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URBAN TRANSPORT MOBILITY PLANNING FOR KABUL CITY

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Abstract: Transportation is the key factor for the economic, Industrial, social and cultural development of a region. The rapid urban growth and increase of population in urban areas and increased use of motor vehicles simultaneously has led to urban sprawl and the higher demand for motorized travel caused many challenges in urban transportation system like congestion, traffic accidents environmental pollution, air pollution, noise pollution, greenhouse gas emission, increase delay and travel time, increase vehicle operating costs and fuel consumption, decrease in road surface lifetime. The summation of all these effects results a significant loss for the society and the economy of an urban area.In this research paper Kabul city transport system is analyzed and evaluated based on road network, traffic and land use characteristic. Road network analysis and fractal analysis is done by using ArcGIS software and road network indices and fractal dimensions are calculated to evaluate the effectiveness, performance, connectivity and density of road network.

The main objective of this research paper is to understand the existing condition of Kabul city urban transport system and to provide policy and urban transport mobility plan in order to improve mobility, accessibility and road network functionality as well as to reducing congestion, accidents and environmental pollution and to have a safe and secure, affordable and an integrated and well-managed sustainable transport system. These goals can be achieved by supply and demand strategy and land-use planning and policy.

Index Terms **-** Road Network, Fractal Analysis, ArcGIS, Mobility, Traffic, Land use, Congestion.

I. INTRODUCTION

Transportation plays an important role to the economic, Industrial, social and cultural development of a country. transportation is the key factor for the economic development of a region since every commodity produced whether its food clothing, industrial products needs transport at all stages from production to distribution. The adequacy of transportation system of a country indicates economic and social development. (Khanna &Justo,2011)

In transportation system the speed, cost, and capacity have a significant impact on the economic development of an area and the ability to make maximum use of its natural resources. The movement of people, goods and services from one location to another which is the basis of transportation system must be efficient, safe and economically affordable to the people. Despite this broad goal, there are many environmental hazards that commonly disrupt or damage these systems at a variety of spatial and temporal scales.

The rapid urban growth and increase of population in urban areas and increased use of motor vehicles simultaneously has led to urban sprawl and higher demand for motorized travel, since demand exceeds the capacity of the existing transport system and is unable to cater high travel demand as a result congestion occurs which has negative effects on drivers, road users, environment, health, and the economy of a region like road accidents, environmental pollution, air pollution, noise pollution, greenhouse gas emission, increase delay and travel time, increase vehicle operating costs and fuel consumption, decrease in road surface lifetime. The summation of all these effects results a significant loss for the society and the economy of an urban area. (UN-Habitat,2013)

To improve mobility and accessibility while at the same time reducing congestion, accidents and environmental pollution, there is need to have a proper planning, strategy and policy to tackle this issue. This can be achieved by urban transport mobility planning which is a planning tool that consists of objectives and measures aims to provide safe, efficient, accessible, affordable, quick, comfortable, reliable and sustainable transportation system to the residents of a city to have access to jobs, education, health recreation and such other needs within the cities. (Baedeker et al., 2014).

In this research paper Kabul city transport system is analyzed and evaluated based on road network, traffic and land use characteristic to understand the existing condition of Kabul city urban transport system. Transport indices and fractal dimensions are calculated by using ArcGIS which shows the effectiveness, performance, connectivity and density of road network.

The deficiency and non-functionality of Kabul city transport system is assessed based on land use, traffic and road network characteristics. Possible policies and strategies are developed to improve mobility, accessibility, efficiency and safety and reducing congestion and travel time and to have a safe and secure, affordable, less harmful to the environment and an integrated and well-managed sustainable transport system.

These goals can be achieved by supply and demand strategy and land-use planning and policy. Supply measures add capacity to the system or make the system operate more efficiently. Their focus is the transportation system like road widening, providing elevated flyover, constructing bypass and use of intelligent transportation system. Demand measures, on the other hand, focus on motorists and travelers and attempt to modify their trip-making behavior like congestion pricing, parking pricing, Staggering of office hour and flexible time of work, bus priority and so on. land-use planning and policy can be used to control the number and growth of major traffic generators along congested corridors, to establish sensible allocations of land for future development given present constraints and expansion plans for the transportation network, and to enforce balanced employment and residential development, thus reducing long home-to-work trips.

II. Literature Review:

Urban transport mobility planning is a strategic plan and policy for having a sustainable and uniform transport system to reduce congestion, pollution and travel time and increase mobility, safety, accessibility and efficiency of transport system various factors needs to be considered like land use characteristics, road network characteristics and traffic. This section describes the previous studies carried out on urban transport mobility planning.

Rupprecht et al. (2019) suggested guidance on developing sustainable urban transportation systems to make urban mobility cleaner and more sustainable by reducing traffic-related air and noise pollution, congestion and accidents while improving accessibility and quality of life cities. And a variety of responses to urban transport challenges around the world are discussed. Also, the relationship between urban form and mobility are analyzed to have more efficient and compact cities and the role of urban planning in developing sustainable cities is highlighted and they have suggested non-motorized travel and public transport are the preferred modes of transport.

Sreelekha et al. (2015) are attempted to analyze the road network connectivity and spatial pattern existing in Calicut city in India by using ArcGIS software, they have calculated the network indices to evaluate the properties and performance of a road network, and concluded that there is significant relationship between the level of road network development and the network spatial structure within the study area and higher values of indices shows greater road network connectivity.

Dasari & Gupta (2019) are attempted to apply the concept of fractal analysis by using ArcGIS software in evaluation of urban road networks for Karimnagar city in South India. The study shown that there is good relation between the road network lengths and built-up area in the city and hence by using fractal analysis the spatial requirements of incremental road network can be identified rationally while considering for the likely impact of road network augmentation on development patterns. Finally, they have concluded, that fractal analysis is an excellent tool for evaluating road networks, including addressing the issue of inequity in road network supply within urban areas, and it is particularly useful as an interactive planning tool to incrementally build road networks in urban situations, particularly in developing countries.

Papacostas and preveduras(2015) discussed urban transportation issues like congestion, Environment concerns of emissions and noise pollution and traffic accident. For having an efficient, affordable and environmentally friendly transportation system they have proposed a combination of measure to mitigate these ill effects of transportation system these measures are basically classified into supply and demand measures. Supply measures add capacity to the system or make the system operate more efficiently such as new freeways, transit lines, lengthy road widening, bridge replacements, permanent freeway lane conversions, technology conversions (a new rail technology, a modernized bus fleet, and intelligent transportation systems).and Demand measures, on the other hand, focus on motorists and travelers and attempt to modify their trip-making behavior like congestion pricing, parking pricing, restrictions on vehicle ownership and use.

Kadiyali (2017) explained travel demand management techniques which is most productive and cost effective use of existing transportation facilities, services and modes to reduce congestion and travel time and increase the safety and efficiency of transportation system like Road Congestion pricing ,Parking restraint, Peripheral parking scheme ,Carpooling and other ride sharing programs ,Staggering of office hour and flexible time of work, Entry fee, Priority for buses in traffic and Restrictions on entry of trucks during day time.

III. Methodology:

Methodology of data collection and analysis for urban mobility planning of Kabul city is shown in flowchart in figure 1.

