AN ANALYTIC FRAME FOR ANALYSIS OF CAR TRIP ATTRACTIONS BY LAND USE TYPES IN DEVELOPING COUNTRIES; A TOOL FOR ASSESSMENT OF UNPLANNED URBAN DEVELOPMENT

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Abstract

Unplanned conversion of land use activity types into attractive ones, i.e. "*adaptive reuse*", creates traffic problems in developing countries cities. Lacking the tools to predict generated traffic local authorities issue permits of conversion without impact assessment. An analytic frame for "in-depth" analysis & modelling of car trip attractions by land use types is proposed. Examples of its application in Cairo are given with comparisons with US cities trip rates. Impact studies procedure that considers the effect of adaptive reuse on traffic and the environment is suggested leading to denial of authorisation or estimation of "impact fees" that should be borne by activity developers as licensing condition if the impact is tolerable.

INTRODUCTION

Urban development takes place in many of the big cities of developing countries in various fashions; in some cases planned and in many instances unplanned. Conversion of land use activities from certain types into mostly more attractive ones (usually referred to as "adaptive reuse") is a type of unplanned urban development that creates transport problems. In Greater Cairo (GC) this happens quite often. It has been experienced over the last 15 years, for instance, to see a house converted into a hospital, a villa converted into a primary school and a ground floor flat converted into a modern boutique or an elegant restaurant. Local authorities issue permits of conversion of land use activities without assessment of their possible effects on traffic and the local environs. They lack the appropriate knowledge and tools to predict generated traffic and the expected impact. This sudden change of land use activities brings about several transport problems. Many of the peaceful streets started afterwards to be busy ones occupied by business, services, commercial and/or recreational activities. Car trip attractions double, sometimes triple, all of a sudden on streets that are not originally designed to accommodate increased traffic volumes. This leads to dissatisfaction of all road users and residents.

This paper presents an analytic frame for "in depth" analysis and modelling of car trip attractions by land use types. The developed frame suggests basic steps for more understanding of the issue revealing the underlying activity/location variables and gives the relevant rates (and equations in some cases) for prediction of car trip attractions expected to take place by a land use unit. Although this frame is applicable in any city, yet selected results of its application in GC are given. Comparisons with relevant rates obtained for US cities are discussed. The paper also presents a suggested procedure for impact studies that considers the effect of land use activity development not only on traffic but also on the environment and energy consumption. Finally the paper urges city transport engineers and authorities not to authorize a change in land use activities before appropriate impact studies are carried out using appropriate trip attraction rates. Thus, the cost of the required traffic management measures can be estimated and allocated as an "impact fee" to the activity developer as a condition for authorization.

CAR TRIP ATTRACTIONS ANALYSIS APPROACH

The proposed analysis approach, Ali (1995), aims at investigating the main variables that attract car trips to a land use activity leading to determination of appropriate simple trip rates or equations incorporating these variables. The prime focus of interest in this approach is to bring the analyst very close to both trip attraction features and the underlying explanatory variables. In other words we are trying to clarify many issues and to answer important questions. For instance, what are the main factors that attract car trips to a land use activity? Are they related to the unit characteristics and attractiveness attributes? Are they related to the location of the land use unit and the surrounding environment? Or do they depend on both? What are the densities (rates) of car trip attractions in terms of the size of the attraction unit? Would the size be expressed by the area of the unit, the number of jobs offered (employment) or other attractiveness powers? As shown in Figure 1 the proposed analysis approach involves five stages.

In **Stage-I** a clear and precise definition of the considered land use activity is to be set out based on the available information and official documentation. The definition may call upon setting out a minimum or a range of the activity size (e.g. hotel category & number of rooms).

