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DOES ROAD TRAFFIC CONGESTION INCREASE FUEL CONSUMPTION OF HOUSEHOLDS IN KATHMANDU CITY?

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ABSTRACT

The growth of vehicle and road traffic congestion is characteristics of urbanization and urban city and indicators of urban life in developing countries. In Nepal, non-economic factors and non-state factors have accelerated unexpectedly and haphazardly urbanization process, although the country was reengineered into seven provincial federal structure. In this backdrop, this paper empirically examines the growth of traffic congestion and its impact on urban households and livelihood based on 160 vehicle owners and users' survey at six major traffic routes of two urban cities by applying mixed analytical methods (qualitative cum quantitative), descriptive statistics and multiple regression model. The descriptive statistics result of the study reveals nearly 94 percent acceptance level of vehicle owners and users about the growth of traffic congestion. Despite short distances of the road i.e. 2-4 kilometers and vehicle efficiency, the growth of traffic congestion increases 14036-liters fuel additional consumption. Per month, additional cost of fuel is estimated at 18,808 US dollars for a sum of distance i.e. 72,992 km between residence location and workplace each month. In the case of commuters, the estimation result of the study is 1188 hours of additional time loss with 6706 US dollars' worth per month. The estimation of total economic loss is 25514 US dollars per month. Specifically, per month, economic loss of doctors and taxi drivers is 6556 US dollars but teachers and bankers have not economic loss.

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INTRODUCTION

In the 21st century, the growth of traffic congestion has become a big issue in the world, particularly in big and small cities, despite the achievement of advanced technology and the new innovative context of the fourth industrial revolution and smart city. In the world, the different cities have various traffic congestion and its socio-economic losses. In 2019, Bogota city lost 191 hours with first rank because of heavy traffic congestion. Similarly, France, UK, and New York City lost 165 hours with seventh rank, 149 hours with eighth rank, and 140 hours with fourteenth rank respectively by INRIX Global Traffic scoreboard 2019 (INRIX Global Traffic Scorecard, 2019). During peak times, 70 percent of the workforce travel by car in Britain (INRIX and Centre for Economics and Business Research, 2014). Additionally, World Economic Forum mentioned huge economic value of traffic congestion accounting time loss value and marginal change of additional fuel consumption of vehicles across the world including big and small cities. Interestingly, in 2013, economic cost of the traffic congestion was 300 billion USD to UK. Similarly, it was 160 billion USD to USA in 2015 and 10.8 billion USD to India in 2012. Besides, its economic value in Bangladesh and Sri Lanka were 3 billion USD and 0.32 billion USD respectively (WEF, 2020). Mao et al. (2012) accounted 58 billion Yuan RMB (4.22% of GDP) in Beijing in 2010, including time delay cost, extra oil combustion, traffic accident direct economic loss, vehicle loss cost and environmental pollutants. The proportion of GDP is higher than New York and London. Thus, developed and developing countries have been suffering from the economic loss of traffic congestion.

Likewise, this issue has social costs to vehicle users and owners. Cambridge Systematics (2008) mentioned in the study, the estimated cost of fright involved in highway bottlenecks, social cost to time delay and operating expense. However, Mao et al. (2012) in their paper, the social cost of Traffic Congestion and Countermeasures in Beijing mentioned its social cost to only time delay. The study argued higher social costs during trips by car. Assessing the marginal cost due to congestion using the speed flow function, Gavanas et al. (2016) argued delays as social cost, along with accidents, scarcity of infrastructure and the society, like Qi (2016). Likely, Kim (2019) estimated the social cost of congestion using the bottleneck model in which he argued social cost to time delay as queuing time with 29 billion USD economic costs to all US commuters. Additionally, Weisbrod et al. (2003) found its effects on regional economic competitiveness and growth in the USA. Graham (2007) mentioned the reducing productivity level in the heavy traffic congestion urban areas in the UK. Similarly, INRIX and the Centre for Economics and Business Research (2014) mentioned both a direct and indirect economic impact on car commuting households. Direct costs relate to the value of fuel and the time wasted rather than being productive at work, and indirect costs relate to higher freighting and business fees from company vehicles idling in traffic, which is as additional costs to household bills. Therefore, the social cost has become another outcome of traffic congestion. As a result, Joshua et al. (2008) marked social and economic factors, road factors, vehicles, and accidents as are main factors contributing to the traffic chaos in Lagos State. Therefore, the growth of traffic congestion in the cities is a big challenge not only to urban planning but also to the world economy and the welfare of the people.

It is a fact that Asian countries are not free from traffic congestion. Greenwood and Bennett (1996) and WEF (2020) marked the effects of traffic congestion on fuel consumption. The study stated that traffic congestion is a global problem but more serious in many cities of Asia. It pointed out that traffic congestion has three prime effects. They increase travel time, vehicle operating cost, and volume of emissions from vehicles. In Asia, China and India are emerging giant economies with an 8-10 percent economic growth rate per annum. Despite command economy, the growth of urbanization and the urban population drive to critical to traffic congestion in China. Its result is the growth of fuel consumption and of loss of production time. Its cost was 74 billion USD. Similarly, India has a big challenge of traffic congestion because of the rapid growth of the urban population in Indian cities. In India, its cost is 10.4 billion USD (WEF, 2020). Syarifullah (2014) found a 0.64 billion USD loss per annum in Jakarta as the consequences of traffic jams, namely fuel loss, loss caused by wasted time, and the impact of air pollution on health. The study found a huge gap between 11 percent vehicle growth per annum and 7.65 km road growth. Therefore, traffic congestion in Asia is an emerging issue.