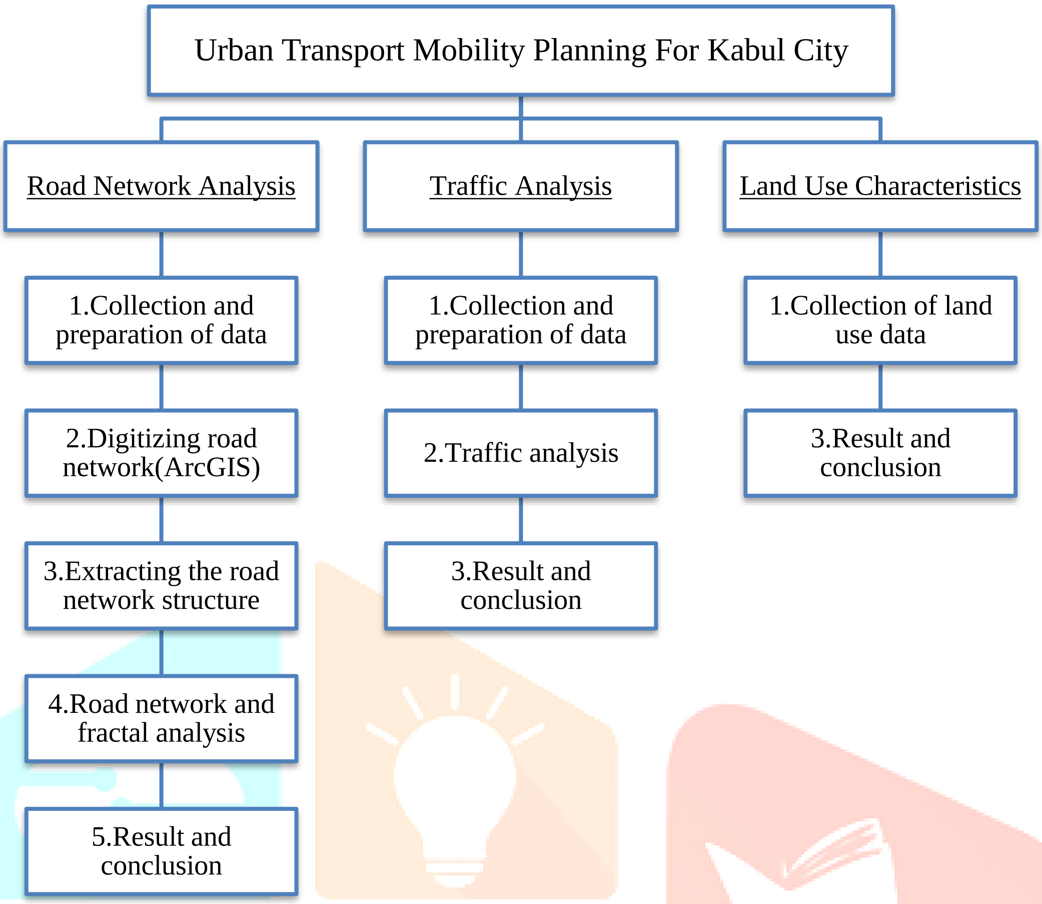

Figure 1: Flowchart of methodology

In road network analysis and evaluation of Kabul city ArcGIS 10.8 and Google Earth Pro softwares are used and shape file data of Afghanistan's road network and provinces as a whole are downloaded for road network and fractal analysis.
For traffic analysis of Kabul city traffic volume data of Karte Mamorin intersection is considered and data is taken from Kabul municipality, department of public transport and the data analysis have done in excel sheets to compute peak hour volume, peak hour factor and percentage of vehicle composition and also to assess level of service of intersection.

3.1 Study area:

Kabul is the capital of Afghanistan located in the north eastern part of the country, this city is situated at latitude 34.53° N and longitude 69.17° E at 1800 meters above sea level and its population is estimated 5,385,52 by National Statistics and Information Authority in 2021, total area of Kabul city is 4462 Km^2 which is mostly covered with hills and mountains and its built-up area and land use is approximately 1023 Km^2 as shown in figure 2.
Kabul city consist of 22 districts, Kabul, is the most important political, business and cultural center of the country. As a political, trading and cultural center Kabul City has been the main destination of immigrants. The increase in population and population density of the city has resulted in increased motorization, hence traffic congestions and air pollution.

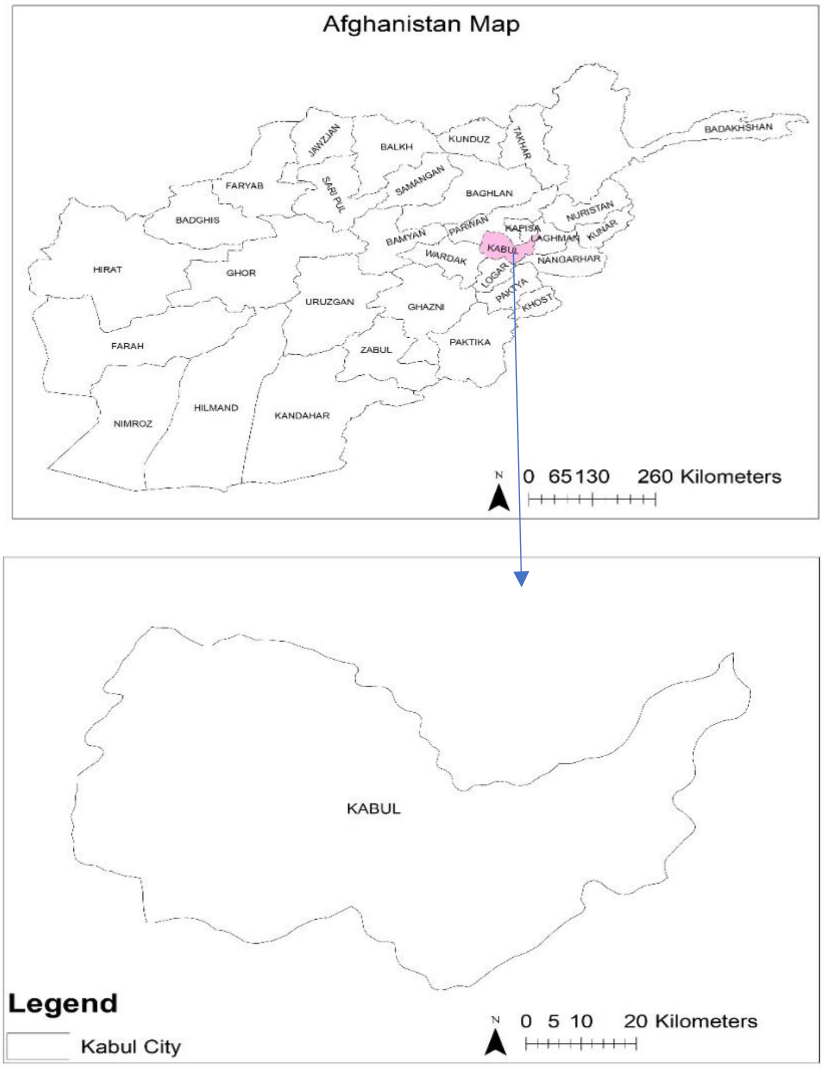

Figure 2: Kabul City study area

IV. Road Network Analysis:

In urban area road network is one of the essential infrastructures for the development of the city and to meet the demands of the people. With the rapid rise of urban population and development of technology, travel demand also increased which caused many roads user facing problems of mobility accessibility and connectivity within a road network.

