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# DETERMINING THE ENVIRONMENTAL COST DUE TO TRAFFIC CONGESTION AT INTERSECTIONS OF KAPTAI ROAD

**Shoukat Ahmed[1] and Nahin Bahar Chowdhury[2]**

[1]Department of Urban and Regional Planning, Chittagong University of Engineering and Technology
[2]Department of Mechanical Engineering, Chittagong University of Engineering and Technology

[1]eshan0905027@gmail.com,[2]nahin1003123@gmail.com

***Abstract****-For quite some time, professional planning is being practiced in our cities. Unfortunately, some time proper planning and management do not maintain in some sector and proper forecasting is not performed for planning. The transportation network design in the rural roads of this Chittagong is such type of sector. To understand the problems and negative impact of low planning guidance and poor maintenanceKaptai road is selected as the case study area for future exploration and analysis. This case study examines the existing situation and assessing causes behind the problems, inquiring about the likings and disliking of the stakeholders and identifying possible solutions as an essential input towards arriving at appropriate planning decisions. Considering physical characteristics, topography, catchment area and the routes of existing road major intersection points is selected for the analysis purpose. It is observed that this road is gradually losing its functionality. The study thus helps us to understand the nature, type and magnitude of the problems faced by the road users.*

**Keywords:** Planning and Management, Transportation, Physical Characteristics, Topography, Planning Decisions.

## 1. INTRODUCTION

The Kaptai road is an important road in Chittagong. This road is connected with many important place or institutions such as Modunaghat sub power station, Chittagong University of Engineering & Technology, Raozan power plant, Kaptai Lake, Chondroghona paper mill, Kaptai water electricity plant etc. Environmental cost is a significant cost and an externality in terms of economic efficiency and to some degree in terms of equity due to differences in pollutants released by different modes. Thought pollutants are released by different vehicles and it is affected the environment as well as road users. The pollutants cause disease and harms different ingredientsof environment.Because it is largely internal to road users as a group, it is inappropriate to add environmental cost with other costs when calculating total costs. This framework incorporates environmental costs creates by individuals when they suffer from many diseases for the pollutants and spend money for treatment. When the Pollutants make corrosion different ingredients of environment, environmental cost occurs. These costs are measured as environmental cost.Traffic congestion can be awful not just for drivers, but economies and the environment as well. We will examine environmental costs due to pollutants released by traffic at the intersections of Kaptai Road.

## 2. LITERATURE REVIEW

Traffic congestion causes cars to slow down, even to stop. When cars are idle, they are still burning fuel and releasing fuel into the atmosphere. Vehicle fuel emissions, or volatile organic compounds, are one of two main ingredients in smog. Cars idling in pockets of traffic congestion use more fuel than cars not required slowing down because they spend more time on the roads, thereby using more gas.

In their 2004 study, the American Highway Users Alliance reported that adequate repairs to our highways could reduce smog-contributing emissions by 50%, and would reduce rush hour delays by 74%, saving commuters an average of 30 minutes more each day. [1]A full assessment of the cost of traffic jams would require the impacts on the economy, the environment and health all to be taken into account, which is not yet possible with current data and models.

There are, however, a number of estimates, based inter alia on the loss of productivity resulting from employees arriving late, obtained by multiplying the hours of jams by the average hourly wage. According to the report, congestion caused cars to produce an extra 56 billion pounds of carbon dioxide nationwide, with Cincinnati commuters producing 421 million pounds. [2]

Recent studies show that breathing street-level fumes for just 30 minutes can intensify electrical activity in brain regions responsible for behavior, personality and decision-making, changes that are suggestive of stress. Children in areas affected by high levels of emissions, on average, scored more poorly on intelligence tests and were more prone to depression, anxiety and attention problems than children growing up in cleaner air [3]. In recent years, planning has begun to stabilize greenhouse gas emissions at levels far below today's emissions rate, while still meeting our long-term energy needs. Goals are being set to stabilize these greenhouse gas emissions in order to avoid global climate change. As one of key greenhouse gases to control, particular focus has been placed on carbon dioxide ($CO_2$), generated from various vehicular traffic at the time of congestion. In order to reduce $CO_2$ emissions from the transportation sector, policy makers are primarily pushing for more efficient vehicles and the use of alternative fuels.

## 3. METHODOLOGY

To determine the environmental cost due to congestion occurring at the intersections of KaptaiRoad,it needs to collect all data related to vehicle type, types of fuel used, and congestion duration including current conditions of junctions. The data will be collected by observation as well as from the Secondary data.

