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A SPATIO-TEMPORAL STUDY FOR THE APPRAISAL OF TRAFFIC CONGESTION ISSUES IN LAHORE, PUNJAB, PAKISTAN

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ABSTRACT

Lahore being the second largest city of the country encountering severe traffic issues on many major and minor corridors. Current study based on spatio-temporal technology highlights the traffic congestion issues on major roads including Niazi Terminal, General Hospital and Lytton Road. Temporal datasets acquired from Transport department of Punjab have been processed in Arc GIS environment in integration with Google earth software. Topological refined road network datasets have been utilized to meet the objectives of the study. Results of the study revealed spatio-temporal traffic patterns on three corridors. Mainly, traffic congestion issues have been observed in afternoon and evening peak hours on these corridors, while Lytton Road segment reported with traffic congestions in morning peak hours as well. Results of the study compared with google traffic maps and found consistent which authenticates the reliability of the adopted approach. Temporal vehicles growth depicted a significant rise (4.5 million) of registered vehicles in last 15 years with unsubstantiated planning and management which is the main cause behind this traffic congestion. Based on the findings of the study it is concluded that GIS based integrated solutions must be adopted for effective and efficient traffic planning, traffic management and ultimately eradicating traffic congestion issues.

KEYWORDS*:* Traffic Congestion, Spatio-temporal, Geographical Information System (GIS), Corridors, Traffic Volumes, Google Traffic Maps.

1. INTRODUCTION

Now, it is globally recognized that urban transport is playing a very vital role in the development and growth of the communities. Though, recent abrupt increment in population growth and urbanization has put very serious challenges for urban transport (Spirin *et al*., 2020; Kalašová*et al*., 2019; Comtois and Slack *et al*.,2009). More specifically, major cities are facing traffic congestion problems in almost every country of the world. The major cities are the main power hoses of economic growth for any country. For economic activities and other daily life purposes must be produce the movements. Transport system provides the daily movements for economic activities and other working purposes. Insufficient transport

network is responsible for the development of economic activities (Akimova *et al*., 2020). In the most developing countries, which has huge population and poverty, rise economic activities and opportunities results in fast increase in urban population and demand the proper transport network facilities (Zhuge and Shao, 2018). Traffic congestion has negative influence on the economy of any country as productive hours are lost in traffic congestion. Road capacity is also responsible for congestion (Noor and Ashrafi, 2021). When the vehicles are greater than road capacity, traffic congestion generates. Approximately, Traffic congestion problem occurs in peak hours of the day such as morning, evening when the people travelling to work (Marshall and Dumbaugh, 2020; Pisano and Goodwin, 2004; Zhang *et al.,* 2004). Construction works, incidents, signal timings, daily recurring traffic and somehow weather conditions are the major causes of traffic congestion. Other researchers also reported the same results that around 65 percent traffic congestion is usually occurred on morning and evening peak hours. Commuting is also another reason behind traffic congestion; out of 4 million economically active persons around 1.4 million persons usually use their own to commute between their place of work and residence. The traffic congestion is also produced by travelers when they travel to work. They use their personal cars, motorcycles instead of public transport when they travel (Yu and Zhao, 2021). They have no proper awareness the road and traffic rules. The traffic congestion also produced due to important events which held in a particular city which has already huge population. Moreover, traffic congestion may occur daily at the same time on specific locations of the city due to working peak hours and people trends (Goodwin, 2003; Stern *et al.,* 2003; Golob and Recker, 2003; Helman, 2004). Severe traffic congestion is mainly because of abrupt increase vehicles volume in the past few years. Congestion usually occurs when the road network fails to accommodate the traffic volume (Szele and Kisgyörgy, 2018). Along with network capacity, improper parking, mixed type of traffic and slow speed are also major contributors in causing traffic congestion. Geographic information system (GIS) is proved to be a reliable tool in efficient management and planning of traffic congestion projects (Sureshkumar *et al.,* 2015). Spatial datasets i.e., transit infrastructure, location of traffic congestion spots along with other relevant data layers can be integrated in a GIS platform for spatial analysis. However, non-spatial datasets i.e., Vehicle types and traffic volume vehicle at a specified time may also be incorporated in a GIS environment for efficient decision making. Based on the patio-temporal assessment of traffic volumes it is easy to establish reasonable solutions for traffic congestion (Boskovic *et al.,* 2013).

