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Statistical Application for the Analysis of Traffic Congestion and Its Impact in a Hill City

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Abstract

Traffic congestion has been a severe problem of any growing urban area in the world that imposes drastic economic and social cost on the urban population. The livelihood activity and welfare are highly associated with the traffic flow pattern in the city. Over the years, with rising affluence, number of vehicles has increased disproportionately with road length and space. In East Khasi Hills district of Meghalaya, road length increased from 1696 KM in 2001 to merely 2050 KM in 2015, i.e., by 20.87 per cent. However, number of vehicles during the same period increased from 34996 to 137753, i.e., by 293.63 per cent. The problem is more acute in the hilly areas like Shillong due to scarcity of land space to enhance road width, hill topography and curvature along with difficulty and huge cost of construction. Steep hill slops and narrow space with rising vehicles in the peak hours block speedy movement of people, when there is an urgent need. However, congestion varies across space and time of the day. It depends on topography of road, activity pattern and timing of vehicle use, locational pattern of institutions across length and breadth of the city. In this paper, an attempt has been made to examine the level of congestion across important road intersections on the national highway passing through Shillong city and find its major impact on the commuters. Analysis of congestion index and other indicators shows that there is traffic congestion across the Shillong city almost throughout the day excepting Sunday. The congestion becomes severe towards the intersection points surrounded by government offices and educational institutions especially during opening and closing hours of the offices. It has severe impact on the activity pattern, productivity and earning of the commuters with social and psychological consequences. For crossing a stretch of 250 meters around a crossing throughout the day,

on an average a vehicle loses from 74 to 87 minutes of time. Of course, the adverse effect of congestion varies across category of people in different occupation having diverse objectives of movements from home to regular destination involving varied opportunity cost.

Keywords: Traffic Congestion, Impact of Congestion, Fuel Cost, Travel Time, Opportunity Cost, Shillong.

AMS Classification: 62P20.

1. Introduction

Traffic congestion has been a severe problem of any growing urban area in the world that imposes drastic economic and social cost on the urban population. Shillong, the capital city of Meghalaya has also been facing congestion increasingly with rapid growth of population, socio-economic activities and vehicular movement. Pressure on road has been increasing exponentially and the adverse impacts of congestion sometimes surpass the beneficial effects of transportation. In other words, there is a rapid increase in negative externalities in the form of severe traffic congestion due to increasing number of vehicles with limited road space.

Population of Shillong has increased from about 223366 in 1991 to 354759 in 2011 (Census Reports 1991 and 2011). As per records of District Transport Office in Shillong, number of registered vehicles increased from merely 30456 in 1990-91 to 137753 in 2015-16 (Govt. of Meghalaya, 2018). Whereas, total road length of Shillong was still about 356 KM in 2009 with a road density of 2.05 Km/Sq. Km, which changed very little over previous decade. So, there has been a drastic rise in pressure of car on the available road network in the town and its vicinity.

In the contemporary lifestyle with rising affluence, a great transformation is observed where almost everybody owns a vehicle and prefers to travel with her/his own car even for a shortest distance. One may argue that it is a sign of progress and people have scarcity of time to avail a public mass-transportation that causes delay. Personal vehicles are mostly used for dropping and picking up of children from school instead of using school buses or pooled vehicles. Given the limited road infrastructure and improper location of various institutions, problem of traffic congestion is compounded.

Traffic congestion may be defined as the situation in which the demand for road space exceeds supply, thereby leading to increase in its negative impacts. The congestion is reflected in rising travel time, fuel expenditure, and delay for some activities, loss of opportunities and business activities, anxiety and so on. Traffic congestion in Shillong has become one of the severe problems that every individual has been facing. Prolonged hours in traffic jam adversely affects workers' productivity, business and other activities in daily life along with the emotional state of commuters. Congestion is observed throughout the day in all major road intersections. The rush hours vary from location to location depending on the economic and other activities. With schools and colleges resuming, traffic congestion is at its worst, making it difficult for people to reach their destination on time. Besides traffic congestions witnessed all over the city, it is more pronounced in areas of educational institutions, business activities and government offices. Therefore, it is high time to examine the pattern of traffic congestion and its impact on the society.

2. Review of Literature

Several studies have examined the issues related to traffic congestion. According to Azeem Uddin (2009) rapid growth in passenger vehicles due to increase in income and the development of low-cost cars into the market is one of the prime causes of traffic congestion. Ukpata and Etika (2012) find poor driving habits, poor road networks, inadequate road capacity and lack of parking facilities are the major causes of traffic congestion in Nigeria. Further, poor road traffic management, lack of adequate town planning, lack of space for expansion of road infrastructure, etc. have also been identified as the reasons behind traffic congestion in the developing nations (Jain et al, 2012). For detecting congestion in the critical areas, they used a simple image processing algorithm to analyse CCTV video feeds from traffic cameras. With the help of this algorithm they tried to show evidence of actual congestion in Sao Paulo, Brazil and Nairobi in Kenya. The reasons for traffic congestion as identified include unplanned cities, poor discipline of drivers, alternate traffic means, tighter budget, etc. Study showed high congestion in Brazil during 4:30 p.m. to 8:30 p.m. In Kenya it was highly erratic and busy schedule is stretched from 10 a.m. to 2 p.m. Inadequacy of traffic police, narrow roads, illegal parking, increasing population, higher purchasing power of the public, improper city development planning development are also

cited to be some important reasons for traffic congestion in the city places (Rahane and Saharkar, 2014; Bhatt and Gandhi, 2014).

With every increase in population and economic activities in Delhi, the travel demand increased manifolds (Singh and Sarkar, 2009). In the study, costs associated with roads are classified as private cost in terms of fuel lost, time lost, wear and tear of vehicles. Commuting costs associated with traffic congestion are noise, fumes, and dangers of accidents and loss of amenity. In this study, two approaches - engineering and economic approach are mentioned by the authors for analysing congestion costs. Through engineering approach time lost is measured by pricing time lost at average income levels and under economic approach an optimum traffic level as a function of the demand for road use and optimum speed that is further linked to willingness to pay by the road users. Average vehicular speed during peak and off-peak hour varies between 10-35 Km/Hr.

Harriet *et. al.* (2013) examine the extent to which traffic congestion negatively affects worker productivity in Kumasi Metropolis, Ghana. The authors examine it by using primary data collected through an appropriate questionnaire from drivers of taxis and minibuses. The result shows that the average number of trips by the drivers is lower than the expected trips and hence it adversely affects their earning. The magnitude of loss incurred by the drivers in terms of productivity loss is estimated at 14.3% of the whole expected activity.

Khan and Islam (2013) analyse travel time costs, vehicle operating costs and externality costs due to traffic delay and environmental damages. They have tried to estimate the cost of traffic congestion in monetary terms through travel time cost and vehicle operating cost in Dhaka city, Bangladesh. They have observed the time spent on travelling that has an opportunity cost that includes Total Time Variability loses (Rahane and Saharkar, 2014).

The objective of this paper is to examine incidence of traffic congestion at some major traffic intersections in Shillong. Also, the impacts of traffic congestion on commuters including private car owners, taxi drivers and businessmen has been examined.