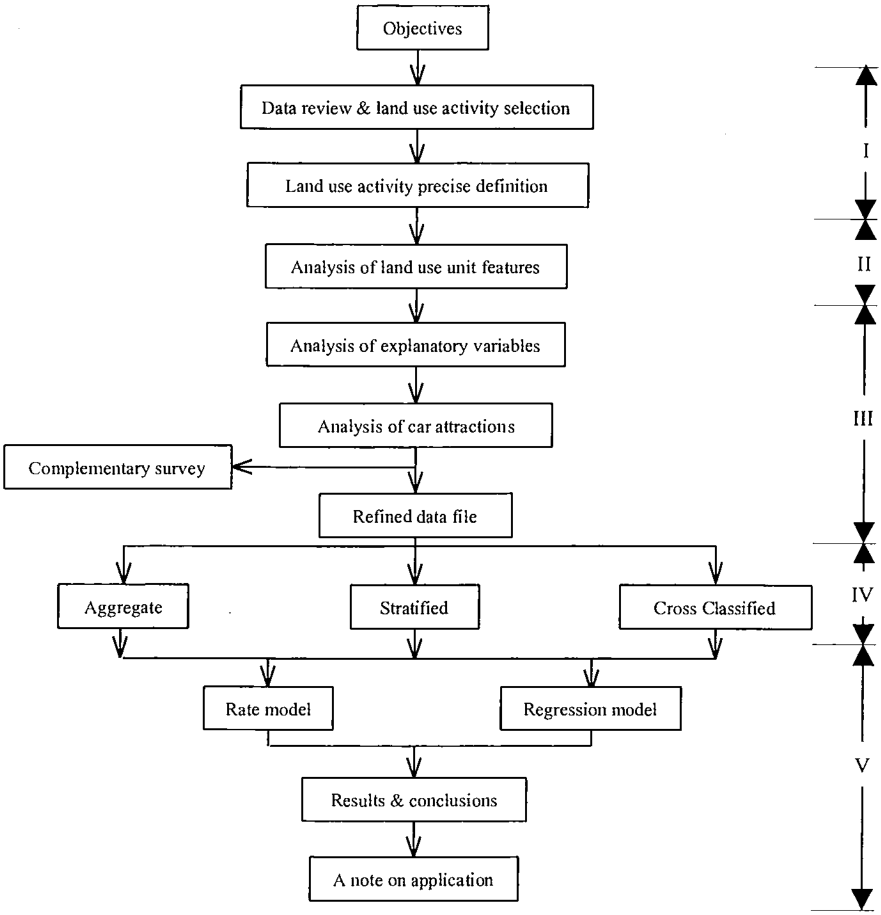

Figure 1: Flow chart of the suggested car trip attraction analysis approach (Source: Ali, 1995)

Stage-II is concerned with studying the general features of the units of the selected land use types. This includes the various attractiveness powers of the units and the main characteristics of their surrounding environs.

In **Stage-III** main statistics and inter-correlation among the quantifiable land use attractiveness variables are to be analyzed and tested. Furthermore, this stage involves setting out precise definition of the considered trip attraction (dependent) variables, e.g. daily trips, peak hour of generator trips and/or peak hour of adjacent street trips. The definition is also to precise whether the trips visiting the land use unit are those which only start (trip origins), only terminate (trip destinations) or both (trip attractions) as in the current work. Then, further simple statistical analysis can be performed on these dependent variables and their correlation with the land use units independent variables.

In **Stage-IV** the data are to be manipulated at three levels. In Level-1 we consider the whole data set in an aggregate form. Whereas, in Level-2 the data set is to be stratified in order to subgroup it into distinct strata and in Level-3 the data is to be cross classified in a two-way stratification fashion. These three levels of analysis are discussed below.

In Level-1 the analysis is based on the total sample considering all of the surveyed units of each land use type. The analysis can in some cases end up with a satisfactory model formulation in terms of certain variables. However, variables that cannot be quantified such as location variables are impossible to study at this level. This warrants a shift to the next analysis level. Yet, analysis of data at level-I gives necessary insight for stratification criteria needed at the second level of analysis. Indeed investigation of the data of all the analysis units in one step reveals differences between them, if any. For instance, drawing a scatter diagram of the areas of the considered land use units versus generated trips may indicate the necessity of splitting the surveyed units into two groups each having different area range.

Level-2 of the analysis concentrates on data stratification. This enables studying the existence of different subgroups of units within one land use type, each including units of similar characteristics Three basic grouping techniques are used.

- Grouping according to formal standard classification given by the industry as in the case of travel agents that are officially classified into distinct subgroups by the regulations of the Ministry of Tourism.
- Grouping by introduction of variables that are only characterizing a stratum in the sample. Examples are the location variables (in CBD / out CBD) and parking lot availability.
- Grouping according to an arbitrary logical judgment by the analyst supported by field observations. For instance, boutiques can be sub-grouped according to the image of the place and supermarkets can be sub-grouped according to their size (e.g. area or employment).

Level-3 of the analysis procedure is the cross classified level which subgroups the surveyed units of the land use type under consideration in a two-way stratification manner according to two selected features of splitting the units. Such two-way stratification can be achieved in terms of the land use unit size (area or employment) and location (in CBD /out CBD), for example. This allows a very fine level of understanding of car trip attractions and the attractiveness powers of the land use units of similar nature. Thus, more reliable trip attraction rates and/or equations can be reached for each subgroup compared to those obtained for the aggregated heterogeneous data (level-1).

Bearing in mind the above discussion, it is clear that levels 1&2 of the analysis aim at achieving better modelling of car trip attractions by land use types. The decrease in sample size of the sub-grouped observations is the main demerit, however. Fortunately, the decrease in sampled observations in the application on GC, Ali (1995), mentioned later, due to stratification and cross classification analyses levels was not so important due to the large original samples of the surveyed units of the selected land use types. Besides, sample/population ratios for the selected land use types were reasonably high. Only in few cases the stratified and the cross classified data reduced the sample size to an extent that made it inappropriate to obtain reliable trip attraction rates or equations. This of course occurred for certain cells of the stratified data and did not alleviate modelling trip attractions for the remaining cells. Contrary these latter models can be more reliable than those calibrated for the aggregated data as they are based on the homogeneous observations of the cross classified subgroup.

