Estimation of Trip Production Rates for Al Adhamiyah District in Baghdad city using Cross-Classification Technique

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Abstract. Trip generation is the first and the basic component in the four step of urban transportation planning studies. Baghdad city had limited work on this field despite its importance. This research focuses on estimate trip production rates of AL-Adhamiya district in Baghdad city as a case study and determine the household travel characteristics pattern according to the dataset from the field survey taking into consideration the socioeconomic factors. The study area divided into 3 sectors consisting of 28 zones, 2001 form collected by using two basic mechanisms, Household survey and questioner survey, then online survey had been used due to the circumstances that occurred in the country, beginning with the demonstrations down to corona Epidemic, which lead to close the vital facilities such as schools and universities. The collected forms have been processed and analysed by using cross classification Technique. The results of the study are considered as a data presentation that can be used as guidance for the local government agencies and researchers.

Results showed that the trip rate of the Studied Sectors was 5.9 trips /HH with 2001 house hold in the data set and total number of trips (11832), and the trip production effected by family size, age group, income level and car ownership. However, the increase in trip production duo to car ownership is not significantly big due to the advantage of the study area location and its characteristics, which allows to use the different travel mode available in the districts such as walk and public transportation.

1. Introduction

The evaluation and development of highway or any transit facilities need urban transportation planning to serve present and future travel demand. Forecasting of travel demand is considered an essential part of transportation planning and helps to provide a benchmark for the proper design of transportation system.

In Baghdad city the population growth and migration from other Iraqi governate beside the growth in the composition of vehicles lead to increase travel demand, add to that the restrictions on using some of the streets due to the security issues especially after 2003, all that made the daily performing activities a burden with the huge traffic jam for the whole network. It became necessary to make a comprehensive study for the transportation network in the city, in this thesis AL-Adhamiyah district
taken as a case study on trip generation by estimate trip production rates of the district and recognize the causes of these journeys as well as determine the household travel characteristics pattern.

2. Literature Review
Travel demand is defined as the number of vehicles or persons expected to travel on a given segment of a transportation system under certain socioeconomic, environmental conditions per unit time. Travel demand forecasting is a basic component in transportation engineer, it allows to predict the traffic volume on the future transportation system and explain what the future needs might be to provide proper design and efficient transportation system operation. To forecast the Travel demand there is several methods range from a simple way of observation to a complicated computerized process including comprehensive data gathering and mathematical modelling [1]

The basics urban travel estimation process to determine present and future travel patterns are Land use Analysis and Population, economic analysis [2]. In Baghdad city, the population had increased over the years as it shown in Table 1 according to the previous census due to social and economic reasons.

| Census year | Population | Growth rate |
|-------------|------------|-------------|
| 1979        | 3060000    | 2.79%       |
| 1989        | 3997000    | 2.36%       |
| 1999        | 5068000    | 2.59%       |
| 2009        | 5521000    | 4.52%       |
| 2019        | 6974000    | 2.38%       |

Also In the last fifteen years, prompt changes have happened in land uses of the city as a result of population growth, migration, and the random expansion that happened mostly without official approvals. Green and agricultural areas are gradually decreased with the increasing demand for residential, commercial buildings and industrial regions [3]. Figure.1 describes the Land Uses of Baghdad City.

![Figure 1. Land Uses of Baghdad City (REF: Amanat Baghdad).](image)
Trip generation is the first step in travel demand forecasting process which is divided into conventional four-steps which are (Trip Generation, Trip Distribution, Modal Split, and Traffic Assignment) [1],

Trip generation classified into two types of trips: "Trip production" and "trip attraction", and this thesis focuses on Trip production which is the first and the most critical step in travel demand forecasting, it uses to predict the number of trips "produced" in the city [4].

Trip production has a different type of trips based on the trip activities which is:

- Home-based work trips (HBW): representing the trips from Home to work.
- Home-based education trips (HBE): trips from home to all kinds of learning places.
- Home-based other (HBO) trips: Trip from Home to any destination except work and education like shopping, social, religious visit.
- Non-home-based (NHB) trips from work to shop or any place except Home.

