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RESEARCH ARTICLE

Enhancing the Sustainable Transportation Facilities Infrastructure Need with the Trip Generation Modeling

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ARTICLE INFO

Article history
Received: 18 September 2023
Revised: 20 October 2023
Accepted: 23 October 2023
Published Online: 3 November 2023

Keywords:
Transportation
Model
Trip generation
Infrastructure
Urban area
Questionnaire
Sustainability

ABSTRACT

The transportation system is considered as one of the most important sustainable infrastructures in a country. Enhancing its need for development to cover the requirements of the inhabitants in a city is vital and the starting point for that is the consideration of the total number of trips generated to cover the commercial, educational, work and entertainment needs. In the present work, the trip generation in Baghdad was monitored and modeled. A questionnaire was designed and distributed among the western part of the city to obtain information regarding the number of trips generated daily by the household. Various aims of the trips and their duration as conducted by the members of each household were obtained, analyzed, and modeled. The obtained trip generation statistical model of Baghdad urban area can be implemented in the future development of the sustainable transportation infrastructure and predict its need for expansion and development.

1. Introduction

The sustainability of the transportation system is concerned with any means of transportation of people which is green, has low influence on the environment, affordable to users by the people, and can balance future and current needs. A comprehensive overview of the planning for transportation facilities studies that took place during the past six decades for Baghdad city was demonstrated by Sarsam [1]. The study covers the proposals that were submitted by the major international consulting firms for managing the urban transportation scheme of Baghdad for the future and improving the sustainability of the existing transportation system. The proposal for the establishment of freeways, ring roads, metro tubes, and light train were exhibited by Kirkpatrick and Partners [2]. It was revealed that due to the economic restrictions, military action during the eighties, and security issues in the region, a

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DOI: https://doi.org/10.55121/tdr.v1i1.98

minimal part of those proposals have been implemented. It was concluded that the execution of a sustainable transport system is essential to solving traffic congestion and environmental problems. The economic considerations which influence the sustainability of transportation are the speed and cost of the trip, flexibility, capacity, and reliability. Figure 1 exhibits the target sustainable transportation system which includes energy efficiency, urban planning, sustainable tourism, and climate mitigation as revealed by Cruz et al. [3]. Implementation of new techniques for data collection using GPS was reported by Kattan et al. [4]. A follow-up public opinion survey was conducted using a questionnaire by Albrecht et al. [5]. The questionnaire was focused on gathering information on the most relevant traffic-related experiences, priority areas, public attitudes, and driving behaviors. Sarsam and AL-Khafaji [6] conducted a field survey among the driving population in Baghdad across various age and educational levels. A questionnaire was created and developed. It was concluded that attention should be focused on traffic safety rather than the experience or physical condition of the driver.

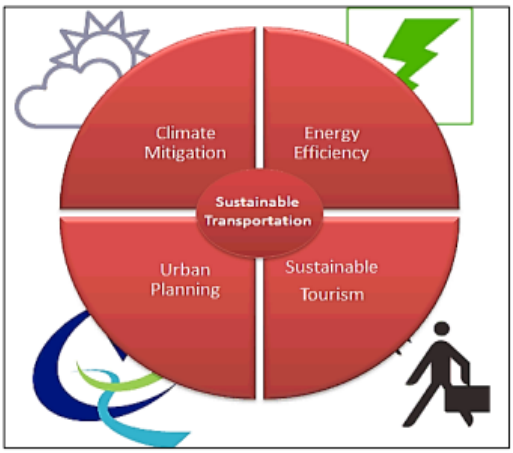

Figure 1. The sustainable transportation system.

2. Research Methods

The data of traffic-generated accidents and causalities were provided by the traffic directorate of Baghdad. Data were presented in histograms as demonstrated in Figure 2.

It can be observed that such high accident and fatality rates are due to the limited roadway facilities and higher population of vehicles. The accident rates decline through the years 2013-2015, then increase sharply. This may be attributed to restrictions on travel on the roadways due to military action during that period.

2.1 Design of Questionnaire

A questionnaire was prepared based on many research works through the literature [7-10], a questionnaire was prepared. The prepared questionnaire consists of questions regarding the household size, age group, number of daily trips by individuals, vehicle ownership, and purpose of the trip (work, education, entertainment, and commercial). The questionnaire was distributed through the west side of the city and then collected for analysis.

