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Conventional Four Steps Travel Demand Modeling for Kabul New City

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***Abstract*—**This research is a very essential towards transportation planning of Kabul New City. In this research, the travel demand of Kabul metropolitan area (Existing and Kabul New City) are evaluated for three different target years (2015, current, 2025, mid-term, 2040, long-term). The outcome of this study indicates that, though currently the vehicle volume is less the capacity of existing road networks, Kabul city is suffering from daily traffic congestions. This is mainly due to lack of transportation management, the absence of proper policies, improper public transportation system and violation of traffic rules and regulations by inhabitants. On the other hand, the observed result indicates that the current vehicle to capacity ratio (VCR) which is the most used index to judge traffic status in the city is around 0.79. This indicates the inappropriate traffic condition of the city. Moreover, by the growth of population in mid-term (2025) and long-term (2040) and in the case of no development in the road network and transportation system, the VCR value will dramatically increase to 1.40 (2025) and 2.5 (2040). This can be a critical situation for an urban area from an urban transportation perspective. Thus, by introducing high-capacity public transportation system and the development of road network in Kabul New City and integrating these links with the existing city road network, significant improvements were observed in the value of VCR.

***Keywords*—**Afghanistan, Kabul New City, planning, policy, urban transportation.

I. Introduction

KABUL city (capital of Afghanistan) is located in the eastern section of the country. Currently the city is suffering from a highly congested traffic, which is mainly due to dramatic increase of its population and economic growth of the city last 15 years. The population of Kabul will further increase due to rapid increase of population to approximately 7 million by 2025 which will also cause the increase of illegal housing in the city. At the same time, the number of privately owned automobiles will also increase significantly due to national economic growth. In order to cope with this dynamism, Government of Afghanistan decided to build a new capital city as a complement of the current city. It is estimated that about 1.5 million people will be living in Kabul New City (KNC) by 2025 [1] and it will reduce challenges and problems of current Kabul city including transportation problems. The new city is strategically located at the north part of existing Kabul city between Kabul International Airport and Bagram Air base.

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II. Study Area

This study covers the 26 Traffic Analysis Zones (TAZs), namely 22 zone of existing Kabul city and the 4 newly add zones of KNC (Phase-1, 2, 3 and Barikab) [2].

III. Base Year (2008) Trip Pattern and Share

Overall, 3.3 million trips were generated by the inhabitant in 26 traffic zones throughout Kabul city with an average trip rate of 2.1 T/D. Out of which, 70.0% were males as the largest portion of trip makers while only 30.0% of it were females [1], [2].

TABLE I
Trips by Purpose

Purpose	Total Trips
Work	628829
School	733793
Business	127812
Shopping	111693
Home Return	1645723
Other	93614
Grand Total	**3341464**

TABLE II
Trip by Mode

Mode	Total Trips
Walk	1318559
Public Transport	1623496
Private Transport	399409
Total	**3341464**

TABLE II
Traffic Assignment Result for Base Year

Case	PCU*km ('000)	Total PCU*hr	VCR	Avg Speed (km/h)	Peak hr Speed (km/h)
2008 Traffic assignment	11.563	40233	0.41	35.7	28.1

IV. Models for Forecasting the Future Trips

A. Trip Production

In this research, the regression analysis (1) & (2) was considered to estimate the amount of trip generation and attraction in each zone [3], [4].

$$G_p^i = \theta_0 + \theta_1 X_{1i} + \theta_2 X_{2i} + \theta_3 X_{3i} + \cdots \theta_k X_{ki} \quad (1)$$

$$A_p^j = \theta_0 + \theta_1 Y_{1j} + \theta_2 Y_{2j} + \theta_3 Y_{3j} + \cdots \theta_k Y_{kj} \quad (2)$$

