EFFECTS OF LAND USE ON TRIP GENERATION IN URBAN AREAS: COMPARISON BETWEEN ESTIMATED TRIP GENERATION RATES AND PLANNING PRACTICES IN DAR ES SALAAM, TANZANIA

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ABSTRACT
In developing countries cities, the development of planned urban areas is associated with rapid changes in land uses. The number of vehicles trips generation in the planned area is related to the types, patterns and characteristics of land uses in that particular area. However, still it is unclear to what extent the change of land use affect trip generation rates in urban planned areas. This study has examined the effects of land use changes on trip generation rates for different residential land uses. A methodology for deriving trip generation rates for different residential land uses was developed. Additionally, the study made comparisons between vehicles trip generation rates provided in land use and transport planning manuals for local practitioners and rates obtained in the study area. Furthermore, the study identified the factors considered by planners and policy makers in order to reduce the effects of land use change in planned urban areas. This study therefore recommended the need of conducting site or city specific vehicle trip rates rather than adopting trip rates from different transport manuals.

Key words: Trip generation rates, household characteristics, travel attributes and dwelling categories.

1.0 INTRODUCTION

In developing countries cities, the changes in land use have great impacts on trip generation. A number of studies have described the causal relationships between the changes in land use and trip generation. Consequently, correlations between land use variables and trip generation have been established. However, it is still unclear to what extent the change of land use affects trip generation rates in planned urban areas. This knowledge gap has made it difficult for decision makers, planners and policy makers to effectively practice the changes in land use policies without affecting transport infrastructure.

The objectives of this study are: (1) to examine the effects of changes in land use on trip generation rates used by local practitioners for different residential land uses; (2) to develop methodology for deriving trip generation rates for different residential land uses in the study area; (3) to compare trip generation rates provided in land use planning manuals and rates obtained in the study area; (4) identify factors which need to be considered by planners and policy makers in reducing the effects of land use changes in urban planned areas.

A case study approach was adopted in carrying out this study whereby 304 households were surveyed in the study area. Regression models were used to determine number of vehicle trips generated per household per day. The model coefficients and values of independent variables were used to determine vehicle trips generated for work, school, shopping and recreation purposes. Then, trip generation rates for each purpose were aggregated in order to determine vehicle trips generated in detached, semi-detached, terraced and apartment dwelling categories.

The process of determining vehicle trip generated by the household per day was in two main parts. The first part includes determination of values of household characteristics (independent) variables applied in the model and second part entailed aggregation of trip generation rates for different purposes within specific dwelling category (dependent variables). The difference between rates in the manual and study area have depicted that extra vehicle trips were generated by individual household per day in detached, terraced and apartment dwelling categories and fewer trips were detected in semi-detached dwelling category.

The rate of change in household characteristics variable and trip generation rates which were analysed in this study and created questions regarding the application of rates provided in Urban Land use and Transport Planning Manual (ULTPM) in estimating and forecasting transport demand.

2.0 LITERATURE REVIEW

The process of estimating trip rates includes determination of the actual amount of travel in the region or specific planned zone which is functionally related to land use distributions. The estimate of trip rates is described in terms of character, intensity and location of activities. Factors influencing the amount of travel in the planned area include automobile ownership, income, household size, density and type of developments, and availability of transport infrastructures. The purpose of trip estimation is to determine the number of person trips or vehicle trips of designated land uses. Person trips estimates are based on population projection data from residential dwellings and household sizes whereby number of vehicle trips are estimated to every individual person per day, while trips per land uses are based on functions of land parcels and sizes in terms of ground areas or floor areas (Kitamura *et al*., 2006). Trip estimates are categorized into three major groups:

(i) Site specific impact analysis for assessing the effects of new developments together with vehicle trips expected to be generated by the proposed development.
(ii) Short and long term development alternatives for evaluation of transport needs in specific urban areas.
(iii) Long term development plans which consider vehicle trip generated by different types of developments in the country or entire region.