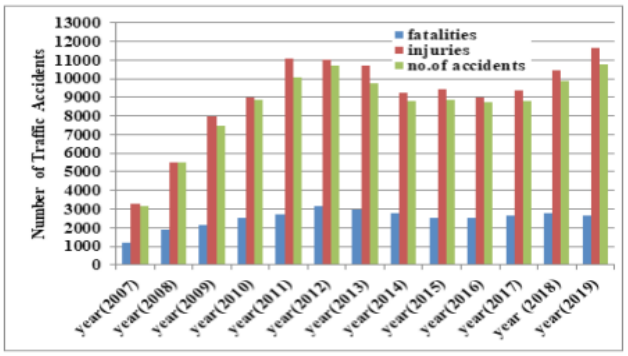

Figure 2. Traffic accidents and casualties in Baghdad as per the traffic police directory.

2.2 Case Study of Baghdad

Baghdad city of 8000000 inhabitants was considered in this assessment. The distribution of people in the city's population is variable, and the density of the population is more on the outskirts of city around the center at the residential zones of the city. It was noticed that the demand of people for the transport system has increased, which may be attributed to the increase in the population and in the labor force, the estimated increase of population in Baghdad is nearly 45% as compared with the first comprehensive study for Baghdad which was conducted during the early 70s. The study of integrated development project had expected for the year 2000, that the city center of Baghdad has 22% of the population and 53% of the employment, and outside the center is 47% of job opportunities and 78% of the population. Table 1 demonstrates the dramatic increase in the population of Baghdad through the past four decades and its expectation for the next decade. It also exhibits the variation in the average household size and the number of households through the investigated decades.

The area of the west side of Baghdad was divided into 10 sectors. For the purpose of data collection and monitoring, each sector is sub divided into a number of zones, each zone representing 1000 households. The zoning is based on the administrative divisions of council municipals. Figure 3 demonstrates the zoning scheme of the study area. The Traditional household survey has five sections; personal characteristics, dwelling unit information,

Table 1. Household growth rate and population at Baghdad.

Variable	1987	1997	2007	2017	2027
Population of Baghdad (millions)	3.841268	5.365989	7.145470	7.916847	8.354156
Number of household	527002	774637	1114000	1203400	1505300
Average household size (person/family)	7.28	6.92	6.41	6.57	5,54
Population of Iraq (millions)	16.33	22.04	29.68	35.6	42.1
% of urban area of Baghdad	70	90	86.7	88	86
% of population (Baghdad/Iraq)	23.5	24.3	24.07	22.2	19.8

car ownership characteristics, household characteristics, and trip details as recommended by Mathew and Rao [11]. The number of households was 423,728 as per the Ministry of Trade, 2020. The minimum sample size is 1/100 from the total number of households, so the sample size will be 4237. This sample will be allocated to the sectors in the study area based on the proportion of households in the sectors from the total household in the study area. Details of the questionnaire can be found in Sarsam and Al-Hassani [12]. The percentage of response for households was determined as the ratio between the households who agree to participate and complete the questionnaire with a reasonable accuracy to the total household interviewed. The response was 74% which is considered as reasonable. Such finding agrees with the work reported by Jayashree et al. [13].

Figure 3. Zoning of the study area.

2.3 Trip Generation Modeling

The trip production model was developed by the implementation of the stepwise multiple linear regression statistics because of their power and simplicity. The regression modeling is the statistical process that may be used to evaluate the relationship between two or more quantities variables to generate a model that predicts one variable from the others in order to present the data in the best fit. The usual goal of the multiple linear regressions is to develop the best trip generation model at selected confidence level and satisfy the basic assumptions of regression analysis.

3. Results

Data were fed to the SPSS-V17 software, the dependent variable was the total trips by a person in the household, while the independent variables included the household size and structure (number of person in the dwelling house, total household workers, and total household students), vehicle ownership, and the household by the age group. The above variables were defined and then fed in the same arrangement as in the form of questionnaire to facilitate the entry process. Figure 4 exhibits the number of inhabitants in the households. Similar findings were reported by Sarsam [14].

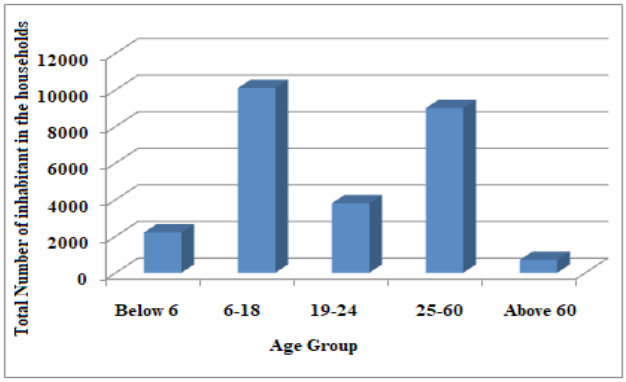

Figure 4. Total number of inhabitants in the households.