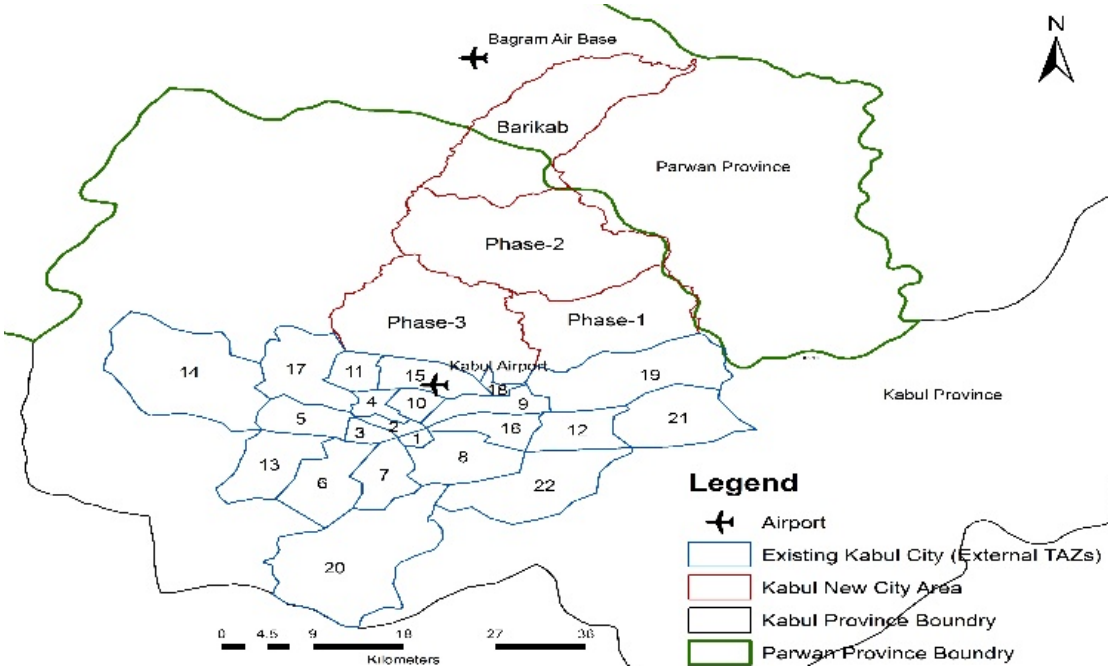

Fig. 1 Kabul metropolitan area

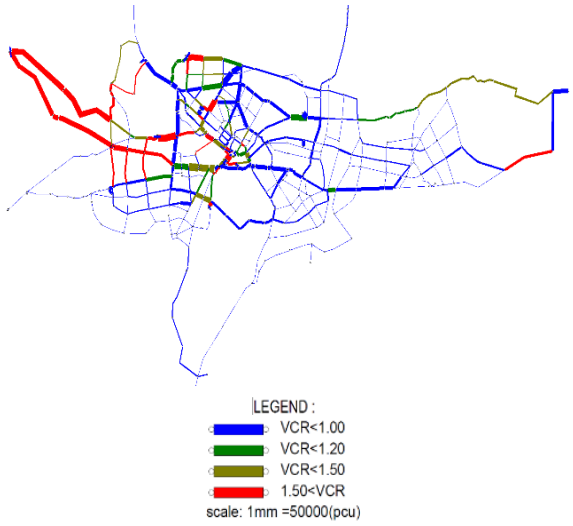

Fig. 2 Base year route assignment

TABLE III
SIGNIFICANT PARAMETERS FOR TRIP PRODUCTION

Variable name	Generation Parameter	Attraction Parameter
Population	0.15	0.08
Service Worker	0.001	0.49
Constant	1323.40	-3380.18
Correlation Coefficient	0.96	0.89

B. Trip Distribution

There are many trip distribution models; however, the basic Gravity Model (3) has been used.

$$T_{i-j} = \frac{k\ G_i^{\alpha}\ A_j^{\beta}}{d_{i-j}^{\alpha}} \quad (3)$$

TABLE IV
SIGNIFICANT PARAMETERS FOR TRIP DISTRIBUTION

Variable name	Parameter
Generation (i)	0.83
Attraction (j)	0.87
d i-j	-0.19
Constant	0.000165
Correlation Coefficient	0.94