This review have concentrate with item number two, but specifically for vehicle trip rates generated in urban residential development areas which are most vulnerable for change of land use.

Residential trip generation rates are a fundamental component of transportation planning. Miller *et al*., (2012) conducted the household surveys in four residential neighbourhoods in order to determine trip generation rates from travels made by individual households in the neighbourhoods. Obtained rates were compared with the national trip generation rates provided in the manual by the Institute of Transportation Engineers (ITE). Generally, rates obtained in the study area were different from the manual rates. Single-family detached homes indicated slight different between site-specific household surveys and ITE's trip generation rates. However, rates were significantly different on apartment dwellings. A summary of different in vehicle trip rates between ITE and observed trip rates are not frustrating transportation planners, rather, they illustrate the need of determining self-controlled rates for specific planning area, town or city. Even when equivalent methods for determining rates are used for similar neighbourhoods, differences will occur because of the large and random variation inherent in trip generation. Borrowing rates from ITE or other sources may indeed be tolerable, but only if one gives the full range of rates possible from this process which is of probability rather than just the expected mean rate which are prone to uncertainty and biases.

Ellys and Reid (2009) cautioned the application of ITE trip generation rates in cities of developing countries. The study was concerned with change of land use patterns and informal development of these cities. The ITE trip rates were called ''borrowed rates''. They suggested the best application of borrowed rates whereby analysts must consider whether the rates can be modified in order to fit for the proposed application. Cities of developing countries have its own growth and travel patterns which are different to developed countries. For example, change of residential detached house to multi storey business complex or hotel is predominantly taking place in cities of developing countries, but happening very rarely in cities of developed countries. Therefore, precautions are need for practical application of borrowed rates in cities of developing countries.

Williams *et al.*, (2006) in ANCHRP-American National Cooperation Highway Research Program, deliberate the techniques for determining parameters for trip generation which is either site specific vehicle trip rates, or household vehicle trip production rates. According to Williams, determining site specific vehicle trip rates involve identification of major land use categories and the number of trips produced or attracted at each land use category. For best practice, vehicle trip data from general land uses such as residential, commercial, institution, recreation and industrial that should be collected in details presented in Table 1.

On the other hand, Filitowish (2011) showed household trip production rates obtained by collecting data sets on ground area or floor area of specific land use category, employee working in the planning area, population, and household size for the specific dwelling unit. Other data include gender, age, household employee, number of vehicle owned in the household, school going children, children not going to school, number of licensed drivers in the household and annual household income.

Totems and Darks (2009) insisted on developing the site specific trip rates rather than adopting the rates developed at different locations for general applications. On the study made to access the limitations for model and trip rates transferability, the major recommendations were to avoid unbranded assumptions that travel estimation factors are universal and therefore travel requirements are the same for all cities worldwide. Therefore, the study insisted to respect the unique characteristics of city travel patterns and to develop the site or city specific trip rates for travel estimation and forecasting.

Institute of Traffic Engineers (ITE) (2012), Trip Generation Manual 9th Edition give the second set of trip generation rates. The rates were derived from household survey data and traffic survey inventories. Generally, the ITE trip generation rates which are also documented in Urban Land use and Transport Planning Manual (ULTPM) 2008 for different land use categories in Tanzania are presented in Table 1. The ULTPM trip rates are categorized into residential and non-residential land use categories. Residential land uses include rates for detached, semi-detached, terraced and apartment which are represented as the number of vehicle trips generated by individual household or dwelling unit per day. Non-residential land uses include rates for commercial, institution, open spaces and industrial which are represented as the number of vehicle trips generated by the floor or ground area per day. The rates are presented in table 1 below.

