ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230**, ISSN (online):** 2412-3986**, DOI: http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Vehicle Traffic Volume and Origin Destination Characteristics for Erbil Rural Highways

Abdulhakim O. Salih[1], Aso Faiz Saeed Talabany[1]

[1] Department of Civil Engineering, College of Engineering, Salahaddin University -Erbil, Kurdistan Region, Iraq

A B S T R A C T

The economic growth of Kurdistan region-Iraq is influenced by the traffic flowing expressed in vehicles miles traveled (VMT) because, they are correlated. To get smooth traffic, it is important to know the traffic volume characteristics and the origin – destination pattern. The vehicle traffic volume and the origin destination data at rural area near the outside 120-m ring road at a distance of about 400 m from the proposed interchanges (under construction) with the five main radial roads Kirkuk, Koya, Shaqlawa, Mosul, and Makhmur in Erbil city-Kurdistan region-Iraq is investigated. The classified vehicle volume count, and the origin-destination data on these five locations is collected. Vehicle traffic volume data is collected using video recording technique to determine the number, type and percentages of passenger cars, buses, trucks and other components of the traffic stream for the selected locations. The highest daily traffic volume is on Erbil – Koya highway (49175 vehicles for 24 hours) where, the percentage of heavy vehicles is about 14% and pickups about 21%. The origin - destination study is conducted through a curb-side survey for drivers and the data is collected directly by interview method. The origin-destination study is conducted to know and evaluate the trip characteristics of the traffic and to create the origin - destination matrix (O-D matrix). This matrix is then used to estimate the turning movements at the proposed interchanges. The vehicle occupancy, the purpose of trip and the trip frequency also were investigated. The vehicle occupancy rate is < 2.8 due to the road user's behavior. A projection is made for the future traffic operations which accounts for the diverted traffic, the generated traffic, the progress traffic, and the normal growth of traffic. The hourly expansion factors (HEF) are between 1.288 and 1.295 depending on the location. The p-factor is also determind and its values ranges between 3.59 and 7.15.

KEY WORDS: Vehicle Traffic volume, Traffic Characteristics, Origen- Destination, Hourly Expansion Factor
DOI: http://dx.doi.org/10.21271/ZJPAS.35.5.2
ZJPAS (2023) , 35(5);12-23 .

1. INTRODUCTION

The economic growth of any region is to high extent, influenced by the operation and distribution of goods and services system. The parameters that are interesting to a traffic engineer cannot be reproduced in the laboratory. Even if road and vehicles could be set up in large laboratories, it is impossible to simulate the behavior of drivers in the laboratory. (Arash Moradkhani, at el, 2009). The traffic volume and origin-destination study are conducted to evaluate the traffic and to know the trip characteristics. In the transportation planning, origin– destination (O-D) matrices, are needed. These matrices specify the travel demands between the origin and destination nodes in the network.

* **Corresponding Author:**
Aso Faiz Talabany
E-mail: aso.talabany@su.edu.krd
Article History:
Received: 01/01/2023
Accepted: 27 /03//2023
Published: 25 /10/2023

O-D studies are conducted to understand the pattern of the movement of persons and freight in a particular area during a particular period of time. In these studies the houshold charachteristics of the trip making family, time of the day when journeys are made, trip purpose and mode of travel are collected. (Catling, I O-D studies on rural highways are necessary to mange the freight related issues and problems. While, for urban roads they are conducted for solving public related issues and problems, focusing on trip length rather than tonnage and purpose of trip. (Franco Basso, et al, 2022)

There are five methods for conducting O-D survey: Roadside interview, licence plate, tag on car, return post card and home interview. The O-D data is used to establish O-D matrices which is the most common way to define demand for simulation. It is a two-way table giving the connectivity between zones. In each cell of the matrix the demand for the specific O-D pair is given. (Reilly, R. and Gardner, C., 1977)

The vehicle occupancy rate is the number of passengers in a vehicle during a specified trip. It is expressed as the number of persons per vehicle. For public transport it is expressed by the percentage of occupied seats. As the vehicle occupancy rate increases, fewer vehicles will be needed to transport the same number of people, less energy consumption and higher economic efficiency. (Beilei Xu; at el, 2014)

In 2016, Yung, at el, studied the analysis of the vulnerability of road networks that largely dependent on the assumption of a known traffic model in the simulations. In their study, they suggested a new approach for quantitatively evaluating the vulnerability of highway networks based on real-world highway tollgate data that reflect the highway's characteristics. Origin-destination tollgate data are collected across three major highway networks in China (Beijing city and Shanxi and Anhui Provinces) for three months. The case study examines the vulnerability of highway traffic networks from both macroscopic and microscopic perspectives. Moreover, a more in-depth study of vulnerability is conducted from residential and transportation perspectives. Their results will serve as guidelines for improving the toll highway system.

In 2018, Martin, et al presented an overview of the characteristics of travel to work trip using 2011 census data for England and Wales. They studied the geovisualization of 2.4 million small area interactions including 26 million travels to work flows. Their results do not take into consideration the social characteristics of the origin and destination zones but only presents the geometry and magnitude of interactions of the study area. They presented a method for the analysis of aggregate travel to work data through combining separate geodemographic classifications of the origin-destination of trips and they explored the flows between the clusters in these classifications. They applied their origin-destination method to the collected data to combine separate classifications of places of work and residence, each based on the most appropriate geographical units and variables, exploiting separate small area geographies optimized for residential and workplace-based data products. They used the official geodemographic classification of residential Computers, Environment and Urban Systems. Their aim is the demonstration of a new way to present and understand travel to work using origin-destination geodemographics.

In 2022 Noor and Zainab studied reducing the cost of moving goods through road freight modeling in Baghdad-Iraq. They collected the truck traffic data is using roadside interview surveys at the seven main entrances in Baghdad-Iraq. The O-D matrix for efficient freight transportation system is established.

In 2022, Franco Basso, at el, conducted a case study on Autopista Central, one of Santiago de Chile’s most important urban highways. In their study they estimated an origin-destination matrix for the truck movement. Their aim is to further understand the urban freight transportation. They used full real-world microscopic information of freight vehicles’ movements along the highways. They used data which is collected from the toll collection gates in the study area which is equipped with intelligent technology for the vehicle identification. To estimate the origins and destinations of the trips, they proposed a multisource methodology that uses the geographic positioning system GPS information. They used an input data which is complemented by other public databases to build a decision tree model for the estimation of the trips’ origin. This is made to reduce the bias in the results. While, for the computation of trip destinations they used proportionality factors obtained from the data. According to their results they concluded that most of the estimated origins belonged to outskirt municipalities, while the estimated destinations were mainly located in the downtown area.

