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Trip Generation Development Models of Land Uses in Developed Countries

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Abstract: This paper describes the progress of a major program to develop trip generation models for land use in Developing Countries and reports the results of the first of a series of trip generation studies for land uses in Developing Countries (Mansoura City in Egypt as a case study). The study was carried out in two major stages:

- Field data collection.
- Office data analysis and regression model development.

Data were collected between October 2014 and February 2015 to obtain the number of total daily trips, work trips, cars per household, work per household and persons per household.

The data were analyzed to obtain inputs for the development of the regression models for total daily trips. The research work will be helpful in the planning and design of the intersections. They will also be helpful in the planning of land uses and transportation networks.

Keywords: Trips, Household, Regression Model, Land Uses, Transportation Networks.

1. Introduction

Trip generation models are available for land uses in many developed countries. These models serve many purposes, primarily the prediction of number of trips attracted to and generated by land uses.

These predictions are useful in the planning and design of highway facilities and traffic management schemes, these models may not by adequate and appropriate for use in a developing country, such as Egypt. These is because of the differences in the cultural and socioeconomic background of the trip make and also in the type of land use that exist in the different settings. It is therefore necessary to develop models that will appropriately describe the trip-making patterns for setting in developing countries.

This paper describes the progress of major program to develop trip generation models for land uses in Egypt and reports the results of the first of a series of trip generation studies for land uses in Egypt.

Different housing units in Mansoura City (as a case study) were studied. the high number of trips from these housing units cross the major road traffic stream creates congestion problems and accident hazards.
Therefore, this paper will be helpful in the planning and design of intersections. They will also be helpful in the planning of land uses and transportation networks.

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2. Data Collection Procedure

The study was carried out through two major phases; Field data collection, and Office data analysis and regression model development. The data of housing units is divided into three zones according to type of housing unit [1,7,9]:

- Zone 1: Low-income workers,
- Zone 2: medium-cost housing units,
- Zone 3: high-income group housing units.

Data were collected between October 2014 and February 2015 to obtain the number of total daily trips, work trips, cars per household, workers per household and persons household.
The home Interview survey sheet (hiss) requested information in origin and destination of trips, as well as purpose of trips. (as shown in Fig. 1).

3. Data Collection Analysis

The data were analyzed to obtain inputs for the development of the regression models for total daily trips, Y1, total work trips, y2 and total car trips y3.

The inputs obtained from the analysis are number of cars owned in the zone, X1, number of workers in the zone, X2, and population of zone, X3.

Observed trips were categorized into different income levels in increasing scale of (P) = 500 (P = is the symbol for Pound, the Egypt currency) in order to facilitate date handling.

Of the 500 Home Interview Survey Sheet (HISS) distribution. 305 (60%) were completed and returned the distribution of responses per zone is 80 housing units for zone 1, 134 housing units for zone 2, and 91 housing units for zone 3.

A sampling factor, k, was calculated for each zone for the purpose of extrapolating the data to cover the total number of households in each zone. K was based on the following formula [2], [8].

$$K = [A - (C * A / B)] / [B - (C+ D]$$

Where:
A = total households in zone,
B = number of households selected for sampling,
C = number of households vacant, and.
D = number of households that would not participate in the study.
The calculated K values for the zones are 3.9 for zone 1, 3.3 for zone 2 and 1.3 for zone 3.

4. Results and Discussion

4.1. Population Estimate

The population estimate, using the K values, for the all-housing units is 5340. This compares well with the projected population of 7000 persons when the housing unit becomes fully occupied. At the time of the study, Zones 2 and 3 were not fully occupied. The Zone1 distribution of the total estimated population is presented in table (1). Clearly, Zone 2 is the most populated, while Zone 3 is the least populated.

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TABLE I: Zonal Distribution of Housing Units and Population.