Unlikely, Nepal has a traffic congestion issue in major urban cities, although Nepal's rank is in developing countries with slow and gradual economic growth at more than 7 percent. On this issue, large international literature is available but in Nepal, its literature is very handful. This issue is a by-product of the unplanned rapid urbanization process, higher rate of internal migration from major and minor cities of urban and rural areas, no traffic rules, 13 percent annual growth rate of vehicles, and no road, vehicle, and population density (CBS, 2011). In Nepal, its estimated cost was 16.5 billion NRs (165.0 million USD) in 2018. It is 0.55 percent of GDP. Besides, the disaggregating level economic cost to vehicle riders has reduced production and income loss induced welfare loss. Kumarage (2004) found insufficient flyovers as a driver of heavy traffic congestion and its effect in terms of fuel wastage and loss of labor. Its cost value was 32 billion NRs per annum. However, a handful of literature has covered this issue but differently. Therefore, this study is relevant.

This study has a query whether the traffic congestion occurs in Kathmandu or not, whether the growth of traffic congestion is higher or not, whether the growth of traffic congestion increases fuel consumption and additional cost or not.

This paper examines empirically the impact of traffic congestion growth on household welfare. Its specific objects are as follows: a) to examine the growth of traffic congestion in urban cities and b) to assess urban household fuel consumption due to the growth of traffic congestion.

Challenge of Traffic Congestion in Nepal

Nepal is the so-called least urbanized country in the world. Its rank is 184th rank with 3.5 % urbanization rate and 29 percent urban population. In recent years, Nepal is one of the top ten fastest urbanizing countries. UNDESA (2014) reported 18.2 percent of Nepal's urbanization level with 5.1 million urban populations. It is geared up with a higher economic growth rate of 7 percent from 2015 to 2019 (MoF, 2019) and urban center service sector expansion-tourism sector, trade, construction, and real estate. Its result is being worst traffic congestion in major cities across the country with a 13 percent growth of vehicles. Its cost is estimated at 16.5 billion NRs (165.0 million USD based on 1USD=100 NRs) based on wasted time and additional fuel cost estimation (ADB, 2019). Furthermore, ADB (2019) projected its undesired threats to Nepal.

Kathmandu valley is a highly urbanized mega city with the fastest outward expansion among major cities of the country. Its result is growing traffic congestion on the roads of Kathmandu. ADB (2019) mentioned 0.6 million vehicles in 2015 and projected 0.9 million vehicles by 2021 if the number of vehicles growth rate is not below 13 percent in the limited wider road networks. It is complicated by no flyovers in crossings and no alternative roads, uncontrolled, unmanaged, and undesired illegal street parking habit and footpath business by a large number of people, no automatic traffic system, no adequate public transport system, no transport schedule, no alternative mass transport system, no integrated land transport system and no traffic culture and behavior of the passenger. To date, the disequilibrium between the growth of road and the growth of vehicles, between demand and supply of transport services, and between quality and quantity of transport services if is not responded with proper pro-active road and transport planning, it may be so complicated that increases waste of productive time and unnecessary fuel consumption.

METHODOLOGY

Theoretical Framework

Traffic congestion refers to stopped or stop-and-go traffic (ADB, 2019). Similarly, but differently, Weisbrod et al. (2001) argue it explicitly to a condition of traffic delay. It means slow traffic flow below the reasonable speed. Both studies have unanimously explained specifically it as slow traffic flow below reasonable speeds. ADB (2019) considers excess of vehicles on the proportion of road as its driver. Differently, Weisbrod et al. (2001) and Weisbrod et al. (2003) argue it as the gap between the number of vehicles and the design capacity of the traffic network. Thus, traffic congestion is the result of excess vehicles and a gap in the capacity of the traffic network. As a result, the growth of traffic congestion depends on the change in the number of vehicles and the capacity of the traffic network (Figure 1).

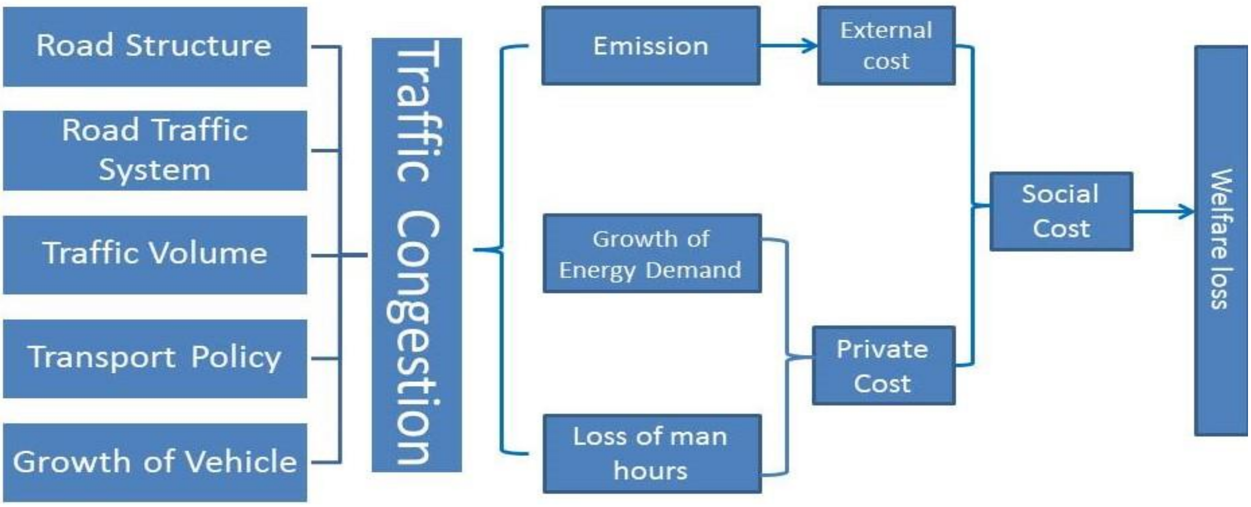

Figure 1. Theoretical Framework.

