AN ALTERNATIVE MEASURE TO MITIGATE CONGESTION ALONG BASELINE ROAD THROUGH CAPACITY AUGMENTATION OF AVAILABLE LINKS – A GIS BASED APPROACH

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ABSTRACT:

The issue of urban congestion had so far been an unresolved issue despite having very expensive mobility infrastructure already in place and it seems many more similar expensive infrastructures are further lineup for implementation. We have now realized that the steel flyovers erected over at grade intersections have not been an effective intervention to mitigate congestion on the long run, instead they take up the burden from one end and pass over to another point few hundred meters away, yet life spans of these steel structures will remain up to 100 more years. When the impact of high mobility expressway network (170.8km) is concerned it has been a relief mainly for long distance travellers, but the contribution of this network towards mitigation of city congestion & its immediate suburb so far had been very marginal.

Congestion along Baseline road has reached to unbearable status warranting immediate relief measures. Study of temporal and spatial variation of volume/ capacity of selected alternative routes revealed that a considerable share of traffic bounded for Rajagiriya and Battaramulla, coming along A1, A3, E03 could make use these alternative links instead of entering to Baseline road via New Kelani Bridge. An analysis had been carried out by adopting. “volume/capacity balancing approach” to illustrate quantitatively, what share of traffic could be diverted out from the Baseline road.

This study confirmed that volume/capacity balancing approach could be effectively managed using GIS based decision supportive environment. This approach could be used to bring down the congestion of Baseline road to optimum levels and the same approach could be adopted for other cities in general. Further through this study authors have arrived at recommendations for the formulation of evidence based policies for the management of urban city congestion.

1.0 INTRODUCTION

Sri Lanka incurs massive financial and man-hour losses due to traffic congestion, particularly in and around Colombo and its suburbs and in 2009 this loss had been estimated as Rs.32 billion per annum. Obvious reasons for congestion had been the ever increasing vehicle ownership, resulted mainly due to ever deteriorating public transport system, in disciplined users, un planned land use practices and the total absence of transport demand management strategies. The country in general experiencing increasing car ownership while current ownership being 250 vehicles per 1000 households.

Today most default congestion relief measures rely on erecting flyovers over at grade intersections or else by constructing more roadway capacities, but it has now been realized that the contributions of these expensive mobility infrastructures, particularly those already in place had been very marginal in freeing up capacities of congested links.

In general the issue of urban congestion along main roads leading to large cities had so far been an unresolved issue, yet in particular the status of Baseline road in Sri Lanka which has been the entry gate to Colombo city via KANDY road (A1), NEGOMBO road (A3) and COLOMBO – KATUNAYAKE expressway (E03) has become worst. Though it has been estimated that congestion within the city and its suburb is causing a loss of LKR 32b an year, a separate study has not been done to estimate the impact of Baseline road congestion alone. When the solutions that are lineup are concerned, all of them fall into the category of adding on new roadway capacities. Adding a new capacity will take 10-15 years, provided credit facilities could get arranged in line with the countries debt repaying capacities. Instead of adding expensive infrastructures, pieces here & there capacities and capabilities of information and communication technologies in other words Intelligent Transport System (ITS) tools could be deployed to manage and bring down congestion to affordable levels.

The objective of this research study was to explore the possibilities of using alternative available links by way of augmenting their capacities using the capabilities of GIS, information & communication technologies as short to medium interventions to manage congestion of Baseline road as a case study. Further the outcomes of this study will facilitate arriving at informed decisions for transport authorities, so that economically viable practical means to manage congestion in and around large cities of the country could be developed and executed.

2.0 LITERATURE SURVEY FINDINGS

Congestion takes many faces, occurs in many different contexts and is caused due to many different processes. Because of this, there is no single best approach for managing congestion. As such even through this study, authors have taken an attempt to come out with an economically viable alternative mean to manage severe congestion but not to eradicate congestion.

Congestion is essentially a relative phenomenon that is linked to the difference between the roadway system performance that users expect and how the system actually performs. A better way of defining excessive congestion is, when the marginal costs to society due to congestion exceed the marginal costs of efforts to reduce congestion (such as adding new capacities through road or other transport infrastructure), If it is the case, we could clearly conclude that the congestion is excessive and action to manage the same is better warranted. Any road cannot be built to deliver free-flow speeds 24 hours a day, 7 days a week 365 days a year. Congestion management policies too should not seek to do so either.

In general congestion is caused due to two principle broad categories of causal factors; micro- level factors (e.g. those that relate to traffic “attributes on the road”) and macro-level factors that relate to overall demand for use of roads. In this context, congestion is “triggered” at the “micro” level (e.g. on the road), but it is “driven” at the “macro” level by factors that contribute to the incidence of congestion and its severity. The question we need to address is not to eradicate congestion at all, but to avoid excessive congestion and this should be the most bottom line reality of any congestion management policy.