C. Mode-Split

The growth curve function (4) was considered in this study to estimate mode split specifications.

$$P_{ij} = \frac{1}{1+e^{(at_{ij}+b)}} \quad (4)$$

TABLE V
SIGNIFICANT PARAMETERS FOR MODE SPLIT

Modal Split Tree-1			Modal Split Tree-2		
Variable	Standard Error	T-Value	Variable	Standard Error	T-Value
Travel Time Difference (Public Tr-Private Tr)	-0.000784	-1.1024	Travel Time Difference (Walk-Vehicle)	-0.000784	-1.1024
Constant	2.101571		Constant	2.101571	
Corr. Coefficient	0.85		Corr. Coefficient	0.85	

D. Traffic Assignment

All the traffic volume for the B-YR 2008 and target years have been assigned to the transport network based on the BPR (Bureau of Public Road) method (5):

$$t = t_0 \left\{1+\propto \left(\frac{x_a}{c_a}\right)^{\beta}\right\} \quad (5)$$

V. Short-Term (Current-2015) Forecasted Trips

A. Trip Production

The outcome signifies that in total 4.23 million trips per day were made in 2015 for different purposes and by different modes. In contrast to 2008 (3.34 million trips/day), the outcome shows the growth of approximately 27% (0.89 million trips/day).

TABLE VI
SHORT TERM TRIPS BY PURPOSE

Work	School	Business	Shopping	Home	Other	**Total**
895976	857807	182500	289712	2007851	4886	**4238732**

TABLE VII
SHORT TERM TRIPS BY MODE

Mode	Walk	Public Transport	Private Transport	Total
Trips	1623125	493311	2122245	4238732

B. Trip Distribution

As Fig. 3 illustrates, most of the trips are concentrated central area of the city where most of the residential area, commercial centers and governmental administration are located in these areas. The central area is the most congested area of the city.

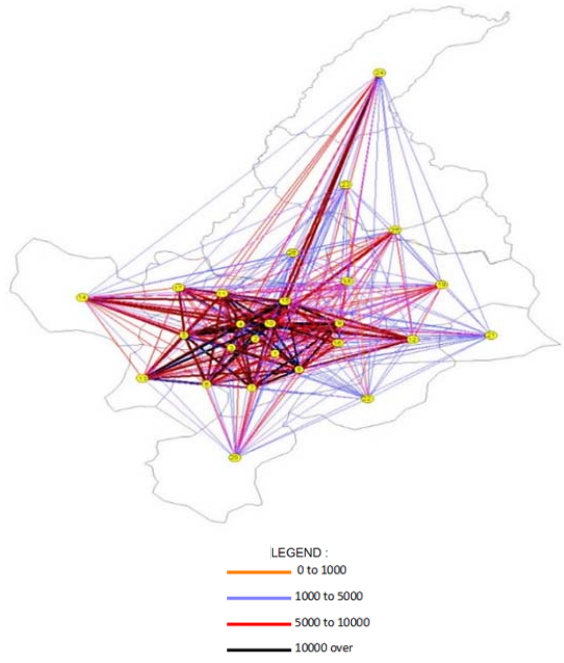

Fig. 3 Trip distribution for short term

C. Mode Split

In order to estimate the mode split for 2015, the forecasted OD table by mode (8 mode) for 2015 was converted in to 3 mode OD table namely (by walk, private transport and public transport). Car, bike and other modes were considered as private transport while taxi, microbus, minibus and large bus were considered as public transport. Later on, the converted OD table was assigned as independent variable while average travel time by walk and average travel time by public and private transport was used as dependent variable to estimated mode split for 2015. For modal split modeling, Matrix Manipulator (Modal Split Model function) [5] was used. As a result, no major changes were observed in the outcome of 2008 and 2015 result.