### 3.1 Primary Data

Primary data of this study are congestion duration of different intersection at different times of the day, what type's vehicle creates congestion and their fuel type.

### 3.2 Secondary data

Secondary data of this study is emission rate of pollutant by different types of vehicles.

### 3.3 Data analysis

After completing the field work and data collection, the data is represented in tabular form. The result of survey was summarized both in map form and statistically. We determined numbered of premature death by,

$$Number\ of\ premnature\ death \equiv V + 69\ SOX + 97.5\ PM10 + 11.7\ NOX$$

And Mortality Cost by,

$$Mortality\ Costs = Number\ of\ premature\ death\ (N) \times Value\ of\ Statistical\ Life\ (VSL)$$

## 4. STUDY AREA PROFILE

The study area is the Kaptai road. It is started from the KaptaiRastarMatha and ends at LichuBagan. It is about 47 kilometer long. The width of the road is about 20ft.In the road there are a few congestion points such as Noju Mia Hat, Madunaghat,Noapara, Pahartoly, Moriomnagar, Roajar hat and LichuBagan. Among them Noju Mia Hat, Noapara, Pahartoly, Moriom Nagar and LichuBagan are the most important congestion points.

Noju Mia Hat comes at first. It is one of the most important road junctions of Kaptai road. In this place there are a number of banks, offices, shops, a kacha bazaar is found. People from the adjacent area as well as outside people of the come here for different purpose. There is a CNG filling station beside Noju Mia Hat and also a CNG station at that place. It creates congestion also. People and cars gather there and a large amount of pollutants released.

Noapara is a commercial area. Its land use attracts people and people from different places gather here as a result different types of vehicle gather. So congestion occurs.

Pahartoly is another place of importance. It is a commercial place and a road junction. Roads from four direction ends here and bus, truck, CNG, micro bus creates congestion. It happens at the morning and at the evening.

Moriomnagar is a famous fish market. Some scrap shops and saw mill is also found there. So loading and unloading goods createcongestion.

LichuBagan is a bus station as well as a CNG station. Land use of this area is also important. So cars gather there and congestion creates.

### 4.1 Physiographic Condition

**T**he study isflooded during rainy season.It lies within a sub-tropical monsoon climate range, characterized by a pronounced warm south-west monsoon rainy season occurring between April and October. The period November to April (May) is referred to as the dry season. Average annual rainfall is 2500 mm, rising to approximately 3000 in the extreme south-east. The average temperature is near 20 degree Celsius. A difference also varies in these months. June to September less varies of temperature. Hottest temperature is near 32 degree in the month of May**.** The study area receives on average 2735 mm (107.7 in) of precipitation annually or 228 mm (9.0 in) each month. On balance there are 135 days annually on which greater than 0.1 mm (0.004 in) of precipitation occurs or 11 days on an average month[4]. The month with the driest weather is January when on balance 6 mm (0.2 in) of rain across 2 days. The month with the wettest weather is July when on balance 598 mm (23.5 in) of rain falls across 26 days.Mean relative humidity for an average year is recorded as 73.7% and on a monthly basis it ranges from 58% January & February to 86% in August[5].

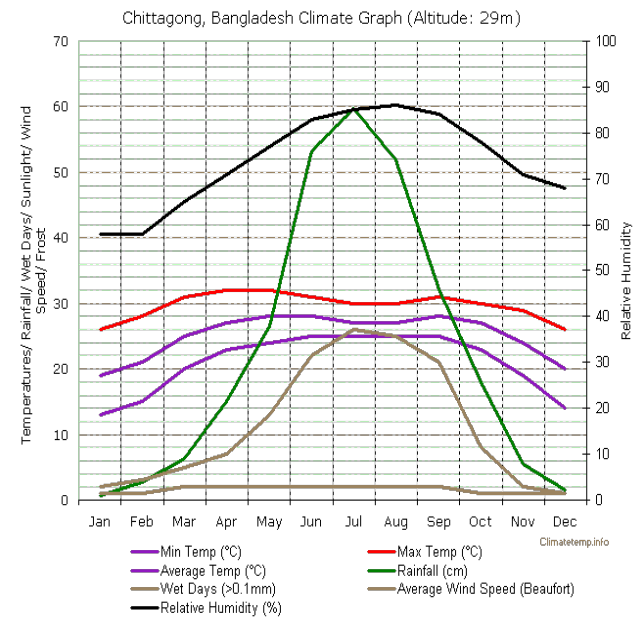


Fig.1: Temperature versus Month graph (Chittagong).