The last stage, **Stage-V**, focuses on modelling car trip attractions and goes along two streams which are to be undertaken at each of the above mentioned three levels of data processing. <u>Stream-1</u>, is concerned with developing and analyzing simple car trip attraction rates (e.g. trips/sq. m of the floor area of a bank or trips/bed for a hospital). <u>Stream-2</u> is, however, devoted to trying to understand the relationship between trip attractions and the land use unit features through regression modelling. Although rate models are very simple, yet they can give very good short term results; much better than many of the sophisticated formulae. Usually car trip attraction rates by land use types are given in three values, the minimum, the average and the maximum. The coefficient of variation (c.v.) is to be examined in order to test the reliability of the obtained rates, with those associated with smaller cv's are more reliable than the contrary. As for car trip attraction model equations they are obviously tested using the standard regression analysis statistical evaluation techniques. However, it should be noted that examining logicality of the regression equations and the associated variables is always more important than relying only on statistical testing.

THE CONSIDERED LAND USE ACTIVITIES AND REQUIRED DATA

As mentioned above it is essential to set out precise definitions of the land use activities taken into consideration right from the beginning of the analysis in order to: (a) allow specifying the populations from which samples of land use units are to be drawn and (b) reduce the error of having land use units of different nature (e.g. type of conducted business) within the surveyed sample of a single land use type. For example, a shop selling only clothing should not be mixed up within a group of shops selling clothing plus other articles.

Five groups of data are required as briefly outlined below, ITE (1987) and Ali (1995).

a- site related data: the administrative zone in which the unit is located, socio-economic characteristics of the residents of that zone, traffic on adjacent streets (volumes and peak hours), parking availability in the vicinity and distance from the CBD.
b- unit general features: layout, number and locations of entrances/exits, working days and hours and price range (and unit image) for commercial land use types.
c- unit basic information: these are the attraction variables of a land use unit such as number of pumps in a petrol station, number of rooms in a hotel and area of a shop, for example.
d- trip attraction data: these include the total number of car trips attracted to each land use unit over a predefined time period and a directional ratio of, say, in-bound to all attractions. The time period during which car trip attractions are to be measured can be the whole working day, peak hour of generator and peak hour of adjacent street. It is also possible for more detailed investigation to disaggregate trip attractions by purpose, e.g. customers, employees and deliveries for a commercial activity. It is also useful when detailed analysis is need, to identify trip types as follows: primary trips made directly from origins to the unit and back to origins, secondary trips in which a stop is made at the land use unit on the way from the origin to another destination with a significant diversion of route and pass-by trips which are similar to secondary trips but without any significant route diversion. Finally, if possible information about trip origin and length can be useful to obtain.
e- trip maker data: such as sex, age, occupation and income if possible.

APPLICATION OF THE ANALYSIS APPROACH ON GREATER CAIRO

Available data

The present work utilizes data collected in a pioneer study, Huzayyin et al (1994) in which private car trip attraction rates were developed for major land use types in GC for the first time. These covered private banks, travel agents, air lines, private primary language schools, private hospitals, boutiques and supermarkets located in high income zones, sporting/social clubs and hotels of different categories. All of these activities are known to attract considerable numbers of private car trips made either by clients and visitors or by the regular travelers such as owners, managers, senior staff and/or car owning employees. Except for clubs and hotels sample size ranged between 15 and 89, with sample to population ratios ranging between 12% to 70%. Counting trip attractions in the sample units lasted for the whole duration of the working hours of each unit.. The adopted definition of car trip attractions was as follows: "the total number of private car trips that end/start at the land use activity during specified time period". If more than one person were coming and leaving by the same car, only one car trip attraction was counted. Two time periods were considered, namely "daily" (D) for a working day and "peak hour of generator" (PHG) during a working day. The study produced several D and PHG car trip attractions rates and presented practical manual type sheets of appropriate rates for each of the considered land use types that are very useful for the practicing city engineers. However, it did not aim at going into the details of the affecting factors and reasons of variation in the developed rates and did not try data stratification or further modelling of car trips.

Selected land use activities

From amongst the available data, six land use types were selected representing three major sectors as given below. Detailed definitions are, given in ref. (Ali, 1995).

Private Business Sector:

- Private Bank (PB): a private bank whether it is the main premise or a branch.
- Travel Agent (TR): a travel agent main office or a branch.

Private Merchandise Sector:

- Boutique (B): a boutique located in the 7 highest income zones of GC (excluding the CBD) and at least selling clothing
- Supermarket (S): a self service supermarket selling a complete assortment of food, food preparation and household cleaning and servicing items and is located in the 9 highest income zones of GC (excluding the CBD).