Road users generally accept a certain degree of congestion hence any congestion management strategy should take in to consideration of acceptable congestion thresholds of popular main links leading to main cities. Because congestion is a spatial – temporal phenomena an effective mean to manage excessive congestion is to keep the users informed the status of congestion along major links in advance and this could be done by deploying appropriate ITS tools.

Ideally, urban transport policies should be developed on the basis that congestion is caused as a result of:

- The behavior of traffic as it nears the physical capacity of the road system.
- The difference between road users' expectations of the system's performance and how the system actually performs.

3.0 OBJECTIVE OF THE STUDY

Objective of this study was to explore economically viable interventions to manage congestion along main arterial roads, leading to major cities by way of capacity augmentation of already available links, considering the baseline road of Sri Lanka as a case study.

In this study managing congestion at acceptable levels along busy streets had been attempted by way of monitoring and managing the spatial and temporal variations of volume/capacity along already available alternative links and conveying the status in advance to road users.

Further outcomes of this study will keep the decision makers aware that GIS based decision support approaches enriched with ITS tools could generate economically viable yet practically executable means to manage congestion along main arterial roads through capacity augmentation of available links. Authors carried out the analysis taking Baseline road of Sri Lanka as a case study.

4.0 SIGNIFICANCE OF THIS STUDY

Today road users hate negotiating the Baseline road, mainly due to unbearable congestion, air pollution and for wasting of their valuable time. During peak hours travel speed of baseline road comes down to 5-6km/hrs, causing users to consume 45 minutes to 1 hour to travel a length of 4.5 km. This congested situation of Baseline road clearly warrants immediate measures to bring down the congestion to affordable levels.

Through this study volume/capacity balancing approach make using alternative links had been attempted to reduce the excessive congestion along Baseline road to expectable levels. Further study outcomes have resulted several recommendations for the formulation of evidence based congestion management polices with particular reference to developing countries.

5.0 THE METHODOLOGY

In this research study a GIS based decision support approach had been used, presuming that road users generally accept a certain degree of congestion, so to keep users informed the status of congestion along Baseline road and of alternative links well in advance.

Development of a GIS based decision support approach involved the preparation of information layers, namely existing capacity layers of road network (peak/off peak), design capacity layers of road network, travel time layers and operations such as visualization, comparison, overlaying, crossing and multi-criteria analysis. Major steps followed in this study are status below.

1. The status of congestion of the Baseline Road – An overview

2. Identification of a study area

3. Identification, mapping of available alternative links that could be used instead of Baseline Road and assessment of existing and ultimate volume / capacity ratios of these links.

4. Mapping of spatial and temporal status of "volume/capacity" ratios of alternative links and to develop conceptual plan for information dissemination mechanism for users by developing a local version of ITS tools.

6.0 INFORMATION COLLECTION AND ANALYSIS

6.1 The Status of Congestion of The BASE LINE Road (BL ROAD) – An Overview

The length of the section from New Kelani Bridge (NKB) to Borella = 4.7km.
Number of lanes = 6
Peak hour volume = (↑↓) = 136259 Veh /per/day (Projected to 2015)
Maximum technical capacity i.e. at level of service - F = 89960 Veh/per/day

This implies that the BL road experiences excessive congestion caused both due to micro (Quick queuing triggering factors) & macro factors. The figure 01 shows durations to travel between NKB and Borella along BL Road depending on the time you commence the trip at NKB.

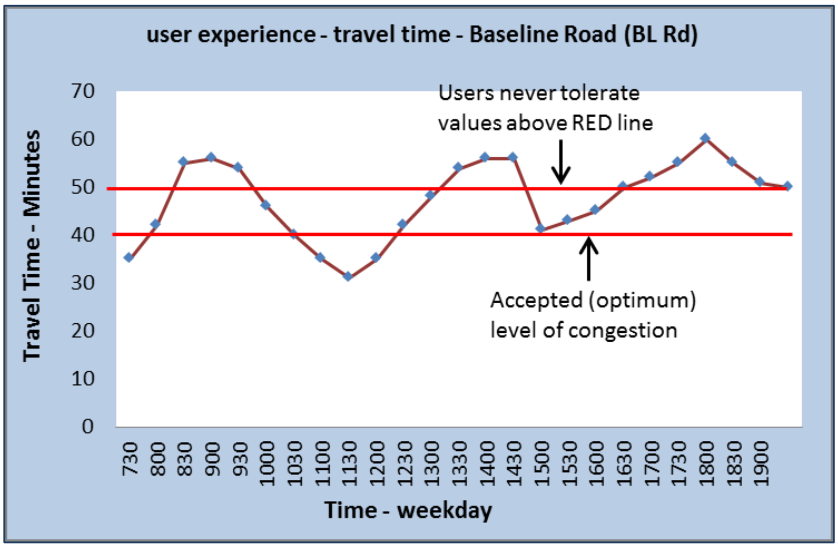

Figure 01: Travel Durations needed to travel from NKB to Borella depending on the commencing time of the day at NKB.

