EFFECT OF INDIVIDUAL CHARACTERISTICS AND SPATIAL CONFIGURATIONS ON ACCESSIBILITY AND MOBILITY: CASE OF DELHI*

by Kirti Bhandari**, Noriyasu Kachi***, Hirokazu Kato****, Yoshitsugu Hayashi*****

1. Introduction

The purpose of this study is to understand "accessibility" and "mobility" concerns in a developing mega city taking Delhi as an example. This study tries to explore people's perception towards accessibility to different land use activities by population groups and location. Further, it tries to assess the affect of household characteristics such as income level and vehicle ownership on mobility.

2. Relationship between accessibility and mobility

"Accessibility" may be defined as the description of proximity to destinations of choice and facilities offered by transportation systems. It may be regarded with four components, land use, transport, temporal and individual. "Mobility" on the other hand is the ability to travel to destinations and the freedom to undertake desired travel activities, or simply the efficiency of movement. It refers to the time and cost required for travel between destinations. It is higher when the travel times and costs are low. Mobility may be regarded to be comprised of 'push' and 'pull' factors. Economic growth and lifestyles contribute to increase in mobility and constitute the 'push' factors. Factors related to traffic and transport may be regarded as the 'pull' factors

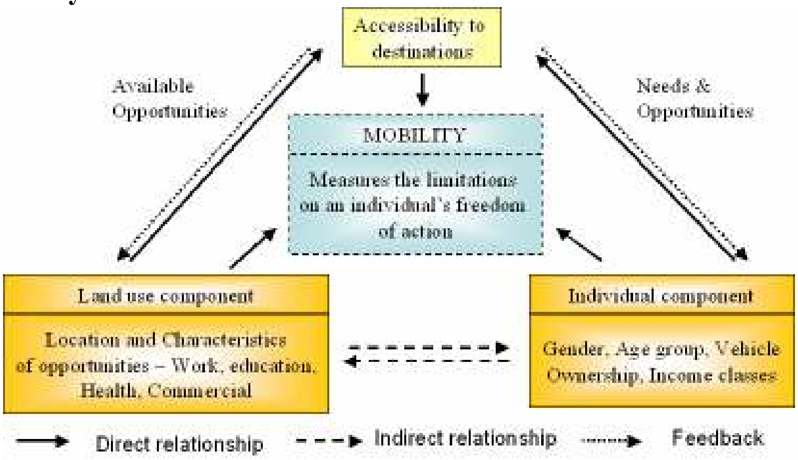

Fig 1. Relationship between accessibility and mobility

Fig 1 shows relationship between components of accessibility and mobility. Distance separates people's homes and the destinations that they desire to reach according to their needs. Mobility enables people to overcome this distance. Land use and transport component (and therefore accessibility) is thus crucial factor in determining mobility. Access to destinations is directly influenced by the available opportunities in each zone. Similarly, access is also directly influenced by individual needs and opportunities. The individual component (of gender, age, vehicle ownership and income) directly affects mobility, since these factors may influence the time and cost to travel. Accessibility strongly influences mobility. Land use component is an important factor in determining accessibility which is also influenced by people's opportunities. Mobility, which is the measure of an individual's freedom to undertake desired activities, is also influenced by the land use and individual components of accessibility. The present study tries to capture

*Key Words: Attitude survey of transportation
**PhD candidate, Graduate School of Environmental Studies, Nagoya University,
(Chikusa-Ku, Furo-Cho, 464-8603, Nagoya, Japan. TEL: 052-789-2773, FAX: 052-789-3837)
***Dr. of Env., Graduate School of Environmental Studies, Nagoya University
****Dr. of Eng., Graduate School of Environmental Studies, Nagoya University
*****Fellow of JSCE, Dr of Eng., Graduate School of Environmental Studies, Nagoya University

accessibility components and individual components related to mobility needs of different population groups (by gender, age, location, vehicle ownership, income class) in the case of a developing city, taking Delhi as an example.