Congestion problem does not overcome by applying the physical

construction such as underpasses, road bridges, and motorways but it could be control by advance technology and advance techniques and proper awareness to the people that how to use roads. In the developing countries, there is no proper road infrastructure and practices of advance technology to control the flow of traffic. In Pakistan there is no advance technology and no advance a technique for the management of traffic is currently under practice. Therefore, almost every major city of the country is experiencing the traffic congestion problems (Ali and Sheng, 2019; Das, 2015).

Immediate attention and solutions are required in Lahore city; due to the second largest city of the country and importantly serving as a major economic hub This Study highlights the potential traffic congestion corridors and aimed at providing the solutions for reduction of traffic congestion problems. There is need to introduce latest technologies to counter the existing traffic challenges in the country. Currently GIS based solutions are proved very reliable in managing and planning of such issues across the globe. So, this is the need of the hour to adopt such technologies in establishing efficient decision-making tools. This study mainly focuses on the objectives; i) Assessing the current traffic situation over selected corridors of the city at different time scales of the day, ii) Spatio-temporal assessment of the volume to capacity ratio of Passenger car units in order to calculate the traffic congestions, and iii) Comparison of the calculated results of the study with the Google traffic maps for accuracy assessment

1.1. Study Area

Lahore, being the provincial capital and major economic hub of the country, huge number of commuters from other cities and within the cities travel on the roads of the Lahore. Lacking in efficient and reliable public transport, people usually prefer to travel by their personal vehicles which is a major factor in incrementing the traffic volume on roads. Furthermore, conventional methods are yet in practice to cater these traffic congestion issues i.e., road widening, construction of flyovers, underpass etc. These are temporary solutions as induced traffic caused by them usually. Existing situation demands adoption of modern technologies for sustainable planning and management. This study presents the GIS and open-source Google imagery-based solutions in identifying the potential hotspots in city. Temporal assessment of the traffic data also exhibits the road capacity status in accordance to the increased traffic volume over time period. Data of vehicle type also helps in estimating the usage and increase of personal vehicles rather than commuters switching on public transport (Donald and Cooper, 2014).

2. MATERIALS AND METHODS

Lahore being an economic hub and provincial capital of the Punjab province of the country, Lahore city receives huge traffic volume from other cities. Currently, more than 50 public transport routes including HTV and LTV are in operation within the city along with a huge number of taxi services (Uber, Careem, Rickshaws, Cabs etc.). Since last two decades a significant increment in vehicles addition has been observed in Lahore city. As per Transport department, more than 4.5 million vehicle registrations have been done in last 15 years. It has been noticed that use of personal vehicles (cars) keeps increasing. This is mainly because of unreliable and poor infrastructure of existing public transport system. Therefore, people usually do not prefer and rely on this which results in increase of personal vehicles and ultimately traffic congestion. However, currently one metro bus service and orange train service has been added to cater the public transport issues. In addition, infrastructure development in the form of road widening, underpass, flyovers etc. are continuously improving in the city to resolve the traffic issues. Major issues in the existing transport system are of the nature of planning and management. Fig 1 depicting the study area corridors (red color) for which traffic counts data acquired from Transport Department Punjab.

