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Reducing Congestion in Dhanmondi Residential Area: Introducing Cordon Pricing

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Abstract— *Dhanmondi is one of the most affluent residential areas in Dhaka city was planned and developed by the Public Works Department (PWD) according to the order Dhaka No. 11413 requ.-9th December 1952. In 1984 about 28 percent of the houses in this area were used for non-residential purpose although the area was planned as a residential area. Since 1984 to 2006 the residential purpose of land use has decreased from 71.86% to 46.09% whereas commercial use has increased from 28.35% to 52.91%. Residents of this area own nearly 25,000 private cars. That is 209 cars per thousand populations. Numerous schools, hospitals, private universities, business institutions lead an enormous volume of traffic into and out of the area every day. Study showed that through traffic in this area is dominated by autos and smaller sized vehicles, which is one of the major causes of congestion. To reduce this congestion in this paper the prospects of introducing cordon pricing in Dhanmondi residential area is elaborately discussed. Among the various technology and scheme available a suitable scheme with a feasible technology is advised. It will cost government a total of 213.05 million taka capital and in return it is expected to earn minimum revenue of about 288.32 million taka with a profit of 75.27 million taka in the base year. It is estimated that the average traffic speed inside the Dhanmondi residential area will increase by 30%. This will increase the peak hour speed of 14.4km/hr to 18.72km/hr. It is expected to save travel time cost of 101.89 million taka, fuel cost of 23.56 million taka every year. Also it will reduce emission the monetary value of which is estimated to be 1.31 million taka.*

Key Words—car, congestion, land use, residential area.

I. INTRODUCTION

Dhanmondi is one of the most affluent residential areas in Dhaka city. It was planned and developed by the Public Works Department (PWD) according to the order Dhaka No. 11413 requ.-9th December 1952[1]. Beginning as the residential area for the city's elite, over the decades evolved into a miniature city, where one can find everything from hospitals to malls, schools, banks, offices and universities. Numerous schools, hospitals, private universities, business institutions lead an enormous volume of traffic into and out of the area every day. Being the place for all amenities, ironically this place has many problems derived from these amenities. For the last few years congestion has become a mind boggling problem for the residents. Having a grid iron pattern road network this place has always been attracting the lucrative investors. According to a study of Housing and Building Research Institute (HBRI), in 1984 about 28 percent of the houses in this area were used for non-residential purpose although the area was planned as a residential area [1]**.** Since 1984 to 2006 the residential purpose of land use has decreased from 71.86% to 46.09% whereas commercial use has increased from 28.35% to 52.91% [2]**.** Its road network originally developed to be used for residential purposes is facing a hard time to cope with the ever rising traffic volume with its limited capacity. This place is one of the most heavily built up area of the city; hence increasing the capacity of the road network is almost impossible. Under the circumstances the solution to this problem has to be found out within the area.

1.1 METHODOLOGY

On this paper case studies of various other examples of similar schemes around the world have been included. For cost-benefit analysis some data concerning the volume of traffic and peak hour of the day were collected from field survey. Raw data are not included in this paper but used for the detail calculation. Other necessary data were collected from World Wide Web. Data concerning the user travel time and vehicle operating cost have been used from previously conducted survey by the Roads and Highway department of the government.

1.2 IDENTIFYING THE RESPONSIBLE PARTIES

Dhanmondi residential area (DRA) is bounded by road no. 2 and road no. 27(old 16) at its south and north respectively and by Mirpur road and Satmosjid road at its west and east side respectively. With an area of about 1.7 square kilometer it is the home for 23898 households with a population of about 119,500. It is the home for the high income group of the city with an anticipated car ownership of nearly 100%. People here own nearly 25,000 private cars. That is 209 cars per thousand populations[3]. For Hong Kong, Singapore and Seol, Jakarta and Bangkok this number is 50, 100, 200 and 300 respectively. No wonder 209 cars per 1000 people is too high for a developing country like Bangladesh. In addition to this everyday thousands of non-resident's cars travel in, out and through this place. Undoubtebly private cars are the major cause of congestion within the residential area. Among the institutions the schools have the highest trip attraction. Over the past fifteen years there have been uprising of a myriad of private schools and now Dhanmondi houses more than 100 schools. Sultana (n.d) [4] reports that this has led to increasing traffic congestion during school hours. Most of the schools do not have their own transport buses for the students. So the students ride their own cars to school. Moreover, it has been found that 72% of the students don't share rides, making the student-to-vehicle ratio very high [5]. So the congestion level becomes high during the school hours (7:30am-9am and 12:30pm-2pm). Apparently,The primary cause of congestion in Dhanmondi is the sheer volume of traffic, which far exceeds the carrying capacity of existing roads. An extent of the growing non-residential activities due to grid pattern road network of Dhanmondi residential area and their impacts on Mirpur road are revealed by the questionnaire survey conducted both for the residents of Dhanmondi and non-residents but using Dhanmondi roads or Mirpur road by T. Khan et al (2011) [6]. In their study it was found that 42% of the trips are originating within Dhanmondi residential area with destination outside of the area; 37% of the external to internal traffic represent the non-residential traffic which is a significant amount.