## 5.VEHICLE COUNT AND DELAY TIME SURVEY

Vehicles create congestion and make the environment polluted. These factors increase the cost of man. It is needed to determine the congestion points, number of vehicles during the congestion, congestion duration, vehicle type, type of fuel. So this data are collected in different congestion points. They are given below.

### 5.1 Noju Mia Hat

It is one of the important congestion points of Kaptai Road. Congestion occurs here frequently. During the survey congestion duration and vehicle types and their number are counted. For Noju Mia Hat the congestion duration is 3.03 minute. The congestion duration, type of vehicle and their numbers are shown in the table 1.

### 5.2 Noapara

Noapara is a busy place for its land use. For 10 minutes survey time it is found that 9.97 minute congestion duration. Congestion duration, vehicle number and their types are shown in table 1.

### 5.3 Pahartoly

Pahartoly is another road junction. Congestion duration is 1.3 minute. CNG is mainly responsible for congestion here. Congestion duration, vehicle number and their types are shown in table 1

### 5.4 Moriom Nagar

It is another road junction. Congestion is found 2.08 minutes. There congestion occurs for the reckless behavior of CNG drivers. During the congestion time 34 CNG was found. Congestion duration, vehicle number and their types are shown in table 1.

### 5.5 LichuBagan

Congestion duration of Lichubagan was 1minute found. Congestion duration, vehicle number and their types are shown in table 1.

Table 1: Vehicle count and Delay Time survey at 5 different intersection point

| Name of the vehicles | Intersections Name | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nojumia Hat | | Noapara | | Pahartali | | Marium Nagar | | LichuBagan | |
| | Vehicle number | Delay( minute ) | Vehicle number | Delay time (minute) | Vehicle number | Delay time (minute) | Vehicle number | Delay time (minute) | Vehicle number | Delay time (minut e) |
| Bus | 2 | 3.03 | 5 | 9.97 | 1 | 1.3 | 1 | 2.08 | 1 | 1 |
| Car | 3 | 3.03 | 6 | 9.97 | 2 | 1.3 | 3 | 2.08 | 2 | 1 |
| Microbus | 1 | 3.03 | 13 | 9.97 | 1 | 1.3 | 3 | 2.08 | 2 | 1 |
| Rickshaw | 2 | 3.03 | 3 | 9.97 | 2 | 1.3 | 2 | 2.08 | 0 | 1 |
| CNG | 48 | 3.03 | 172 | 9.97 | 38 | 1.3 | 34 | 2.08 | 6 | 1 |
| Motor Cycle | 8 | 3.03 | 26 | 9.97 | 4 | 1.3 | 6 | 2.08 | 4 | 1 |
| Bi-Cycle | 2 | 3.03 | 1 | 9.97 | 1 | 1.3 | 1 | 2.08 | 1 | 1 |
| Human Haular | 3 | 3.03 | 7 | 9.97 | 2 | 1.3 | 1 | 2.08 | 1 | 1 |
| Truck | 1 | 3.03 | 5 | 9.97 | 2 | 1.3 | 1 | 2.08 | 1 | 1 |
| Pick up | 1 | 3.03 | 6 | 9.97 | 1 | 1.3 | 0 | 2.08 | 2 | 1 |
| Van | 2 | 3.03 | 5 | 9.97 | 3 | 1.3 | 0 | 2.08 | 0 | 1 |

## 6. ENVIRONMENTAL COST ANALYSIS

Environmental pollution is one kind of external cost of congestion. At rural road intersection fixed delay is occurred which is responsible for extra fuel consumption by motorized vehicle and this extra fuel consumption increases the emission of pollutants.Six categories of motorized vehicle: cars, CNG, bus, truck, motorcycle& micro bus had been considered.Only air pollution due to the extra fuel consumption by the motorized vehicles is considered.Four major pollutants are emitted from motorized vehicle according to *'USEPA (2003) Emission Inventory'*[6]. They are Volatile organic compound (V), Oxide of Sulfur ($SO_x$) , Oxide of Nitrogen ($NO_x$) and Particulate Matter -10 (PM-10) (U.S. Environmental Protection Agency, 2003).Engines of all motorized vehicles are considered to be turned on during the congestion period.