Many studies were conducted to develop trip generation models and the transportation planning process in Iraq. In Baghdad precisely Polservice's study in 1973 was the first master plan for Baghdad city which prepared to make plans for the transportation of the city and finding number of daily trips in Baghdad city and other goals. [5]

Amin in 1974 used the data of Polservice office to make a study for construction of trip generation model. The study developed two aggregate equations, the first equations has $R^2 = 0.897$, the second equation has $R^2 = 0.884$. Then in 1982 there was Scott Wilson Study which initiated in 1979 by Ministry of Planning and supervised by Ammant Baghdad, the objective of the study was to produce comprehensive plan for Baghdad city transportation for the years 1985, 1990, and 2000 and evaluate alternative transport strategies. The survey work done by Scott Wilson and partners as well as the processing, the study area is divided into 372 zones, 301 zones are internal and 71 zones are external. [6]

In 1997 Hazim Abdul-Hafid, made a study for Baghdad city and the surrounding areas to find the effect of the number of zones on the accuracy of transportation studies. The study area was divided into 37, 63, 90, 120, and 150 zones, then comparison was made between these division and Scott Willson comprehensive transportation study made in 1982. It is concluded that, increasing number of zones leads to increase the accuracy of the results. [5]

In 2010 Al-Hasani made a study to develop statistical models to predict the volume of trips production and the trip rate for the family from selected zones at Al-Karkh side of Baghdad city, The study area is divided into 10 sectors with 45 total number of zones based on the administrative divisions. Two techniques have been used for survey, full interview and home questionnaire and models are developed by using stepwise regression technique. Results show that total persons trips per household are related to family size and other variables such as total number of workers, number of person more than 6 year age, number of students in the household, number of private vehicles. The coefficient of determination for this model is equal to 0.669 for the whole study area. [6]
3. Research Objectives
The aim objectives of this study is to estimate trip production rates of AL-Adhamiya district using cross classification technique through collecting accurate and detailed information about travel characteristics of household in the study area, which is quite useful to forecast the future travel pattern to provide a bench marks for the planner to develop the existing road network and provide efficient transportation system operation.

4. Methodology and Data Collection
To achieve the research objectives, a work plan for the study should be accomplished with a sequence steps to avoid the flustering. The following steps are convenient to be followed to achieve the requirements:

4.1 Review the Study Area
Baghdad city is the capital of Iraq, it had 20 administrative districts and AL-Adhamiyah district is one of the oldest districts in it.
AL-Adhamiyah district has a strategic location, it is located in the north-west of Baghdad, and lies on the banks of the Tigris River, on Al-Rusafa side, with 4 bridges associated with it, these bridges are:

• AL-Aimmah Bridge.
• 14 Ramadan Bridge (AL-Adhamiyah Bridge).
• Al-sarafia Bridge.
• Bab al muadham Bridge.

Therefore, it considers a center for commercial, administrative and educational activity that produced a lot of transportation trip movements, especially in the center of AL-Adhamiyah district (AL-Adhamiyah city). Fig. 2 display the location of AL-Adhamiya district in Baghdad.

![Figure 2. The Location of AL-Adhamiyah District in Baghdad (Ref: Satellite Image).](image)
The area of AL-Adhamiyah district is approximately 25 km² [8]. The estimated population of the district according to the latest statistics is 297,157 (ministry of planning, 2019), with a gradual increase in population over the years as shown in Figure 3.

![Population By Year Chart](image)

**Figure 3** Population Growth for Center of AL-Adhamiyah District (Ministry of planning, 2019).

4.2 Zoning the Study Area

To facilitate the data collection of any study area it must be divided into several units, the process of dividing the area into small units called traffic analysis zones (TAZ) [9]. This process (zoning process) used to have better understand for the land use and the activity of the study area which lead to reducing the time needed for data processing [10].

According to the division of Baghdad governorate Council, the study area is divided into 3 sectors as shown in Table 2 and 28 zone illustrated in Table 3 and Figure 4.

**Table 2.** Sectors of the Study Area (Ref: Baghdad governorate council, 2019).

| Sector No. | Name of the sector | Description |
|------------|--------------------|-------------|
| 1          | Center of the district | 10 zones |
| 2          | AL-Shamasiah district | 9 zones |
| 3          | AL-Rabye district | 9 zones |

**Table 3.** Internal Zones in AL-Adhamiyah district (Ref: Baghdad governorate council, 2019).

| Sector | Name of the Zone | Number of zones | District no. |
|--------|------------------|-----------------|--------------|
| 1      | Al-Wazeria       | 3 zones         | 301-303-305  |
|        | Al-Maghrib       | 3 zones         | 302-304-306  |
|        | Al-Adhamia       | 4 zones         | 308-310-312-314 |
| 2      | Al-Kabera        | 4 zones         | 307-309-311-313 |
|        | Al-Shamasiah     | 5 zones         | 316-318-320-322-324 |
| 3      | Al-Rabia         | 3 zones         | 326-328-330  |
|        | Tunis            | 6 zones         | 332-334-336-338-340-342 |
4.3 Design of the Questionnaire Form

A criterion should be used to design the questionnaire form, the traditional household survey includes 5 sections with information of: dwelling unit; household characteristics (age, household income, family size, the number of cars owned by the household, the number of students, and the number of workers); car ownership characteristics; personal characteristics and trip data characteristics [11] and most of these criteria had been used in the Questionnaire Form of this thesis.