The aim of this research is to study the traffic volume and origin-destination characteristics (origin, destination, vehicle occupancy, purpose and frequency) on the five main link highways in Erbil city. Then for understanding the freight and people transportation in Erbil, Kurdistan, Iraq, the O-D matrix for the trips from the study locations to the zones and vice versa is established. After that these matrices were used to estimate the turning movements at the proposed 120-m ring road interchanges which were under construction during the data collection period.

2. METHODOLOGY

A suitable methodology is followed to obtain the necessary elements through the data collection process and the analysis of the results.

The important elements that should be considered when selecting a methodology are site selection, time of day for observation, period of observation and type of data. Five locations on the five main link highways near the interchange of them with the 120-m ring road in Erbil city rural area are selected for the purpose of this study as shown in Figure (2-1). The summary of the geometric data is given in Table (2-1).

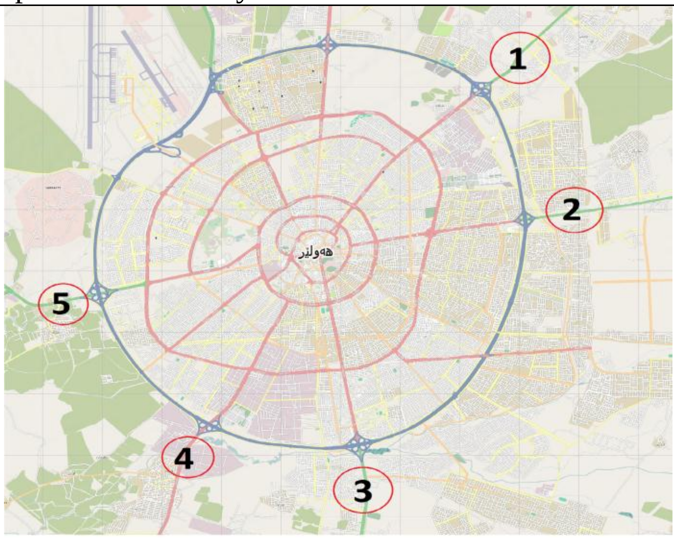

Figure (2-1): Erbil map showing the five locations of data collection.

Table (2-1): Geometric Data for the five studied locations

Location No.	Highway Name	Total Width (m)	Lanes in both direction	Lane width (m)	Grade %	Median Width (m)	Shoulder Width (m)	Direction
1	Erbil-Shaqlawa	26.00	6	3.4	0	6.0	3.0	N - E
2	Erbil-Koya	43.65	7	3.5	3	7	3.0	E
3	Erbil-Kirkuk	28.00	4	3.5	2	7	3.5	S
4	Erbil-Makhmur	26.00	4	3.5	0	6.0	3.0	W - S
5	Erbil-Mosul	38.50	5	3.5	3	14.0	3.0	W

The data is collected for a complete day started at 07:00 for 24 hours in a normal working day. The collected data is as follows:

1- Geometric data, including number and width of lanes, medians and shoulders, and grades.
2- Classified vehicle counts (24 continuous hours).
3- Origen – destination data.

The geometric data is collected directly in the field, while vehicle traffic volume data is collected using video-recording technique. After that the traffic volume data is abstracted by replaying the video film for many times with the aid of a computer program named EVENT which is developed by Al-Neami, A.H.K., 2000.

The total 24-hour traffic volume counts are observed at the five studied locations. The values between 19:00 and 7:00 are low, therefore only those between 7:00 and 19:00 is presented. The hourly expansion factors (HEF) are calculated to expand the traffic volume counts for durations less than 24 hours to 24-hour volumes, they should be multiplied by. These factors could be determined using equation-1: N.J. Garber, and Hoel, 2009

$$\text{HEF} = \frac{\text{Total volume for 24} - \text{hour period}}{\text{Volume for particular hour}} \quad --(1)$$

In order to obtain the average annual daily traffic from the the average daily traffic obtained from short-term traffic counts, the p-factor is determined using equation-2. The value of p-factor ranges between 0 and 1.0. (NRA, 2012):

p-factor = a + b – 2c ------------------------ (2)

Where:

a = The maximum hourly percentage of traffic between 0:00 and 12:00 on a weekday

b = The maximum hourly percentage of traffic between 12:00 and 24:00 on a weekday
c = The minimum hourly percentage of traffic between 08:00 and 18:00 on a weekday

$$AADT = \frac{ADT}{p} \quad (3)$$

Where:
AADT = Average Annual Daily Traffic
ADT = Average Daily Traffic Obtained from short-term traffic counts
p = Peak Hour Factor for determining the AADT from the ADT

The road side interview method is used for O-D study in this study. A total of 2000 vehicles were stopped and the drivers were interviewed with prescribed questionnaire form as shown in Figure (2-2). The origin-destination data is collected at the same time and location of vehicle traffic volume data collection. As the five locations are dual carriageways, both directions are dealt simultaneosly as shown in Table (2-2).

Origin – Destination Study Form

Date:
Station:
Interviewer's Name:

Form Number:
Traffic Direction:
Time:

No.	Time of	Type of Vehicle	Origin	Destination	Trip Purpose	Trip	Occupancy
1		PC - Private			Work	1	1
2		PC - Taxi			Shopping	2	2
3		Pickup			Study	3	3
4		Small bus			Social-Recreational	4	4
5		Large bus			Goods Transporting	5	5
6		2-axle truck			Construction & building	6	6
7		3-Axle truck			Tourism	7	7
+8		>3axle truck			Others	+8	+8
		Military					
		Others					

Figure (2-2): The questionnaire form used in O-D data collection

Table (2-2): No. of vehicles stopped for origin-destination data interview

Location No.	Direction	No. of vehicles stopped for interview						
		PC	PC-Taxi	Pickups	Buses	Trucks	Others	Total
1	Erbil – Shaqlawa	150	15	15	10	20	0	210
	Shaqlawa - Erbil	140	5	20	10	10	0	185
2	Erbil – Koya	140	20	15	15	10	0	200
	Koya – Erbil	130	20	15	15	30	0	210
3	Erbil – Kirkuk	100	10	30	20	40	0	200
	Kirkuk – Erbil	100	10	30	15	15	0	170
4	Erbil – Makhmur	150	25	25	5	15	0	220
	Makhmur – Erbil	150	15	15	10	20	0	210
5	Erbil - Mosul	140	15	15	10	15	0	195
	Mosul - Erbil	140	15	15	10	20	0	200
Total for all locations		1340	150	195	120	195	0	2000

3. DATA ANALYSIS

3.1. Vehicle Traffic Volume

The existing traffic flow survey data is obtained and then analyzed. The average daily traffic and morning and evening peak hour volumes were determined then the graph of the fluctuation of traffic volume for observation times between 7:00 and 19:00 is generated as shown in Figures (3-1) to (3-5). The summary of the peak hour volumes and other important traffic parameters for the five locations are given in Tables (3-1) to (3-4).

