

EVALUATION OF THE ONE-WAY TRAFFIC SYSTEM ALONG THE GALLE ROAD CORRIDOR

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Degree of Master of Engineering in Highway and Traffic Engineering

Department of Civil Engineering

University of Moratuwa
Sri Lanka

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Thesis submitted in partial fulfillment of the requirements for the degree Master of
Engineering

Department of Civil Engineering

University of Moratuwa
Sri Lanka

January 2011

DECLARATION

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ABSTRACT

Traffic congestion is an extensive problem in urban environments in Sri Lanka. This is in particular a serious problem in Colombo especially during peak periods. As a result of congestion, increase in following parameters; travel time, delays at intersections, accidents, fuel waste, and air pollution can be observed. To tackle the congestion problem several remedial actions have been used. As one such measure one way traffic flow system was introduced in 2006 between Bambalapitiya and Kollupitiya by City Traffic Police with the objective of reducing the traffic congestion.

The objective of this research is to evaluate the performance of the one-way traffic arrangement along the Galle Road corridor. Quantitative research methodology was utilized in this study. The research data (traffic, accidents, new registered vehicles etc.) were gathered from several organizations and sources, which represent before and after the traffic system conversion. The traffic flow, travel time, number & severity of accidents, travelling speed, and emissions before and after the traffic conversion were analyzed in the specific stretch and compared.

The results show that the traffic flow along the Galle Road has moderately reduced after the implementation of the one-way system but traffic flow on R.A. de Mel Mawatha has increased significantly. However, there is no significant difference in travel time along the both roads. The amount of emission along the Galle Road has reduced by about 50% of the earlier amount but along R.A. de Mel Mawatha it has increased. Travel distances have increased for many user groups especially the public transport users. Particularly bus commuters were faced lots of problem while they reach the bus halts and their destinations. Parking has been severely restricted on both road segments causing inconvenience to general public. After the implementation of one-way system the numbers of accident have been reduced but there is a clear indication of lack of enforcement. The above shows that the social cost of the present one-way system outweighs its expected benefits.

Keywords: one-way traffic, accident, emission, travel time, public transport.

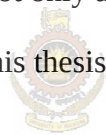
DEDICATION

I dedicate this thesis to my parents, who have adored my life from birth with affection and love. Thank you for giving me a chance to prove and improve myself through all my walks of life.

Also, this thesis is dedicated to my loving husband, who has been a great source of motivation and inspiration. I give my deepest expression of love and appreciation for the encouragement that you gave and the sacrifices you made during this graduate program.

And this thesis is dedicated to my lovely brother, who has encouraged me in several ways as not only a brother but also a friend.

Finally, this thesis is dedicated to all those who believe in the richness of learning.



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LIST OF ABBREVIATIONS

Abbreviation	Description
CMA	Colombo Metropolitan Area
CTB	Ceylon Transport Board
Mw	Mawatha
TSP	Total Suspended Particles

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Chapter 1: INTRODUCTION

1.1. General

Roads are the backbone of the transport sector in the country. They are vital for the movement of people and goods and play an important role in integrating the country, facilitating economic growth, and ultimately reducing poverty. National roads carry over 70 percent of the traffic in Sri Lanka. However, uncontrolled roadside development, as well as years of neglect and poor road maintenance has resulted in low travel speeds and poor transport service. This has discouraged long distance traffic and hindered the spread of economic activities and development in regions other than the Colombo Metropolitan Area (CMA).

Sri Lanka is a country which has a high population density in urban areas. Annually Rs.30 billion is spent on fuel due to traffic congestion. Nearly 830,000 people come to Colombo city daily. From this total number nearly 500,000 people come to Colombo in 12,000 buses while 100,000 people travel by train. The balance 230,000 comes to Colombo in their own vehicles. In addition 250,000 vehicles have been registered only within the Colombo city limit [Sri Lankan News & Discussion, Lanka Newspaper.com, September 22, 2009]

Although Sri Lanka enjoys a higher road density than in many developing countries, the conditions and standards of the roads are inadequate to meet rapidly growing freight and passenger traffic. More than 50% of the national roads have poor or very poor surface condition and many are seriously congested. Even though there are many possible mechanisms to overcome the congestion, one-way traffic system is one of the efficient and economic remedial arrangements to keep away from this congestion.

A one-way traffic flow is a system on which vehicles should only move in one direction. These are effective in improving operational efficiencies at intersections as they reduce the number of conflicts from opposing flows. However, they require a set of parallel roads with similar standard to minimize increases in trip distance and avoid bottleneck. An advantage of one-way traffic system is that, the drivers do not have to watch for vehicles coming from opposite direction.

1.2. Reasons for being One-way

A two-way street is a street that allows vehicles to travel in both directions. The idea of those two-way streets is more pedestrian friendly. But it will increase congestion, pollution, and traffic accidents. In some cases, two-way traffic arrangements are not effective than the one-way arrangement. These are;

- Street is too narrow for movement in both directions-in this case parking will only be allowed on one side of the street or not at all.
- To prevent drivers from cutting through residential streets rat runs to bypass traffic lights or other requirements to stop.
- Part of a one-way pair of two parallel one-way streets in opposite directions (a divided highway).
- For a proper functioning of a system of paid parking or other paid access. Traditional names for such products are: traffic spikes, tiger teeth, alligator teeth, tire spikes, and flow plates.
- To eliminate turns that involve crossing in front of oncoming traffic.
- To reduce pollution from automobiles by reducing slowing down
- One-way streets allow for more vehicles, thereby decreasing congestion
- Easier than two-way streets to time stoplights (timed lights improve traffic flow and decrease idling (& therefore pollution))
- More on-street parking and possibly; safer for pedestrians

1.3. Problem Statement

When it was a two-way traffic system, vehicle demand was very high in Galle road, especially during the peak hours. Much of the traffic congestion is caused by private vehicles. Mostly two types of traffic cause this problem, the one is traffic due to school time over lapping the peak office hours and the other is the traffic created by vehicles of shoppers, due to lack of parking space. Travel time and operational cost were increased tremendously and the numbers of accidents also have increased within this time periods.

The one-way system of traffic, which was put into action from 25th October 2006, has proven to be a blessing for some, while others can only describe it as an absolute nightmare. The changes in bus routes on Galle Road and R.A. de Mel Mawatha

(Duplication Road) have caused inconvenience to some, while benefiting others. People who travel from South to Pettah daily takes a shorter time to go to work in the morning, but getting back home, on R.A. de Mel Mawatha takes much longer than it did before.

The new system has also proved a dreadful for bus commuters along Galle Road, who now have long walks to get to their respective bus stops, as opposed to the conveniently situated halts with easy access they had gotten used to. They are undoubtedly the worst affected, with merchants along the main streets coming in a close second.

1.4. Objective

The main objective of this thesis is evaluating the effectiveness of the one-way traffic arrangement along the Galle Road corridor. To evaluate the benefits & costs of the one way arrangements the followings are taken as targets.

- Analyze of current one way and previous two way traffic systems.
- Selection of influencing factors of the traffic system.
- Collection of data relevant to the influencing factors.
- Evaluation of the influencing factors with the collected data before and after the one way traffic system.

1.5. Organization of Report

This report consists of seven chapters. An Introduction of one-way traffic system and traffic density in Sri Lanka is provided in Chapter One.

In Chapter Two, a literature review is presented, in which the relevant information found in the literature related with the topics is addressed. This includes some basic concepts regard one-way arrangements in operation and factors affecting the one-way traffic system.

Chapter Three describes the methodology and data collection. Observation and results from the analysis of collected data are provided with details in Chapter Four.

In Chapter Five, the experimental results obtained in Chapter Four are discussed with details and reasons. Chapter Six summarizes the main conclusions of the present work.

Finally, Chapter Seven recommends some suggestions for future demand.

Chapter 2: LITERATURE REVIEW

2.1. Introduction

For the purpose of the research work, conversion of one-way system between Bambalapitiya and Kollupitiya along the Galle Road and R.A. de Mel Mawatha were taken as testing segments.

Colombo Police City Traffic unit has introduced a permanent traffic plan for all vehicles which enter and leave the city from 25th October 2006, with several main roads being made one-way because of the growing security risks. According to the new plan twelve (12) main roads in Kollupitiya, Bambalapitiya, Kompannaweediya and Cinnamon Gardens will be made one-way while several other roads interconnecting Galle Road, R.A. de Mel Mawatha and Thurston Road also made access only roads hereafter. The following main roads made one-way.

1. R.A. de Mel Mawatha - To enter Colombo from Buller's Road Junction to Liberty round-about.
2. Thurston Road - To enter Colombo from Thurston junction to J.O.C round-about.
3. Cambridge Place - To enter Colombo from J.O.C round-about to National Museum on Marcus Fernando Mawatha.
4. Independence Road - To exit from Nanda Motors junction to Public Administrative junction.
5. Maitland Place - To enter Colombo from Public Administrative junction to Maitland Crescent.
6. Maitland Crescent - To exit Colombo from Horton place to Independence round-about.
7. Reid Avenue - To exit Colombo from Independence round-about to Reid Thurston junction.
8. Rajakeeya Mawatha - To enter Colombo from Reid Rajakeeya junction J.O.C round-about.
9. Gilford Crescent - To exit Colombo from Cambridge junction to Reid Avenue.
10. Ananda Kumara swami Mawatha - To exit Colombo from Liberty round-about.

11. Dharmapala Mawatha - To enter Colombo from Red Cross junction to Liberty round-about.
12. Marks Fernando Mawatha - To enter Colombo from Glass House junction to Liberty round-about.

Meanwhile to enter into Perahera Mawatha from Alfred Place junction and Hudson Road junction will be completely prohibited hereafter. The access only roads could be driven through from Galle Road to R.A. de Mel Mawatha.

1. Abdul Caffoor Mawatha
2. Deal Place
3. Walukarama Road
4. Simon Hewavitharana Mawatha
5. Pentreve Gardens
6. Bagatale Road
7. Alfred House Gardens
8. Temple Road
9. Edward Lane

The access only roads could be entered from R.A. de Mel Mawatha to Galle Road.

1. Milepost Avenue
2. St. Anthony's Mawatha
3. Deanstone Place
4. Fifth Lane
5. Simon Hewavitharana Road
6. Pentreve Gardens
7. Alfred Place
8. Bagatale Road
9. Alfred House Avenue
10. School Lane

Among these main roads, the following two popular routes are taken into account to reach Kollupitiya Liberty junction from Bambalapitiya Junction (See Figure 2.1.1).

- i. Along the Galle Road (AA002)
- ii. Along the R.A. de Mel Mawatha Road (CD002)

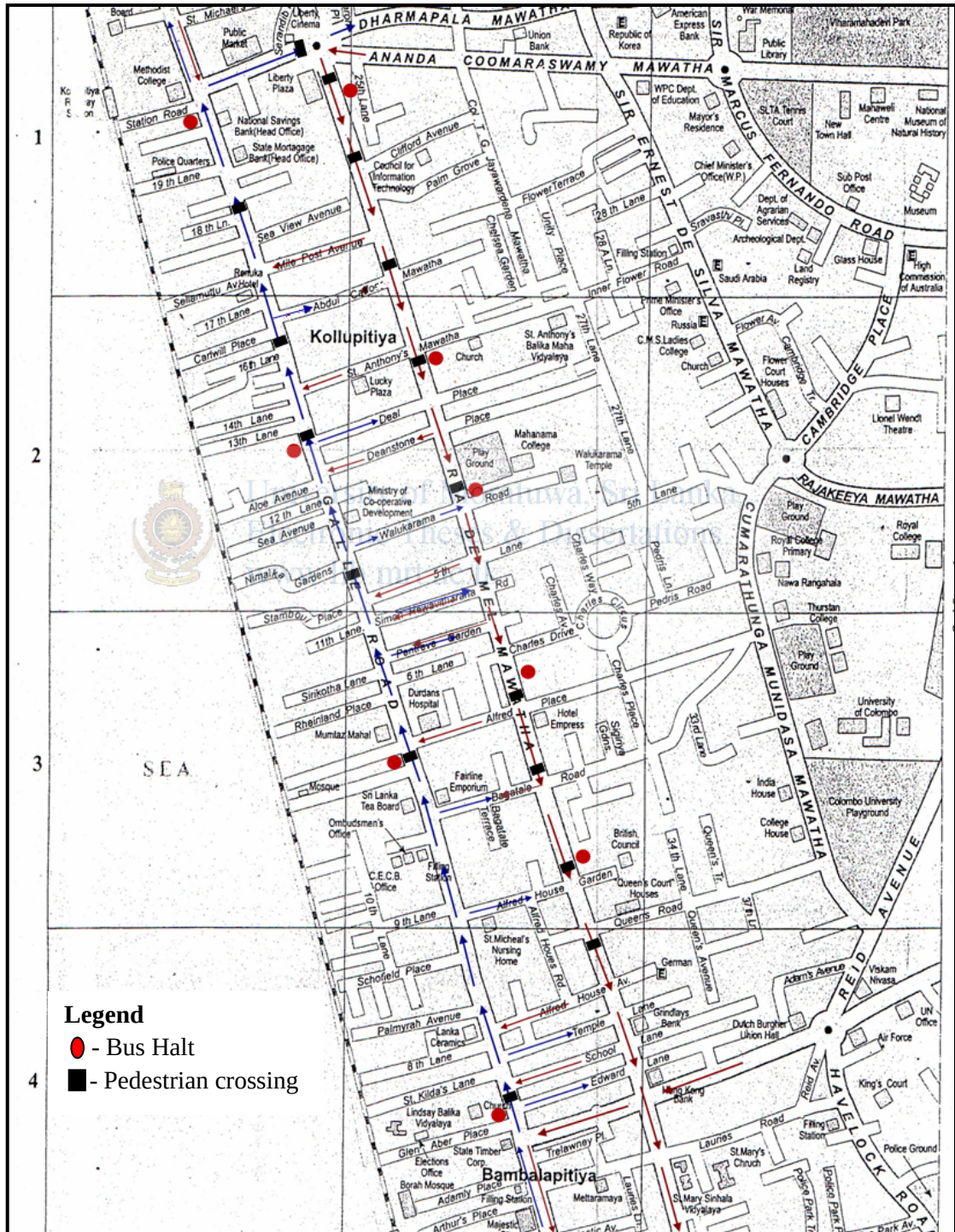


Figure 2.1.1: New traffic system in Colombo city

2.1.1. Along Galle Road

Earlier Galle Road had 2-way divided 4-travel lanes. Around 1.2m centre median and some sections have 3.56m wide bus bay or parking lane. Therefore carriageway of the Galle Road varied from 20m to 24m approximately.

Presently these 4-lanes are used by traffic which travels towards to Colombo where inner lane width is 3.7 m and outer lane width is approximately 4 m. At the same time on-street parking also prohibited along this section.

This route runs through a highly developed area used for educational, medical and commercial activities. Lindsay Balika Vidyalaya, Methodist College and Ministry of Co-operative Development etc. are situated along this route. These activities create a high demand for access resulting in high pedestrian and vehicular attractions. It is observed that there are many access roads that induce high volumes of turning vehicles, which increases vehicle-vehicle conflicts (mostly right-turning conflicts).

Land-use development on either side of the road makes it necessary to have high volumes of crossing pedestrians introducing a large number of vehicle-pedestrian conflicts. Poor implementation of building regulations with respect to provision of parking is there. Poor enforcement of parking regulations has made roadside parking the popular answer to the chronic problem of inadequate parking supply.

In some locations the road has insufficient width of shoulders. Most of the shoulders are encroached by vendors and further widening of shoulders is restricted by adjoining land-uses. All these factors make this road a typical access road by character although administered as a part of the trunk road network of Sri Lanka.

2.1.2. Along R.A. de Mel Mawatha Road

Earlier configuration of this road was 2-way undivided 4-lanes (approximately 3.5m wide each) with 1.5m sidewalks in both directions outer lanes are used as parking lanes in both sides.

Now all four travel lanes are using by traffic which moves towards to Bambalapitiya junction. Simultaneously on-street parking is highly restricted. Lot of commercial and social activity places are situated along this route. For example Liberty Plaza, Mahanama College, British Council, Council for Information Technology, Hong

Kong Bank etc. are located here. The roadside land-use developments are rapidly increasing. Even though many of these developments attract large volumes of pedestrians and vehicles, some of them are without adequate off-street parking of their own. Such unregulated developments would inevitably result in high volumes of pedestrians, vehicles, conflicts and demand for roadside parking.

2.2. Factors Affecting One Way System

The following factors are affecting the one-way traffic system in a positive manner as well as negative manner.

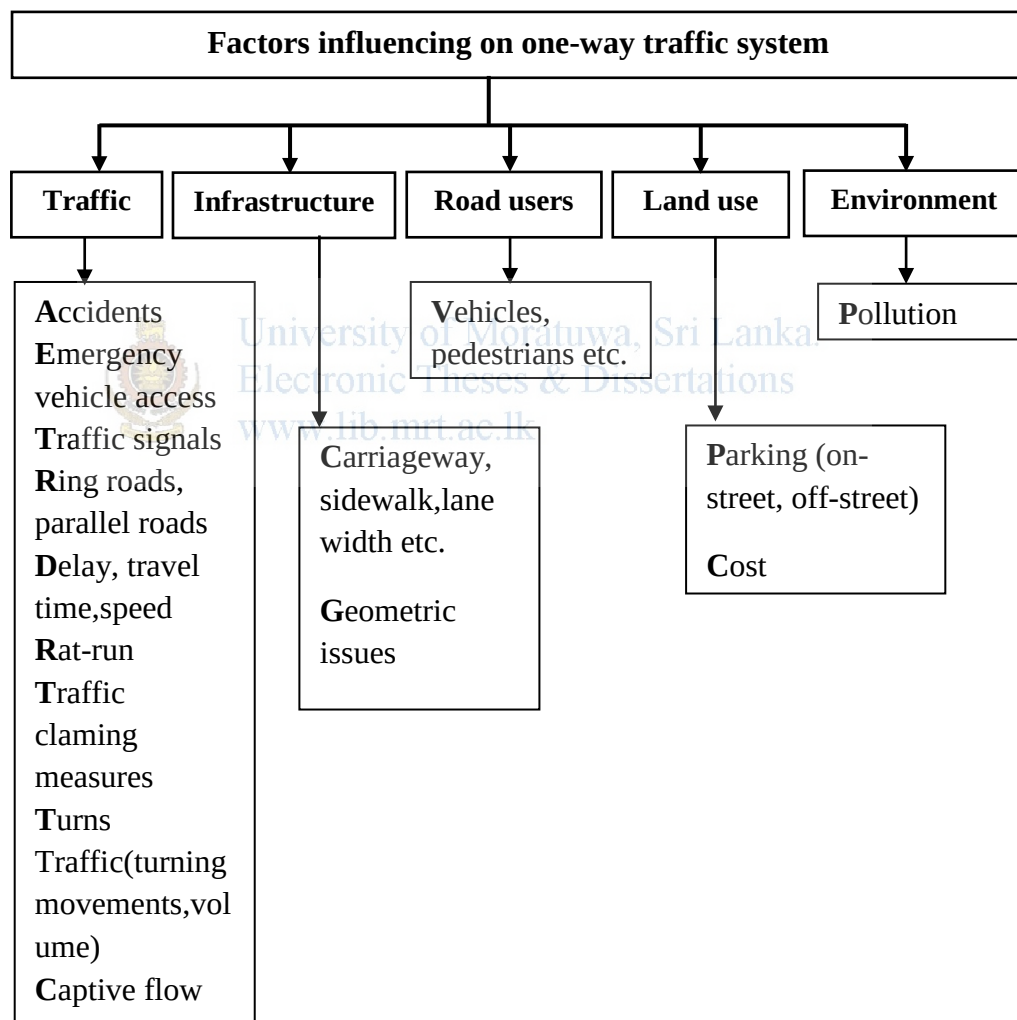


Figure 2.2.1: Factors affecting one-way traffic system.

2.2.1. Air pollution

Colombo is the main commercial and business center of Sri Lanka and as a consequence, many people are drawn into the city daily. The central district, which comprises of Fort and Pettah, provides more than 100,000 jobs and is estimated to have a daytime population of more than 650,000. The greater Colombo area contains over 4 million people or 26% of the island's population, but covers only 5.6% of the total land area. Increased vehicle emission in Colombo is one of the most important environmental issues that have drawn the attention of policymakers, administrators, and environmentalists in the recent past. Outside the city, Katunayake International Airport and the Free Trade Zone further increase traffic congestion in Colombo. As the most important business and administrative center, Colombo attracts the highest number of vehicles and individuals and is therefore highly vulnerable to health hazards due to vehicle emissions.

Various studies undertaken by regulatory agencies and researchers clearly indicate that inefficient combustion of petroleum in motor vehicles is the primary cause of growing air pollution in Colombo. Lack of information on economic and environmental costs of vehicle emission and its mitigation and prevention have inhibited public response and enforcement, and impeded the implementation of existing laws, and the development of further regulations.

According to the Sri Lanka situation usage of petrol vehicles are higher than the usage of diesel vehicles. Table 2.2.1 lists the registered petrol and diesel vehicles from 2003 to 2009. The deviation between the petrol and diesel vehicles is shown in the figure 2.2.2.