6.2 THE STUDY AREA

An area that covers a cordon of 15km – 20km along A_1, A_3 from NKB entry point was considered as the study area and the figure 02 shows the alternative, yet available mortarable links that could be make use to reach destinations considered in this study i.e. RAJAGIRIYA & BATTARAMULLA.

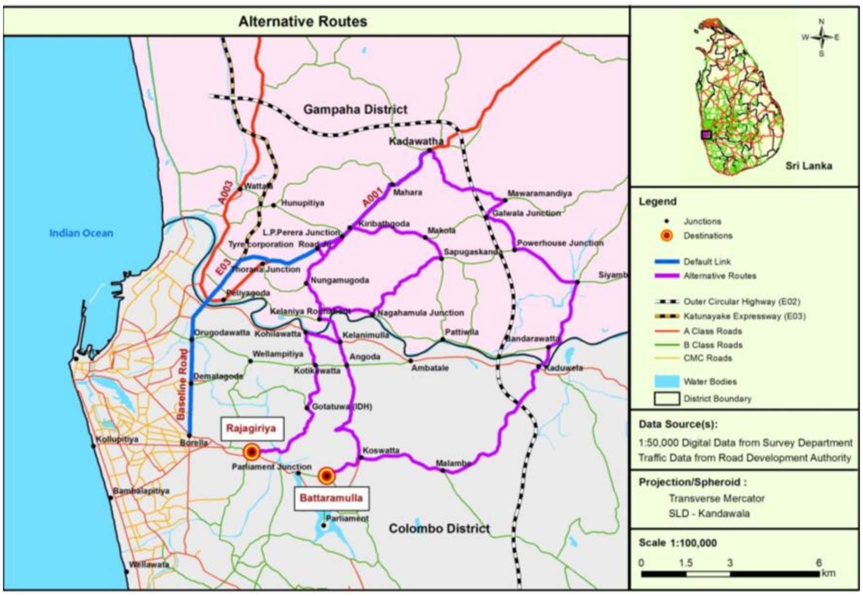

Figure 02: Traversable yet available links that could be used to reach RAJAGIRIYA & BATTARAMULLA

For this study it was considered that the BL-Road is the default link to access cities RAJAGIRIYA & BATTARAMULLA for those commuters reaching NKB via A_1 and A_3, Initially to elaborate the concept alternative links associated with A_1 road were considered.

Less congested alternative links were recognized based on the local knowledge yet an alternative mean to capture all other potential links is through satellite imageries captured covering cordon areas of A_1 and A_3. The figure 03 shows the geometric capacities of BL road and that of alternative links.