Private Service Sector:

- Private Primary Language School (PPLS): a private primary language school whether it is only for primary education or a part of a larger education institution that includes nursery, preparatory and/or secondary education.
- Private Hospital (PH): a private hospital with 50 + beds excluding charity and psychiatric ones.

Stratification criteria for the land use units

Stratification of land use units for each type of activity can be achieved according to several criteria after careful examination of the units attractiveness variables including the tangibles (e.g. size) and the intangibles (e.g. location). Three groups of classification criteria are identified as given below.

Unit General Criteria:

- size variables: e.g. area, employment.
- location variables: e.g. in CBD/out CBD.
- unit combined characteristics: combined ranking of the ranks of the variables which reflect the main features of the land use unit (e.g. area, employment, etc.)

Unit Site Criteria:

- zone combined characteristics: combined ranking of the ranks of the variables which reflect the main features of the zones of the city (e.g. average income of the residents, accessibility, etc.)
- transport system characteristics: combined ranking of the ranks of the variables which reflect the main characteristics of the transport system adjacent to the land use unit (e.g. street width, side walk width and condition, parking availability, etc).

Activity Specific Criteria:

- These criteria are related to the specific features of each land use activity type such as: number of counters for banks, travel agents and supermarkets, ownership for private banks (local, foreign, joint venture), school type for private primary language schools (boys, girls, mixed), and existence of medical insurance and bed price range per night for private hospitals.

Car trip attraction models

Numerous trials were performed to obtain car trip attractions rates and regression equations, Ali (1995). In each case logicality of the model and the independent variable(s) were considered. In addition, for rate models the coefficient of variation (cv) of each rate were looked at to select rates with lower cv's. For regression equations the standard statistical evaluation was performed.

Table 1 gives selected examples of trip attraction rates and regression equations based on the aggregate data (analysis level-1). Whereas, Table 2 gives selected examples of trip attraction models based on stratified data (analysis level-2) and cross classified data (analysis level-3). In order to examine the effect of analysis levels 2 and 3 on the obtained trip rates the change in the cv's were examined. The reduction in the cv is considered as an improvement in the obtained rate models as this implies a more reliable rate. In cases of regression models the changes in R^2 due to data stratification or cross classification was examined with any gain considered as an improvement bearing in mind that other statistical tests still prove to be significant and the logicality of the equation variables holds. Of course, the analysis approach was applied on the above mentioned six land use types, for the cases of D (daily) trips and PHG (peak hour of generator) trips, though only selected examples are given in Tables 1 and 2 for D trips. Comments are discussed below for both D and PHG cases, however.

Table 1: Selected Examples of Daily (D) Car Trip Attraction Rates and Equations for the Aggregated Data "Level-1", Ali (1995).

Land use	Trip rate	n	cv	Regression equation +	N	R^2
PB	1.91 trip/e	28	0.72	41+0.06 (a)	30	0.7
PH	7.23 trip/hpb	10	0.61	56.3+0.06 (fa)	8	0.44
S	44.72 trip/eps	28	0.79	-292+372.7(c)+203(e)	28	0.71
B	5.16 trip/mwl	52	0.7	--------------	----	-----
PPLS*	0.85 trip/nsbp	21	0.51	4.9+0.23(pp)+4.75 (pp/pc)	21	0.63

* school morning entry hour trips   +All regression coefficients and equations are statistically significant.
e = employee   hpb = high price bed   eps = e / shift   mwl = metre of window length   nsbp = non-school-bus pupils
a = area   fa = floor area   c = counters   pp = primary pupils   pc = primary classes

Table 2: Selected Examples on the Effect of Data Stratification and Cross Classification, on Modelling daily (D) car trip attractions, Ali (1995).

Level of agg	Car trip rate (trip/e)	N	cv	cv change (%)	Regression equation	N	R^2	Chg. R^2 (%)
a) Land Use: Private Bank (PB)								
1	1.91	28	0.72		41 + 0.06 (a)	30	0.70	
2	2.21 (I)	22	0.63	-13	0.05 (a) + 0.46(e) + 34.3 (d)	26	0.82	+12
	0.81 (ii)	6	0.28	-61				
3	2.41 (iii)	18	0.6	-17				
b) Land Use: Travel Agent (TA)								
1	1.5	31	0.84		6.6 + .07 (a)	15	0.7	
2	1.78 (iv)	16	0.56	-33				
	0.97 (v)	15	0.71	-15				
3	1.52 (vi)	26	0.58	-31	5 + 0.84 (e)	12	0.73	+3

level 1 = aggregated data (i) e<50 (ii) e>100 (iii) out of CBD & e<50 (iv) low combined unit Characteristics
level 2 = stratified data (v) high combined unit Characteristics (vi) e ≤ 30 & counters ≥ 5
level 3 = cross classified data
e = employees   a = area   d = dummy variable = 1 em <50 & = 0 em >100
all equations and coefficients are statistically significant

For business (PB and TA) and shopping (S and B) sectors car trip attractions are greatly affected by both the area of the land use unit and its size (employment). For the services sector the independent variables which proved to be effective differ from land use to another depending on the nature of the offered service. In the case of PPLSs the most important variables out of the tried ones are number of primary classes, number of primary pupils, number of primary teachers and number of non-school bus pupils (those who do not use the school bus). As for the PHs case the best variables are those expressing the number of beds as the trip attraction power of the hospital.