Table 2.2.1: Registered vehicle classification

Year	Registered Petrol Vehicles/(Nos)	Registered Diesel Vehicles/(Nos)
2003	148,122	32,378
2004	193,515	28,804
2005	193,176	34,391
2006	254,099	44,364
2007	251,191	44,426
2008	220,129	43,183
2009	176,636	25,993

Source: Department of Motor Traffic, Colombo, Sri Lanka

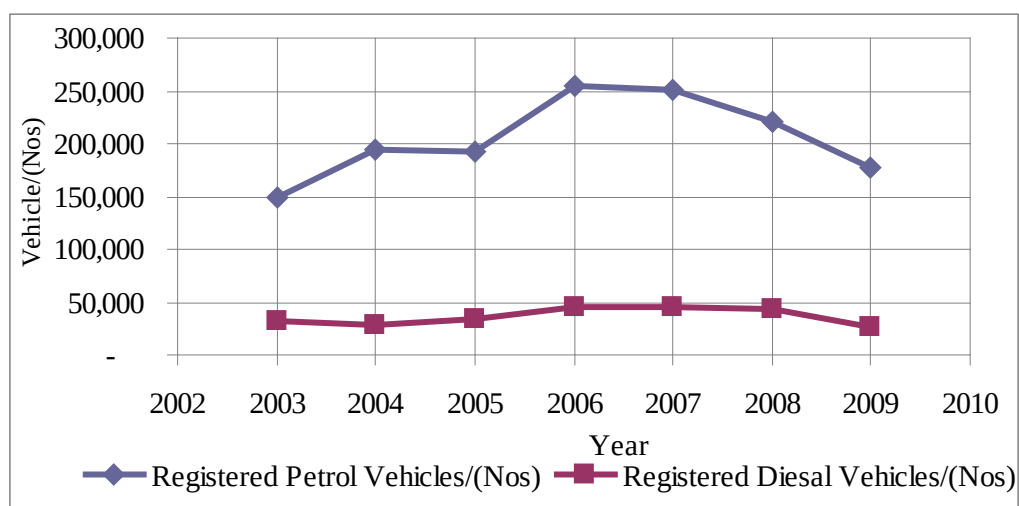


Figure 2.2.2: Vehicle classification in Sri Lanka

The worst prevalent air pollutants emitted from vehicles include particulate matter (PM), lead (Pb), non methane volatile organic components (NMVOC), nitrogen oxide (NO_x), sulfur dioxide (SO₂), and carbon monoxide (CO). Of these, particulate matter and lead are the most harmful components of vehicle exhaust that affect the environment and human beings. Apart from pollutants emitted by petrol-driven vehicles, the amount of exhaust from diesel-driven vehicles is large and therefore a matter of major public concern due to its undesirable environmental effects. Although diesel-engine exhaust contains less toxic gases, it has a much higher particulate matter concentration than petrol-engine exhaust. In Sri Lanka, the observed levels of TSP, SO₂, O₃, and lead are significantly higher than air quality standards recommended by the World Health Organization (WHO) and the Central Environmental Authority (CEA) in Sri Lanka. This clearly demonstrates the special nature of the vehicle emission problem in the country which is directly linked with a wide range of factors such as composition and increase in number of vehicles, price structure of fuel, lack of traffic management, use of low-quality fuel, and absence of alternative fuels [Controlling Automotive Air Pollution: The Case of Colombo City, Sunil Chandrasiri 2003]

Cars pollute more at lower speeds than at higher speeds. They also pollute more when they accelerate than when they travel at a constant speed. Thus, the stop-and-go traffic that is more likely on two-way streets than one way. Faster speeds meant less congestion and lower emissions.

Table 2.2.2: Emission factors used in Sri Lanka

Vehicle type	CO	CO ₂	NO _x	HC	CH ₄	NMV	PM	Pb	So _x	N ₂ O
Motor Car (diesel)	1.5	275	2.2	0.75	0.01	0.25	0.4	-	1.2	0.014
Motor Car (petrol)	32.5	200	1.4	4.2	0.07	4.16	0.1	0.4	0.05	0.003
Three wheeler (petrol)	30	130	0.65	4.3	-	-	0.3	0.02	0	-
Motor cycle (petrol)	26	60	0.25	2.5	0.11	6.74	0.1	0.01	0	0.001
Large Bus (diesel)	2.5	800	5.7	3.7	0.06	2.02	1.5	-	3.7	0.032
Medium Bus (diesel)	8.93	788	10.63	-	0.06	2.02	-	-	-	0.032
Van (petrol)	45	285	2.5	6	-	-	0.05	0.06	0.05	-
Van (diesel)	1.8	400	3	2	-	-	0.8	-	1.7	-
Goods vehicle (petrol)	45	285	2.5	6	-	-	0.05	-	0.05	-
Goods vehicle (diesel)	2.5	800	5.7	3.7	0.05	1.62	1.5	-	3.7	0.026

Source: University of Moratuwa, Sri Lanka. Note: Unit g/km



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2.2.2 Rat – Run

Rat running refers to the use of secondary roads or residential side streets as opposed to the intended main roads in urban or suburban areas in order to avoid heavy traffic, lengthy traffic signals, or other obstacles lengthening a travel. Rat runs are frequently taken by motorists (especially motor cyclist, cars and three wheelers) who are familiar with the local geography. They will often take such short cuts to avoid busy main roads and junctions, even at the expense of having to negotiate traffic calming measures that may be in place to discourage them or even laws that are enacted against certain moves.

There is no mention of cars, three wheelers and motor cycles in the obiter dictum. The Court's focus on buses is surprising because they constitute only one per cent of new vehicle registrations. Over 50 per cent of new registrations are of motor cycles, followed by three wheelers (over 20 per cent) and private cars (over eight per cent) as shown in Table 2.2.3.

Table 2.2.3: New registration by vehicle type

Vehicle Type	2004	2005	2006	2007	2008	2009
Buses	2,167	2,069	3,346	2,637	1,180	739
Private Cars	19,116	17,283	27,578	22,603	20,237	5,762
Three wheelers	43,789	41,085	64,466	43,068	44,804	37,364
Dual purpose vehicles	10,736	6,851	7,245	5,193	2,856	1,280
Motor cycles	124,474	130,696	156,625	182,508	155,952	135,421
Goods transport	10,703	14,262	20,436	18,408	14,038	8,225
Land vehicles	12,857	17,423	20,825	23,475	26,132	15,284

Source: Department of Motor Traffic, Sri Lanka

If observe the road stretches between Alfred House Garden and Temple Lane, people who travel along Alfred House Garden and they wish to reach Bambalapitiya should continue their travelling along R.A. de Mel Mawatha. To avoid the major conflict on R.A. de Mel Mawatha, they choose the short-cut path as shown Figure 2.2.3.

Alfred House Road is a link road joining Alfred House Garden and Alfred House Avenue as shown below.

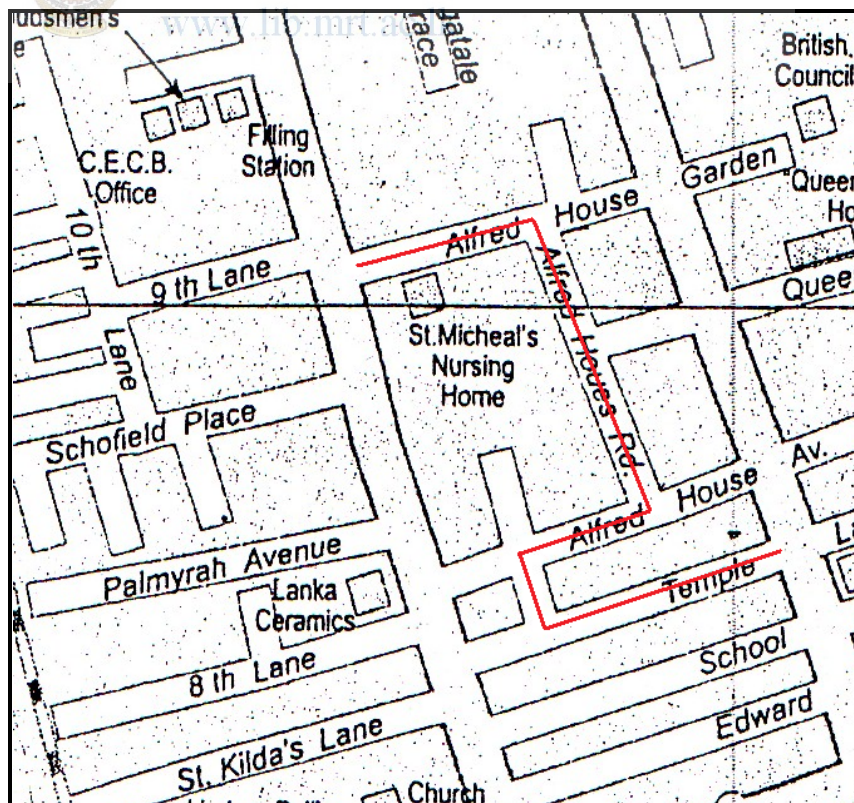


Figure 2.2.3: Rat-run path within the one-way stretch

2.2.3 Intersections and Link roads

One-way systems are effective in improving operational efficiencies at intersections as they reduce the number of conflicts from no opposing flows.

Turning movement restrictions at intersections eliminates many movements and makes intersection operation more efficient. Alternatively, those vehicles wishing to make the prohibited movement must find an alternative route to get the destination, which could increase the distance traveled. If the alternative route is inconvenient, the negative impacts become significant and could negate the benefit of the restriction. Thus, careful study on traffic volumes and available alternative routes are necessary before implementing turning restrictions.

A link road is an important transport infrastructure road that links two conurbations or other major road transport facilities, often added because of increasing road traffic. They can be controversial, especially if they threaten to destroy natural habitat and green field land.

When observe the one-way, approximately the length of this stretch is 2km. But the number of intersections within this section is fairly high.

If the number of intersection increases, turning movements will also increase. At the same time effects of merging traffic and immerging traffic will influence at intersection. Therefore amount of conflict points may vary. Before doing the conversion of one-way, most of the conflict pattern at link roads is describe below;

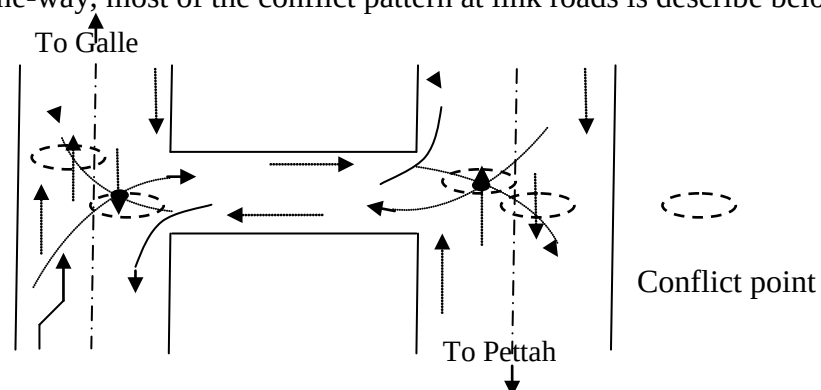


Figure 2.2.4: Conflict patterns in the two way arrangement

(A).Left-Turn, same direction conflict: A left-turn, same-direction conflict occurs when the first vehicle slows to make a left turn, thus placing a second, following vehicle in danger of a rear-end collision.

(B).Right-Turn, same direction conflict: A right-turn, same-direction conflict occurs when the first vehicle slows to make a right turn, thus placing a second, following vehicle in danger of a rear-end collision.

(C).Slow vehicle, same direction conflict: A slow-vehicle, same-direction conflict occurs when the first vehicle slows while approaching or passing through the intersection, placing a second following vehicle in danger of a rear-end collision.

(D).Lane change conflict: A lane-change conflict occurs when the first vehicle changes from one lane to another, thus placing a second, following vehicle in the new lane in danger of a rear-end or sideswipe collision.

(E).Opposing-Right-Turn conflict: An opposing right-turn conflict occurs when an oncoming vehicle makes a right turn, thus placing a second vehicle, going in the other direction, in danger of a head-on or broadside collision

(F).Cross traffic conflict: A cross-traffic conflict occurs when a vehicle (In the cross street turns or crosses into the path of a second vehicle on the main street that has the right-of-way and places the second vehicle in danger of rear-end, sideswipe, or broadside collision.

(G).Pedestrian conflict: There can also be pedestrian conflicts. They occur when a pedestrian (the road user causing the conflict) crosses in front of a vehicle that has the right-of-way, thus creating a possible collision situation. The vehicle brakes or swerves, then continues through the intersection area. There were no pedestrian crossings in main road, so more chances for this kind of conflict.

The above major conflict patterns are occurred at intersections in Galle Road as well as R.A. de Mel Mawatha. In some sections, conflict patterns are very severe because of the traffic through the cross roads, for an example traffic through the Alfred Place, Bagatelle Road and St Anthony's Mawatha is significantly high. Due to this congestion, traffic stagnation formed in the intersections of the cross roads.

2.2.4 Parking

Parking is the act of stopping a vehicle and leaving it unoccupied for more than a brief time. Parking on one or both sides of a road is commonly permitted, though often with restrictions. Parking facilities are constructed in combination with most buildings, to facilitate the coming and going of the buildings' users.

For most motorized vehicles, there are three basic modes of parking, based on the arrangement of vehicles such as parallel parking, perpendicular parking, and angle parking. These are self-park configurations where the vehicle driver is able to access the parking independently.



(a) Parallel parking



(b) Perpendicular parking



(c) Angle parking



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Figure 2.2.5: Different parking methods

The R.A. de Mel Mawatha from Kollupitiya to Bambalapitiya is becoming the shopping hub of the City of Colombo. The city should welcome the big businesses to the area to open departmental stores and mega shops. The R.A. de Mel Mawatha consists of four traffic lanes going south. The four lanes should be narrowed down to three to accommodate wider footpath for the benefit of shoppers. The Colombo Municipality can rent part of the footpath frontage to restaurants to have open air eating places during day and night. The beautification of footpaths can be done in discussion with restaurant owners and other shop owners. The funding for adornment work can be shared between the shop owners and the Council or the government.

Before conversion of one-way, along the R.A. de Mel Mawatha outer lanes were occupied with parallel and perpendicular parking. But parking is highly restricted in this area after conversion of one-way. Some shop owners are provided the parking space beside their shop or in front of their shop. Due to the lack of space requirement only parallel parking is exist alongside the Galle Road.

2.2.5 Accident

The total population had risen from 18.7 million to 20.45 million between 2001 and 2009, and the population growth is reducing and comparatively small about 1.10%. More than population increases; the increasing fleets have had a damaging effect on the number of road accident in Sri Lanka. Registration of motor vehicle of all varieties is enormously increased as shown in Table 2.2.4.

Table 2.2.4: Yearly registered vehicles in Sri Lanka

Year	Amount of registered motor vehicles (all varieties) / Million
2001	0.073
2002	0.113
2003	0.181
2004	0.224
2005	0.230
2006	0.300
2007	0.298
2008	0.265
2009	0.204

Source: Department of Motor Traffic, Colombo, Sri Lanka

Vehicle population had increase from 1.779 million to 3.595 million within the period from 2001 to 2009. This vast variation is shown in the Figure 2.2.6.

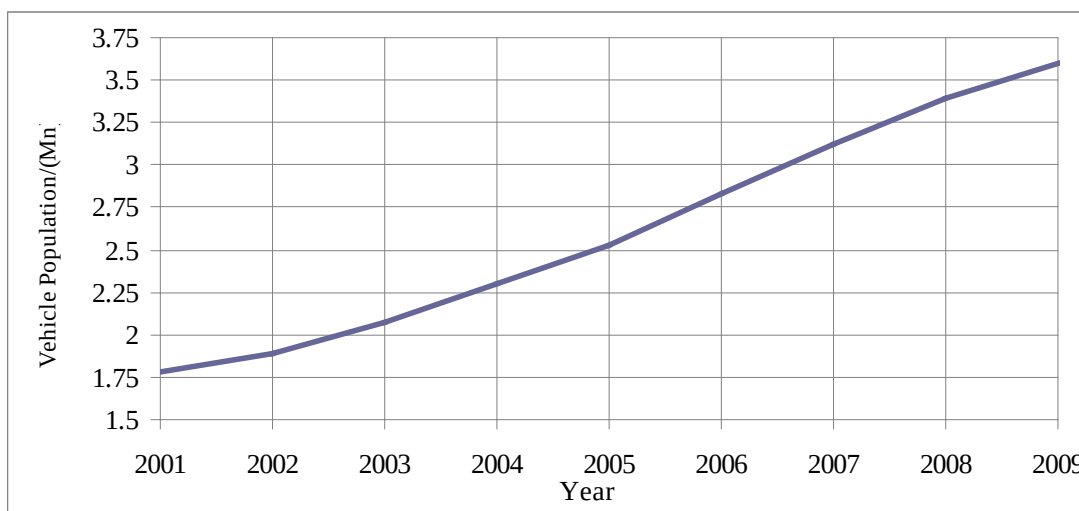
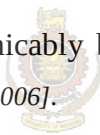


Figure 2.2.6: Total vehicle population of Sri Lanka

As a result of the two factors such as increases in number of vehicles and very poor development of road infrastructure, the traffic accident in Sri Lanka shows an increasing trend and the significant numbers of fatality. Another important factor is driver skills. While drivers in Sri Lanka have vehicle skills such as controlling the vehicle, their knowledge of road rules is minimum and they are a potential hazard for other road users. Since a sizeable portion of the deaths and injuries affect vulnerable road users - pedestrians, cyclists and motorcyclists - the loss of life and damage of health at these people should be avoided.

Road accident causes an estimated loss of Rs. 15 billion annually to the country's economy. It is reported that around 35 percent drivers have obtained driving licenses by producing bogus medical certificate and responsible for the rise in the number of fatal accidents. [www.dailynews.lk/2010/03/29/main_News.asp]

The number of reported accidents to the Police has increased from 26,196 in 1989 to 52,444 in 2009. However, it should be noted that these figures were based on the total accidents, which were reported to the Police. But, normally most of the minor accidents are not reported to the police and any of the damage only accidents are settled amicably by both parties. [*Accident Statistics in Sri Lanka*, A.K.Somasundaraswaran March 10, 2006].



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Chapter 3: METHODOLOGY

3.1. Plan of study

- I. Select the road stretches
- II. Identify the factors which affect the present one-way system
- III. Analyze and compare the factors with the past traffic system (two-way traffic system)
- IV. Find the impacts (whether positive or negative)
- V. Find out the conclusion

3.2. Traffic Studies and Acquisition of Data

Studies relevant to the issues under discussion have been carried out by many organizations in the past. For example, the Road Development Authority (collection of Turning Movements), the Department of Civil Engineering of the University of Moratuwa (Traffic Data) and Sri Lanka Police (Accident Data) has conducted such studies and data from them have been used in the present study. Owing to the fair number of schools present along the Galle Road, realistic traffic patterns cannot be observed during school vacations.

3.2.1. Travel time and speed

Traffic data required for the travel time analysis were taken from Road Development Authority and University of Moratuwa. The traffic survey had been conducted at Liberty Plaza Junction on 3rd August 2005 and 26th June 2009 (by Road Development Authority, Sri Lanka - Turning Movements). Similarly in 2006 the survey was made at Bagatale Junction (by University of Moratuwa, Sri Lanka -Traffic Data). Then, on 24th June 2008 another survey was carried out at Bambalapitiya Junction (by Road Development Authority, Sri Lanka- Turning Movements). These surveys have been carried out in week days. Otherwise actual traffic pattern created by school traffic as well as the traffic generated by workers cannot be predicted. Data is gathered for the time period from morning 6.00 am to evening 10.00 pm. All types of vehicles have been considered for the traffic count (excluding bicycles). Other physical infrastructures related to road users are given in the following table;

Table 3.2.1: No of bus halts & pedestrians crossings along one way stretches

Road Stretch	No of Bus Halts	No of Pedestrian Crossing
Galle Road	4	6
R.A de Mel Mawatha	5	9

Generally in Sri Lanka, vehicles have “stop-and-move” concept. Most of the busses are waiting at the bus halts to collect the people. These delay times have been differing from time to time. Similarly, time for cross the pedestrian crossing also varying due to the type of people and number of people. Before conversion of one-way these two activities were in very worst condition. There is no traffic signal within the one-way stretch along Galle Road and R.A. de Mel Mawatha. There are quite amount of diverted traffic on Galle Road and R.A. de Mel Mawatha due to railway station, Lindsay Balika Vidyalaya, Durdans Hospital and Mahanama College, British Council respectively. Compare with the total traffic these amount can be negligible. Due to these reasons the following assumptions were made for easiness of the travel time analysis;

- No captive flow
- No delay due to pedestrian crossings
- No delay due to bus halts
- No delay due to traffic signals

3.2.2. Lane arrangement along the R.A. de Mel Mawatha

Lane widths, foot walk widths, lane separation and the traffic movements before and after the one-way arrangement of R.A. de Mel Mawatha is shown in figure 3.2.1.

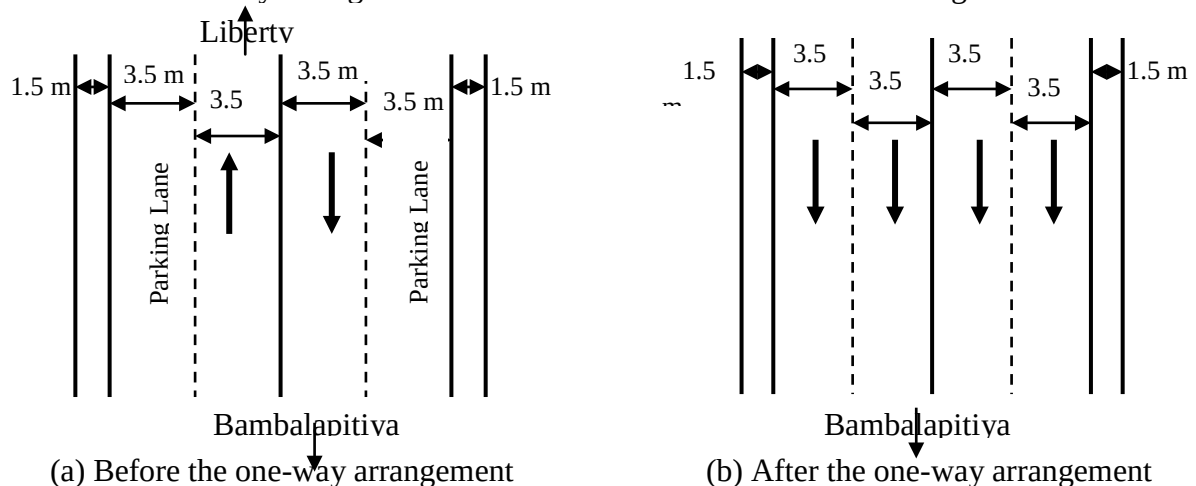


Figure 3.2.1: Lane arrangement in R.A. de Mel Mawatha

3.2.3. Lane arrangement along the Galle Road

Width of the lanes, foot walk and centre median, lane separation and the traffic movements before and after the one-way arrangement of Galle Road is shown in figure 3.2.2.