### 6.1 Procedure

Total amount of emitted pollutants (V, $NO_x$,$SO_x$ and PM-10) from the motorized vehicles has been collected from Vehicular Emission Inventory ofDhaka City (2004). In this inventory, specific pollutants emitted from the specific types of vehicles during operational time have been calculated in tons/year unit.

Table 2: Vehicular emission inventory of Bangladesh (tons/year)[7]

| Vehicle | km/ day | Emission (tons/year) per vehicle | | | |
|---|---|---|---|---|---|
| | | NOx (ton) | SOx (ton) | V (ton) | PM-10 (ton) |
| Car | 40 | 2865 | 153 | 7640 | 191 |
| Taxi | 130 | 612 | 0 | 816 | 12 |
| 3W-CNG | 130 | 819 | 0 | 1091 | 16 |
| LD Diesel | 60 | 4770 | 224 | 1122 | 449 |
| Bus | 130 | 9978 | 470 | 2348 | 939 |
| Truck | 60 | 7188 | 338 | 1691 | 677 |
| Motorcycle | 30 | 382 | 25 | 5095 | 127 |
| **Total** | | **26614** | **1210** | **19803** | **2411** |

Then Per Vehicle Emission Rate (mg/min) is calculated. Then obtained emission rate is divided by the number of the specific vehicle to calculate the per vehicle emission rate.

Table 3: Emission of pollutant per unit of vehicle (mg/min)

| Vehicle | Emission rate per vehicle (mg/min) | | | |
|---|---|---|---|---|
| | $NO_x$ (mg) | $SO_x$ (mg) | V (mg) | PM-10 (mg) |
| Car | 37.79 | 2.02 | 100.77 | 2.52 |
| Taxi | 122.80 | 0.00 | 163.74 | 2.41 |
| CNG | 122.90 | 0.00 | 163.71 | 2.40 |
| Micro Bus | 321.25 | 15.09 | 75.56 | 30.24 |
| Bus | 1391.96 | 65.57 | 327.55 | 130.99 |
| Truck | 642.46 | 30.21 | 151.14 | 60.51 |
| Motorcycle | 5.67 | 0.37 | 75.59 | 1.88 |

Then total amount of pollutants (mg) emitted from six categories of vehicles are calculated by multiplying the per vehicle emission rate (mg/min), the number of specific vehicles and the delay time (min). This procedure is applied when congestion occurs.

Table 4: Amount of emitted pollutants (mg) in 2013

| Intersection | Pollutants | | | |
|---|---|---|---|---|
| | NOx (mg) | SOx (mg) | V (mg) | PM-10 (mg) |
| Noju Miahat | 29183.79 | 516.21 | 29562.13 | 1404.11 |
| Noapara | 319942.356 | 4991.38 | 317604.65 | 14589.56 |
| Pahartoly | 9847.04 | 85.72 | 9801.72 | 476.94 |
| Morium Nagar | 14140.13 | 216.45 | 15301.18 | 644.42 |
| Lichubagan | 3160.9 | 105.34 | 2335.29 | 224.64 |

The total amount (mg) of annual emitted pollutants and the total amount (mg) of annual emitted pollutants have been converted in ton unit.

Table 5: Amount of emitted pollutants (ton) in 2013

| Intersection | Pollutants | | | |
|---|---|---|---|---|
| | NOx (ton) | SOx (ton) | V (ton) | PM-10 (ton) |
| Noju Mia hat | 0.264 | 0.00432 | 0.24 | 0.01224 |
| Noapara | 2.88 | 0.0432 | 2.88 | 0.1272 |
| Pahartoli | 0.0864 | 0.000768 | 0.0864 | 0.00408 |
| Morium Nagar | 0.1248 | 0.00192 | 0.1344 | 0.00552 |
| Lichubagan | 0.0288 | 0.000912 | 0.0204 | 0.001968 |

ThenThe effect of pollutants has been determined in monetary term by calculating mortality cost. To calculate this cost, the number of premature death of an infant has been determined. A grouping strategy for the pollutants has been followed to determine the number of premature death. The equation is given below:

$$Number\ of\ Premature\ Death \equiv V + 69\,SOX + 97.5\,PM10 + 51.7\,NOX \quad \ldots\ldots (6.17)$$

Table 6: Number of premature death in each intersection

| Intersection | Number of premature death |
|---|---|
| Noju Mia hat | 5 |
| Noapara | 52 |
| Pahartoli | 2 |
| Morium Nagar | 2 |
| Lichubagan | 1 |