Road transport network is primarily designed to connect local resources and people to distant markets and population centers. There must be an efficient transport network for maintaining and improving the quality of life within cities and urban areas and to have a sustainable development.

cities are growing at a rapid rate with reference to Business, Commercial, Educational and technological aspects, the land use pattern is also getting promoted to decentralized activities of business, educational and residential. Due to this the functionality of the road is changing but then the geometrical condition remains same which leads to many urban traffic issues. (Lakshmana Rao & Ali baig,2016)

the level of service of road network is falling down when traffic volumes are equal or sometimes exceeds the capacity of the road. Kabul city which is the capital of Afghanistan geometrical conditions are considerably according to the standards providing all the facilities, but they are being used by the roadside business activities which cause congestion.

To improve the functionality of the existing infrastructure it is necessary to analyze the road network based on various parameters like Accessibility, Mobility, Connectivity, Self-Similarity (Visualizing the fractal view) and etc. By keeping these points in view an attempt is made in this part of paper to analyze the different characteristics of Urban Road Network.

4.1 Characteristics of road network:

Road network shows both topologic and geometric variations in their structure. Different indices are used for evaluating road network characteristics and in transportation planning. A road network consists of links and nodes. In transportation engineering, a link is a road segment between two intersections which represents a means of travel from one point to another like a bus route between two stops, and so on. The nodes are the endpoints of the links which represents an intersection may adjoin multiple links representing road segments. The level of detail in a network depends on its application. For multistate freight models, major highways may be the only links, and major cities the only nodes. For a city's planning model, all major and minor arterials may be included as well. (Sreelekha.M.G et al., 2015)

4.2 Network indices and measurements:

Network measures and indices which are supply based indicators are used to evaluate the properties and performance of a transport network. Quantifiable indicators can abstract the properties of complex network structures and helps to analyze structure from a spatial perspective. Indices are used to evaluate the properties and performance of a road network. One of the indicators used to measure network performance is the connectivity measure. Connectivity is the primary purpose of any transportation network, as it links the places that people will want to travel between.

In road network analysis ArcGIS 10.8 and Google Earth Pro software are used for evaluating the road network of Kabul city. total road network length of Kabul city is calculated which is 8468.2 Km and it is shown in figure 3 and the built-up area of Kabul city calculated in google earth which is 1023 Km^2. from attribute table of links and nodes layer in ArcGIS, ArcMap10.8 the total number of links and nodes are calculated, the total number of links are 60767 and total number of nodes are 46221

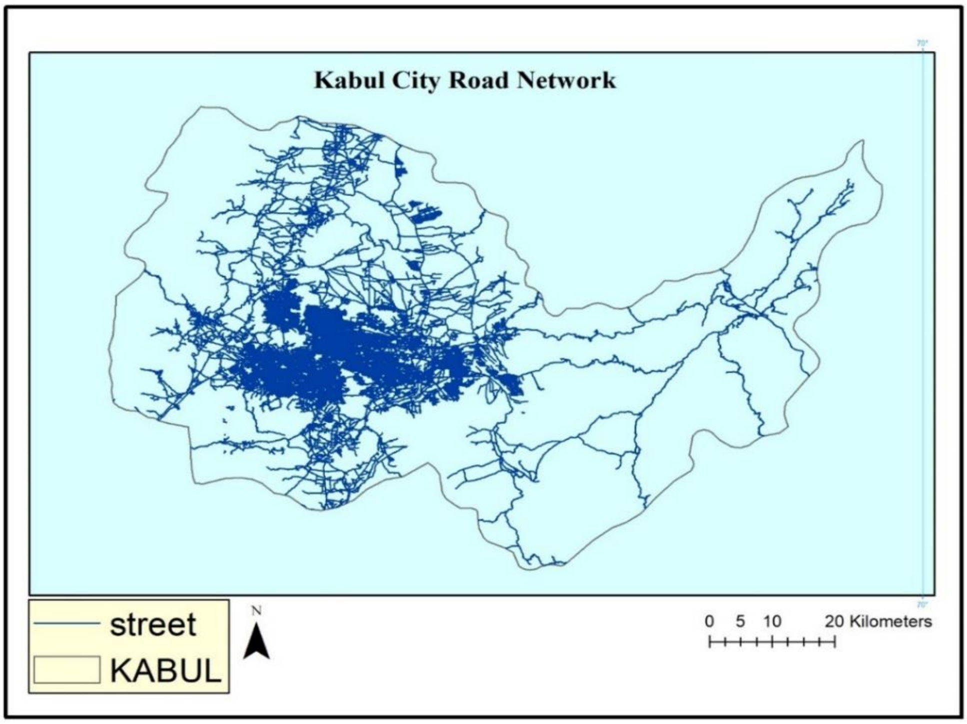

Figure 3: Road network of Kabul city

a. **Network density:**

Network density (N_d) is a measure of road network connectivity which is the ratio of the kilometer of network per square kilometer of surface. Network density measures of transport network development depending on the scale of analysis. Cities with limited infrastructure score low (like lessthan10%).

$$N_d = \frac{l}{A} \quad (1)$$

N_d= denotes the network density
l =total length of transport network in study area depending on scale
A= represents the area of say the city, district or traffic analysis zone .The dimensions are normally in (km/km^2) depending on scale of network.

$$N_d = \frac{l}{A} = \frac{8468.2}{1023} = 8.3\ km/km^2$$

The road network density of Kabul city is shown in raster density(km/km2) as shown in figure 4. in this raster density, the areas with high road network density which are in central business district is shown in dark blue color which most congestion occur in this area.

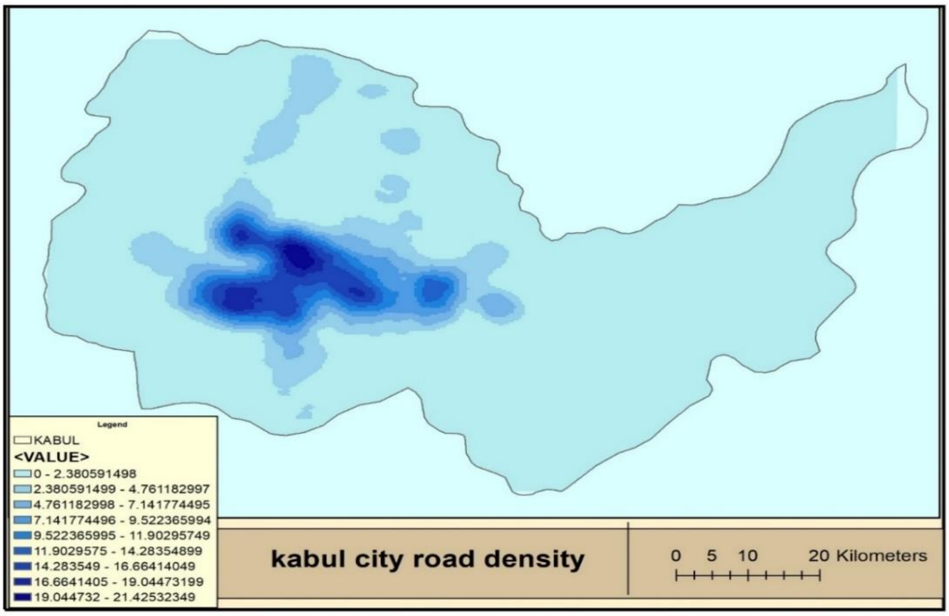

Figure 4: Road network density of Kabul City

b. Beta index (β):

The beta index is a measure of road network connectivity, which is the ratio of road links to the number of nodes measures the "completeness" of a graph.