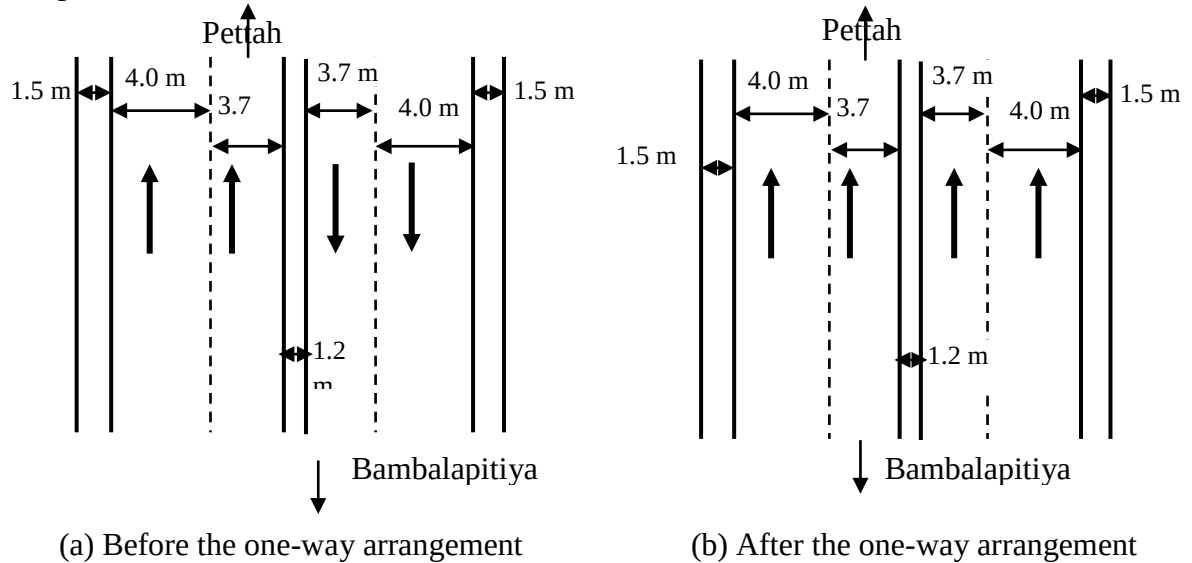


Figure 3.2.2: Lane arrangement in Galle Road

3.2.4. Travel Time Analysis

For the travel time calculations, Greenshield traffic flow model was used. The Greenshield traffic model was proposed by Greenshield which is stating the relationship between speed, flow and density. As field measurement of speed, flow and density became available; several researchers evolved traffic flow models based on actual curve fitted and statistical testing. The evaluation of models proceeded along two lines;

- Relationships of q - k - v were tested in terms of goodness of fit to actual field data.
- Relationships were supposed to satisfy certain boundary conditions.

Where; q - flow, k -density, v -speed.

This is a reliable and easy method but there are some drawbacks also. Greenshield traffic model is only applicable for the undisturbed steady flow but within the stretch flow pattern is changed due to some interruptions. In some places traffic moves as a stop and slow move pattern, in which places prediction of the speed is very difficult. Here steady state condition of traffic is assumed for the calculation purpose.

For steady state condition Greenshield Model (original model empirical) is given below;

$$U = U_f [1 - k/k_j] \text{ ----- (1)}$$

General equation for traffic flow; $q = u \times k \text{ ----- (2)}$

Where;

$$u = \text{Speed}$$

$$k = \text{Density}$$

$$k_j = \text{Jam density}$$

$$U_f = \text{Free speed}$$

$$q = \text{traffic volume per hour per lane}$$

By solving the equations (1) and (2), the following results were found.

$$U_o = U_f / 2$$

$$k_o = k_j / 2$$

$$q_{\max} = u_o \times k_o = u_f \times k_j / 4$$



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Where;

$$q_{\max} = \text{Maximum flow}$$

$$U_o = \text{Optimum speed}$$

$$k_o = \text{Optimum density}$$

Traffic flow (PCU) along the Galle Road and R.A.de Mel Mawatha has varied around 25,000 – 40,000 per day in both cases and throughout the stretch terrains are flat. When travel through these stretches the free speed is observed almost 60 km/hr and the jam density is 100 v/km. Depend on the situation the following parameters are considered along the stretches of Galle Road and R.A.de Mel Mawatha;

$$\text{Jam density, } k_j = 100 \text{ v/km}$$

$$\text{From the Greenshield Model ; } k_j = 2 k_o$$

$$\text{So, Optimum density, } k_o = 50 \text{ v/km}$$

$$\text{Free speed, } U_f = 60 \text{ km/hr}$$

$$U_f = 2 U_0$$

$$\text{So, Optimum speed, } U_0 = 30 \text{ km/hr}$$

$$\begin{aligned} \text{Then, Maximum flow, } q_{\max} &= 50 \times 30 \\ &= 1500 \text{ v/hr} \end{aligned}$$

Consider the mixed traffic flow model;

$$\begin{aligned} q &= (80 - k) k \text{----- (3)} \\ &= 80k - k^2 \end{aligned}$$

$$dq/dk = 80 - 2k$$

$$\text{When; } dq/dk = 0$$

$$q = q_{\max}$$

$$k = k_0$$



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$$\begin{aligned} \text{Now } k_0 &= 40 \text{ v/hr} \\ q_{\max} &= (80 - 40) \times 40 \\ &= 1600 \text{ v/hr} \end{aligned}$$

When compare the parameters (density, flow etc.) which got from mixed traffic flow model and the parameter for actual situation (selected parameter); there are small deviations between them. So, the selected model is acceptable for the analysis.

$$\text{Therefore selected } q_{\max} = 1500 \text{ v/hr}$$

$$\text{From the equation (3); } k = 40 \pm (1600 - q)^{0.5}$$

Before conversion of one way in the peak hours assumes as congested situation, where

$$k = 40 + (1600 - q)^{0.5}$$

On the other hand off peak tours considered as uncongested situation, so

$$k = 40 - (1600 - q)^{0.5}$$

$$\text{Then; Velocity, } U = q / k$$

From the above equation velocity can be predicted

$$\text{But; Travel time} = \text{Distance} / \text{velocity}$$

$$t = d / u$$

Distance can be measured at site. Travel time can be estimated if velocity is known.

For an example along the Galle Road;

Before conversion of one way from Bambalapitiya to Kollupitiya direction, the maximum q_{demand} is 1236 v/hr/lane (8.00 am–9.00 am) in the morning peak hour and the congested situation.

$$\text{Where, } k = 40 + (1600 - q)^{0.5}$$

But in the off peak from 17.00 pm – 18.00 pm in an uncongested situation the q_{demand} is 671 v/hr/lane along the same direction,

$$\text{Where, } k = 40 - (1600 - q)^{0.5}$$

Similarly travel times have been calculated for peak and off peak time in the congested and uncongested situations along the both roads for before and after conversion of one way system.

Green shield's model is a linear model used for uninterrupted flows. To use this model, there are some limitations should be considered. There is no stop and go situation and no delays due to any kind of interruptions. According to these factors the following limitations are considered;

For flow; $0 < q < q_{\text{max}};$ $0 < q < 1500 \text{ v/hr}$

For speed; $0 < U < U_f;$ $0 < U < 60 \text{ km/hr}$

For density; $0 < k < k_j;$ $0 < k < 100 \text{ v/km}$

3.2.5. Vehicle Emission Analysis

Yearly registered total number of petrol and diesel vehicles data is gathered for the period of 2003-2009 (Department of Motor Traffic, Sri Lanka). The percentage of petrol and diesel vehicles of a particular year is calculated based on the ratio of newly registered petrol and diesel vehicles in that year. Vehicle speed is influencing in the emission. When they travel in high speed, the amount of burning fuel is less, which decreases the amount of emission. But slow movement results in high emission.

From the emission formula;

$$\text{Emissions (g)} = \text{Emissions Factor (g/km)} \times \text{Vehicle traveled distance (km)}$$

The vehicle travelling distanced already known from measurement. It is taken as two kilometers in the stretch. Emission factors (used in Sri Lanka) are taken from the data provided by University of Moratuwa. [Vehicle emission inventory for Sri Lanka].

3.2.6. Accident Analysis

Accident data from 2005 to 2009 have been gathered from the Kollupitiya Police Station within the one-way stretch along the Galle Road and the R.A. de Mel Mawatha. These data classified as the yearly accident type and the yearly injured road users type. Data analyzed in the graphical method. Amount of accidents compare to before and after comparison of one-way arrangement. Amount of accidents have been converted as a percentage for the easy comparison among them.

3.2.7. Inconvenience for public transport user

To identify the inconvenience of the public transport users due to the one-way arrangement, several interviews have been made within workers who use the public transport, school students, residents and people who have the shops within the system (owners) as well as customers also.

3.2.8. Estimation of additional travel distance

Major disadvantage of the one-way arrangement is “increment of travel distance”. This is a general statement, not only for Sri Lanka. But within the one-way system there are some set of people face the problem regarding this additional travel distance. Especially people who live in one arm of the one-way system and they have to travel to other arm of the system daily. For an example how the distance is varies as shown in figure 3.2.3.

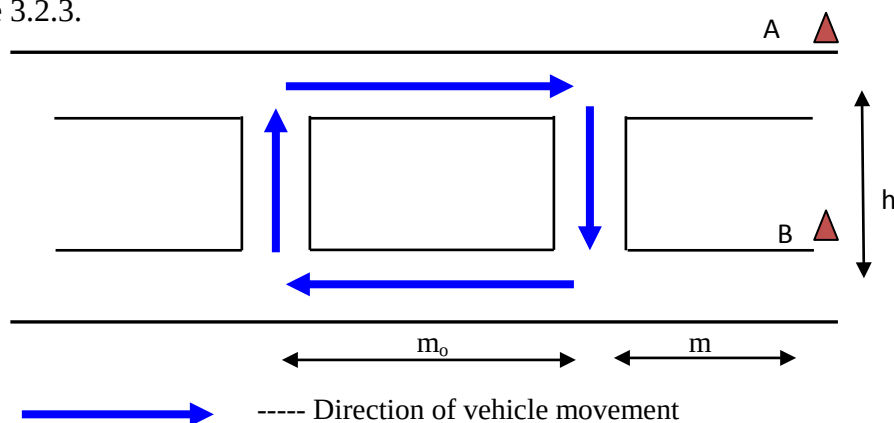


Figure 3.2.3: Lane arrangement in one way traffic system

Travel distance between A and B;

$$\begin{aligned} \text{Before the one-way conversion, } d_1 &= m + h + m \\ &= 2m + h \end{aligned}$$

$$\begin{aligned}\text{After the one-way conversion, } d_2 &= m + m_o + h + m_o + m \\ &= 2m + 2m_o + h\end{aligned}$$

Therefore, $d_1 < d_2$

Where additional travel distance is calculated by $(d_2 - d_1) = 2m_o$

The values of m , m_o and h will vary from section to section.

3.2.9. Traffic flow analysis on connecting roads

Traffic data for analysis of connecting roads collected from University of Moratuwa. Traffic survey for the connecting roads of Abdul Capoor Mawatha and the St Anthony Mawatha had been done on 13th June 2007 (after conversion of one-way). Similarly, traffic data for the connecting roads of Bagatale road and Alfred place had been carried out of year 2006 (before conversion of one-way). Traffic counts have been taken for the analysis.

3.2.10. Traffic flow analysis at junctions

Traffic data for analysis of traffic at junctions gathered from University of Moratuwa. The survey has been done on 4th March 2010. Liberty junction, Bagatale junction, and Dharmapala Mawatha junction have been analyzed after conversion of one-way arrangement. Direction of traffic movements at Dharmapala Mawatha junction, Bagatale junction and Liberty junction are shown in the figures 3.2.4, 3.2.5 and 3.2.6 respectively.

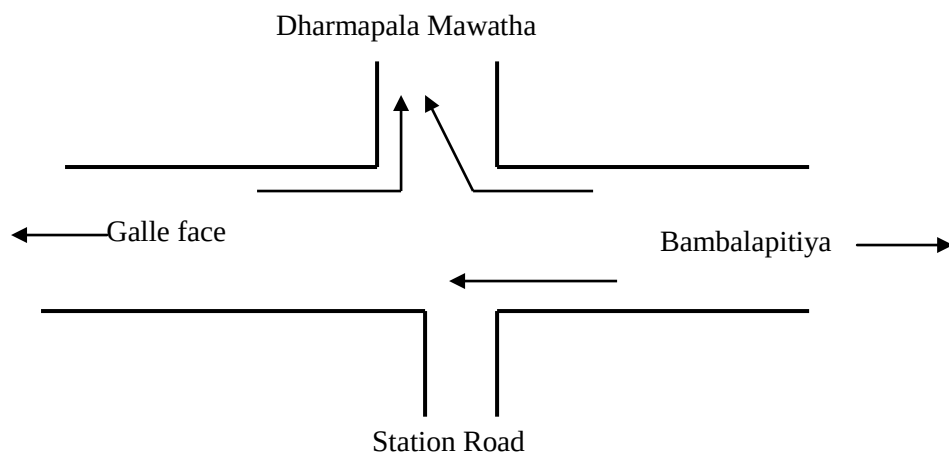


Figure 3.2.4: Dharmapala Mawatha junction

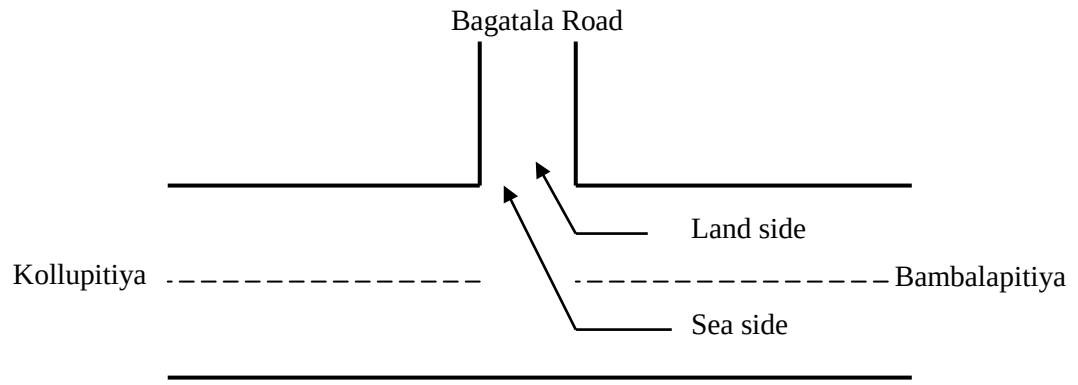


Figure 3.2.5: Bagatale junction

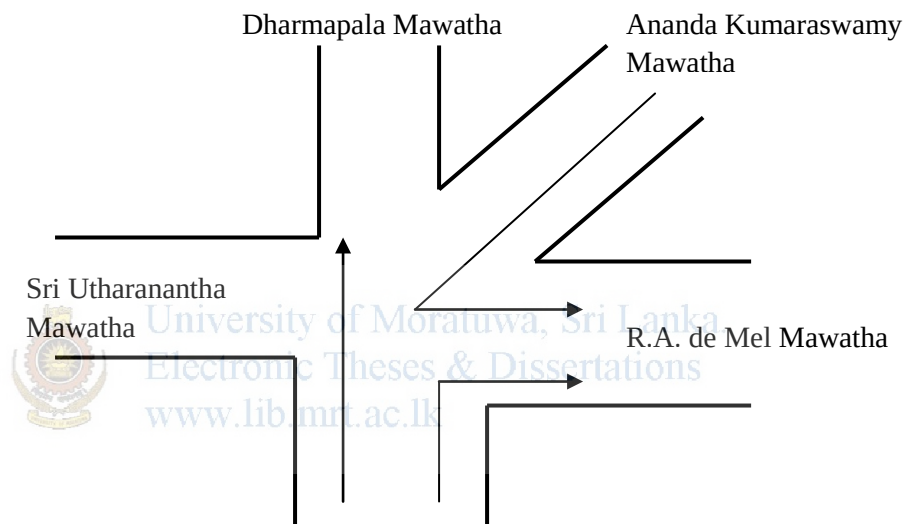


Figure 3.2.6: Liberty junction

Chapter 4: OBSERVATION & RESULTS

4.1. Observation of After Conversion of One Way

a) The one way traffic arrangement which was in operation from October 2006 did not result much significant improvement in congestion. Traffic congestion during the "school rush hours" prevailed though not so acute as in the past. Further, due to the fact that all buses, lorries, and other heavy vehicles moved in one direction on one road all times of the day, traffic jam did occur at different times of the day. On the other hand there were times when certain sections of the Galle road and the R.A. de Mel Mawatha were virtually empty because of the one-way movement.

Traffic congestion takes place mostly on the following days;

On week days when schools and offices are in session (i.e. school days);

- From 7.00 am to 9.00 am there is congestion on Galle road during school commencing times. At this time R.A. de Mel Mawatha is not congested that much. But from 11.30 am to 17.00 pm (during the evening peak) congestion highly appears on R.A. de Mel Mawatha.
- A large percentage of vehicles using Galle road and R.A. de Mel Mawatha during peak hours used for drop off or pick up school children.

b) During the study it was observed that at all times, inconsistent driver behavior especially that of bus drivers on both roads contributed a big portion to the congestion. These behaviors are,

- Bus drivers picking up and dropping off passengers outside designated bus stops.
- Unwarranted halting of buses in the lane itself to pick up and/or drop off passengers at or outside the designated bus stops, holding all the following vehicles in the lane.
- Unwarranted waiting by buses at halting places even after picking up / dropping off passengers
- Some drivers driving on the wrong side of the road and wedging into the traffic stream in violation of traffic rules thereby interrupting smooth flow of traffic.
- Erratic parking along the both roads.

4.2. Traffic Flow Analysis Results

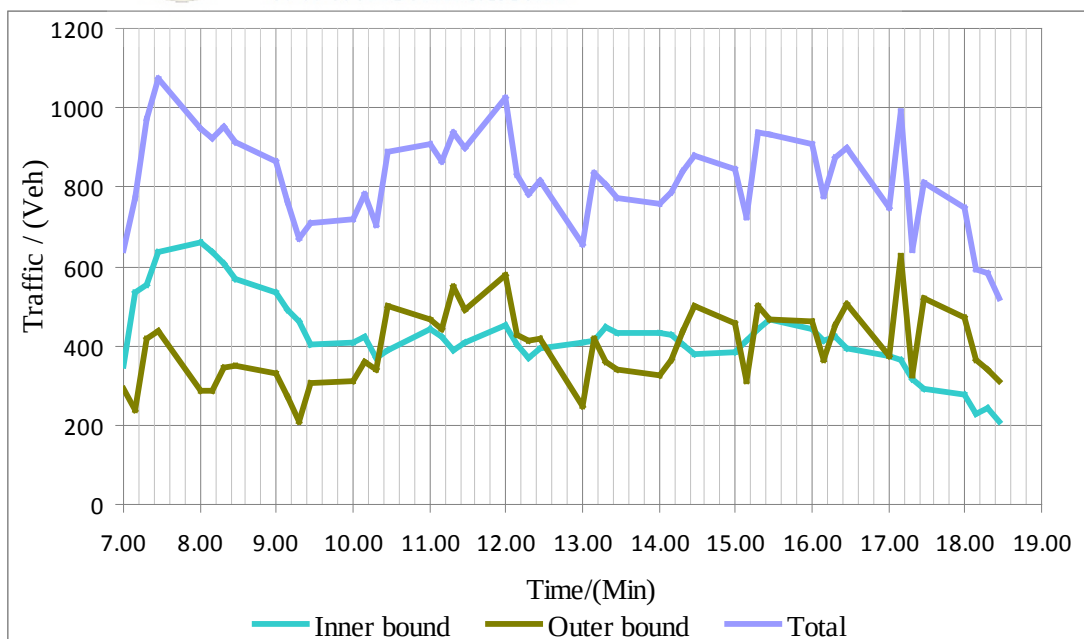
4.2.1. Traffic flow analysis along the Galle Road

For the traffic flow analysis along the Galle Road corridor for before and after conversion to one-way system, predicted traffic patterns are shown below. Figure 4.2.1 describes the traffic flow along the Galle Road before doing the conversion of one-way traffic. Traffic towards to Pettah is considered as “Inner bound traffic” and traffic towards to Bambalapitiya junction is considered as “Outer bound traffic”. Both these bound traffics are plotted separately and the addition of these two traffics is considered as “Total traffic” and plotted in the same graph. During this analysis traffic flow is stated in number of “vehicles”.

During the morning hours from 7.00 am - 9.00 am inner bound traffic is higher than the outer bound traffic (because of the school services and the staff services). Then in the evening hours from 16.00 pm - 18.00 pm the outer bound traffic is higher than the inner bound traffic. The main reason for this peak is, “office closures”. During 10.30 am to 12.30 pm also outer bound traffic is high because of the school closings.