D. Traffic Assignment

Although the analysis shows that there are sufficient links and right of way (RoW) considering the current population and the number of vehicles in Kabul city but as the result shows (Fig. 5), most of the link especially in city center area are overloaded. This could be due to improper transportation facilities, lack of reliable public transportation system, damaged road surface, etc.

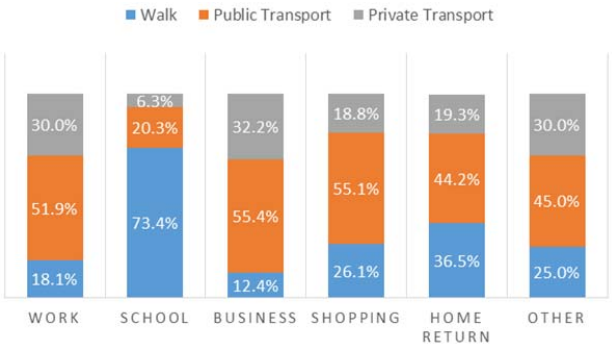

Fig. 4 Mode split for short term

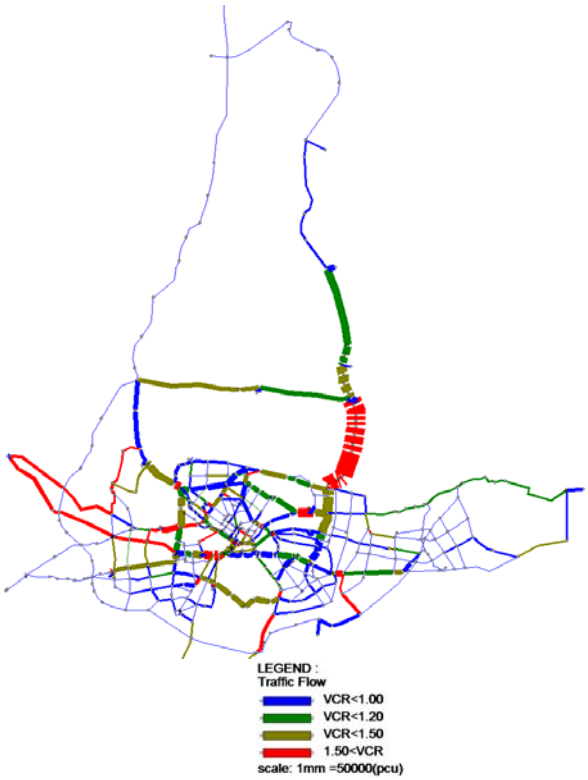

Fig. 5 Route assignment for short term

TABLE VIII
TRAFFIC ASSIGNMENT RESULT FOR SHORT TERM

Case	PCU*km ('000)	Total PCU*hr	VCR	Avg Speed (km/h)	Peakhr Speed (km/h)
2015 Traffic assignment	18915	745752	0.79	28.4	19.9

VI. MID-TERM (2025) FORECASTED TRIPS

A. Trip Production

It is estimated that in total 7.82 million trips/day will be made by 2025 which indicated a dramatically growth of (71%) comparing with 4.23 million trips/day in 2015. This is mainly due to development of KNC, 26 Dalwa (Located in Phase-2) and also the annual population growth of existing Kabul city. Among 7.82 million trips/day, 6.4 million (82%) of it will be generated by Kabul city inhabitants while the remaining 1.37 million (18%) will be generated by KNC residence. As Table X indicates, Phase-2 of KNC will generate higher percentage of trips compared to other zones of KNC, it is mainly due to 26 Dawla project which is estimated to accommodate large portion of inhabitants.