This index measures the level of connectivity of the transport network. The beta index for connectivity can be calculated from the simple formula below:

$$\beta = \frac{e}{v} \qquad (2)$$

e= number of segments, edges

V= number of nodes

$$\beta = \frac{e}{v} = \frac{60767}{46221} = 1.3$$

Greater the value of β, greater the connectivity which shows more efficient and developed network.

The nodes are the transport network intersections or junctions, and edges are connections between the nodes. Beta index of a road network ranges from 0 which consists of only nodes without any arcs, through 1.0 and greater where networks are well connected. Simple networks possess values less than 1.0 which shows disconnected networks, a connected network involving a single circuit has a value of 1.0, while networks of greater complexity, which include several circuits, have values higher than 1.0.

The beta index is very useful in very simple networks where no circuits are involved. A perfect grid has a ratio of 2.5. A beta index of about 1.4 (which is say half way through the extreme of values) is a good target for network planning purposes. Increasing the links in the network increases connectivity measure. This index does not however show the length of the links.

c. Alpha index (α):

Alpha index (α) is a measure of transport network connectivity which is the ratio of the number of fundamental circuits to the maximum possible number of circuits which may exist in a network. Alpha index is based on the concept of a circuit a finite, closed path starting and ending at a single node, this index is a measure of the redundancy or duplication in the system. Alpha index can be calculated by the formula below:

$$\alpha = \frac{e - v + 1}{2v - 5} \qquad (3)$$

e= number of segments, edges

V= number of nodes

$$\alpha = \frac{e - v + 1}{2v - 5} = \frac{60767 - 46221 + 1}{2 \times 46221 - 5} = 0.157$$

The alpha index values range from 0 to 1. The higher the alpha index the greater the degree of connectivity. Simple networks will have nil values. An α value of 1 indicates a highly integrated network in which every possible link exists between the various nodes. But in some instances, the alpha index value can be negative and this is due to poor connectivity of transport networks in the study area.

d. Gamma index (γ):

Gamma index (γ) is a measure of transport network connectivity which is the ratio of the actual number of segments (edges) in the graph to the maximum number of segments (edges) which may exist in the graph. Gamma index measures the theoretical maximum connectivity of a network. In numerical terms the gamma index connectivity is given by the formula below:

$$\gamma = \frac{e}{3(v-2)} \qquad (4)$$

e= number of segments, edges

V= number of nodes

The values range from $0 < \gamma < 1$. The value of 1 indicates a completely connected network and the value 0 indicates a poor connectivity or when gamma index approaching zero are capable of differentiating various types of disconnected networks and trees.

$$\gamma = \frac{e}{3(v-2)} = \frac{60767}{3(46221-2)} = 0.44$$

e. Eta index (η):

Eta index expresses the relation between the transportation network as a whole and its routes as individual element of the network. The eta index (η) measures the average edge length in the network and is used as a measure of speed in a traffic network. The formula is as below:

$$\eta = \frac{L_e}{e} \qquad (5)$$

L_e=summation of all edges in the network (kilometers)

e= number of edges in the network

$$\eta = \frac{L_e}{e} = \frac{8468.2\ km}{60767} = 0.14$$

Higher values of Eta index or longer the segments in the network, the better it is to ensure maximum speed of the segment concerned. Adding a new link will cause decrease in eta as average length per link declines. The scale of application of the index is meaningful at the city level.

V. FRACTAL ANALYSIS:

Fractal is a Latin word and is defined by "Benoit Mandelbrot" an American mathematician which means broken or fractured. Fractals are rough or fragmented geometric objects that can be split. Fractals may be exactly the same at every scale and they may be nearly same at different scales. A fractal has the following characteristics:

1. A fractal is self-similar. Parts of a fractal look like the whole, remain the similar form of irregularity from scale to scale.
2. A fractal is scale invariant. That is, appears to be the same at all scales of observations.
3. A fractal possesses to be infinitely complex. That means zooming in will bring up more and more details until infinity.

Fractal analysis is used to capture the spatial pattern, which describe the structural attribute including compactness, shape, fragmentation and irregularity of the road network. Fractal dimension indicates to what extent the street segments are more or less uniformly distributed and fill the space in the study area when zoomed to finer scales.

Fractal dimension can be determined in number of ways as cell count method, box counting method, mass radius method etc. In this study, mass radius method has been used for evaluating the fractal dimension. (Sreelekha.M.G et al., 2015).

Fractal geometry provides an effective and way to for evaluating and analyzing transport networks and complex properties of geographical features of urban area fractal modeling is a suitable approach for analyzing the overall structure of road network and its impact on development pattern and transport quality. (Dasari &Gupta,2019)

Fractal theory has been extensively applied in urban planning and road network analysis. in fractal analysis the entire transportation network in city as well as parts of the network in the city exhibited the property of self-similarity or fractal. This microscopic analysis could help policy makers and planners see details of a city more clearly and make accurate predictions.

Fractal analysis of Kabul city road network is done using ArcGIS 10.8 and Google Earth Pro software, whole Kabul city study area is divided into 36 circles or zones of radius 5km and by using multiple ring buffer in ArcGIS, ArcMap each circle is converted into concentric circles of radius 1km,2km,3km,4km and 5 km. Finally, fractal analysis is done by using three layers (Nodes, Links, Multiple ring buffer) as shown in figure 5 ,6 and fractal dimension of number of nodes and length of links(road) is calculated separately in each 36 circles or zones and for each radius of 1km,2km,3km,4km and 5 km.

In this paper mass radius method is used for calculating fractal dimension of Kabul city road network and the following formulae is used for mass radius method of fractal dimension and results are shown in table 1,2 and 3.

$$D_{Li} = \frac{Log(L_{Ri}/L_{Ri-1})}{Log(R_i/R_{i-1})} \qquad (6)$$

D_{Li}= Fractal dimension.
L_{Ri}= Length of road network in km in radius of i.
L_{Ri-1} = Length of road network in km in radius of(i-1)
R_i= Radius of the buffer.
R_{i-1}= Radius of predecessor buffer zone which are multiple of the radius