3. Data and Methodology

The Shillong city is well connected by a network of roads within the state and with all important cities in the neighbouring states by National Highway 44. For the assessment of traffic congestion, first of all zones or road intersections on the stretches of national highway passed through the city between Mawyong and Nongthymmai have been chosen. Thereafter, the sample respondents were selected. Since the vehicles were mobile, it was not possible to have direct interview on the spot (by stopping cars on the road would have created anarchy in the traffic movement on the narrow hilly road). Therefore, only the contacts of the respondents were collected at random in different time intervals and then at a later stage information were collected from them at convenient locations by using a structured questionnaire. For the purpose, 600 individuals were selected randomly in the city of which 200 were private individuals owning car and daily commuters, 200 taxi drivers and 200 businessmen.

Top 5 road intersections out of 16 major road intersections in terms of traffic flow and congestion in Shillong have been chosen on the basis on ranking by the respondents. These are Mawlai point, Garikhana, Police Bazar intersection, Dhankheti and Nongthymmai intersections (Appendix 1). These points are located in various places covering the major portion of the city and also on the National Highway that passes through the town (Fig. 1). Also, these intersections observe multiple traffic varieties at different time intervals of the day. Mawlai, Garikhana and Police Bazar records office, educational institute and market visitors with more concentration of business traffic, while the other two record major educational institute visitors along with other domestic and commercial traffic.

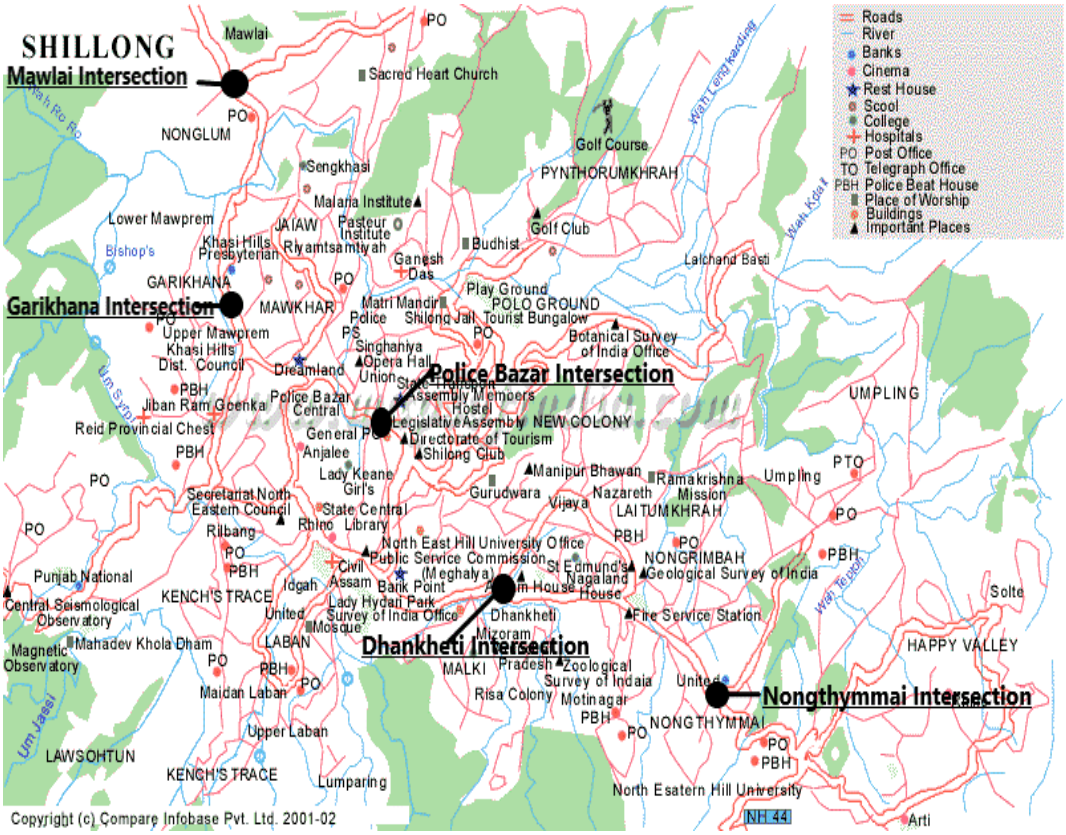

Figure 1: Location of the surveyed intersections in Shillongcity
Source: Mappery, downloaded from: http://www.mappery.com/Shillong-City-Map, Accessed: 20th April 2019.

At these five locations, manual vehicle traffic count has been made on alternate working days during July to September 2018. Vehicle count has been conducted for 12 hours in a day from 7:00 a.m. to 7:00 p.m. The traffic volume starts increasing after around 7.00 a.m. in the morning and starts declining after 7.00 p.m. in the evening and under normal circumstances there is no traffic congestion after 7.00 p.m. till 7.00 a.m. Traffic congestion is examined by Volume/Capacity (V/C) Ratio (Guidelines for Capacity of Urban Roads in Plain Areas, Indian Road Congress, 1990.). It is the most suitable way for traffic congestion analysis in arterial roads and intersections, which is ideal for a place like Shillong. The intensity of congestion can be understood from the level of service of any road intersections. Level of Service (LOS) of any road intersection gives information

about both the amount of traffic and the quality of traffic flow (Eddington, 2006). Traffic volume in peak hours is used to compute Volume/Capacity Ratio. V/C varies between 0 (a car enjoys free flow) and 1 (heavily congested or maximum number of cars are there in a particular point/junction at a given time).

Also, intensity of congestion of various intersections is examined by the amount of time lost in crossing a stretch of road intersection (250 metres) on an average for the vehicles moving from any direction. The loss of time is the time in excess of the normal time required to pass the same stretch in a freeway condition. In the freeway condition also, a little variation in required time is recorded due variation in curvature, presence or absence of speed-breaker and condition of road.

Thereafter, the overall regional Volume/Capacity ratio is evaluated by using Roadway Congestion Index (RCI), which is a useful indicator to examine the regional congestion (Shark and Lomax, 1998; Mahama, 2012). The Index is given by the formula

$$\text{RCI} = \frac{\frac{\sum(Vehicle\ per\ peak\ hour)}{(Link\ Capacity)} + (Vehicle\ per\ peak\ hour * Link\ Length}{\sum(Vehicle\ per\ Peak\ Hour * Link\ Length)}$$

(Mahama, 2012)

For impact on time loss by the commuters, extra time taken over the normal timing required to cross a road intersection, 250 metres from either direction has been computed. Congestion causes number of trips to come down and hence the earning of the taxi drivers or owners. Thereafter, using sample observations, average per kilometre consumption of fuel on congested driving day and on freeway driving (Sunday) and the rate of increase due to recorded congestion in the city road has been computed. The computation has been done for all three sample groups (private individual car owners, taxi drivers and businessmen) having varied objective and timing of driving vehicle and occupational impacts. Calculations are made for all five major selected locations to understand the locational variation of impact with varied congestion level.

Further, the opportunity lost by the individuals due to congestion and lost time either for delay in opening shops and thus sale, contracts by daily commuters, loss of trips by taxi drivers/owners meeting by self-driving private individuals etc have been assessed and the money value have been computed. Similarly, variation in

vehicle operating costs across locations have been computed to understand the variation in such cost due to variation in congestion level. Thereafter, by aggregating these major financial implications, annual total cost of congestion is computed for all three categories of individuals.

