety of sustainable modes of transportation and services through a network of physical locations or "mobile points", by physically and electronically linking the elements necessary for a seamless, integrated, sustainable door-to-door trips, should be explored. India's significant investments on Intelligent Transportation Systems and the telecommunications sector, and the rapid adoption of mobile phones, can greatly facilitate the use of such hubs. Many specially designed mobile phones are now in the market, putting these devices within reach of the poor. Facilities that connect pedestrians, bike-rentals, bike-sharing stations and indigenous modes of non-motorized transportation such as rickshaws to rail and BRT stations, and that are integrated with these high-speed systems by means of real-time travel and connection protection information, as well as subscription and payment systems, are a part of a concept. For longer trips, these fixed-route transit services can also be connected to auto-rickshaws (motorized rickshaws), station cars and ridesharing programs.

Investment in data programs are needed: In order to effectively include job accessibility for all income groups as a performance measure in the transportation planning process, far greater investments are needed in household travel surveys and special purpose surveys on the travel behavior, activity patterns and residential location of low-income workers. It is equally important to link such transportation data with information on labor markets, workforce development housing and land-use. Researchers should also be given special access to small-area transportation, economic and workforce-related data, so that the fundamentals that drive transportation demand and job accessibility are better understood.

CONCLUSIONS

Job accessibility should become an essential ingredient in planning sustainable transportation systems, so that the social equity aspects of metropolitan areas in developing cities can be enhanced. Accessibility to jobs is recognized to be important in achieving beneficial labor market outcomes, but is often ignored in the practice of transportation planning and in the prioritization of expensive infrastructure projects .

This paper attempts to add to the discussion on the importance of considering job accessibility

in sustainable transportation planning in developing cities, by examining the case of Delhi. The paper shows that job accessibility is affected by a myriad of economic development, housing, land-use and demographic processes and the solutions to enhance accessibility should likewise be multi-pronged and based on a combination of transportation and urban development, workforce development and human services strategies. As the transportation policy environment evolves in response to choking congestion, bad air and road fatalities, it is essential that the job accessibility considerations of the urban poor become an integral part of the overall agenda towards planning sustainable transportation systems in developing cities. The strategies that need to be leveraged in order to improve job accessibility are likely to be different in different cities, but sustainable transportation planning necessitates that planners attempt to understand where workers live and where the jobs are and the underlying processes, which contributed to spatial distribution of jobs and workers.

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