TABLE IX
MID-TERM TRIP COMPOSITION BY ZONE

KMA Total Trips (2025)		
Location	Total Trips	Share
Existing Kabul	6453077	82%
KNC -Phase-1	168844	2%
KNC - Phase-2	603035	8%
KNC - Phase-3	360984	5%
KNC - Barikab	239263	3%
Total	**7825203**	**100%**

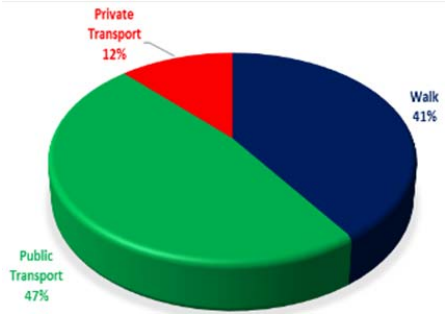

Fig. 6 Mid-term trip share by purpose

Fig. 7 Mid-term trip share by mode

B. Trip Distribution

As Fig. 8 illustrates, in contrast to 2015 trip distribution, the trips are more concentrated in to the peripheral of the city rather than the center. This is mainly due to development of KNC and the growth of population in these areas.

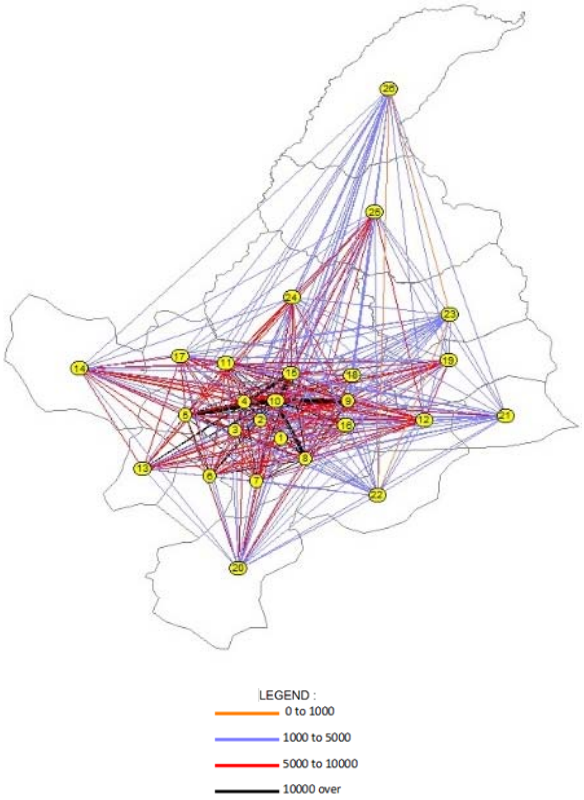

Fig. 8 Trip distribution for mid term

C. Traffic Assignment

In a compression of Figs. 9 and 5, by 2025, it seems that most of traffic congestions and transportation issues will be reduced. This is mainly due to development of KNC and integration of KNC's newly developed road networks with existing road networks.

The volume to capacity ratio will be dramatically reduced for 0.79 in 2015 to 0.31 while the average speed will increase form 28.4 km/h to 46.1 km/h which could be ideal condition for urban area.

TABLE X
TRAFFIC ASSIGNMENT RESULT FOR MID TERM

Case	PCU*km ('000)	Total PCU*hr	VCR	Avg Speed (km/h)	Peak hr Speed (km/h)
2025 Traffic assignment	27020	586130	0.21	46.1	35.5

Fig. 9 Route assignment for mid term

D. Mode Split

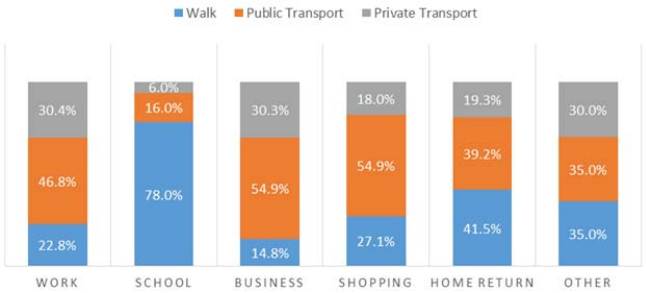

Fig. 10 Mode split for mid term

VII. Long-Term (2040) Forecasted Trips

A. Trip Production

It is estimated that in total 9.88 million trips/day will be made by 2040. The result indicates that 7.3 million (74.5%) of these trips will be generated by Kabul city inhabitants while the remaining 2.52 million (25.5%) will be generated by KNC residence (Table XII).