4. Observation and Analysis

4.1 Traffic Congestion Scenario in Shillong

Shillong being the state capital of Meghalaya is the busiest administrative centres of the state and main commercial and institutional centres. It is an important centre of education, administration and tourism. Continuous and rapid increase in the number of registered vehicles in Shillong with rising affordability of the people has resulted in chaotic traffic situation. Regression of log of road length, number of vehicles, road density and vehicle density on time for the data of 15 years in East Khasi Hills (whose headquarter is Shillong) from 2001 to 2015 has been presented in Table 1. It shows a clear rise in pressure of growing vehicles on the slowly expanding road capacity.

Table 1: Regression Results of LnRoad Length, LnRegistered Vehicles, LnRoad Density and LnVehicle Density on Time (t)

LnRoad Length = 7.40 + 0.0147 t (434.05) (8.32)	Adj R^2 = 0.82
LnRegistered Vehicles = 10.46 + 0.076 t (252.70) (17.73)	Adj R^2 = 0.954
LnRoad Density = -0.52 + 0.015 t (-31.02) (8.56)	Adj R^2 = 0.828
LnVehicle Density= 3.066 + 0.0612 t (66.80) (12.90)	Adj R^2 = 0.917

Source: Directorate of Economics and Statistics. Government of Meghalaya, Statistical Handbook of Meghalaya, (2001, 2011, 2018).

Note: Figures in the parentheses represent t values.

Table 2: Major road intersections in Shillong

Zone	Intersections	Types	Associated Issues
1	Mawlai Point	4- Legged	Four arm intersection, traffic due to regional trucks, rush during school and office hours, on street parking, etc.
2	Garikhana	3- Legged	Major intersection, on street parking of tourist buses and taxis for dropping and picking up passengers.
3	Dhankheti	4- Legged	Poor geometrics, traffic due to school and offices in the morning and after peak hours due regional trucks traffic, Improper channelizes.
4	Police Bazaar	4- Legged	High pedestrianized traffic, 7 roads meet together
5	Nongthymmai	3- Legged	Major traffic of local taxis due to school and offices.

Source: City Development Plan, Shillong (2009).

Table 3: Traffic flow data of Mawlai, Garikhana, Dhankheti, Police Bazar and Nongthymmai

Time (Hr)	Mawlai	Garikhana	Dhankheti	Police Bazar	Nongthymmai
07:00-08:00	568	766	522	534	402
08:00-09:00	1238	2050	2434	1076	1308
09:00-10:00	3112	2824	4594	1766	2420
10:00-11:00	4016	2314	3352	2518	1208
11:00-12:00	3778	2098	2274	4082	1194
12:00-13:00	2762	3072	2360	4002	1106
13:00-14:00	1708	2666	1542	3362	1418
14:00-15:00	1894	2456	3498	2774	2110
15:00-16:00	2258	3326	4270	2810	2318
16:00-17:00	3068	3386	3764	3518	2084
17:00-18:00	3268	3626	2612	3768	1946
18:00-19:00	2608	2288	2600	3910	1848

Source: Field Survey, conducted during July to September 2018.

Majority of the road corridors suffer from several inadequacies like capacity constraints in the road networks, poor definition of road hierarchy, on street parking, mixed traffic, poor traffic management, slow journey speeds, poor safety situations, inadequacy enforcement of traffic rules, lack of pedestrian facilities and other street furniture. Also, the construction of activity centres and shopping

centres along already congested road are putting additional pressure on these congested roads. The traffic points that have been taken for the study and their geometric characteristics are shown in Table 2. In Table 3 the traffic volume count of five major locations have been presented.

Here, traffic volume in peak hours has been measured using Volume/Capacity Ratio. V/C varies between 0 (free flow) and > 1(heavily congested). LOS gives information about both the amount of traffic and the quality of traffic flow (Eddington, 2006). The LOS at any intersection on a highway has a significant implication for its overall performance. It denotes a range of operating conditions from Level A to Level F, which occur on a transportation facility when it accommodates a range of traffic volumes (Table 4) (Kadiyali, 2015).

Table 4: Levels of Service (LOS)

LOS	V/C	Detailed Description
A	0.00-0.35	Represents the best operating conditions and is considered free flow. Individual users are virtually unaffected by the presence of others in the traffic stream.
B	0.35-0.58	Represents reasonably free-flowing conditions but with some influence by others.
C	0.58-0.75	Represents a constrained constant flow below speed limits, with additional attention required by the drivers to maintain safe operations. Comfort and convenience levels of the driver decline noticeably.
D	0.75-0.90	Represents traffic operations approaching unstable flow with high passing demand and passing capacity near zero, characterised by drivers being severely restricted in manoeuvrability.
E	0.90-1.00	Represents unstable flow near capacity. LOS E often changes to LOS F very quickly because of disturbances (road conditions, accidents, etc.) in traffic flow.
F	>1.00	Represents the worst conditions with heavily congested flow and traffic demand exceeding capacity, characterised by stop and go waves, poor travel time, low comfort and convenience and increased accident exposure.

Source: Hartgen, D.T. (2006) Building Roads to Reduce Traffic Congestion in America's City. Reasons Foundation. Appendix B.

For various intersections, on road the highway capacity manual measures congestion in terms of average delay per vehicle and similarly LOS are defined based on the average amount of delay.

LOS A ------ < 10 Secs

LOS B ------ 11-20 Secs

LOS C ------ 21-35 Secs

LOS D ------ 36-55 Secs

LOS E ------- 56-80 Secs

LOS F -------- > 80 Secs

Table 5 describes the Volume/Capacity ratio of the major road intersections in Shillong. It revealed that the ratio exceeds 1 during most of the interval hours of the day and the intensity is more during school and office hours. This clearly represents the worst conditions of traffic flow with heavy congestion and traffic demand exceeds drastically the existing road capacity. The hourly traffic volume of locations presented in Table 3 has been divided by the standard road capacities as shown in Table 6 and the results has been presented in Table 5.

Table 5: Volume/Capacity Ratio of Mawlai, Garikhana, Dhankheti, Police Bazar and Nongthymmai

Time (Hr)	Mawlai	Garikhana	Dhankheti	Police Bazar	Nongthymmai
07:00-08:00	0.47	0.51	0.35	0.36	0.34
08:00-09:00	1.03	1.15	1.62	0.72	1.09
09:00-10:00	2.59	1.88	3.06	1.18	2.02
10:00-11:00	3.35	1.54	2.23	1.68	1.01
11:00-12:00	3.15	1.40	1.52	2.72	1.00
12:00-13:00	2.30	2.05	1.57	2.67	0.92
13:00-14:00	1.42	1.78	1.03	2.24	1.18
14:00-15:00	1.58	1.64	2.33	1.85	1.76
15:00-16:00	1.88	2.22	2.85	1.87	1.93
16:00-17:00	2.56	2.26	2.51	2.35	1.74
17:00-18:00	2.72	2.42	1.74	2.51	1.62
18:00-19:00	2.17	1.53	1.73	2.61	1.54

Source: Field Survey, conducted during July to September 2018.