Empirically and theoretically, traffic congestion grows, when road structure, road traffic system, traffic volumes, transport policy, and growth of vehicles are heavily active. Its reflection is above theoretical framework of this study. This theoretical framework shows these variables as independent variables of traffic congestion. Its effects are mainly three: emission, growth of energy demand, and loss of person-hours. It is assumed that household welfare will lose through the growth of excessive private and external cost of the household. Therefore, the growth of traffic congestion may be either a positive or a negative relationship with household welfare will be a relevant matter.

Data Analysis Tool

Within the above theoretical framework of traffic congestion and fuel consumption and its external cost, the study employed descriptive statistics (mean, graph, table, and chart) to examine the growth of traffic congestion in an urban city in depth quantitatively based on primary cum secondary data sets collected. Besides, the relationship between the growth of traffic congestion and fuel consumption was assumed positive. The correlation analysis tested it for understanding its depth.

Data Collection Method

Study Area

This paper examines the above objective to determine urban household welfare in Kathmandu. This study area is purposively selected by i) its traffic congestion is recorded at a heavy level in above road routes in Kathmandu in 2014, ii) its crowd effect of the growth of vehicles at these road routes, iii) its urban household's perception, income and behavior change, iv) welfare loss issue of urban households and manual traffic system.

Considering the oldest city in the world, Kathmandu is the capital of the country spreading in the geographical bowl surrounded by green hills in the East, West, and South and White Himalaya series in the north (Figure 2). Although the city is popular as an ancient city with unlisten mythology, unseen archeology, world heritage, great rules and rulers, ancient and medieval art and culture, indigenous knowledge, skills and behaviors, faiths and habits. However, vertical and horizontal growth of urbanization of this city as outwards the center of Kathmandu is one of unplanned city of Asia with the growth of internal and external migration, the growth of connectivity and vehicles (Figure 2).

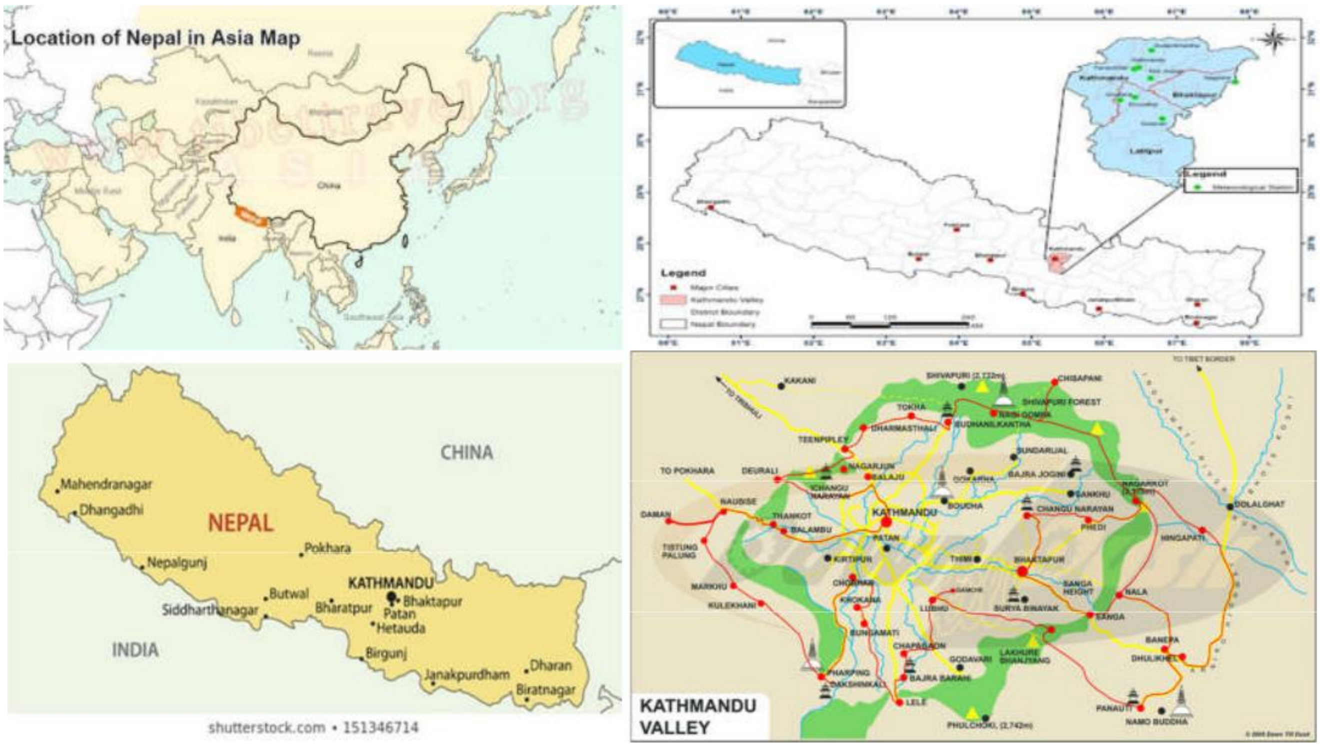

Figure 2. Study Area.