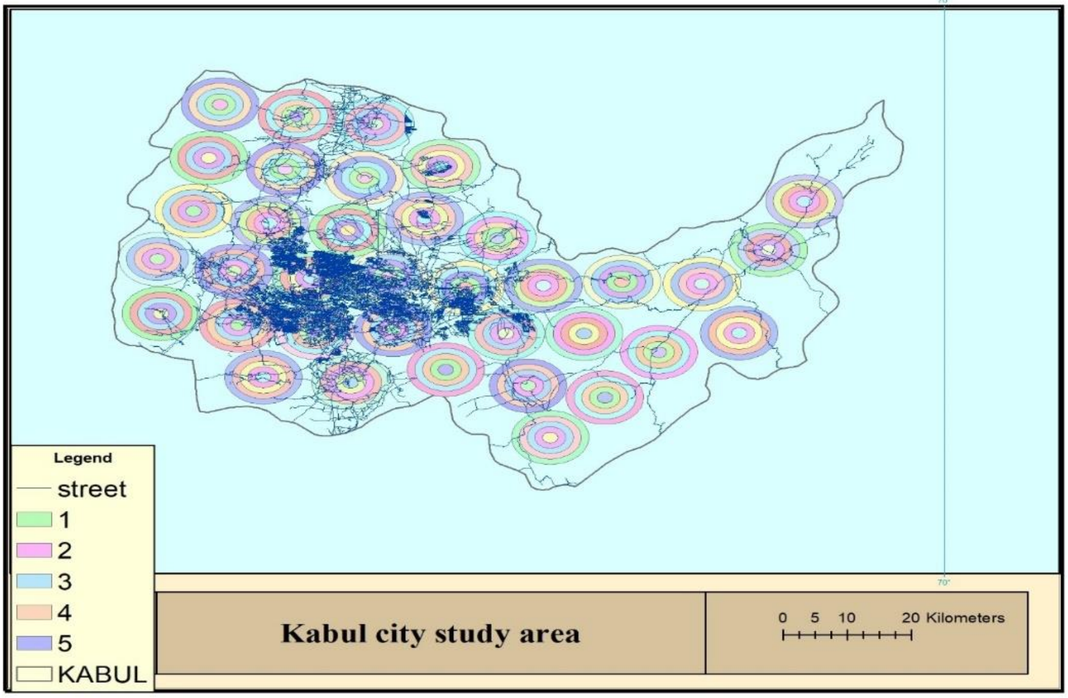

Figure 5: Multiple ring buffer for fractal analysis of road lengths

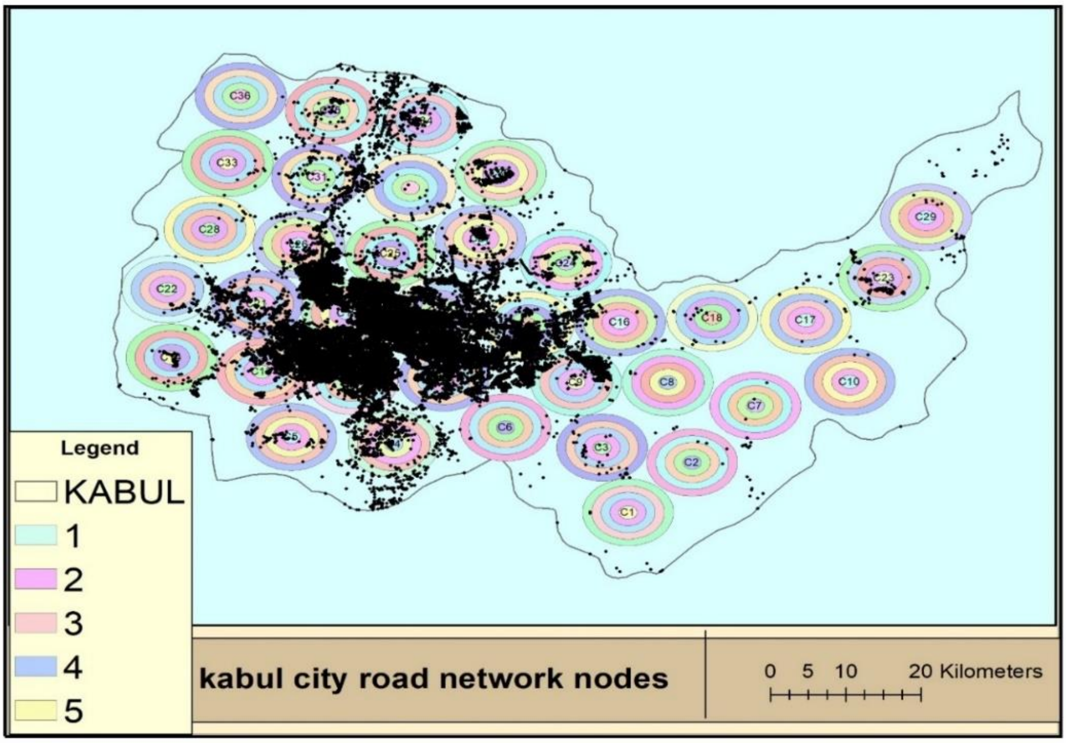

Figure 6: Multiple ring buffer for fractal analysis of nodes

Table 1: Fractal dimension of nodes

fractal dimension of Nodes				
zones	1km-2km	2km-3km	3km-4km	4km-5km
c1	/	/	/	/
c2	/	/	/	-4.92
c3	2.81	1.53	-1.28	-0.53
c4	1.08	1.39	0.89	0.25
c5	0.77	0.64	-1.33	2.11
c6	/	/	/	/
c7	/	0	0	3.11
c8	/	/	/	3.11
c9	2.70	5.38	3.34	-0.71
c10	/	/	/	/
c11	1.64	1.26	1.44	0.66
c12	1.54	1.22	2.06	0.27
c13	4.00	4.11	0.28	1.69
c14	-1.10	-3.80	2.95	7.81
c15	0.90	0.75	1.21	-0.02
c16	/	/	3.36	3.96
c17	/	/	/	4.92
c18	0.58	2.09	-1.17	0.82
c19	2.45	2.39	1.26	1.13
c20	2.17	0.66	1.49	1.88
c21	3.11	1.41	0.64	1.83
c22	/	/	3.69	0.93
c23	5.02	-0.85	-2.41	0.37
c24	2.32	3.76	-1.56	-2.53
c25	3.46	1.15	2.15	17.48
c26	3.30	1.87	4.38	0.74
c27	-0.15	-3.89	7.27	-2.34
c28	/	/	/	2.51
c29	/	/	-3.19	7.64
c30	0.58	-1.00	8.00	4.85
c31	2.46	3.18	4.04	2.02
c32	0.68	-1.16	-4.72	-3.11
c33	/	/	1.00	-1.29
c34	1.14	0.88	0.33	6.65
c35	1.67	-3.19	-1.17	4.61
c36	/	/	/	/

Table 2: Fractal dimension of road length

fractal dimension of road length				
zones	1km-2km	2km-3km	3km-4km	4km-5km
c1	/	/	/	1.42
c2	/	/	/	-1.48
c3	2.77	1.44	0.68	-1.66
c4	1.35	2.08	-1.17	2.75
c5	0.24	1.42	-0.78	0.43
c6	/	/	/	/
c7	0.16	-0.04	-0.01	0.60
c8	/	/	/	6.19
c9	1.47	3.17	2.68	-1.37
c10	/	/	/	0.32
c11	1.56	1.11	1.24	1.04
c12	1.76	1.15	1.42	0.57
c13	2.72	2.76	0.22	1.49
c14	-0.71	-1.47	3.42	5.52
c15	1.43	0.91	1.33	-0.02
c16	/	/	2.91	2.14
c17	/	0.32	1.07	5.16
c18	1.26	1.30	1.53	-1.63
c19	2.67	2.35	1.54	1.05
c20	1.98	0.89	1.30	0.08
c21	2.47	1.88	0.29	1.34
c22	/	/	6.50	0.17
c23	2.16	-4.28	5.81	-0.17
c24	1.59	1.67	-0.26	-0.37
c25	-2.05	10.03	0.95	1.99
c26	-1.10	7.32	3.45	0.85
c27	0.29	-1.66	4.36	-0.58
c28	/	/	3.45	3.23
c29	0.93	1.78	0.01	1.89
c30	0.62	0.95	1.36	5.44
c31	2.81	1.96	1.46	2.83
c32	0.19	0.34	-2.27	-1.15
c33	/	/	2.36	1.18
c34	0.98	1.46	0.09	4.54
c35	1.11	-1.21	-0.22	4.69
c36	/	/	/	/

