DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF TRANSPORT

URBAN TRANSPORT SYSTEM DEVELOPMENT PROJECT FOR COLOMBO METROPOLITAN REGION AND SUBURBS

Technical Report No. 2

Present Road Network and Traffic Condition

AUGUST 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ORIENTAL CONSULTANTS CO., LTD.

URBAN TRANSPORT SYSTEM
DEVELOPMENT PROJECT
FOR
COLOMBO METROPOLITAN
REGION AND SUBURBS

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CHAPTER 1 Road Network

1.1 Road Classification

This section shows the definition of road classes and the latest conditions of road development in Sri Lanka. The existing road network of Sri Lanka has been divided into five classes from A to E as defined in Table 1.1.1 based on the "Geometric Design Standards of Roads (RDA, 1988)". Classes A and B are applied to national roads managed by RDA, classes C and D are applied to provincial roads managed by the Provincial Road Development Department (PRDD), and class E is applied to local authority roads managed by local authorities.

The developed road length of each class is shown in Table 1.1.2.

Table 1.1.1 Classification of Roads in Sri Lanka

Class	Description	Type of Road	O & M	Note
A	A class roads are arterial roads or long routes that connect between major cities and towns	National road	RDA	Colombo Municipal Council (CMC) has managed the maintenance work of A and B class roads except the Baseline Road funded by Japan's loan and some roads constructed by other donors in Colombo city.
B	B class roads form the next level of the hierarchy and distribute traffic between residential areas, industrial areas, town centres and feed the A class roads.			
C	C class roads are the main collectors/distributors within any zone or area that feeds the A and B classes.	Provincial Road	Provincial Road Development Department (PRDD)	CMC has managed the maintenance work of C and D class roads in Colombo city.
D	D and E classes are local roads that provide access to settlements and villages			
(E)		Local authority road	Local authority	This class in the standard, in fact, is not generally used.
E	This road connects between major cities.	Expressway	RDA	Although the class of expressway is not defined in the standard, "E" has been used for convenience.

Source: Geometric Design Standards of Roads (RDA, 1998)

Table 1.1.2 Road Length by Road Class in the Western Province

Class	Developed Length	Composition	Note
A	AA: 278.51km	CMC*: 39 km Colombo District: 393.38 km Gampaha District: 738.94 km Kalutara District: 421.25 km Western province: 1,553.57km	A class consists of AA, AB and AC.
	AB: 65.09km		
	AC: 30.19km		
	Total : 373.79km		
B	1,286.35km		
C	941.47km	CMC**: 44 km Colombo Dist.: 399.78 km Gampaha Dist.: 881.50 km Kalutara Dist.: 632.52 km	
D	804.02km		
(E)	11,295km*		
E	90.0km***	Southern Expressway:53.2km Outer Circular Highway:11.0km Colombo Katunayake Expressway:25.8km	

Source: RDA, Western Provincial Ministry of Road Development and the CMC

*, **: These values are from the Urban Transport Development of The Colombo Metropolitan Region (2006).

***: This value of the Outer Circular Highway shows the 1st section which will be opened at the end of 2013.

1.2 Road Network

The existing road network of the Western Province is shown in Table 1.2.1 and Table 1.2.2.

(1) Expressways

Planned and existing expressways of the Western Province are shown in Table 1.2.1 and Figure 1.2.1.

The expressways in service in the Western Province as of April 2014 are the Southern Expressway (SEW) including an extension section (Pinnaduwa - Godagama), the Colombo - Katunayake Expressway (CKE) and the 1st section of the Outer Circular Highway (OCH). Additionally, the Outer Circular Highway (OCH) is also under construction. The opening schedules are shown in Table 1.2.1

In addition, there is a plan for the Northern Expressway that is still under a feasibility study.

After construction of the OCH and CKE, access between the SEW and Bandaranaike International Airport is going to be connected as an expressway link. However, due to these expressways basically running outside the suburbs around Colombo city, there are some serious issues such as a) low accessibility to/from Colombo city and between the northern and southern areas of Colombo city and b) a lack of alternative routes in case of emergency.

Table 1.2.1 Planned and Existing Expressways in Western Province

Name of Expressway	Description	Status
(1) Southern Expressway	a) Developed section Kottawa – Pinnaduwa : 95.3km Pinnaduwa – Godagama : approx. 30km b) Design speed : 120km c) Lanes : Future - 6 , Temporarily – 4	Opening schedule Kottawa - Pinnaduwa : in-service Pinnaduwa – Godagama: in-service
(2) Outer Circular Highway	a) Developed section 1st section Kottawa - Kaduwela : 11.0km 2nd section Kaduwela - Kadawatha : 8.9km 3rd section Kadawatha - Kerawelapitiya: 9.2km b) Design speed : 100km/hr c) Lanes : Future - 6 , Temporarily – 4	Opening schedule 1st Section: in-service 2nd Section: 2015 3rd Section: 2016
(3) Colombo Katunayake Expressway	a) Developed section New Kelani Bridge - Katunayake: 25.8km b) Design speed : 80km and 100km c) Lanes : New Kelani Bridge - Peliyagoda : 6 Peliyagoda - Katunayake : 4	Opening schedule in-service
(4) Northern Expressway	Feasibility study is in progress.	

Source: RDA

(2) Major arterial roads

Major arterial roads of the Western Province are shown in Figure 1.2.1. According to Figure 1.2.1, although radial roads have already been developed to some extent, these roads don't work well under the existing conditions because the connections between each major arterial road are not sufficiently developed. Especially, this has become a serious issue outside of the suburbs around the CMC boundary due to low road network development. On the other hand, traffic demands on the existing roads are almost at capacity or exceed each capacity in the CMC and around the CMC boundary, and have caused traffic congestion at each point.

In order to solve these problems, although some partial improvement plans, such as the development of fly-overs, widening of existing roads and the development of new roads are planned by RDA, drastic improvement is difficult without a comprehensive planning policy including public transport such as BRT and railway, and traffic control and management.

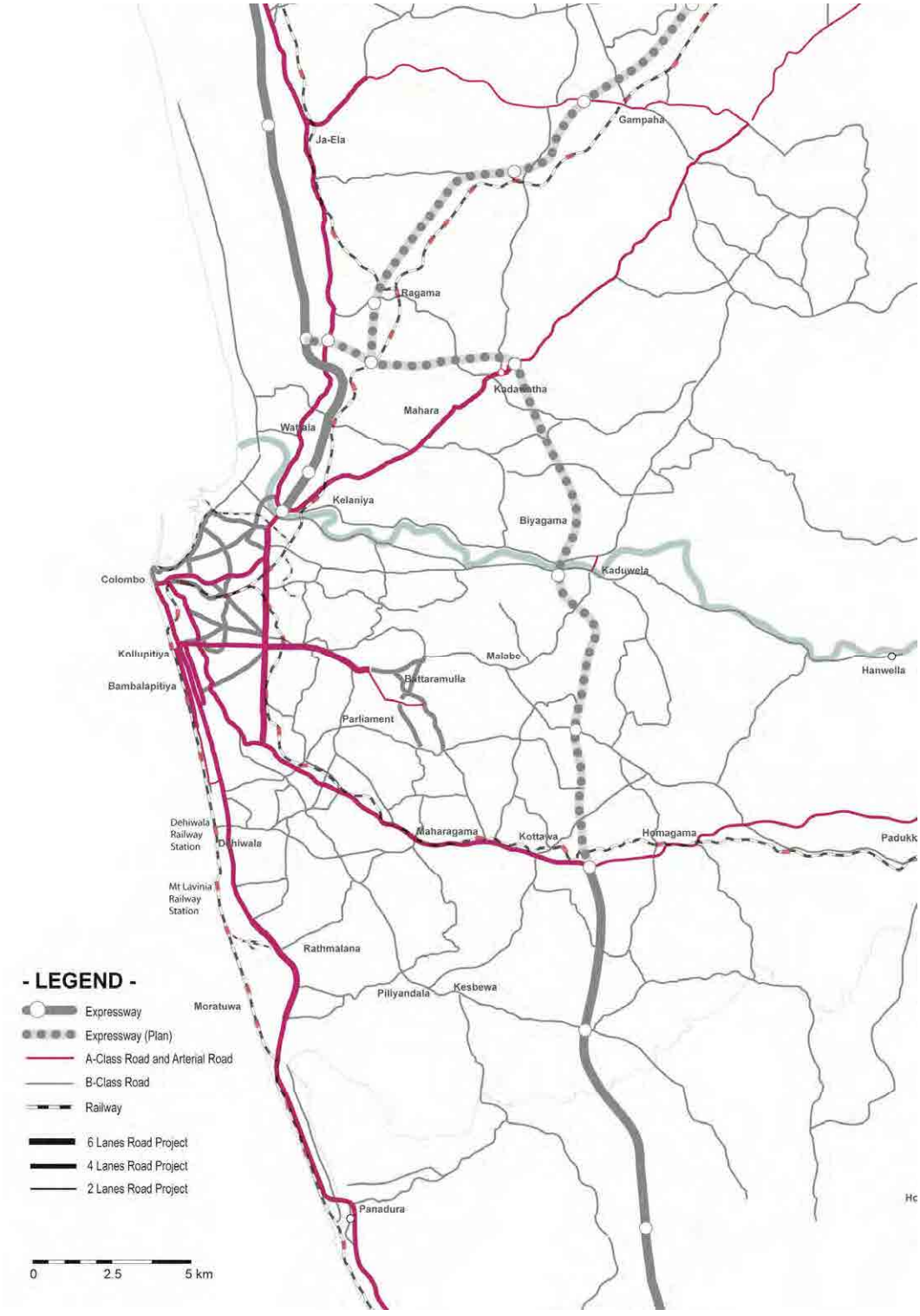
Table 1.2.2 Existing National Road Network

Road Name	Number of Lanes	Road Width*(m)	Length (km)**
(a)Negombo Road (A3)	4	20	37.8
(b)Kandy Road (A1)	1)Colombo – Kadawatha:4	18 - 20	13.7
	2) Kadawatha - : 2	13	41.8
(c)Low Level Road (B435)	2	10 - 12	24.5
(d)Malabe Road (A0 – B240)	1) Colombo – Battaramulla:6	18 – 25	8.1
	2) Battaramulla – Malabe: 2	12	27.8
(e)High Level Road (A4)	1) Colombo – Kottawa:4	12 - 18	20.8
	2) Kottawa -: 2	12	41.2
(f)Horana Road (B84)	2	12	28.0
(g)Galle Road (A2)	1) Colombo – Ratmalana:4	18 - 25	13.0
	2) Ratmalana – Moratuwa:6	30	48.5
(h) Baseline Road	6	28 - 30	8.0

Source: RDA, Western Provincial Council Ministry of Road Development, CMC

Road width*: This value is not the width of ROW, but existing cross section.

Length**: This value is calculated using the data provided by RDA and Google Earth. The Baseline Road includes a section which overlaps Kandy road.