Economically, this haphazardness has visibly and invisibly huge socio-economic cost to the dwellers of Kathmandu valley as traffic congestion and mobility obstacles to deliver public goods and services by the metropolitan city as well as the planned well-designed infrastructure development. In this critical situation, around 2.5 million population love to live in Kathmandu (CBS, 2011). Demographically, Newar community that is the indigenous community dominates the demographic figure but the non-Newar migrant community from the different parts of the country has also a predominant share. CBS (2011) shows heterogeneous caste and sub-caste in the city. Besides, this city is the center of all offices of the government and constitutional bodies, along with the corporate offices of all private sectors (1000 private colleges, 30 commercial banks, more than 5000 cooperatives, three industrial estates), and 90 percent ancient heritage. Furthermore, the city has high tech communication systems and better connectivity with 0.44 million registered vehicles. About six main road routes of the city (Table 1) are as follows.

Table 1. Study Road Routes.

No	Route	Descriptions
1	Kalanki-Kalimati-Teku-Tripureswor-Thapathali-Ratna Park	This route from the West (Kalanki) to the center of Kathmandu (Ratna Park) is blacktopped with four Len. Its length is 5.5. km. If traffic is normal, its time duration is 15 minutes by car and bus, despite its curliness.
2	Balaju Chowk-Naya Bazar-SorhaKhutte-Lainchour-Jamal-Ratna Pank	This route from the West and North (Balaju) to the center of Kathmandu (Ratnapark) is blacktopped fine road with four Len. Its length is 4.3 km. Its travel time is 15 min by vehicle, despite its curliness.
3	Chabel-Battisputali-Maitidevi-Dillibazar-Putalisadak-Ratna Park	This route from the East and North (Chabel) to the center of Kathmandu (Ratnapark) is graveled with four Len. Its length is 4.6km. Vehicle travel time is around 17 minutes, despite its roughness and curliness.
4	Koteswor-Tinkune-New Baneshwor,- Maitighar-shahid Gate-Ratna Park	This route from the East-South (Koteswor) to the center of Kathmandu (Ratnapark) is blacktopped four Len. Its length is 6.3 km. Travel time is around 18 minutes.
5	Narayangopal Chowk-Panipokhari-Lazimpat-Lainchour-Jamal-Ratna Park	This route from the North (Narayagopal Chowk) to the center of Kathmandu (Ratnapark) is blacktopped four Len. Its length is 4.6 km. Its travel time is around 14 min.
6	Lagankhel-Jawalakhel-Kupondol-Thapathali-Ratna Park	This route from the South (Lagankhel) to the center of Kathmandu (Rantnapark) is blacktopped curliness road. Its length is 6.1 km. Its duration is around 17 minutes.

All above roads have heavy traffic congestion by Kathmandu Metropolitan City Traffic Office (KMCTO). Therefore, these routes are the study areas (see Table 1).

Data Sets and Data Collection Method

Data sets of this paper are quantitative nature relating to roads, several vehicles, and traffic congestion. The data was collected from secondary sources including the department of road, the department of transport and Kathmandu Metro Politian Traffic City Office as well as from the Ministry of Home (MoH) and the Ministry of Transport (MoT) from 2019 to 2020. As complementary cum supplementary, primary data relates to household socio-economic information, fuel consumption expenditure, vehicle expenditure, emission cost, and perception. The primary data was collected from the opinion survey conducted from September 2015 to October 2015 to collect reliable and accurate data and information.

The opinion survey is a main data collection tool of this study, along with Key Informant Interview (KII). In the sample selection of the survey, two-stage sampling method was designed. Under this first stage design, four clusters based on-road routes including taxi drivers, medical doctors, bankers, and college teachers were conveniently selected. Similarly, the second stage designs, 200 respondents' samples (19.3%) were randomly selected from four clusters by using random sampling methods. Thereby, tool of the opinion survey is structural questionnaire. The questionnaire covering socio-economic information about them (land holding, income level, source of income, size of family, gender, age, caste, etc.), traffic congestion, income loss, and fuel cost was administered in the schedule time. Further, descriptive statistics and correlation model was to measure the effects of traffic congestions on household income loss.

RESULTS AND DISCUSSION

The growth of traffic congestion in the urban city is a result of the nature and characteristics of the road and the growth of vehicles. Theoretically and empirically, better roads and the growth of traffic congestion have a negative correlation, although the growth of traffic congestion exists in the case of better roads. Similarly, the growth of vehicles and the growth of traffic congestion have positive correlations. Therefore, the nature and characteristics of the road and the growth of vehicles determine the traffic congestion.

Nature and Characteristics of Roads in the Urban City

Assuming that road network provides better connectivity, better mobility and better accessibility for enhancing economic activities and welfare of the people, the objective of the infrastructure development policy was to construct well-engineered road network across the country, particularly in the urban city. Total roads account 31,393 km length from the 1950s to 2019. The black toppled roads are only 45 percent dominated by Graveled and Earthen road (Table 2).

Table 2. Nature & Characteristics of Urban Roads.

Road Types	2010	2011	2013	2019	%
Black Topped (km)	10,192	10,659	10,810	14102	45
Graveled(km)	5,787	5,940	5,925	7881	25
Earthen (Fair Weather) (km)	8,410	88,666	8,864	9410	30
Total	24,389	25,265	25,599	31393	100

Source: MoF, 2019.

MoF (2019) shows that most blacked topped road concentrates only in urban roads and in national high ways. In Kathmandu valley, all main roads (229 km) are blacktopped but connecting roads and minor roads are still at the level of blacktop. The sample road of Kathmandu valley that is 31.4 km is also black topped with four lengths, despite random nature and characters of these urban roads. The lengths of roads are less than the minimum need of the vehicle density. One of its results is randomness in the scientific and systematic traffic as needed in the urban city.