Inner bound – Traffic toward to Pettah

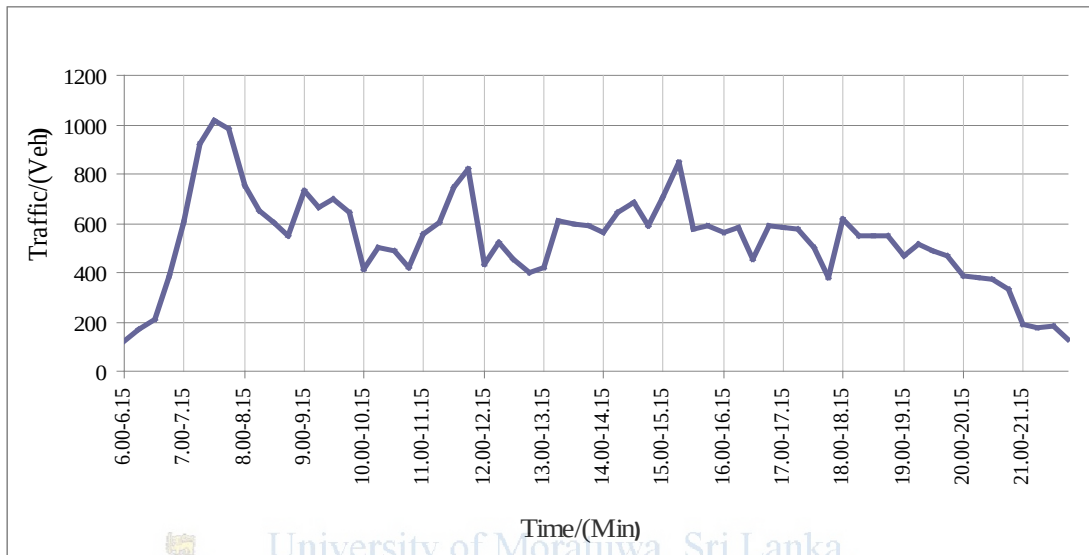
Outer bound - Traffic towards to Bambalapitiya Junction



Source: University of Moratuwa, Sri Lanka

Figure 4.2.1: Traffic flow along Galle Road- Before the one way system (2006)

Traffic pattern along the Galle Road after conversion of one-way is shown in figure 4.2.2. Here no traffic flows towards to Bambalapitiya junction. Only inner bound traffic flow has been considered. Due to the school services and the office traffic the total flow came to peak within 7.00 am - 8.00 am, 11.00 am - 12.00 pm and 15.00 pm - 16.00 pm time periods



Source: Road Development Authority, Sri Lanka

Figure 4.2.2: Traffic flow along Galle Road- After the one way system (2009)

Comparison of traffic flow along the Galle Road before and after conversion of one-way arrangement is described in figure 4.2.3. Directly it shows that the traffic flow along the Galle Road is reduced after conversion of one-way system.

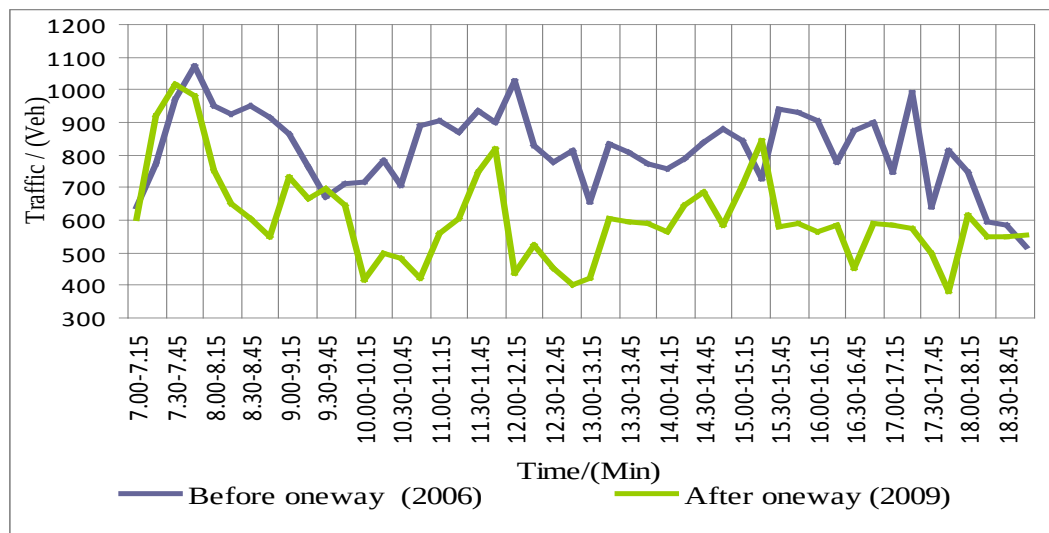
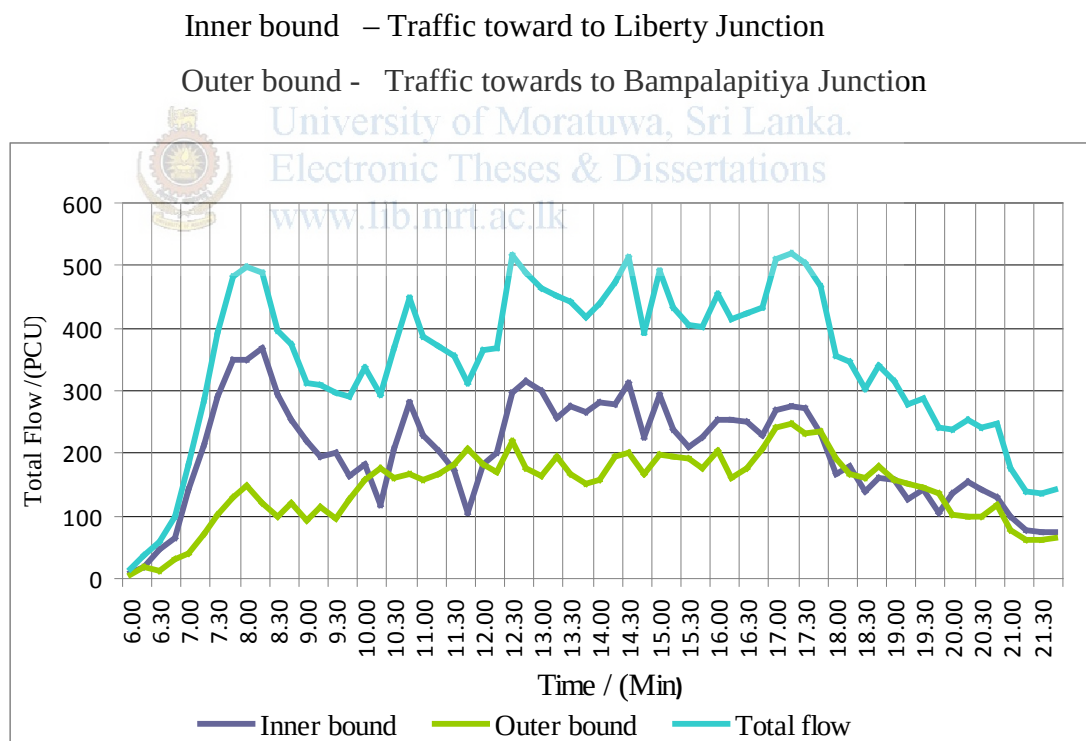


Figure 4.2.3: Comparison of traffic flow along the Galle road

4.2.2. Traffic flow analysis along the R.A. de Mel Mawatha

For the traffic flow analysis along the R.A. de Mel Mawatha, before and after conversion to one-way system, predicted traffic patterns are described below. Figure 4.2.4 describes the traffic flow along the R.A. de Mel Mawatha before the conversion of one-way system. Traffic towards to Liberty junction is considered as “Inner bound traffic” and traffic towards to Bauddhaloka Mawatha is considered as “Outer bound traffic”. Both these bound traffics are plotted separately and the addition of these two traffics is considered as “Total traffic”, which is also plotted in the same graph. During this analysis traffic flow is stated in “Passenger Car Unit (PCU)”.

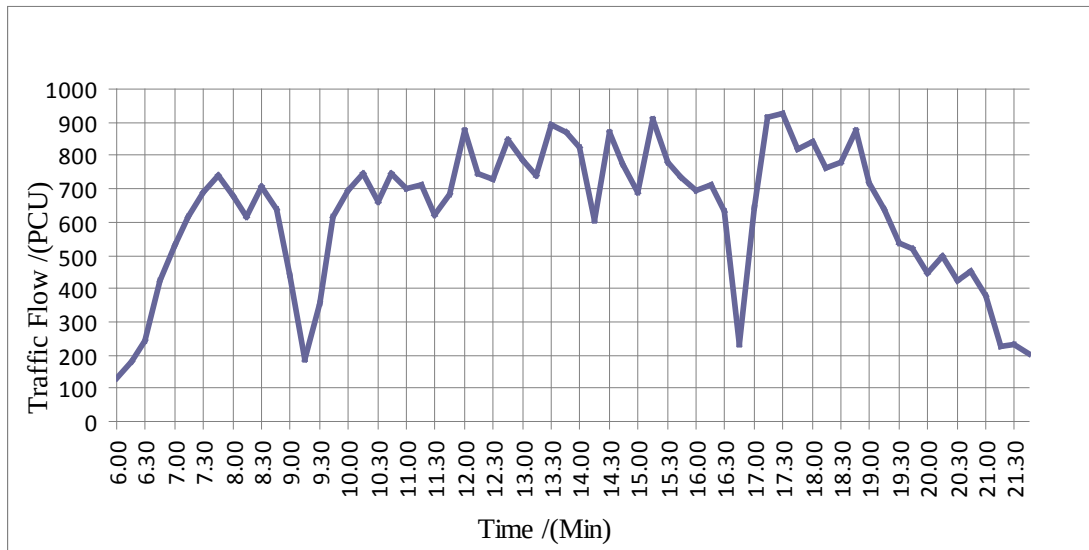
During the morning hours from 7.30 am – 9.00 am and evening hours from 12.00 pm - 15.00 pm inner bound traffic is larger than the outer bound traffic. The reason is same as the higher traffic along the Galle Road. But in the evening hours (after 18.00 pm) traffic in inner and outer bounds are almost closer to each.



Source: Road Development Authority, Sri Lanka

Figure 4.2.4: Traffic flow along R.A. de Mel Mawatha before the one way system

Figure 4.2.5 describes the traffic flow along the R.A. de Mel Mawatha after conversion of one-way arrangement. There are two low flow points found due to the road closures at Kollupitiya in morning 9.15 am and evening 16.45 pm at Ananda Kumaraswamy Mawatha. Here the large traffic flow predicted specially in evening.



Source: Road Development Authority, Sri Lanka

Figure 4.2.5: Traffic flow along R.A. de Mel Mawatha - After the one way system.

Comparison of traffic flow along the R.A. de Mel Mawatha before and after conversion of one-way arrangement is described in figure 4.2.6. Directly it shows the traffic flow along the R.A. de Mel Mawatha is increased after conversion.

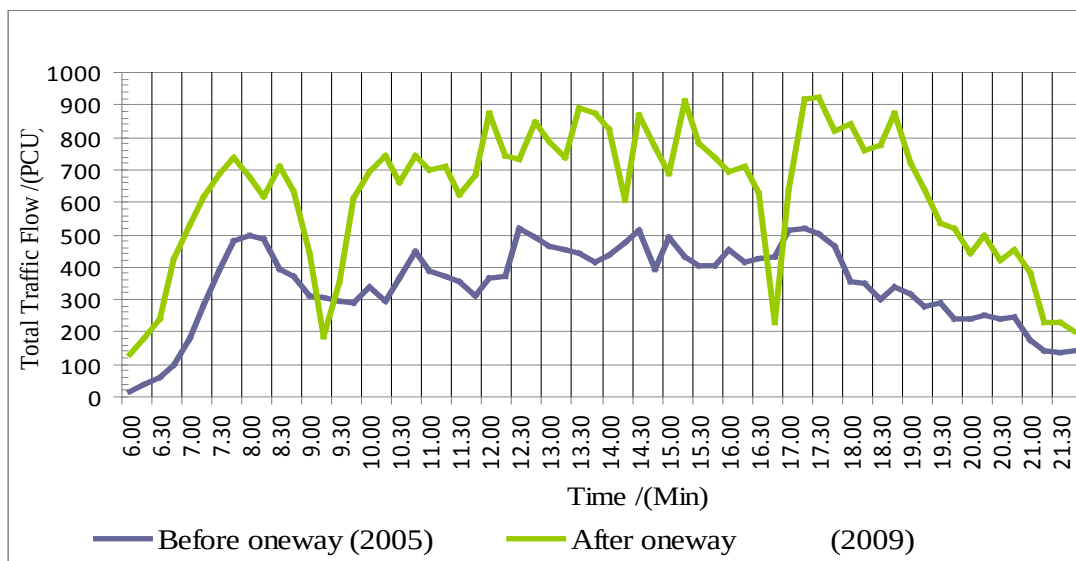


Figure 4.2.6: Comparison of traffic flow along the R.A. de Mel Mawatha

4.3. Travel Time Analysis Results

4.3.1. Travel time analysis along the Galle Road

Time required traveling from Bambalapitiya junction to Liberty junction is considered as travel time. Travel time predicted before and after conversion of one-way system along the Galle Road. It is calculated from the velocity equation (which is mentioned in the chapter 3.2.4). Predicted travel times and the vehicle hours are tabulated in the table 4.3.1

Table 4.3.1: Comparison of travel time along the Galle Road

Time Period	Before conversion of one way (Bambalapitiya - Kollupitiya)				Before conversion of one way (Kollupitiya - Bambalapitiya)				After conversion of one way (Bambalapitiya - Kollupitiya)			
	Flow/veh/hr/lane	Status	Travel Time/Min	Vehicle Hours	Flow/veh/hr/lane	Status	Travel Time/Min	Vehicle Hours	Flow/veh/hr/lane	Status	Travel Time/Min	Vehicle Hours
07.00-08.00	1037	C	7.38	127.48	692	NC	1.71	19.73	880	C	9.11	133.65
08.00-09.00	1236	C	5.74	118.16	422	NC	1.61	11.35	639	NC	1.69	18.00
09.00-10.00	944	C	8.34	131.22	561	NC	1.66	15.52	686	NC	1.71	19.52
10.00-11.00	793	NC	1.75	23.17	756	NC	1.74	21.90	455	NC	1.63	12.34
11.00-12.00	831	NC	1.77	24.54	974	C	8.02	130.06	682	NC	1.71	19.40
12.00-13.00	809	NC	1.76	23.75	916	C	8.67	132.31	454	NC	1.62	12.29
13.00-14.00	851	C	9.50	134.74	684	NC	1.71	19.45	553	NC	1.66	15.29
14.00-15.00	822	NC	1.77	24.21	812	NC	1.76	23.86	620	NC	1.68	17.40
15.00-16.00	853	C	9.48	134.68	869	C	9.26	134.07	680	NC	1.71	19.33
16.00-17.00	837	NC	1.77	24.76	891	C	8.98	133.27	548	NC	1.66	15.13
17.00-18.00	671	NC	1.70	19.04	924	C	8.58	132.02	510	NC	1.64	13.97
18.00-19.00	479	NC	1.63	13.02	744	NC	1.73	21.47	567	NC	1.66	15.71
Total	10,161			798.96	9,242			795.00	7,274			312.04

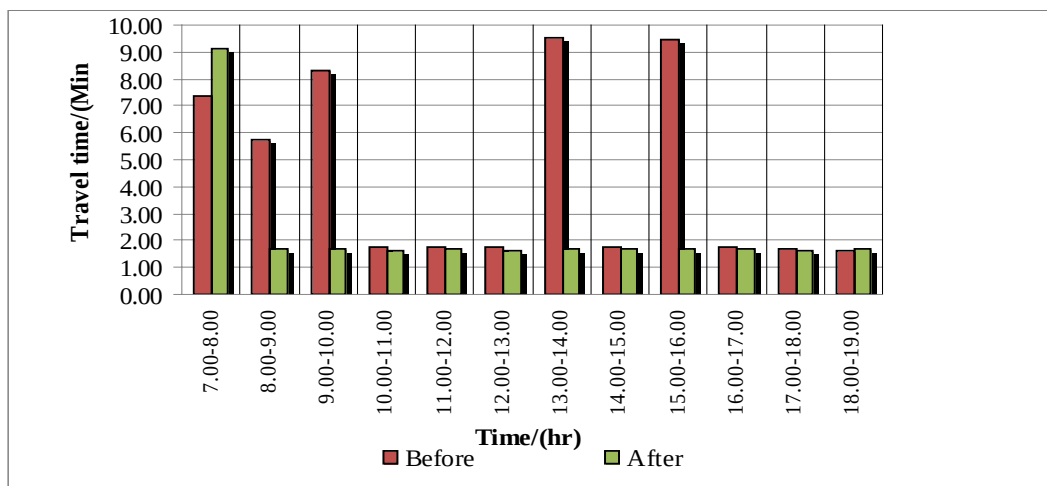


Figure 4.3.1: Comparison of travel time along the Galle Road

Note: C- Congestion. NC-Non congestion

The differences between the travel times are shown in the figure 4.3.1. Along this stretch travel time has been reduced. Before conversion of one-way, during the peak hour's congestion situation was there. Even though after conversion of one way, especially in the morning peak the travel time is higher than the travel time of before conversion of one way. Because during the morning time more traffic density attracted by the city centre. Other than in morning and evening peaks no big deviation in the travel time along this road before & after conversion along the Galle Road.

4.3.2. Travel time analysis along the R.A. de Mel Mawatha

Time required traveling from Liberty junction to Bauddhaloka Mawatha considered as travel time. Travel time and vehicle hours predicted for before and after conversion of one-way system along the R.A. de Mel Mawatha and calculated by the method used in chapter 4.3.1. Predicted travel times are tabulated in the table 4.3.2.

Table 4.3.2: Comparison of travel time along the R.A de Mel Mawatha

Time Period	Before conversion of one way (Bambalapitiya - Kollupitiya)				Before conversion of one way (Kollupitiya - Bambalapitiya)				After conversion of one way (Bambalapitiya - Kollupitiya)			
	Flow/ veh/hr/lane	Status	Travel Time/Min	Vehicle Hours	Flow/ veh/hr/lane	Status	Travel Time/Min	Vehicle Hours	Flow/ veh/hr/lane	Status	Travel Time/Min	Vehicle Hours
06.00-07.00	71	NC	1.52	1.78	36	NC	1.51	0.89	244	NC	1.56	6.35
07.00-08.00	498	C	17.6	146.41	172	NC	1.54	4.42	644	NC	1.69	18.15
08.00-09.00	633	C	13.4	142.19	246	NC	1.56	6.39	659	NC	1.70	18.64
09.00-10.00	390	NC	1.60	10.43	214	NC	1.55	5.54	399	NC	1.61	10.68
10.00-11.00	394	NC	1.61	10.53	331	NC	1.59	8.74	711	C	11.7	139.64
11.00-12.00	357	NC	1.59	9.47	356	NC	1.59	9.46	680	C	12.4	140.65
12.00-13.00	498	NC	1.64	13.59	374	NC	1.60	9.97	798	C	10.2	136.63
13.00-14.00	550	NC	1.66	15.18	339	NC	1.59	8.96	823	C	9.90	135.74
14.00-15.00	548	NC	1.66	15.12	361	NC	1.60	9.60	768	C	10.7	137.68
15.00-16.00	485	NC	1.63	13.20	382	NC	1.60	10.20	778	C	10.5	137.34
16.00-17.00	493	NC	1.64	13.44	373	NC	1.60	9.93	566	C	15.3	144.31
17.00-18.00	525	NC	1.65	14.41	477	C	18.43	147.02	825	C	9.87	135.67
18.00-19.00	324	NC	1.58	8.54	349	C	25.92	150.74	814	C	10.0	136.07
19.00-20.00	267	NC	1.57	6.97	296	C	30.86	152.22	603	C	14.2	143.15
20.00-21.00	282	NC	1.57	7.38	208	NC	1.55	5.37	454	NC	1.62	12.29
21.00-22.00	164	NC	1.54	4.20	134	NC	1.53	3.42	260	NC	1.57	6.78
Total	6,472			432.84	4,645			542.89	10,026			1,459.8

Note: C- Congestion. NC-Non congestion

After conversion of one-way, traffic flow increased along the R.A. de Mel Mawatha by vast amount and travel time also increased. Figure 4.3.2 clearly states that the travel time after conversion of one way is increased by a significant amount during the evening peak hours. Between 17.00 - 20.00 pm traffic flow is increased but the traffic density is decreased, which directly impacts the travel time positively.

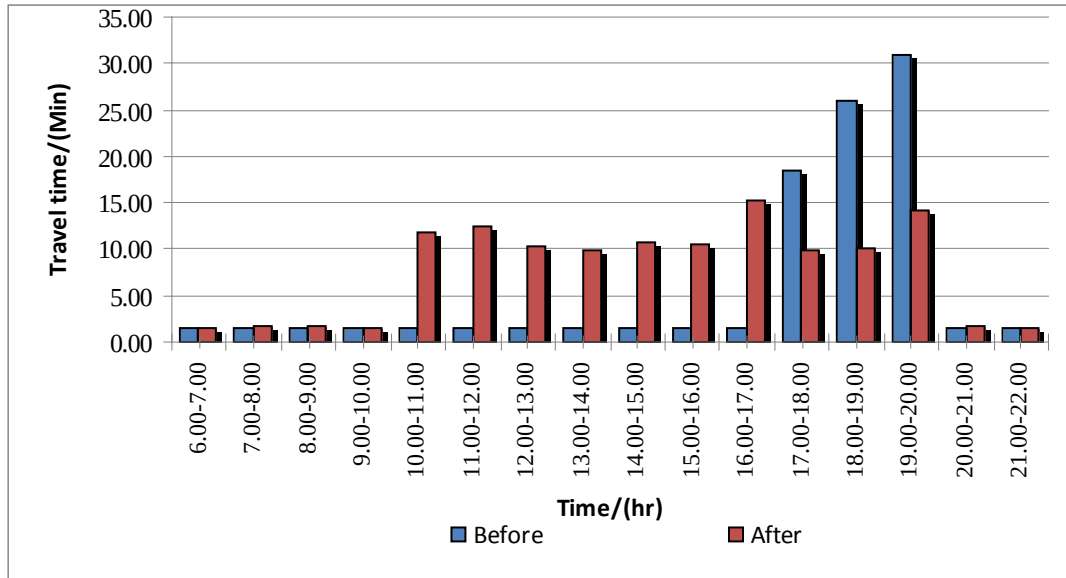


Figure 4.3.2: Comparison of travel time along the R.A de Mel Mawatha

After conversion of one way, hourly passenger hours along the Galle Road are described in the table 4.3.3.