Table 1: Vehicle Trip Rates in Different Land Categories

Land use	**Vehicle trips**	**Land use**	**Vehicle trips**	**Land use**	**Vehicle trips**
Residential: Vehicle trips per household/dwelling unit per day					
Detached	9.55	Semi-detached	9.55	Block flats and terraced	6.45
Other land uses: Vehicle trips per square meter per day					
Office	0.12	Park	0.14	Schools	0.11
Retail shop	0.7	Bus terminal	0.12	Collage/university	0.12
Bank	1.4	Religious	0.32	Health	0.23
Bank	0.96	Hall	0.11	Medical services	0.34
Shopping Centre/market	0.3	Open space/ recreation	0.013	Reserved/ conserved area	0
Service station	1.5	Sport ground	0.37	Bar & restaurant	0.08
Business park	0.14	Service/light industry	0.06	Manufacturing/heavy industry	0.03

Source: Urban Land use and Transport Planning Manual 1982 revised on 2008

The shortcomings of applying manual trip rates in Tanzania and other developing cities for urban transport planning were described by Filitowish (2011) and TiIsdor (2012) as follows.

- Rapid increase of population in urban planned areas causes high rate of urbanization. Commonly, population is the most important aspect in calibration of trip generation rates. Therefore, over increase of urban population ultimately affect the implication of trip rates.
- Emergency of formal and informal land use changes that do not go in hand with provision of transport infrastructure.
- Uncontrolled housing systems whereby many people are accommodated in the house. This situation is mainly caused by high rate of housing demand and lack of housing stocks in urban areas whereby two or more households can be accommodated in one house or dwelling unit (Gordian et all, 2014).
- Long travel distances to work that necessitate maximum use of automobile transport to the urban majority. This is mainly caused by great percentage of employment opportunities being located far away from residential neighbourhoods (Berry 2003).

3.0 DATA COLLECTION

The study was conducted in Dar es Salaam, the largest city in Tanzania located in the eastern part along the shore of India Ocean. The study area was selected based on the criteria that it has been planned and developed for more than twenty years, covers three or more neighbourhoods and has undergone fast land use changes. Two categories of data were collected in the study area; the first category was land use change data obtained by using the planed land uses of 1992 and satellite images of 2012 digitized in the Arc GIS software. The differences between planned and existing land uses were obtained through overlay functions, which were also verified physically by using GPS receivers in the study area.

Second category include social economic and travel attributes data collected by performing household survey in the study area. To determine the sample size, a random sampling method was applied to avoid biases of respondents in the study area. The responded population were total number of houses or dwelling units which were 6743 houses. The sample size of 377 houses or dwellings was obtained by the formula $n=N/(1+N(e)^2)$ where n is the sample size, N is total number of houses which is the population, and e is the level of precision, that is 0.05 at 95% confidence level (Glenn 1992). The limitations during household survey include inaccessibility to the sampled houses, unavailability and unwillingness of interviewees, however, eighty one percent (81%) which is 304 households of the sample size was interviewed. The respondent was required to state the chain of trips made for the previous working day, and for each trip, the provided data included start and end times, origin and destination of locations, purpose, mode of transport used and distance travelled. Also, the household characteristics data were collected.

4.0 THE MODEL FORMULATION

Models were formulated by using bivariate structure based on household survey data. The salient characteristic of this structure is that, the determined or dependent variables are defined by independent variables in linear form. The number of vehicle trips generated by the household for a specific purpose was expressed by linear function of independent variables such as number of people in the household, number of household employees and non-employed adults, annual household income, number of children in household of pre-school and school age, number of vehicles owned by the household and licensed drivers in the household. In addition, dwelling categories were expressed by dummy variables.