Source: CoMTrans Study Team

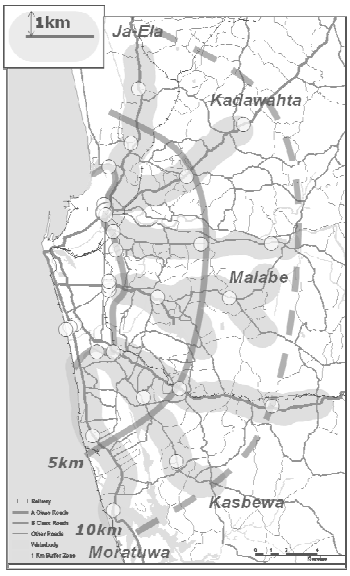
Figure 1.2.1 Existing Road Network of CMA

1.3 Vehicular Traffic Demand on the Current Road Network

1.3.1 Existing Vehicular Traffic Volume and Demand

(1) Traffic Volume on 3 Sections

To compare transport characteristics of each corridor, the survey locations of SLS at i) the CMC boundary, ii) 5km from the CMC boundary and iii) 10km from the CMC boundary were chosen. Figure 1.3.1 shows the selected locations of the SLS.



Selected Locations from SLS for the selected Corridors

To/from		CMC Boundary	5km	10km
1	Negombo Ja-Ela	Negombo Road (A03) *Japan Friendship Bridge* + Mattakkuliya Bridge	*Welegoda*	*Welisara*
2	Kadawatha	Kandy Road (A01) *New Kelani Bridge*	*Warakanatta*	*Kadawatha*
3	Kaduwela	Low Level Road (Avissawella Rd.) + Wellampitiya Road	*Belagama*	*Kaduwela*
4	Malabe	Malabe Road + Dr.N.M.Perera Mw. + Bauddhaloka Mw.	*Battaramulla*	*Malabe*
5	Homagama	High Level Road (A04) *Nugegoda*	*Maharagama*	*Makumbura*
6	Kesbewa	Horana Road *Nugegoda*	*Boralesgamuwa*	*Piliyandala*
7	Moratuwa	Galle Road (A02) + Duplication Rd. + Marine Drive	*Mt. Lavinia*	*Moratuwa*

Source: CoMTrans Screen Line Survey, 2013

Figure 1.3.1 Selected Locations for SLS

<u>Traffic Volume (24 hours)</u>

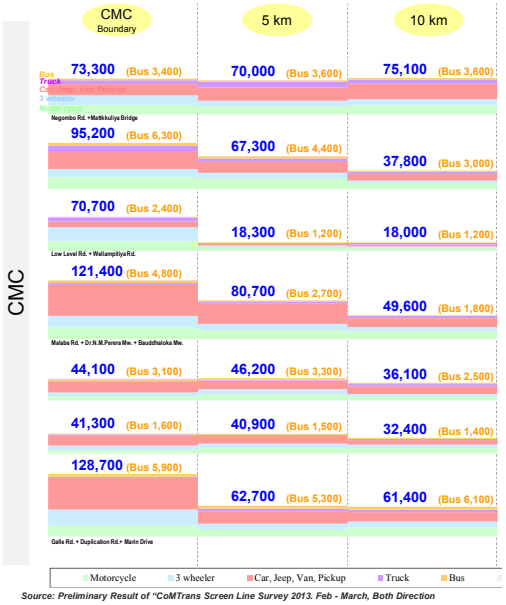
Figure 1.3.2 illustrates the daily traffic volume of both directions and the vehicle composition type for each corridor. The blue number shows the total number of vehicles, which includes Motorcycles (Green), Three-wheelers (Sky Blue), Car-Jeep-Van-Pickup (Red), Trucks (Purple), Buses (Orange) and others (Grey). Note that motorcycles and three-wheelers are half of the number of vehicles even at the CMC boundary. The following are the characteristics which can be observed from the result:

- More than 120,000 vehicles travel on the Malabe and Galle roads including around 5,000 buses.
- On the Kandy road, there are nearly 100,000 vehicles, which include 6,000 buses.
- The vehicles on Negombo road have some other alternative routes or share the route of new Kelani Bridge to enter the CMC area.
- The High level road carries around 3,000 buses a day, which is more than Horana Road.

Peak Hour Traffic Volume (from 6 a.m. to 9 a.m.)

The peak hour traffic volume can be obtained from the SLS counted hourly volume on each corridor. Figure 1.3.3 illustrates the morning peak hour traffic volume only for the direction towards the CMC. The findings are as follows:

- The total number of vehicles on Kandy and Malabe roads account for over 5,000 vehicles per hour.
- Roughly 300 buses are travelling on the Kandy and Galle roads during peak hour. To put it simply, five buses are passing per minute. Thus, insufficient bus parking space on the kerb decreases road capacities.
- Even in the morning peak hour, the ratio of motorcycles and three wheelers is high on the Kandy and Malabe roads.



Source: CoMTrans Screen Line Survey, 2013

Figure 1.3.2 Daily Traffic Volume

Source: CoMTrans Screen Line Survey, 2013

Figure 1.3.3 Peak Hour Traffic Volume

1.3.2 Existing Average Travel Speeds

In order to understand the level of traffic congestion, travel speed is a key indicator, and it helps us to find congested intersections and road sections.

Average travel speeds on the roads are illustrated in Figure 1.3.4 to Figure 1.3.7 based on the survey results of the Travel Speed Survey (TSS). Figure 1.3.4 to Figure 1.3.5 shows the travel speed of inflow traffic during the morning peak hour from 8 to 9 am. Figure 1.3.6 and Figure 1.3.7 show travel speed of outflow traffic during the evening peak hour from 5 to 6 p.m. In the Study, the section with 20 km/hour or less travel speed is defined as congested considering the perception of drivers, travel speed survey results and international examples.

(1) Travel Speed of Morning Peak Hour (Inflow to City Centre)

In the morning peak hour from 7:00 am to 8:00 am, travel speeds in CMC and its surrounding area are mostly less than 20 km per hour and some sections are observed at even less than 10 km per hour.

a) The Maradana roundabout and Town Hall intersection are the most remarkably congested points in the city centre.

b) Traffic congestion is seen at many intersections on the Baseline road intersecting with radial roads since major traffic flows go from the suburbs to the city centre in the morning and road traffic capacity is limited at the intersections.

c) The other congested points are the intersections where the roads merge with the arterial road in Battaramulla. This is caused by lack of east-west direction arterial roads in the suburban area.

d) Traffic congestion is seen at flyover sections such as the Dehiwala flyover. Despite construction of the flyover, it is still congested because of the straight traffic volume, which is more than the one-lane traffic capacity on the flyover section.

(2) Travel Speed of Afternoon Peak Hour (Outflow from City Centre)

The area to the west of the baseline road is heavily congested in the late afternoon from 5:00 pm to 6:00 pm. The traffic congestion is more severe than that in the morning period. In the city centre, many intersections and roundabouts are congested.

a) The Maradana roundabout and Town Hall intersection are congested in the late afternoon as well. At these intersections traffic flows come to this point from various directions and traffic volume often exceeds traffic capacity of the intersections.

b) Compared to the traffic congestion in the morning peak period, outbound directions are congested at many major intersections on the Baseline road.