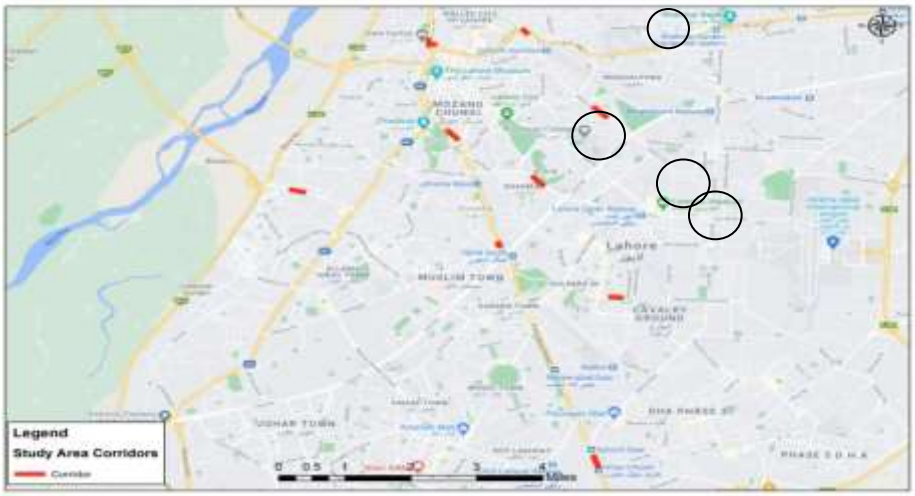
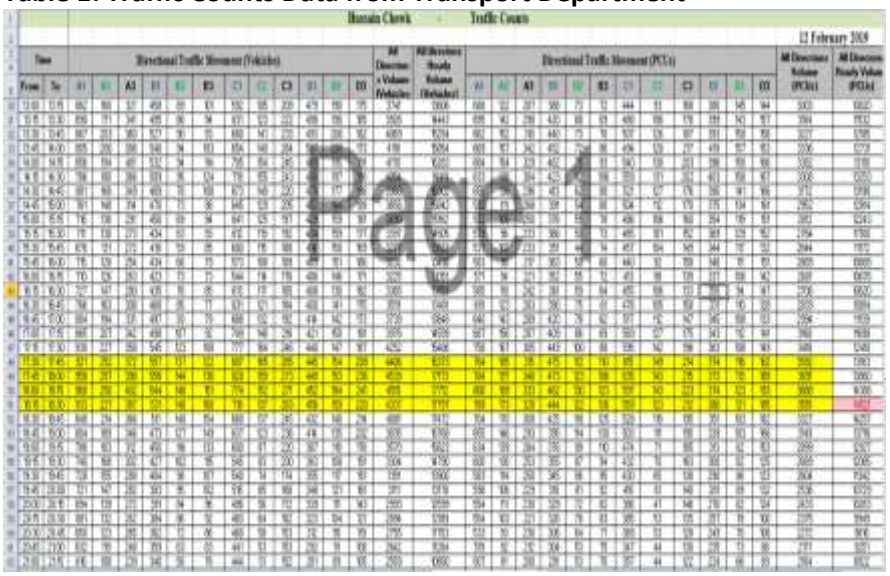


Fig. 1. Study Area Map

Data of traffic counts were acquired from Transport department Punjab for the year 2019. Acquired datasets comprising of the corridors usually facing traffic congestion issues in different time spans of the day. Traffic counts in provided datasets were available, however for this study traffic counts at peak hours were considered. Table1 showing the

structure/layout of the provided datasets for each corridor. Data was much comprehensive as information about vehicle types was available at every 15 minutes time interval.

Table 1: Traffic Counts Data from Transport Department



Traffic counts data were in the form of vehicle type passing per 15 minutes on each corridor. However to assess the traffic congestion, traffic counts are required in the form of passenger car unit (PCUs). As per standards, volume to capacity ratio of a single lane allows 2000-2100 PCUs per hour. Therefore, traffic counts based on vehicle type were converted to PCUs by using the standard conversion method (NHM, 2010). Table2 describes the category-wise PCU weight of each vehicle type.

Using Google earth imagery, width of both side corridors at Niazi bus service has been calculated. Objective of this measurement was to calculate the no of lanes on each corridor. As per National Highway Manual width of intra-city lanes vary between 10-12 feet. Fig2 depicting the measurements of both side corridors in front of Niazi bus service. Both side corridors measurement are above 30 feet which means each side having minimum 3 lanes.