4.4 Sample Size Selection

It is impractical to interview all the residents of the study area, so it became necessary to have a sample size to calculate the data required. The sample size depends on the total population and the number of households in the study area. [10] The estimated population of the district according to the latest statistics is 297157 and the total number of households is (32929), compare it with the recommended values shown in Table 4.

Table 4. Standard of Bureau for Sample Size selection.

| The population of the study area | Sample Size |
|---------------------------------|-------------|
| Minimum                         | Recommended |
| Under 50,000                    | 1 in 10     | 1 in 5       |
| 50 000 – 150 000                 | 1 in 20     | 1 in 8       |
| 150 000 – 300 000                | 1 in 35     | 1 in 10      |
| 300 000 – 500 000                | 1 in 50     | 1 in 15      |
| 500 000 – 1,000,000              | 1 in 70     | 1 in 20      |
| Over 1 million                  | 1 in 100    | 1 in 25      |

Fig. 4 The Zoning of AL-Adhamiyah district (Ref: Amanat Baghdad, 2018).
It can be noticed from Table 4 that the recommended sample size according to the population of the study area should be 1 in 15 (1/15). So the required sample size will be:

\[
\text{Sample Size} = \text{the recommended sample size} \times \text{the total number of households} = \frac{1}{15} \times 32929 = 2195.2
\]

Therefore, near 2200 questionnaire forms had been distributed in the study area.

### 4.5 Data Collection and Implementation

Data collection is one of the most difficult stages in urban transportation process. It requires a good preparation and accuracy in choosing the appropriate required question to get the accurate information.

Two basic mechanisms had been used in data collection, Household survey and questioner survey, distributed in many institutes, schools and colleges. Then due to the circumstances that occurred in the country, beginning with the demonstrations down to corona Epidemic, which lead to close the vital facilities such as schools and universities, additional method (online questionnaire) had been used to overcome these difficulties by sending the survey forms through social media. 793 samples were distribute as ((home interview)) survey, 1200 samples as a questionnaire survey and 571 collected by online questionnaire survey.

As a result, 2001 from 2200 samples were valid and used as a data set in the analysis by using cross classification Technique. Table 5 illustrate the number and percentage of the valid samples in the 3 studied sectors.

#### Table 5. Distribution of the valid samples in the study area.

| Sector No. | No. of household unit sample | Percent of household unit sample |
|------------|-----------------------------|---------------------------------|
| 1          | 886                         | 44.3%                           |
| 2          | 624                         | 31.2%                           |
| 3          | 490                         | 24.5%                           |

### 5. Cross Classification Technique

Cross classification is a technique used to determine the number of trips that begin or end at home and develop a relationship between socioeconomic measures and trip production, this technique developed by the Federal Highway Administration (FHWA) [1].

It applied as a matrix and each group of the matrix contains rows and columns to describe its cross variables in cells such as income level class and car ownership. This technique need enough data for each cell of the matrix In order to ensure sufficient household records in each cell.

The matrix table illustrated the results of the average values of its row and column for each cell and the total average of the haul matrix, the predicted result will be plotted, and smooth curves will be drawn [12].

### 6. Results and Analysis

#### 6.1 Preliminary Analysis of the Results

With 2001 house hold in the data set and total number of trips of 11832, the trip rate of the studied district was 5.9 trips /HH, and the trip rate for each of the three studied sector illustrated in table 6
Table 6: Total Daily Trips rate (trips/HH) of the Studied Sectors.

| Sector | Total number of trips | TripRate (Trips/HH) | No.of Samples (HH) |
|--------|-----------------------|---------------------|-------------------|
| 1      | 5094                  | 5.74                | 886               |
| 2      | 3800                  | 6.1                 | 624               |
| 3      | 2938                  | 6                   | 491               |
| TOTAL  | 11832                 | 5.9                 | 2001              |

Also, in this section, preliminary results will explain the differences of each household from another's neighborhoods according to the collected dataset in terms of socioeconomics and travel characteristics for the three studied sectors as below:

![Distribution of Age group across sectors](image1)

**Fig 5:** Age Group Distribution in the studied Sectors

![Distribution of Trip purpose across sectors](image2)

**Figure 6:** Distribution of Trip purpose for all the Studied Sectors
1. Figure 6 shows that the age group (6 to 18 years old) had the highest percentage in all sectors which represents the students in elementary, middle, and high school, and the second-highest age group was (25 to 60 years old) which represents the worker's group of age which is the most important age group because it linked to income level that lead to a high potential for trip making.