The model was defined as follows:

$$\mathrm{Y}_i^{\,m} = \alpha_0^m + \alpha_i^m \mathrm{X}_{i1} \ldots\ldots + \alpha_9^m \mathrm{X}_9 \ + \ \beta_1^m \mathrm{D}_{i1} \ldots\ldots + \beta_4^m \mathrm{D}_{i4} \ + \ \xi_i^{\,m}$$

Where

$\mathrm{Y}_i^{\,m}$ = Number of vehicle trips made by individual household *i* for purpose *m*

α_0^m = Constant coefficient for purpose *m*

α_k^m = The associated coefficient of household characteristic variable *k* for purpose *m*

β_j^m = The associated coefficient of dummy variable *j* for purpose *m*

X_{ik} = Value of characteristic variable *k* for household *i*

D_{ij} = Dummy variable: 1 if household *i* is living in dwelling category *j*, 0 otherwise

$\xi_i^{\,m}$ = A random error term of household *i* for purpose *m*

4.1 Variables

Both dependent and independent variables are shown in table 2. Dependent variables include vehicle trips made by individual households for the purposes of work, school, shopping and recreation. Explanatory variables are variables that describe household characteristics and dummy variables characterising the dwelling category of the household such as detached, semi-detached, terraced or apartment dwelling.

Table 2: Specification of the Variables in the Vehicle Trip Generation Models

Dependent variables (Y_i^m)			
VTW	Vehicle trips for work	VTSh	Vehicle trips for shopping
VTS	Vehicle trips for school	VTR	Vehicle trips for recreation
Independent variables - Household characteristics (X_{ik})			
NPHH	Number of people in the household (household size)		
EmpHH	Number employees in the household		
UnEmp	Number of adults in the household who are not employed		
VOHH	Number of vehicles owned by the household		
LDHH	Number of licensed drivers in the household		
PSchHH	Number of pre-school children in the household (between 0-5 years)		
SchHH	Number of children of school age in the household (between 6-18 years)		
AHH	Number of adults going to high school and college (19 years and above)		
AIHH	Household annual income (in Tanzanian Shillings)		
Independent variables - Dwelling categories (D_{ij})			
VTODH	1-if the household lives in a detached dwelling, 0 otherwise		
VTOSDH	1-if the household lives in a semi-detached dwelling, 0 otherwise		
VTOTH	1-if the household lives in a terraced dwelling, 0 otherwise		
VTOAH	1-if the household lives in an apartment dwelling, 0 otherwise		

4.2 Model Estimation Results

All models were estimated by using Ordinary Least Squares (OLS) regression procedures. Coefficients were determined for the work, school, shopping and recreation trips, and the dummy variable for detached, semi-detached terraced and apartment dwelling categories. The R^2 (R-square) value determines the percentage of total variance that is explained by the predictor variables in the model. The higher the R^2 value, the less error in the model and therefore the better the model prediction. Also, t-test is applied as perceived functional ability (PFA) of the predictor variables. Each predictor variable is measured within 95 percent confidence level at *p-value* $\leq .05$.

4.2.1 Trip Generation Model for Work

The model results for work trip are shown in Table 3. The independent variables can reliably explain and predict the dependent variable at 57.6 percent (R^2 = 0.576). All independent variables included in the model are positively associated with the dependent variable. The model has also been tested for the dummy variables. The results show that household living in apartment dwellings have significantly higher work trips than those living in detached dwellings; however, work trips for households living in semi-detached and terraced dwelling categories are not significant to the model.

Table 3: Trip Generation Model –Vehicle Trips for Work (VTW**)**

Variable	Alfa/b**eta**	Std error	t-statistics	Significance
NPHH	0.226	0.048	4.790	0.000*
EmpHH	1.187	0.207	5.795	0.000*
VOHH	0.268	0.124	2.179	0.030*
LDHH	0.304	0.123	2.532	0.012*
VTODH (Dummy)	-0.848	0.324	-2.614	0.009*
VTOAH (Dummy)	1.315	0.184	3.425	0.001*
Constant	0.490	0.134	2.128	0.046*
N=304	R^2=0.576		F=80.849	

Alfa/beta: Estimated model coefficients; * Significant at p-value $\leq$ 0.05

4.2.2 Trip Generation Model for School

The model results for school trip are shown in Table 4. The independent variables can reliably explain and predict the dependent variable at 28.7 percent (R^2 = 0.287). All independent household characteristic variables included in the model are positively associated with dependent variables. The model has also been tested for the dummy variables related to the dwelling category. The results show that household living in terraced dwellings have significantly and increasingly higher school trips than those living in semi-detached and apartment dwellings, however, school trips for households living in detached dwelling category are not significant to the model.