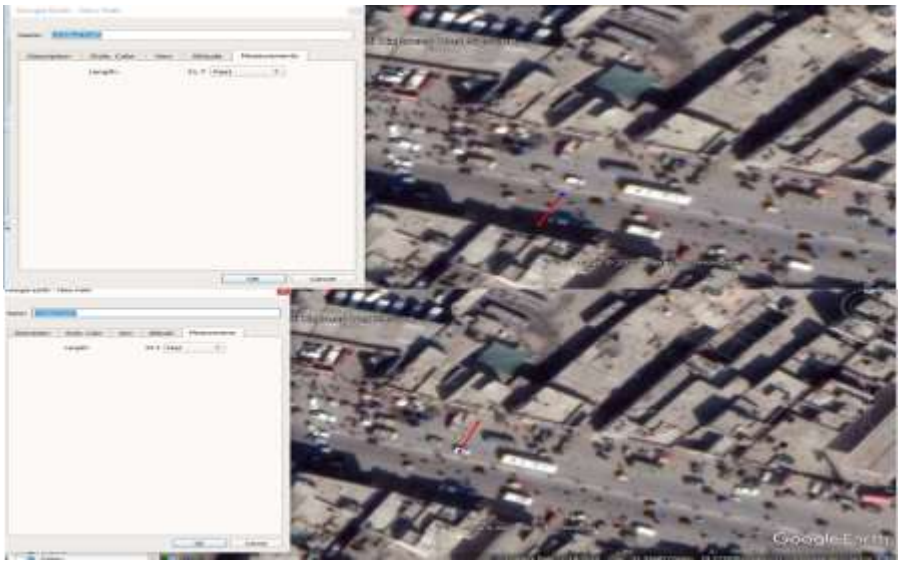


Fig. 2. Lane's calculation at Niazi Terminal Corridor

Corridor measurement in front of General hospital has been described in figure 3. One side of the corridor showing 3 lanes while other side width showing 2 lanes. This is mainly because of the metro corridors which reduced the width of the road being available for general traffic.

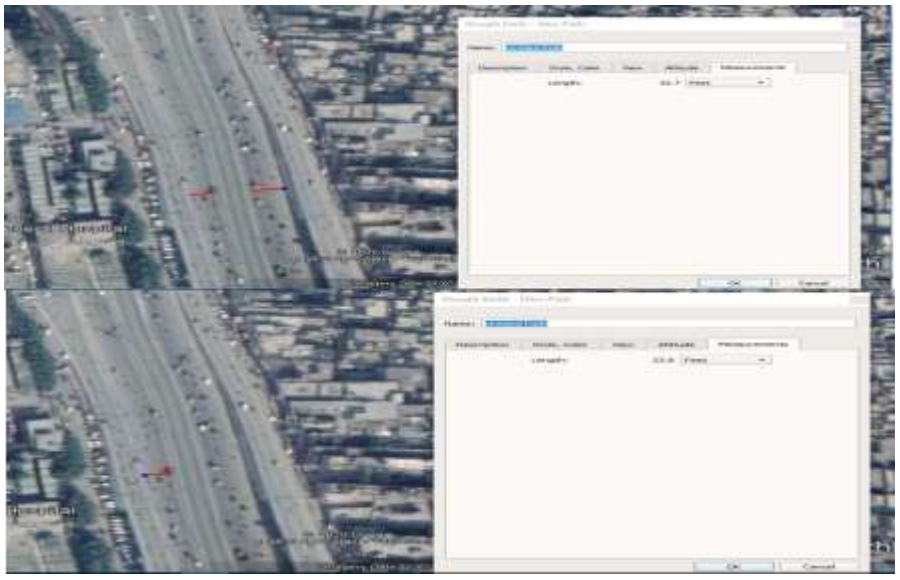


Fig. 3. Lane's calculation at General Hospital Corridor

Fig. 4 describing the status of corridor at Lytton Road corridor. This segment having very less width on both sides, one side is with 2 lanes, while other one is hardly wide enough to accommodate 1.5 lanes.