TABLE XI
Long-Term Trip Composition by Zone

KMA Total Trips (2040)		
Location	Total Trips	Share
Existing Kabul	7365408	74.5
KNC - Phase-1	494328	5.0
KNC - Phase-2	840344	8.5
KNC - Phase-3	790922	8.0
KNC - Barikab	398706	4.0
Total	**9889708**	**100**

Fig. 11 Long-term trip share by purpose

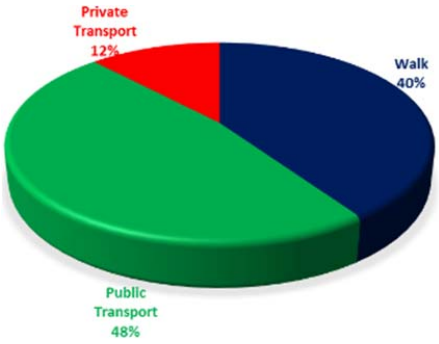

Fig. 12 Long-term trip share by mode

B. Trip Distribution

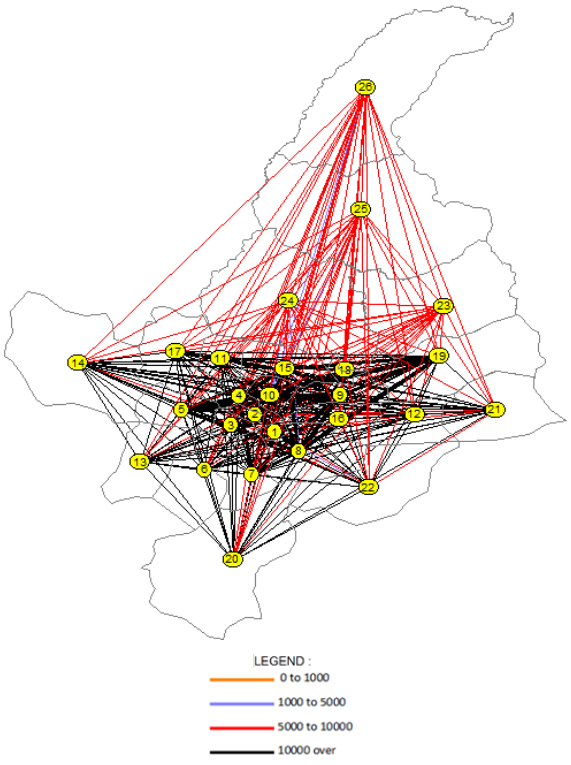

Fig. 13 Trip distribution for long term

C. Mode Split

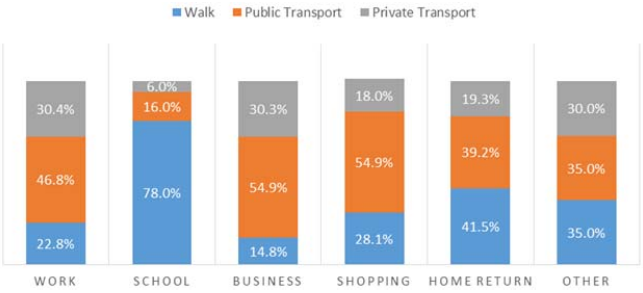

Fig. 14 Mode split for long term

Fig. 15 Route assignment for long term (Option-1)

D. Traffic Assignment

The KNC is initially designed to accommodate approximately 3 million people. According to plans, it is estimated that between 2040 and 2050 the city will reach to its ultimate level from accommodation perspective.

As the result of traffic assignment (Fig. 15) indicates, by 2040, many links inside the Kabul New City area will be congested. In order to overcome on this issue, three scenarios were analyzed and proposed as follows:

- Proposing a system like current public transportation (micro bus, mini bus, large bus and taxi) + flyovers at major intersections
- Proposing a BRT and LRT + flyovers at major intersections
- Proposing a tunnel to connect zone 15 of existing Kabul city with south of Phase-3.