Table 6: Recommended design service capacity for urban roads

			Total Capacity per hour for Various Traffic Condition (PCU/hour)		
Sl. No	Width of Carriageway	Traffic Flow	Roads with no frontage access, no standing vehicles, very little cross traffic	Roads with frontage access, no standing vehicles, high traffic intersections	Roads with free frontage access, parked vehicles and heavy traffic
1	2-Lane * (3.5-4.0 m)	Two way	NA	1200	NA
2	2-Lane (7-7.5 m)	One way	2400	1500	1200
		Two Way	1500	1200	750
3	3-Lane (10.5 m)	One way	3600	2500	2000
4	4-Lane 14m	One way	4800	3000	2400
		Two Way	4000	2500	2000
5	6-Lane 21m	One way	3600	2500	2200
		Two Way	6000	4200	3600

Source: Guidelines for Capacity of Urban Roads in Plain Areas, Indian Road Congress, 1990.

Note: * Calculated by the authors by using the proportion of road width as it is not given for the 3.5-4 metre width road category. NA means not available and also not applicable for Shillong urban area.

Traffic volume count data, collected through manual count and conducted for 12 hours duration (7:00 AM to 7:00 PM), reveal that traffic flow characteristics of zones surrounded by educational offices and institutions are more or less identical (Fig 2). Flow pattern in Mawlai junction, the entry point to the City, traffic congestion remains very high during 9.00 AM to 1.00 PM and from 4.00 PM to 5.00 PM.

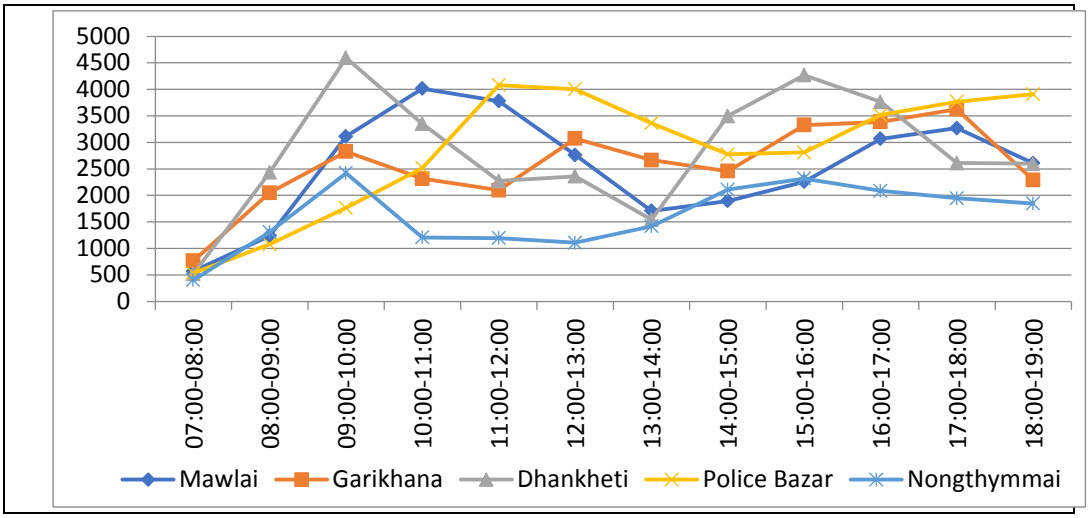

Figure 2: Traffic flow data of Mawlai, Garikhana, Dhankheti, Police Bazar and Nongthymmai from 7.00 AM to 7.00 PM (Number)

The highest level of congestion is observed in the Dhankheti junction point, especially from 8.00 AM to 9.00 AM and then again it reaches a peak around 3.00 PM. This junction caters to the flow of traffic for the major educational institutions located in the surrounding. This point is also located at the heart of the city and it links many other alternative routes to various locations. Thus, most of those commuters must pass through this intersection and face congestion at major part of the day. Apart from local taxis and cars; tourists' vehicles are also observed to pass in greater number through both the Mawlai and Dhankheti points and thus the points remain congested more during office and school hours (10:00 AM to 11:00 PM & 5:00 PM to 6:00 PM) (Fig 2).

Through the Mawlai junction also a crossing is there for the entry to North Eastern Hill University (NEHU), Shillong Campus, and Umshing area and thereby Institute buses cross that junction during most of the time of the day along with other public transportation buses. It is 2.5 km away from Garikhana junction and its traffic flow depends on the traffic flow in Garikhana. If there is traffic jam in Grikhana, its effect spreads to other road stretches connecting Garikhana, thereby affect Mawlai intersection.

Similar traffic behaviour is also observed in Garikhana and Nongthymmai but with less intensity. Peak hour traffic in Garikhana has been witnessed in the morning office hours from 9:00 AM to 10:00 AM, and again around 12.00 Noon

due to heavy business activity. During evening hours, it is observed to be congested from 5:00 PM to 6:00 PM. It is one of the main points of vehicle stoppage as it is very near to the commercial market Barabazar that is extended to Police Bazar. Several loading and unloading of luggage take place in Garikhana since the sumo and bus stands are located just in the intersection. Despite having similar pattern of movement, traffic flow in Nongthymmai remains comparatively lower than the other points, but sometimes long queue of vehicles in the afternoon has been observed.

The Police Bazar point is the centre of official institutions as well as hub of commercial activities. Here, traffic flows are found to increase after 9.00 AM and reaches its peak during 11:00 AM to 12:00 Noon and after a lean patches traffic volume rises after 4:00 PM till 7.00 PM due to increasing business activities, and flow of office people who moves there after office hours and sometimes the congestion continues beyond 7.00 PM for a while.

Table 7: Level of service of Mawlai, Garikhana, Dhankheti, Police Bazar and Nongthymmai

Time (Hr)	Mawlai	Garikhana	Dhankheti	Police Bazar	Nongthymmai
07:00-08:00	B	B	A	B	A
08:00-09:00	F	F	F	C	F
09:00-10:00	F	F	F	F	F
10:00-11:00	F	F	F	F	F
11:00-12:00	F	F	F	F	F
12:00-13:00	F	F	F	F	E
13:00-14:00	F	F	F	F	F
14:00-15:00	F	F	F	F	F
15:00-16:00	F	F	F	F	F
16:00-17:00	F	F	F	F	F
17:00-18:00	F	F	F	F	F
18:00-19:00	F	F	F	F	F

Source: Primary survey.
Note: Authors' calculation using volume capacity ratio.

Table 7 presents the LOS in five major locations within the city. It clearly shows that except for some early morning hours, in general throughout the day the level

of service reaches F that is it exceeds the maximum capacity and thereby leads to severe traffic congestion.

The intensity of congestion at different points of time can also be examined through the loss of time in crossing a stretch of road intersection. Table 8 reveals the average amount of time lost over the freeway timing required to cross the stretch of 250 metres from either side of these three or four-legged road intersections in weekdays. We observe similar pattern of congestion or loss of travel time as that of traffic flow across different time intervals of the day (Fig 3). The variation in loss of time changes across the time interval of the day is associated with the location (presence or absence of educational institutions, government offices or market around the intersection) of the road intersection and timing of schools, offices and markets. The loss is more in a road intersection during the opening and closing hours of the institutions located around it.

