A Micro-Analysis of Accessibility and Travel Behavior of a Small Sized Indian City: A Case Study of Agartala

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***Abstract*-Changing land use and lack of proper transportation planning is highly correlated with the implications of traffic congestion. Ample evidence exist that the degree of accessibility, the land use and the various opportunities available in an area, represents one of the most effective tools available for dealing with various kinds of issues related to the sustainable development of any town or city. Agartala is one of the small cities in north eastern part of India which is growing rapidly in a short span. As a result there is a need for efficient public transport infrastructure and policies which have to be adopted in order to shift the dependency on motorised private vehicles to transit facilities and other non motorised transport modes. In this study an attempt has been made to link few aspects of travel behaviour i.e. choice of motorized/non-motorized modes and trip length changes with land use, accessibility and to find the effect of travel behaviour on the same. This study quantifies the effect of accessibility of various opportunities available, in the form of cumulative and gravity indicesusing geographic information system. In both the cases it was found that accessibility to opportunities along with socioeconomic parameters; significantly affects the travel behaviour parameters.**

Keywords – Accessibility, Mode choice, Travel behaviour

I. INTRODUCTION

In recent years, the economic and environmental implications of traffic congestion have been linked to the lack of coordination between land use and transportation planning. Many researchers have so far studied that the geographic distribution of various opportunities and population is far more crucial than density alone in creating changes in travel in different locations. It has been noted that land use connected to the degree of accessibility and the various opportunities available represent the most fundamental and potentially effective tools available for coping with the kinds of travel related issues.

The term accessibility is related to two major components which are land use and transport infrastructure. This is clearly understood as accessibility to facilities is directly related to location of activities, distances to various centres and facilities which are again related to land use mix. Accessibility also refers to the ease of reaching destinations. People who are in places that are highly accessible can reach many other activities or destinations quickly; people in inaccessible places can reach fewer places in the same amount of time. This is the simplest approach towards defining accessibility. Thus accessibility of a location is found to be an important determinant of the development potential of a location. Hansen (1959) was the first to define accessibility as "the potential of opportunities for interaction [7]." Thus it can be stated that accessibility works as an intermediary between land use and transport elements.

Density, diversity and design are the features which influence travel demand, as stated by Handy and Niemeier (1997)[6].In the past studies it is inferred that the built environment is defined as consisting of three general components: land-use patterns, transportation system and design. Increased density reduces per capita vehicle ownerships and results in alternative modes of Transport. In the cities of developing countries like India, urban densities are significantly increasing and this situation has led to increasing traffic congestions. So it is obligatory to study this alteration and its effect on the travel behavior and adopting congestion management policies for dealing with this problem.

II. CHARACTERISTICS OF THE COLLECTED SAMPLE

A. Details study area

Agartala the capital city of Tripura is one of the seven sister states located in the north-east corner of India. It is having a population of about 3.99 lakhs as per census 2011 with an area of 58.84 sq km. The Agartala Municipal Corporation or AMC consisting of 35 municipal wards is the municipal body which governs and maintains the city of Agartala.

B. Details of the collected sample

Sample data including travel data and socioeconomic details have been collected from the study area. The socioeconomic and travel characteristics include age, gender, driving licence status, vehicle ownership, years of education, travel cost, travel time, etc. The land use details of the study area have been collected The collection of data has been carried out in two intervals; one day travel diary for work trips have been collected through a household survey conducted in the study area during March-September, 2012 and another during October-December, 2014. Statistics of sample data are given in Table 1. The modal split of the collected data is shown in Figure 1. Mode of travel were generally categorised to Car, Bus, Motorized Three Wheeler (MThW), Rickshaw, Bicycle, Motorized two wheeler (MTW).Land use data has been classified into four groups, namely commercial, educational, service, social welfare centres. ArcGis10 has been used for storing and analyzing the collected data. Data were collected at microscopic level using GPS technology and digitized in ArcGIS10.