1.3 ROAD PRICING

Targeting private cars as the main contributor to the congestion; measures need to be taken to control their number into the residential area. Introduction of road pricing can prove to be a suitable solution to this problem. Road pricing can be different types, such as:

- Cordon based
- Time based
- Distance based
- Congestion based

Since Dhanmondi residential area is a small zone cordon pricing is most suitable for this area. In many countries around the world it has proven to be useful in reducing the congestion in a significant level. Cordon pricing of London is quintessential in this regard. It has been operational since February 17 of 2003. London installed hundreds of cameras throughout the congestion zone, charging £10 to anyone driving within it (between operational hours of 7am-6pm, Monday to Friday). Impacts of London Congestion Pricing according to third year annual report stated that the average traffic speed during the charging days increased by 37%, peak period congestion delays declined to 30%, bus congestion delays declined 50%, and bus ridership increased by 14% [7].

In a whole it has reduced the use of private cars significantly within the charging area, increased the use of NMT and public transport to a large extent. 31% of the residents believed that the overall environment and the air quality of the charging area have improved during 2006 to 2007. A study showed that there has been a 13percent reduction in nitrogen oxide, a 15 percent reduction in particulate matter, and a 16 percent reduction of carbon emissions since the congestion charge was put into effect [7]. Besides this cordon pricing has also become a source of government income. London's administration has been using this revenue to improve the quality of public transit throughout the city and especially within the charged area. According to Transport for London, the annual net income (the annual costs minus the annual expenses) of the congestion charge since 2003 is as follows [9].

- 2003: (£58.3 million) (or a loss of $116.6 million USD)
- 2004: £45.3 million ($90.6 million USD)
- 2005: £96.4 million ($192.8 million USD)
- 2006: £106.3 million ($212.6 million USD)
- Net Operating Total of £189.7 million ($379.4 million USD)

According to Transport for London, the £42 million supplementary investment on safety (provided by the congestion charge), has resulted in a 40 percent decrease in serious injuries or fatalities, and a 40 to70 percent reduction in private vehicle crashes. The £42 million have been used to increase the number of cameras, increase traffic calming measures and increase the number of safety campaigns throughout the city. Inspired by the success of London's congestion charge, and with a desire to more evenly distribute the flow of traffic entering its city centre, Stockholm introduced its own congestion pricing system on January the 3rd, 2006. Stockholm's congestion tax has something else in common with London's equivalent – it's been a big success. Public transport has seen a 4.5% increase in ridership, traffic is down by 18%, and waiting time to enter the city centre during peak hours has been reduced by 50%. There have also been environmental and economic benefits. Carbon emissions have dropped by 14-18%, ownership of taxexempt environmentally sustainable vehicles has almost tripled, and retailers have seen a 6% increase in business [10]**.** Cordon pricing today is on operation in Genoa, Copenhagen, Prague, Shanghai, Honk Kong and is proven to be a successful tool in reducing congestion. The benefits that they achieved are summarized in the following Table I:

TABLE I: **B**ENEFITS OF CONGESTION PRICING AROUND THE WORLD

Location	Year of Launch	Benefits
Singapore	1975	Traffic in the zone reduced by 13% during charging periods, average traffic speed increased 20%
Durham, UK	2002	85% reduction in vehicle trip.
Rome, Italy	1998	Car traffic reduced 15-20%, public transport increased 5%.
Oslo, Norway	1990	Reduction am peak traffic 10% (region) and 20% (ring area), growth in public transport 6-9%.
The Netherland s	2012 (heavy good vehicles), 2016 (all vehicles)	40% less congestion expected
Helsinki, Finland	2011 (proposed)	Congestions will be reduced 2/3, average speed will be increased by 5-7km/h (expected)