Table 8: Average Time loss of vehicles in five major intersections for crossing 250 metres (from either approach) in Shillong (Second)

Time Interval	Mawlai	Garikhana	Dhankheti	Police Bazar	Nongthymmai
7:00 am-7:15am	0.0	0.0	0.0	0.0	0.0
7:30am-7:45am	18.4	22.0	19.0	10.8	14.0
8:00am-8:15am	58.4	58.2	125.2	48.3	58.6
8:30am-8:45am	102.9	107.2	195.1	65.3	82.8
9:00am-9:15am	125.2	131.1	144.3	73.8	95.3
9:30am-9:45am	87.1	94.2	97.4	94.7	91.6
10:00am-10:15am	86.0	97.0	100.8	120.1	104.8
10:30am-10:45am	71.3	97.2	67.7	128.6	102.1
11:00am-11:15am	77.6	87.6	83.5	125.9	67.9
11:30am-11:45am	74.4	89.4	81.6	129.7	72.8
12:00 noon-12:15pm	76.3	88.9	95.7	134.3	76.8
12:30pm-12:45pm	75.6	91.0	84.9	109.0	75.6
1:00pm-1:15pm	79.6	81.6	90.8	116.1	77.8
1:30pm-1:45pm	86.3	87.1	95.9	134.2	75.1
2:00pm-2:15pm	119.4	120.2	120.3	123.4	118.9
2:30pm-2:45pm	121.1	121.3	125.3	129.8	131.6

Time Interval	Mawlai	Garikhana	Dhankheti	Police Bazar	Nongthymmai
3:00pm-3:15pm	124.7	127.4	137.9	141.0	130.7
3:30pm-3:45pm	130.0	133.4	141.2	146.0	134.3
4:00pm-4:15pm	133.0	137.2	74.7	147.9	125.1
4:30pm-4:45pm	139.0	142.0	73.8	145.2	137.1
5:00pm-5:15pm	140.7	140.2	123.8	147.0	152.6
5:30pm-5:45pm	129.9	115.7	126.8	137.4	134.1
6:00pm-6:15pm	80.7	76.7	83.4	97.7	76.0
6:30pm-6:45pm	88.7	88.1	69.9	108.4	69.1
Total Estimated Time Loss per Vehicle per Day	*4452.6*	*4669.4*	*4718*	*5229.2*	*4409.4*
Total Estimated Time Loss in Minutes in a Day for Each Vehicle	74.21	77.82	78.63	87.15	73.49

Note: Average delay of vehicles moving from all directions crossing the intersection is computed.

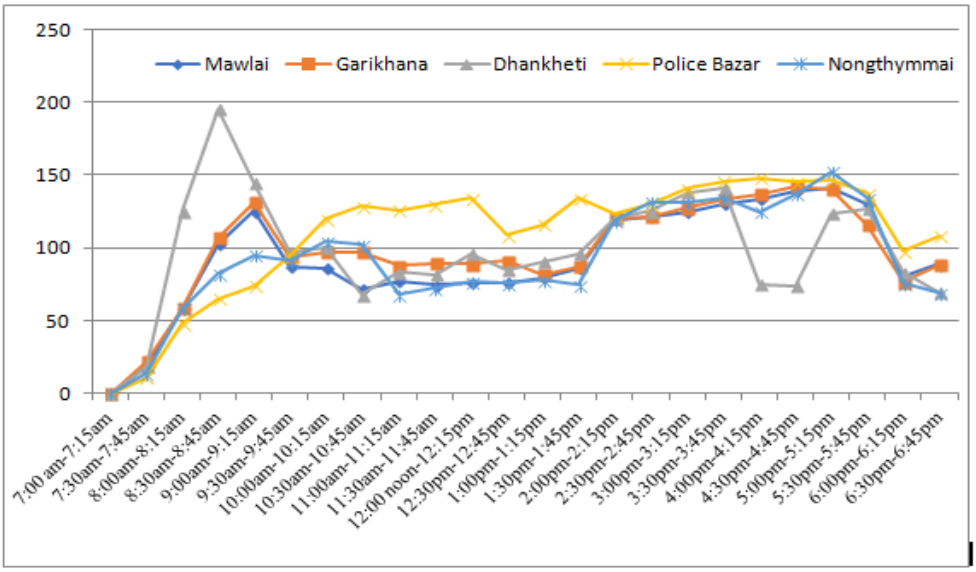

Figure 3: Average loss of time of vehicles in five major intersections for crossing 250 metres (from either approach) in Shillong (Second)

4.2 Roadway Congestion Index (RCI)

Shark and Lomax (1998) stated that the overall regional Volume/Capacity ratio, evaluated by using Roadway Congestion Index (RCI) is a useful indicator to examine the regional congestion (Mahama, 2012). The Index is given by the formula

$$RCI = \frac{\frac{\sum(Vehicle\ per\ peak\ hour)}{(Link\ Capacity)} + (Vehicle\ per\ peak\ hour * Link\ Length}{\sum(Vehicle\ per\ Peak\ Hour * Link\ Length)}$$

(Mahama, 2012)

Table 9: Roadway Congestion Index in the whole stretch of road between Mawing to Nongthymmai, Shillong

Col 1		**Col 2**	**Col 3**	**Col 4**	**Col 5**	**Col 6**	**Col 7**	**Col 8**	**Col 9**	**Col 10**
Origin	Destination	Peak Traffic Density Hours	Peak Hour Volume	Link Capacity	Link Width	Link Length (KM)	∑(Vehicle per peak hour)/Link Capacity	Peak hour Vol*Link Length	Col 7* Col 8	**RCI**
Mawiong	Mawlai	10:00-11:00 AM	3788	1200	4	7.7	3.2	29167.6	92072.4	
Mawlai	Garikhana	10:00 - 11:00 AM	3664	1500	7	2.5	2.4	9160	22374.8	**3.00**
Garikhana	Dhankheti	9:00-10:00 AM	4644	1500	7.5	3.5	3.1	16254	50322.4	
Dhankheti	Nongthy-mmai	9:00 - 10:00 AM	2660	1200	3.5	2.2	2.2	5852	12971.9	
Total								**60433.6**	**177741.5**	

RCI has been used to evaluate the congestion level along the road stretch from Mawiong to Nongthymmai. The result reveals that the value of RCI is 3.00, which reflects very high level of congestion (Table 9).

4.3 Impacts of Traffic Congestion

4.3.1 Loss of Time

Loss of time is an important impact of traffic congestion inflicted upon the commuters. Table 8 above reflects the wide variation in loss of time in crossing 250 metres from either direction on an average by a car across time intervals from

morning to evening and across various points of road intersections or crossings. In the whole day, on an average per vehicle loss of time is computed as 78.26 minutes. It varies from lowest 73.49 minutes in Nongthymmai to 87.15 minutes in Police Bazar crossing.

4.3.2 Enhanced Fuel Cost

Fuel costs incurred by the respondents depend greatly on whether they commute on daily basis with their own private vehicle. Respondents revealed that about 94.5 per cent of them commute daily with their private car. Among businessmen about 57 per cent commute daily with their own car (Appendix 2).

Fuel cost due to traffic congestion is one of direct economic costs incurred by commuters daily. Fuel expenditure of the daily commuters on daily basis, has been collected for days with traffic jam and without traffic jam.