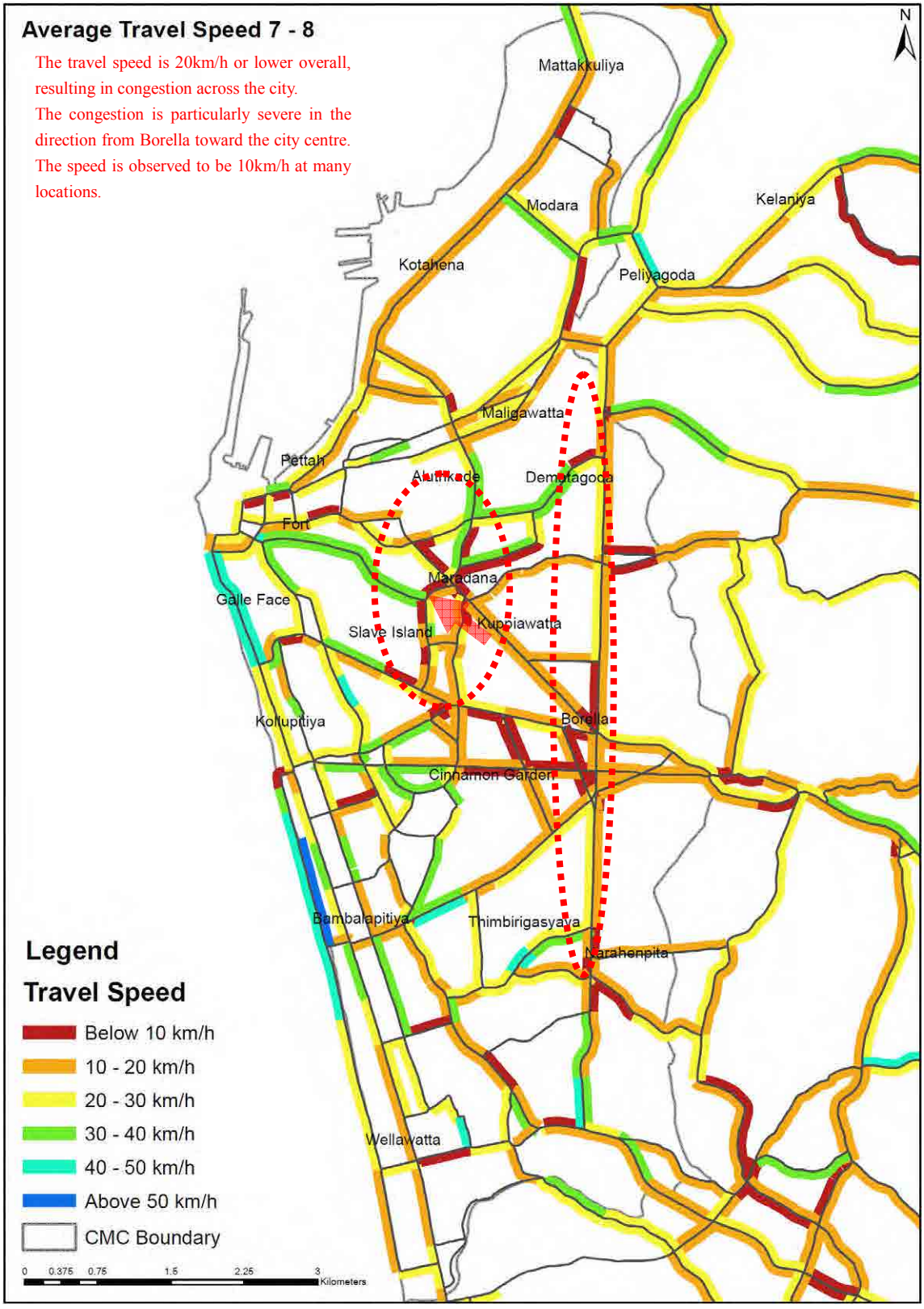


Figure 1.3.4 Travel Speed in CMC in Morning Peak Hour

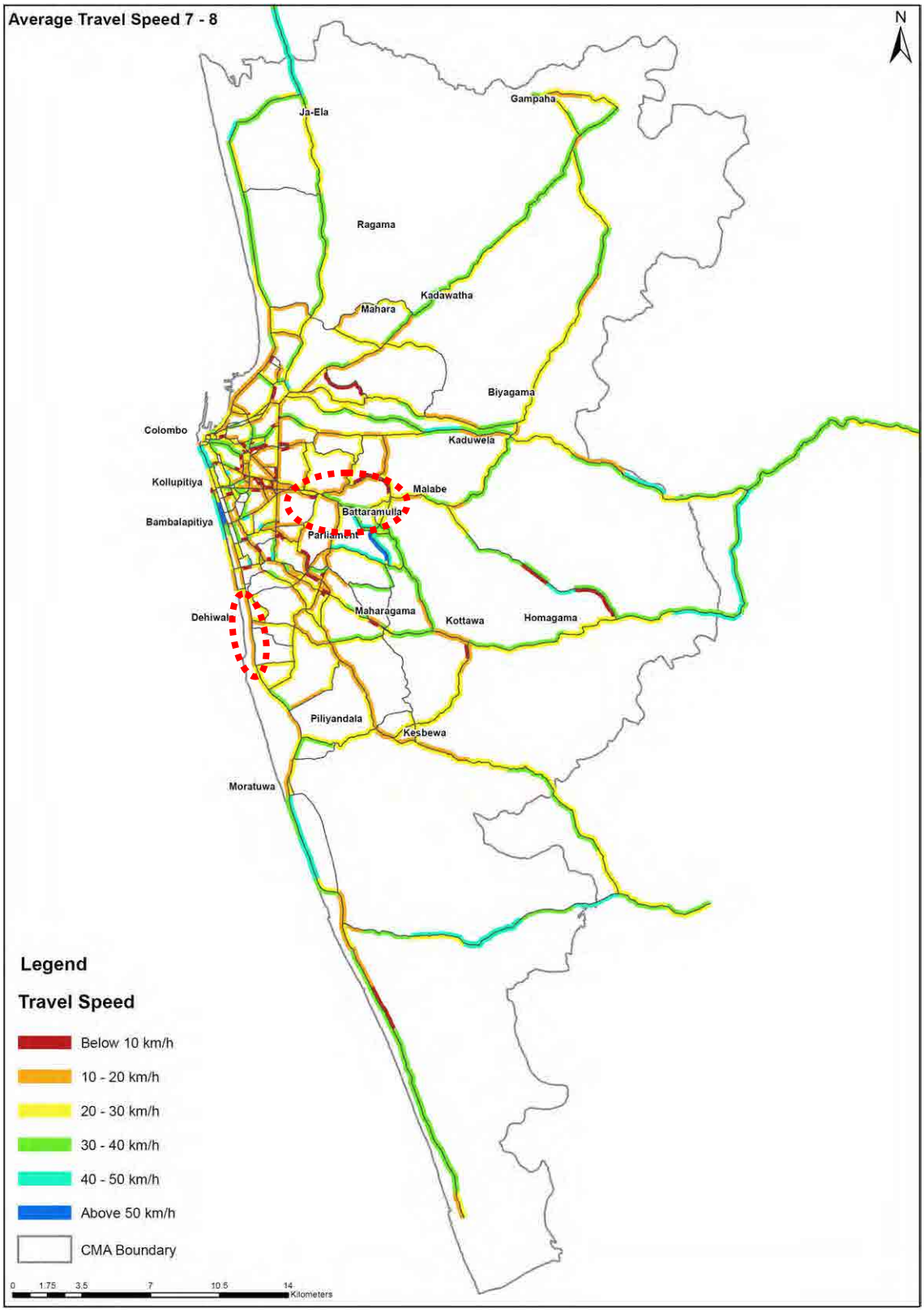


Figure 1.3.5 Travel Speed in CMA in Morning Peak Hour

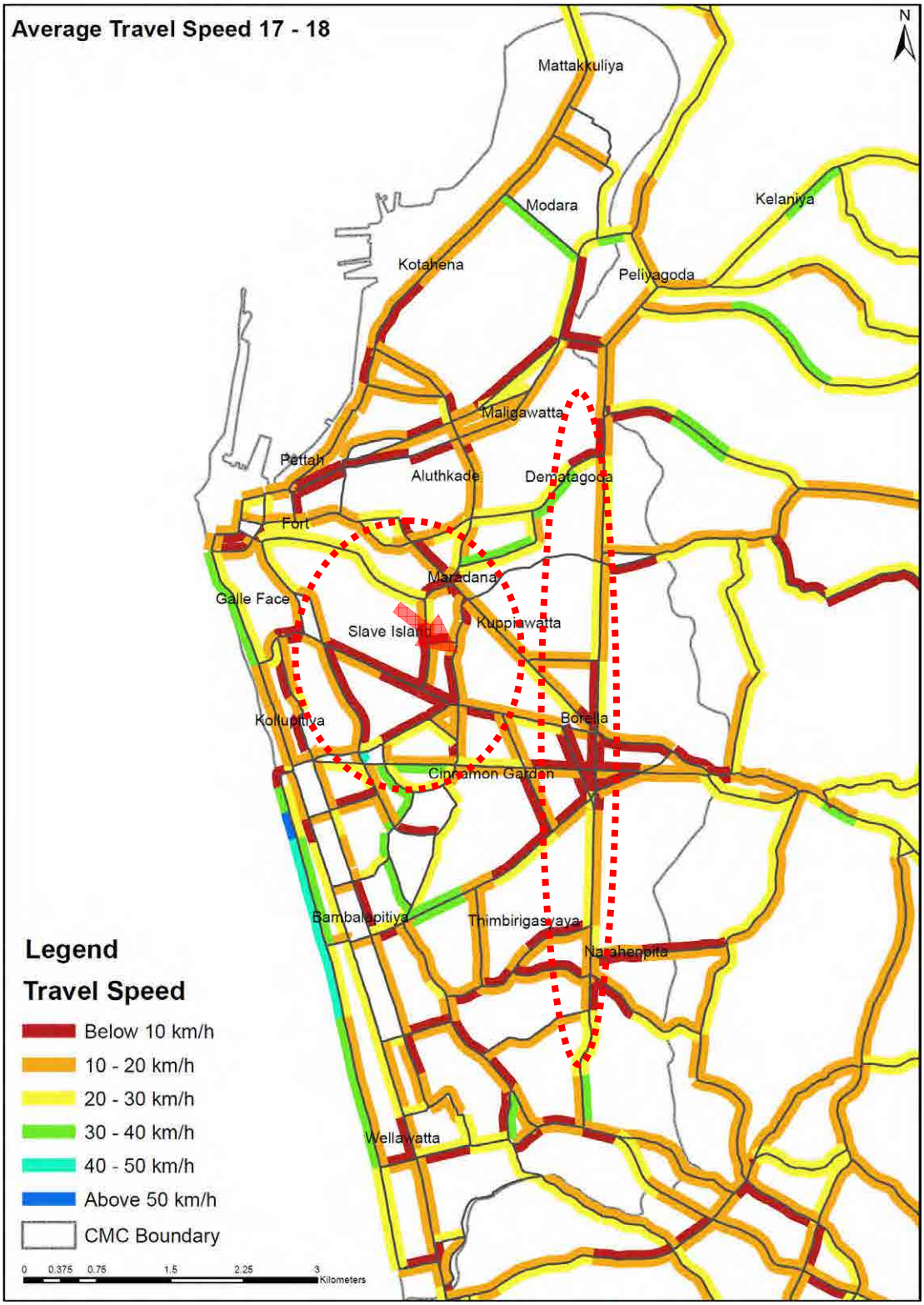


Figure 1.3.6 Travel Speed in CMC in Afternoon Peak Hour

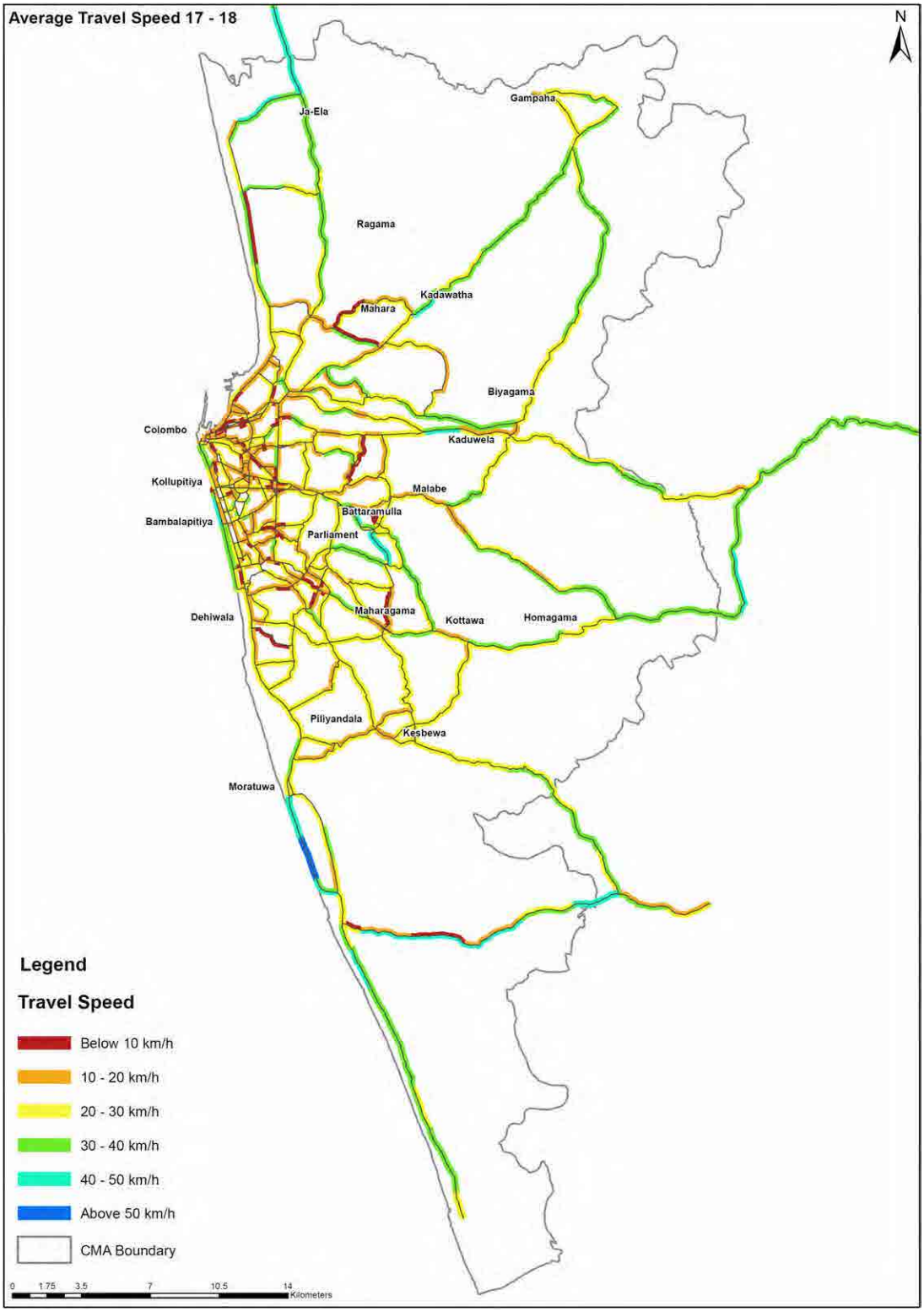


Figure 1.3.7 Travel Speed in CMA in Afternoon Peak Hour

1.3.3 Existing Congestion points

From the results of the Travel speed survey, defined traffic congestion points originating from the sections which have low-speed (20km/h or less) have been organised as follows:

The Legend for each point is as follows.
Red point: Congestion during morning and evening peak hour.
Green point: Congestion during morning peak hour.
Blue point: Congestion during evening peak hour.

a) There are many traffic congestion points in the CMC and each corridor including Base Line Rd.

b) Traffic congestion in the morning and afternoon is occurring at major intersections mostly in the areas that surround Borera, Maradana and the Town Hall in the CMC.

c)Traffic congestion occurs more in the evening than in the morning.