The morning peak hour traffic occurs at 8:00 to 9:00 for all studied locations while, the evening peak hour traffic occurs at 16:00 to 17:00 for all studied locations except Erbil – Koya highway for which the peak hour occurs between 12:00 and 19:00.

There are differences in hourly expansion factors (HEF) due to the differences in traffic volume depending on the location. In order to obtain the average annual daily traffic from the average daily traffic calculated from short-term traffic counts, the p-factor may be used.

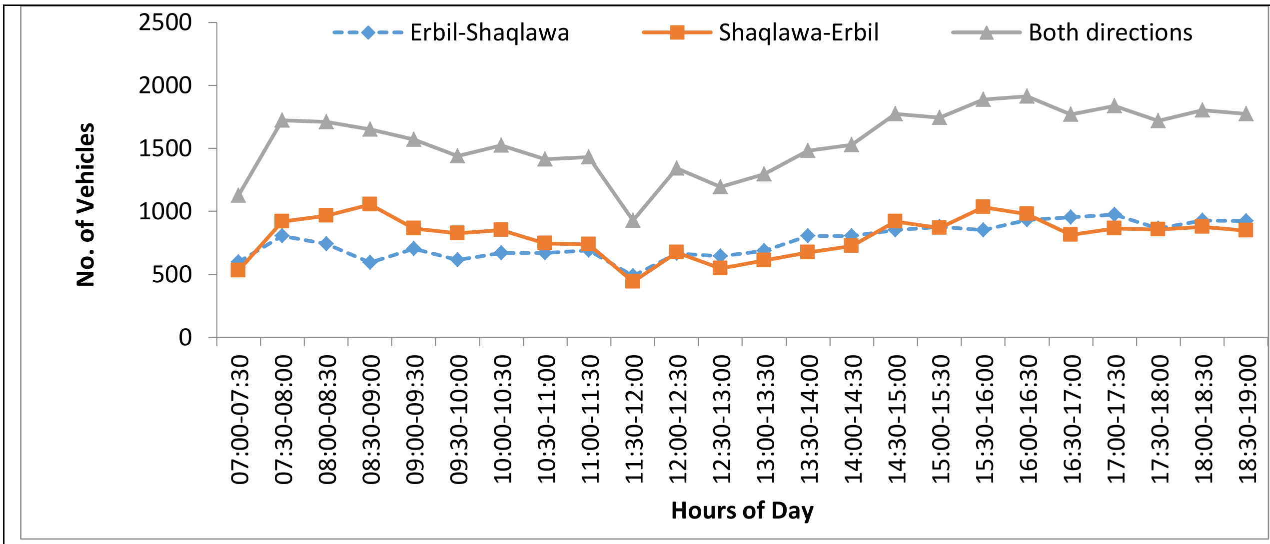

Figure (3-1): Vehicle Traffic Volume Data for Both Directions at Location-1 (Erbil-Shaqlawa Highway) between 07:00 – 19:00 (12-Hour).

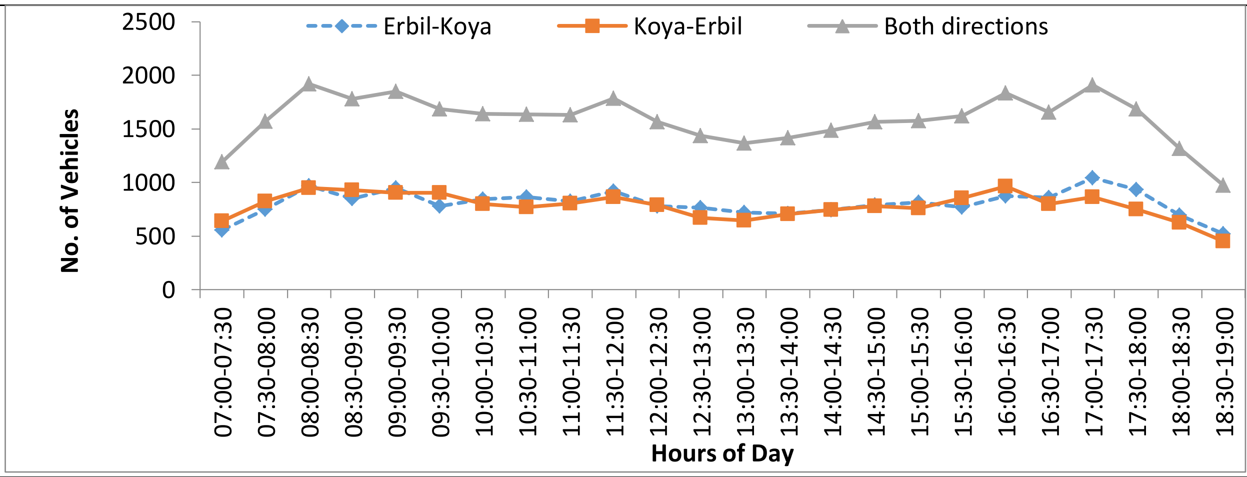

Figure (3-2): Vehicle Traffic Volume Data for Both Directions at Location-2 (Erbil-Koya Highway) between 07:00 – 19:00 (12-Hour).