As revealed by the respondents, they commute daily for meeting their daily needs and comfort. Majority of the respondents commute daily for more than two purposes. Since they commute for several purposes, their costs associated with fuel expenditure is also high. Among private individuals about 41 per cent commute daily for school, office and marketing purpose. In case of the taxi drivers, they commute daily for their sustenance. Thus, as observed during primary survey at selected intersections; concentration of taxi is very high throughout the city. This is because they commute daily and multiple times in each day for their earnings. However, during personal interview, taxi drivers also revealed that there is drastic reduction in the number of trips due to the prevalence of traffic congestion in Shillong roads. In case of the businessmen, about 75.5 per cent commute daily for business purpose, school purpose and marketing. They revealed that whenever they commute, they face traffic jam which, increases costs of the daily commuters in terms of increase in travel time and increase in fuel costs. Therefore, being stuck in traffic jam daily (whenever they come out with car) it increases fuel costs of the daily commuters (private individual, taxi drivers and businessmen other than taxi drivers).

Table 10 depicts the increase in fuel expenditure per Kilometer travelled by different categories of the sample respondents. Among private individuals, increase in fuel expenditure is the highest in Dhankheti junction (89.62 per cent) as this is the most commuted intersection among private individuals for the

purpose of work and going to school or college. Among taxi drivers, highest increase in fuel expenditure per Kilometer is recorded in Dhankheti junction (67.34 per cent) followed by Garikhana junction. In case of businessmen, increase in fuel expenditure per Kilometer is highest in Nongthymmai Junction (109.51 per cent) followed by Garikhana junction (102.59 per cent).

Table 10: Increase in fuel expenditure per Kilometer

	Pvt Ind (INR)			***Taxi Drivers (INR)***			***Businessmen (INR)***		
Locations	***F_E_Jam/ KM***	***F_E_ Freeway/ KM***	***Increase (%)***	***F_E_ Jam/ KM***	***F_E_ Freeway/ KM***	***Increase (%)***	***F_E_ Jam/ KM***	***F_E_ Freeway/ KM***	***Increase (%)***
Mawlai	40.43	22.38	**80.65**	20.07	13.32	**50.68**	37.57	20.42	**83.99**
Garikhana	46.15	24.36	**89.45**	39.91	25.84	**54.45**	41.43	20.45	**102.59**
Dhankheti	38.05	20.16	**88.74**	28.13	16.81	**67.34**	32.51	16.08	**102.18**
Police Bazaar	35.97	18.97	**89.62**	33.45	21.69	**54.22**	38.71	21.97	**76.19**
Nongthymmai	27.31	14.5	**88.34**	24.02	16.48	**45.75**	37	17.66	**109.51**
Overall Increase	187.91	100.37	**87.22**	145.8	94.14	**54.64**	187.22	96.58	**93.85**

Source: Primary data collected during July to September 2018.

Note: (1) F_E_ Jam/KM indicates fuel expenditure during traffic jam per Kilometer and **F_E_Freeway/KM** indicates fuel expenditure during freeway per Kilometer.

Table 11: Increase in fuel expenditure as per location per day

	Pvt Ind (INR)			***Taxi Drivers (INR)***			***Businessmen (INR)***		
Locations	***F_E_ Jam***	***F_E_ Freeway***	***Increase (%)***	***F_E_ Jam***	***F_E_ Freeway***	***Increase (%)***	***F_E_Jam***	***F_E_ Freeway***	***Increase (%)***
Mawlai	428.33	239.28	**79.01**	851.83	569.50	**49.58**	307.78	171.94	**79.00**
Garikhana	439.30	231.63	**89.66**	875.92	532.041	**64.63**	320.00	163.71	**95.47**
Dhankheti	322.22	169.44	**90.16**	713.09	428.09	**66.57**	260.67	139.33	**87.08**
Police Bazaar	301.00	159.30	**88.95**	926.8	546.8	**69.50**	350.89	182.11	**92.68**
Nongthymmai	253.50	134.25	**88.83**	840.00	576.40	**45.73**	247.24	132.24	**86.97**
Overall Increase	1744.36	933.90	**86.78**	4256.65	2767.77	**53.79**	1485.66	792.91	**87.37**

Source: Primary data collected during July to September 2018.

Note: (1) F_E_ Jam indicates fuel expenditure during traffic jam and ***F_E_Freeway*** indicates fuel expenditure during freeway.

Among private individuals highest increase in fuel expenditure is recorded in Dhankheti, which is followed by Garikhana and then Police Bazaar. Dhankheti

junction being located at the heart of the city, many vehicles have to pass through this junction in order to reach their destinations. Being a junction surrounded by educational institutions, hospitals, clinics and many shops, the rising fuel costs associated with congestion in this junction is the highest for the private individuals as they are a part of major commuter in this junction. Cost on fuel is high due to the same work timings and increase in the number of vehicles passing through this junction for dropping and picking up of children from school simultaneously. Apart from this, the bus stoppages also restrict the flow of the vehicles and thereby add to the costs of traffic congestion.

In case of taxi drivers, the highest increase in fuel expenditure is incurred in Police Bazar crossing, followed by Dhankheti and Garikhana. As mentioned earlier, Police bazaar is characterized as a commercial hub with growing business activities. The area is inhabited by many offices and banks along with local and tourist taxi stands. The average rise in fuel costs of the taxi drivers is the highest in this intersection as it remains congested for most of the hours of the day starting from 10.00 A.M. to beyond 7.00 P.M. in the evening. Also, its geometric characteristics are not conducive for smooth driving when there are some cars on the road and narrow space especially from the Keating Road approach.

Among businessmen other than taxi drivers, highest fuel expenditure growth is observed in case of Police Bazaar intersection and followed by Garikhana. These two intersections being surrounded by business and commercial activities, most of the commuters in this junction are businessmen or people come for marketing. Businessmen daily pass through these junctions and face traffic congestion daily bearing its impact in terms of enhanced fuel expenditure.

On per day impact on fuel expenditure, it is found that among study locations, the highest increase in fuel expenditure in case of private individuals is found in Dhankheti (90.16 per cent) intersection; which is followed by Garikhana (89.66 per cent) and thereafter Police Bazaar (88.95 per cent). The reason behind this is due to the fact that commuters commute on daily basis to Dhankheti mainly for dropping and picking up their children (Table 11). Dhankheti is the most commuted location as it is situated at the heart of the city and surrounded by many institutions - office as well as educational. As described earlier, this location bears the burden of largest number of vehicles every day and thus remains congested in

most part of the day. Private individuals commuting daily through this junction faces traffic jam every day that cause significant increase in fuel costs. Apart from students, teachers and parents also regularly face traffic congestion throughout the day. Further, Woodland Hospital is located just near the intersection, and the stretches on either side of the crossing remain congested with vehicles as well as people. Also, among the selected intersections considered in this study, it has been found that location with the highest number of surrounding institutions is Dhankheti. There are about 45 major institutions surrounding Dhankheti intersection, and thus concentration of vehicles is high in this intersection.

Among taxi drivers highest increase in fuel expenditure is for Police Bazaar Intersection (69.50 per cent) followed by Dhankheti (66.57 per cent) and Garikhana (64.63 per cent). Most of the taxi drivers commute through Police Bazaar daily for their day to day earnings. Police Bazaar hardly remains without congestion all through the days of the week except Sunday.

Increase in fuel cost also depends on the quality of road and expenditure on fuel rises with poor road surface. The road condition of the Keating Road in Police Bazaar is very rough with severe ups and down and pot-holes and this route is among the highly congested road sections. Therefore, impact on fuel costs among taxi drivers is very high in this intersection.