Trend of Vehicles

The trend of vehicles' load density per annum is positively rocketing with double digits of change. One of its reasons is open transport policy, along with random public transportation system and revenue perception to vehicles. Besides, the government assumes that more vehicle means quality transportation system. In reality, it was a mess, except for the growth of vehicles. In 2019, total vehicles are 3.5 million across the country. It is said that its sixty percent registration (2.1 million) is only in Kathmandu valley (Table 3).

Table 3. Vehicle Data of National Level (2020).

Types of Vehicles	2012	2014	2019
Bus	30,138	31,594	51672
Minibus/Mini Truck	13,307	14,023	27346
Car/ Jeep/ Van	1,38,735	146,124	100369
Tractor/Power Thriller	83,101	89,031	255611
Motorcycle	1,207,261	1,316,172	62960
Tempo (3 Wheelers)	7,510	7,515	9089
Microbus	2,636	2,709	55457
Truck/Dozer/Crane/Excavator	50,192	51,874	2780303
Pick up	18,171	21,943	153727
Others	6,427	6,493	7865
Total	1,557,478	1,687,478	3539519

Source: MoF, 2019.

Table 2 and 3 shows the national vehicle-road ratio per km is 112 in 2019. Relatively, this ratio is incremental because of unexpected growing vehicles relative to road length growth. In 2014, the ratio was only 55. Over 5 years, its growth rate is double in 2019. Still, the ratio seems to be comfortable. Definitely, the ratio is not similar in Kathmandu. In 2019, its ratio is 9274. It is 83 times more than the national vehicle-road ratio per km in 2019. Comparatively, this ratio is extremely higher. Notably, it indicates growing traffic congestion in Kathmandu. Table 4 provides the results of routes, distance (km), mean travel time (normal), and three times: time I, time II, and time III. In the results of descriptive statistics, the mean parameter represents all variables that explain the status of routes, distance(km), mean travel time (normal), and three times: time I, time II and time III. Similarly, it's mean to mean difference of different routes and different time frame describes the travel period and level.

Table 4. Results of Routes, Distance & Mean Travel.

No	Route	Distance (km)	Meantime (Minute)	Time		
				7:0 AM-10AM	11AM-1.0PM	4.0 PM-5.0PM
1	Kalanki-Kalimati-Teku-Tripureswor-Thapathali-Ratna Park	5.5	15	45	30	50
2	Balaju Chowk-Naya Bazar-SorhaKhutte-Lainchour-Jamal-Ratna Pank	4.3	15	50	25	60
3	Chabel-Battisputali-Maitidevi-Dillibazar-Putalisadak-RatnaPark	4.6	15	55	30	67
4	Koteswor-Tinkune-New Baneshwor,-Maitighar-shahidGate-Ratna Park	6.3	18	40	25	45
5	NarayangopalChowk-Panipokhari-Lazimpat-Lainchour-Jamal-Ratna Park	4.6	14	44	35	50
6	Lagankhel-Jawalakhel-Kupondol-Thapathali-Ratna Park	6.1	17	60	30	65
	Mean	5.23	15.6	49	29.16	56.16

Source: MoF, 2019 and Field Survey, 2020.

Table 5 presents the mean and standard deviation of key variables. In the table, there are five key variables (distance, no congestion, congestion I, congestion II and congestion III). Mean represents all cross-sectional databases of these five key variables properly collected from the Field Survey and the Standard deviation of these variables from the mean is no so far significant.

Table 5. Descriptive statistics.

Indicator	N	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Distance	6	4	6	31	5.23	0.852	0.727
No congestion	6	14	18	94	15.67	1.5	2.267
Congestion I	6	40	60	294	49	7.48	56
Congestion II	6	25	35	175	29.17	3.764	14.167
Congestion III	6	45	67	337	56.17	9.065	82.167

Source: Field Survey, 2020.

Table 6 provides the results of congestion of Road I: Kalanki-Kalimati-Teku-Tripureswor-Thapathali-Ratna Park, Road II: Balaju Chowk-Naya Bazar-SorhaKhutte-Lainchour-Jamal-Ratna Pank, Road III: Chabel-Battisputali-Maitidevi-Dillibazar-Putalisadak-Ratna Park, Road IV: Koteswor-Tinkune-New Baneshwor-Maitighar-shahid Gate-Ratna Park, Road V: Narayangopal Chowk-Panipokhari-Lazimpat-Lainchour-Jamal-Ratna Park and Road VI: Lagankhel-Jawalakhel-Kupondol-Thapathali-Ratna Park based on two independent variables: travel time and no of vehicles. It explains how much travel time is needed at congestion and non-congestion across six routes of the Kathmandu valley.

Mean distance of six routes of the Kathmandu Valley is 5.23 km. On average, travel time of vehicle is 15.6 minutes with 30-40 km per hour speed in non-congestion. One of its reasons is lower vehicle density on road. Of course, in three time clusters of congestion, there are different travel times. On average, travel time of vehicle is 56.16 minutes during peak time III: 4.0 PM to 5.0 PM, 49 minutes during peak time I: 7.00 AM to 10 AM, and 19.16 minutes during day time II: 11 AM to 1.0PM. In peak time, travel time of vehicle on these routes 2 times more than in non-peak time. This travel time indicates the occurrence of traffic congestion in Kathmandu Valley. Categorically, the congestion of the time cluster III: 4.0 PM to 5.0 PM is extremely higher than the congestion of the time cluster I: 7.00 AM to 10 AM and time cluster II: 11 AM to 1.0 PM because of higher vehicle density on road. Despite proper traffic system, the traffic congestion in short distance road of Kathamdu valley has become a big challenge with significant social cost.

Table 6. Results of Congestion Road.