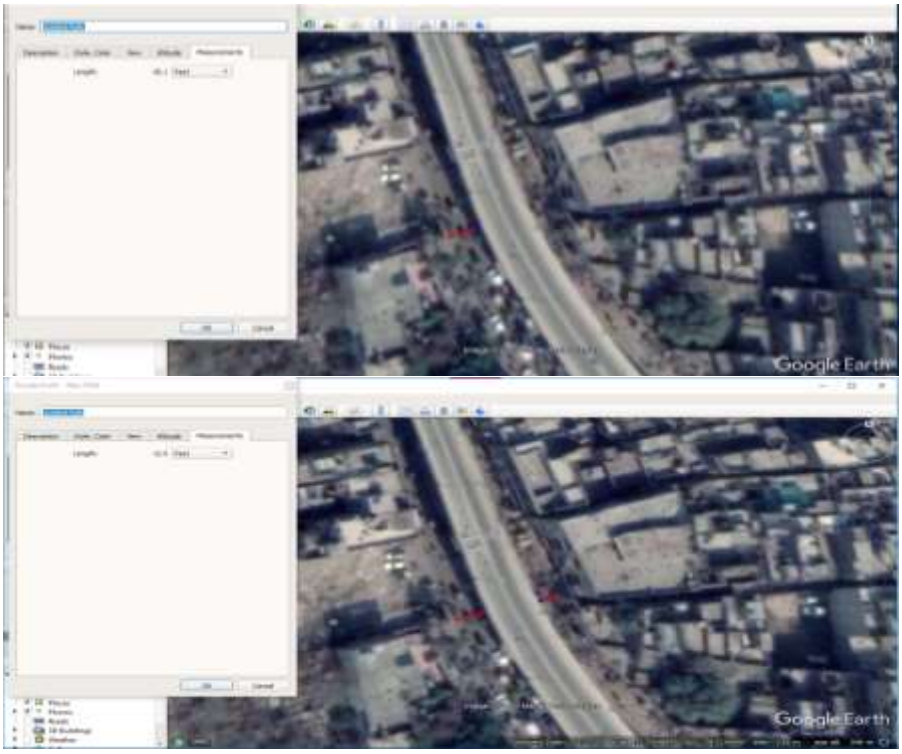


Fig.4. Lane's calculation Lytton Road Corridor

After calculation the lanes of each corridor, volume to capacity analysis were performed in order to measure the traffic congestions at different time spans of the day. The traffic congestion has been calculated based on the PCUs and lanes measurement, these results were validated with the Google traffic maps. This was done in order to check the accuracy of the calculated results. Google traffic maps provide live traffic congestion data along with the typical traffic patterns in each day of the week based on the archives. Major cause behind the traffic congestion in all the major cities across the globe is increase in traffic volume / addition of new vehicles. A significant increment in vehicles has been observed in last two decades in Pakistani especially in major cities of the country. Lahore being the capital of province and economic hub experiences a huge addition of vehicles on roads in this time span. Increasing number of vehicle every year resulting in the form of severe traffic congestions in the city and this issue keeps growing by every day. Table 2 illustrates the registered vehicles status in last 15 years in Lahore city.

Table2: Registered Vehicles in Last 15 Years

Year	Total Regd. Vehicles	Motor Cars, Jeeps & Station Wagons	Motor Cycles & Scooters	Trucks	Pickups/ Delivery Vans	Mini Buses/ Buses/ Flying/ Luxury Coaches	Taxis	Auto Rickshaws	Tractors	Other Vehicles
2004	878,730	300,635	480,528	9,329	21,638	19,493	10,535	36,372	-	-
2005	1,011,960	333,509	546,493	9,478	24,282	21,353	10,540	45,910	19,485	910
2006	1,253,101	394,965	702,485	9,806	27,878	23,515	11,883	57,137	24,488	944
2007	1,464,344	473,311	822,264	11,439	33,243	27,792	10,586	58,024	26,540	1,145
2008	1,703,007	561,500	957,939	14,146	37,036	31,365	11,660	59,627	28,415	1,319
2009	1,944,709	637,787	1,110,218	15,999	40,133	32,518	11,771	66,246	28,575	1,462
2010	2,129,990	673,449	1,245,389	17,029	42,315	33,335	11,771	74,259	30,757	1,686
2011	2,387,993	722,012	1,432,639	18,683	45,094	34,132	11,789	87,541	34,220	1,883
2012	2,687,987	764,265	1,647,842	20,806	48,046	35,345	11,867	102,029	37,305	20,482
2013	3,022,126	801,403	1,894,324	22,772	78,621	36,841	14,766	113,007	39,551	20,841
2014	3,391,268	871,244	2,172,760	24,683	81,922	40,485	15,146	122,517	42,191	20,320
2015	3,991,517	1,023,110	2,588,254	27,344	86,753	43,972	15,247	139,927	45,971	20,939
2016	4,287,662	1,070,243	2,763,872	36,265	130,344	50,519	17,404	149,562	47,356	22,097
2017	4,926,325	1,251,556	3,228,438	30,739	100,581	48,350	23,140	171,818	50,434	21,269
2018	5,349,073	1,194,064	3,706,449	29,424	87,059	76,586	16,349	180,296	53,915	4,931