Table 3: Average fractal dimension of road length and node

zones	fractal dimension of road length	fractal dimension of nodes
c1	1.42	/
c2	-1.48	-4.92
c3	0.81	0.63
c4	1.25	0.90
c5	0.33	0.54
c6	/	/
c7	0.18	1.04
c8	6.19	3.11
c9	1.49	2.68
c10	0.32	/
c11	1.23	1.25
c12	1.23	1.27
c13	1.80	2.52
c14	1.69	1.46
c15	0.91	0.71
c16	2.53	3.66
c17	2.18	4.92
c18	0.62	0.58
c19	1.90	1.81
c20	1.06	1.55
c21	1.50	1.75
c22	3.34	2.31
c23	0.88	0.53
c24	0.66	0.50
c25	2.73	6.06
c26	2.63	2.57
c27	0.60	0.22
c28	3.34	2.51
c29	1.15	2.23
c30	2.09	3.11
c31	2.26	2.93
c32	-0.72	-2.08
c33	1.77	-0.14
c34	1.77	2.25
c35	1.09	0.48
c36	/	/

Higher values of fractal dimension indicate high road network density or central business district. The major advantage of the fractal analysis is it is a straight forward model and it takes less time and cost and it also helps in the preparation of masterplan (network augmentation section). This model is very useful for smaller size cities in developing countries. (Abid et al.,2021)

From the analysis, it is observed that, increase in buffer interval leads to decrease in the build-up area. As moving away from the city center to the outside area, the build-up area of the city will decrease due to the residing population in the outer areas will be less with comparing to inner areas. Fractal dimension values between 2 and 3 shows good connectivity of road network in urban areas.

VI. TRAFFIC ANALYSIS:

The basic measure of traffic on road network is the volume of traffic using the road in a given interval of time it's also called as flow and it's expressed in vehicle per hour (veh/hr).

Vehicular volume is important for knowing the efficiency of the system and the level of service offered to road users from the flow data the capacity of a road section can easily be determined that whether its above or below the capacity, therefore volume counts are indicator of the need to improve the transport facilities. (kadyali,2017)

Traffic volume studies are carried out to collect the number of vehicles which are passing through a specific point on a roadway during a specified time period. Depending on the usage of data, the duration of conducting traffic volume counts ranges from 15 minutes to a year.

The collected data are classified into subclasses such as directional movement, occupancy rates, vehicle composition, and pedestrian age. the term volume is used when flow is measured over the course of an hour and it's shown in vehicles per hour (veh/h).

Intersections are the major source of crashes and vehicle delays or congestion, hence in this paper Karte Mamorin intersection is analyzed to compute peak hour volume ,peak hour factor and percentage of vehicle composition as shown in table 4 and figure 7,8 and 9.

Table 4: Traffic analysis of alawuddin intersection

Karte Mamorin intersection			
Morning data 07:00-10:00 AM	Approach	PCU(veh/hr)	PHF
	From Silo street	1296	0.93
	Char rahi qambar	1348	0.9
	From Karte Parwan	3272	0.94
Afternoon data 3:30-5:30	From Silo street	1378	0.95
	From char rahi qambar	2316	0.8
	From Karte Parwan	3659	0.91