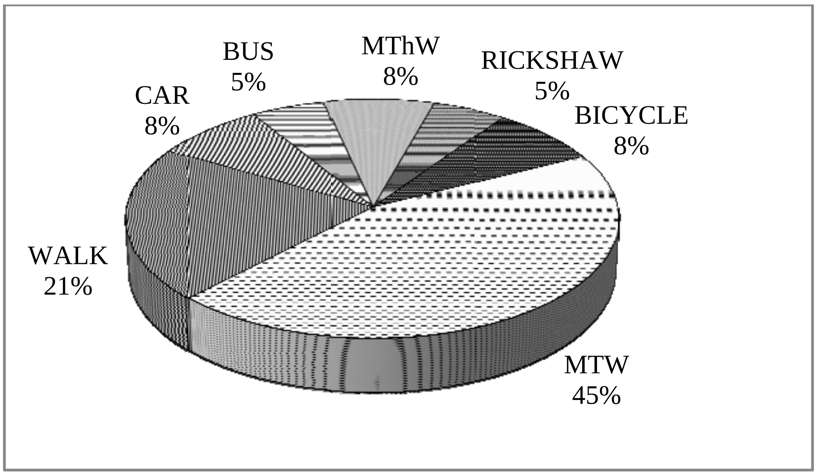

Fig.1. Modal compositions for work trips

From Figure 2 it can be seen that most of the trips were undertaken by walk and rickshaw mode, for trip distance varying from 0-2 km. Thus it is clearly evident from the above distribution that when the trip distance is small commuters prefer walking and availing rickshaw as their mode of travel while making the wok trips. This also indicates that the more accessible opportunities are the lesser will be the trip length.

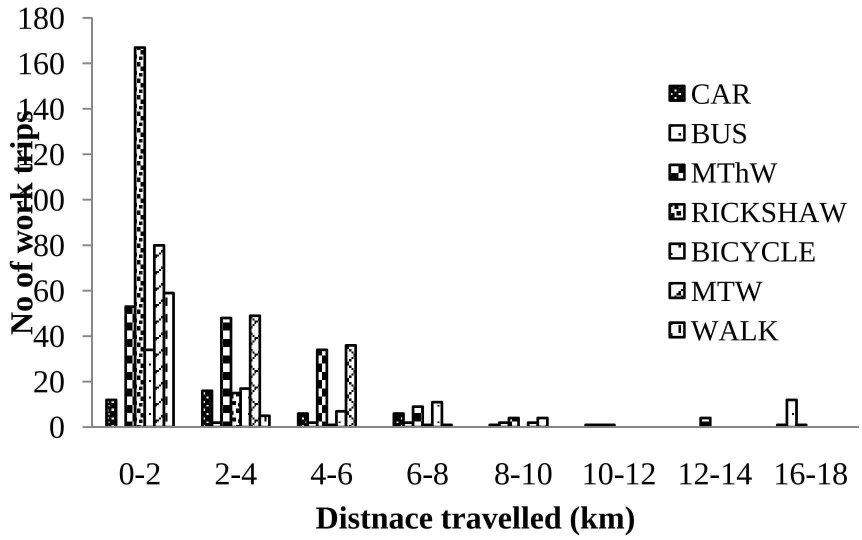

Fig.2. Distribution of mode choice for work trips based on trip length

Table I: Summary of socio-demographic data obtained from the sample

Socio-demographic data	Value in percentage
Gender	
Female	18.61
Male	81.38
% of individual in the age category	
<20	1.01
20-30	15.44
30-40	20.78
40-50	30.59
50-60	28.14
>60	4.04
% of household having driving license	
having	51.08
not having	48.92
% of individuals (years of education)	
0-6	3.17
6-12	28.86
12-18	64.07
>18	3.90
Monthly personal income (in Indian rupees)	
0-2000	0.14
2000-10000	25.83
10000-20000	25.40
20000-50000	36.94
>50000	11.69
Car ownership	20.78%
MTW ownership	52.67%
Bicyle ownership	14.86%