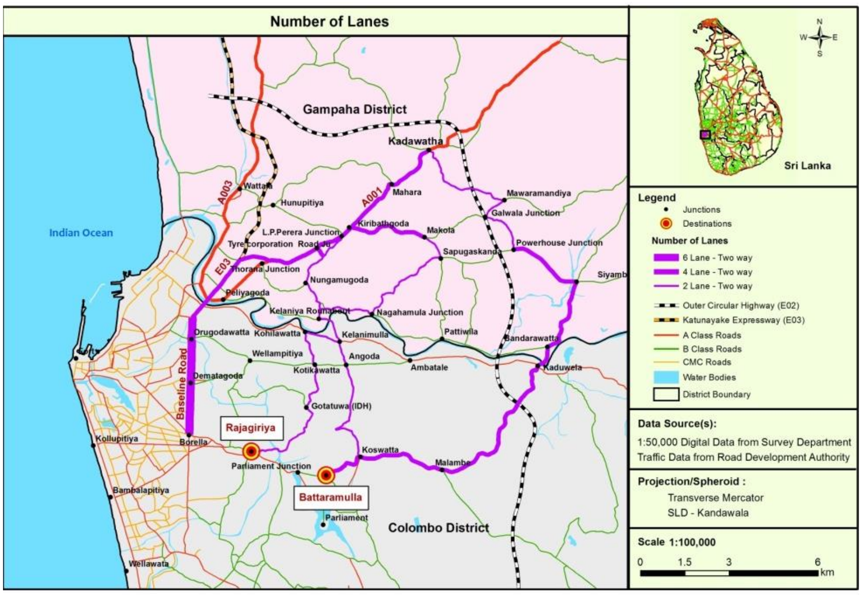

Figure 03: Geometric capacities of BL – road and that of alternative links

6.3 Assessment of Degree of Reliability of "Travel Durations" Along Alternative Links

Degree of "travel duration reliability" of the alternative links, selected for this study was estimated using the travel durations recorded by frequent users, who had been used to negotiate these alternative links, AL_1, AL_2, AL_3 & AL_4 in reaching the destinations RAJAGIRIYA & BATTARAMULLA. Table 01 provides the degree of reliabilities of travel durations along alternative links AL_1, AL_2, AL_3 & AL_4 respectively.

Table 01: Degrees of reliabilities of travel durations along alternative links AL_1 – AL_4

Default link (DL) & Alternative Links (AL)	**Distance (km)**	**Travel time (Minutes (2015)**	**Degree of reliability (2015)**
DL (BLR)	**19.5**	**120 – 150**	
AL 1	**21.0**	**78 – 88**	**91%**
AL 2	**22.0**	**60 – 70**	**90%**
AL 3	**15.4**	**45 – 55**	**95%**
AL 4	**16.6**	**73 – 83**	**96%**

Although there were other alternative links, for this study only AL_1, AL_2, AL_3 & AL_4 alternative links were considered to illustrate the concept of "volume/capacity" balancing approach.

6.4 Roadway Capacity Assessment of BL – ROAD & Alternative Links

For this study, capacity analysis was carried out considering the existing number of lanes and other existing geometric settings of BL- Road & that of alternative links AL_1, AL_2, AL_3 & AL_4 respectively, with the objective of assessing the traffic absorbing potential until a desired threshold is met. Equation (1.0) was used to assess the potential capacities of alternative links, all of which are 2 lanes, away roads. Under ideal considerations a two way two lane road could carry 2800 passenger cars per hour total for both directions.

$$\vartheta i = 2800 \text{ X } [V/C]_i \text{ X } fd \text{ X } fw \text{ X } f_{HV} \quad \ldots\ldots (1.0)$$

here ϑi = Potential capacity

$[V/C]_i$ = Maximum $[V/C]_i$ ratio that could be accommodated at level of service (i)

Fd = Adjustment factor for directional distribution of traffic

Fw = Adjustment factor for narrow lanes & shoulders

f_{HV} = Adjustment factor for heavy vehicles.

Authors realized the need to reconsider the applicability of current adjustment factors to suit our traffic environments.

The figure 03 shows the graphical representations of volume / capacity (v/c) values of BL – road and that of alternative links AL_1 – AL_4

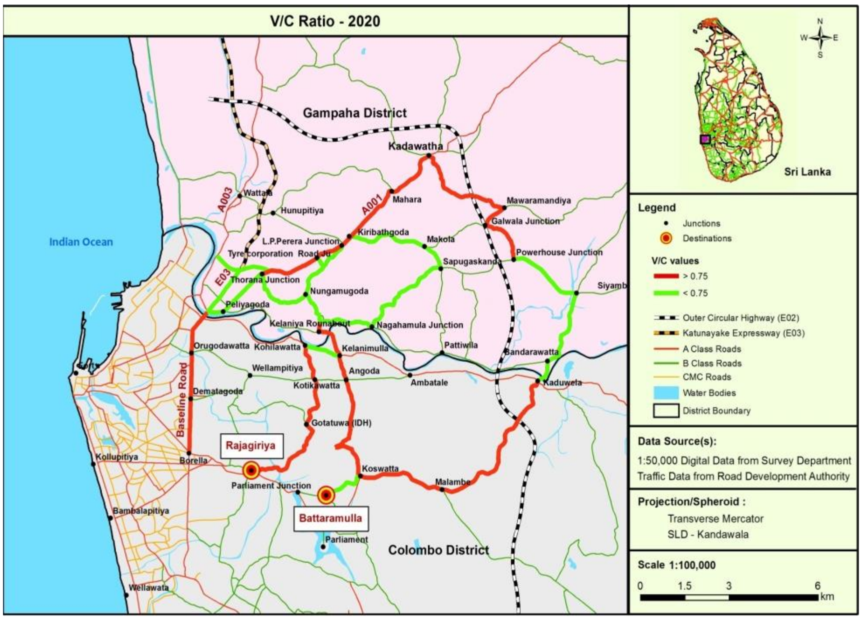

Figure 04: Prevailing (V/C) values of alternative links $AL_1 – AL_3$ and that of BL Road

The table 02 shows, by how much the capacities of alternative links $AL_1 – AL_3$ could be augmented while maintaining a threshold of 0.8 (2016).