Source: The Credit Dynamics of Congestion Charging [10]

1.4 CORDON PRICING IN DHANMONDI RESIDENTIAL AREA

1.4.1Charging Area

The residential area is bounded by four roads at its four sides as stated earlier. The area has totaled 31 entrance points, 4 of which end in a cul-de-sac. Charging area will be bounded by the red line as given in the Fig. 1.

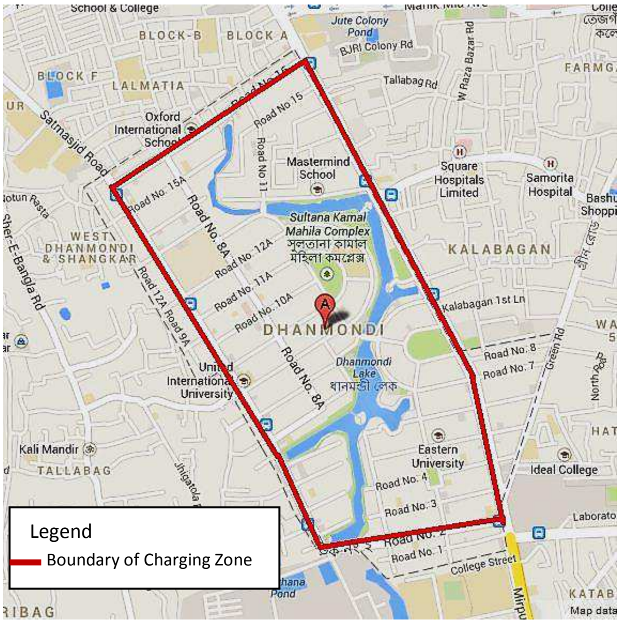

Fig.1. Proposed Cordon Pricing Zone

Vehicle will be charged each time as they enter into the area. Only the private cars will be charged. Taxi cabs, CNGs, other public transports, school buses, police cars, government vehicles and emergency vehicles will be exempted. No charge will be implied as the vehicles drive out of the cordon.

1.4.2 Charging Hour

There is no definite peak hour within which traffic volume is highest within the residential area. Morning rush hour is 7:30am to 9am. At midday morning shifts of most of the schools break out. From 12:00 at noon to 1:30pm volume remains higher than normal. From 4:30pm the evening shifts of the schools break out. So the evening rush hour starts at around this time and continues up to 8pm. Charging period will be 7:30am to 8:00pm on weekdays (Sunday to Thursday).

1.4.3Congestion Charge

Congestion Charge is estimated based on the annual per capita GDP of Bangladesh. As following the idea of London Congestion charge, comparing their charge of £10 and annual per capita GDP (Purchasing Power Parity, PPP) of $36700 with per capita GDP of Bangladesh of $2000 (PPP) [12], congestion charge is estimated to be £0.545 or 65tk. Cars owned by the residents will enjoy 90% exemption, i.e. they have to pay 6.5tk every time they enter into the area. But to enjoy this benefit, residential cars will have to register first with a minimal cost of 100tk. For an optimistic analysis a congestion price of 100tk has also been considered.

1.4.4 Technology/ Charging Mechanism

Most common charging mechanisms are [13]:

1. Area Licensing Schemes (ALS): Need to buy and display coupon or license.

2. Electronic Road Pricing (ERP): Based on in-vehicle transponder units (IUs) that accept stored-valued smart cards for payment, each time vehicles pass through a gantry when the system is in operation, the ERP charges will be automatically deducted.

3. Electronic Toll Collection (ETC): Based on microwave technology and in vehicle tags. When a car passes tolled booths the system reads data about the car taking into account the time and place of the passing.

4. Initial Electronic Security Systems (IESS): Cameras record images of traffic and send them to a central processor to have their number plates read and checked against the list of vehicles that have been paid for.

5. Tag and Beacon Technology: Tag and beacon involves cars having an electronic tag on the windscreen, which emits radio signals when it passes a roadside beacon, automatically paying the congestion charge.