Table 4.3.3: Travel time after the conversion along Galle Road

Time Period	After conversion of one way (Bambalapitiya - Kollupitiya)	
	Travel Time	Passenger Hours
07.00-08.00	9.11	2,376.54
08.00-09.00	1.69	428.98
09.00-10.00	1.71	372.44
10.00-11.00	1.63	249.61
11.00-12.00	1.71	374.20
12.00-13.00	1.62	252.38
13.00-14.00	1.66	295.91
14.00-15.00	1.68	256.80
15.00-16.00	1.71	317.57
16.00-17.00	1.66	216.81
17.00-18.00	1.64	277.59
18.00-19.00	1.66	240.83
Total		5,659.65

Before and after conversion of one way, hourly passenger hours along the R.A.de Mel Mawatha are described in the table 4.3.4.

Table 4.3.4: Travel time after the conversion along R.A de Mel Mawatha

Time Period	Before conversion of one way (Bambalapitiya - Kollupitiya)		Before conversion of one way (Kollupitiya - Bambalapitiya)		After conversion of one way (Kollupitiya - Bambalapitiya)	
	Travel Time	Passenger Hours	Travel Time	Passenger Hours	Travel Time	Passenger Hours
06.00-07.00	1.52	8.25	1.51	4.67	1.56	132.15
07.00-08.00	17.66	795.40	1.54	29.62	1.69	253.41
08.00-09.00	13.48	743.04	1.56	30.18	1.70	273.96
09.00-10.00	1.60	53.58	1.55	27.16	1.61	108.91
10.00-11.00	1.61	49.68	1.59	33.65	11.79	1,659.90
11.00-12.00	1.59	43.61	1.59	40.14	12.41	1,482.05
12.00-13.00	1.64	59.45	1.60	41.76	10.27	1,524.97
13.00-14.00	1.66	72.91	1.59	42.79	9.90	1,360.77
14.00-15.00	1.66	66.11	1.60	44.77	10.76	1,393.62
15.00-16.00	1.63	58.84	1.60	47.87	10.59	1,193.84
16.00-17.00	1.64	62.05	1.60	49.27	15.30	1,559.14
17.00-18.00	1.65	63.10	18.49	662.37	9.87	1,197.31
18.00-19.00	1.58	40.23	25.92	787.59	10.03	1,351.14
19.00-20.00	1.57	32.27	30.86	794.78	14.24	1,480.78
20.00-21.00	1.57	38.14	1.55	28.57	1.62	109.77
21.00-22.00	1.54	20.38	1.53	19.56	1.57	45.29
Total		2,207.05		2,684.75		15,127.00

To estimate the passenger hours, passenger equivalent factors are described in following table.

Table 4.3.5: Passenger Equivalent factors

Vehicle	Equal Passenger
Large Buses	40
Medium Buses	28
Van	4
Cars	3
3 wheelers	1.37
Motorcycle	1
Trucks & Heavy Vehicles	0

4.4. Air pollution Analysis Results

For the purpose of emission analysis Galle Road and R.A. de Mel Mawatha is selected and findings of the analysis are described below; (Please refer the tables in the next two pages)

Table 4.4.1 shows the total amount of emission regarding the traffic flow along the R. A. de Mel Mawatha before and after conversion of one-way system. Total number of vehicles before conversion of one-way is 23,207 (petrol-20,805 & diesel-2,402). After conversion of one-way the total number of traffic is 39,053 (petrol-30,211 & diesel-8,842).

Along this section total number of vehicles increased by 68.28%, petrol vehicles increased by 45.21% and diesel vehicles increased by 268%. Diesel vehicles have been increased by a large percentage. Generally diesel vehicles are emitted more than the petrol vehicles [*Controlling Automotive Air Pollution: The Case of Colombo City*, by Sunil Chandrasiri]. Due to this reason the total amount of emission for after conversion of one-way came two times of the emission before conversion of one-way.

Traffic along the Galle Road is reduced due to the one-way conversion. Total amount of vehicles before conversion of one-way is 36,508 (petrol-26,584 & diesel-9,924). And the total number of vehicles after conversion of one-way is 27,412 (petrol-22,439 & diesel-4,973).

Along this section total number of vehicles decreased by 33.18%, petrol vehicles decreased by 18.47% and diesel vehicles decreased by 99.55%. Diesel vehicles have been decreased by a large percentage. This deviation leads to decrease the emission in total. Due to this reason the total amount of emission for after conversion of one-way decreased by half of the emission before conversion of one-way. These are shown in the table 4.4.2.

Table 4.4.1: Emission Analysis along R.A. de Mel Mawatha

Vehicle Type			Before conversion of one-way (2005)	After conversion of one-way (2009)	Emission factors used in Sri Lanka (g/km)									Amount of Emission/ (g)		
					CO	CO2	NOx	HC	CH4	NMV	PM	Pb	Sox	N2O	Before conversion of one-way (2005)	After conversion of one-way (2009)
Motor Cars	Petrol		11,135	14,067	33	200	1.4	4.2	0.1	4.2	0.1	0.4	0.1	0	5,408,998.93	6,833,168.90
	Diesel		355	3,390	1.5	275	2.2	0.8	0	0.3	0.4	-	1.2	0	199,746.39	1,907,494.19
Motor Tricycle	Petrol		4,832	8,387	30	130	0.7	4.3	-	-	0.3	0	0	-	1,597,201.77	2,772,338.26
	Diesel		16	523	Negligible											
Motor Cycle	Petrol		3,483	5,358	26	60	0.3	2.5	0.1	6.7	0.1	0	0	0	1,400,191.08	2,153,954.58
Buses	Petrol		0	19	Negligible											
	Diesel	LB	124	1,193	2.5	800	5.7	3.7	0.1	2	1.5	-	3.7	0	203,164.58	1,955,112.07
		MB	80	312	8.9	788	11	-	0.1	2	-	-	-	0	129,547.52	505,480.75
Dual Purpose vehicles	Petrol		1,318	2,359	45	285	2.5	6	-	-	0.1	0.1	0.1	-	892,619.18	1,597,490.44
	Diesel		1,541	3,242	1.8	400	3	2	-	-	0.8		1.7	-	1,261,569.66	2,654,272.77
Goods vehicles	Petrol		37	21	45	285	2.5	6	-	-	0.1	-	0.1	-	24,830.52	14,062.71
	Diesel		286	179	2.5	800	5.7	3.7	0.1	1.6	1.5	-	3.7	0	468,897.52	293,512.23
Total															11,586,767.14	20,686,886.90

Table 4.4.2: Emission Analysis along the Galle Road

Vehicle Type		Before conversion of one-way (2003)	After conversion of one-way (2008)	Emission factors used in Sri Lanka (g/km)										Amount of Emission/ (g)		
				CO	CO2	NOx	HC	CH4	NMV	PM	Pb	Sox	N2O	Before conversion of one-way (2003)	After conversion of one-way (2008)	
Motor Cars	Petrol	11,054	12,160	33	200	1.4	4.2	0.1	4.2	0.1	0.4	0.1	0	5,369,751.52	5,906,704.48	
	Diesel	1,125	1,683	1.5	275	2.2	0.8	0	0.3	0.4	-	1.2	0	633,057.49	947,179.92	
Motor Tricycle	Petrol	7,274	5,467	30	130	0.7	4.3	-	-	0.3	0	0	-	2,404,398.50	1,807,074.04	
	Diesel	11	262	Negligible												
Motor Cycle	Petrol	6,020	3,559	26	60	0.3	2.5	0.1	6.7	0.1	0	0	0	1,152,420.64	681,306.49	
Buses	Petrol		8	153	Negligible											
	Diesel	LB	2,555	1,501	2.5	800	5.7	3.7	0.1	2	1.5	-	3.7	0	4,185,728.06	2,458,562.13
		MB	1,275	233	8.9	788	11	-	0.1	2	-	-	-	0	2,065,303.08	376,603.15
Dual Purpose vehicles	Petrol		2,101	1,063	45	285	2.5	6	-	-	0.1	0.1	0.1	-	1,423,173.17	720,235.91
	Diesel		3,988	1,097	1.8	400	3	2	-	-	0.8		1.7	-	3,264,972.86	897,708.40
Goods vehicles	Petrol		127	37	45	285	2.5	6	-	-	0.1	-	0.1	-	85,687.16	24,789.05
	Diesel		970	197	2.5	800	5.7	3.7	0.1	1.6	1.5	-	3.7	0	1,589,231.38	323,252.12
Total														22,173,723.86	14,143,415.68	

4.5. Accident Analysis Results

For the research purpose accident statistics were analyzed in Galle Road corridor (from Bambalapitiya junction to Liberty round-about, Kollupitiya), along the Galle road and R.A. de Mel Mawatha. Accidents are classified in two types such as damaged category and user category. Year 2005 & 2006 are considered as the period for before conversion of one-way. From 2007 to 2010 (up to June) considered as the period for after conversion of one-way. Yearly accident types & number of accident along Galle Road are described in table 4.5.1. The unit is equal to number of cases.

Table 4.5.1: Number of reported accidents along Galle Road by damage category

Year	Fatal Accidents	Grievous (Accidents involving serious injuries)	Non-Grievous (Accidents involving slight injuries)	Damage only (Property damage only involving no casualties)	Total Accidents
2005 (Before)	1	2	30	247	280
2006 (Before)	0	2	40	174	216
2007 (After)	1	4	20	66	91
2008 (After)	5	8	41	141	195
2009 (After)	1	2	38	182	223
2010(up to June)	2	0	19	74	95

Source: Traffic Division - Kollupitiya Police station, Sri Lanka

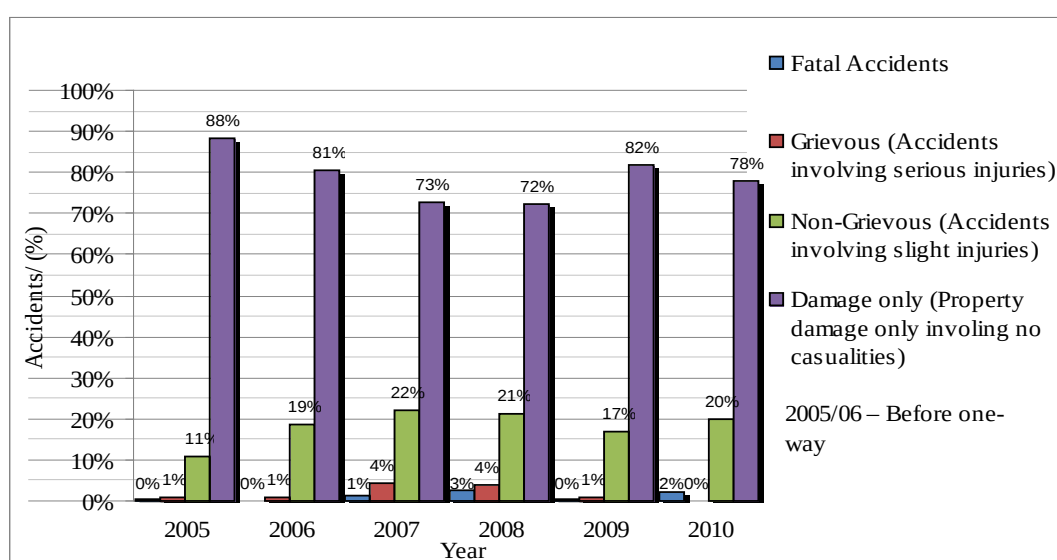


Figure 4.5.1: Percentage of accidents along Galle Road by damage category

Figure 4.5.1 shows that the amount of accidents suddenly reduced immediately after introduction of one-way. The accidents have been increased for a significant amount in year 2008. Then numbers of fatal, grievous and non-grievous accidents are reduced gradually. But the damage only accidents have been increased in 2009. Accident type & number of accidents per year along R.A. de Mawatha is described in table 4.5.2. Year 2005, 2006 are considered as the period for before conversion of one-way. From 2007 to 2010 (up to June) considered as the period for after conversion of one-way.

Table 4.5.2: Number of accidents along R.A.de Mel Mw by damage category

Year	Fatal Accidents	Grievous (Accidents involving serious injuries)	Non-Grievous (Accidents involving slight injuries)	Damage only (Property damage only involving no casualties)	Total Accidents
2005 (Before)	0	1	9	96	106
2006 (Before)	2	0	11	73	86
2007 (After)	0	0	8	27	35
2008 (After)	0	0	14	52	66
2009 (After)	1	1	16	62	80
2010(up to June)	0	0	4	52	56

Source: Traffic Division - Kollupitiya Police station, Sri Lanka

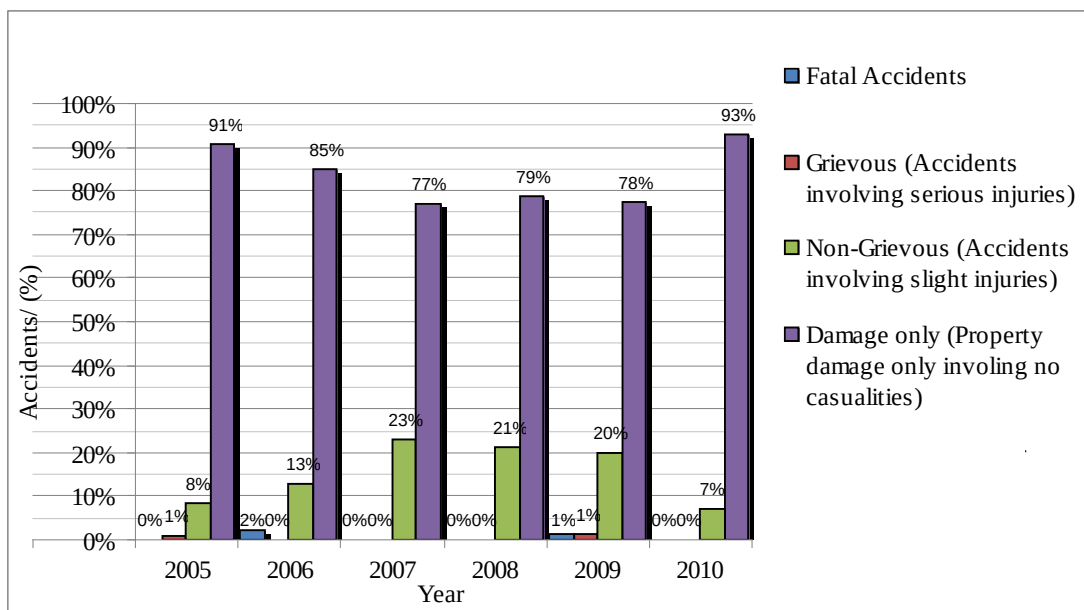


Figure 4.5.2: Percentage of reported accidents category along R.A. de Me Mw

Consider the figure 4.5.2; total number of accidents along the R.A. de Mel Mawatha is decreased due to the new one-way system. Here also the amount of accidents suddenly decreased in year 2007. In 2008, the accidents amounts have been increased gradually but these amounts are lesser than the earlier amount.

The following data are taken within the one way stretch and unit is equal to number of persons. Injured people are classified in five types as pedestrians, passengers, cyclist, drivers and others. Year 2005 & 2006 are considered as the period for before conversion of one-way. From 2007 to 2010 (up to June) considered as the period for after conversion of one-way. Yearly injured number of people along Galle Road is described in table 4.5.3.

Table 4.5.3: Number of victims along Galle Road by user type

Year	Pedestrians	Passengers	Riders (Bicycle & motorcycle)	Drivers	Others (such as road side businessman)
2005 (Before)	17	7	3	4	0
2006 (Before)	21	3	12	4	0
2007 (After)	37	7	9	6	0
2008 (After)	35	0	7	15	0
2009 (After)	25	9	10	4	0
2010(up to June)	13	0	2	6	0

Source: Traffic Division - Kollupitiya Police station, Sri Lanka

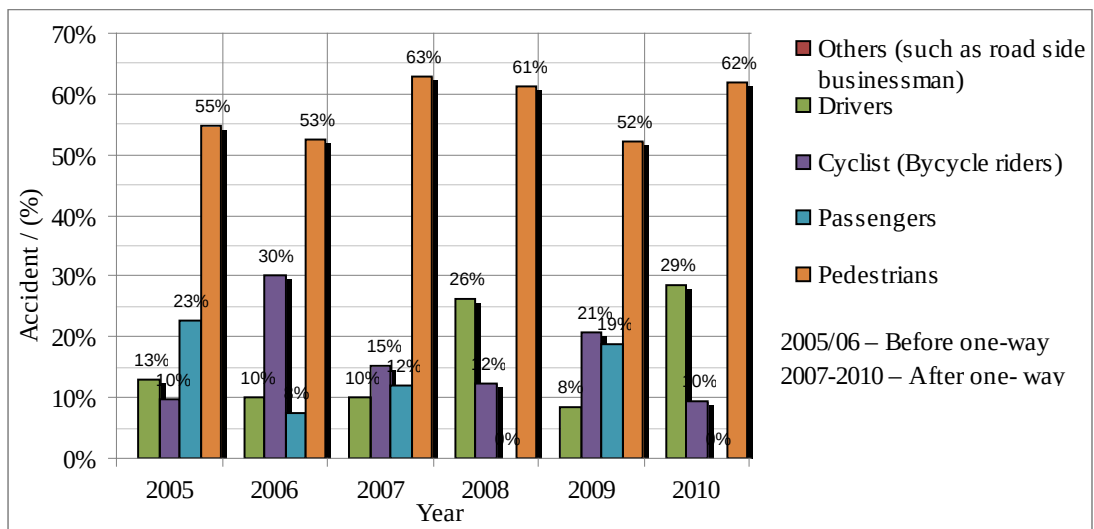


Figure 4.5.3: Percentage of fatalities along Galle Road by user type

Figure 4.5.3 clearly shows that the injured percentages of pedestrian are increased due to the conversion of one-way. Especially in year 2007 (immediate after the conversion of one-way) it shows the high percentage. Because when a new system implemented people do not familiar with that. After that the percentage has been reduced gradually. Not only for pedestrians but also for passengers, drivers and cyclist have the similar variation with their percentages. Here the significant thing is no injuries occurred to the “others (such as road side businessmen)” category

Accident data for injured people along R.A. de Mel Mw described in the table 4.5.4.

Table 4.5.4: Number of victims along R.A. de Mel Mawatha by road user type

Year	Pedestrians	Passengers	Riders (Bicycle & motorcycle)	Drivers	Others (such as road side businessman)
2005(Before)	3	3	1	4	0
2006(Before)	7	5	1	1	0
2007 (After)	5	2	4	1	0
2008 (After)	4	0	1	9	0
2009 (After)	10	8	5	1	0
2010(up to June)	1	0	1	4	0

Source: Traffic Division - Kollupitiya Police station, Sri Lanka

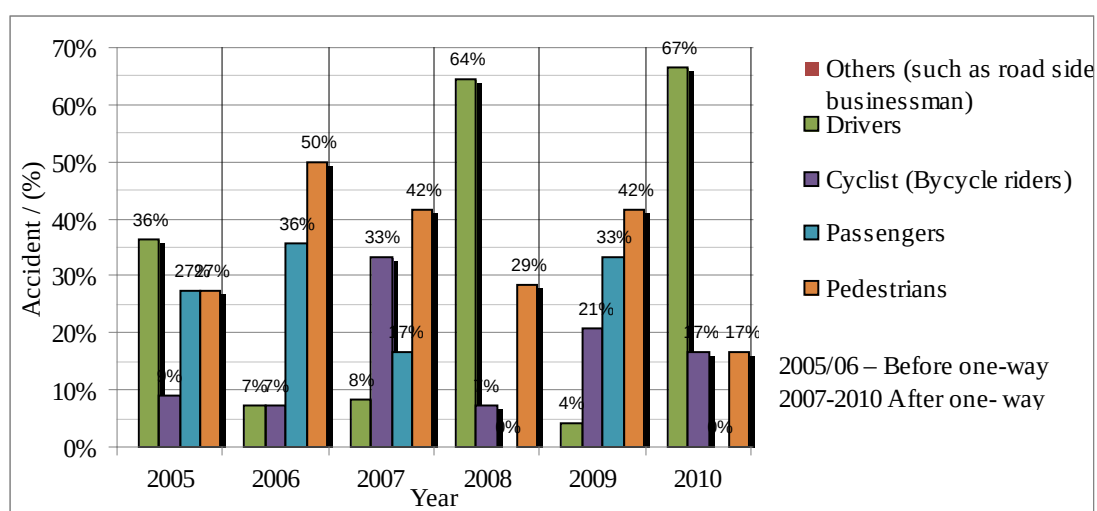


Figure 4.5.4: percentage of fatalities along R.A. de Mel Mawatha by road user type

Along the R.A. de Mel Mawatha the accident pattern differs from the Galle Road pattern. Here the accident percentage for pedestrians, passengers and drivers is decreased in year 2007 (immediate to the implemented year). But in 2009 percentage for pedestrians, passengers and cyclist is significantly increased. One significant observation is that, in 2008 the percentage for drivers is fairly high but the percentage for passenger is zero.

