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Impact of Traffic Bottleneck on Urban Road: A Case Study of Maitighar–Tinkune Road Section

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Abstract
Kathmandu valley is experiencing rapid population growth resulting in unexpected vehicular growth, especially private vehicles, which are leading to various traffic problems such as undesirable level of congestion, pollution, safety problem and delay. Matighar - Tinkune road section is one of the major road of the Kathmandu valley but due to lack of suitable infrastructure, always there is formation of bottleneck leading to traffic congestion and loss in human capital hour in this road segment. CCTV footage and manual survey of the traffic for Maitighar – Tinkue road section was used to calculate total travel time for the each type of vehicles during peak and off-peak hours, traffic volume, occupancy and travel time delay in peak hours to evaluate the total human capital loss. This study found that total of 6464.90 capital hour is being lost in the morning and evening peak hour of the working day due to the bottleneck in this road section. In this way total of 211.81 capital year is being lost due to bottleneck. Similarly, the study found Standard Bus and Buses are responsible for more than 70% of the human capital loss in this road section.

Keywords
Travel Time, Delay, Occupancy, Capital Hour Loss

1. Introduction

Bottlenecks are the sections of the roadways that either have capacity less than or demand greater than other sections during peak period. When demand exceeds bottleneck's capacity breakdown occurs which reduces a roadway's maximum flow causes congestions

Congestion can be defined as "an excess of vehicles on a portion of roadway at a particular time resulting in speeds that are slower – sometimes much slower – than normal or free flow speeds [1]. In urban transportation network, traffic congestion is likely to occur at some locations, which are called traffic bottlenecks [2], and that may account for 40 percent of significant factors causing traffic congestion.

Traffic congestion will be of two types, recurrent and non-recurrent. Recurrent congestion occurs at the same place and same time in every weekday or weekend. It is a capacity problem and will be reduced by raising roadway capacity. While nonrecurring congestion results from incidents such as accidents, road way maintenance or inclement weather.

Congestion can be defined as the situation when traffic is moving at speeds below the designed capacity of a roadway [3]. Congestion may be defined as state of traffic flow on a transportation facility characterized by high densities and low speeds, relative to some chosen reference state (with low densities and high speeds) [4]. Traffic congestion is a condition of traffic delay (when the flow of traffic is slowed below reasonable speeds) because the number of vehicles trying to use the road exceeds the traffic network capacity to handle those [5]. Traffic congestion refers to incremental delays and vehicle operating costs caused by interactions among vehicles, particularly as traffic volumes approach roadway capacity [6].

Due to change in carriageway width and vehicle composition, the traffic stream speed and flow also encounter more congestion level along the length of link[7].

The impacts of bottlenecks in a road sections are Delay, vehicle Operating Cost such as Fuel, Lubricants (engine oils, other oils and grease), Tyre, Spare Parts, Maintenance Labor Cost and Depreciation. The cost of congestion in terms of delay and wasted fuel is estimated to be about $103 billion in urban areas in the United States. One of the key elements that determine the extent of congestion is freeway bottleneck[8].

A travel time study determines the amount of time required to travel from one point to another on a given route. In conducting such a study, information may also be collected on the location, duration, and causes of delays. When this is done, the study is known as travel time and delay study. Data obtained from travel time and delay studies give a good indicator of the level of service on the study section. These data also aid the traffic engineer in identifying problem locations, which may require attention in order to improve the overall flow of traffic on the route [9].

In order to find an alternative strategy to improve the efficiency of the existing freeway system, bottlenecks should be carefully studied and analyzed as they are a primary reason for traffic congestion. Kathmandu, being the urban area traffic jam is the current issues due to bottleneck sections at certain stretches of road. These issues of congestion on any road network of Kathmandu are characterized by slower speeds, longer trip times and increased queuing. When traffic demand is greater enough that the interaction between vehicles slows the speed of traffic stream, congestion is incurred. As demand approaches the capacity of a road (or of bottleneck sections on the road), extreme traffic congestion occurs.

2. Research Objective

The overall objective of the study is to study the impact of bottleneck in Maitighar-Baneshwor-Tinkune road section. Besides that, the specific objectives of the study is to determine the delay due to bottleneck in this road section for estimating total loss in human capital hour due to congestion in peak hour.

3. Methodology

3.1 Study Area

Maitighar-Baneshwor-Tinkune road section is one of the busiest road sections of the Kathmandu valley. Even though it has been expanded up to 6 lanes consists of two bridges located at Dhobikhola, Bijulibazar and Bagmati Bridge, Tinkune which are of two lanes only. Due to this traffic capacity of the road section decreases and cause bottleneck. Also, there is Baneshwor intersection which has to serve traffic of this major road along with Sankhamul-PuranoBaneshwor road section. Due to this bottleneck at Baneshwor intersection occurs and leads to delay in travel time. As being busiest road, many vehicles need to pass this road and during peak hour this road section becomes crowded. Due to this fact, during peak our time, there is always delay delay in travel time which results high human hour loss.