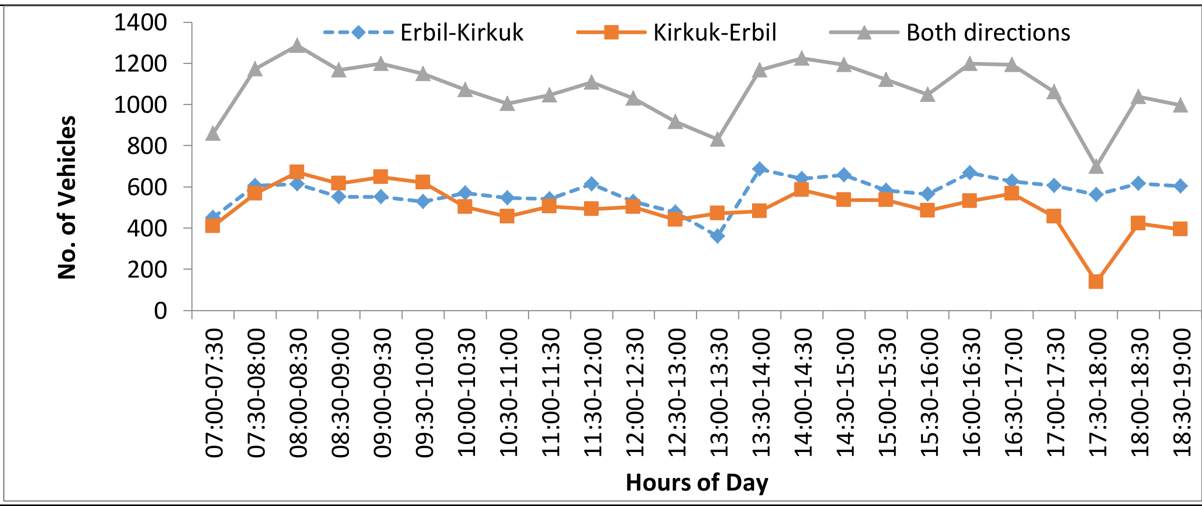

Figure (3-3): Vehicle Traffic Volume Data for Both Directions at Location-3 (Erbil-Kirkuk Highway) between 07:00 – 19:00 (12-Hour).

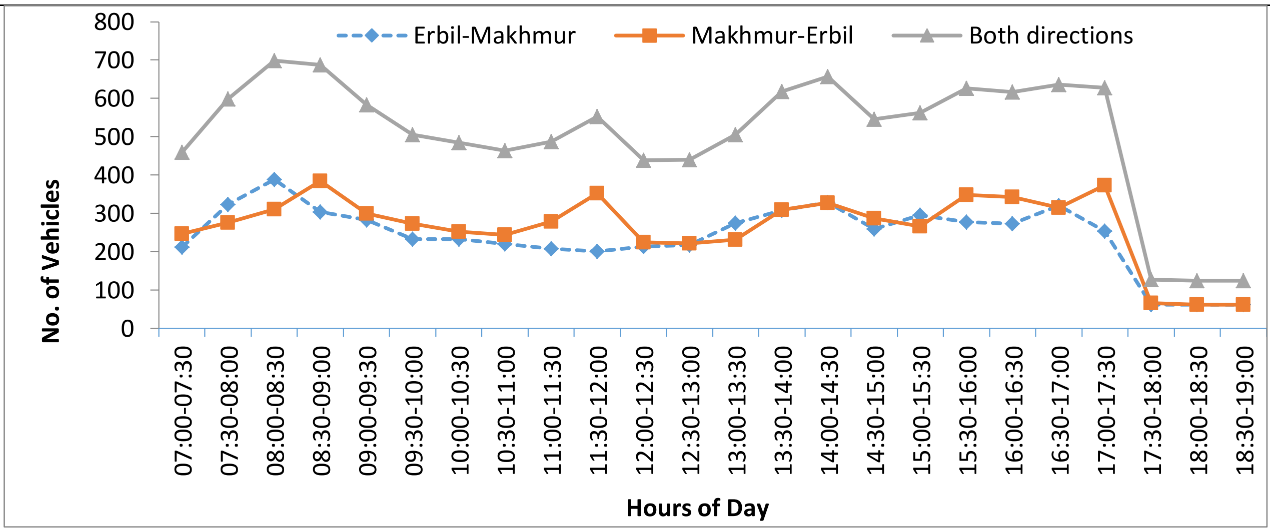

Figure (3-4): Vehicle Traffic Volume Data for Both Directions at Location-4 (Erbil-Makhmur Highway) between 07:00 – 19:00 (12-Hour).

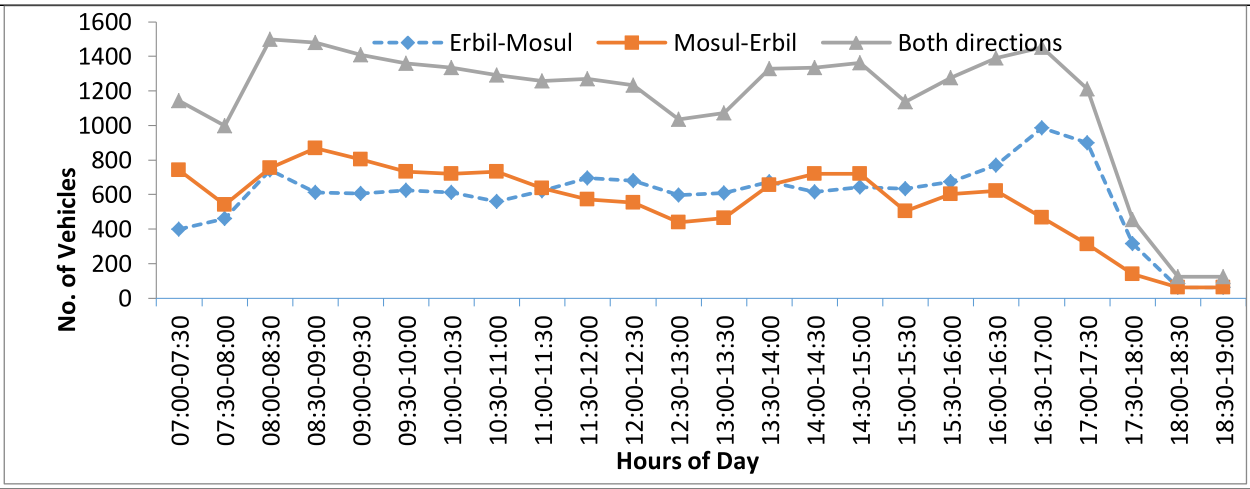

Figure (3-5): Vehicle Traffic Volume Data for Both Directions at Location-5 (Erbil-Mosul Highway) between 07:00 – 19:00 (12-Hour).