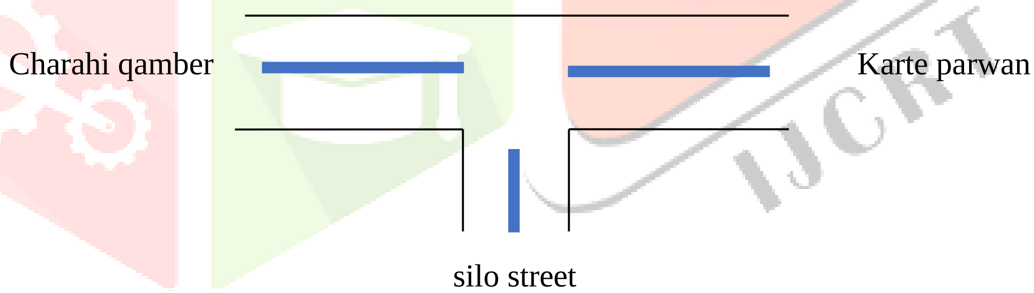

Figure 7: Karte mamorin intersection

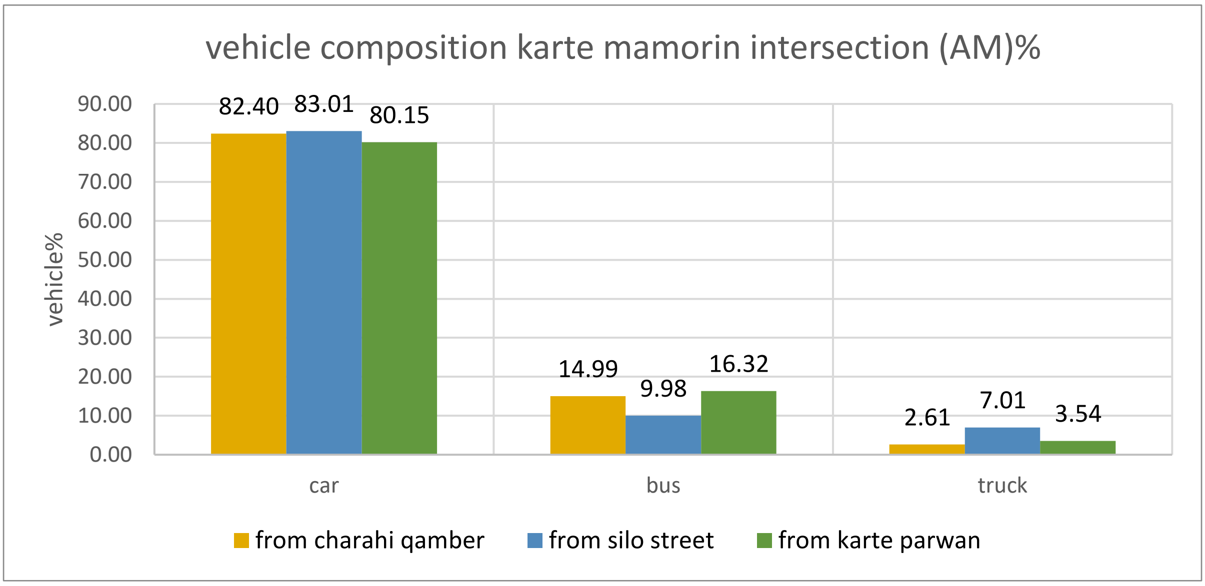

Figure 8: vehicle composition in morning at karte mamorin intersection

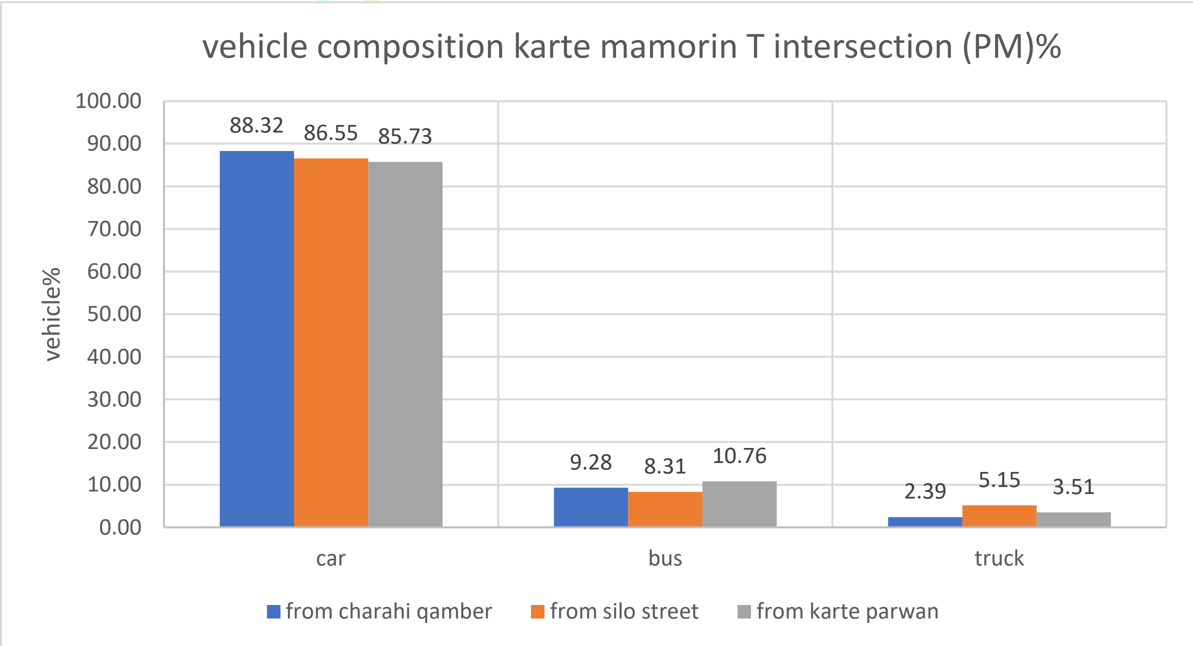

Figure 9: vehicle composition in afternoon at karte mamorin intersection

From traffic analysis of intersection, we can conclude that the highest vehicle percentage in composition are cars or private vehicles and the peak hour factor ranges from 0.8-0.95 which represents the most critical period for operations and has the highest capacity requirements period. The maximum possible value of the PHF is 1.0 which occurs when the volume in each interval is constant under very congested conditions PHF approaches 1.
Based on data analysis peak hour volume in morning occurs between 7:30-8:30 as government and educational institution start at 8:00 am and peak hour volume at afternoon occurs between 3:45-4:45 as government and other institution work end at 4:00 pm.

There are several factors that causes delay at intersection and impact the level of service of intersection like existence of high number of private vehicles composition are the major cause of congestion since road network capacity cannot handle all traffic during the peak demands then vehicle interruption and delay occurs by one vehicle to another, improper functioning of signalization, road side parking, inappropriate lane discipline, road surface condition, pavement markings traffic signal operations, traffic signal visibility, information guidance systems, physical features of the intersection. Other factors are Geometric impacts on mobility like number of lanes, lane width, Land use impacts availability of shops, illegal parking impact on mobility, Traffic islands, Neighbor signals and junctions less than 500m.

VII. LAND USE:

Land use is the use of land in urban areas, towns, cities, land use features and transportation networks are interdependent. The land use term is based on the fact that through development, urban space put up a variety of human activities. Land is a convenient measure of space and land use provides a spatial framework for urban development and human activities. Demand for transportation is created by the location of activities and their need for interaction, while provision of transportation facilities influence the location itself. The primary goal of urban planning is to ensure efficient balance between land use activity and transportation capability.

Land use means spatial distribution or geographical pattern of the city or town which is used for different purposes of residential area, working areas, education areas, industry, commercial areas and the space set for governmental, institution or recreational purposes. Most human activities whether economic, social, or cultural, involve a variety of functions, such as production, consumption, and distribution.The areas which have high accessibility will be attractive to many people or business, hence the land will be more expensive and likely more densely developed, the land use transport interaction is shown in figure 10.

Obviously, population growth requires additional transportation demand, but rising incomes too. Trip patterns can change in a variety of ways, including the number of trips, the timing of trips, their origin or destination, the mode, and trip chaining. These changes in travel demand have a significant impact on the development of new transportation infrastructure or services.Objective of land use management is to improve travel efficiency and reduce vehicle travel, including infill, mixed-use, higher densities, compact/walkable neighborhoods, transit-oriented development, pedestrian design, and parking management.

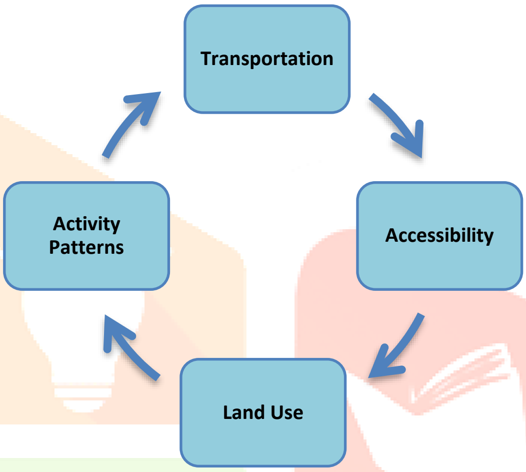

Figure 10: Transportation-land use interaction

In Kabul city due to population growth and rapid urbanization has resulted in increased motorization, hence traffic congestion and air pollution and many other environmental hazards which occurred in the city. The rapid increase of population is forcing the expansion of built-up area. There are a range of formal and informal approaches to residential development in Kabul city Formal' development is defined to development facilitated by the legal acquisition of land, and construction in accordance with master plans and building regulations.

Khairandish et al. (2020) developed the study to detect the Land use and land cover change of Kabul city River Sub-basin from 1972 to 2019 ,ArcGIS and ERDAS Imagine are used finally they found that the built-up area (settlement) has increased from 3.20 to 9.41% of the total area which shows a rapid increase of population and forest area decreased from 3.94% to 1.67% as shown in figure 11 and table 5.