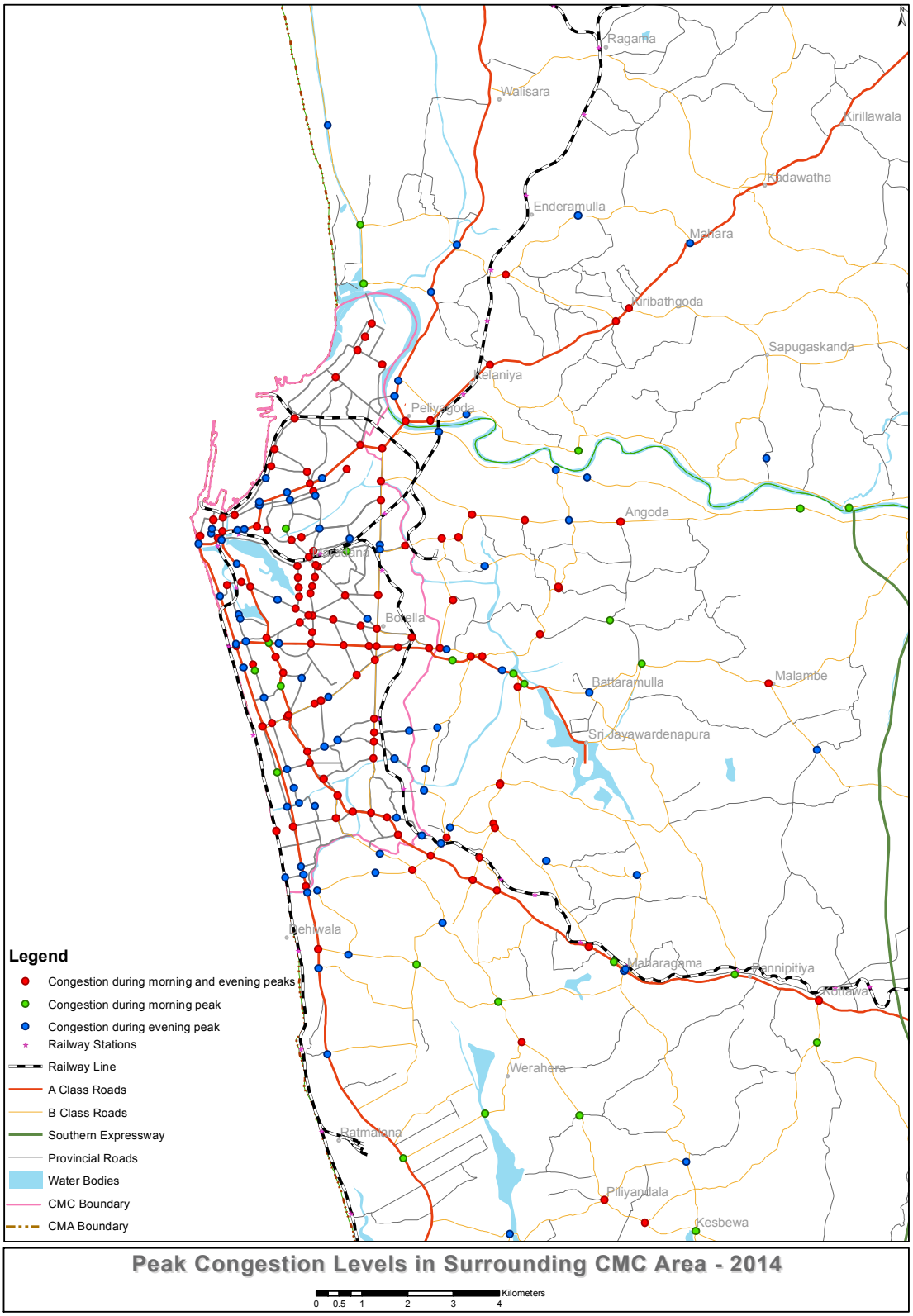


Figure 1.3.8 Congestion points in CMC

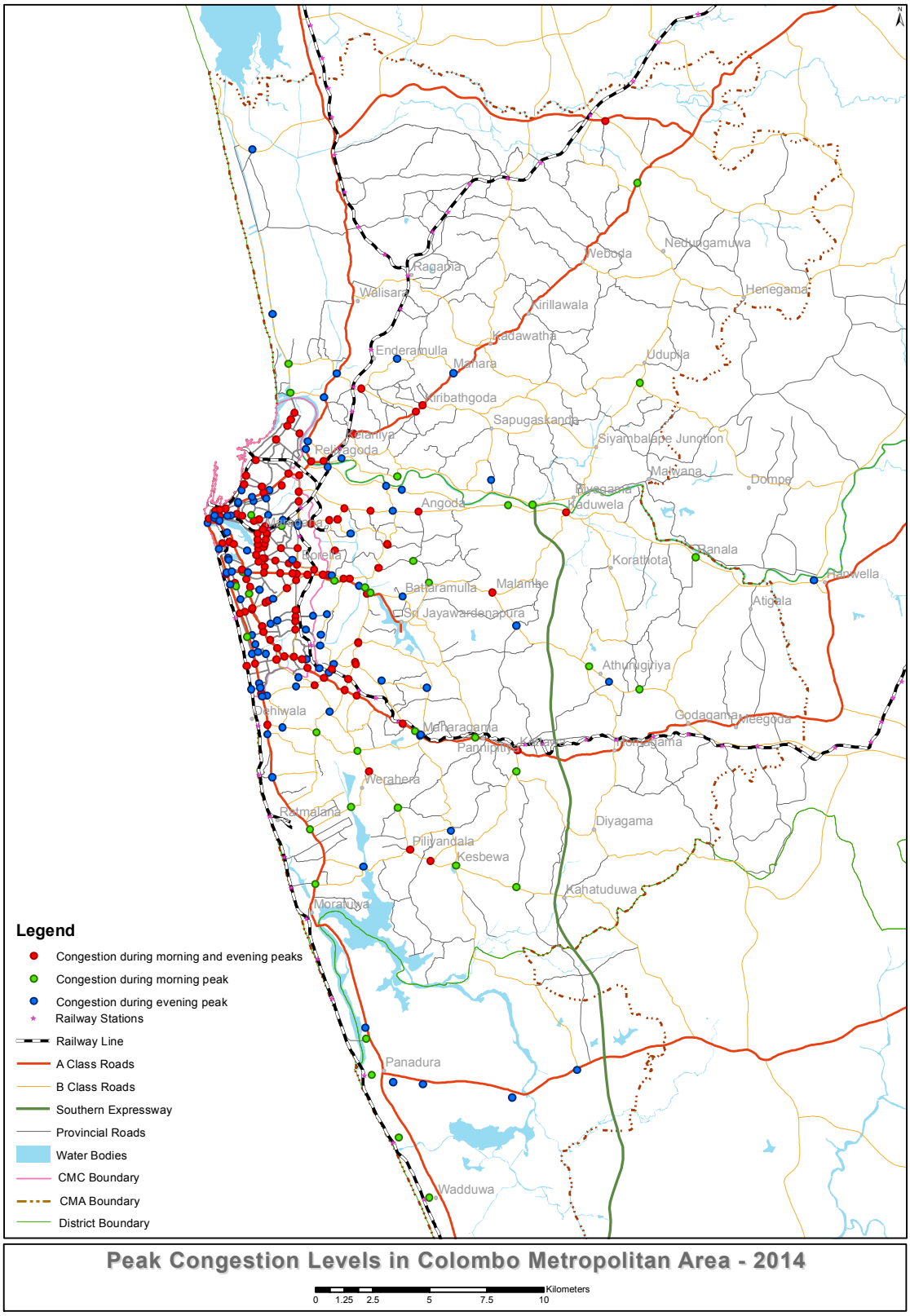


Figure 1.3.9 Congestion points in CMA

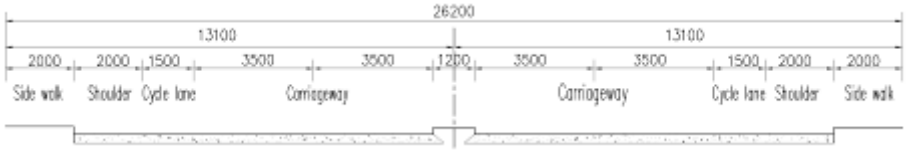
1.4 Geometric Conditions of Roads

(1) Standard cross section

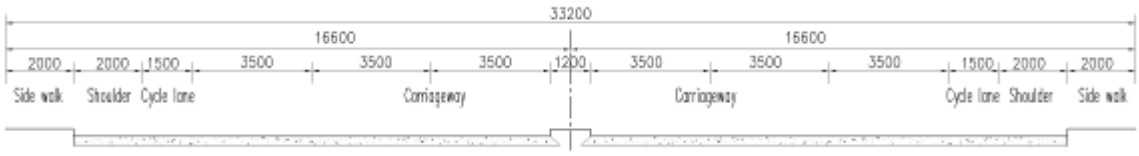
Although standard cross sections for each case are shown in the "Geometric Design Standards of Roads (RDA, 1988)", cross sections as shown in Figure 1.4.1 are recommended by RDA because this standard is usually used as just a guideline. However, these cross sections are not necessarily applied to each road because of some differences between urban areas and rural areas, such as the difficulty of acquiring additional land and high compensation expenses, have not been considered.

2 lanes

4 lanes



6 lanes



Source: RDA

Figure 1.4.1 Standard Cross Sections

(2) Road traffic capacity (road width) of the selected corridors

The Study team examined existing road widths and the number of lanes of each corridor. The general lane composition and widths are illustrated in Figure 1.4.2 and Figure 1.4.3.

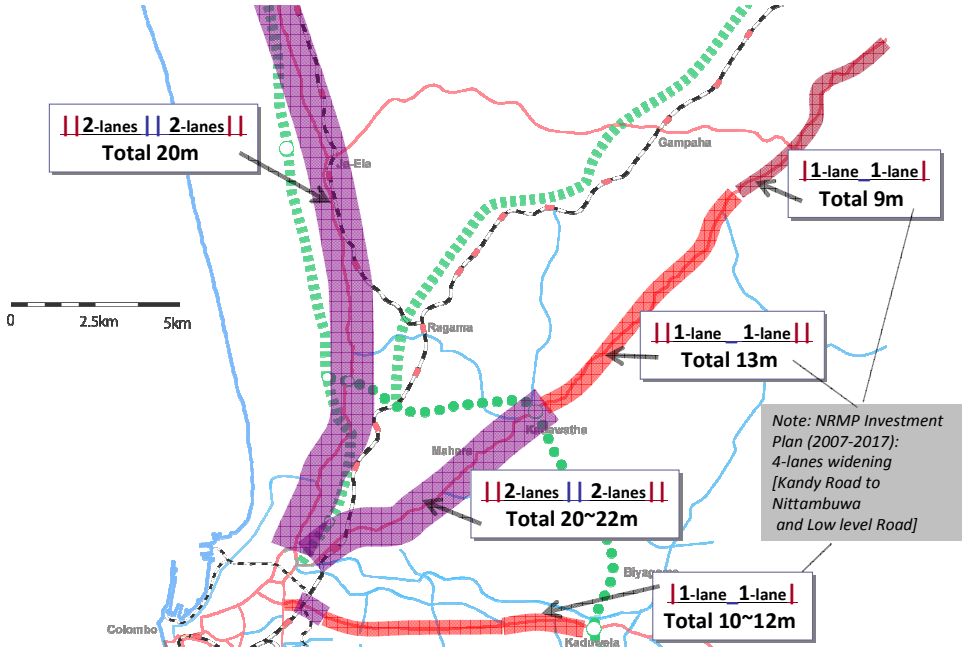


Figure 1.4.2 Cross Section Composition and Road Width (1)