3. Accessibility within NCT and DMA townships

Table 1. Background information about Delhi (2001-2002)

Population	13, 850,000
Population Density	10,360 persons/km^2
Area	1483 sq. km.
GDP per capita	Rs 29037
Average trip length	14 Kms
Average trip time	60 mins
Average speed on road	21 Km/hr

Table 1 provides background information about NCT Delhi. The population of Delhi in 2001 stood at almost 13 million, with a density of 10,360 persons/Km^2. Delhi has a strong and growing economy. A large number of office locations are now being located in the DMA townships, which are a part of the NCR region.

Accessibility for different types of land use activities within National Capital Territory (NCT) of Delhi and the satellite cities as shown in Figure 2. Potential accessibility measures (also called gravity-based measures) have been used to estimate accessibility to different land use opportunities. Figure 2 shows that the city centre produced the highest accessibility which decreases towards the city periphery. Peripheral zones in NCT tend to show low values of accessibility. However, the DMA towns show relatively higher accessibility. The basic form of gravity based accessibility function is given by equation 1.

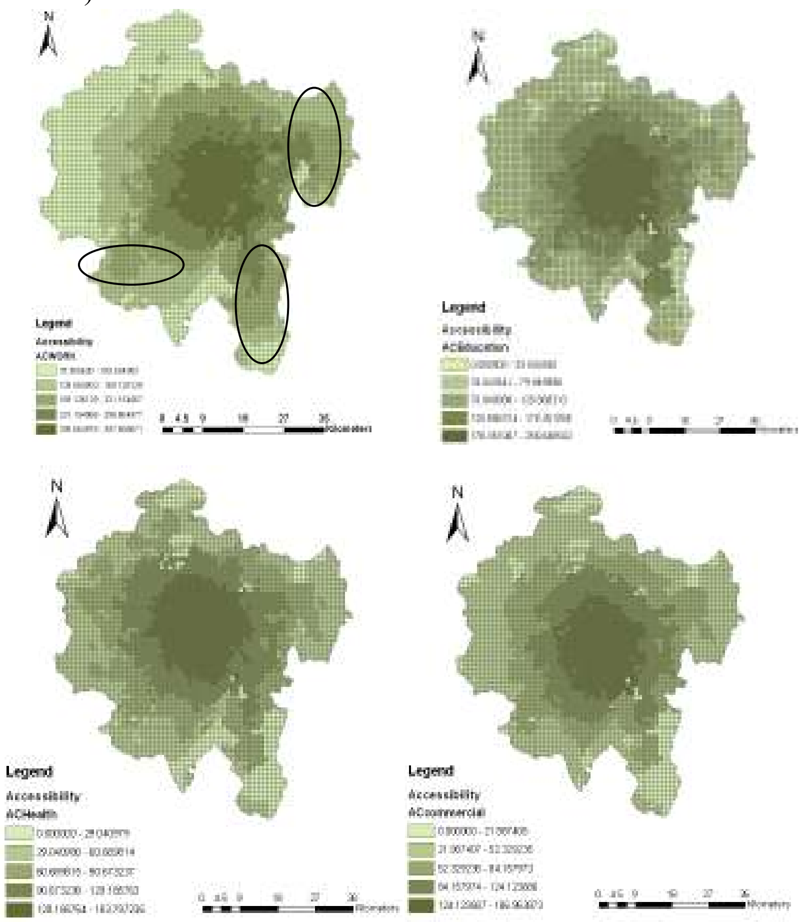

Fig 2 : Accessibility to different land use activities within NCT and satellite townships of Delhi (2007)

Position of DMA towns

$$A_i = \sum_j L \ \exp^{-\beta t_{ij}} \qquad (1)$$

Where, A_{ij} = Accessibility of origin zone *i* by the destination zones *j*; L is the number of opportunities in zone *j*; $f(t_{ij})$ is impedance function in terms of C_{ij} as travel time between zones *i* and *j* for all type of trips.