4.6 Traffic Flow Analysis on Connecting Roads

For the analysis of traffic flow on connecting roads, before and after conversion of one-way system, following roads are selected and the predicted flow patterns are described below;

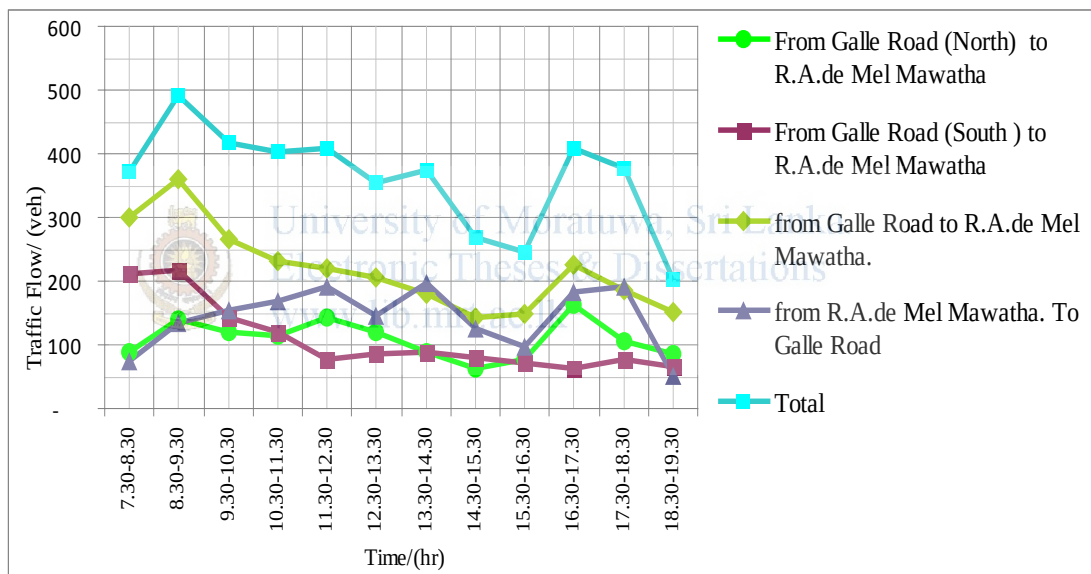


Figure 4.6.1: Hourly traffic flow on Bagatale Road before one-way traffic system

Traffic contribution to Galle Road and R.A. de Mel Mawatha through Bagatale Road is shown in figure 4.6.1. In morning traffic from Galle Road to R.A. de Mel Mawatha is high. Therefore in figure 4.2.4, inner bound traffic along R.A. de Mel Mawatha is very high. In evening traffic towards to Galle Road from R.A. de Mel Mawatha is higher than the morning traffic. It clearly shows in figure 4.2.1. Therefore before conversion of one-way outer bound traffic amount is very high in evening along the Galle Road.

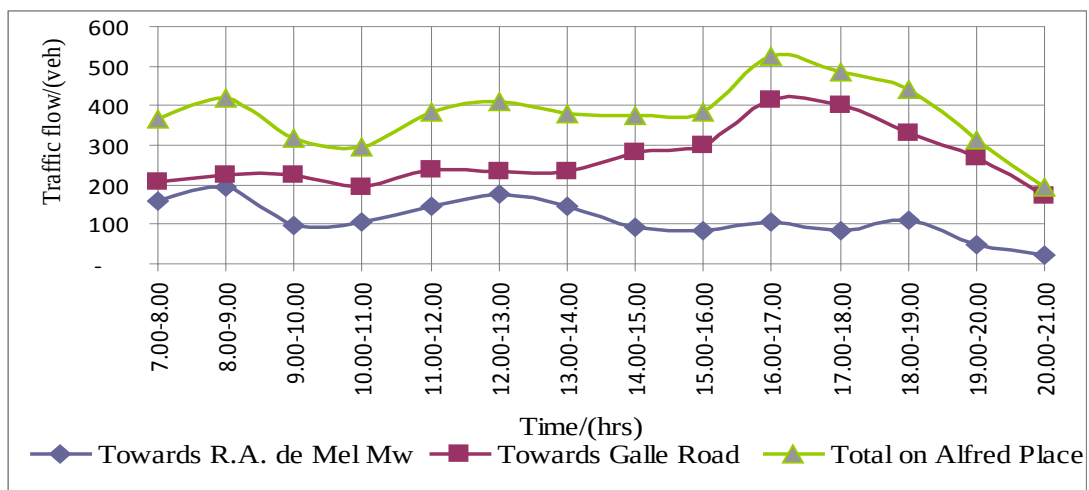


Figure 4.6.2: Hourly traffic flow on Alfred Place before one-way traffic system

Traffic contribution to Galle Road and R.A. de Mel Mawatha through Alfred Place is shown in figure 4.6.2. Here also traffic towards to Galle Road is large in the evening. On the other hand in morning traffic towards to R.A. de Mel Mawatha is bigger than the evening traffic.

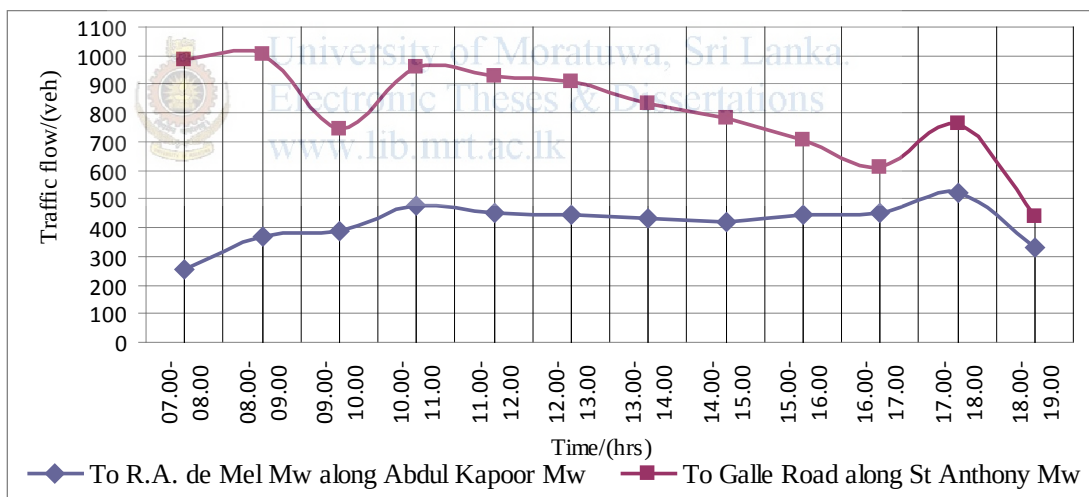


Figure 4.6.3: Hourly traffic flow on Abdul Capoor Mawatha and St Anthony Mw after one-way arrangement

Figure 4.6.3 shows that the traffic contribution to Galle Road and R.A. de Mel Mawatha along Abdul Capoor Mawatha and St Anthony Mawatha. Here clearly stated that the traffic towards to Galle Road in morning is larger than the traffic in evening. Similarly traffic toward to R.A. de Mel Mawatha in evening is bigger than the traffic in morning. These are the one of the reasons for high morning traffic on Galle Road and high evening traffic on R.A. de Mel Mawatha.

4.7 Traffic Flow Analysis at Junctions

For the analysis of traffic flow on junctions after conversion of one-way system, following junctions are selected and the predicted flow patterns are described below;

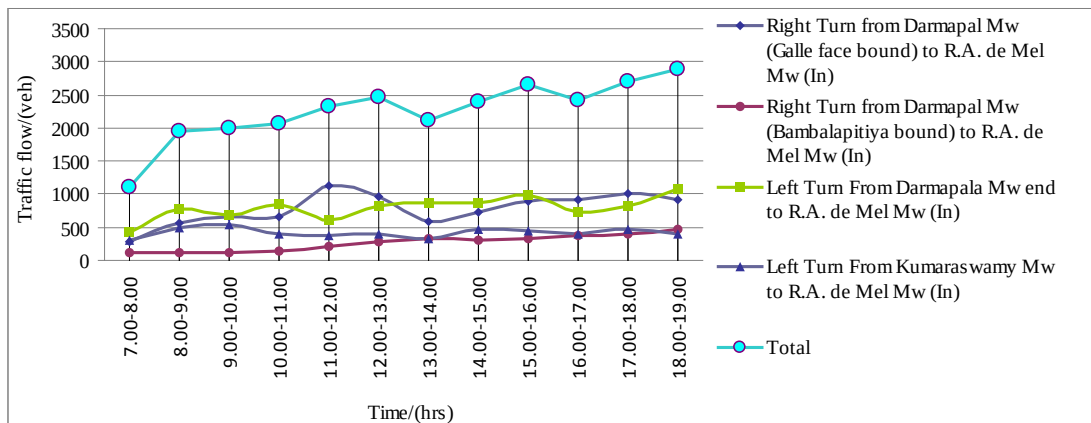


Figure 4.7.1: Hourly traffic flow on Liberty junction

Traffic flow variations at Liberty junction is shown in figure 4.7.1. Traffic due to left turn from Dharmapala Mawatha is quite higher in the whole duration. From 10.00 am to 14.00 pm traffic due to right turn from Dharmapala Mawatha (Galle face bound) is large. But the total traffic flow clearly stated that the traffic towards to R.A. de Mel Mawatha in evening is larger than the morning hours

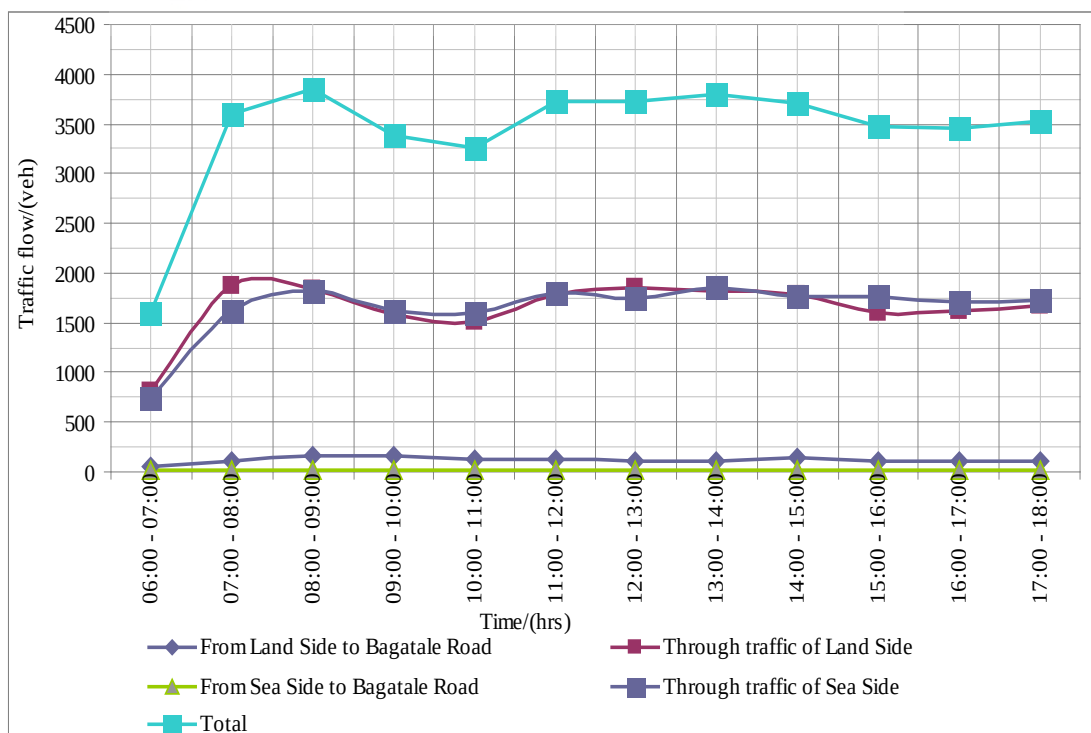


Figure 4.7.2: Hourly traffic flow on Bagatale junction

Traffic flow variations at Bagatale junction (at Galle Road) is described in figure 4.7.2. The figure clearly says the through traffics from land and sea side are larger than the traffic turned to Bagatale Road. However total traffic flows in morning (from 8.00 am - 9.00 am) is higher than the other time periods.

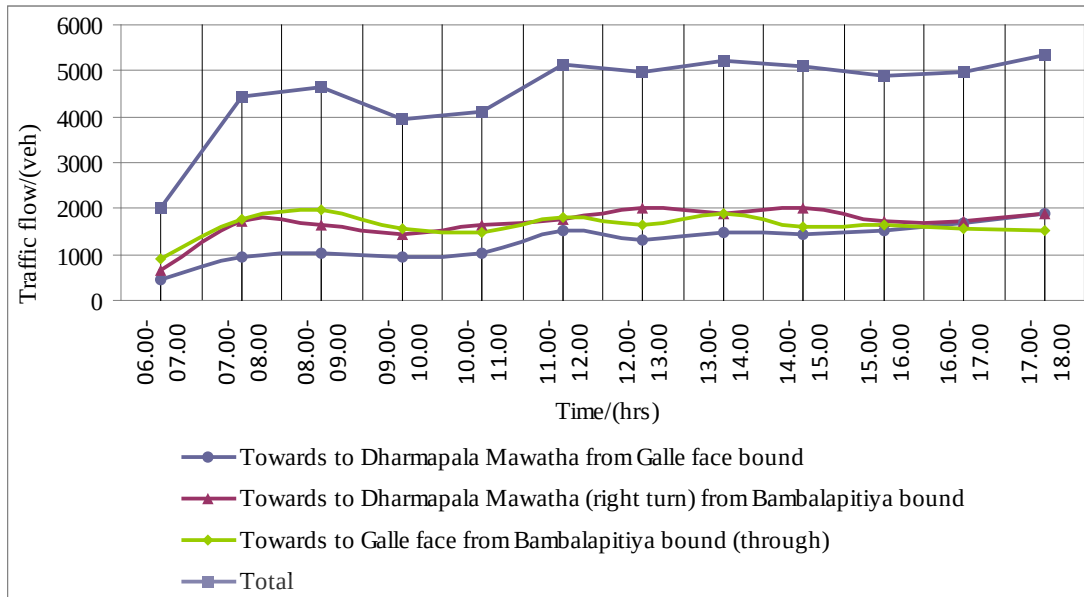


Figure 4.7.3: Hourly traffic flow on Dharmapala Mawatha junction at Galle Road

Traffic flow variations at Dharmapala Mawatha junction (at Galle Road) is described in figure 4.7.3. The figure clearly says that the through traffic towards to Galle face is quite higher than the other two turning traffics. These changes spread the whole time period. When consider the total traffic, this junction is filled with the traffic in evening.

4.8 Road user views

After conversion of one-way system several interviews have been done to identify the inconvenience and the advantages of the public transport users, motorist, employers and residents.

After few months of the one way traffic system implementation, The Nation newspaper published interviews of several people. From these interviews numerous opinions have been identified and given below.

[Commuters inconvenienced, The Nation on Sunday www.nation.lk/2007/01/07/newsfe1.htm].

- The employees travel to work in private office buses feels that they are getting late when going back home because of the high traffic in R.A de Mel Mawatha.
- Managers of the Business Institutions said that it is difficult to find the address of their companies for the customers, have to turn their vehicles and the customers have to take a detour via R.A. de Mel Mawatha if they want to retrace their way.
- Most of the bus commuters respond that they have to come a long way to reach the bus stop on R.A. de Mel Mawatha and it is almost tiring after work because crossing the roads and getting the bus from R. A. de Mel Mawatha is chaotic.
- Some bus commuters notice the one way arrangement as an advantage and replied that their travelling time to get the office in the morning is greatly reduced.
- The response from boutique owners in R.A de Mel Mawatha, says that there are loosing the business because of the parking problems.
- Motorist responds that limited parking reduces unwanted hassle and the people who want to park will somehow find spaces.
- The residents of these stretches have a big hassle in getting to the Galle Road or R.A. de Mel Mawatha, travels more distance due to the lack of proper connecting roads which increases the fuel cost and travelling time.

Even most of the people feel this new traffic system as problematic, some people commented in positive manner. The people who travel through R.A. de Mel Mawatha face the problem in the evening time and the residents of this area spends more time because of the one way traffic system.

In 2010 July, after four years of the one way traffic system implementation, a group of people were interviewed to accrue their views about the one way traffic system. The members of group were selected to represent different type of road users such as private vehicle drivers, students, employees, pedestrians and residents. The outcome of the interview can be summarized as follows:

- The residents of Kollupitiya area feels that they need to travel more distance and spending for fuel because of inadequate connecting roads in between Galle Road and R.A de Mel Mawatha.
- The private vehicle drivers, including office/school van drivers expressed that the travelling time along the Galled Road toward Pettah reduced significantly in between Bambalapitiya and Kollupitiya, but the congestion in Galle road starts from Dehiwela increase the travel time and effective delay almost same as earlier.
- From the point of students, the travel time and delay are reduced significantly along the Galle road and R.A de Mel Mawatha, but the road signs and pedestrians crossing controls need to be improved.
- Public bus commuters had difficulties to walk for bus halts on the starting days on the one way traffic implementation, but the advantage of the improved travel time along the Gall road toward Pettah was realized even the travel time along the R.A de Mel Mawatha towards Bambalapitiya is significantly high.
- The parking problem along the R.A de Mel Mawatha is still expressed by most of the private vehicle users and shop owners.

From these road users views, which were obtained within the interval of three years the following points, can be summarized.

1. The improvement in the travelling time and reduction in congestion along the Galle Road was realized by the most of the road users during this three years period, but still the travelling time along the R.A de Mel Mawatha during the evening time need to be improved.
2. Some users believe that the use of Marine drive will provide most of the benefits of the one way traffic system in future.
3. In the past as well as now, improvement in the road sign, traffic control arrangement and connecting road in between Galle raids, R.A de Mel Mawatha and Marine Drive are expected by most of the people.

For further analysis of the extra travel distance due to one-way conversion, the following example provides evidence with values. Consider that, within the one-way stretch a person who located in A and wants to go to destination B (Lindsay Balika Vidyalaya) by his own vehicle with multiple path options.

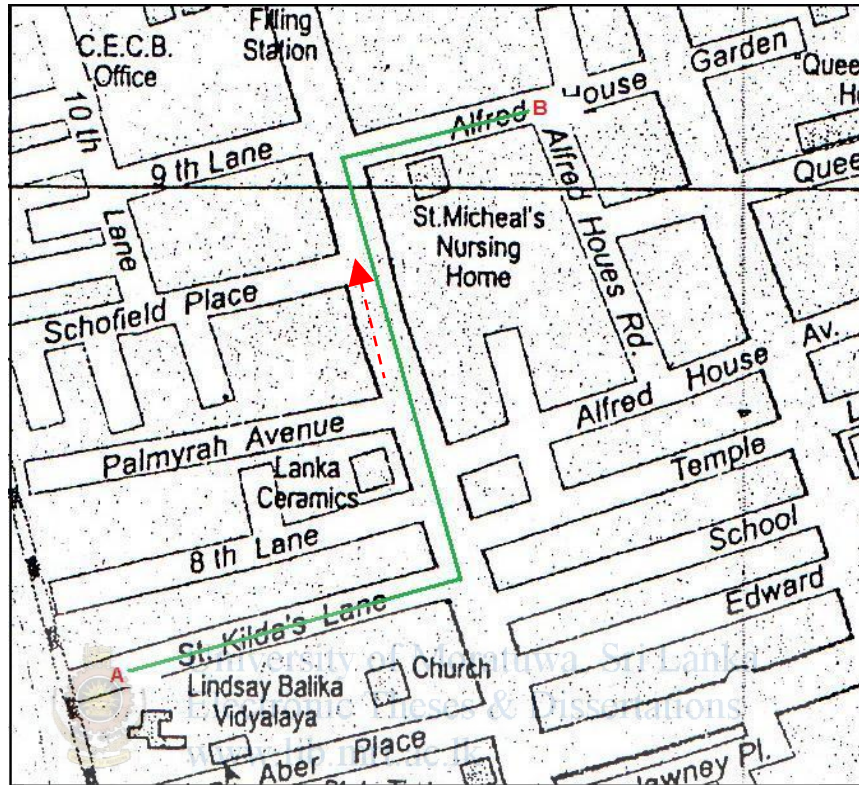


Figure 4.9.1: Travel path between two location before conversion of one-way

Figure 4.9.1 shows that the convenient path for reach the specific place when before conversion of one-way system. First go to Galle Road from A then take a left turn, straightly go along Galle Road and turn to right turn to reach the place B. The total distance along this path is around 700 m.

The following figure 4.9.2 shows that the convenient path from A to B after conversion of one-way system. Start from B towards to R.A. de Mel Mawatha then, take right turn towards to Bauddhaloka Mawatha again turn to right, and come up to the required destination A. The total distance along this path is about 1100m.

From this sample it clearly understood, that the travel distance between A and B is increased by 400m due to this one-way arrangement. If another location is taken for analysis, the distance value may vary but the distance sequence will not vary in most sections. When the public transport is chosen for this same example, walking distance will increase and take one more buses because of the route changes.

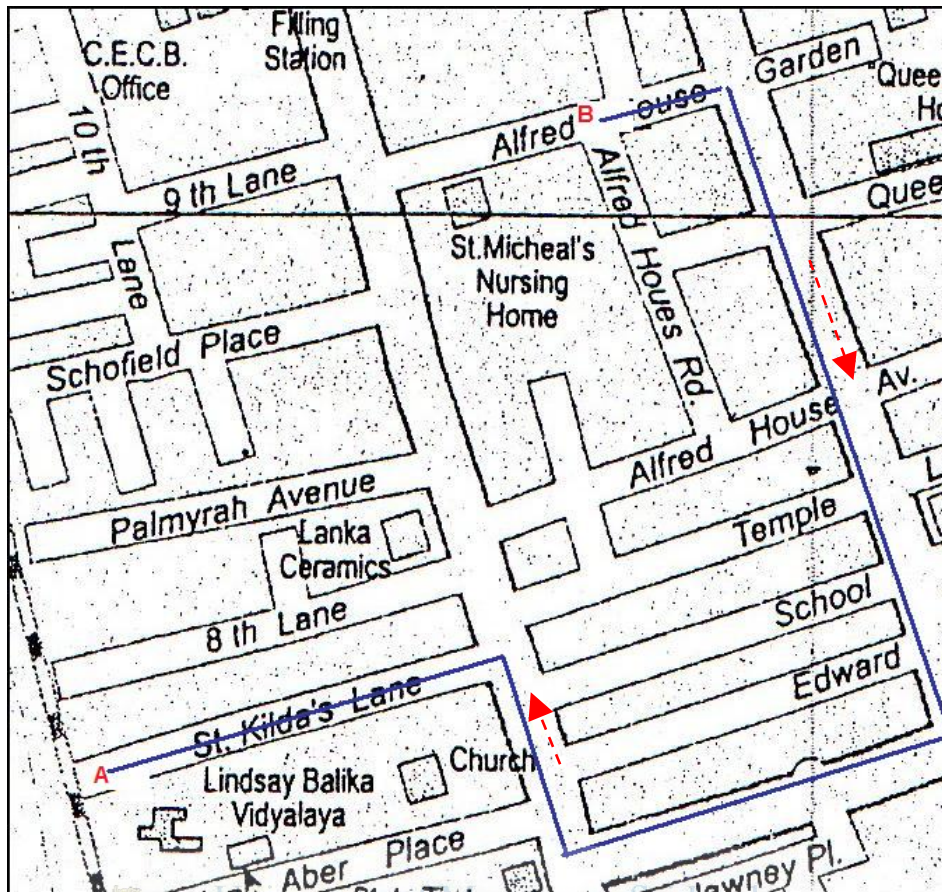


Figure 4.9.2: Travel path between two location after conversion of one-way

It is clearly observed that the change in traffic arrangement has its own pros and constraints in different aspects.