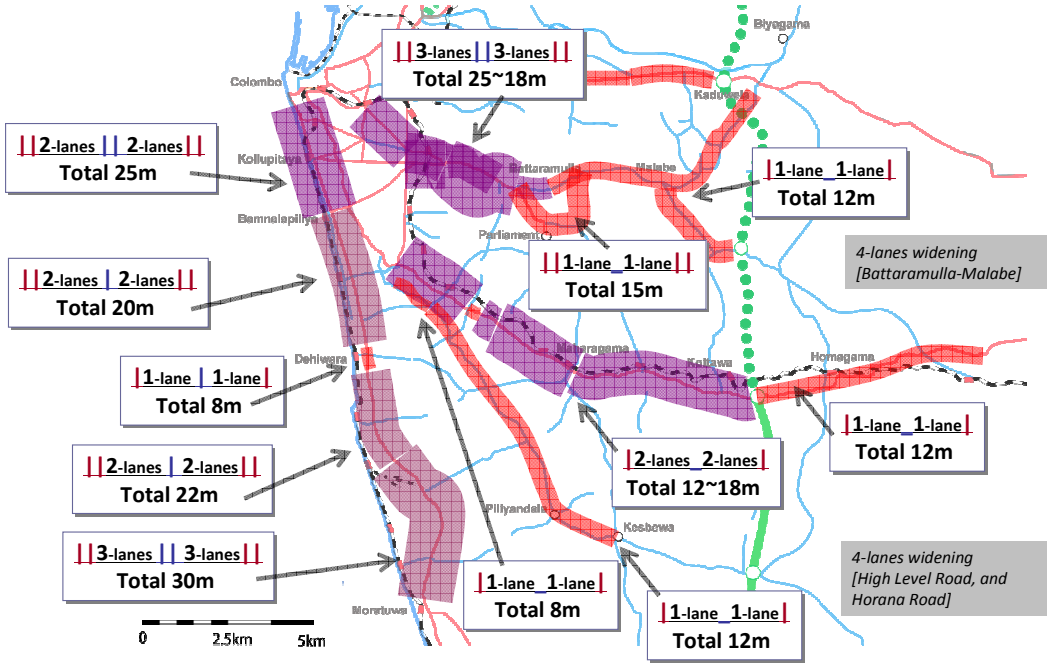


Figure 1.4.3 Cross Section Composition and Road Width (2)

Cross sections of some major arterial roads such as Kandy Road, High Level Road, Galle Road and the Baseline Road based on the site survey are shown in Figure 1.4.4 to Figure 1.4.7 below. According to these cross sections, it is confirmed that most of them have not satisfied the standards for cross sections.

(3) Potential for Bus Rapid Transit (BRT) introduction under existing road condition

On the other hand, it is confirmed that there have been several proposals for a Bus Rapid Transit (BRT) system in the CMA. Although a BRT is considered as an inexpensive and immediate transport measure, especially in developing countries, sufficient road width is required for installation. The width of the cross section for a BRT line is shown at the bottom of each cross section. In this case, the width of a BRT "7.5" m is applied as a minimum value. The 20~25m width road section would make it very difficult to install a BRT line with the same lane arrangement without widening.

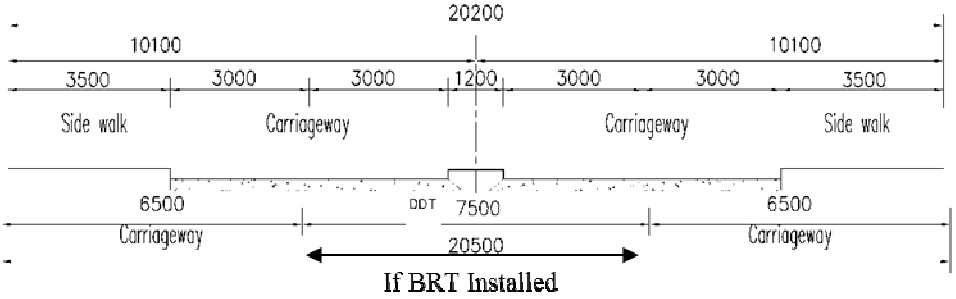
(4) Kandy Road (A1)

The Kandy Road has been basically developed as a four lane road up to Kadawatha town, however, that cross section is not fixed, and some sections don't have enough shoulder space. The section from Kadawatha to Nittauwa is planned to be widened to a 4-lane road according to the Investment Plan of the National Road Master Plan (2007-2017).

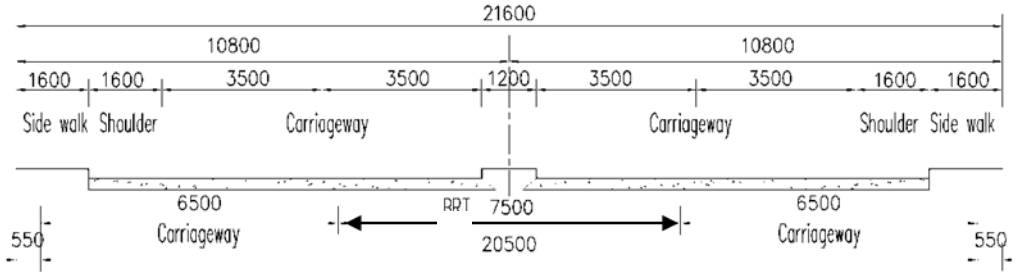
Within the area of the CMC, land use along the Kandy Road (A1) is mainly commercial buildings, residential houses and governmental and educational facilities. From the Kelani River to Kadawatha, the residential land use gradually increases except for some areas in towns such as Kiribathgoda. Low density residential houses, marshland and forests are major land uses of the north-eastern section beyond Kadawatha.

While there are several intersections with major B class roads in the CMC, major intersections after Kelaniya area are limited except for the intersections with B220 and B221 at Kiribathgoda; B460 at Maharaja; and B13, B58 and B169 at Kadawatha.

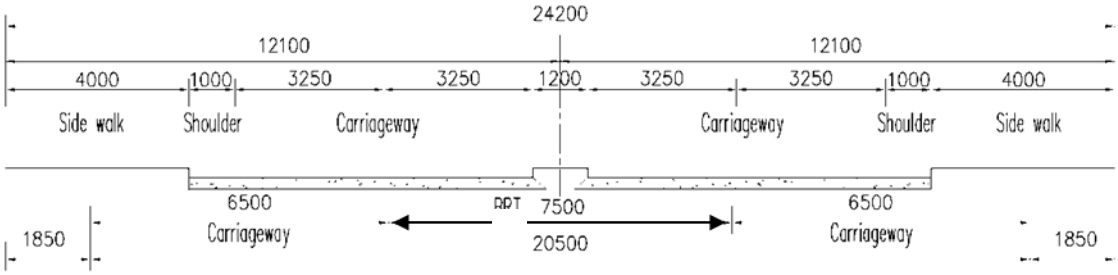
Basic type of four lanes



Basic type of four lanes with shoulder



Kadawatha town



Beyond Kadawatha town

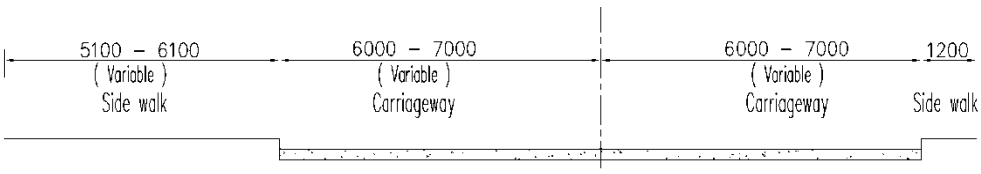


Figure 1.4.4 Cross Sections of Kandy Road

(5) High Level Road (A4)

The High Level Road has been developed as a four lane road except for two sections up to the Kottawa IC of SEW, the first is a fly-over section and the second is a cut section due to a problem with vertical alignment. The section from Vilasitha Nivasa and Colombo to Godagama is planned to be widened to a 4-lane road according to the Investment Plan of the National Road Master Plan (2007-2017). The basic type of suburban roads with four lanes is illustrated in Figure 1.4.5. This cross section doesn't secure safety for pedestrians due to lack of separated spaces for the sidewalk and shoulder.

There are a number of commercial buildings and shops along the High Level Road (A4), especially in the CMC and the towns along the road such as Nugegoda, Delkanda, Maharagama and Kottawa. Dense habitation is also observed in the CMC and the section till Hommagama. The land gradually shifts to residential and agricultural use in the section beyond Hommagama.

The High Level Road crosses a number of B class and other arterial roads in the section from the CMC to Maharagama at roughly one km intervals. These cross roads include B84 (Horana Road), AC8 (Baseline Road), B120, B389, B134, B316, B291, B504, B94.

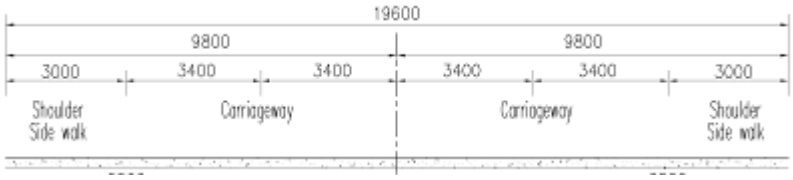


Figure 1.4.5 Cross Section of the High Level Road

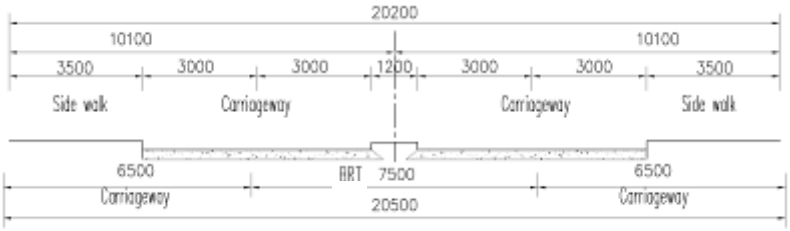
(6) Galle Road (A2)

The southern part of the Galle Road from Dehiwala has four lanes till Ratmalana airport and six lanes to the bypass to Moratuwa station. The section from Moratuwa to Katukurunda is planned to be widened to a 4-lane road according to the Investment Plan of the National Road Master Plan (2007-2017).

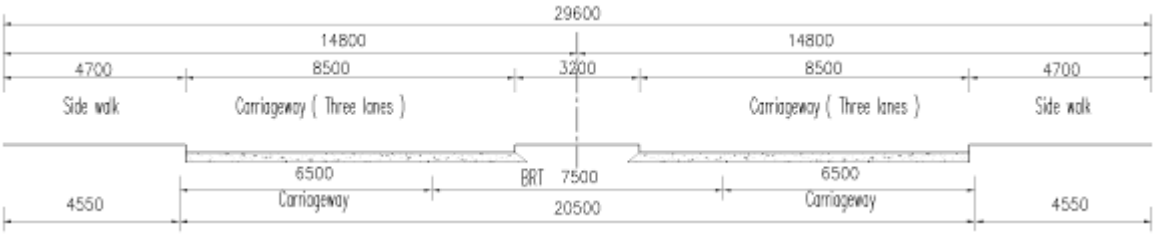
The area along the Galle Road is relatively well developed compared with other corridors. There is the conurbation of municipalities; the CMC, Dehiwala – Mount Lavinia Municipal Council and Moratuwa Municipal Council. The land along the Galle Road from Colombo to Moratuwa is mainly of commercial and partially residential use. Residential land is mainly observed in the section beyond Moratuwa except for in some town centres such as Panadura.