For PBs, stratification by employment size (<50) improved the derived rates with reasonable sample sizes compared to the case of aggregate data. Location stratification (out CBD) produced PBs trip rates that are very slightly less superior than for stratification by employment size. Rates with the least cv's were obtained via cross classification by employment (>100) and location (in CBD), but associated with sever reduction in sample size. However, for the class of employment <50 and location out CBD, the derived rate is still better than the one based on aggregate data, with a 17% reduction in the cv. The calibrated regression equations for car trip attractions by PBs include dummy variable denoting size of establishment in addition to area and employment in the cases of D and PHG. These independent variables appear with the logical sign and are statistically significant with R^2 reaching .82 and .84 for the D and PHG cases, respectively.

For TAs stratification by combined unit characteristics gives more reliable rates than those based on aggregated data but with reduced sample. However, cross classification by employment ≤30 and counters ≤5 produces a trip rate associated with a cv of .58 which is 31% less than the aggregate case with a high sample of 26 units. A slightly lower cv of .56 is obtained for rates derived on a stratified data of low combined unit characteristic, but the sample is reduced to 16 units. It is interesting to note that the most reliable regression equations were only obtained for average values of the dependent variables; average D and PHG. Furthermore, it was only possible to reach the selected model equations after cross classification of the TAs by size (employment ≤30) and counters (≤5). Accordingly, the sample is reduced from 31 units to 12 and 15 units for D and PHG cases, respectively. The calibrated equations have employment as the independent variable and a slightly higher R^2 than for the aggregate data case.

In the case of PPLSs, the aggregated data produced a trip rate with .51 cv and a sample of 21 schools. However, data stratification by school type (girl schools) produced a trip rate with a smaller cv of .38 but with a reduced sample of 10 schools. With data stratification the calibrated regression equations were non-linear and statistically significant at a .05 level with the independent variables appearing with the expected signs. For girls schools the trip attractions equation has R^2 of .83, which is 20% more than the explanatory power of the equation based on aggregate data.

All types of stratification criteria yielded considerable change in both average rate and cv compared to the aggregated data case for PHs. A much lower car trip rate per bed is obtained for PHs introducing medical insurance service than those for PHs which do not offer such service. This is a very reasonable result as the former types of PHs are expected to attract more trips of low income groups visitors with low car ownership. Statistically significant car trip attraction equations were obtained via data stratification with the number of beds as the most important explanatory variable, but the sample size was reduced. Therefore, it was also not possible to cross classify the data.

In the case of Ss it was always a must to stratify the data in order to obtain trip rates with reasonably low cv's. Therefore, distinction was made between Ss that offer whole sail prices and ordinary Ss selling at the usual retail prices. Also, within each group, stratification by other criteria such as counters and unit characteristics was tried and achieved trip rates with reduced cv's compared to those for the aggregate case. The obtained regression equations for retail sales Ss are statistically significant with the number of counters and employment as independent variables, a sample size of 28 and R^2 of .76.

For Bs, stratification was made according to: unit characteristics (employment, area and window length), transport system characteristics (adjacent street width and parking availability), price range, boutique image (quality of goods and layout of the boutique), type of sold clothing and articles (ladies, children and men and ladies and children only), fashion of sold clothing (classic and casual) and location (in a shopping area and out of a shopping area). The obtained rates of minimum variation were always indexed to either "area" or "window length". The best enhancement occurred in the high unit characteristics stratum. Bs located in a shopping area have D trip rates slightly higher than those obtained for the aggregate data. This is a reasonable outcome as people may be attracted to visit a boutique just because they are originally visiting the shopping area in the first place. For the D case the rate with minimum variation (cv = .4) is that developed for Bs selling "ladies, children and men's ware". However, this type of Bs is represented by a small sample of 11 units. For the PHG case, the rate associated with the minimum variation (cv = .43) is the one developed for the "high unit characteristics" stratum, with a reasonable sample of 23 Bs. The relevant rate for the D case produced a rate with a cv of .49 and a sample of 23 Bs of "high unit characteristics". As for regression models the ones with the highest explanatory power have "employment per shift" as the independent variable appearing with the expected positive sign. For the D case R^2 is .82 and for the PHG case R^2 is .74 and in both cases the stratification is for Bs selling casual clothing.