Table 4: Trip Generation Model –Vehicle Trips for School (VTS)

Variable	Alfa/beta	Std error	t-statistics	Significance
SchHH	0.462	0.062	7.483	0.000*
AHH	0.191	0.034	5.582	0.000*
VOHH	0.148	0.068	2.167	0.031*
VTOSDH (Dummy)	0.548	0.235	2.335	0.020*
VTOTH (Dummy)	1.215	0.386	3.146	0.002*
VTOAH (Dummy)	0.362	0.174	2.086	0.038*
Constant	-0.687	0.171	-4.026	0.000*
N=304	R^2=0.287		F=20.142	

Alfa/beta: Estimated model coefficients; * Significant at p-value ≤ 0.05

4.2.3 Trip Generation Model for Shopping

The model results for shopping trips are shown in Table 5. The independent variables can reliably explain and predict the dependent variable at 41.0 percent (R^2 = 0.410). All independent household characteristic variables included in the model are positively associated with dependent variables. The model has also been tested for the dummy variables and the results show that household in semi-detached dwellings have significantly higher shopping trips than those living in detached and apartment dwellings. However, shopping trips for households living in terraced dwelling category are not significant to the model.

Table 5: Trip Generation Model –Vehicle Trips for Shopping (VTSh)

Variable	Alfa/beta	Std error	t-statistics	Significance
NPHH	0.108	0.040	2.698	0.007*
EmpHH	0.770	0.168	4.576	0.000*
AIHH	0.044	0.011	3.962	0.000*
VOHH	0.312	0.123	2.537	0.012*
VTODH (Dummy)	1.243	0.629	1.974	0.049*
VTOSDH (Dummy)	1.759	0.728	2.416	0.016*
VTOAH (Dummy)	-1.411	0.672	-2.100	0.037*
Constant	-1.415	0.709	-1.995	0.047*
N=304	R^2=0.410		F=29.359	

Alfa/beta: Estimated model coefficients; * Significant at p-value ≤ 0.05

4.2.4 Trip Generation Model for Recreation

The model results for recreation trips are shown in Table 6. The independent variables can reliably explain and predict the dependent variable at 33.2 percent (R^2 = 0.332). All independent household characteristic variables included in the final model are positively associated with the dependent variable. The model has also been tested for the dummy variables related to the dwelling category. The results show that, households living in detached dwellings have significantly higher recreation trips than those living in terraced and apartment dwellings; however, recreation trips for households living in semi-detached dwelling category are not significant to the model.

Table 6: Trip Generation Model –Vehicle Trips for Recreation (VTR)

Variable	Alfa/beta	Std error	t-statistics	Significance
NPHH	0.424	0.089	4.783	0.000*
EmpHH	-0.269	0.136	-1.989	0.048*
UnEmp	0.407	0.154	2.641	0.009*
VOHH	0.639	0.171	3.745	0.000*
VTODH (Dummy)	3.134	1.325	2.365	0.019*
VTOTH (Dummy)	1.741	0.692	2.514	0.012*
VTOAH (Dummy)	1.909	0.816	2.339	0.020*
Constant	-1.970	0.785	-2.508	0.013*
N=304	R^2=0.332			F=22.150

Alfa/beta: Estimated model coefficient; * Significant at p-value ≤ 0.05

5.0 VALUES OF INDEPENDENT VARIABLES

After having the model coefficients that represent α and β values, we supposed also to determine values of independent variables represented *X and D* in the model. In this aspect, more concentration were in determination of *X* values simply because *D* values is 1 for trip originating in the defined land use category, and 0 for trips originated in other land use categories. As presented in Table 7, *X* values were determined by using the data collected during household survey, and presented separately for detached, semi-detached, terraced and apartment dwelling categories. Therefore, value for each independent variable was obtained by simply dividing the number of households surveyed in the dwelling category over the total counts obtained from the surveyed households of the same category.