6. Global Positioning Systems (GPS): Motor vehicles have a tracking device which constantly records the time and location of the vehicle through satellite.

Among the above mentioned methods tag and beacon with ANPR (Automatic Number Plate Recognition) camera could be considered as most effective according to the cases around the world as shown in Table II.

For local condition in Bangladesh a tag and beacon system may seem to be too costly. Thereby the ANRP (Automatic Number Plate Recognition) camera that will be used for enforcement will be enough. Automatic charge collection may be done by using cell phones or a simple procedure of sending a text message while a vehicle drives into the charging zone. GPRS type is also popular in many countries but will again too costly for

TABLE II: TECHNOLOGY CONSIDERED FOR CONGESTION CHARGING AROUND THE WORLD

	ANPR	Tag and Beacon	GPRS Type
Local Scheme			
London	√	√	
Geona	√	√	
Copenhagen	√	√	
Prague	√	√	√
Helsinki			√
Stockholm	√	√	
San Francisco	√	√	√
Seattle	√	√	√
Auckland	√	√	√
Shanghai	√	√	
Hong Kong			√
National Scheme			
England			√
Netherland			√

Source: See Reference [12]

Bangladesh. In GPRS system all the vehicles of the city have to be equipped with an in vehicle unit costing 150USD (12,500BDT) each unit. That will require huge amount of capital which may not be feasible. Charge can be collected by online, by text message, by phone, by post services. No new exclusive system has to be developed for collection of charge. Users can pay in advance or the day at which they enter the charging zone. A penalty is to be added for the late payers. In the cost benefit analysis penalty charge is estimated to be half of the congestion charge. Charge collection by mobile phone or by text message may prove to be most convenient for the users. Up-to now there are 6 different mobile phone operators providing service throughout the country.

4.5 Enforcement

Available most common enforcement techniques are [13]:

X-Wave Camera: Analogue, colour and used to give an image of the vehicle in the context of its surroundings.

CCTV Camera: Analogue, monochrome and provide images for reading number plates.

Automatic Number Plate Recognition (ANPR) Technology: All images are sent to the ANPR via a telecommunications system. This system is based on dedicated DWDM (dense wave division multiplexing) technology which links the central data hub with each of the network cameras over analogue video circuits. The ANPR creates a data block for each recognized number plate showing the time and date that the images were taken. These are then checked against a database to verify payment or eligibility for discounts and exemptions.

Cost benefit analysis in the next section will be based on the use of ANRP camera for the operation and enforcement of cordon pricing in DRA.

1. COST-BENEFIT ANALYSIS

Every vehicle entering the area must have digital registration plate that is readable by an ANPR (automatic number plat recognition) camera. At present government has made it mandatory for all the vehicles to have digital license plate. A total of 76 ANPR cameras are estimated to be needed for the enforcement of congestion pricing. The estimated cost of an ALPR system is defined by the following equation:

(\$20,000 * C) * 1.2 = Total Cost of an ALPR system (Eberline, 2008).

- C = the no. of cameras (there is always one camera per lane at each proposed camera site)
- \$20,000 = the cost of each ALPR camera

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- 1.2 = takes in to account the 20% estimated soft costs such as installation and fiber optics.

Hence total cost = ($20,000 * 76) * 1.2 = $1824000
In BDT installation cost = 1824000*77.867=142.03 Million Taka.
Operating Cost of Each Year (50% of Installation Cost) = 71.02 Million Taka. The cost benefit of the first year of implementation is given as follows:

TABLE III: COST BENEFIT ANALYSIS FOR CONGESTION CHARGE = 65TK

Residential vehicles as %of total vehicles	Total Cost Million BDT	Total Benefit** Million BDT	Net Profit** Million BDT
80	213.05	288.32	75.27
70	213.05	380.19	167.14
60	213.05	472.06	259.01

***Detailed Calculation is not provided.*

Now, as congestion charge is a form of social cost, it must depend on the level of congestion created in the charging zone. Comparing the population density of London's CCZ (Congestion Charging Zone) of 12,333/sq.km with the that of DRA which is 70,289/sq.km, the congestion created in DRA should impose 5.7 times as much problem to the population inside the DRA as London's CCZ. Hence a more reasonable, yet a little optimistic congestion charge can be applied. Thus the cost benefit result comes as follows:

TABLE IV: COST BENEFIT ANALYSIS FOR CONGESTION CHARGE = 100TK

Residential vehicles as %of total vehicles	Total Cost Million BDT	Total Benefit** Million BDT	Net Profit** Million BDT
80	213.05	442.22	229.17
70	213.05	583.55	370.51
60	213.05	724.89	511.84

***Detailed Calculation is not provided*

From the calculation the cost of implementation and operation for each year the authority has to pay an amount of 213.05 million taka. From the system minimum profit is expected to be 75.27 million taka and the most optimistic operation will bring a profit of 511.84 million taka at the base year.