The Galle Road crosses major arterial roads and B Class roads in the urbanised section from Colombo to Moratuwa including A0 at Kollupitiya, Bauddaloka Mawatha, Dhammarama Road, Silva Mawatha, B229, B11, B94, B547, B32, B389, B388, B204, B295 at roughly one km intervals. The intersection intervals gradually increase in the sections beyond Moratuwa.

Four lanes type, north of Ratmalana airport



Six lanes type



Moratuwa area

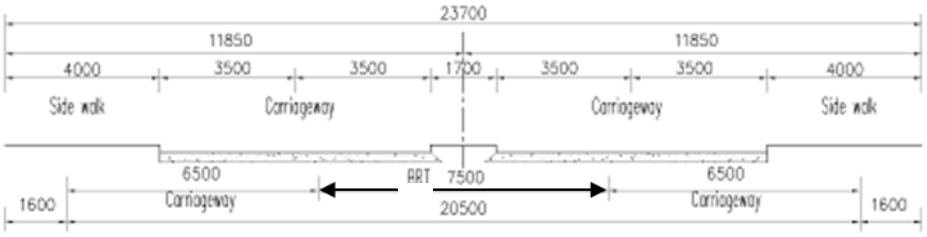


Figure 1.4.6 Cross Sections of Galle Road

(7) Baseline Road (Basic type, six lanes)

Baseline Road has been developed as a six lane road from New Kelani Bridge to Kirullapone. It connects with Kandy Road (A1) at the northern end and High Level Road (A4) at the southern end. A median and sidewalk are installed in this road.

Land use along the Baseline Road is a mixture of business, commercial, residential, and some other uses. Borella Junction is one of the busiest areas in CMC.

There are some intersections with major radial roads, Low Level Road (B435), B96, B62 at Borella Junction, A0, B307, and High Level Road (A4)

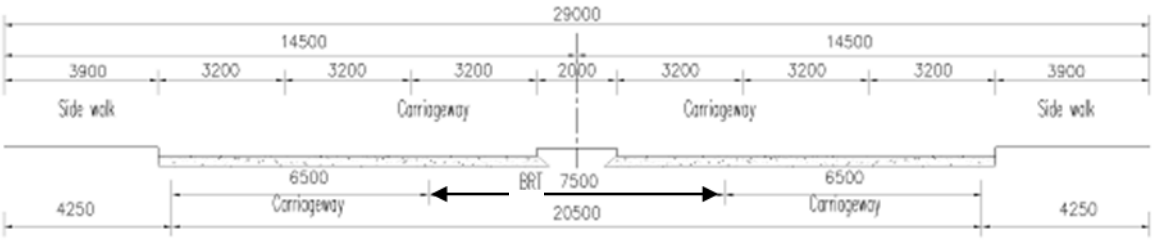


Figure 1.4.7 Cross Section of Baseline Road

1.4.1 Road-Related Organizations

(1) RDA

- Roles

  The role of RDA consists mainly of the maintenance and development of the roads and bridges in the national road network and the planning, design and construction of new highways, bridges and expressways to augment the existing network in accordance with the latest National Road Master Plan. The latest one is the National Road Master Plan (NRMP) 2007-2017.

- Actions

  National Road Master Plan (NRMP) 2007-2017

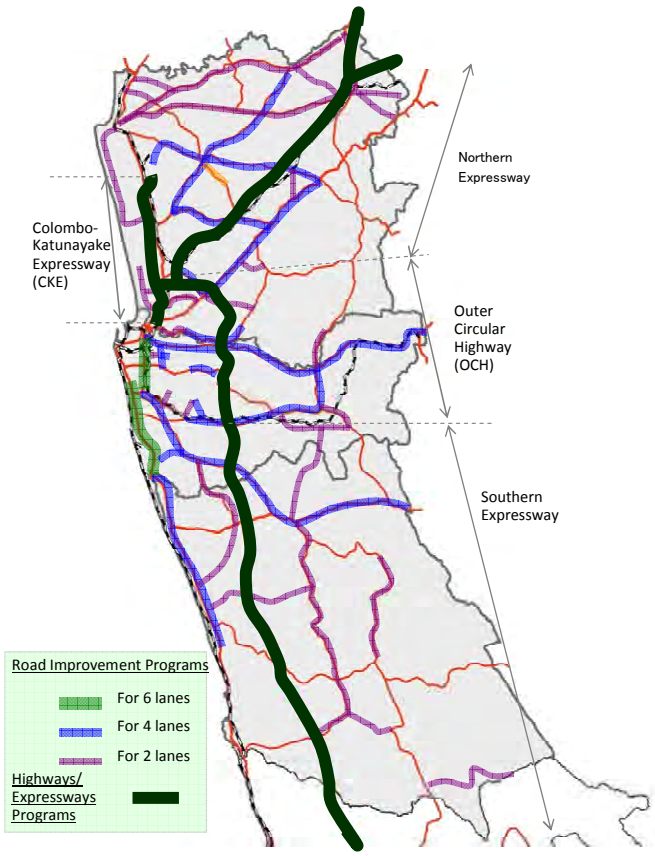
  Figure 1.4.8 shows the road improvement programmes in the Western Province that were identified in the NRMP investment plan.

  The NRMP contains a 10-year investment programme with six priorities including i) construction of expressways and highways, ii) widening of highways, iii) reduction of traffic congestion by the construction of flyovers and junction improvements, signalisation and construction of a system of ring roads and major bypasses, iv) road maintenance and rehabilitation, v) bridge rehabilitation and reconstruction and vi) land acquisition and resettlement.

  As mentioned above, the construction of the expressways has been proceeding surely and steadily. All expressways around CMC will soon be interconnected as an expressway network.

  On the other hand, the widening of Galle Road to six lanes has not been undertaken yet due to some problems, such as difficulty in land acquisition.

  Figure 1.4.8 shows the road improvement programmes in the Western Province that were identified in the NRMP investment plan.



Source: CoMTrans Study Team based on the Investment Plan 2007-2017 in NRMP

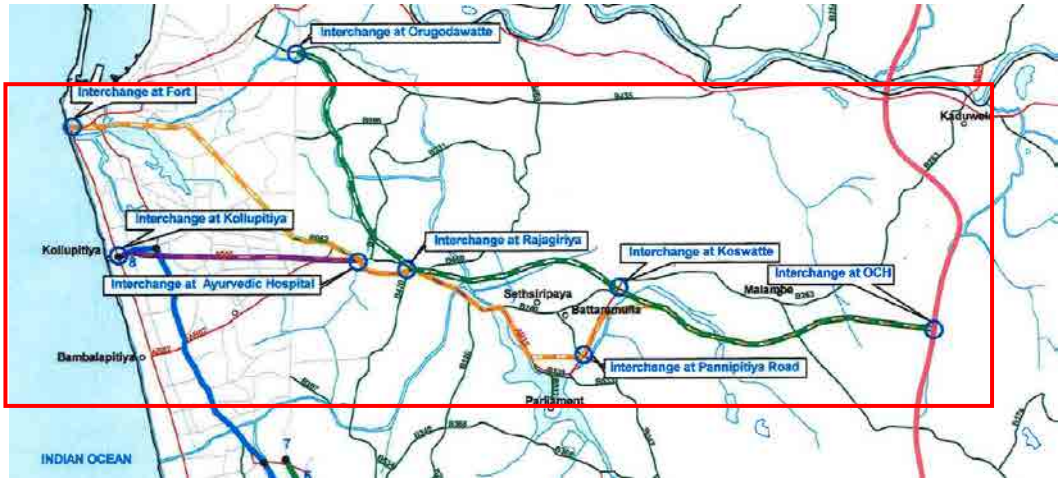
Figure 1.4.8 Road Improvement Projects in NRMP 2007-2017

- On-going development plans

  RDA has conducted some additional projects in order to meet the needs brought about by the change to a motorised society. Those projects are shown in Table 1.4.1.

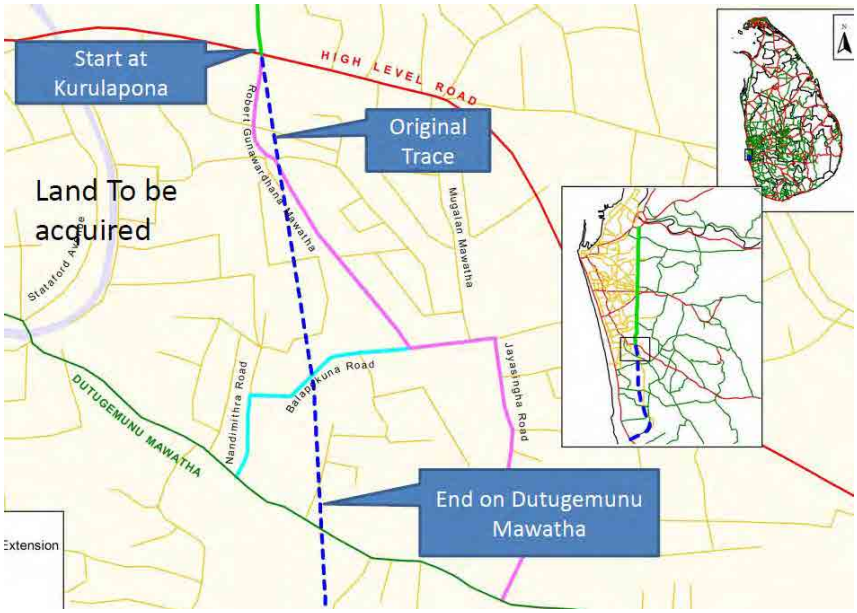
Table 1.4.1 Additional Development Plans by RDA

Classification	Description	Note
1. Expressway	Colombo - Malabe - Pore Expressway (Figure 1.4.9)	Conceptual study is in progress by the University of Moratuwa.
	Second New Kelani Bridge	Feasibility study is in progress.
2. A and B Class Roads	Widening of each road a)Kandy road: to 6 lanes b)Horana road: to 4lanes	a) This is still in the conceptual phase. b) It has been planned by ADB.
	Extension of each road a)Baseline Road,(Figure 1.4.10) b)Marine Drive (to Dehiwala Station) c)B214	Land acquisition for these projects is proceeding.