Table 7: Values for Independent Household Characteristics Variables

Independent variable (*Kij*)	Values (*Xi*) in Dwelling Category (*j*)			
	Detached	Semi-detached	Terraced	Apartment
Household size (NPHH)	6.36	5.65	5.63	5.34
Household pre-school age between 1-5 years (PSchHH)	1.07	0.85	0.63	0.89
Household School age between 5-18 years (EmpHH)	1.38	1.25	1.63	1.13
Household Adult School age19 years and above (AHH)	3.92	3.55	3.45	3.34
Household employees (EmpHH)	1.67	1.50	1.53	1.82
Household Non-employed adults (UnEmp)	2.24	1.75	1.81	1.68
Household Annual income Mil. Tanzania Shs (AIHH)	25.16	22.17	20.85	25.02
Household vehicle ownership (VOHH)	1.14	0.95	0.91	1.21
Household licensed drivers (LDHH)	1.44	0.75	1.54	1.61

6.0 DETERMINATION OF VEHICLE TRIP RATES

The model equation was applied to determine vehicle trip rates per household per day for work, school, shopping and recreation purposes. The inputs include coefficients and values of independent variables significant to the model. As presented in Table 8, each purpose depicted vehicle trip rates in detached, semi-detached, terraced and apartment dwelling categories, as well as vehicle trip rates per household per day for each dwelling category obtained by the summation of vehicle trip rates for work, school, shopping and recreation.

Table 8: Vehicle Trips per Household per Day

Dwelling Category	Vehicle Trips - Purpose				Vehicle Trip Rate
	Work	School	Shopping	Recreation	
Detached	4.59	1.42	3.38	4.66	**14.04**
Semi-detached	4.02	0.71	3.27	1.34	**9.34**
Terraced	3.81	1.01	1.57	3.46	**9.85**
Apartment	5.99	2.08	1.63	3.25	**12.94**

7.0 RESULT DISCUSSION

The trip generation rates obtained in this study are obviously a consequence of the impacts of land use changes that have occurred on the planned residential areas. In fact, the total vehicle trip rate is highest for households living in detached dwellings and slightly lower for those living in apartment dwellings. This is partially contrary to the situation in cities in developed countries where vehicle trip generation rates usually are higher for households living in detached and semi-detached dwellings as compared to these rates for households living in terraced and apartment dwellings. This observation is also partially contrary to the planning standard provided in Urban Planning Guidelines (2007) in Tanzania. The Guidelines suggest high rates of vehicle trips for households in detached and semi-detached dwellings, and lower rates for households in terraced and apartment dwellings. Major cause of this difference is probably the change of lifestyle in planned urban areas caused by changes of land use, whereby a great percentage of high and middle income households and employees are living in apartment dwellings, whereas a majority low income households and unemployed people live in detached and semi-detached houses. The study also found the number of employees and vehicles were higher for households living in apartment dwellings. This contributes to higher vehicle trip rates for household living in apartments compared to those in semi-detached and terraced dwellings.

Another observation in the results was the relationship between household income and number of employees, and vehicle trip rates for work and recreation. The results show that, the households or dwelling units which have higher annual income and number of employees also have higher vehicle trips rates for work, but low vehicle trip rates for social and leisure. Also the households or dwelling units with lower annual income and number of employees also have low vehicle trip rates for work, but higher vehicle trip rates for social and leisure. This observation support the notion which states that, if individual households spend more time on work and other development activities, they use less time for social and leisure activities and therefore will generate fewer trips for recreation. Although, most of recreation trips were generated by non-employees members of households, this statement is still valid in this study. However, further investigations are recommended in order to determine the relationship between social travels and employees in households.