No	Route	Distance (km)	Mean Time (Minute)	No. of Vehicles	Time			No. of Vehicles		
			Non-congestion	Non-congestion	I: 7.00AM-10:0 AM	II: 11.00AM-1.00PM	III: 4.00PM - 5.00PM	Cong-I	Cong-II	Cong-III
1	Kalanki-Ratna Park	5.5	15	110	45	30	50	302.5	220	385
2	Balaju Chowk-Ratna Pank	4.3	15	86	50	25	60	236.5	172	301
3	Chabel-Ratna Park	4.6	15	92	55	30	67	253	184	322
4	Koteswor-Ratna Park	6.3	18	126	40	25	45	346.5	252	441
5	Narayangopal Chowk- Ratna Park	4.6	14	92	44	35	50	253	184	322
6	Lagankhel-Ratna Park	6.1	17	122	60	30	65	335.5	244	427
	Mean	5.23	15.6	-	49	29.16	56.16	287.3	209.3	336.3

Source: Field Survey, 2020.

Correlation between Growths of Traffic congestion, Fuel Consumption and Fuel Cost of Different Vehicle Riders

Number and efficiency of vehicle determines traffic congestion and fuel consumption. If large number of the vehicle is on road, traffic congestion will happen. Its result is more fuel consumption and more cost to vehicle owners and riders. Eventually, fuel consumption and cost depend on vehicle efficiency. Therefore, the composition of vehicles is significant to understand correlation between the growth of traffic congestion, fuel consumption, and fuel cost. Figure 3 shows the composition of vehicles in the above six routes mentioned as the sample routes in which heterogeneous vehicles (Taxi, Private Car, Public Transport and Others) used by the different professions have movement. Thus, it shows the fuel efficiency level of vehicles.

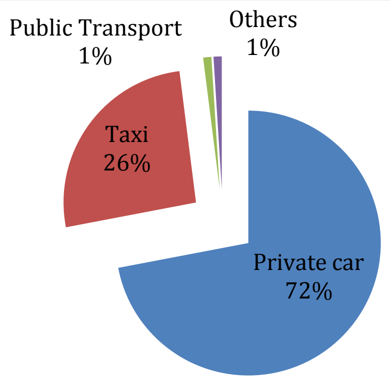

Figure 3. Composition of Vehicles.

In Kathmandu Valley, private car dominates to all vehicles but taxi is also significant size. Firstly, this composition shows failure public transport system and secondly, the professional peoples (Doctors, Teachers and Bankers) love to ride their own car and then after taxi, although these are relatively costlier travel to their destination in the city. Besides, these vehicles are fuel-efficient because of their mile per liter and scheduled maintenance system. Nature of profession determines travel of the professionals. In general, the professionals have higher mobility to deliver their own services. As per profession, different Professionals (Medical Doctors, Teachers, Bankers and Taxi drivers) have heterogeneity in their travel related to their profession.

Table 7 shows the monthly travel of different professions (Medical Doctors, Teachers, Bankers, and Taxi Drivers). This table covers the result of the survey on their monthly mean travel in column I, monthly mean travel in column II, percent of monthly mean travel in column III, and daily travel in column IV.

Table 7. Results of Monthly Travel of Different Professions.

Professions	Monthly Mean Travel (km)	%	Main Daily Travel (km)
Medical Doctors	5860	11.9	195
Teachers	1,875	0.74	62.5
Bankers	2,170	9.56	72
Taxi Drivers	95,00	77.7	316
Total	19405	100	645.5
Mean	4851		161

Source: MoF, 2019.

Monthly mean travel of these four professions is 19405 km. Out of total monthly mean travel of these professions, monthly mean travel of taxi drivers dominates to all professions with 9,500 km. Then after, monthly mean travel of medical doctors, bankers and teachers are 5860 km, 2170 km and 1875 km respectively. Interestingly, monthly mean travel of bankers and teachers is below on average 4851 km but taxi drivers and medical doctors have higher. In the structure of monthly mean travel, taxi drivers share 77.7%. Daily, on average, all professions travel 161 km. Relatively, taxi drivers and medical doctors have higher but bankers and teachers have lower. Thus, all professions have significant travel monthly and daily.

This travel naturally determines their fuel consumption and fuel cost because of their positive correlation and complementary relationship between two activities. This study is to estimate fuel consumption liter per day and per month and fuel cost per day and per month by using 108 NRs fuel cost per liter in the above six routes of Kathmandu Valley. Table 8 shows the result of fuel consumption per day and per month and fuel cost per day and per month.

Table 8. Result of Fuel Consumption.

Occupations	Fuel Consumption per day (Ltr.)	Monthly Fuel Consumption (Ltr.)	Per day fuel cost(NRs)(1=108 NRs)	Monthly fuel cost (NRs)
Medical Doctors	19.5	585	2106	63180
Teachers	6.2	186	669.6	20088
Bankers	7.2	216	777.6	23328
Taxi Drivers	31.6	948	3412.8	102384
Total	64.5	1935	6966	208980
Mean	16.1	483.7	1741.5	52245

Source: MoF, 2019.

Table 9. Result of Congestion Survey.

No	Route	Distance (km)	Time			No of Vehicles			Additional Fuel Consumption (Liters)		
			I: 7.00AM-10.00AM	II: 11.00AM-1:00 PM	III: 4.00PM-5.00PM	Cong-I	Cong-II	Cong-III	I	II	III
1	Kalanki-Ratna Park	5.5	45	30	50	302.5	220	385	605	220	1155
2	Balaju Chowk-Ratna Park	4.3	50	25	60	236.5	172	301	473	172	903
3	Chabel- Ratna Park	4.6	55	30	67	253	184	322	506	184	966
4	Koteswor-Ratna Park	6.3	40	25	45	346.5	252	441	693	252	1323
5	Narayangopal Chowk- Ratna Park	4.6	44	35	50	253	184	322	506	184	966
6	Lagankhel-Ratna Park	6.1	60	30	65	335.5	244	427	671	244	1281
	Total	31.4	294	175	337	1727	1256	2198	3454	1256	6594
	Mean	5.23	49	29.16	56.16	287.3	209.3	366.3	575.6	209.3	1099

Source: Field Survey, 2020.