Table 02: Extent of augmented Capacities of alternative links by absorbing traffic up to an “v/c” threshold of 0.8 – (2016)

Alternative Routes	Augmented Traffic Volume - vpd
Al 1	10517
Al 2	11811
Al 3	11396
Total	**33724**

6.5 Use of Intelligent Transport System(ITS) Tools For Communication

We have realized that the default congestion relief measures such as freeing up existing capacities by adding new roadways are not always the economically viable option, particularly in the context of economies of our nature, instead Transport Demand Management (TDM) strategies enriched with appropriate ITS tools can yield out affordable interventions to manage the congestion.

Effective augmentation of capacities of alternative links $AL_1 – AL_4$ could be done, by introducing traffic information provision for road users in advance on A_1, A_3 & that of B_1 – Road. For this purpose deployment of ITS tools within National Roads Network is needed.

7.0 RESULTS

7.1 Short, Medium & Long Term Interventions

1. Economically viable short-range alternative is to augment capacities of AL1 – AL4 until V/C reaches 0.7 - 0.8 threshold.

2. Medium range intervention is the augmentation of capacities of AL1, AL2, AL3 & AL4 by widening Narrow sections, bridges etc. Figure 05 shows a narrow, single lane bridge on alternative link AL_3.

Figure 05: A Narrow, Single Lane Bridge on alternative link – AL_3

3. Long range capacity augmentation interventions are to enhance capacities by converting links from 2 lanes 2 ways to 4 lanes 2 ways and enhancement of at grade intersection discharges etc.,

4. The toll fee for the section from KW (IC) – ATHU - (IC) is Rs.100.00. Lowering the toll fee to Rs.50.00, for this section, will also be a medium range intervention that will directly bring down considerable share of congestion of Baseline Road (BL).

i. During 18th, 19th, 20th and 23rd of May 2016, the OCH - section from KW IC to KOTTAWA IC was allowed to negotiate free of toll due to the severe floods.

ii. Following observations provide a clear proxy to justify that around 4600 vpd bounded towards RAJAGIRIYA & BATTARAMULLA had used E02 during toll fee lifted flooding period (Refer Figure 06)

iii. It could be presumed with 50% toll fee reduction between KW (IC) & ATHU (IC), BL road traffic could be brought down by 3000vpd, i.e. 65% out of 4600 vpd

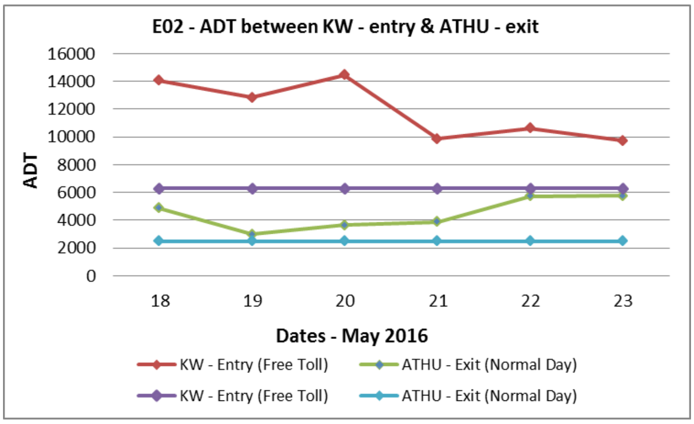

Figure 06: ADT variation between KW (IC) & ATHU (IC) of E02 during floods period

8.0 CONCLUSIONS & RECOMMENDATIONS

1. By balancing (v/c) ratio along alternative links, congestion along major roads would be brought down to manageable status

2. Congestion being a spatial – temporal phenomena dynamic balancing of v/c needs extraction of congestion information , processing them and dissemination to road users in advance

3. Deployment ITS tools will facilitate grasping of information such as, inundation due to floods, closer of roads, accidents, incidents such as feasts of temples, churches. Through the control center these real time information could be conveyed to road users

4. By adjusting toll, fees between interchanges congestion along major city approaches could be reduced and this strategy will be a desirable mean for economies of our nature
5. Congestion could not be eradicated fully. Road users generally accept a certain degree of congestion. Hence most bottom line reality of a congestion management policy should be to avoid excessive congestion

6. A congestion management policy should look for both holistic & integrated strategies that go beyond visible incidence of congestion "on the road(micro)" and should extend towards the management of land use in and around RAJAGIRIYA & BATTARAMULLA region as a whole

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