3. RESULTS AND DISCUSSION

Traffic congestion analysis at the Niazi bus service corridor describes that traffic volume increased temporally from morning to evening times. Comparatively, high flows of traffic have been reported in sherakot direction than Yateem khana chowk (Fig5). When the results of this corridor compared with the Google traffic maps for verification of the results, more or less same behavior has been reported in Google maps just with the difference on one side of corridor towards sherakot (Fig5). In Google maps traffic congestion has been reported between 06:00 am to 07:00 am from Yateemkhanachowk towards sherakot, while results of this study showing normal traffic during this hour.

Fig.5 Spatio-Temporal Traffic congestion Status at Niaz Terminal Corridor

Fig.6. Spatio-Temporal Traffic congestion Status at Niazi Terminal (Google Traffic Maps)

Fig**.** 6 depicting the traffic status in front of the General Hospital corridor at Ferozpur road. High traffic flows has been reported from Qainchi towards Gajjumattah however in this direction, road capacity is better as road is wide in comparison to the other side. Therefore high inflows are manageable in morning peak hours while in afternoon and evening hours both sides of the corridor resulted with traffic congestions. Results of the

study found consistent more or less with same patterns when compared with the Google traffic maps (Fig7).

Fig.7. Spatio-Temporal Traffic congestion Status at General Hospital Corridor

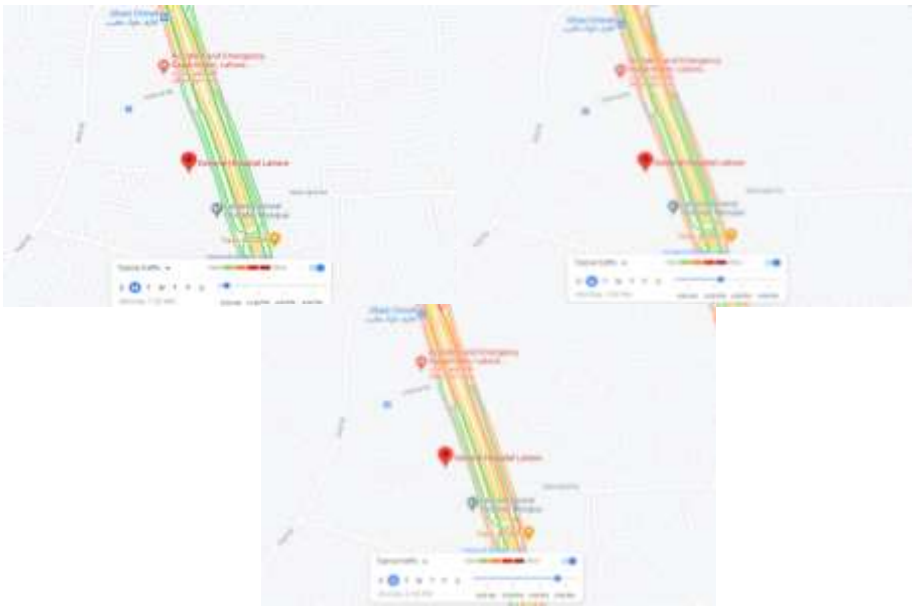
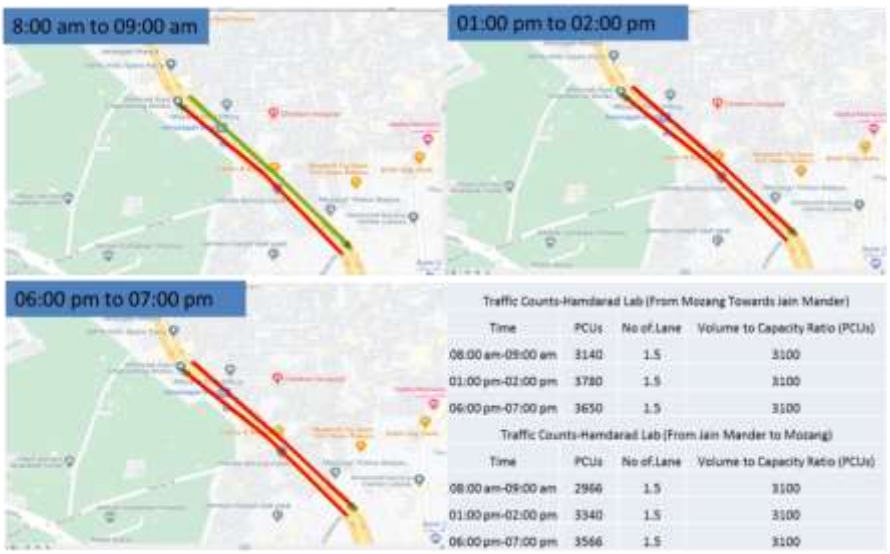