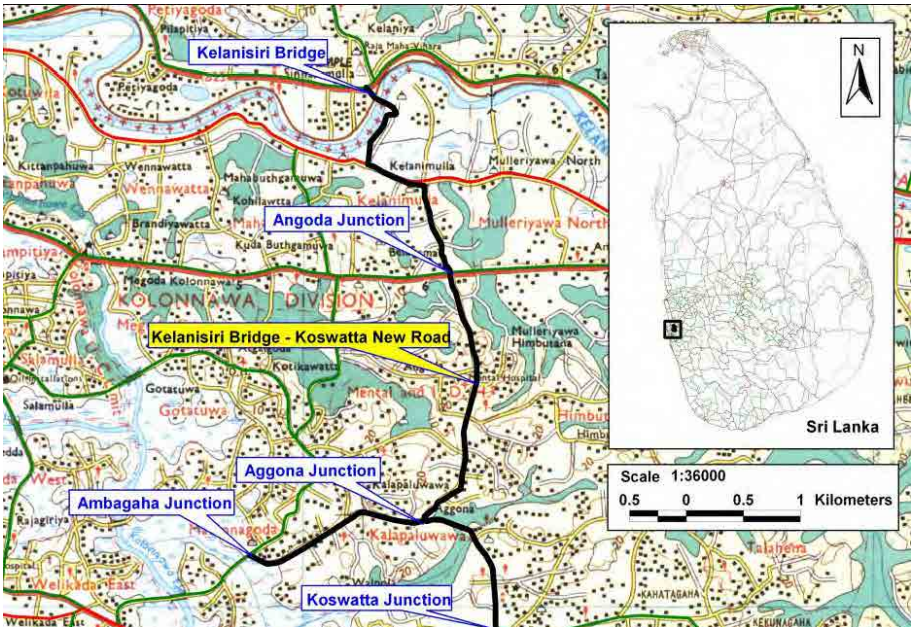
Source: RDA

Figure 1.4.9 Colombo - Malabe - Pore Expressway



Source: RDA

Figure 1.4.10 Extension of Baseline Road



Source: RDA

Figure 1.4.11 Kelanisiri Bridge – Koswatta Road

(2) Western Provincial Council Ministry of Road Development

- Roles

  The roles of the Western Provincial Council Ministry of Road Development include the construction and maintenance of all C & D class roads of the National Road System within the Western Province totalling 2,000 km.

- Actions

  Development Plan 2010-2014

  The Development plan contains a 5-year investment program with four priorities including i) road improvement, ii) road rehabilitation, iii) road safety improvement, iv) reconstruction of major structures and so on. In addition, the Western Provincial Council Ministry of Road Development has proposed the improvement plans to RDA from the view point of road management.

(3) Local Authority

The roles of local authorities are the construction and maintenance of local roads in each Municipal Council (MC). Additionally, the MCs have some projects such as widening and rehabilitation of roads and installation of sidewalks under a World Bank Funded Project and so on.

On the other hand, unlike other local authorities, the CMC has managed not only local roads but also some A and B class roads in the CMC area, and this includes some major arterial roads.

CHAPTER 2 Traffic Control and Management

2.1 Traffic Control and Management

Traffic control and management can be regarded as an essential countermeasure to tackle the traffic congestion in the metropolitan area. At present many intersections exist with various geometrical and roadside conditions. Especially in urban areas, the improvement of the layout of intersections as well as the enhancement of signal control should be carefully examined to increase its traffic capacity and to enhance traffic safety at intersections.

2.1.1 Traffic signal system

(1) Traffic Signals

At many intersections in CMC, traffic demand exceeds traffic capacity of the intersections, in particular, during peak hours. The majority of traffic signals at these intersections are stand alone; therefore, the signals do not coordinate with each other. The existing signals apply a pattern control unit for the day of the week and for the time of day; therefore, the existing signal system does not provide efficient traffic control.

Different types of signal control systems are installed at intersections managed by RDA and CMC. These systems are currently manufactured by domestic system and equipment companies. Even though countdown display devices are installed at some intersections, the current controllers are basically multi-pattern controllers with different phasing parameters based on the time of day. Traffic-actuated signal systems with vehicle detectors which adjust signal timing to optimise throughput have not been introduced yet. In the past, coordinated signal operation was installed along Malabe Road (A0), centring at Senayayaka intersection where the Malabe road intersects with Baseline road. The system does not work at present due to poor maintenance; hence the signals are being used as a stand-alone system. Police officers switch off the signals and control traffic by hand signals at signalised intersections when congested.

(2) Signals for Pedestrian Crossings

A few signals for pedestrian crossings have been installed in the Colombo metropolitan area. Some pedestrian signals have been installed on Galle Road and Baseline Road.

Figure 2.1.1 Traffic control by hand signal

Figure 2.1.2 Signal switch

Figure 2.1.3 Pedestrian signals

Figure 2.1.4 Countdown display

(3) Roundabouts

Symbolic monuments (Buddha statues, big trees) have been placed in the centre of many roundabouts. Under a certain level of traffic demand, roundabouts are known as an efficient intersection solution because of non-stop operation that maintains higher throughputs based on first-come-first-in principle. However, once traffic volume exceeds a certain level and there is not enough space to accommodate the enlargement of the roundabout layout and circulating lanes to secure room for inbound traffic flows, congestion will occur. In such cases a roundabout should be converted to a signal controlled intersection. Basically, a signal controlled intersection is more compact than a roundabout, so that it could provide more space for pedestrians and vehicular traffic flows. Current roundabouts with heavy traffic congestion shall be examined carefully to determine whether they will remain as roundabouts or be converted to signal controlled intersections in view of current traffic conditions and the projected traffic demand.

Traffic signals have been installed since the 1980's and the most of the current traffic signals were installed in the 1990's at various intersections. Figure 2.1.8 shows the locations in which traffic signal systems have been installed and roundabouts in CMC and its surrounding area.

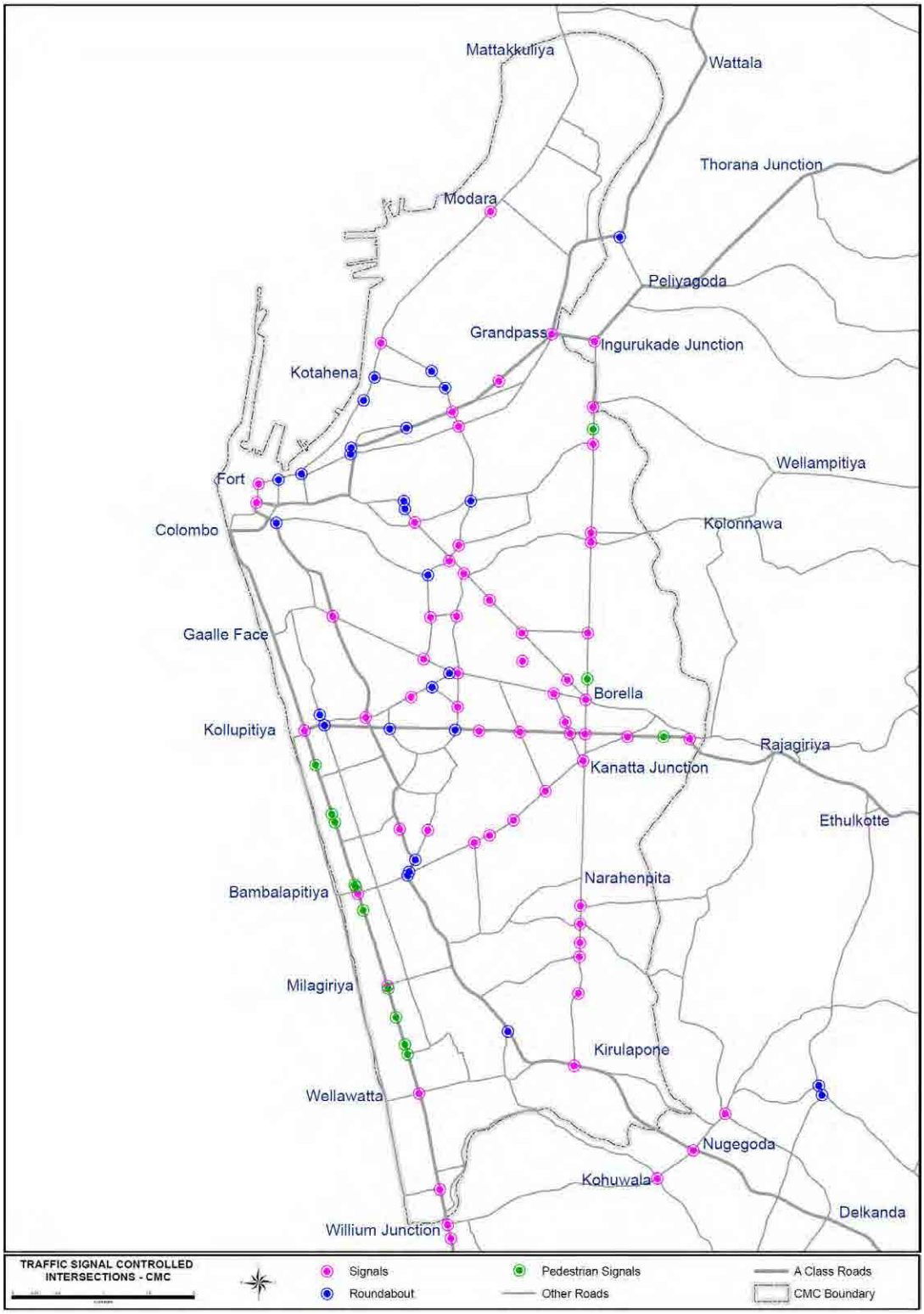
Figure 2.1.5 Roundabout at Panadura

Figure 2.1.6 Roundabout at Main St and Fort St

Figure 2.1.7 Roundabout at ODEL

(4) Non-Signalised Intersections

Outside of CMC, almost no signals or roundabouts have been installed in any crossings. This is satisfactory at a crossing with little traffic. However, it has become a dangerous place at the points where the traffic volume exceeds a certain level, because it is necessary to find a short inter-vehicle space in order to flow into the intersection and traffic crossing point of many intersections.



Source: RDA,CMC, CoMTrans Study Team

Figure 2.1.8 Traffic Signals and Roundabouts in CMC

2.1.2 One-way system Operation

The one-way system and turning restrictions are applied to various sections, especially in the CMC area. These are proposed by the traffic police based on their daily experience in traffic control and patrol, and discussions with CMC and RDA.

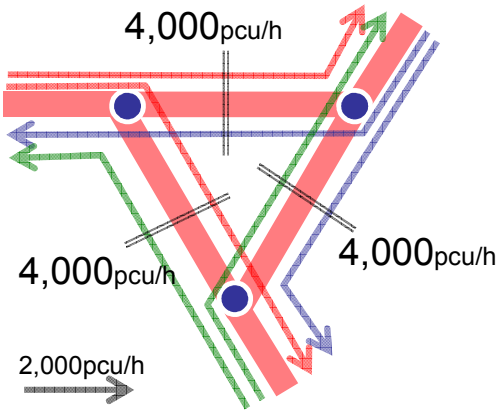
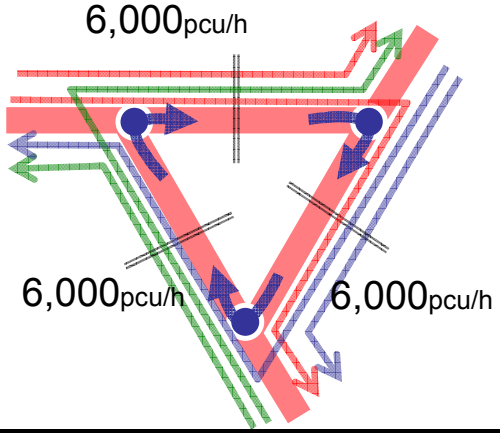
It should be noted, however, that the one-way system increases the traffic capacity of the one-way areas by connecting two-way two-lane roads while taking advantage of the difference produced by extending the travel distance of some vehicles and increasing the traffic volume of routes covered. In this sense, the system should not be applied to two-way roads with four or more lanes, because there is no increase in traffic capacity

In the CMC, several new one-way systems have been applied to reduce congestion. A typical example is the triangle roads connecting at Maradana junction, Technical junction and Panchikawatta junction. While the one-way system can contribute to alleviate traffic congestion in certain conditions, it might aggravate traffic congestion and increase vehicle-kilometres in other settings. Application of a one-way system should be carefully examined taking into consideration the directional traffic flow, road capacity, geometric condition of the intersection and urban development along the roads.