Variations were also observed in school trip rates generated in detached, semi-detached and apartment dwellings. Despite more school age youths being found in detached and semi-detached dwellings but vehicle tip rates for school are more increased in apartment dwelling. This situation is probably influenced by the location of schools in relation to dwelling categories. In most cases, schools are located near to detached and semi-detached dwellings at maximum of 1 kilometre working distance, but a bit far from apartment dwellings. Location therefore influences great use of private cars and public transports for school related journeys for households located far away from schools. Dwelling category of higher vehicle ownership, employee and income rates have higher vehicle trips for school. Additionally, high rate of employees and income make dwellers afford to pay for school buses which also contribute on vehicle trip rates for school.

Shopping and recreation vehicle trips rates are quite different from school and work. More trips for shopping and recreation purposes are generated in detached and semi-detached, but minimized in apartment dwelling, while trip generated for work are maximized in apartment and minimized in detached and semi-detached. Few shopping trips in apartment dwellings are probably caused by location of local markets and shopping centres near the apartment dwellings, whereby most of apartment dwellers tend to walk for shopping activities. In most cases, detached and semi-detached dwellers use public transport for shopping and recreation activities.

8.0 COMPARISONS

The comparisons were categorized into two parts. First part is comparison between household characteristic values obtained in this study and those provided in Urban Land Use and Transport Planning Manual (ULTPM) of 2008. In the manual, variables assume higher values in detached and semi-detached dwelling categories, and lower values in terraced and apartment dwellings. Contrariwise, in the study area it varies among dwelling category. In some cases, variables have depicted higher values in detached and apartment dwelling categories, and lower values in semi-detached and terraced dwelling categories. This is probably an effect of land use changes in the study area and general demographic and economic trends which have resulted in a large change of household characteristics in the study area.

Second part is the comparisons between vehicle trip rates presented in the ULTPM and those obtained in the study area. As presented in Table 9, the trip rates obtained in the study area for detached, terraced and apartment dwelling category are quite higher than the rates provided in the manual, however rates for semi-detached dwellings are almost the same. The observed differences can be partially explained by changes in household characteristics which probably are caused by land use change.

. **Table 9: Comparison of Trip Generation Rates**

Dwelling category	Vehicle trip generation rates		Difference in trip rates	Difference in percentages
	ULTP manual	Study area		
Detached	9.55	14.04	4.49	47.0
Semi-detached	9.55	9.34	-0.21	-2.2
Terraced	6.45	9.85	3.40	52.7
Apartment	6.45	12.94	6.49	100.62

9.0 CONCLUSIONS AND RECOMMENDATIONS

Trip generation rates obtained in different residential dwelling categories have depicted the inconsistency of using manual trip rates in estimating and forecasting travel demand. The differences between the trip generation rates obtained at the study area and the rates provided in ULTPM are quite large, and therefore, the validity of manual must be questioned. As indicated in the study area, the observed differences are perhaps caused by change of land uses, economy, lifestyles and other household characteristics that influence more vehicle trips to be generated by individual households per day. In order to minimize effect of using disadvantaged manual rates in transport planning, we recommend planners to carry out an empirical study for the specific city or site with the goal of determining city or site specific vehicle trip rates. For the case of transferability or borrowing of trip generation rates, a comparative analysis between sites where trip rates were obtained and sites to be applied should be done before using the borrowed rates in transport planning.

It is also important to consider how often trip generation rates need to be reviewed. The standards in the Urban Land use and Transport Planning Manual were developed in 1982 and reviewed in 2008. The time frame for such review was bit far, and the applied trip generation rates were too old to be able to cope with the changes in the fast growing city. This study therefore recommends maximum of five years review of trip generation rates.

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