Monthly total fuel consumption and mean monthly fuel consumption of these four professions are 1935 liters and 483.7 liters respectively. Subsequently, monthly total fuel cost and means monthly fuel cost are 0.20 million Nepali Rupees and 52245 Nepali Rupees respectively (Table 8). Thus, per person per km fuel cost is 10.76 Nepali Rupees in non-traffic congestion. This study is to calculate additional fuel consumption and fuel cost due to traffic congestion with an assumption of increasing additional fuel consumption during traffic congestion. Table 9 provides the result of a survey on six routes of Kathmandu valley with its distance, time consumption in a vehicle in three times: the time I: morning, time II: daytime and time III: evening time, traffic congestion in three times and additional fuel consumption in these traffic congestions. Table 10 provides the result of a survey on six routes of Kathmandu valley with its distance, time consumption in a vehicle in three times: the time I: morning, time II: daytime and time III: evening time, traffic congestion in three times and additional fuel consumption in these traffic congestions.

Table 10. Results of Congestion and Non-congestion Survey.

Occupations	Non-Congestion Fuel Consumption per day (Ltr.)	Non-Congestion Per day fuel cost (1=108 NRs)	Congestion I	Congestion II	Congestion III	Congestion I: Fuel Cost per day	Congestion II: Fuel Cost per day	Congestion III: Fuel Cost per day
Medical Doctors	19.5	2106	21.5	20.5	22.5	2322	2214	2430
Teachers	6.2	669.6	8.2	7.2	9.2	885.6	777.6	993.6
Bankers	7.2	777.6	9.2	8.2	10.2	993.6	885.6	1101.6
Taxi Drivers	31.6	3412.8	33.6	32.6	34.6	3628.8	3520.6	3736.8
Total	64.5	6966	72.5	68.5	76.5	7830	7397.8	8262
Mean	16.12	1741.5	18.12	17.12	19.12	1957.5	1849.4	2065.5

Source: Field Survey, 2020.

Additional fuel consumption measures the economic effect of traffic congestion. In these six routes of Kathmandu valley, mean additional fuel consumptions per day are 1099 liters during traffic congestion time III: evening time, 575.6 liters during traffic congestion time I: morning, and 209.3 liters (Table 9). In total, total additional fuel consumptions per day are 6594 liters during traffic congestion time III, 3454 liters during traffic congestion time I, and 1256 liters during traffic congestion time II (see Table 9). By route, top three routes of additional fuel consumption are Route 4: Koteshwor-Ratna Park, Route 6: Lagenkhel-Ratna Park, and Route 1: Kalanki-Ratna Park (see Table 9). By profession, mean additional fuel costs during traffic congestions I, II, and III are 1957.5 Nepali Rupees, 1849.4 Nepali Rupees, and 2065.5 Nepali Rupees respectively (Table 10). In rank, top four additional fuel cost bearers are namely, taxi drivers, medical doctors, bankers, and teachers. By the level of traffic congestion, the professions bear additional fuel costs per day. It means extremely higher additional fuel cost per day during the congestion III: evening time than traffic congestion II: morning time and traffic congestion I: daytime (Table 10). Thus, there is a positive relationship between traffic congestion, additional fuel consumption, and additional fuel cost.

Table 11 presents the result of a survey on non-traffic congestion and traffic congestion and fuel consumption led fuel cost across three times on six routes of Kathmandu valley.

Table 11. Results of Congestion & Non-congestion Survey.

Occupations	Non-Congestion Per day fuel cost(NRs) (1=108 NRs)	Non-Congestion monthly fuel cost	Congestion I: Fuel Cost	Congestion II: Fuel Cost	Congestion III: Fuel Cost	Congestion I: Monthly Fuel Cost	Congestion II: Monthly Fuel Cost	Congestion III: Monthly Fuel Cost	Mean Monthly Fuel Cost
Medical Doctors	2106	63180	2322	2214	2430	69660	66420	72900	69660
Teachers	669.6	20088	885.6	777.6	993.6	26568	23328	29808	26568
Bankers	777.6	23328	993.6	885.6	1101.6	29808	26568	33048	29808
Taxi Drivers	3412.8	102384	3628	3520.6	3736.8	108864	105618	112104	108862
Total	6966	208980	7830	7397.8	8262	234900	228420	247860	237060
Mean	1741.5	52245	1957	1849.4	2065.5	58725	57105	61965	59265

Source: Field Survey, 2020.

The results of descriptive statistics explain difference in mean additional fuel cost between non-traffic congestion and congestion times, and the economic loss of different vehicle riders across six routes. On average, non-congestion monthly fuel cost is 52245 Nepali Rupees meanwhile congestion monthly fuel cost is 59265 Nepali Rupees. By difference method, difference mean additional fuel cost per month is 7020 Nepali Rupees. By traffic congestion, the difference additional fuel cost with traffic congestion I, II, and III are 6480 Nepali Rupees, 4860 Nepali Rupees, and 9720 Nepali Rupees respectively. In total, the difference of total fuel cost between non-congestion and congestion is 28080 Nepali Rupees. This is economic loss per month of the professionals due to traffic congestion. Its negative economic consequence falls on their expenditure and saving and then after welfare of the people.

Table 12 provides the results of correlation analysis of monthly fuel consumption and traffic congestion to explain whether traffic congestion drives to monthly fuel consumption.