4. Data Collection

Primary and secondary data have been collected for the study.

4.1 Secondary Data:

For this, CC TV footage of Kathmandu Kathmandu District Court, Babarmahal and Tinkune intersection footage for mentioned duration was collected.CCTV data for the morning peak hours (9:00-11:00) and evening peak hours (16:00-18:00) for three working days for Kathmandu District Court and Tinkune intersection has been collected from the Metropolitan Police Office, Ranipokhari, Kathmandu. Similarly, CCTV footage of same locations for Saturday off-peak hour (6:00-8:00) and peak hour data of one day (9:00-11:00) for Baneshwor intersection also has been collected from traffic police office.For spot speed of different vehicles in peak hours was referred from the report.

From the observation of the study area, it was found that public vehicles passes Maitighar to Tinkune without diversion but in case of private vehicles (Car and Motorcycle) the percentage of straightly travelling vehicles was extracted from the CC TV footage of Baneshwor intersection of 9:00-11:00 peak hour and was applied for the private vehicles to determine the exact volume of vehicles travelling from Maitighar to Tinkune. Similarly, for Tinkune-Maitighar direction

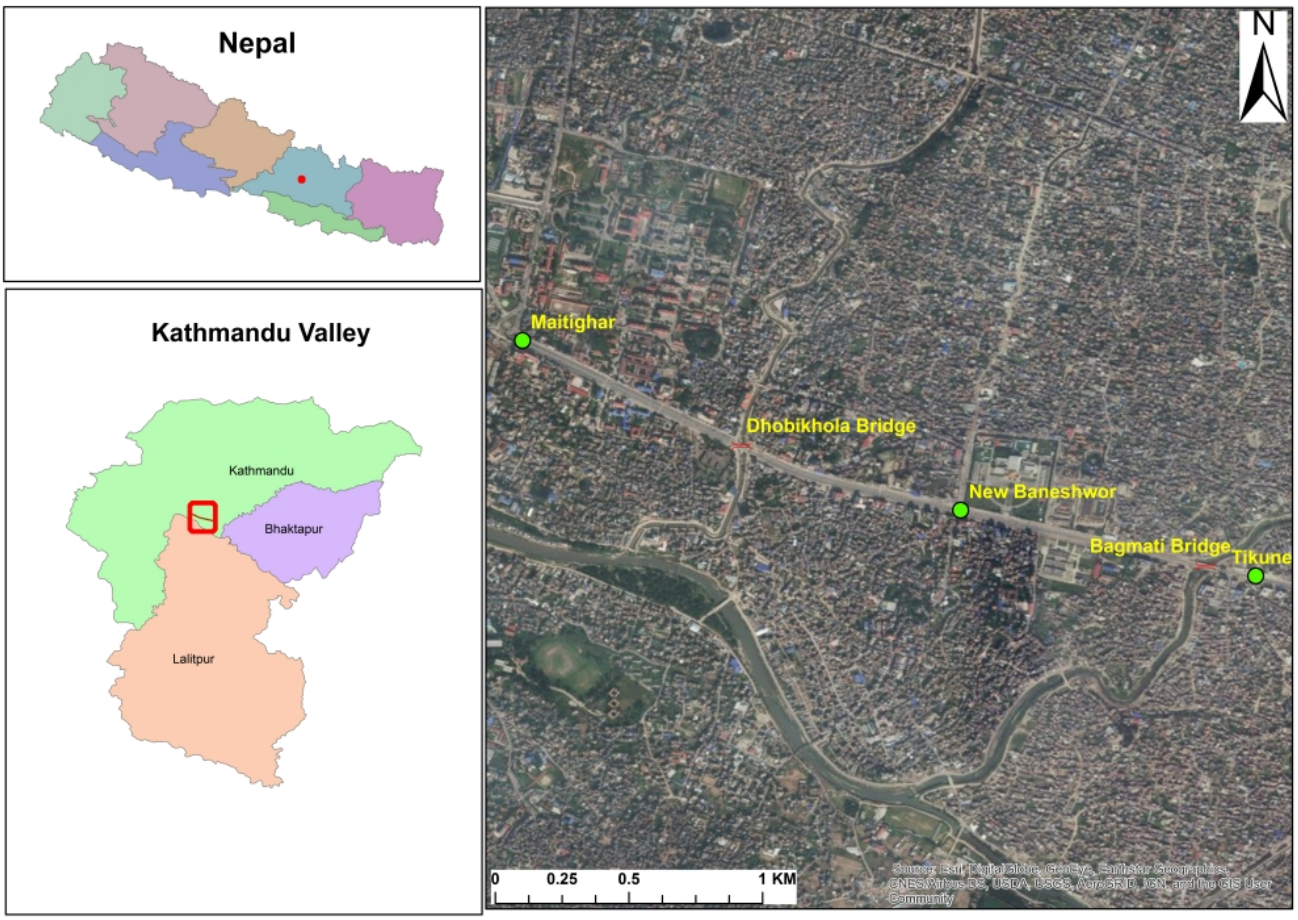

Figure 1: Study Area

same time data was used and there is certain percentage of public bus diversion (Nepal Yatayat) in Baneshwor towards Old Baneshwor. So, this was also counted for Tinkune-Maitighar direction. Other merging and diverging at different places were neglected as being very few in the field observation.