Comparisons with rates developed for US cities

In this section comparisons between trip rates developed in the current work for certain land use types in GC and relevant ones obtained for US cities, ITE (1987), are discussed. For instance, the US rate for a.m. PHG school trips is 0.263 trip/pupil, which is nearly half the rate for GC of 0.47 trip/pupil. Tow reasons can express this difference. Firstly, the US rate corresponds to students between kindergarten and high school ages whereas the rate for GC is obtained for primary level only. US preparatory and high school students are older, they can very often walk and/or ride a bicycle to school. This is quite expected in US, and other developed countries cities where street safety standards are always considered and hence students are encouraged to walk and/or ride a bicycle to school. Furthermore, it is emphasized, ITE (1987), that the schools in US cities are usually centrally located in residential areas which facilitates access to young students they are there to serve. Secondly, the school bus is very often used in the US as it offers a very efficient service of relatively reasonable journey times, compared with those practiced in GC. In the latter case many parents drive their children to school in order to avoid exposing them to the lost time during the daily school bus ride.

For sake of comparison the weekday average trip rate for the surveyed PHs in GC was determined, Huzayyin et al (1994). This was found to be 3.68 trips/bed which is nearly one third of that quoted for US cities, ITE (1987), of 11.75 trips/bed. This is a logical finding bearing in mind the very big difference between car ownership levels in the two contexts.

The available US experience, ITE (1987) gives D and PHG vehicle trip rates of 1.4 and 0.1 trips/m sq. for Ss, respectively. The corresponding rates for GC are 1.1 and 0.14 car trips/m sq., Huzayyin et al (1994). These very close rates may be attributed to the fact that areas (m sq.) of supermarkets in the US are believed to be bigger than those of the GC ones. Note also that the considered Ss in the present study are located in the highest income zones of GC where land prices are extremely high (the average area of the surveyed Ss in GC is 28.2 m sq.). In addition, US supermarkets usually display much more commodities on the average than those in GC. This certainly warrants more space. Nevertheless, it is stated, ITE (1987), that the above mentioned US rates for Ss are based on small sample sizes and should be used with caution.

The given car D rate for "walk- in" banks in the US is 63.3 trips / employee, ITE (1987), which is nearly 23 times higher than the relevant rate of 2.7 trips / employee for GC based on the aggregate data, Huzayyin et al (1994). Such very high difference is to be attributed to the extremely big banking business in the US compared to Egypt. However, another very important factor that may have reduced the GC rate is the fact that Egyptian banks, and other business, employ many staff compared to US where most of the relevant services are automated (un-manned). It is also interesting to observe that the US relevant rate per bank area is 2.1 trips / m sq. compared to a rate 0.29 trips / m sq. in GC, which is only about 7 times greater. In addition to the above mentioned reason of the size of banking activities, the difference in area based rates may have been smaller than that for rates based on employment because of the limitation on acquiring space compared to that on staff employment in GC.

GENERAL CONCLUSIONS ON THE SUGGESTED ANALYSIS APPROACH

Based on the above mentioned results the following conclusions are derived. For the PHG case it was always possible to obtain car trip attraction rates with cv's smaller than those obtained for D trips. This relative accuracy may be related to the stratification implied in the former trip type which is concentrated in the peak hour rather than being spread all over the whole working hours of the day. However, the calibrated regression equations for the D case appeared slightly statistically superior (higher R^2's) than those for the PHG case. This can be attributed to the less variation in trip attractions of the latter case compared to those of the former one of a less homogeneous nature, irrespective of the variation of the unit characteristics that do not always vary with time of day.

Stratification and/or cross classification of land use units of similar features within a single land use activity type can produce better and more reliable trip rates. This is due to the homogeneity that results from such stratification, thus reducing the diversities within the stratified group.

The calibrated regression models are always linear except for the case of private services sector (schools and hospitals). Although this is rather difficult to explain, it may be related to the behavior of the demand of people with car available on such activities within the context of urban travel in congested cities like GC. Any slight increase in the service attractiveness would involve a great counter increase in car trip attractions. The demand on services may be of a rather arbitrary nature as they are not an obligation, some kind of choice may always be involved which could be very sensitive to the level of the offered service by the land use units. Whereas, in cases of private business and shopping a somewhat steady (linear) pattern of car trip attractions increase is quite reasonable to occur in terms of the unit explanatory positive improvements. This conclusion is very interesting and warrants further investigation, Ali (1995).

The following general lessons drawn from the current research can be made. First of all, careful understanding of the land use features is very important. This helps the analyst to gain thorough knowledge of the available data and leads to more sensitive mastering of model calibration results and selection of the most appropriate variables and models. Second, stratification of the considered land use units for each activity type proved to be very useful. It produces more reliable models and helps so much in understanding the factors involved in more depth. Furthermore, cross classification of data has shown in some cases reasonable effect on the calibrated car trip attraction rate and regression models. The main problem, under which powers of cross classifying the data are hidden, is the resulting reduction in sample sizes of the land use units in each class. If it is possible to achieve relatively large samples, it is anticipated to obtain more reliable rates for each class observations. In addition, stratification and cross classification of the land use units of a certain activity type help so much in reflecting intangible variables. These include, for example, unit location, certain unit characteristics and the features of the surrounding domain. Finally, if trip attractions are clustered around successive observations of an independent variable, regressing the averages of each of these clustered readings on the relevant readings of the variable can achieve successful modelling.