In this research, the Value of Statistical life (VSL) for Bangladesh has been used to convert the number of premature death of an infant in monetary terms. There are several published estimates of VSL for Bangladesh. They are given below:

Table 7: Published Estimates of VSL for Bangladesh[8]

| Author | Estimation of VSL for Bangladesh |
|---|---|
| Miller (2000) | Suggests a value of US$ 40,000 (1997 US$) with a range of US$30,000 – US$ 0.7 million. |
| Mahmud (2005) | Estimates VSL for Bangladesh to be in the range of US$ 1,783 to US$ 2,922. But this estimation is very smaller compare to the previous study. |
| Wadud and Khan (2010) | Suggest US$ 190,000 (2007 US$) as the median VSL estimates for Bangladesh, while the lower and upper bound values are respectively US$ 53,000 and US$ 327,000. |

The VSL for Bangladesh which is estimated by Wadud and Khan (2010) has been considered in this research. In their estimation, they transfer the central value of few of the above mentioned estimates to Bangladesh context.

In this research 2013 has been considered as base year. So, every monetary value has been discounted by applying inflation rate and USD-BDT exchange rate. The discounted value of VSL for 2013 is21247472BDT. The calculation is given below:

Table 8: VSL for Bangladesh (2007)[8]

| VSL For Bangladesh (2007 ) USD | USD-BDT Exchange Rate (2007) | VSL For Bangladesh (2007BDT) |
|---|---|---|
| 190,000 (2007 US$) | 1USD = 69.893 BDT | 1,32,79,670 (2007 BDT ) |

Table 9: VSL for Bangladesh (2011)[9]

| Calculation of Discounting Factor | | | VSL For Bangladesh (2013-BDT) |
|---|---|---|---|
| Year | Inflation Rate (%) | Discounting Factor | |
| 2007 | 9.1 | 1 BDT (2007) = 1.60 BDT (2013) | 21247472 |
| 2008 | 8.9 | | |
| 2009 | 5.4 | | |
| 2010 | 8.1 | | |
| 2011 | 10.7 | | |
| 2012 | 7.5 | | |

Mortality cost due to vehicular emission and VSL has been calculated.

The calculation is based on the equation given below:

$$Mortality\ costs = No\ of\ premature\ death\ (N) \times Value\ of\ Statistical\ Life\ (VSL)$$

Table 10: Calculation of intersection wise mortality cost

| Intersection | Number of premature death | VSL for Bangladesh (BDT) | Annual mortality cost (BDT) |
|---|---|---|---|
| Noju Mia hat | 5 | 21247472 | 106237360 |
| Noapara | 52 | | 1104868544 |
| Lichubagan | 2 | | 42494944 |
| Morium Nagar | 2 | | 21247472 |
| Pahartoli | 1 | | 21247472 |

Therefore, the Environmental Cost (EnC) for 2013 is 1296095792 BDT.

## 7. CONCLUSION

The survey gave a clear idea about the environmental cost due to traffic congestion in the intersection. This congestion has a great negative impact on the environment. As a result of long term effect they suffer various diseases. This thing is also responsible for many premature deaths.

## 8. REFERENCES


[1] http://www.experts123.com/q/how-does-congestion-affect-the-environment.html

[2] http://www.citybeat.com/cincinnati/blog-4372-traffic_congestion_c.html.

[3] http://www.foxnews.com/health/2011/11/08/hidden-health-effects-traffic-jams/#ixzz2SAIiF5ZC

[4] Chittagong storm water drainage and Flood control master plan, 1995

[5] http://en.wikipedia.org/wiki/chittagong

[6] USEPA (2003), Air Trends Report. Retrieved May 14, 2011, from U.S.A. Environmental Protection Agency Website:http://www.epa.gov/air/airtrends/aqtrnd03/fr_table.html

[7] ]Khaliquzzaman, M. “Emission Inventory for Motor Vehicle Fleet in Dhaka”, Internal Paper, the World Bank, 2006.

[8] Bangladesh Economy 2011. (2011, February 9). Retrieved March 2, 2012, from Bangladesh Economy 2011Website:http://www.theodora.com/wfbcurrent/bangladesh/bangladesh_economy.html

[9] Miller, T. R., “Variations between Countries in Values of Statistical Life”, Journal of Transport Economics and Policy, Vol. 42, No 1, pp. 29-48, 2004