Table 12. Correlation between Monthly Fuel Consumption & Traffic Congestion.

		Monthly Fuel Consumption
Monthly Fuel Consumption		1
	Sig. value	
	N	146
Traffic Congestion		.830**
	Sig. value	.000
	N	146

***. Correlation is significant at the 0.01 level (2-tailed).*

Statistically, the correlation analysis shows a positive correlation between monthly fuel consumption and traffic congestion with significance at 0.01 levels. Thus, theoretical assumption on the relationship between monthly fuel consumption and traffic congestion is statistically valid.

CONCLUSIONS

Considering the above descriptive results of congestion survey in the six main roads (31.4 km) as the sample of this study as follows: Road I Kalanki-Kalimati-Teku-Tripureswor-Thapathali-Ratna Park, Road II Balaju Chowk-Naya Bazar-SorhaKhutte-Lainchour-Jamal-Ratna Pank, Road III: Chabel-Battisputali-Maitidevi-Dillibazar-Putalisadak-Ratna Park, Road IV: Koteswor-Tinkune-New Baneshwor-Maitighar-shahid Gate-Ratna Park, Road V: Narayangopal Chowk-Panipokhari-Lazimpat-Lainchour-Jamal-Ratna Park and Road VI: Lagankhel-Jawalakhel-Kupondol-Thapathali-Ratna Park including two time periods: nontraffic congestion and traffic congestion (the time I: morning, time II: day time and time III: evening, they provide strong evidence of non-traffic congestion and traffic congestion and their contribution to time consumption, fuel consumption, and additional fuel cost. The descriptive result is of the status of non-traffic congestion and traffic congestion from time and route. In the result, there is divided three-time period to understand travel times based on mean to mean difference of Time I: 7 AM-10 AM, Time II: 11 AM-1 AM, and Time III:4PM-5 PM with reference travel time. Mean of travel time of vehicles during all three times: I, II, and III are 49 minutes, 29 minutes and 56 minutes respectively higher than the reference of 16 minutes mean travel time. Mean travel time of time III (56 minutes) over 5.23 km is the highest of all followed by the mean travel time of time I (minutes) and of time II (29 minutes). It indicates traffic congestion level more in time III (evening time) and time I (morning time) than time II (day time), whereas mean vehicle density in these routes was 287 in time I, 209.3 in time II, and 336.3 in time III. Thus, time III (Evening) has a heavy vehicle density more than time I (Morning) and time II (Daytime). It shows heavy traffic congestion in evening and morning time more than in daytime. Out of six routes, heavy traffic congestion was found in three top routes: Route IV: Koteswor-Ratna Park, Route VI: Lagankhel-Ratna Park, and Route I: Kalanki-Ratna Park.

The above results of correlation between the growth of traffic congestion, fuel consumption, and fuel cost of different vehicle riders are r=0.83. This estimate explains a highly positive correlation between traffic congestion and the monthly fuel consumption of the vehicle riders in the above six routes. It is supported by the above result of vehicle's types and components in these routes in which private car with 72 percent dominates to 26 percent of public taxi and others (2%) in public travel for their socio-economic activities. In these vehicles, per day mean travel length is 161 km, and further its monthly accumulated mean travel length is 4851 km. Out of total travel length, taxi drivers share 77.7 percent dominating to a medical doctor (11.9 %), bankers (9.56%), and teachers (0.56%). Similarly, the above result of non-traffic congestion shows 16.1 liters fuel consumption per day with 1741.5 NRs fuel cost. Its estimated monthly fuel cost is 52245 NRs. Above result of traffic congestion at three times: the time I: morning, time II: day time and time III: evening provides evidence of traffic congestion higher in time III: an evening with 19.2 liters fuel consumption (2065.5 NRs fuel cost worth) than the time I: morning with 18.12 liters fuel consumption (1957.5 NRs. Fuel cost worth) and time II: day time with 17.12 liters fuel consumption (1849.4 NRs. Fuel cost worth). Considering fuel consumption and cost during non-traffic congestion, the growth of traffic congestion increases travel time, fuel consumption, and fuel cost based on mean-mean difference. In time III: evening, traffic congestion increases 324 NRs (3 USD) additional fuel cost to vehicle riders more than 216 NRs (2 USD) additional fuel cost in time I: morning and 107.9 NRs (1 USD) additional fuel cost in time II: day time. Therefore, vehicle riders suffer traffic congestion in time III: evening and time I: morning more than time II: daytime. At month level, vehicle riders have lost 9420 NRs (87.2 USD) in heavy traffic congestion time III: evening, 6480 NRs (60USD) in heavy traffic time I: morning, and 4860 NRs (45USD) in lower-traffic congestion time II: daytime. Per annum such fuel cost lost maybe 113040 NRs (1046.6 USD) in heavy traffic congestion time III: evening, 77760 NRs (720 USD) in heavy traffic congestion time I: morning, and 58320 NRs (540 USD) in lower-traffic congestion time II: daytime. As a result, the growth of congestion in the metropolitan city of Nepal that is an undesired natural phenomenon is the main determinant of fuel consumption and external cost of vehicle owners if we assume the vehicle is efficient. Besides, statistically, the correlation between monthly fuel consumption and traffic congestion with significance at 0.01 levels is positive. Thus, theoretical assumption on the relationship between monthly fuel consumption and traffic congestion is statistically valid. It is clear that blacktopped road and high technology-based traffic systems may be the best alternative to respond higher vehicle-road ratio per km and heavy traffic congestion during peak hours in Kathmandu valley. Therefore, blacktopped road and high technology-based traffic system should be Asian Standard, along with better mass transportation system and density of efficient vehicles based on per road kilometer, per density of population and standard.

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