Zone	Number of Housing Unites	Population
1	290	1870
2	440	3210
3	115	260
Sum.	845	5340

Fig. (1) Home Interview Survey

Day	Date	Month	Thinking about all the transport model that you can use for the same travel you are going to do. Please answer the following questions.	Which Transport mode do you usually use to go to / from the school?
Recorded by:				1. Walk 7. Tram car 2. Private bicycle 8. Subway 3. Private motor cycle 9.Train 4. Private Car 10. others 5. Taxi 11. Don't Know 6.Bus
Site:				
Destined Station / Terminal / Taxi Spots:		1	Please answer the departure bus terminal and the taxi spot that you usually / possibly use for the travel of today.	
Departure Time from Home: AM / PM				
Departeture Station / Terminal / Taxi Spot		2	Please answer the arrival bus terminal and the taxi spot that you usually possibly use for the same travel today.	
Arrival Station / Terminal / Taxi Spot		3	How much is the normal travel fare for each transport mode?	_____Egypt Pound / person
		4	How long is the travel time between the stations / terminals / taxi spots?	_____Hour _____minutes.
		5	How do you pay your travels fare? (Method of payment)	1.Seasonal, (Monthly) 2.conductor. 3.Kilometer, (km) 4. cash 5. other
		6	How do you come to the departure station / terminal / taxi spot? Please answer the major transport mode that you usually / possibly use from the origin place to the departure station / terminal / taxi spot.	1.Walk 7.tram car 2.Private bicycle. 8.subway 3.Private motor cycle 9.train 4.Private car 10.others 5.taxi 11.Don't know 6.bus
		7	How much is the usual travel cost from the origin place to the departure station / terminal / taxi spot?	_____Saudi Riyals / person
		8	How much is the usual travel time from the origin place to the departure station / terminal / taxi spot?	_____Hour_____minutes.

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Your Personal Matter Nationality: Egyp. Non Egyp. Sex: Male Female Age: Years old Type of cars if you or your family have any. 1.No Car 2.Car 3.Motorcycle 4.Bicycle	9	How do you go to the destination place from arrival terminals / station / taxi spot? Please answer the major transport mode that you usually / possibly use from the arrival station / terminals / taxi spot to the final destination place.	1.Walk 7.tram car 2.Private bicycle. 8.subway 3.Private motor cycle 9.train 4.Private car 10.others 5.taxi 11.Don't know 6.bus
	10	How much is the usual travel cost from the arrival station / taxi spot terminal to the final destination?	_____Saudi Riyals / person
	11	How much is the usual travel time from the arrival station / terminal / taxi spot to the final destination?	_____Hour_____minutes.
Present Residence Province: District: City: Town: N0:	12	which of the listed are dominant reasons to decide to use the transport mode as usual or to decide to change to use the railway from other alternative transport modes? please select more than one choice.	(To dominant reasons to use this mode as usual mode) 1. Absolute availability (no other alternative modes 2. travel cost reasonable in comparison with other modes. 3.Travel time faster and suitable to your travel purpose 4.convenience with regard to time table and transferring to other train or modes. 5. comfort (seat. Air conditioning no smoking car. Less bumping and etc.) 6. others.

Please select one choices of all the other available transport modes that you can use for the same travel as you are usually using despite different travel condition (cost. time…etc)	Please select another one choice of all the other available transport modes that you can use for the same travel as you are usually using despite different travel condition (cost. time…etc)
1. Walk 7. Tram car 2. Private bicycle 8. Subway 3. Private motor cycle 9.Train 4. Private Car 10. others 5. Taxi 11. Don't Know 6.. bus	1. Walk 7. Tram car 2. Private bicycle 8. Subway 3. Private motor cycle 9.Train 4. Private Car 10. others 5. Taxi 11. Don't Know 6.Bus
Station / Terminal	Station / Terminal
Station / Terminal	Station / Terminal
Saudi Riyals /Person 2. Don't Know	1. Saudi Riyals / person 2.Don't know
1. Hour Minutes 2.Don't know	1. _____Hours _____minutes 2. Don't know
1.Seasonal, (Monthly) 2.conductor.	1.Seasonal, (Monthly) 2.conductor.
3.Kilometer, (km)	3.Kilometer, (km)