4. Discussion

Data were fed for each zone and the models were built for each sector and hence, in the modeling process the data were merged. Data were tested and verified for being most reasonably related to the dependent variable and were considered in the modeling. Correlation analysis and analysis of variance (ANOVA) were used for this purpose

to check the strength and direction of the relationship between two quantitative variables. The goodness to fit of linear models and the errors were tested. This was achieved by scatterplot for standardized residuals on Y axis and the estimated values of the dependent variable on X axis. The points should be distributed equally about zero line. Figure 5 presents scatter plot of standardized residuals of the dependent variable.

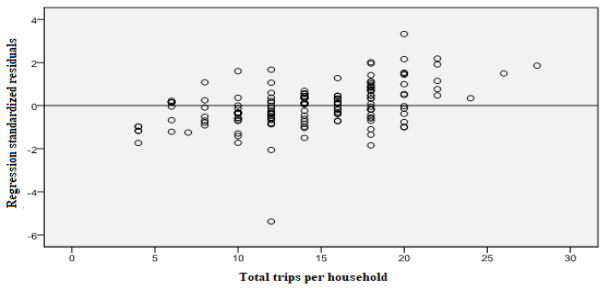

Figure 5. Scatter plot of standardized residuals of the dependent variable.

Figure 6 exhibits the normal probability of errors for the whole data of the study area. It can be observed that the points of scatter lie between the range of (0,1) and errors are normally distributed.

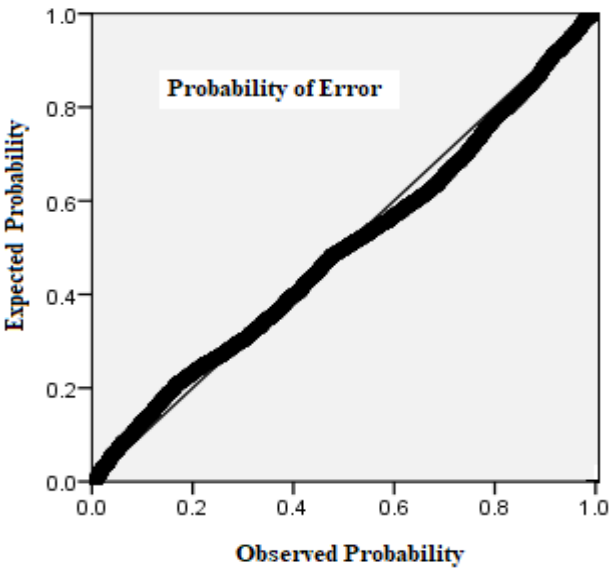

Figure 6. Normal distribution of the probability of error.

The stepwise multiple linear regression statistics method was implemented, this method can compute the simple regression model for each independent variable. The independent variable that has the largest F-statistic is selected as the first entering variable. If at least one variable exceeds the standard, the procedure continues. The procedure considers whether the model will be improved by adding a second independent variable and so on. It examines all variables to determine which has the F-statistic or probability of 0.05 which corresponds to 3.84 F value. Table 2 demonstrates the distribution of the trip purpose; it can be observed that a significant portion of the trips are executed on education purposes while minimal percentage of the trips is for shopping. This may be attributed to the tradition of the people to shop one day for the whole week.

Table 2. Distribution of trip purpose.

Trip purpose	Education	Shopping	Recreation	Work
Percentage	40 %	13 %	24 %	23 %

The developed trip generation model is listed in Equation (1) below.

$$Y = 1.673 + 1.839X_1 + 0.576X_2 + 0.512X_3 \quad (1)$$

With $R^2 = 0.809$, Adjusted $R^2 = 0.807$, SEE = 1.756.

where:

Y = Total trips per household.

X_1 = Number of inhabitant with age of more than 6 years in the household.

X_2 = Number of students in the household.

X_3 = Number of male workers in the household.

The statistical validity of the trip generation analysis derived through the stepwise multiple linear regressions can be assessed by considering the standard statistical tests. A higher coefficient of determination R^2 of 0.809 and a lower value of standard error of estimate SEE of 1.756 exhibits an acceptable validity of the model.

5. Conclusions

Based on the limitation of the field work, the following remarks could be addressed.

1) The trip generation model can provide suitable information for present and future trips and the need to develop a sustainable transportation system.

2) The questionnaire can provide the data for the prediction of future needs to enhance the sustainability of the transportation facilities.

Conflict of Interest

The author declares that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This research received no external funding

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