Table (3-1): Vehicle Traffic Volume Data of Each Highway between 07:00 – 19:00 (12-hours)

Location	Highway Name	Passenger car		Pickup (%)	Bus (%)		Truck (%)			Motor-cycle	Others (%)	Total for Day-hours 07:00 – 19:00	Total for Night hours 19:00 – 07:00
		Private	Taxi		Small < 24 Seats	Large >24 Seats	2-axle	3-axle	>3-axle				
1	Erbil-Shaqlawa	56.0	10.5	21.4	2.7	0.1	4.4	3.7	0.7	0.5	0.0	18327	22733
	Shaqlawa- Erbil	60.0	8.4	20.6	2.5	0.1	3.9	3.8	0.5	0.1	0.0	19227	25637
	Both	**58.0**	**9.5**	**21.0**	**2.6**	**0.1**	**4.2**	**3.8**	**0.6**	**0.3**	**0.0**	**37554**	**48370**
2	Erbil-Koya	45.2	19.1	19.0	1.7	0.9	7.8	1.8	2.4	0.4	1.7	19309	10040
	Koya- Erbil	45.1	19.0	19.1	1.5	0.8	7.4	2.6	2.7	0.5	1.3	18782	39135
	Both	**45.2**	**19.1**	**19.1**	**1.6**	**0.9**	**7.6**	**2.2**	**2.6**	**0.5**	**1.5**	**38091**	**49175**
3	Erbil-Kirkuk	46.5	12.5	21.6	2.4	0.2	7.2	2.3	7.0	0.1	0.2	13750	17636
	Kirkuk- Erbil	51.9	14.0	22.9	2.6	0.2	3.7	0.7	3.6	0.2	0.2	12026	15641
	Both	**49.2**	**13.3**	**22.3**	**2.5**	**0.2**	**5.5**	**1.5**	**5.3**	**0.2**	**0.2**	**25776**	**33277**
4	Erbil-Makhmur	39.4	12.0	29.4	2.0	0.0	9.0	3.8	3.6	0.1	0.7	5814	7412
	Makhmur- Erbil	37.0	11.3	27.2	1.9	0.0	9.0	3.3	9.6	0.1	0.6	6359	8360
	Both	**38.2**	**11.7**	**28.3**	**2.0**	**0.0**	**9.0**	**3.6**	**6.6**	**0.1**	**0.7**	**12173**	**15772**
5	Erbil-Mosul	47.0	11.6	19.8	2.1	0.1	8.3	2.9	7.9	0.1	0.2	14144	18384
	Mosul-Erbil	49.8	12.7	18.9	2.2	0.1	7.4	2.9	5.7	0.1	0.2	13421	17299
	Both	**48.4**	**12.2**	**19.4**	**2.2**	**0.1**	**7.9**	**2.9**	**6.8**	**0.1**	**0.2**	**27565**	**35683**

Table (3-2): Hourly Proportions of Vehicle Traffic Volume of Each Highway (24-hours)

	Erbil-Shaqlawa	Erbil-Koya	Erbil - Kirkuk	Erbil-Makhmur	Erbil-Mosul
07:00 - 08:00	5.89	5.62	6.11	6.71	6.00
08:00 - 09:00	6.94	7.52	7.37	8.79	8.35
09:00 - 10:00	6.22	7.19	7.05	6.90	7.76
10:00 - 11:00	6.07	6.66	6.24	6.02	7.35
11:00 - 12:00	4.87	6.95	6.47	6.59	7.08
12:00 - 13:00	5.23	6.11	5.85	5.57	6.35
13:00 - 14:00	5.74	5.66	6.00	7.13	6.72
14:00 - 15:00	6.83	6.21	7.26	7.63	7.56
15:00 - 16:00	7.50	6.50	6.52	7.53	6.76
16:00 - 17:00	7.60	7.11	7.19	7.94	7.96
17:00 - 18:00	7.35	7.31	5.29	4.79	4.66
18:00 - 19:00	7.39	4.66	6.11	1.57	0.69
19:00 - 07:00 (12 Hrs)	**22.36**	**22.52**	**22.54**	**22.82**	**22.75**
Total	100.00	100.00	100.00	100.00	100.00

Table (3-3): Summary of the Peak Hour Volumes and Some Traffic Parameters at the Five Locations

	Erbil - Shaqlawa	Erbil - Koya	Erbil - Kirkuk	Erbil–Makhmur	Erbil - Mosul
Morning Peak Time	8:00-9:00	8:00-9:00	8:00-9:00	8:00-9:00	8:00-9:00
Evening Peak Time	16:00 - 17:00	17:00 - 18:00	16:00 - 17:00	16:00 - 17:00	16:00 - 17:00
Peak Hour	8:00-9:00	8:00-9:00	7:30-8:30	15:30 - 16:30	8:00-9:00
Peak Hour Volume (vph)	3359	3695	2452	1387	2978
Directional Distribution D%	48.8/51.2	49.3/50.7	47.3/52.7	47.8/52.2	48.7/51.3
% of daily traffic in peak hour (k)	7.60	7.52	7.37	8.79	8.35
Peak Hour Factor (PHF)	0.81	0.93	0.88	0.87	0.85
Hourly Expansion Factor (HEF)	1.288	1.290	1.291	1.296	1.295

Table (3-4): p-factor for the Five Locations

No.	Highway	AM Peak	PM Peak	a	b	c	p-factor	ADT	AADT
1	Erbil-Shaqlawa	08:00 - 09:00	16:00 - 17:00	6.94	7.60	4.87	4.8	48376	10078
2	Erbil-Koya	08:00 - 09:00	17:00 - 18:00	7.52	7.31	5.62	3.59	49150	13691
3	Erbil - Kirkuk	08:00 - 09:00	16:00 - 17:00	7.37	7.19	5.29	3.98	33277	83611
4	Erbil-Makhmur	08:00 - 09:00	16:00 - 17:00	8.79	7.94	4.79	7.15	15774	2206
5	Erbil-Mosul	08:00 - 09:00	16:00 - 17:00	8.35	7.96	4.66	6.99	35687	5106

3.2. Vehicle Occupancy

The results of vehicle occupancy data are given in Table (3-5). The results show that the vehicle occupancy rate of private passenger cars are about 2.0 persons per vehicle. The lack of bus services caused an increase in the demand for private cars, but the car occupancy rate users desire to use their passenger car ownership is small due to the road private cars individually resulting in low common trips which results in the reduction of car occupancy rates.

The rate of car occupancy may continue to decline, due to the greater individualization of society and the increase in private.

Table (3-5): Vehicle Occupancy Rate (Person/Vehicle)

Vehicle Type		Erbil-Shaqlawa		Erbil-Koya		Erbil-Kirkuk		Erbil- Makhmur		Erbil- Mosul		Average
		From	To	From	To	From	To	From	To	From	To	
PC-Private		1.7	1.9	1.7	1.7	2.1	2.1	2.1	1.9	2.0	2.2	2.0
PC-Taxi		3.2	1.2	1.6	2.2	2.8	2.7	2.2	2.4	2.4	3.7	2.4
Pick up		2.3	2.2	1.1	2.4	1.9	1.7	1.9	1.8	1.7	2.4	1.9
Truck		1.9	1.5	1.0	1.4	1.2	1.1	1.1	1.4	1.6	1.4	1.4
Small Bus	N	1.7	6.4	2.0	10.0	10.0	7.0	8.6	10.0	10.3	12.0	7.8
	%	8.5	32.0	10.0	50.0	50.0	35.0	43.0	50.0	51.5	60.0	39.0
Large bus	N	11.8	6.0	9.5	16.1	17.0	12.3	0.0	10.1	14.8	12.1	11.0
	%	29.5	15.0	23.8	40.3	42.5	30.8	0.0	25.3	37.0	30.3	27.4

3.3. Trip Purpose

O-D survey data from the five locations were analyzed for different travel behavior. This data can be used for travel demand estimation and forecasting. As shown in Table (3-6), the highest percentages of trips involve work trips at four locations. More specifically, work trips represent about 24.5 to 80.3 of all trips at the study locations. This may be due to that the work trip is mandatory activity/purpose.