TABLE XII
TRAFFIC ASSIGNMENT RESULT FOR LONG TERM (DIFFERENT CASES)

Case	PCU*km ('000)	Total PCU*hr	VCR	Avg Speed (km/h)	Peak hr Speed (km/h)
Current Public Transportation Pattern	36164	828652	0.51	37	31.5
BRT+ Flyover	25147	624567	0.42	45.1	37.1
Tunnel	34617	738651	0.48	39	32.7

Fig. 16 Route assignment for long term (Option-2)

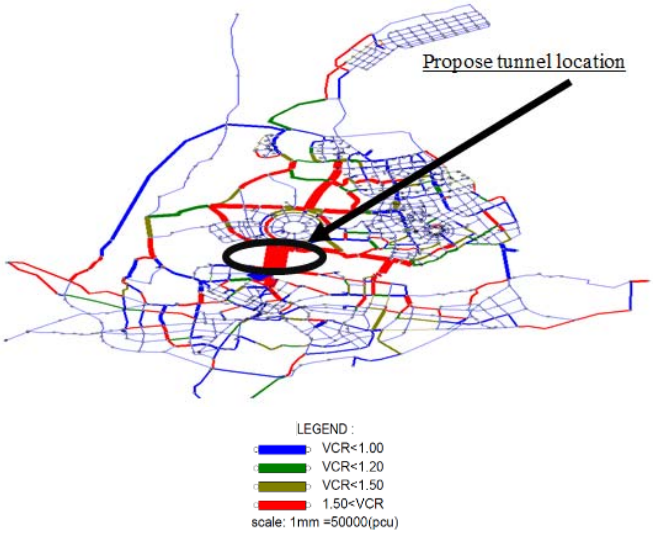

Fig. 17 Route assignment for long term (Option-3)

VIII. Conclusion

This study has mostly concentrated on transportation pattern for KNC. The model parameters created based on B-YR 2008, PT survey data, and then the models were used to forecast trips for 2015 (Current), 2025 (Mid-term) and 2040 (Long-term).

Analysis revealed that after walking, the greater percentage of trips is made by public transport. Thus in the short-term, Kabul city urgently requires a large amount reliable of public transport while there is lack of high capacity public transportation facilities. On the other hand, it was revealed that, though the traffic volume is less than the maximum capacity of road network, yet the city is coping with daily traffic jams and congestions. This issue is mainly caused due to lack of transportation management, absence of proper policies and improper public transportation system. Furthermore, the observed results indicate that, by the growth of population and in case there will be nether development in road network nor transportation facilities, by 2025, the current VCR value (0.79) will increase to (1.40) and subsequently to (2.5) by 2040. This can directly affect the travel time and speed. Hence, by development of the KNC road network and integrating the newly developed links with existing road network, significant improvements have been observed in the value of VCR and average speed.

It has been found from this study that, in long term, many routes inside the KNC area will be congested. In order to cope with this issue, BRT and LRT systems are recommended to be introduced

Update and accurate traffic and person trip survey needs to be conducted in order to have more accurate and precise result in the future.

References

[1] The study for the development of the master plan for the Kabul metropolitan area in the Islamic republic of Afghanistan, Land use and GIS sector, Japan International Cooperation Agency (JICA), September 2009.

[2] Kabul city master plan, sub project for revise the Kabul city master plan, Japan International Cooperation Agency (JICA), June 2011.

[3] Clifford H. Spiegelman, Eun Sug Park, and Laurence R. Rilett 2010 " Transportation Statictics and Microsimulation

[4] Mcnally, M. G. The Four Step Model. Tech. Rep. UCI-ITS-AS-WP-00-51, Center for 507 Activity Systems Analysis, 2000.

[5] Moshe Ben-Akiva and Steven R. Lerman "Discrete Choice Analysis – Theeory and Application to Travel Demand"