II. USER BENEFITS

Users are surely the beneficiary of the cordon pricing. User can be benefited in various ways, such as their travel time will be saved, fuel cost will be saved, as from the environmental point of view the emission is also reduce to some extent. The Australian Transport Council [15] suggests a method for estimating decongestion benefits using the following three elements: 1. an estimate of the quantity of road traffic removed from the road system, 2. an estimate of the change in travel speed, and 3. a value of travel time for car occupants.

As seen from international experience the removal of traffic volume after the implementation of cordon pricing ranges from 15% to 40% of volume before the implementation. In the case of Dhanmondi R/A, a reduction of 25% road traffic volume can be expected. The model of finding the extent of user benefits used in this study in the most generalized form is as follows:

Total financial value of benefits = Travel time value (TV)* total time saving (TS) + Fuel cost (FC) * Fuel saving (FS) + emissions reduction cost (EC)* amount of emissions reduction (ES) [13]

To find the financial values of benefits the VOT (Value of Travel Time) and VOC (Vehicle Operating Cost) are calculated and the result is added to the emission reduction cost. The volume of 38070 vehicles entering into the area during the charging period has been used for the cost benefit analysis. To find out the VOC, VOT and emission savings an estimated larger volume has been used. It is very likely that the all the vehicles inside the DRA will have the benefits not just the vehicles entering into the area. Some vehicles will travel out of the area, some will circulate within the area. Taking that into consideration the volume will be considered 40% more. So for calculation of user benefits 53298 vehicles per day have been used.

Travel Time Savings:

From international experience the increase in traffic speed after the implementation of cordon pricing ranges from 20% to 35% of volume before the implementation. We assume that the average traffic speed inside the DRA will increase by 30%. This will increase the peak hour speed of 14.4km/hr [16] to 18.72km/hr. Hence a vehicle traveling at least 1 km inside the charging zone each day will have a saving of travel time equal to 0.967 minute or 0.161 hour.

VOC and VOT savings:

To calculate the VOT and VOC saved due to congestion pricing the values provided by "RHD Road User Manual 2004-05" is used. To convert the values to meet the present scenario the inflation factor of Bangladesh is used. The following Table V shows the inflation factor used for the study.

TABLE V: INFLATION RATE USED IN CALCULATION.

Year	2004	2005	2006	2007	2008
Inflation Rate*	6.103	7.04	6.77	9.109	8.9

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Year	2009	2010	2011	2012	2013
Inflation Rate*	5.426	8.126	10.7	6.6	7.6

*** Source: CIA World Factbook[12]*

In calculating the vehicle operating cost (VOC) following parameters were used from "RHD Road User Cost 2004-2005". The values provided in the following table are converted to present value (2014) by using the inflation rates for each year. The parameters used to calculate the VOC is given in the Table VI.

TABLE VI: PARAMETERS USED IN VOC CALCULATION.

Vehicle Type	Car	CNG	Motor Cycle	Bus
Average Hour Driven	1276	1695	588	2864
Maintenance Cost (BDT/hr)	57.12	16.52	14.53	59.22
Crew Wage Cost (BDT/hr)	49.04	31.39	_	86.3
Fuel (BDT/hr)	20.65	14	12.95	109.46
Lubricant (BDT/hr)	25.5	17	8.5	76.5
Total VOC (BDT/hr)	152.31	47.52	35.98	331.49

On this particular research the VOC and VOT of private cars, CNGs and Motor Cycle are calculated. The VOC of particular type of vehicle is calculated as following method:

*VOC of Car for one year= [VOC of Car in Taka/hour * Travel time Saved in hour * number of car entering each day into the area * 320 days.]*

320 days is used by subtracting the weekends and holidays. The savings of operating cost is given in the Table VII.