Table (3-6): Trip Purpose

Link	Vehicle Type	Interviewed Vehicles	Trip purpose (%)							
			Work	Shopping	Study	Social-	Goods	Construction	Tourism	Others
Erbil-Shaqlawa	PC-Private	281	72.6	0.0	0.0	5.3	0.4	0.0	1.8	20.0
	PC-Taxi	23	78.3	0.0	0.0	0.0	0.0	0.0	0.0	21.7
	Pick up	34	67.6	0.0	0.0	8.8	14.7	0.0	0.0	8.8
	Truck	33	15.2	0.0	0.0	0.0	66.7	0.0	0.0	18.2
	Small Bus	13	92.3	0.0	0.0	7.7	0.0	0.0	0.0	0.0
	Large bus	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	All Types	**400**	**68.3**	**0.0**	**0.0**	**4.9**	**7.2**	**0.0**	**1.3**	**18.3**
Erbil-Koye	PC-Private	271	32.1	0.3	0.0	20.7	0.0	45.2	1.4	0.3
	PC-Taxi	35	9.8	0.0	0.0	7.3	2.4	65.9	7.3	7.3
	Pick up	28	6.3	0.0	0.0	15.6	6.3	68.8	3.1	0.0
	Truck	36	0.0	2.4	0.0	9.8	63.4	24.4	0.0	0.0
	Small Bus	8	37.5	0.0	0.0	12.5	25.0	12.5	0.0	12.5
	Large bus	22	20.0	0.0	0.0	8.0	8.0	32.0	0.0	32.0
	All Types	**400**	**24.5**	**0.5**	**0.0**	**17.2**	**7.6**	**45.5**	**1.8**	**3.0**
Erbil-Kirkuk	PC-Private	223	57.0	0.0	0.0	17.5	0.0	0.0	2.2	23.3
	PC-Taxi	17	94.1	0.0	0.0	0.0	5.9	0.0	0.0	0.0
	Pick up	59	78.0	0.0	0.0	6.8	6.8	0.0	0.0	8.5
	Truck	68	31.9	0.0	0.0	0.0	62.3	0.0	0.0	5.8
	Small Bus	20	45.0	0.0	0.0	5.0	45.0	0.0	0.0	5.0
	Large bus	13	53.8	0.0	0.0	0.0	46.2	0.0	0.0	0.0
	All Types	**400**	**56.6**	**0.0**	**0.0**	**11.0**	**15.7**	**0.0**	**1.2**	**15.5**
Erbil-Makhmur	PC-Private	222	57.0	0.0	0.0	17.5	0.0	0.0	2.2	23.3
	PC-Taxi	17	94.1	0.0	0.0	0.0	5.9	0.0	0.0	0.0
	Pick up	59	78.0	0.0	0.0	6.8	6.8	0.0	0.0	8.5
	Truck	69	31.9	0.0	0.0	0.0	62.3	0.0	0.0	5.8
	Small Bus	20	45.0	0.0	0.0	5.0	45.0	0.0	0.0	5.0
	Large bus	13	53.8	0.0	0.0	0.0	46.2	0.0	0.0	0.0
	All Types	**400**	**56.6**	**0.0**	**0.0**	**11.0**	**15.7**	**0.0**	**1.2**	**15.5**
Erbil-Mosul	PC-Private	277	90.5	0.4	0.0	3.2	0.0	0.0	2.1	3.9
	PC-Taxi	28	82.1	0.0	0.0	0.0	0.0	0.0	0.0	17.9
	Pick up	35	85.7	0.0	0.0	0.0	14.3	0.0	0.0	0.0
	Truck	38	31.6	0.0	0.0	0.0	68.4	0.0	0.0	0.0
	Small Bus	4	50.0	0.0	0.0	0.0	25.0	0.0	0.0	25.0
	Large bus	18	16.7	0.0	0.0	0.0	44.4	0.0	5.6	33.3
	All Types	**400**	**80.3**	**0.2**	**0.0**	**2.2**	**9.8**	**0.0**	**1.7**	**5.7**

3.4. Origin-Destination

The information from the interview forms is transferred to the computer to manage and analyze the data needed for this study. A pre-defined zoning system by the author is used to cover the origin-destination of the interviewed vehicles as shown in Figure (3-6)

For each interviewed vehicle at each origin-destination survey station, the vehicle type, number of persons in vehicle, type of cargo, origin of trip, destination of trip, the trip purpose, and weekly repetition of the trip is obtained from the origin-destination survey forms. After that the O-D matrix is established for the trips from the study locations to the zones and vice versa as shown in Tables (3-7) and (3-8). Information about the trips of the vehicles at the studied locations is obtained. After that the turning movements at the proposed interchanges is estimated depending on the direction of travel of interviewed vehicles as shown in Tables (3-9) and (3-10).

Table (3-7): Average Daily Trips (Trip Frequency) to Erbil Zones from Study Locations