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4. cash	5. other	4. cash	5. other
1.Walk	7.tram car	1.Walk	7.tram car
2.Private bicycle.	8.subway	2.Private bicycle.	8.subway
3.Private motor cycle	9.train	3.Private motor cycle	9.train
4.Private car	10.others	4.Private car	10.others
5.taxi	11.Don't know	5.taxi	11.Don't know
6.bus		6. | |	
1._____ Saudi Riyals / person 2. Don't know		1._____ Saudi Riyals / person 2. Don't know	
1. _____hour ____minutes	2.Don't know	1. _____hour ____minutes	2.Don't know
1.Walk	7.tram car	1.Walk	7.tram car
2.Private bicycle.	8.subway	2.Private bicycle.	8.subway
3.Private motor cycle	9.train	3.Private motor cycle	9.train
4.Private car	10.others	4.Private car	10.others
5.taxi	11.Don't know	5.taxi	11.Don't know
6.bus		6.bus	
1._____ Saudi Riyals / person 2. Don't know		1._____ Saudi Riyals. / Person 2. Don't know	
1. _____hour ____minutes	2.Don't know	1. _____hour ____minutes	2.Don't know
(The dominant response to change to use from		(The dominant response to change to use from	
this alternative mode to the railway as usual mode)		this alternative mode to the railway as usual mode)	
if you are using the railway as usual mode, you don't need answer.		if you are using the railway as usual mode, you don't need answer.	
1. Travel Cost more reasonable in comparison with other modes		1. Travel Cost more reasonable in comparison with other modes	
2. Travel Time faster and more suitable of your alternative travel purpose		2. Travel Time faster and more suitable of your alternative travel purpose	
3. More convenient (time table and change to other train or modes		3. More convenient (time table and change to other train or modes	

4.2. Zonal Household Characteristics

The zonal household characteristics, in terms of average household family structure and average household car Ownership are presented in Table (2)

TABLE 2: Zonal Average Household (HH) Structure and Car Ownership

zone	Average HH Family structure	Average HH Car Ownership
1	6.4	1.2
2	7.3	2.1
3	2.3	3.5

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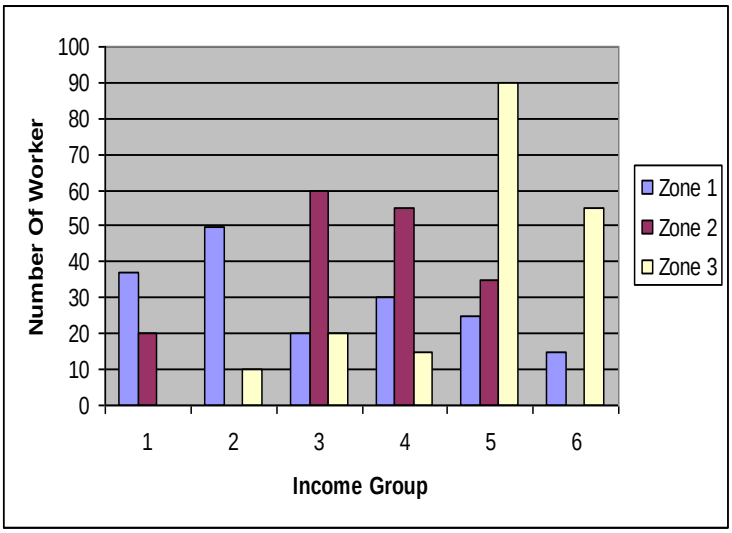

Income Grouping

Group	Income
1	Equal or less than 500 Egypt Pound
2	500 to 750
3	750 to 1000
4	1000 to 1250
5	1250 to 1500
6	Greater Than 1500

Fig. (2) Zonal Income Distribution

In Zones 1 and 2, the average household family structure would be expected to be on the order of 4.6. The value for Zone 3 is low because the Zone has not been fully occupied. In table (2), the zonal average household car ownership seems to correspond to the family structure. This is not much against expectation. However, it Zone 1 would not be as the 1.2 value recorded, because preliminary information from this zone indicated that families in zone 1 are low – income earners. Under normal circumstances, average car ownership for high – income families in Egypt could be as high as 3.