C. Accessibility parameters

Since this study concentrates on the relationship between urban form, accessibility measures and choice of the people, the study focuses on the integral measures of accessibility derived from the residential locations of households. Handy and Niemeier (1997) state there is no best suited approach in connection with measuring accessibility [6]. A few of them relate to degree of attractiveness, size or areal extent of zones, origins and destinations, and others are function of time and cost known as the impedance factor. Out of the various measures of accessibility two trips based measures namely cumulative and gravity measures have been used in the evaluation process on the basis of certain criteria based on specification, calibration and interpretation. The study includes the comparison of these two measures of accessibility and the suitability of the same. The entire study area has been divided into transport analysis zones (TAZs) based on the municipal wards and integral measures of accessibility have been calculated. Cumulative opportunity measures and gravity based measures for all trip purposes within an arbitrary buffer zone of 1000 meters from each household location have been measured. Since most of the trips were found to be ending within a distance of 1000m, thus 1000m was considered as the cutoff region. The attractiveness portion of accessibility was taken as the entire landuse area of each buffer zone expressed as a proportion of the entire area of a buffer created around each household location. An impedance function was also incorporated with this attractiveness component.

$$A_j = \sum_j a_j W_j (1)$$

Where, in a buffer zone j,$a_j$is thetotal land use area expressed as a proportion of the buffer area

$$W_j = 1, if\ C_{ij} \leq C_{ij} *$$

$= 0$, otherwise

$C_{ij}$is the measure of impedance between origin i and destination j,C_{ij} * is the threshold region of 1000m buffer.

III. RESULTS

Many of the past studies have pointed out a strong influence of accessibility of opportunities on the VKT (vehicle kilometres travelled). As a proxy to the VKT, trip length was analysed for any significant effect of the land use mix and accessibility.

Table II Model on Trip length per individual for work trips

Socioeconomic parameters	**Base model with socioeconomic variables only**	**Cumulative accessibility**	**Gravity measures**
	Coefficient (t value)	Coefficient (t value)	Coefficient (t value)
Constant	2.822 (3.033)	2.672 (2.884)	2.801 (3.017)
Age	-0.036 (-2.860)	-0.035 (-2.797)	-0.036 (-2.859)
Vehicle ownership	0.492 (1.712)	0.546 (1.907)	0.535 (1.858)
Cumulative accessibility		-0.823 (-2.772)	
Gravity measures			0.000 (-1.924)
R2	0.035	0.049	0.042

The accessibility indices were found to have strong influence on individual's trip length for the trips. The coefficients, with negative sign, represent that the trip length will be more if there is less accessibility to opportunities.

Several logit models were also framed to check the effect of the proposed indices on the utility of each travelling mode. A multinominal logit model and a binary logit model have been used to find the most probable mode choice based on the utility of the commuters. The attributes were used to check utility maximization of different modes. BIOGEME (BIerlaire's Optimization package for GEV Models Estimation) was used to construct the modelling framework.

Table III: Non-motorized and motorized vehicle choice model for work trips

Socioeconomic parameters	**Base model with socioeconomic and other travel parameters**	**Model with Cumulative accessibility parameter**
	Coefficient (t value)	**Coefficient (t value)**
Constant (motorised)	Fixed	Fixed
Constant (non-motorised)	0.583 (1.85)	0.543 (1.17)
Income	-0.0878 (-1.79)	-0.0848 (-1.72)
License	-0.885 (-3.28)	-0.915 (-3.36)
Bicycle ownership	1.05 (4.02)	1.08 (4.13)
MTW ownership	-1.13 (-4.32)	-1.15 (-4.35)

Motorised travel time	-2.87 (-1.73)	-2.83 (-1.72)
Non-motorised cost	-0.0207 (-1.98)	-0.0207 (-1.97)
Cumulative accessibility non-motorised mode		0.346 (1.69)
R^2	0.270	0.273

Table3 describes the result from binary logit model on motorized and non-motorized mode choice for work trips.Having driving license, less monthly income, non-motorised vehicle ownership, increases the utility of non-motorized modes; while having motorised vehicle ownership reduces the utility of non-motorized modes. An increase in cumulative accessibility was also found to be enhancing the utility of non-motorized modes. When accessibility measure entered the model, the improvement in the model was relatively better than the model with only socioeconomic variables. The gravity measure of accessibility was found to be insignificant in explaining its behaviour in this model. The final model contains cumulative accessibility index along with socioeconomic variables. The base model was estimated by considering only individual specific and mode related variables. Increasing accessibility increases the utility of the non-motorised modes. Increasing travel cost and travel time as expected significantly reduces the utility of the non-motorised modes.