Normal flow time of the car for both directions has been extracted from the CC TV footage of Saturday off-peak hour (6:00-8:00). This extracted travel time gave the time from Kathmandu District Court to Tinkune and vise-versa. Time to cover the remaining portion have been asseseed from respective journey speed.

Travel time in the peak hours for different means of vehicles also have been collected via data extraction from video along with use of spot speed data obtained from secondary sources. Travel time from

4.2 Primary Data:

For the determination of the normal travel time manual survey was conducted for public vehicles. For this, traveling through the public vehicles in both direction and time was notedto get the exact journey time. From this we had eliminated high operational delay in off peak hours for public vehicles. For this, travelling from Maitighar to Tinkune for Bus (Mini Bus and Bus), Standard Bus (Sajha, Nagar Yatayat and City Metro), Micro and Tempo was carried out and travel time and delay time was noted. From this, actual journey time has been calculated.

Vehicular occupancy for the vehicles types for both the directions has been surveyed in the field for both morning and evening peak hours. To maintain consistency constant location was used (in front of Red Mug Cafe) for public vehicles for Maitighar-Tinkune

direction and just after Baneshwor intersection towards Maitighar (Bus stop) for Tinkune-Maitighar direction.

4.3 Data Analysis

Traffic volume data has extracted playing CCTV footage again and again for all types of vehicle. Percentage of through vehicle has extracted from the footage of Baneshwor intersection of morning peak hour (9:00-11:00) to get the number of through vehicles. From the occupancy survey data, total number of passengers traveling for each types has calculated. Calculating the travel time from Maitighar to Kathmandu district court by using spot speed and distance and extracting travel time from Kathmandu district court to Tinkune has been extracted from the video. From this,travel time was calculated from Maitighar to Tinkune and vise-versa and compared with normal travel time of the off peak hour of Saturday, delay for each period has calculated. Using the number of passenger for respective time period and delay, human capital hour loss was calculated.

5. Result and Discussion

From the extracted data, first delay in the peak hour for different traffic has been calculated and after this by using volume and occupancy data, total human capital hour delay of different types of vehicles has been calculated for both the direction.

5.1 Traffic Volume Data:

Volume of the classified vehicles in peak hours extracted on both direction and the proportion of through vehicle from Maitighar to Tinkune and vice versa by use of Baneshwor intersection have been summed up in Table 1 and Table 2.

For Maitighar-Tinkune direction, 77.9 % of the Bike and 77.2 % of the car were found to move straight from Maitighar to Tinkune and rest of the percentage have been diverted to Old Baneshwor or Sankhamul area. For other vehicle types there was no any significant diversion.

For Tinkune-Maitighar direction, 78.5 % of the Bike and 80.2 % of the car and 93 % of Bus were found to move straight from Tinkune to Maitighar and rest of the percentage have been diverted to Old Baneshwor or Sankhamul area. For other vehicle types there was no any significant diversion.

Table 1: Volume of vehicle (Maitighar-Tinkune Route)

Total no of Vehicle						
Time	Bike	Car	Micro	Tempo	Std Bus	Bus
9.00-11.00	3807	1327	100	97	21	271
16.00-17.00	5644	1515	104	94	24	351
Total no of through Vehicle						
Time	Bike	Car	Micro	Tempo	Std Bus	Bus
9.00-11.00	3019	1025	100	97	21	271
16.00-17.00	4476	1170	104	94	24	351

Table 2: Volume of vehicle (Tinkune-Maitighar Route)

Total no of Vehicle						
Time	Bike	Car	Micro	Tempo	Std Bus	Bus
9.00-11.00	4862	1521	101	98	20	352
16.00-17.00	5075	1439	100	97	22	318
Total no of through Vehicle						
Time	Bike	Car	Micro	Tempo	Std Bus	Bus
9.00-11.00	3817	1220	101	98	20	328
16.00-17.00	3984	1154	100	97	22	295

5.2 Vehicular Occupancy:

By analyzing the number of through vehicles and occupancy of the vehicles for every 15 minute intervals, vehicular occupancy in every 15 minutes for morning and evening peak hours for both directions has been summarized in Table 3 and Table 4.