SUGGESTED PROCEDURE FOR IMPACT STUDIES

Due to many of the existing forces of urban form, lack of space, very high land values and commercial desires, it has become a trend in many cities of the developing countries to see dramatic changes in land use activities in what is referred to as "adaptive reuse". Many of the existing residential premises are converted into a host of other activities. These include, for example, restaurants, boutiques, supermarkets, banks and even hospitals and schools. This, unfortunately, takes place irrespective of any considerations of the impact of such activities on traffic and the environment. The result is always disastrous; all of a sudden a quiet local street is converted into a heavy congested road. Peaceful residential sites are transformed into busy commercial and/or other services locations taking no consideration for local residents. Developers enjoy commercial benefits at the expense of the community. They do not pay or even share the cost of required measures to reduce the traffic delays, parking problems and the adverse impact on the environment caused by their projects. In some cases the situation is even worse where several new activities are concentrated in one site. It is quite customary that local authorities are unaware of the need for traffic impact studies, do not have the tools and qualified engineers to do the job and/or do not possess the power to stop licensing such imposed activities.

In many of the developed countries, however, traffic impact studies (e.g. Lalani and Calkins, 1989 and ITE, 1991) have become a common practice for proper urban development and community decisions. The most important objectives are "to determine the expected traffic to be generated by a proposed land use", "to design the required traffic management measures to cope with the generated traffic", and "to determine the fees (impact fees) that should be born by the activity developer towards implementation of the required traffic management scheme".

With the growing concern about the environment and sustainable development it is suggested, to add a fourth objective. This is to take into account the effect of generated traffic on the environment. Hence, a decision to authorize a new land use activity would also be based on environment quality considerations. A flow chart of the suggested procedure for impact studies is given in Figure 2, Huzayyin (1995).

The interaction between "*land use / transport*" and "*transport / environment*" are the crux of impact studies as suggested in Figure 2. Trip generation models by land use types are the link between land use and travel demand, whereas environment models are the link between generated traffic and its effect on environment quality. In other words, it is clear that trip generation models are in the heart of impact studies. These models receive land use as input to produce traffic volume estimates which are then to be used as input into environment models in order to arrive at the expected corresponding effects on the environment. For further detail refer to ref. (Huzayyin, 1995) which also describes the different steps of this procedure showing two different paths. The first is for overall assessment that allows for evaluation of the expected traffic and environment effects of a new land use on the community before taking any decisions on refusal of licensing this land use. The second gives priority to the environment by allowing refusal of license on environmental grounds before starting to assess traffic impacts. Both cases, nonetheless, when traffic and environment impacts are successfully passing the acceptable relevant community standards, end up with three essential steps: the design of the required traffic management schemes and measures , determination of the needed impact fee (cost) of implementing these solutions and, then, negotiating licensing with the land use developer(s) in view of the impact fee as a condition for authorization. Accordingly, local authorities can play the expected role in protecting interests of the local community.