TABLE VII: VOC SAVED IN THE BASE YEAR OF INTRODUCING CORDON PRICING.

Vehicle Type	VOC (BDT/hr) for 2014	Delay for 1 vehicle in hour	Number of Vehicle in a day	VOC (Million BDT/Year)
Car	152.31	0.0161	53298	41.82
CNG/Auto rickshaw	47.52	0.0161	5330**	1.305
Motor Cycle	35.98	0.0161	5330**	0.988
Total savings in Base Year =				44.113

***10% of Private cars.*

It can be seen from the above table that the total VOC saved will be 44.113 million BDT. The major portion will be saved from the VOC of private cars as they form the prime share of vehicle fleet inside the residential area. It should be noted that for the simplification of analysis the volume of motor cycle and CNG is estimated to be 10% of private cars.

With the same approach the VOT saved for the passengers is calculated. For this the TTC (Travel time cost) of each passenger of each mode was used. The simple method used is:

*VOT of Car for one year= [TTC of Car in Taka/hour * Travel time Saved in hour * number of car entering each day into the area *Average occupancy of car* 320 days.]*

The summary of VOT is given in the Table VIII.

TABLE VIII: COST ESTIMATION OF AIR POLLUTION.

Vehicle Type	Number of Vehicle in One day	Delay (hour/ Vehicle day)	Average Occupancy	TTC (Taka/ Passenger hour) for 2012-13	VOT per Year (Million BDT)
Car	53298	0.0161	3	78.35	64.543
CNG/Auto rickshaw	5330**	0.0161	3	50.46	4.157
Motor Cycle	5330**	0.0161	1	60.6	1.664
Total savings in Base Year =					70.364

***10% of Private cars.*

From the table it is seen that the total VOT saved in the base year is 70.364 Million BDT which is greater than the saved VOC. Again the main contribution is from the travel time savings of the private car passengers. As the value of travel time for the high income group is higher it is obvious that they will be benefited more from this pricing scheme. This may also help in reducing the CNG fare as the driver will face less congestion while driving inside the area.

The congestion pricing will also have environmental significance as the emission from the vehicles will also reduce. To calculate the cost of emission the emission reduction is first calculated. The emissions from the CNG driven vehicles are considered as most of the private cars use CNG as fuel. The following Table IX provides the emission rate of CNG driven vehicles used in the study.

TABLE IX: ESTIMATED EMISSION RATE OF CNG DRIVEN VEHICLES.

	Pollutants in kg/cumec		
	NOx	HC	CO
Acceleration Emissions rates	3.286	1.255	2.761
Idle Emissions Rate	--	0.02	0.33

Source: Cost/Benefit Analysis of Electronic License Plates [13]

Reduction of Pollution:

Pollution will also minimize as the volume of traffic inside the area is expected to decrease. Table 10 provides the cost estimation of emission by different researchers and the values used in this study.

TABLE IX: COST ESTIMATION OF AIR POLLUTION

Source	Cost of Pollutants in (USD/Kg of pollutant)		
	CO	NOx	HC
Wang and Santini	0.00	27.84	22.69
Bernard and Thoroe	1.1 3.04	8.21 3.04	6.7 3.63
Small and Kazimi	0.0063	1.22~1.33	1.22~1.33
Value used in the study	1	_	2

Source: Cost/Benefit Analysis of Electronic License Plate [13]

Now the CNG fuel used for per Kilometer of road traveling at an average speed of 14 to 17 kmph is 0.25 m^3. Again the fuel used by idle vehicle in congestion or traffic jam is 0.008 m^3 per hour.

Hence, Total Vehicles (private cars and Auto rickshaws) traveling in the charging zone per day is 58628 as used in the Table V and Table VI.

Total yearly time will be saved by all these vehicles are 302051 hours. It will result in the savings of 2416.4 m^3 of CNG fuel. Hence saving in emission

Emissions: HC = 3032.6kg, CO = 6671.6kg

Emission costs will be saved = $69750 = 5.675 Million Taka.

Total user benefit in = VOT + VOC + emission reduction = 70.364 + 44.113 + 5.675 = 120.152 Million BDT/year.