In case of businessmen, the highest increase in fuel expenditure is observed in Garikhana (95.47 per cent), followed by Police Bazaar (92.68 per cent) and Nongthymmai (87.37 per cent). This is because most of the businessmen mainly commute through this junction daily. Garikhana being located very near Bara Bazaar, it is found during survey that most of the commuters passing through this junction are businessmen. Also, this point remains congested during business hours, thus, fuel costs among businessmen is highest in this junction. Same in case of Police Bazaar, this is also highly commercialised intersection and most of the commuters are businessmen, thus fuel cost incurred by businessmen is also high in this intersection.

4.3.3 Opportunity Cost

Changing opportunity costs and monthly vehicle operating costs form important part of direct cost associated with traffic congestion. With limited time resources,

every time an individual makes choice about any trip to particular destination, with delay in traffic has to forgo other options available to him. Rising opportunity costs on account of enhanced travel time may be examined in monetary value assigned to it. The estimated value of opportunity costs associated with congestion is estimated from the responses and presented in Table 12. Among private individuals, average opportunity cost is comparatively highest in Dhankheti and Police Bazaar intersections. This is due to the reason that the ability to forecast travel time in these intersections is almost impossible as it remains congested most of the time of the day. Therefore, opportunity cost incurred by them is also very high in these locations. Among taxi drivers, comparatively higher opportunity cost is recorded when they pass through Dhankheti and Police Bazaar intersections than the other three. The Dhankheti intersection from Malki approach remains severely congested for sometimes more than an hour, therefore opportunity cost reaches very high as per people response. Similarly, the Keating road in Police Bazaar remains congested during the peak business hour of the day, and some passengers prefer to get down and walk instead of sitting in the taxi idle.

Vehicle Operating Costs (VOC) are costs associated with the maintenance of vehicle from time to time. Costs associated with car maintenance include besides fuel costs, costs on lubricants like engine oil, grease and other oils, expenditure on tyre, spare parts, garaging charges etc. Among private individuals VOC increases mostly in Mawlai intersection followed by Dhankheti and Police Bazar. The VOC depends on the geometry of road and its condition. In Mawlai intersection from Mawdatbaki approach the road condition is very poor that leads to increase in costs on tyre, spare parts, etc. thereby lead to increase in total VOC.

Similar situation is observed in case of the rising VOC of the taxi drivers, where highest vehicle maintenance costs are recorded in Mawlai intersection followed by Garikhana and Police Bazaar intersection. In case of Garikhana approach, the road structure is not very smooth and therefore adds to the costs of maintenance. Also, in case of Police Bazaar, Keating road remain congested due to erratic parking of vehicles on the roadsides. Moreover, severe upward and downward slopes of the road compound the problem of VOC. For businessmen, as most of them travel to

Police Bazaar and Bara Bazaar, additions to VOC mostly occur in Police Bazaar intersection and followed by Mawlai and Garikhana.

Table 12: Average opportunity costs and monthly vehicle operating costs of private individuals, taxi drivers and businessmen

	Average Opportunity Cost (Rs)			**Monthly Vehicle Operating Costs (Rs)**		
Locations	***Pvt Ind.***	***Taxi drivers***	***Businessmen***	***Pvt Ind.***	***Taxi drivers***	***Businessmen***
Mawlai	426	937	522	786	1771.67	472.22
Garikhana	458	896	574	653	1361	351.61
Dhankheti	522	1043	880	733	790.48	373.33
PB	522	940	807	684	850	402.222
Nongthymmai	297	671	868	445	522.92	328.95
Coef. of Var.	**18.61**	**13.72**	**20.78**	**17.67**	**42.27**	**12.86**

Source: Primary data collected during July to September 2018.

Here we observe significant variation in opportunity across five locations with varied congestion and thus the variation has been due to significant variation in congestion level.

4.3.4 Total Annual Costs of Congestion

For the estimation of total annual costs of congestion, daily fuel cost, opportunity cost data and monthly vehicle operating costs of the respondents have been taken into consideration. Daily fuel costs and opportunity costs of the individuals for days with traffic jam and for days without traffic jam have been collected from the respondents (private individuals, taxi drivers and businessmen). Then, it is multiplied by 313 (365 days less 52 days since on Sundays there is no congestion as revealed by the respondents) to convert into annual data. Annual increase in fuel costs and opportunity costs in terms of percentage has also been calculated for all locations (Table 13 and Table 14). Likewise, monthly vehicle operating costs of the respondents have been multiplied by 12 to estimate yearly car maintenance costs (Table 15).

Table 13 depicts annual fuel costs location wise for all categories of individuals. Results showed that the rate of increase in fuel expenditure is highest for Nongthymmai intersection (134.88 per cent) followed by Dhankheti junction (90.16 percent). This is because Nongthymmai junction consumes more fuel due to steep curved road and long queue, which is prevalent throughout the day. In

case of taxi drivers, rate of increase in fuel expenditure is highest in Dhankheti junction (68.11 per cent) followed by Garikhana (54.83 per cent). Among businessmen, increase in fuel expenditure is the highest in Nongthymmai (98.61 per cent) followed by Dhankheti (97.84 per cent) and Garikhana (95.47 per cent). Table 14 depicts the location wise increase in annual opportunity costs. Results showed that highest opportunity is incurred by the private individuals when they commute through Garikhana junction (233.90 per cent) followed by Mawlai (210.76 per cent). In case of taxi drivers, the highest increase in opportunity costs is for Police Bazaar intersection (173.26 per cent) followed by followed by Mawlai (163.85 per cent) and Dhankheti intersection (160.71 per cent). Among businessmen highest opportunity costs is incurred by those who commute by Nongthymmai (145.63 per cent) followed by Garikhana (115.76 per cent).

Maintenance costs of vehicles is highest among private respondents commuting through Police Bazaar, among taxi drivers Vehicle Opportunity Costs (VOC) is highest in Mawlai and among businessmen VOC is highest for respondents commuting through Nongthymmai (Table 15).

Table 13: Annual fuel costs and percentage increase due to traffic congestion (location wise)

	Pvt Ind (INR)			***Taxi Drivers (INR)***			***Businessmen (INR)***		
Locations	**A_F_ Cost_ Jam**	**A_F_ Cost_ Freeway**	**Rate of Increase (%)**	**A_F_ Cost_ Jam**	**A_F_ Cost_ Freeway**	**Rate of Increase (%)**	**A_F_ Cost_ Jam**	**A_F_ Cost_ Freeway**	**Rate of Increase (%)**
Mawlai	5630870	3145650	**79.00**	15997430	10695210	**49.58**	1734020	968735	**79.00**
Garikhana	5912570	3117480	**89.66**	13433960	8676360	**54.83**	3104960	1588475	**95.47**
Dhankheti	4538500	2386625	**90.16**	9965920	5928220	**68.11**	2469570	1248870	**97.74**
PB	4710650	2493045	**88.95**	7283510	4735690	**53.80**	4666830	2698060	**72.97**
Nongthymmai	49948540	21265220	**134.88**	6573000	4510330	**45.73**	6269390	3156605	**98.61**

Source: Primary data collected during July to September 2018.
Note: A_F_Cost_Jam indicates annual fuel cost during Jam and A_F_Cost_Freeway indicates annual fuel cost on Freeway.