4. Individual mobility needs and opportunities

Social recognition and satisfaction surveys and related empirical analysis have found fairly more applications in the developed nations than in developing countries. Presented below are the results of the questionnaire survey that provide some insight about individual preferences regarding accessibility to different land use activities in the developing cities, where there is still a gap in research. Surveys were conducted in September 2007 at five selected locations in Delhi. The total sample size is 352 consisting of 81% males as against 19% females. Given the perception of mobility associated with access to different urban facilities, respondents were asked to rank by importance among the four accessibility components of: time to work, time to educational facility, time to hospital and time to commercial centers, when deciding there place of residence. Following this the respondent was asked to choose the most desired combination of alternatives of the chosen indicator among the seven options available.

The mathematical structure for the multinomial logit model (MNL) which gives the choice probability of each alternative as a function of the systematic portion of the utility of all the alternatives is given below. The general expression for the probability of choosing alternative '*i*' (*i* = 1,2,3…*J*) from a set of J alternatives is:

$$\Pr(i) = \frac{\exp(V_i)}{\sum_{j=1}^{J}\exp(V_j)} \qquad (2)$$

Where,

$\Pr(i)$ is probability of the decision maker choosing alternative *i* and

V_j is systematic component of the utility of alternative *j*

Table 2 shows the estimated results of weights for mobility preference by population groups. The four components of accessibility are work, education, health facilities and commercial facilities. Accessibility to work is given the highest priority by the men in the age group of 20-29 years. However this priority shifts towards education in the following age bracket, where work still remains important. In the older age groups of men work gets the highest priority, followed by education. In the age groups of 60-69 years access to heath has been weighed as the most crucial. In general, access to heath has remained fairly important over different age brackets, where as accessibility to commercial facilities has been perceived as the least important. In the case of women, access to education has been perceived to the most important in the age group of 20-29 years. This remains of the highest priority in the following age group of 30-39 years, where work takes the second priority. However, in the age groups of 40-49 years access to work and health are perceived to be more important. As in the case of men, access to commercial facilities is the least important also for women. Perceived importance of access to commercial facilities has been given by men in the age group of 60-69 years and women of age group 20-29 years.

Table 2: Estimated parameters for mobility preferences by population groups

Gender	Age Group	Accessibility Indicator			
		Work	**Education**	**Health**	**commercial**
Male	20-29 yrs	3.53 (6.61)	1.95 (3.75)	2.15 (4.16)	1.32 (2.61)
	30-39 yrs	2.49 (7.27)	2.89 (8.35)	2.14 (6.34)	1.05 (3.20)
	40-49 yrs	4.74 10.45)	2.09 (4.65)	2.11 (4.82)	0.544 (1.32)
	50-59 yrs	4.74 (6.89)	3.13 (4.61)	0.782(1.28)	0.621 (1.03)
	60-69 yrs	2.06 (2.33)	1.15 (1.33)	3.16 (3.48)	2.06 (2.33)
Female	20-29 yrs	0.840(1.20)	3.74 (4.90)	2.23 (3.12)	2.50 (3.38)
	30-39 yrs	3.87 (5.16)	4.02 (5.37)	1.80 (2.63)	0.862 (1.33)
	40-49 yrs	5.00 (3.38)	2.92 (2.16)	4.08 (2.80)	-0.831(-0.717)

Values in parenthesis are t-value

Table 3 shows the estimated results of weights placed on each parameter of accessibility by location. It is evident that the respondents from the suburbs placed higher weights on the all components of accessibility, except for education. In order to assess mobility, we assess the effect of Income and vehicle ownership on an individual's freedom to perform activities. Mobility preferences for suburban respondents are comparatively higher as compared to the respondents from city centre (Fig 3). The study also shows that as incomes become higher, mobility preferences shift towards education and health, as shown in Fig 4, whereas for lower income classes work remains a priority. Personal mobility is also influenced by ownership of private vehicles which is depicted in Fig 5. Respondents with no personal vehicle placed higher priority for work, whereas mobility to

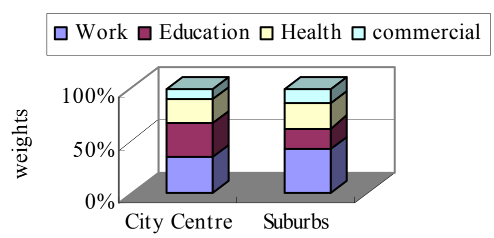

Fig. 3 Mobility preferences with respect to location

reach different destinations increases with possession of private vehicle.