Fig. 8. Spatio temporal Traffic congestion Status at General Hospital (Google Traffic Maps)

Lytton road corridor near Hamdarad chowk shows high traffic volume / traffic congestion in morning peak hours in one direction (Mozang towards Jain Mander). However, other side of the corridor showing normal traffic volume. This corridor is very congested as having almost 1.5 lanes on both sides and usually faces high traffic congestions throughout the day (Fig8). Afternoon and evening peak hours showing traffic congestions on both sides with more or less same reporting of Google maps (Fig9).



Traffic Counts-Hamdarad Lab (From Mozang Towards Jain Mander)

Time	PCUs	No of Lane	Volume to Capacity Ratio (PCUs)
08:00 am-09:00 am	3140	1.5	3100
01:00 pm-02:00 pm	3780	1.5	3100
06:00 pm-07:00 pm	3650	1.5	3100

Traffic Counts-Hamdarad Lab (From Jain Mander to Mozang)

Time	PCUs	No of Lane	Volume to Capacity Ratio (PCUs)
08:00 am-09:00 am	2966	1.5	3100
01:00 pm-02:00 pm	3340	1.5	3100
06:00 pm-07:00 pm	3566	1.5	3100

Fig.9. Spatio-Temporal Traffic congestion Status at Lytton Road Corridor

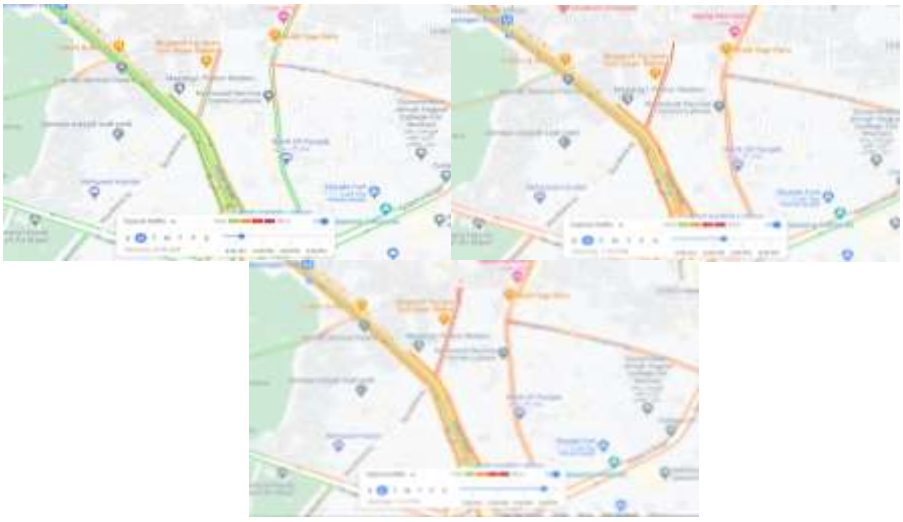


Fig. 10. Spatio-Temporal Traffic congestion Status at Lytton Road (Google Traffic Maps)