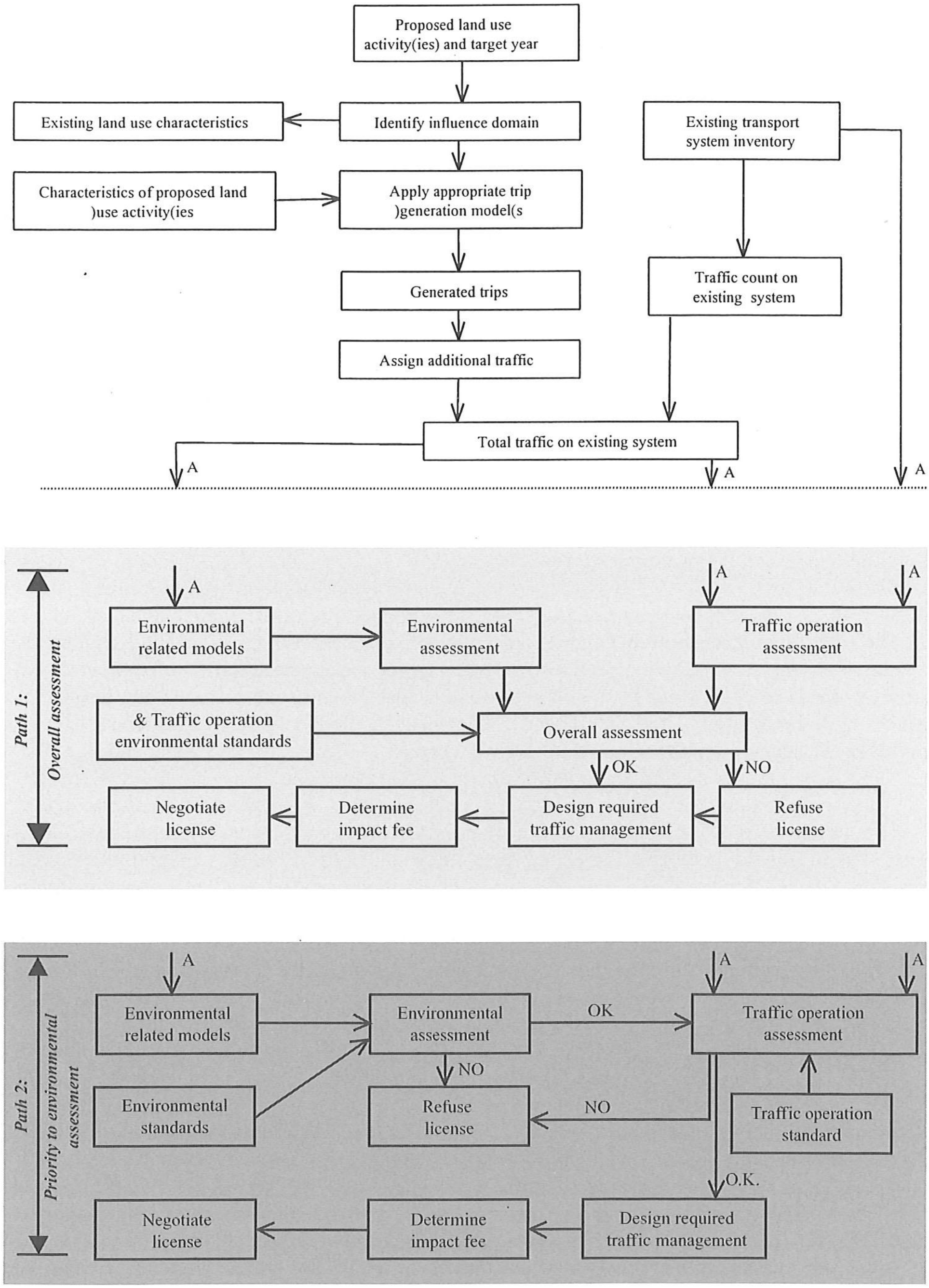

Figure 2: Suggested simplified flow chart for impact studies (Source: Huzayyin, 1995)

CLOSURE

The problem of "*adaptive reuse*" of land use units within cities of the developing countries is a main concern. The generated traffic usually overload the adjacent street network and disturbs peaceful life of the local residents all of a sudden. Licensing such new activities in many cases takes no consideration of the resulting traffic problems and the relevant environmental adverse impacts. Local authorities do not possess the trained staff and/or the appropriate mathematical tools and procedures for estimating generated traffic by different land use types and their impacts. The paper presents a frame for "in depth" analysis of car trip attractions by land use types. The objective is to bring the analyst more close to the different attraction variables of land use activity types related to the activity and the surrounding domain. The frame also leads to modelling trip attractions in terms of rates and equations at different levels of data stratification which allows more understanding of land use activities as major trip generators in urban areas. Different criteria for data stratification are presented. The results of application of the suggested analysis frame on selected land use types known to attract many private car trips in GC are highlighted showing examples of the developed trip rate and equation models. This is complemented by a discussion on the underlying factors that appear to be the main attributes of car trip attractions for each of the given land use types. Main conclusions about application of the analysis approach are given commenting on the advantages of data stratification.

The paper gives a suggested procedure for impact studies which calls upon estimating the effect of land use activity types on traffic generation and environment quality as bases for determination of impact fees. Local authorities should be urged to study carefully the expected impact of intended development of land use activities on traffic and the environment. If the impact on traffic calls for new traffic management projects, land use developers are to be asked to bear the "*impact fee*" as a condition for licensing the new land use activity. If traffic impacts are not tolerable due to site limitations and/or other reasons, then licensing the new land use activity is to be denied. This also applies to the situation when the expected environmental impacts cannot be accommodated. The suggested procedure for impact studies offers an option that stops authorization of a land use activity on environmental grounds even if its traffic impact can be accommodated. In order to achieve this, it is strongly recommended that city authorities in developing countries should start to develop their own car trip attraction models for the different land use types. Borrowed trip rates from the developed world cannot be used. As demonstrated earlier in the paper (i.e.. GC rates vs. US cities rates) sharp differences occur. In addition, appropriate training programmes are to be performed so that city engineers are to be familiar with the required skills for using/ developing trip attraction models and conducting impact studies. They should, in addition, be given the power of authorization or denying to authorize conversion of land use activities.

Finally, it is recommended to apply the suggested frame for "in depth analysis and modelling of car trip attractions by land use types" as given in this paper in other cities of the developing countries. Exchange of the resulting trip attraction rates for the different land use types can be very useful for the researcher and the practicing engineer. Similarities and differences can be revealed and lessons on rate transferability are indeed very useful to observe.

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