Zones	Average daily trips to Erbil zones from data collection locations									
	Shaqlawa		Koya		Kirkuk		Makhmur		Mosul	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	6.3	3.1	0.0	0.0	0.0	0.0	1.2	0.8	0.0	0.0
2	1.5	0.8	0.0	0.0	0.0	0.0	40.3	28.5	27.4	24.6
3	1.3	0.7	76.4	46.2	9.2	7.1	27.7	19.6	25.3	22.8
4	8.1	4.0	0.0	0.0	21.1	16.4	0.0	0.0	12.7	11.4
5	0.0	0.0	1.7	1.0	2.5	1.9	2.5	1.8	5.2	4.7
6	1.1	0.5	2.0	1.2	0.7	0.6	0.0	0.0	3.9	3.5
7	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.8	0.0	0.0
8	13.3	6.6	0.1	0.1	5.8	4.5	6.3	4.5	2.0	1.8
9	0.0	0.0	0.0	0.0	4.0	3.2	2.5	1.8	0.0	0.0
10	14.2	7.1	0.0	0.0	1.7	1.3	1.2	0.8	1.7	1.5
11	11.1	5.5	12.1	7.3	3.2	2.5	1.1	0.8	3.2	2.9
12	9.9	4.9	3.7	2.2	0.1	0.1	0.0	0.0	2.7	2.5
13	17.6	8.8	2.0	1.2	3.7	2.9	0.4	0.3	0.1	0.1
14	8.3	4.2	0.0	0.0	1.7	1.3	2.7	1.9	1.9	1.7
15	20.9	10.4	2.5	1.5	1.1	0.8	4.6	3.3	0.0	0.0
16	5.1	2.6	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0
17	0.0	0.0	0.0	0.0	0.4	0.3	6.0	4.2	0.0	0.0
18	0.0	0.0	1.2	0.7	0.5	0.4	1.7	1.2	0.0	0.0
19	0.0	0.0	1.2	0.7	12.3	9.6	10.9	7.7	13.6	12.2
20	1.1	0.5	2.7	1.7	9.9	7.7	5.0	3.5	0.0	0.0
21	0.0	0.0	5.6	3.4	0.8	0.6	0.0	0.0	0.0	0.0
22	0.4	0.2	3.1	1.9	6.4	5.0	2.1	1.5	1.2	1.1
23	29.5	14.7	5.2	3.2	1.1	0.8	1.1	0.8	0.0	0.0
24	0.0	0.0	1.1	0.6	1.1	0.8	0.0	0.0	0.0	0.0
25	4.5	2.3	1.2	0.7	2.0	1.6	4.8	3.4	0.0	0.0
26	9.6	4.8	0.0	0.0	3.1	2.4	0.0	0.0	0.1	0.1
27	9.8	4.9	9.9	6.0	1.1	0.8	0.0	0.0	0.1	0.1
28	0.0	0.0	2.3	1.4	3.9	3.1	15.2	10.7	0.1	0.1
29	2.3	1.1	3.8	2.3	0.4	0.3	0.0	0.0	0.0	0.0
30	0.0	0.0	1.7	1.0	16.8	13.1	0.0	0.0	2.7	2.5
31	1.1	0.5	14.3	8.6	2.9	2.2	0.0	0.0	2.4	2.1
32	1.1	0.5	0.0	0.0	8.0	6.2	1.9	1.3	4.9	4.4
33	22.6	11.3	11.8	7.1	3.1	2.4	0.7	0.5	0.0	0.0
Sum.	200.6	100.0	165.5	100.0	128.3	100.0	141.7	100.0	111.4	100.0

Table (3-8): Average Daily Trips (Trip Frequency) from Erbil Zones to Study

Zones	Average Daily No. of Trips to Erbil Zones from Data Collection Locations									
	Shaqlawa		Koya		Kirkuk		Makhmur		Mosul	
	No.	%	No.	%	No.	%	No.	%	No.	%
1	63.7	47.2	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.6
2	0.0	0.0	2.7	0.9	10.7	9.3	5.4	3.3	13.9	10.3
3	0.0	0.0	57.8	18.8	16.3	14.1	12.0	7.3	9.3	6.8
4	1.1	0.8	0.0	0.0	2.0	1.7	0.8	0.5	2.0	1.5
5	0.8	0.6	1.1	0.3	2.0	1.7	4.4	2.7	13.9	10.3
6	0.0	0.0	1.9	0.6	0.5	0.4	1.5	0.9	0.0	0.0
7	0.1	0.1	0.7	0.2	1.1	0.9	0.0	0.0	13.9	10.3
8	1.2	0.9	0.5	0.2	4.4	3.8	3.3	2.0	2.0	1.5
9	0.0	0.0	11.2	3.6	4.0	3.5	1.2	0.7	1.8	1.3
10	2.5	1.9	23.1	7.5	1.1	0.9	0.0	0.0	1.5	1.1
11	6.0	4.4	31.1	10.1	2.4	2.1	0.0	0.0	1.4	1.1
12	11.2	8.3	6.4	2.1	2.7	2.4	1.1	0.7	2.0	1.5
13	1.1	0.8	16.3	5.3	3.9	3.4	1.1	0.7	1.2	0.9
14	0.0	0.0	1.1	0.3	1.1	0.9	8.1	4.9	3.6	2.6
15	0.8	0.6	0.2	0.1	2.3	2.0	33.6	20.5	2.0	1.5
16	1.2	0.9	1.2	0.4	0.8	0.7	0.0	0.0	0.8	0.6
17	0.0	0.0	0.0	0.0	1.2	1.0	6.2	3.8	0.4	0.3
18	0.0	0.0	1.2	0.4	0.1	0.1	8.2	5.0	0.8	0.6
19	1.1	0.8	0.4	0.1	22.6	19.5	18.4	11.2	7.1	5.3

Table (3-8): Continued

Zones	Average Daily No. of Trips to Erbil Zones from Data Collection Locations									
	Shaqlawa		Koya		Kirkuk		Makhmur		Mosul	
	No.	%	No.	%	No.	%	No.	%	No.	%
20	3.9	2.9	22.5	7.3	10.2	8.8	7.1	4.4	3.6	2.6
21	2.9	2.1	4.8	1.5	1.1	0.9	6.0	3.6	0.0	0.0
22	3.9	2.9	2.3	0.7	1.3	1.1	0.1	0.1	3.8	2.8
23	4.8	3.5	23.3	7.6	0.4	0.3	1.1	0.7	1.7	1.2
24	1.1	0.8	0.0	0.0	1.1	0.9	1.1	0.7	4.3	3.2
25	1.1	0.8	0.0	0.0	1.9	1.6	1.8	1.1	11.2	8.2
26	8.3	6.2	0.0	0.0	0.1	0.1	0.0	0.0	2.9	2.1
27	2.0	1.5	40.0	13.0	1.5	1.3	0.0	0.0	0.0	0.0
28	2.0	1.5	0.7	0.2	1.1	0.9	35.9	21.9	13.3	9.8
29	1.1	0.8	2.9	0.9	0.4	0.3	0.1	0.1	0.0	0.0
30	3.9	2.9	14.2	4.6	11.4	9.9	2.7	1.7	9.9	7.3
31	5.2	3.9	39.3	12.8	0.8	0.7	0.0	0.0	3.5	2.5
32	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.9
33	3.5	2.6	0.5	0.2	5.1	4.4	2.7	1.7	0.5	0.4
Sum.	134.8	100.0	307.1	100.0	115.7	100.0	164.0	100.0	135.8	100.0