The result from the analysis is summarized in the following table.

Table 4.9.1: Summary of Results

Description	Along Galle Road	Along R.A. de Mel Mawatha
Traffic flow	Decreased by 26%	Increased by 45%
Travel time	Decreased by 47.77%	Increased by 23.39%
Amount of emission	Decreased by 57%	Increased by 44%
Traffic flow at intersections	Increased	Increased
Traffic flow on by-lanes	Increased	Increased
Accidents	Decreased	Decreased
Extra travel time for people	Increased	Increased
Inconvenience of public	Increased	Increased

Chapter 5: DISCUSSION

From Bambalapitiya junction to Kollupitiya (2.0 km), along the Galle Road made as one way towards Fort and from Liberty Plaza roundabout to Bauddhaloka Mawatha (2.0 km), along the R.A. de Mel Mawatha made as one way towards Wellawatta.

Increase traffic flow on certain roads is one of the inherent disadvantages with one-way street. Therefore traffic flow along R.A. de Mel Mawatha is increased by 45% due to this one-way system. At the same time it has been reduced by 26% through the Galle Road. Further one-way arrangement force additional turning movements at intersections caused by motorists who needs travel “out-of-direction” to reach their destination.

When we scrutinize the observation and results in chapter 4; it can be seen that the traffic flow along the Galle road is fairly reduced after the conversion of the one-way. Before conversion of this system, due to the several reasons traffic jams were occurred along the road, especially during the peak hours. Buses stop at irregular manner at the bus halts, pedestrians crosses the road without pedestrian crossings, driver’s skill shortage, turning movement of vehicles, unsafe driving etc causes for traffic congestions. These are still valid in the new traffic system also. But the main reason of the drawback of this system is “turning movement conflict”. Especially at Bambalapitiya junction high turning traffic congestion has been occurred. Because, this is one of the interchange point for one-way, two way traffic system. Vehicles come from Bauddhaloka Mawatha making turn to Colombo South bound or Colombo North bound from this junction. Traffic towards to city centre makes a lane change on this location. Due to these reasons Bambalapitiya junction more frequently congested.

The traffic flow has increased along the R.A. de Mel Mawatha significantly. Before the one-way conversion, two lanes were used for one direction of the traffic movement. In most of the sections outer lanes were occupied with the parking vehicles. Opposite Mahanama College on R.A. de Mel Mawatha, school vans are parked on both sides of the road all the time. In the existing plan, all four lanes are marked for use of traffic. Numbers of travel lanes are higher than the earlier system but comparatively traffic flow also significantly higher than the previous amount.

The additional turning movements for a one-way street network increase the occurrences of vehicular-pedestrian conflicts at any given intersection, and also result in a system-wide increase in vehicle kilometer as compared to a two-way street network. After doing the conversion of one-way, no opposing traffic. Left-turn, same direction conflict and opposing-right-turn conflicts are totally restricted. At the same time lane change conflict is reduced in a considerable manner.

In the one-way system that has been introduced now, the travel distances for most trips have increased. In fact, travel times too have increased for those who originate or destinate within this section. Even though the motorist may feel they are travelling faster, as the average speed is increased. They do not aware that they now travel more distance than earlier and take as much time or even more. It visibly described in chap 4.9, for that specific example the travel distance increased by 400m (consequently it is about 60%).

When compare the average travel time along the Galle Road before and after the new traffic plan, it reduced by 47.77%. But along the R.A. de Mel Mawatha average travel time has been increased by 23.39%. Therefore one-way system has been slightly reduced the travel time only along the Galle Road. All these major changes are made a difference of few minutes.

Table 5.1.1: Comparison of travel time in total vehicle and passenger hours

Road	Status	Total Vehicle hour/(hrs)	Total Passenger hour/(hrs)
R.A.de Mel Mawatha	Before conversion of one way from Bambalapitiya - Kollupitiya	432.84	2,207.05
	Before conversion of one way from Kollupitiya - Bambalapitiya	542.89	2,684.75
	After conversion of one way from Bambalapitiya - Kollupitiya	1,459.84	15,127.00
Galle Road	Before conversion of one way from Bambalapitiya - Kollupitiya	798.76	Not available
	Before conversion of one way from Kollupitiya - Bambalapitiya	795.00	Not available
	After conversion of one way from Kollupitiya - Bambalapitiya	312.04	5,659.65

When measure up to the vehicle hours, it has been reduced along to the Galle Road due to the one way. It happened other way round along to the R.A.de Mel Mawatha due to the increment of traffic flow. But passenger hours are terrifically increased along the R.A.de Mel Mawatha than the vehicle hours. Therefore amount of buses, vans and cars are increased due to the new traffic system. Generally these transport modes carry fair amount of passengers. Deviation in passenger hours is higher than the difference in vehicle hours.

When monitor the traffic through the connecting roads after conversion of one-way, in evenings high amount of traffic is observed on Abdul Capoor Mawatha. Therefore people who want to go to south direction (especially workers); they use the path along this road. Similarly in mornings, higher traffic volume was identified on St Anthony's Mawatha. In other way round, people who wish to go to Kollupitiya to Fort from east of Colombo use this corridor. Connecting road traffic volumes are comparatively very high, and highly disturb the traffic along the Galle road. Connective roads which have the traffic movement towards to Galle road filled up especially in mornings. Likewise connective road or by lanes which have the traffic movement towards to R.A. de Mel Mawatha get crowded with passage in evenings because of the main traffic stream direction.

After conversion to one-way there are some typical junctions/intersections were considered to analyze the traffic flow. In evenings Liberty junction was highly dense with vehicles. In particular, vehicles come from Dharmapala Mawatha (Galle face bound) is significantly high. In the evening peak hours; most of the vehicles are come from the commercial zones (Pettah, Slave Island, Kollupitiya etc.). In mornings, main flow direction is towards to city centre. Because of this reason junction is highly blocked in mornings. Particularly a large amount of schools are located in the north bound of Colombo and the school traffic contributes towards major part of this congestion. Dharmapala Mawatha junction is also one of the interchange point of the one-way system. It has been crowded frequently, for the reason that with vehicles.

Amount of emission is proportional to the number of vehicles in motion. Due to the new traffic plan amount of vehicles are increased along the R.A. de Mel Mawatha. Therefore, obviously amount of emission also increased by 44%. On the other hand amount of emission along the Galle road has decreased by 57% (around half of the

earlier amount) as described in the Table 4.4.1 & 4.4.2. Same time traffic along by-roads also has increased. According to these factors, conversion of one-way is only advantages to Galle road not for the R.A. de Mel Mawatha or other by-roads.

One-way circulation is a popular traffic management tool used in urban areas to minimize conflicting movements and thereby reduce delays. One-way streets are usually used in city centers where there are many intersections and turning traffic. One-way circulation introduces increased travel distances for some road users but total travel time savings compensate for the loss due to increased travel distances. There are several prerequisites to be met if this system is to be successfully implemented;

1. There should be sufficient link roads to make sure that the increased travel distances, experienced by some road users, are not excessive.
2. The system should not introduce more conflicts.
3. All link roads also should follow one-way circulation.
4. The system should not impose excessive walking for the public transport users.
5. Adequate measures should be taken to ensure the safety of pedestrians and vehicles against possible increases in the vehicle speeds

The worst part in the existing one-way system is the fragmentation of the bus services. For example, major traffic generators such as schools are now served only by one direction of flow. Bus routes that were on two roads have been combined to one. People who want use the public transport now have to walk distances of several hundred meters to take buses. Moreover, the distances between bus stops and train stations have increased. Buses terminating at Kollupitiya and Bambalapitiya now take more time to travel. This is due to increment shortcoming of the one-way system.

People who travel from south of Bambalapitiya to Pettah feel it takes a shorter time to go to work in the morning, but getting back home, on R.A. de Mel Mawatha takes much longer than it did before. All commercial establishments in the Kollupitiya area were faced with severe hardships due to lack of clientele with the absence of parking facilities. Their business was reduced to a third of their original turnover. So, there is no absolute reduction in travel times or distances.

In other words, vehicles have to turn more on a one-way street network, and therefore have more chances of conflicts with pedestrians. When compare the accident data tables 4.5.1 and 4.5.2; number of accidents of before the one-way arrangement was higher than the accidents of after conversion of one-way system. In both roads, amount of accidents suddenly dropped down in the year which next to the year of new traffic plan introduced (2007).

When compare the accidents in terms of users type, amount of accidents suddenly increased on Galle Road in year 2007. Then this amount starts to decrease slowly. In other way round along the R.A. de Mel Mawatha accident amount drop down in year 2007 after that it slowly increased. When measure up the types of the accident, amount of fatal accidents are very lower than the damage only (property damage only involving no casualties) accidents. Similarly pedestrians are the major casualty group and they are highly affected (it shows in figures 4.5.3 & 4.5.4).

Heavy road traffic, absence of speed-limiting traffic signs, lack of accident-preventive traffic arrangements, attitude of the drivers as well as other road users are some of the reasons contributing to this unsatisfactory state of affairs. Generally amount of accidents are reduced due to the introducing of this new traffic plan. At the same time “on the spot” insurances also had the influences between the amounts of accidents. In some of the cases, people did not like to inform to police. They just inform to insurance companies and obtain claims for damages.

R.A. de Mel Mawatha continuously growing as a commercialized area and there are many offices and business establishments situated along this road. Most of these business places and shops have moved to R.A. de Mel Mawatha from other places due to the traffic congestion and difficulty in parking in city centre. The commercial establishments and the customers face inconvenience again. In most of the sections vehicles parked along the by lanes connecting Galle road to R.A. de Mel Mawatha. This affects the movement through these by-lanes. The number, locations, and alignment of link roads available between Galle road and R.A. de Mel Mawatha are insufficient. Most of the present link roads are narrow, long and meandering.

The above chapter 5 clearly discussed the shortcomings and drawbacks, caused by the one-way traffic system, which are need to be improved in future to accommodate the demands.

Chapter 6: CONCLUSION

The Colombo Traffic Police have made plans to reduce congestion in the city by making Galle Road and R.A. de Mel Mawatha one way.

When referring these analyses, it was found that the traffic flow, travel time and the amount of emission have been decreased significantly along the Galle Road. But these have been increased along the R.A. de Mel Mawatha. Traffic flow along by-roads and intersections is vary due to the main traffic stream direction from morning to evening. Especially in mornings, traffic towards to Galle Road on by-roads is higher than the traffic flow in other direction. In evenings it happens on by-roads towards to R.A. de Mel Mawatha.

Public transport users face the problem regarding the extra travel distance. It has been increased due to this new traffic plan. One of the drawbacks of this system is parking. Owners of business establishments as well as customers also face the same kind of problem. But in the case of accidents, amounts of accidents have been reduced fairly along these two stretches.

This new traffic plan (conversion of one-way system) is unbiased with the scope of the traffic planners. The new traffic plan did not provide a more inviting atmosphere for pedestrians. This system may good for car transport but for bus services, an outright disaster. Most drivers have benefited by enjoying faster travel, but a good part of them travel more. So they may actually be spending more time or even more expenditure. But they may still benefit

When compare the positive and negative things within the one-way system, the social cost of the proposed one-way system outweighs its expected benefits.

Chapter 7: RECOMMENDATION

This report provides information to evaluate the effectiveness of the one-way traffic arrangement and evaluated results of the one way traffic arranged along the Galle Road corridor. According to the previous studies traffic flow along the Galle Road has been reduced but, the traffic flow along the R.A de Mel Mawatha has been increased. During the morning and evening peak hours congestion has been reduced along the Galle road. Due to this reason travel time also reduced. But along the R.A. de Mel Mawatha congestion amount has been increased especially during the evening peak hours.

Most probably favorable improvements to traffic situation along the Galle road and R.A. de Mel Mawatha can be achieved by proper traffic management and law enforcement. These traffic management actions are provision of well designed bus stops, lane markings, safety measures and pedestrian facilities. Law enforcement is necessary to control illegal parking, illegal stopping and waiting by buses, lane control and to provide safety to pedestrians. Prohibit road side parking during peak hours and allow limited parking during off peak hours.

Key factor to reduce this major problem is split the traffic flow along these two roads. Currently, the Marine Drive construction is going on to extend the existing Marine drive up to the Kollupitiya junction. Once this is completed the inflow and outflow traffic may distributed and shared by Marine Drive. Traffic flow on the Galle Road is already reduced due to this present one way system but there is no significant improvement in the travel time when considering the extra travel distances. If the traffic amount is reduced further due to Marine Drive extension, a better travel time reduction is expected. However, there can be some issues related to safety due to over speeding. On the other hand expected traffic flow along the R.A. de Mel Mawatha is less and it is estimated that travel time can be reduced by a considerable amount which may contribute to some factors positively. However, better access to Marine Drive for South bound traffic is required to achieve flow reduction on R.A. de Mel Mawatha. According to road users travel time in the morning is lesser than the same in the evening. Once Marine Drive is ready for traffic use, their desires will be satisfied. They can enjoy their traveling even in the evening peak also.

Also the traffic flow on Galle road and R.A. de Mel Mawatha will be reduced by a considerable amount which may contribute to some of the factors which are affecting the traffic as explained below.

- The traffic flow from Bambalapitiya to Pettah along the Galle Road as well as the flow from Pettah to Bambalapitiya along the R.A. de Mel Mawatha split and shared by Marine Drive from Bampalapitiya to Gall Face, which result in the reduction in the traffic congestion along Galle Road and R.A de Mel Mawatha.
- Because of this extension reduction in travel time can be expected in both directions, even though there may be delays introduced due to road intersection and new traffic flow turns.
- The air pollution also will get effected due to reduction in travel time and congestion positively, but there may be additional emission introduced because of new intersections and traffic crossings.
- If public bus route was introduced along the Marine drive in both ways, public bus commuters may experience comfort in terms of the walking distance to reach bust halts.
- The new route along the Marine Drive will introduce more parking spaces along the Galle Road and R.A de Mel Mawatha, because the traffic is shared which increases the opportunities for the shop owners.
- Depending on the arrangements of the cross road between main routes the residents also benefitted regarding the travelling distance and travelling time.

Marine Drive extension drives through an entertainment area. Beach and the railway tracks are situated one side of this extension. Pedestrian density is very high especially in the evenings as well as the holidays. Another terrible thing happen around this area is “accident”.

When Marine Drive is in full operation, safety standards should be highly considered.

- Raised foot walks with the safety hand rails
- Proper pedestrian crossings
- Adequate road markings
- Enforcement officers especially in holidays etc.

The travel time by bus was much longer than the travel time by car for the same journey; the introduction of ‘Bus Lanes’ may overcome this problem. Having these on the following roads will improve the travel time and encourage people to travel in public transport instead of their cars for buses, which reduces the pollution:

- The curbside lane on the western carriageway (north –bound) of Galle road from Bambalapitiya to Kollupitiya can be transformed into a Bus Only Lane. Similar arrangement can be maintained from Liberty junction to Bauddhaloka Mawatha as well.
- A bus lane may affect the flow of other traffic as they get less road space and there will be restriction for turning.

As pointed out above in chapter 5, the proposed one-way system has some advantages and also some shortcomings. Pedestrians are of inconvenience and exposed to accidents. However, there is a general decreasing trend of other accidents. Especially along the R.A. de Mel Mawatha, number of pedestrian injured due to accident is quite high compare with other categories even after the conversion of one-way. The pedestrians do not have a choice other than walking on the road pavement. This can be overcome by the implementation of the following improvements;

- Footpath free of street vendors
- Street beautification works on footpath
- Installation of flag poles on footpath

Increased numbers of right turns are originated at the Bambalapitiya junction. Vehicles come from Bauddhaloka Mawatha takes the right turns at this junction. In mornings this amount is considerably high. Due to this turning traffic Colombo bound through traffic get delayed. Efficient traffic control mechanism is required at this location.

The above ideas are recommended to accomplish the future requirements as well as the current drawbacks.

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APPENDICE A: TRAFFIC FLOW DATA

A.1. Traffic Flow along Galle Road before One Way Conversion

Inner bound – Traffic toward to Pettah

Outer bound - Traffic towards to Bambalapitiya Junction

Table A.1: Traffic flow along Galle Road before the one-way system (2006)

Time		Inner bound/(veh)	Outer bound/(veh)	Total
7.00	7.15	348	292	640
7.15	7.30	535	239	774
7.30	7.45	553	417	970
7.45	8.00	637	436	1073
8.00	8.15	660	289	949
8.15	8.30	638	285	923
8.30	8.45	607	343	950
8.45	9.00	567	348	915
9.00	9.15	533	332	865
9.15	9.30	489	273	762
9.30	9.45	463	208	671
9.45	10.00	403	308	711
10.00	10.15	406	313	719
10.15	10.30	422	360	782
10.30	10.45	367	338	705
10.45	11.00	390	501	891
11.00	11.15	443	464	907
11.15	11.30	423	444	867
11.30	11.45	387	550	937
11.45	12.00	409	489	898
12.00	12.15	450	576	1026
12.15	12.30	404	426	830
12.30	12.45	369	411	780
12.45	13.00	395	419	814
13.00	13.15	408	248	656
13.15	13.30	415	419	834
13.30	13.45	447	359	806
13.45	14.00	432	341	773
14.00	14.15	434	324	758
14.15	14.30	426	362	788
14.30	14.45	405	436	841
14.45	15.00	379	502	881
15.00	15.15	386	459	845
15.15	15.30	413	313	726
15.30	15.45	442	498	940
15.45	16.00	464	468	932

Time		Inner bound/(veh)	Outer bound/(veh)	Total
16.00	16.15	444	463	907
16.15	16.30	414	363	777
16.30	16.45	423	450	873
16.45	17.00	393	505	898
17.00	17.15	373	374	747
17.15	17.30	362	627	989
17.30	17.45	314	326	640
17.45	18.00	293	520	813
18.00	18.15	278	469	747
18.15	18.30	229	365	594
18.30	18.45	242	341	583
18.45	19.00	208	312	520

Source: University Moratuwa, Sri Lanka

A.2. Traffic Flow along Galle Road after One Way Conversion

Inner bound – Traffic toward to Pettah

G- From Galle Road, through traffic

B- From Bauddhaloka Mawatha

Growth rate (r) – 0.05

Years (n) – 1

Table A.2: Traffic flow along Galle Road after the one-way system (2009)

Time	Inner bound/(veh)			
	B	G	Total in 2008	Total in 2009
6.00-6.15	13	102	115	121
6.15-6.30	26	138	164	172
6.30-6.45	42	160	202	212
6.45-7.00	63	308	371	390
7.00-7.15	106	469	575	604
7.15-7.30	169	706	875	919
7.30-7.45	125	842	967	1015
7.45-8.00	143	794	937	984
8.00-8.15	173	544	717	753
8.15-8.30	181	437	618	649
8.30-8.45	179	398	577	606
8.45-9.00	155	367	522	548
9.00-9.15	67	632	699	734
9.15-9.30	78	555	633	665
9.30-9.45	131	534	665	698

Time	Inner bound/(veh)			
	B	G	Total in 2008	Total in 2009
10.00-10.15	81	316	397	417
10.15-10.30	166	310	476	500
10.30-10.45	189	273	462	485
10.45-11.00	149	251	400	420
11.00-11.15	216	316	532	559
11.15-11.30	122	455	577	606
11.30-11.45	149	561	710	746
11.45-12.00	152	627	779	818
12.00-12.15	126	290	416	437
12.15-12.30	168	332	500	525
12.30-12.45	157	275	432	454
12.45-13.00	150	231	381	400
13.00-13.15	94	309	403	423
13.15-13.30	112	466	578	607
13.30-13.45	109	457	566	594
13.45-14.00	155	405	560	588
14.00-14.15	125	413	538	565
14.15-14.30	180	434	614	645
14.30-14.45	182	470	652	685
14.45-15.00	120	439	559	587
15.00-15.15	131	542	673	707
15.15-15.30	147	659	806	846
15.30-15.45	84	466	550	578
15.45-16.00	83	478	561	589
16.00-16.15	133	403	536	563
16.15-16.30	147	410	557	585
16.30-16.45	106	326	432	454
16.45-17.00	101	462	563	591
17.00-17.15	93	463	556	584
17.15-17.30	94	454	548	575
17.30-17.45	82	394	476	500
17.45-18.00	52	311	363	381
18.00-18.15	102	483	585	614
18.15-18.30	103	420	523	549
18.30-18.45	78	447	525	551
18.45-19.00	56	470	526	552
19.00-19.15	59	387	446	468
19.15-19.30	84	409	493	518
19.30-19.45	62	404	466	489
19.45-20.00	61	383	444	466