5.3 Travel time and delay:

By determining the travel time in peak hour and comparing with normal travel time in off-peak hour of Saturday, delay for all public vehicles and car for every 15 minute interval for both directions has been calculated.

Table 3: Volume of through vehicle and passengers in different vehicles (Maitighar-Tinkune Route)

Time	Type of Vehicle											
	Bike		Car		Micro		Tempo		Std Bus		Bus	
	Vehicle	Person	Vehicle	Person	Vehicle	Person	Vehicle	Person	Vehicle	Person	Vehicle	Person
9.00-11.00	3807	4949	1327	2387	100	1340	97	625	21	470	271	5166
16.00-17.00	5644	7338	1515	2952	104	2164	94	1079	24	1379	351	11301

Table 4: Volume of through vehicle and passengers in different vehicles (Tinkune-Maitighar Route)

Time	Type of Vehicle											
	Bike		Car		Micro		Tempo		Std Bus		Bus	
	Vehicle	Person	Vehicle	Person	Vehicle	Person	Vehicle	Person	Vehicle	Person	Vehicle	Person
9.00-11.00	3807	4949	1327	2387	100	1340	97	625	21	470	271	5166
16.00-17.00	5644	7338	1515	2952	104	2164	94	1079	24	1379	351	11301

Table 5: Summary of Human Capital Hour losses due to delay

Capital Hour Loss (Maitighar-Tinkune Route)						
	Mode of Travel					Total
Time	Car	Micro	Tempo	Standard Bus	Bus	
9:00-11:00	239.18	129.27	66.42	66.77	682.66	1184.3
16:00-18:00	251.25	242.77	131.01	217.65	1227.24	2069.92
Total	490.44	372.04	197.43	284.42	1909.89	3254.22
Capital Hour Loss (Tinkune-Maitighar Route)						
	Mode of Travel					Remarks
Time	Car	Micro	Tempo	Standard Bus	Bus	
9:00-11:00	167.96	183.48	88.06	128.09	1434.15	2001.74
16:00-18:00	170.09	132.41	101.76	110.79	693.9	1208.95
Total	338.04	315.89	189.81	238.88	2128.06	3210.68
Capital Hr Loss						
	Car	Micro	Tempo	Standard Bus	Bus	Grand Total
Capital Hr Loss	828.5	687.9	387.2	523.3	4037.9	6464.90
%	12.80%	10.60%	6.00%	8.10%	62.50%	

5.4 Human Capital Hour Loss:

As we have calculated vehicle volume and occupancy, by multiplying these we can get the number of passengers traveling in each types of vehicle in both direction for both morning and evening peak hour. After this, by multiplying respective delay for respective direction and types of vehicle, human capital hour loss (in hour) has been calculated. Human Capital Hour loss due to delay for all public vehicles and car has been summarized in Table 5. From this summary, we can see that more than 70% of the loss in capital hour is due to Standard Bus and Bus. So, special consideration should be provided to these vehicles to reduce the capital hour losses due to bottleneck.

6. Conclusion and Recommendation

As we have analyzed for the delay and human capital hour loss in Car and public vehicles, it was found that, within two hour peak time at evening and morning for Car, Micro, Tempo, Large Bus and Bus for Maitighar - Tinkune and Tinkune - Maitighar, total 6464.90 capital hour was found to be lost. From this, annual loss will be 211.81 human capital year losses only in peak hours for weekdays (excluding Saturday and Holidays)and more than 70% of the human capital hour is lost in Bus and Standard Bus. Human capital hour loss is more in morning peak hour for Tinkune - Maitighar route but in evening peak hour loss is more in Maitighar - Tinkune route.

As there is huge human capital hour/year loss due to bottleneck, we have to think for some remedial measures. Strict lane discipline throughout the section and restriction on right turning in both bridge locations will reduce the capital hour loss due to current traffic condition. As from the field observation and observation in CCTV footage, there is loss due to pedestrian in New Baneshwor intersection. So, construction of the flyover in New Baneshwor intersection in necessary. More than 70 percent of loss is due to Bus and Standard Bus, these modes should be prioritized, for the reduction in human capital hour loss. In morning peak, traffic of Tinkune - Maitighar route and in evening peak, traffic of Maitighar - Tinkune route should be prioritized.

7. Limitations of Study

Each research works are subjected to some sorts of limitation and such limitation may sometime leads to slight variation in research outcome and thus those limitation need to be addressed. The limitation of this particular research works are summarized below:

i) For all types of public vehicles and Car type of vehicles has been analyzed for the study but delay in bike couldn't be considered.

ii) All through vehicles has been considered for the study and diversing vehicles from the Baneshwor intersection has been considered but merging and diverging vehicles for different locations except Baneshworintersection couldn't be considered for the calculation.

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