The Zonal distribution of workers incomes is shown in Figure (2). For the income groupings adopted, groups 1 and 2 represent the low-income class, 3 and 4 the medium-income class, and 5 to 6 the high-income class.

4.3. Trips Generated

The summary of results of analysis totalled for each zone are presented in table (3)

TABLE 3: Summary of Results

Results of Analysis	Zone			Σ
	1	2	3	
Total no. of daily trips	7873	12875	1263	22011
No. of daily work trips	1300	1765	319	3384
No. of daily car trips	3521	10411	827	14759
No. of cars in Household	1166	2827	242	4235
No. of workers in HH	559	815	139	1513
Total no. of persons in Household	1870	3210	260	5340

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The proportion of work trips, non work trips, and car trips of the total daily trips for each zone are presented in table (4).

TABLE 4: Work, non-work and Car trips as a percentage of total daily trips

Trips	Zone		
	1	2	3
Work trips %	16.51	12.27	25.12
Non work trips %	83.49	87.33	74.88
Car trips %	61.32	75.03	66.93

The estimates of the present number of daily trips generated from the housing units are 22856 total trips, 3294 work trips and 15982 car trips.

The highest relative proportion of non work trips (least relative proportion of work trips) was recorded for the zone 2.
The highest proportion of car trips of the total trips was also recorded for this zone.

A high proportion of non work trips was also recorded for zone 1. This is explained by the mix of work types in this zone (a high proportion being self-employed). Moreover, there are situations in this zone where a housing unit is occupied by persons of widely varying work types. This greatly contributed to the relative unpredictability of the trip patterns in this zone.

5. Model Development

The data were used to develop trip generation models for each zone. The models are presented in table (5). In that table, the high correlation between the dependent variables shows that the model is appropriate for the prediction of the trip – making patterns of the dwellers of the housing units with similar characteristics. On the other side, no significant relationship was established for car trips and car ownership for all the zones.

This may be explained by the relatively low maintenance of cars by some car owners (mostly in the low – and medium- income groups) as a result of the high cost of spare parts and accessories.

On the average, the correlation coefficients are lowest for the models developed for zone 1. This is as expected because this zone has a wide variation in category of workers. Workers here range from civil servants to the self-employed.

TABLE 5: Trip Generation Regression Models for all HH zones

Zone	Regression Models	Correlation Coefficient (R)
1	Y_1= 109.54+2.83X_1 + 2.28X_3 Y_2= 11.00+0.098X_1 + 2.00X_2	0.978 0.991
2	Y_1= 336.45+1.47X_1 + 2.39X_3 Y_2= 23.22+0.11X_1 + 1.53X_2	0.977 0.999
3	Y_1= 11.05+0.22 X_1 + 4.31X_3 Y_2= - 3.64 - 0.34 X_1+ 3.01X_2	0.994 0.985

Y_1 = total daily trips in zone, Y_2= total daily work trips in zone,
X_1 = car ownership in zone, X_2= number of workers in zone, and
X_3 = number of dwellers in zone.

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6. Conclusions

The developed models describe very adequately the relationships between daily trips and the selected independent variables. The models differ for the zones as expected because of differences in zonal characteristics. A relatively lesser degree of correlation was recorded for zone 1, which has the widest distribution of category of persons (in terms of workers income), the highest relative proportion of low- and medium-income earners, and the widest variation of work types in the housing units. This has meant less relative predictability of the trip patterns in this zone. The number of daily trips in each zone bears simple relationship with zonal population. The daily number of trips increases with population. The highest relative proportion of non work trips (least relative proportion of work trips) was recorded for the zone with the largest number of high-income workers. This is because of the affluence in which this category of dwellers lives, the high population, and the large number of cars in the zone. The highest proportion of car trips of the total trips was also recorded for this zone. This is also population and car-ownership related.

Generally, no significant relationships were established between number of car-driver trips and car ownership for all zones. This is due to prevailing economic stress.

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