Time	Inner bound/(veh)			
	B	G	Total in 2008	Total in 2009
20.15-20.30	49	311	360	378
20.30-20.45	56	299	355	373
20.45-21.00	49	267	316	332
21.00-21.15	43	135	178	187
21.15-21.30	33	132	165	173
21.30-21.45	44	133	177	186
21.45-22.00	26	97	123	129

Source: Road Development Authority, Sri Lanka

A.3. Comparison of Traffic Flow along Galle Road before and after One Way

Table A.3: Comparison of Traffic flow along Galle Road before and after the one-way

Time	Before one-way (2006)/(veh)	After one-way (2009)/(veh)
6.00-6.15	0	121
6.15-6.30	0	172
6.30-6.45	0	212
6.45-7.00	0	390
7.00-7.15	640	604
7.15-7.30	774	919
7.30-7.45	970	1015
7.45-8.00	1073	984
8.00-8.15	949	753
8.15-8.30	923	649
8.30-8.45	950	606
8.45-9.00	915	548
9.00-9.15	865	734
9.15-9.30	762	665
9.30-9.45	671	698
9.45-10.00	711	646
10.00-10.15	719	417
10.15-10.30	782	500
10.30-10.45	705	485
10.45-11.00	891	420
11.00-11.15	907	559
11.15-11.30	867	606
11.30-11.45	937	746
11.45-12.00	898	818
12.00-12.15	1026	437

Time	Before one-way (2006)/(veh)	After one-way (2009)/(veh)
12.15-12.30	830	525
12.45-13.00	814	400
13.00-13.15	656	423
13.30-13.45	806	594
13.45-14.00	773	588
14.00-14.15	758	565
14.15-14.30	788	645
14.30-14.45	841	685
14.45-15.00	881	587
15.00-15.15	845	707
15.15-15.30	726	846
15.30-15.45	940	578
15.45-16.00	932	589
16.00-16.15	907	563
16.15-16.30	777	585
16.30-16.45	873	454
16.45-17.00	898	591
17.00-17.15	747	584
17.15-17.30	989	575
17.30-17.45	640	500
17.45-18.00	813	381
18.00-18.15	747	614
18.15-18.30	594	549
18.30-18.45	583	551
18.45-19.00	520	552
19.00-19.15	0	468
19.15-19.30	0	518
19.30-19.45	0	489
19.45-20.00	0	466
20.00-20.15	0	383
20.15-20.30	0	378
20.30-20.45	0	373
20.45-21.00	0	332
21.00-21.15	0	187
21.15-21.30	0	173
21.30-21.45	0	186
21.45-22.00	0	129

Source: Road Development Authority, Sri Lanka

A.4. Traffic Flow along R.A. de Mel Mawatha before One Way Conversion

Inner bound- Traffic towards to Liberty Junction

Outer bound- Traffic towards to Bambalapitiya Junction

T-Temple Tree Road

D- Dharmapala Mawatha

A- Ananda Kumaraswamy Mawatha

K-Kollupitiya junction

Table A.4: Traffic flow along R.A. de Mel Mawatha before one way system (2005)

Time		Inner bound/(PCU)					Outer bound/(PCU)					Total
		T	D	A	K	Total	T	D	A	K	Total	
6.00	6.15	0	6	0	4	10	5	1	1	0	7	17
6.15	6.30	2	7	0	10	19	7	2	6	4	19	38
6.30	6.45	8	16	2	20	46	2	7	0	4	13	59
6.45	7.00	4	30	0	32	66	17	5	2	8	32	98
7.00	7.15	40	55	1	46	142	13	7	4	15	39	181
7.15	7.30	3	113	7	89	212	15	23	11	23	72	284
7.30	7.45	10	171	4	105	290	11	51	13	28	103	393
7.45	8.00	40	180	8	123	351	15	61	21	33	130	481
8.00	8.15	25	240	9	175	349	24	66	29	31	150	499
8.15	8.30	7	225	7	130	369	25	36	13	46	120	489
8.30	8.45	9	168	6	112	295	15	42	21	22	100	395
8.45	9.00	14	120	10	109	253	26	58	17	20	121	374
9.00	9.15	4	96	7	113	220	13	46	16	17	92	312
9.15	9.30	3	120	10	62	195	13	49	12	39	113	308
9.30	9.45	8	85	10	98	201	7	40	12	36	95	296
9.45	10.00	16	53	2	93	164	12	61	17	38	128	292
10.00	10.15	7	96	1	77	181	25	64	26	42	157	338
10.15	10.30	0	97	0	22	119	19	87	22	48	176	295
10.30	10.45	12	91	1	103	207	20	66	28	47	161	368
10.45	11.00	26	131	12	111	280	14	84	21	48	167	447
11.00	11.15	14	99	3	113	229	11	59	27	60	157	386
11.15	11.30	13	99	8	84	204	17	64	24	61	166	370
11.30	11.45	0	110	0	64	174	20	73	35	55	183	357
11.45	12.00	4	51	3	48	106	35	82	24	65	206	312
12.00	12.15	1	134	5	44	184	29	84	16	53	182	366
12.15	12.30	0	123	11	66	200	18	61	26	64	169	369
12.30	12.45	29	135	13	120	297	31	111	15	64	221	518
12.45	13.00	26	152	11	125	314	33	68	21	54	176	490
13.00	13.15	21	175	5	99	300	25	76	16	46	163	463
13.15	13.30	14	136	3	105	258	31	89	21	54	195	453

Time		Inner bound/(PCU)					Outer bound/(PCU)					Total
		T	D	A	K	Total	T	D	A	K	Total	
13.30	13.45	25	140	7	103	275	15	79	21	53	168	443
13.45	14.00	64	97	6	99	266	34	50	17	50	151	417
14.00	14.15	15	154	7	104	280	17	85	29	27	158	438
14.15	14.30	24	145	4	106	279	34	83	26	51	194	473
14.30	14.45	18	171	6	116	311	33	75	25	69	202	513
14.45	15.00	14	102	4	105	225	21	79	21	47	168	393
15.00	15.15	22	131	15	126	294	31	85	26	57	199	493
15.15	15.30	11	125	11	92	239	21	86	22	66	195	434
15.30	15.45	17	122	4	68	211	24	110	16	43	193	404
15.45	16.00	15	129	17	64	225	25	74	21	57	177	402
16.00	16.15	26	114	11	102	253	28	94	25	56	203	456
16.15	16.30	22	111	9	113	255	16	69	13	62	160	415
16.30	16.45	22	119	5	103	249	12	90	17	57	176	425
16.45	17.00	17	103	8	100	228	28	89	15	74	206	434
17.00	17.15	21	147	12	89	269	31	96	34	81	242	511
17.15	17.30	43	120	4	107	274	39	107	19	82	247	521
17.30	17.45	17	127	6	123	273	35	103	18	75	231	504
17.45	18.00	28	95	6	104	233	28	116	32	58	234	467
18.00	18.15	4	109	1	52	166	21	99	19	52	191	357
18.15	18.30	3	114	5	58	180	21	67	12	67	167	347
18.30	18.45	7	94	0	39	140	26	65	16	55	162	302
18.45	19.00	2	90	11	58	161	28	68	28	54	178	339
19.00	19.15	6	80	17	55	158	19	54	22	64	159	317
19.15	19.30	0	72	5	51	128	25	61	15	50	151	279
19.30	19.45	1	92	12	38	143	12	66	22	46	146	289
19.45	20.00	0	66	1	37	104	11	70	24	31	136	240
20.00	20.15	0	64	13	58	135	10	39	14	40	103	238
20.15	20.30	7	63	6	79	155	7	42	17	32	98	253
20.30	20.45	11	81	11	40	143	5	45	13	35	98	241
20.45	21.00	10	69	8	43	130	8	49	14	45	116	246
21.00	21.05	2	40	15	42	99	6	40	9	23	78	177
21.05	21.30	2	37	8	31	78	5	24	10	23	62	140
21.30	21.45	4	23	13	35	75	5	36	7	14	62	137
21.45	22.00	5	27	9	34	75	4	34	11	17	66	141

Source: Road Development Authority, Sri Lanka

A.5. Traffic Flow along R.A. de Mel Mawatha after One Way Conversion

Outer bound-Traffic towards to Bambalapitiya Junction

Table A.5 Traffic flow along R.A. De Mel Mawatha after one-way System (2009)

Time		Outer bound/(PCU)					Total
		T	D	A	K	Total	
6.00	6.15	0	0	104	26	130	130
6.15	6.30	0	0	137	43	180	180
6.30	6.45	0	0	185	56	241	241
6.45	7.00	0	0	343	82	425	425
7.00	7.15	0	0	389	140	529	529
7.15	7.30	0	0	417	200	617	617
7.30	7.45	0	0	482	209	691	691
7.45	8.00	0	0	516	222	738	738
8.00	8.15	0	0	511	165	676	676
8.15	8.30	0	0	445	171	616	616
8.30	8.45	0	0	514	194	708	708
8.45	9.00	0	0	462	174	636	636
9.00	9.15	0	0	230	211	441	441
9.15	9.30	0	0	186	186	186	186
9.30	9.45	0	0	193	162	355	355
9.45	10.00	0	0	403	210	613	613
10.00	10.15	0	0	462	233	695	695
10.15	10.30	0	0	501	242	743	743
10.30	10.45	0	0	460	200	660	660
10.45	11.00	0	0	519	225	744	744
11.00	11.15	0	0	434	267	701	701
11.15	11.30	0	0	460	251	711	711
11.30	11.45	0	0	399	225	624	624
11.45	12.00	0	0	464	221	685	685
12.00	12.15	0	0	521	352	873	873
12.15	12.30	0	0	527	216	743	743
12.30	12.45	0	0	546	184	730	730
12.45	13.00	0	0	569	278	847	847
13.00	13.15	0	0	501	287	788	788
13.15	13.30	0	0	491	247	738	738
13.30	13.45	0	0	478	414	892	892
13.45	14.00	0	0	526	346	872	872
14.00	14.15	0	0	537	288	825	825
14.15	14.30	0	0	287	320	607	607
14.30	14.45	0	0	578	291	869	869

Time		Outer bound/(PCU)					Total
		T	D	A	K	Total	
14.45	15.00	0	0	512	260	772	772
15.00	15.15	0	0	363	324	687	687
15.15	15.30	0	0	604	306	910	910
15.30	15.45	0	0	462	317	779	779
15.45	16.00	0	0	433	304	737	737
16.00	16.15	0	0	406	287	693	693
16.15	16.30	0	0	357	354	711	711
16.30	16.45	0	0	403	228	631	631
16.45	17.00	0	0	229	0	229	229
17.00	17.15	0	0	344	298	642	642
17.15	17.30	0	0	484	433	917	917
17.30	17.45	0	0	507	418	925	925
17.45	18.00	0	0	467	350	817	817
18.00	18.15	0	0	512	329	841	841
18.15	18.30	0	0	445	317	762	762
18.30	18.45	0	0	513	265	778	778
18.45	19.00	0	0	629	244	873	873
19.00	19.15	0	0	459	260	719	719
19.15	19.30	0	0	390	248	638	638
19.30	19.45	0	0	350	186	536	536
19.45	20.00	0	0	344	175	519	519
20.00	20.15	0	0	272	172	444	444
20.15	20.30	0	0	300	198	498	498
20.30	20.45	0	0	268	154	422	422
20.45	21.00	0	0	237	215	452	452
21.00	21.05	0	0	189	192	381	381
21.05	21.30	0	0	115	113	228	228
21.30	21.45	0	0	107	122	229	229
21.45	22.00	0	0	85	117	202	202

Source: Road Development Authority, Sri Lanka

Note: After conversion of one way no flow comes from Dharmapala Mawatha and Temple Tree Road to R.A.de Mel Mawatha.

A.6.Comparison of Traffic Flow along R.A. de Mel Mw before & after One-way

Table A.6: Comparison of Traffic flow along R.A.de Mel Mw before & after one way

Time		Before one-way/(PCU)	After one-way/(PCU)
6.00	6.15	17	130
6.15	6.30	38	180
6.30	6.45	59	241
6.45	7.00	98	425
7.00	7.15	181	529
7.15	7.30	284	617
7.30	7.45	393	691
7.45	8.00	481	738
8.00	8.15	499	676
8.15	8.30	489	616
8.30	8.45	395	708
8.45	9.00	374	636
9.00	9.15	312	441
9.15	9.30	308	186
9.30	9.45	296	355
9.45	10.00	292	613
10.00	10.15	338	695
10.15	10.30	295	743
10.30	10.45	368	660
10.45	11.00	447	744
11.00	11.15	386	701
11.15	11.30	370	711
11.30	11.45	357	624
11.45	12.00	312	685
12.00	12.15	366	873
12.15	12.30	369	743
12.30	12.45	518	730
12.45	13.00	490	847
13.00	13.15	463	788
13.15	13.30	453	738
13.30	13.45	443	892
13.45	14.00	417	872
14.00	14.15	438	825
14.15	14.30	473	607
14.30	14.45	513	869
14.45	15.00	393	772
15.00	15.15	493	687

Time		Before one-way/(PCU)	After one-way/(PCU)
15.15	15.30	434	910
15.30	15.45	404	779
15.45	16.00	402	737
16.00	16.15	456	693
16.15	16.30	415	711
16.30	16.45	425	631
16.45	17.00	434	229
17.00	17.15	511	642
17.15	17.30	521	917
17.30	17.45	504	925
17.45	18.00	467	817
18.00	18.15	357	841
18.15	18.30	347	762
18.30	18.45	302	778
18.45	19.00	339	873
19.00	19.15	317	719
19.15	19.30	279	638
19.30	19.45	289	536
19.45	20.00	240	519
20.00	20.15	238	444
20.15	20.30	253	498
20.30	20.45	241	422
20.45	21.00	246	452
21.00	21.05	177	381
21.05	21.30	140	228
21.30	21.45	137	229
21.45	22.00	141	202

A.7. Traffic Flow on Bagatale Road

Table A.7: Traffic flow on Bagatale Road after the one way system

Time	From Galle Road (North) to RA Mw/(veh)	From Galle Road (South) to RA Mw /(veh)	From Galle Road to RA Mw/(veh)	From RA Mw To Galle Road/(veh)	Total /(veh)
7.30-8.30	88	211	299	73	372
8.30-9.30	141	218	359	133	492
9.30-10.30	121	144	265	153	418
10.30-11.30	113	119	232	170	402
11.30-12.30	143	76	219	191	410
12.30-13.30	120	86	206	147	353
13.30-14.30	90	89	179	196	375
14.30-15.30	64	80	144	126	270
15.30-16.30	76	72	148	98	246
16.30-17.30	163	63	226	183	409
17.30-18.30	107	78	185	191	376
18.30-19.30	86	65	151	52	203
Total	1,312	1,301	2,613	1,713	4,326

Source: University of Moratuwa, Sri Lanka

A.8. Traffic Flow on Alfred Place Road

Table A.8: Traffic flow on Alfred Place Road after the one way system

Time	Towards to R.A. de Mel Mawatha along Alfred Place/(veh)	Towards to Galle Road along Alfred Place/(veh)	Total on Alfred Place/(veh)
7.00-8.00	159	206	365
8.00-9.00	193	224	417
9.00-10.00	95	223	318
10.00-11.00	104	192	296
11.00-12.00	146	240	386
12.00-13.00	178	234	412
13.00-14.00	145	234	379
14.00-15.00	92	283	375
15.00-16.00	82	302	384
16.00-17.00	107	416	523
17.00-18.00	84	401	485
18.00-19.00	111	330	441
19.00-20.00	48	267	315
20.00-21.00	20	174	194

Source: University of Moratuwa, Sri Lanka

A.9. Traffic Flow on Abdul Capoor & St Anthony Mawatha

Table A.9: Traffic flow on Abdul Capoor & St Anthony Mw after the one way system

Time	To R.A. de Mel Mawatha along Abdul Capoor Mawatha/(veh)	To Galle Road along St Anthony Mawatha/(veh)
7.00-8.00	255	988
8.00-9.00	367	1002
9.00-10.00	385	747
10.00-11.00	477	957
11.00-12.00	452	931
12.00-13.00	448	911
13.00-14.00	432	832
14.00-15.00	420	784
15.00-16.00	442	708
16.00-17.00	449	610
17.00-18.00	524	766
18.00-19.00	332	440

Source: University of Moratuwa, Sri Lanka

A.10. Traffic Flow on Duplication Junction

Table A.10: Traffic flow on Duplication Junction after the one way system

Time	Right Turn from Dharmapala Mw(Galle face bound) to RA Mw (In)/(veh)	Right Turn from Dharmapala Mw(Bambala pitiya bound) to RA Mw (In)/(veh)	Left Turn From Dharmapala Mw end to RA Mw (In)/(veh)	Left Turn From Kumara swami Mw to RA Mw (In)/(veh)	Total /(veh)
7.00-8.00	276	110	418	302	1106
8.00-9.00	567	107	782	498	1954
9.00-10.00	652	126	682	546	2006
10.00-11.00	667	148	856	394	2065
11.00-12.00	1129	205	603	378	2315
12.00-13.00	963	273	832	390	2458
13.00-14.00	594	319	880	330	2123
14.00-15.00	739	313	879	475	2406
15.00-16.00	897	320	989	457	2663
16.00-17.00	911	368	736	400	2415
17.00-18.00	1012	404	817	477	2710
18.00-19.00	914	481	1076	411	2882
Total	9321	3174	9550	5058	27103

Source: University of Moratuwa, Sri Lanka

A.11. Traffic Flow on Bagatale Junction

Table A.11: Traffic flow on Bagatale junction after the one way system

Time	From Land Side/(veh)	Through traffic of Land Side/(veh)	From Sea Side/(veh)	Through traffic of Sea Side/(veh)	Total/(veh)
06:00 - 07:00	49	805	12	745	1611
07:00 - 08:00	105	1869	10	1623	3607
08:00 - 09:00	169	1840	18	1817	3844
09:00 - 10:00	164	1586	19	1621	3390
10:00 - 11:00	119	1513	22	1611	3265
11:00 - 12:00	126	1782	17	1796	3721
12:00 - 13:00	109	1847	17	1750	3723
13:00 - 14:00	104	1816	14	1861	3795
14:00 - 15:00	140	1790	16	1761	3707
15:00 - 16:00	113	1595	16	1758	3482
16:00 - 17:00	109	1625	16	1706	3456
17:00 - 18:00	105	1679	19	1722	3525

Source: University of Moratuwa, Sri Lanka

A.12. Traffic Flow on Dharmapala Mawatha Junction

Table A.12: Traffic flow on Bagatale junction after the one way system

Time	Towards to Dharmapala Mawatha from Galle face bound/(veh)	Towards to Dharmapala Mawatha (right turn) from Bambalapitiya bound/(veh)	Towards to Galle face from Bambalapitiya bound (through) /(veh)	Total/(veh)
6.00-7.00	444	639	923	2006
7.00-8.00	951	1717	1751	4419
8.00-9.00	1014	1664	1976	4654
9.00-10.00	955	1458	1551	3964
10.00-11.00	1009	1637	1468	4114
11.00-12.00	1540	1768	1815	5123
12.00-13.00	1298	2028	1655	4981
13.00-14.00	1461	1898	1876	5235
14.00-15.00	1457	2033	1605	5095
15.00-16.00	1501	1740	1638	4879
16.00-17.00	1677	1735	1548	4960
17.00-18.00	1907	1895	1539	5341

Source: University of Moratuwa, Sri Lanka

APPENDICE B: REGISTERED VEHICLES BASED ON FUEL TYPE

B.1. Registered Vehicles per Year with the Type of Fuel Usage

Table D.1: Registered vehicles per year with the type of fuel usage

Class of Vehicle	2004					2005					2006					2007					2008					2009				
	Petrol	Diesel	Elec.	Non fuel	Total	Petrol	Diesel	Elec.	Non fuel	Total	Petrol	Diesel	Elec.	Non fuel	Total	Petrol	Diesel	Elec.	Non fuel	Total	Petrol	Diesel	Elec.	Non fuel	Total	Petrol	Diesel	Elec.	Non fuel	Total
Motor Cars	18,807	309	-	-	19,116	16,749	527	7	-	17,283	26,932	644	2	-	27,578	21,246	1,357	-	-	22,603	17,776	2,457	4	-	20,237	4,643	1,117	2	-	5,762
Motor Tricycle	43,724	65	-	-	43,789	40,949	136	-	-	41,085	64,044	422	-	-	64,466	41,941	1,127	-	-	43,068	42,754	2,050	-	-	44,804	35,171	2,193	-	-	37,364
Motor Cycle	124,474	-	-	-	124,474	130,696	-	-	-	130,696	156,611	-	15	-	156,626	182,500	-	8	-	182,508	155,950	-	2	-	155,952	135,420	-	1	-	135,421
Buses	2	2,165	-	-	2,167	5	2,064	-	-	2,069	139	3,207	-	-	3,346	155	2,482	-	-	2,637	47	1,133	-	-	1,180	9	730	-	-	739
Dual Purpose vehicles	4,970	5,766	-	-	10,736	3,158	3,693	-	-	6,851	3,463	3,782	-	-	7,245	2,993	2,200	-	-	5,193	1,406	1,450	-	-	2,856	539	741	-	-	1,280
Goods vehicles	1,538	8,964	-	201	10,703	1,619	12,374	-	269	14,262	2,910	17,269	-	257	20,436	2,356	15,914	-	138	18,408	2,196	11,736	-	106	14,038	854	7,261	-	110	8,225
Land vehicles	-	11,535	-	1,322	12,857	-	15,597	-	1,826	17,423	-	19,040	-	1,785	20,825	-	21,346	-	2,129	23,475	-	24,357	-	1,775	26,132	-	13,951	-	1,333	15,284
Total	193,515	28,804	-	1,523	223,842	193,176	34,391	7	2,095	229,669	254,099	44,364	17	2,042	300,522	251,191	44,426	8	2,267	297,892	220,129	43,183	6	1,881	265,199	176,636	25,993	3	1,443	204,075

Source: Department of Motor Traffic, Colombo, Sri Lanka

C.1. Location Map of One Way Traffic System with Path Arrangement