2. Figure 7 illustrated the distribution of trips according to their purpose, and showed that the Home-Base-Education (HBE) trips had the highest percentage for all the studied sectors, then Home-Base-work (HBw) trips had the second highest percentage, Which is compatible with Figure 6 that indicated the highest age was (6-18) years which represent student's group of age followed by (25 to 60 years old) which represents the worker's group of age.

3. Figure 8 refers to the way of travel used by the traveler in the study area. Result showed that the use of a private car had the highest percentage for all study sectors. Then public transportation as a result of the spread of the principle (transport line) for employee and students in Iraq, also many of resident walking because the commercial center and schools are in walking distance, and it notice that some of the resident using motorcycle because of its low cost and ease of movement to avoid traffic jam.

6.2 Trip pattern characteristics Using Cross-classification Method
In this section House hold dataset have been analyze using Two-way cross-classification technique by the three most influential variables; car ownership, income level and family size, to help in understanding the trip pattern characteristics of all household within the ranges of socioeconomic characteristics.

Family size classified into nine categories, starting from one member, up to nine or more members (+9). Also car ownership classified into three categories; zero car, one car and two or more cars (+2), as well income level classified to three categories (low, mid and high) income level.
Figure 8: Percentage of House hold (%HH) by Family Size and Car Ownership.

Figure 9: Trip Rate by (family size) and Car Ownership.
Figure 10: Percentage of Trips by its Purpose and Family Size.

Figure 11: percentage of Household (HH %) by income level and Car Ownership.
1. It is clear from Figure 9 that the increase in family size leads to increase in car ownership because each person in the household has different trip purposes and number of trips depending on their characteristics.
2. Figure 10 showing that the increase in family size and car ownership leads to increase the trip rate, however the increase due to car ownership is not significantly big, because the traveler have to make most of their trips anyway whether they have a car or not with the help of the study area location and its characteristics which allows to use the different travel mode available in the districts such as walk and public transport.

3. Figure 11 show that the HBO Trips is higher for (1 and 2.) family size, because most of them are adult (exceed Education level) or retired people, then the increase in family size leads to remarkable increase in HBE Trips and it became higher than other trip purposes.

4. Figure 12 showed that there is a clear variance in percentage of house hold that have a car between low income level and high income level. The higher percentage of HH with low income level have (0) vehicle, while the higher percentage of HH with high income level have (+2) vehicle, and that matching the concept of increasing income level lead to increase car ownership and which leads to increase in trip rate as clear in figure 13.

5. Figure 14. showing that HBE trips had the highest percentage of trip purpose in all groups of income level(low, mid ,high) of study area ,and the higher percentage of it was in lower-income groups with 43.79% which shows the interest for educations in the study area despite their income level, supported by the free education applied in the country.

7. Conclusions
The following concluding remarks can be drawn:
1. Home-based. Educational trips (HBE) had the highest value of all trip purposes, due to the high ratio of the students’ member and the student’s age group (6-18) per household. Followed by Home-Base-work (HBw) trips.
2. the trip rate of the Studied Sectors was 5.9 trips /HH With 2001 house hold in the data set and total number of trips (11832), and its effected by family size , age group, income level and car ownership.
3. The increase in family size is the basic variable that leads to increase in the trip making because each person has different trip purposes and number of trips depending on their characteristics.
4. the increase in car ownership leads to increase in trip rate, however the increase is not significantly big, because the travelers have to make most of their trips anyway whether they have a car or not, with the help of the different travel mode available in the districts such as walk and public transport.
5. the study area location and its characteristics allows to use the different travel mode available in the districts especially walk because the commercial center and schools are in walking distance,
6. With the three groups of income level (low, mid, high), the higher percentage of educational trips was in lower-income groups which shows the interest for educations in the study area despite their income level, supported by the free education applied in the country.
7. Online survey considered a good mechanism of survey that recommended to be used more in the future, it decrease time and effort needed by other type of survey.

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