TableIV: Multinomial logit model for work trips

Variable description	**Model socioeconomic parameters**		**Model Cumulative accessibility**		**Model Cumulative and gravity accessibility**	
	Coeff.	**t value**	**Coeff.**	**t value**	**Coeff.**	**t value**
ASC *Car*	0.00	Fixed	0.00	Fixed	0.00	Fixed
ASC *Bus*	-0.731	-0.78	-0.825	-0.88	-0.859	-0.91
ASC *Auto*	0.274	0.45	0.116	0.19	0.0780	0.13
ASC *Rick*	-0.249	-0.74	-0.358	-1.05	-0.323	-0.94
ASC *Bicycle*	1.36	3.39	1.28	3.10	1.26	3.03
ASC *MTW*	0.158	0.22	0.146	0.20	-0.177	-0.23
ASC *Walk*	-0.766	-1.06	-0.876	-1.19	-0.972	-1.31
Age *Bus*	-0.0512	-2.29	-0.0512	-2.29	-0.0514	-2.30
Bike own *Auto*	-0.518	-1.76	-0.485	-1.64	-0.541	-1.83
Car own *Auto*	-0.855	-2.07	-0.815	-1.96	-0.798	-1.91
Education *Auto*	-0.0572	-1.50	-0.0535	-1.40	-0.0519	-1.35
Employment *Walk*	1.60	2.72	1.48	2.50	1.49	2.51
Gender *Rick*	-1.10	-3.30	-1.06	-3.16	-1.11	-3.30
Income *MTW*	-0.223	-2.48	-0.237	-2.59	-0.215	-2.24
Income *Walk*	-0.214	-2.68	-0.220	-2.62	-0.234	-2.74
License *Bicycle*	-0.791	-1.39	-0.768	-1.33	-0.744	-1.27
License *MTW*	2.94	5.38	3.02	5.48	2.95	5.15
Cumulative *Walk*			3.17	2.54	10.5	2.20
Gravity *MTW*					0.00421	1.86
R^2	0.420		0.429		0.438	

Table 4 describes the result from mode choice model based on multinomial logit model for work trips. The first model was estimated considering the socioeconomic parameters only which shows that having lesser MTW (Motorised Two Wheeler) and car ownership increases the dependency on MThW (Motorised Three Wheeler) mode. It has been found that more female commuters opt for rickshaw as their mode of travel. The utility of MTW increases with the possession of driving license and higher income. Out of the two accessibility parameters, both were found to be significant and positive for walk and MTW modes; whereas travel time and cost parameters were not found to be significant enough in the multinomial model. Thus the final model contains socioeconomic and accessibility parameters, where addition of accessibility measures showed a significant improvement in the model.

IV. CONCLUSIONS

In this study an attempt has been made to find the relationship between travel behaviour and the accessibility in the context of a small unplanned city like Agartala. In order to quantify travel behaviour, few factors affecting travel behaviour such as, destination accessibility (expressed as cumulative and gravity measures), distance to destinations in terms trip lengths and the choice of motorized/non-motorized mode were used. Utilities of various modes have been formulated using the socioeconomic, land use, accessibility and mode related attributes. The following are the important conclusions drawn out of the present work on interaction of travel behaviour and land use and accessibility to opportunities:

The accessibility parameters were negatively correlated with the trip length for work trips.

All other socioeconomic parameters showed desired correlation with trip length following the general hypothesis.

The binary model depicted that the cumulative accessibility index was well efficient in explaining the mode choice. In this case effect of gravity measure was found to be negligible.

The coefficients of accessibility are positive for non-motorized modes of transport which implies that the trip makers residing in the areas with better accessibility to their needs prefer non-motorized modes of transport.

From the MNL model estimated on the mode choice for work trips, it can be inferred that the trip makers residing in the areas with better accessibility to their needs prefer walk and MTW modes of transport.

Thus it can be concluded from the models estimated that the socioeconomic variables have significant effect on the utility of different modes. Along with them the proposed measures of accessibility incorporating the land land use mix parameter were found to be efficient in explaining the significance of the accessibility on travel behaviour.

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