Table 14: Annual opportunity costs and percentage increase due to traffic congestion (location wise)

	Pvt Ind (INR)			***Taxi Drivers (INR)***			***Businessmen (INR)***		
Locations	O_Cost_ Jam	O_Cost_ Freeway	**Rate of Increase (%)**	O_Cost_ Jam	O_Cost_ Freeway	**Rate of Increase (%)**	O_Cost_ Jam	O_Cost_ Freeway	**Rate of Increase (%)**
Mawlai	5602700	1802880	**210.76**	17590600	6666900	**163.85**	2942200	1552480	**89.52**
Garikhana	6166100	1846700	**233.90**	13740700	5321000	**158.24**	5571400	2582250	**115.76**

Dhankheti	7355500	2967240	**147.89**	13709400	5258400	**160.71**	8263200	4131600	**100.00**
PB	8169300	2848300	**186.81**	7355500	2691800	**173.26**	11361900	6375810	**78.20**
Nongthymmai	1862350	657300	**183.33**	5042430	2253600	**123.75**	20658000	8410310	**145.63**

Source: Primary data collected during July to September 2018.
Note: O_Cost_Jam indicates opportunity cost during Jam and O_Cost_Freeway indicates opportunity cost on Freeway.

Table 15: Total yearly vehicle operating costs of private individuals, taxi drivers and businessmen

	Yearly Vehicle Operating Costs (Rs)		
Locations	***Pvt Ind.***	***Taxi drivers***	***Businessmen***
Mawlai	396000	1275600	102000
Garikhana	7190500	800400	130800
Dhankheti	8577500	398400	134400
Police Bazaar	9526500	255120	217200
Nongthymmai	2171750	150600	300000
Total	**27862250**	**2880120**	**884400**

Source: Primary data collected during July to September 2018.

5. Testing Significance of Impact of Congestion on Indicators of Productivity/Efficiency

Here we also tried to examine the significance of impacts of traffic congestion by using t-test with respect to indicators like extra time spent on traffic jam, increasing fuel expenditure and decline in productivity of the commuters. Apart from this, decline in frequency of trips of the taxi drivers in Shillong city due to traffic jam is estimated. Traffic congestion not only affects the taxi drivers adversely but also the businessmen who has to incur significant opportunity costs for being unable to start or operate their businesses timely due to traffic congestion. It is found that the opportunity costs of the taxi drivers are much higher as compared to that of the private individuals, as net profit of private individuals are least affected being government servant. Whereas net earnings of the taxi drivers are immensely affected for being caught in traffic jam and thus their productivity is adversely affected to a great extent.

The hypothesis to test is that there is significant difference in number of trips, time spent, fuel expenditure and net profit of the taxi drivers with changes in traffic

congestion. The t-test is used for the said hypothesis and if t is significant, we reject the null hypothesis and accept that there is significant variation in those target variables due to variation in traffic congestion.

Table 16: Test statistics for effects of traffic congestion on drivers' productivity

Indicators	***Mean***	***SD***	***SE***	***t***	***df***	***p-value***
Within Trip with Traffic Congestion and Trip Without Traffic Congestion	-5.145	2.71	0.19	-26.89	199	0.00
Within Time Loss on less Congested day and Time Loss on Severely Congested Days	-87.75	31.90	2.26	-38.90	199	0.00
Within Fuel Expenditure on Less Traffic Days and Fuel Expenditure on Severely Congested Days	-188	105.77	7.48	-25.14	199	0.00
Within Net Profit on Less Congested Days and Net Profit on More Congested Days	281.75	233.89	16.54	17.04	199	0.00

From Table 16 it is evident that there is significant reduction in the number of trips, increase in travel time for identical distance, rise in fuel expenditure and reduction in net profit of the taxi drivers when compared those values of the days of traffic jam with those of the days without traffic jam.

6. Concluding Remarks

This paper reveals almost regular occurrence of traffic congestion in Shillong, which becomes severe at some time intervals of the day. Intensity of congestion varies across road intersections and its impact also varies accordingly from morning to evening. Variation in incidences also observed across different groups of individuals with varied occupations and activities with changing frequency as well as timing of vehicle operations. Therefore, the analysis reflects upon the need of controlling traffic congestion either through engineering solutions like construction of flyovers, use of IT, stopping illegal parking, roadside parking, widening of road wherever possible and better traffic management. Also, relocation of offices, institutions towards less traffic areas along with diversion of upcoming residential establishments can help in reducing such adverse impacts. Solution to traffic congestion is essential for the maintenance of smooth traffic flow and optimum utilisation of communication facilities and its creation to meet growing demand for road facilities and its sustainability.

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Appendix 1: Frequency distribution of five most congested intersections in Shillong

	First		*Second*		*Third*		*Fourth*		*Fifth*	
Locations	***Freq***	***%***	***Freq***	***%***	***Freq***	***%***	***Freq***	***%***	***Freq***	***%***
Laitumkhrah	85	14.2	47	7.8	39	6.5	0	0	24	4.0
Garikhana	107	17.8	**173**	**28.8**	48	8.0	73	12.2	60	10.0
PB	66	11.0	21	3.5	**168**	**28.0**	99	16.5	5	.8
Anjalee Point	3	.5	0	0	130	21.7	81	13.5	0	0
Mawlai	67	11.2	10	1.7	0	0	15	2.5	**130**	**21.7**
Dhankheti	**137**	**22.8**	111	18.5	2	.3	51	8.5	119	19.8
Civil	0	0	101	16.8	92	15.3	1	.2	81	13.5
Bara-bazar	3	.5	31	5.2	64	10.7	61	10.2	106	17.7
Mawkhar	0	0	17	2.8	0	0	0	0	0	0
Rhino Point	0	0	9	1.5	4	.7	0	0	27	4.5
Barik Point	107	17.8	0	0	0	0	6	1.0	11	1.8
Nongthymmai	0	0	50	8.3	0	0	**166**	**27.7**	0	0
Don Bosco	0	0	8	1.3	46	7.7	1	.2	0	0
Malki Point	9	1.5	0	0	0	0	0	0	0	0
Polo Crossing	10	1.7	22	3.7	0	0	37	6.2	0	0
Rilbong	6	1.0	0	0	7	1.2	2	.3	1	.2
Mawiong	0	0	0	0	0	0	7	1.2	0	0
Lachummeire	0	0	0	0	0	0	0	0	11	1.8
IGP	0	0	0	0	0	0	0	0	25	4.2
Total	**600**	**100**	**600**	**100**	**600**	**100**	**600**	**100**	**600**	**100**

Source: Calculated by the author using primary survey conducted during July-September, 2018.

Appendix 2: Distribution of sample respondents according to the use of own car daily

	Private Individuals		***Taxi Drivers***		***Businessmen***	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Yes	189	94.5	100	100	114	57
No	11	5.5	0	0	86	43
Distribution of sample respondents according to the number of days of travel per week						
	Private Individuals		***Taxi Drivers***		***Businessmen***	
Day (s)	*Frequency*	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
1	3	1.5	0	0	0	0
2	12	6	0	0	0	0
3	18	9	15	7.5	21	10.5
4	10	5	5	2.5	65	32.5
5	21	10.5	0	0	114	57
6	50	25	0	0	0	0
7	88	43	180	90	0	0

Source: Calculated by the author using primary survey conducted during July-September, 2018.