Temporal assessment of the registered vehicles for last 15 in Lahore city reported with significant increase in al type of vehicles, specifically motor cycles and motor cars (Fig.11). Almost 4.5 million vehicles have been registered in last 15 years just in Lahore district. Whereas, Lahore city accommodates the traffic from other cities on daily basis, especially from neighbor cities i.e., Kasur, Sheikhupura, Gujranwala etc. This huge increase in vehicles registration every year ultimately producing a very serious challenge in terms of traffic planning, traffic management and infrastructural improvements. However, no reasonable measures have been taken to mitigate and counter these serious challenges. At few locations, infrastructural improvements have been done, whereas very disastrous situation exist when we talk about traffic planning and management.

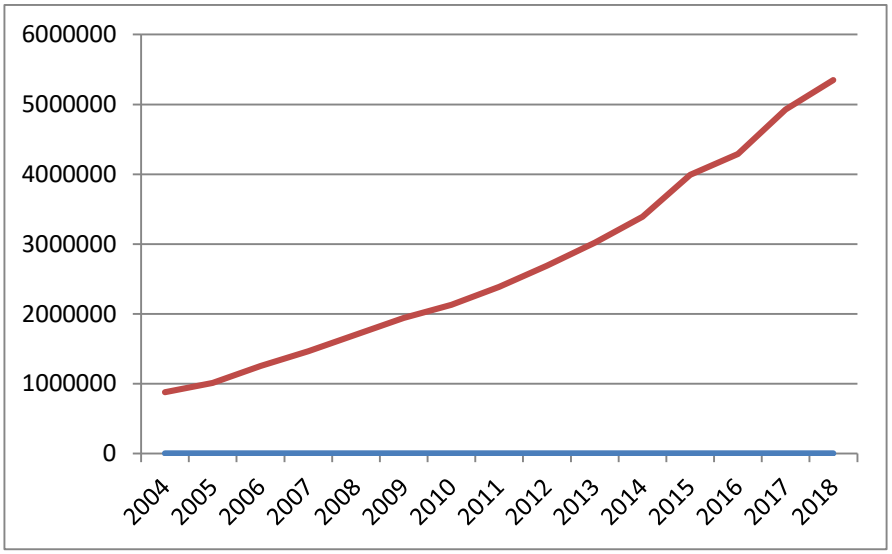


Fig. 11. Temporal Growth of Registered Vehicles in Lahore

4. CONCLUSIONS

This study revealed that traffic congestion problems observed almost on each corridor in afternoon and evening peak hours. Whereas, Lytton Road segment reported with traffic congestion in morning peak hour due to very less road capacity / road width. This study revealed that major traffic congestion issues are due to the poor road infrastructures (e.g., very narrow road near Muslim Town morr and Lytton Road). Second issue associated with the traffic congestion is the lapses in traffic planning and management. After plotting the last 15 years vehicles registration data in Lahore district, it is observed that no proper measures have been taken in

terms of infrastructural improvements, traffic planning and management by considering the fact of huge vehicles addition on roads. Absence of an integrated system comprising on advance geo-spatial and planning technologies worsening the traffic issues to a larger extent.

5. RECOMMENDATIONS

Based on road inventory data, infrastructural improvements should be employed where there is margin or room for development. Traffic planning and management are core issues which must be addressed by the relevant departments and agencies. Ensuring of only registered vehicles permission on roads along with implementation of licensing system in its true spirit which will be also helpful in reducing the traffic volume to a larger extent. Moreover, advanced Geo-spatial techniques must be utilized and comprehensive road inventory of all road infrastructures and assets must be conducted using high resolution imagery in order to save the time resources and time. Furthermore, integration of spatio-temporal traffic counts, traffic type and road capacity data must be done at single platform for better decision making and traffic projections

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