These benefits are only a rough prediction. The whole revenue earned from this project will be used to improve the public transport system. Starting from the boundary zone of DRA, in a progressive and sequential way public transport of the whole city will be benefited**.** From the revenue the government can help the schools situated within the residential area to initiate a well-organized school bus service. With the incorporation of banning on street parking the private car trips to school will be reduced. Because the drivers will have to enter the area twice on a school day, once to drop the student at the school and other to pick up student from school. These will cost them at least 130 BDT. Thus bus ridership will surely increase. Once the school bus service system is able to earn the trust of the parents; it will be a great step towards the mitigation of congestion during the school hours. So the user benefit will have a much higher value than estimated.

III. PREREQUISITES FOR IMPLEMENTING CORDON PRICING IN DRA

Integrated effort is necessary for the success of congestion pricing scheme. A better public transport facility is a must for this. Better means high-quality services; cheap, straightforward fares; public transport that can used by all, regardless of mobility; and an integrated system, so that buses and trams and trains and taxi-buses all connect to each other, giving a door-to-door service. Before implementing cordon pricing some facts must be looked upon:

- Majority of the congestion is caused during the school hours. So before the implementation, a better transportation solution should be provided for the schools of DRA.
- People may tend to park their vehicles outside the DRA. To discourage them from doing so, high penalty for on-street parking on restricted areas should be enforced. Again for the user, who must use the car, should be given a space outside the DRA to park their vehicles for limited time. But due to a very densely populated and heavily grown urban area there are no places to provide such facilities.
- Parking ticket inside the DRA should be introduced. This to discourage the on-street parking inside the DRA.
- Vehicles entering into the DRA with commercial supplies should be charged more. That will discourage the establishment of new commercial institutions within DRA.
- To provide a better option for the through traffic the quality of the public transport should be improved in the major roads surrounding the DRA.
- NMT should be a major concern. As we concentrate on limiting the use of motorized vehicles, it should also be kept in mind that in no way the NMT vehicles particularly the rickshaws be given the chance to thrive in number within the area to create a new problem.
- Use of bicycles and walking should be encouraged for traveling within the area.
- Public acceptance is the major hindrance for the implementation of cordon pricing as experienced

from the earlier cordon pricing systems in London, Stockholm, Oslo and various other cities of the world. There are a number of hospitals situated mostly at the fringe area of DRA. Better access to these facilities can be ensured by optimizing traffic flow in the roads surrounding the residential area. To reach to these destinations emergency vehicles (i.e. ambulance) will be exempted of charge.

IV. ALS (AREA LICENSE SCHEME) IN DRA

One of the major prerequisite of introducing ANPR camera is that there must exist free flow of traffic. Since it is not always achievable in all the entrance point of DRA an alternative road pricing system can be adopted. The major factors of an ALS are:

1. It is a manual scheme based on the display of paper licenses that were purchased prior to their entering the Restricted Zone (RZ).
2. To enter the RZ during the restriction periods, non-exempt vehicles will need to purchase an ALS area license from roadside sales booths located on approach roads to the RZ, petrol stations, post offices or convenient stores. These will be available as daily and monthly ALS area licenses.
3. Enforcement personnel will be stationed at the control points to ensure that non-exempt vehicles displayed valid ALS area licenses on their windscreens, or on the handle-bars in the case of motorcycles and scooters. Violating vehicles had their vehicle license numbers noted down and their owners sent summonses for entering the RZ without a valid license.
4. Vehicles will be free to move around or leave the RZ without having the ALS area licenses.
5. Installation cost is less than ANPR camera system, but operation is costly. Over all it will cost less than introducing ANPR cameras.

V. CONCLUSION

Increasing the capacity in an already heavily built up urban area is almost impossible, therefore certain alternative way of demand management must be utilized to reduce the congestion of Dhanmondi residential area. Cordon pricing has proven its efficiency in many developed urban areas of the world. Though in terms of installation cost it may prove to be a little optimistic but in regard to the problem it can solve, it is the right type of solution for Dhanmondi residential area. Again there is always an option of introducing area license scheme in the area. This system will ensure that the private car owners pay their part of the social cost. Thus this initiative is also expected to discourage multiple car ownership of the residents and increase the habit of carpooling among the residents and non-residents. In accordance with its implementation emphasis must be given toward introducing bus service for the schools, promoting walking and cycling within the area and discouraging new commercial establishments.

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