Table 3: Estimated parameters mobility preference by location (all sample)

Location	**Accessibility Indicator**			
	Work	**Education**	**Health**	**Commercial**
City Centre	3.08(13.89)	2.77(12.54)	1.98(9.22)	0.899 (4.33)
Suburbs	4.10 (9.19)	1.8 (4.38)	2.24(5.27)	1.34 (3.26)

Values in parenthesis are t-value

Table 4: Estimated parameters of mobility preference by Income groups

Income Class	**Accessibility Indicator**			
	Work	**Education**	**Health**	**Commercial**
Low	5.72(11.78)	1.65 (3.62)	2.08 (4.54)	0.59 (1.36)
Middle	3.09 (12.2)	2.83 (11.2)	1.70 (6.99)	1.06 (4.44)
High	1.36 (3.07)	3.22 (8.89)	3.49 (7.40)	1.44 (3.25)

Values in parenthesis are t-value

Table 5: Estimated parameters of mobility preference by Vehicle ownership

Vehicle ownership	**Accessibility Indicator**			
	Work	**Education**	**Health**	**Commercial**
Vehicle owners	3.12 (13.7)	2.89 (12.8)	1.95 (8.9)	0.935 (4.42)
No vehicle owners	6.29340 (9.50)	0.98 (1.66)	2.47 (3.84)	0.246 (0.428)

Values in parenthesis are t-value

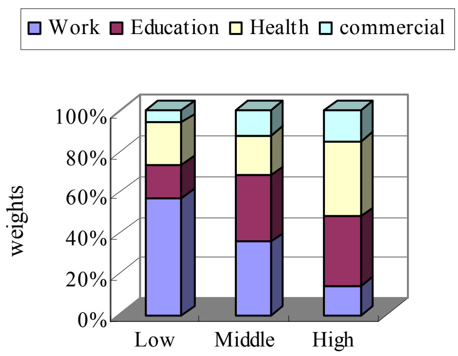

Fig. 4 Mobility preferences with respect to Income class

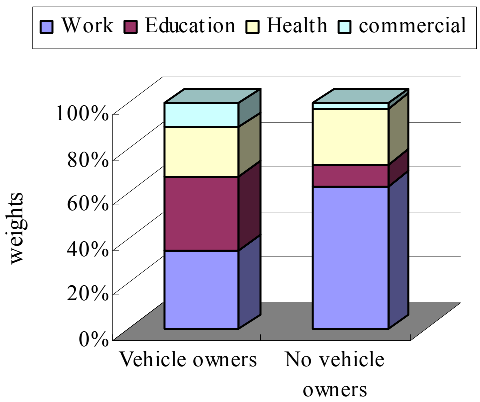

Fig. 5 Mobility preferences with respect to vehicle ownership

5. Conclusions

This main focus of this study was to understand land use and transport accessibility and its relation with individual mobility. Accessibility, governed by land use and transport, is high in the city centre and decreases as we move away from the NCT Delhi into the satellite townships. Factors that influence individual mobility needs and preferences differ by population groups (age and gender), location, income classes and ownership of private vehicle. People with lower income and no personal vehicles regard work as the most important, whereas improving lifestyle leads to an increase importance in the nature of trips undertaken for purposes other than work ("push factors"). Further work involves examination of time and cost as important mobility indicators which influence accessibility and mobility.

References

1. Kachi, N. et al. (2005). Making cities more compact by improving transport and amenity and reducing hazard risk. Journal of Eastern Asia Society for Transportation Studies, Vol.6, pp3819-3834