Table (3-9): Estimated 12-Hour Turning Movements at the Proposed

	Total volume vph	Anticipated Movements (%)		
		Left	Through	Right
Erbil-Shaqlawa	18327	11.9	75.2	12.9
Shaqlawa-Erbil	19227	42.0	40.0	18.0
Erbil-Koya	19309	35.0	38.0	27.0
Koya-Erbil	18782	23.2	52.9	23.9
Erbil-Kirkuk	13750	6.3	84.3	9.4
Kirkuk-Erbil	12026	6.5	87.0	6.5
Erbil-Makhmur	5814	1.8	96.5	1.7
Makhmur-Erbil	6359	1.8	98.2	0.0
Erbil-Mosul	14144	17.0	79.0	4.0
Mosul-Erbil	13421	0.9	93.4	5.7

Table (3-10): Estimated Turning Volumes During Peak Hour at the Proposed Interchanges

	Total volume vph	Anticipated Movements (%)		
		Left	Through	Right
Erbil-Shaqlawa	1639	11.9	75.2	12.9
Shaqlawa-Erbil	1720	42.0	40.0	18.0
Erbil-Koya	1873	35.0	38.0	27.0
Koya-Erbil	1822	23.2	52.9	23.9
Erbil-Kirkuk	1292	6.3	84.3	9.4
Kirkuk-Erbil	1160	6.5	87.0	6.5
Erbil-Makhmur	663	1.8	96.5	1.7
Makhmur-Erbil	724	1.8	98.2	0.0
Erbil-Mosul	1528	17.0	79.0	4.0
Mosul-Erbil	1450	0.9	93.4	5.7

3.5. Projection for the Future

The traffic volumes within the data collection locations, have significantly increased within the past years. Therefore, the future projection estimated based on registered vehicles for the next fifteen years. The future projection is taking into consideration the diverted traffic (2%), the generated traffic (2%), the progress traffic (2%), and the normal growth of traffic (6%). The results are given in Tables (3-11) to (3-13).

Table (3-11): Summary of the Future Peak Hour Volumes and Traffic Parameters for the Five locations

	Erbil - Shaqlawa	Erbil - Koya	Erbil - Kirkuk	Erbil - Makhmur	Erbil– Mosul
Peak Hour Volume	6241	14013	9328	14373	11295
Directional Distribution D%	49.9/50.1	49.1/50.9	49.6/50.4	46.9/53.1	45.5/54.5

% of daily traffic in peak hour (k)		11.6	19.1	10.3	11.2	10.9
Peak Hour Factor (PHF)		0.81	0.93	0.88	0.87	85
Vehicle Types (%)	PC	52.3	64.4	62.4	68.0	63.8
	Pickup	31.4	19.9	22.7	21.4	20.1
	Buses	0.9	2.1	2.6	3.2	2.4
	Trucks	15.0	11.8	12.0	7.2	13.6
	Others	0.4	1.8	0.3	0.2	0.1

Table (3-12): Estimated Peak Hour Turning Movements at the

	Total volume vph	Anticipated Movements (%)		
		Left	Through	Right
Erbil-Shaqlawa	3680	11.9	75.2	12.9
Shaqlawa-Erbil	3862	42.0	40.0	18.0
Erbil-Koya	4205	35.0	38.0	27.0
Koya-Erbil	4091	23.2	52.9	23.9
Erbil-Kirkuk	2901	6.3	84.3	9.4
Kirkuk-Erbil	2605	6.5	87.0	6.5
Erbil-Makhmur	1489	1.8	96.5	1.7
Makhmur-Erbil	1626	1.8	98.2	0.0
Erbil-Mosul	3431	17.0	79.0	4.0
Mosul-Erbil	3256	0.9	93.4	5.7

Table (3-13): Estimated 12-Hour Turning Movements at the

	Total volume	Anticipated Movements (%)		
	vph	Left	Through	Right
Erbil-Shaqlawa	41149	11.9	75.2	12.9
Shaqlawa-Erbil	43170	42.0	40.0	18.0
Erbil-Koya	43354	35.0	38.0	27.0
Koya-Erbil	42171	23.2	52.9	23.9
Erbil-Kirkuk	30873	6.3	84.3	9.4
Kirkuk-Erbil	27002	6.5	87.0	6.5
Erbil-Makhmur	13054	1.8	96.5	1.7
Makhmur-Erbil	14278	1.8	98.2	0.0
Erbil-Mosul	31757	17.0	79.0	4.0
Mosul-Erbil	30134	0.9	93.4	5.7

4. CONCLUSIONS

Based on the results of this study, the following conclusions can be drawn:

1- It is demonstrated that there is a high traffic flow on access roads into and out of Erbil city. The highest traffic volume is on Erbil – Koya highway (37554 vehicles for 12 hours) where, the percentage of heavy vehicles is about 14% and pickups about 21%.

2- The peak hour traffic flow is in the morning therefore, the city government needs to manage this carefully (e.g., the operation of the trucks may be forced to be at night).

3- Because work purpose trip is mandatory activity/purpose, it is appropriate for planning applications for establishing an efficient transit project.

4- The information about the average daily trips (Trip Frequency) from and to Erbil zones from study locations might help improve goods and people transport understanding in Erbil city, enabling the implementation of Intelligent transportation system.

5- The vehicle occupancy rate for private passenger cars is small (≤ 2.23). This is may be due to the road user's behavior to use their private cars individually resulting in low commo trips. Also, the deficiency in bus services affected the vehicle occupancy rate of private passenger cars. This rate may continue to decline, due to the greater individualization of society and the increase in private passenger car ownership.

6- There are differences in hourly expansion factors (HEF) due to the differences in traffic volume depending on the location.

7- In order to obtain the average annual daily traffic from the the average daily traffic calculated from short-term traffic counts, the p-factor may be used.

RECOMMENDATIONS

According to the results of this study, the following recommendations may be followed:

1- Kurdistan region-Iraq, witnessed a number of political issues therefore, further research is needed to take the abnormal traffic operation and growth into consideration.
2- Further research is needed to consider the lane distribution of the traffic flow and using the direction of travel in estimating the expansion factors of arterials due to the unequal distribution of traffic flow over the lanes and the opposite directions.
3- If the duration of traffic counts is limited to several days, it is recommended to use the p-factor presented in this research to estimate the AADT. In order to achieve more reliable estimates of the AADT using the p-factor, short-term counts need to be conducted at urban arterials in the city.
4- A high occupancy lane needs to be allocated to encourage highway users to make common trips, to manage the problem of low vehicle occupancy rate in peak hours. This thus, less private passenger cars in the highway system and enforcing this by using automatic or semi-automatic vehicle occupancy detection.

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