Table 5: Area under land use and land cover

NO	Land use/land cover	Area(km^2)	Percentage (%)
1	Water	13.488	0.3
2	Built up area	419.702	9.41
3	Agricultural plantation	399.564	8.96
4	Forest	74.407	1.67
5	Grass/grazing	111.865	2.51
6	Barren/waste land	3442.22	77.16
Total		4461.247	100.0

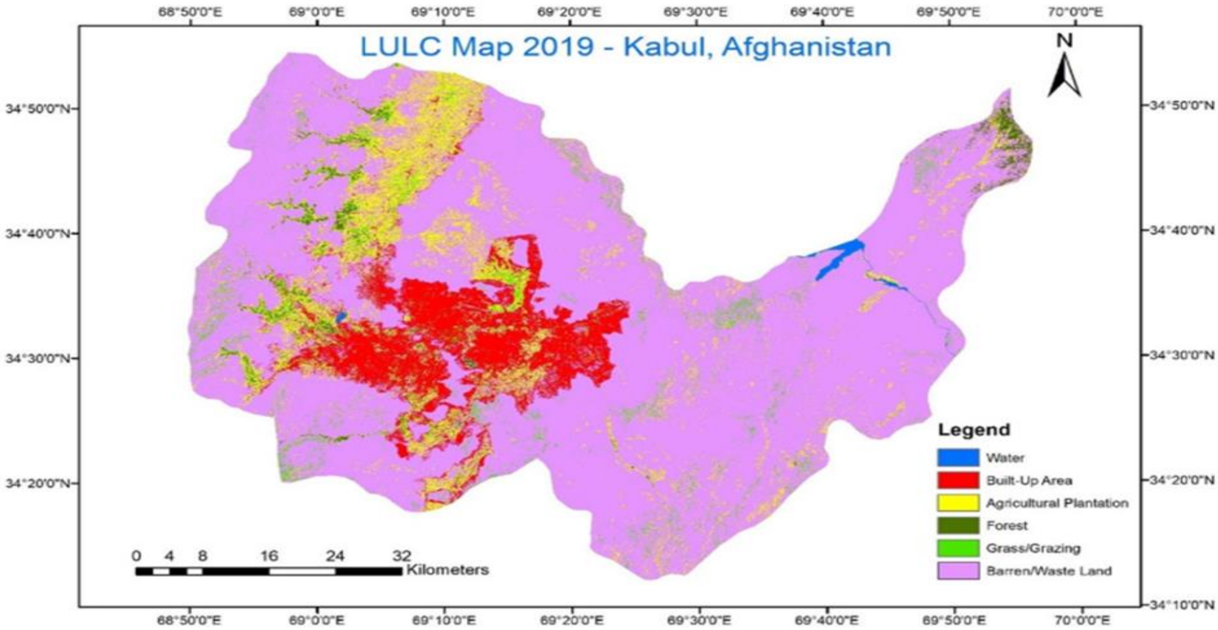

Figure 11: land use land cover map of Kabul city

The city sprawled in many directions especially where the topographical structure of the area is suitable. Informal households sprawled everywhere in the planned area as well. Many planned houses near the unplanned areas have been converted into markets, bazaars, private educational centers, private clinics, currency exchange centers, and small industry workshops and also some residential areas were converted into commercial centers which resulted in increased motorization and traffic congestion because of concentration of activities.

as population densities rise, vehicle use also rises more vehicle miles occur in a confined geographical location, traffic slows down and is subject to more stop-and-go operation, leading to increased time spent in traffic and higher air pollution emissions since most vehicle tailpipe .Disarrangement in the land use impedes the traffic flow roads leading to the market are always crowded by street vendors and on street parking.

There should be an effective land use planning to regulate the use of land in order to improve a community's physical, economic and social efficiency and well-being as well as to protect the environment. By taking into account socio economic trends and physical and geographical features, planning assists in identifying the preferred land uses that will support local development in an efficient and ethical way, thus preventing land use conflicts and improve transportation system. (Swamy et al.,2013).

Current transportation systems can be improved by implementing integrated transportation planning for congested cities. Integrated transportation planning for congested cities as a step towards sustainable transport system can solve and improve the current transport systems and provide the public economic, efficient, easily accessible, smooth, safe and environmentally friendly transport services. integrated land-use planning and policy is an effective and longer-term tool used against traffic problems and has the potential:

- To control the number and growth of major traffic generators along congestion corridors.
- To establish sensible allocations of land for future development given present constraints and expansion plans for the transportation network and
- To enforce balanced employment and residential development, thus reducing the long home-to-work trip
- Sustainable use of urban land (low intensity uses in ecologically and culturally important locations; high intensity of use in locations that can support it)
- Reduced vehicle emissions and higher quality of living environment
- Less time spent in travel and therefore higher productivity as well as quality of life
- Greater access to public transport and thus to jobs; additional health and quality of life benefits by enabling and encouraging more walking and cycling

VIII. CONCLUSION AND RECOMMENDATION:

In this paper Kabul city transportation system is analyzed based on road network, traffic and land use. Road network analysis and fractal analysis is done by using ArcGIS 10.8 software and road network indices values are calculated, Alpha index α =0.157 which means the degree of connectivity is poor since the higher the alpha index shows the greater the degree of connectivity Beta index β =1.3 means it's fairly good since a perfect grid has a ratio of 2.5 and beta index of about 1.4 is a good target for network planning purposes.
Gamma index γ =0.44 it shows fairly good connectivity since gamma index value values range from $0 < \gamma < 1$ and value of 1 indicates a completely connected network.
And based on road network analysis the Intersections in the study area are non-Functional because junctions are located at shorter intervals.

In fractal analysis the higher values of fractal dimension indicate high road network density or central business district. From fractal analysis, it is observed that, increase in buffer interval leads to decrease in the build-up area. As moving away from the city center to the outside area, the build-up area of the city will decrease due to the residing population in the outer areas will be less with comparing to inner areas. Fractal dimension values between 2 and 3 shows good connectivity of road network in urban areas.

Based on traffic analysis of Karte Mamorin intersections peak hour volume in morning occurs between 7:30-8:30 as government and educational institution start at 8:00 am and peak hour volume at afternoon occurs between 3:45-4:45 as government and other institution work end at 4:00 pm. There are several factors that causes delay at intersection impact the level of service of studied intersection like existence of high number of private vehicles, improper functioning of signalization, road side parking, inappropriate lane discipline, road surface condition, pavement markings traffic signal operations, traffic signal visibility, information guidance systems, physical features of the intersection.

The rapid increase of population in Kabul city is forcing the expansion of built-up area due to urban sprawl and informal development created many challenges in transportation there must be efficient balance between land use activity and transportation capability. Disarrangement in the land use impedes the traffic flow roads leading to the market are always crowded by street vendors and illegal on street parking.

Congestion causes environmental pollution, noise pollution air pollution, vibration, accidents. Whenever congestion occurs costs are affected like cost of delay to the people, vehicle operating cost like fuel cost, maintenance cost.in order to improve mobility and accessibility and having uniform mobility while at the same time reducing congestion, accidents and environmental pollution, there is need to have a proper urban mobility planning, strategy and policy to tackle this issue.

These goals can be achieved by supply and demand strategy and land-use planning and policy. Supply measures add capacity to the system like road widening, provision of separate lane for public transport, providing elevated flyover, constructing bypass, use of coordinated traffic signal and use of intelligent transportation system. Demand measures, on the other hand, focus on motorists and travelers and attempt to modify their trip-making behavior like congestion pricing, parking pricing, Staggering of office hour and flexible time of work, bus priority and so on.

integrated transport land-use planning and policy can be used to control the number and growth of major traffic generators along congested corridors, to establish sensible allocations of land for future development given present constraints and expansion plans for the transportation network, and to enforce balanced employment and residential development, thus reducing long home-to-work trips.

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