Figure 2.1.9 shows a hypothetical analysis on congestion level and vehicle-kilometres of one-way system operation and two-way system operation. Three intersections and three connecting roads are assumed for the analysis. For these three connecting roads, four-lane roads and two-lane roads are assumed and analysed separately. It is assumed that 4,000 passenger cars are entering each intersection and half of those go to the left-side of the intersection and the remaining half go to the right-side of the intersection.

In the case of four-lane roads, the congestion level of connecting roads of one-way system operation is higher than the two-way system operation as vehicles going to the right-side of the intersection have to pass three intersections. The total vehicle-kilometres of one-way system operation is also higher than the two-way system.

On the other hand, the congestion level of the three connecting roads decreases in the case of two-lane roads. The road capacity of the two-way road can be roughly half of the one-way road with one-lane each way. However, it is noted that total vehicle-kilometres are still high for one-way system operations.

[Two-Way Operation]	[One-Way System Operation]
	

Four-lane Roads Condition

Case	**Two-Way operation** (Two lanes each way)	**One-Way System operation** (Four lanes one-way)	**Difference**
Capacity	**4,400pcu/h** (=2,200pcu/h*×4Lane×0.5***)	**4,400pcu/h** (=2,200pcu/h*×4Lane×0.5***)	**±0 pcu/h**
Volume	4,000pcu/Lane	6,000pcu/Lane	+2,000 pcu/Lane
Traveller kilometre	***12,000pcu km*** 〔 2,000pcu×1km×6line 〕	***18,000pcu km*** 〔 2,000pcu×1km×3Line 2,000 pcu×2km×3Line 〕	+6,000 pcu km
Congestion degree (V/C ratio)	***0.9*** (v/c=4,000/4,400)	***1.4*** (v/c=6,000/4,400)	**+0.6** point

Two-lane Roads Condition

Case	**Two-Way operation** (One lanes each way)	**One-Way System operation** (Two lanes one-way)	**Difference**
Capacity	**1,250pcu/h** (=2,500pcu/h**×0.5***)	**2,200pcu/h** (=2,200pcu/h*×2Lane×0.5***)	**+950 pcu/h**
Traffic Volume	4,000pcu	6,000pcu	+2,000 pcu/Lane
Traveller kilometre	***12,000pcu km*** 〔 2,000pcu×1km×6line 〕	***18,000pcu km*** 〔 2,000pcu×1km×3Line 2,000 pcu×2km×3Line 〕	+6,000pcu km
Congestion degree (V/C ratio)	3.2(v/c=4,000/1,250)	***2.7***(v/c=6,000/2,200)	**-0.5** point

Note: Traffic Volume shown in Figure **.
Capacity in Japanese standards: Two lane road (One lane each way) is 2,500pcu per hour*,
Multi-lane road is 2,200 pcu per hour**
Correction value***: Study team is virtual in 0.5 the correction value of the road width, heavy vehicles in the stream and signal phase.

Figure 2.1.9 One-Way System Simulation on Congestion Degree

2.1.3 Traffic surveillance system and Traffic information system

(1) Traffic Monitoring System (CCTV)

There is a CCTV Division which undertakes surveillance for security reasons and detects traffic conditions for traffic management. The CCTV centre is located on the 6th floor of the Central Welfare Building in the traffic police offices. A total of 128 cameras at 27 locations are installed at major intersections. The system started its operation funded by the national budget in March 2009. The system and equipment are made in Singapore.

The traffic police are disseminating traffic information to radio companies based on traffic conditions collected by patrol teams on-site and CCTV cameras. Some other media tools, such as twitter based disseminations, are in use on a voluntary basis.

Currently, these CCTV images have been used for crime prevention and monitoring traffic conditions (congestion, accidents). In the future, it is possible to adapt it to a traffic information providing system (unexpected event detection system, congestion information, etc.) by adapting the image analysis technology.

In addition, possible candidates can be considered for forming a communication network to work with each other and use other information, such as Signal Control of the CMA, by utilising an optical cable network, which will be responsible for communication with CCTV images.

Figure 2.1.10 CCTV Image of area around Maradana

Figure 2.1.11 CCTV Image of area around Kollupitiya

(2) Parking Management

Roadside parking is allowed on roads with "P" marks which are managed by RDA, Western Provincial Council Ministry of Road Development, CMC and local authorities. In case of a violation, there is a fine of Rs. 500. This rate is actually so low that the number of violators tends to increase. In the city area of Colombo, fifteen bicycles and five radio cars are monitoring parking violations. Furthermore, the traffic police are considering the implementation of a driving offence point deduction system as a means to reinforce the penalties against violators. CMC is planning to prepare more road side parking spaces and the RDA plans to have car parking facilities distributed through the CMC area. In addition, private parking businesses have been started and are providing parking spaces.

CHAPTER 3 Current Urban Transport Condition and Issues

3.1 Road Safety

The number injured in traffic accidents has continuously increased in the last 5 years in Western Province. Especially, the number of pedestrians injured and killed in traffic accidents is significant compared to other areas in Sri Lanka. If no action is taken, a much more severe situation will develop in the near future.

To reduce traffic accidents, it is necessary to make an effort to decrease both victims and responsible offenders. Therefore, in this section, recent trends and factors of traffic accidents are analysed and discussed from both the victims and offenders side. And based on the analysis, measures to reduce traffic accidents are suggested in the latter part of this section. The analysis is supported by the traffic accident database which is provided by the traffic police.

3.1.1 Overview of recent trends in Western Province

(1) Number of Accidents and Injured/Fatalities

Figure 3.1.1 shows the number of accidents and injured/fatalities in Western Province. The total number of traffic accidents continuously increased from 2008 to 2012, and the growth was 43 percent in that period in Western province.

The number of fatalities has not changed much for the last seven years. On the other hand, the number of grievously injured persons continuously increased and the increase in the 7 years was 47 percent. Especially, the growth between 2009 and 2012 is remarkable.

With regard to Table 3.1.1, the number of grievously injured per 100,000 population has also increased 41 percent. The number of fatalities per 100,000 registered vehicles has decreased, and that of grievously injured remains roughly flat.

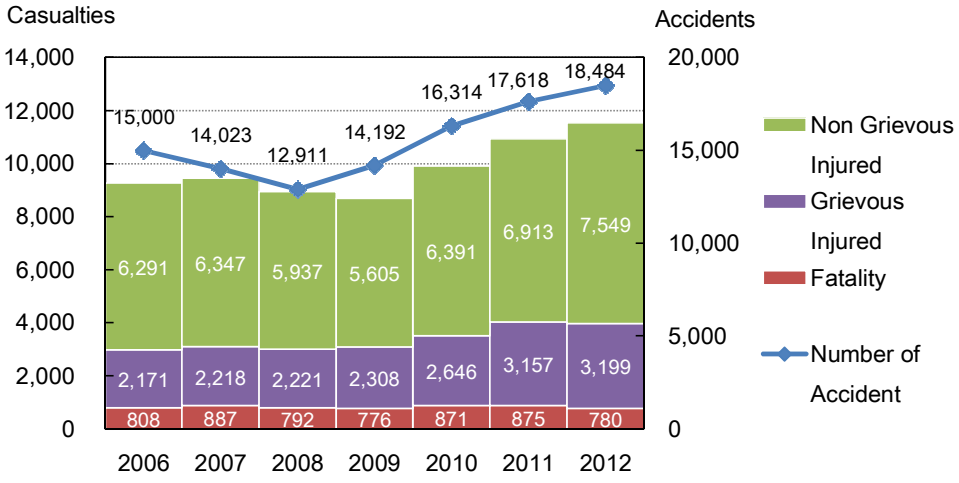


Figure 3.1.1 Number of Accidents and Injured in Western Province

Table 3.1.1 Number of Injured/Fatalities per Population and Registered Vehicles

Western Province						
Year	Population	Fatality per 100,000 population	Grievous Injury per 100,000 population	Registered Vehicles	Fatalities per 100,000 vehicles	Grievous Injury per 100,000 vehicles
2006	5,581,430	14	39	876,109	92	248
2007	5,621,477	16	39	967,022	92	229
2008	5,661,523	14	39	972,787	81	228
2009	5,701,570	14	40	969,720	80	238
2010	5,741,617	15	46	1,075,069	81	246
2011	5,781,663	15	55	1,205,708	73	262
2012	5,821,710	13	55	1,279,616	61	250

Population from 2006 to 2011 is the liner interpolation of Census population in 2002 and 2012.

(2) Number of Fatalities by Transport Mode

Figure 3.1.2 shows the number of fatalities by transport mode. Generally, the most part of the fatalities in traffic accidents are pedestrians and motorcycles/mopeds.

In Western Province, pedestrians have constituted the highest fatality rate for the last 7 years. The second highest group is motorcycles/mopeds and the number has gradually increased. In 2012, there were 780 fatalities and up to 43 percent of fatalities were pedestrians.

Comparing with the whole of Sri Lanka (pedestrian ratio: 31 percent), which is discussed in sub-section 3.1.2, it is clear that the number of pedestrian deaths is significant in Western Province. The number of pedestrian deaths in Western province is almost half of that in all of Sri Lanka, though the other mode is one third in the same value.

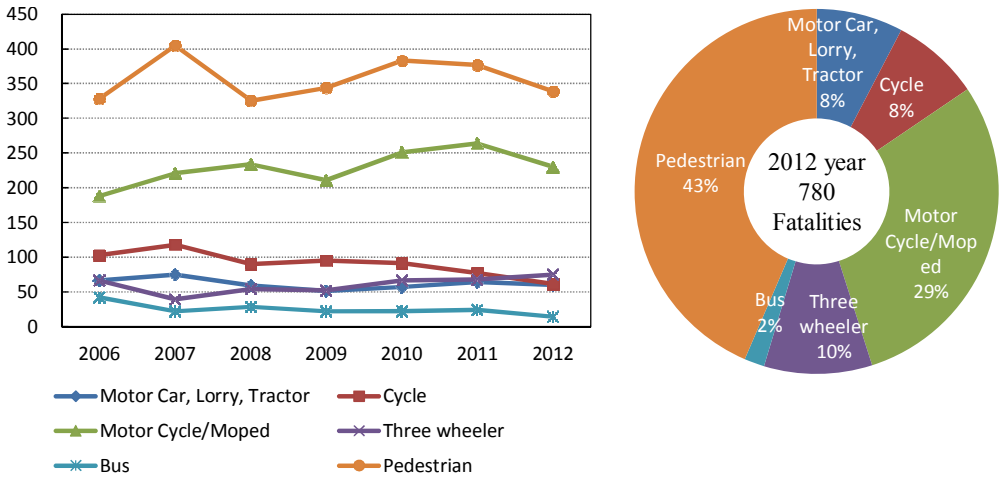


Figure 3.1.2 Fatalities by Transport Mode in Western Province

(3) Number of Grievously Injured by Transport Mode

As shown in Figure 3.1.3, pedestrians and motorcycles/mopeds are remarkable and growing in the number of grievously injured. They combine to more than 70 percent of all grievously injured in 2012. Compared to the values in 2006, grievously injured pedestrians increased 54 percent and motorcycles/mopeds increased 65 percent. Besides, the number of three wheelers also increased 62 percent in the last 7 years.

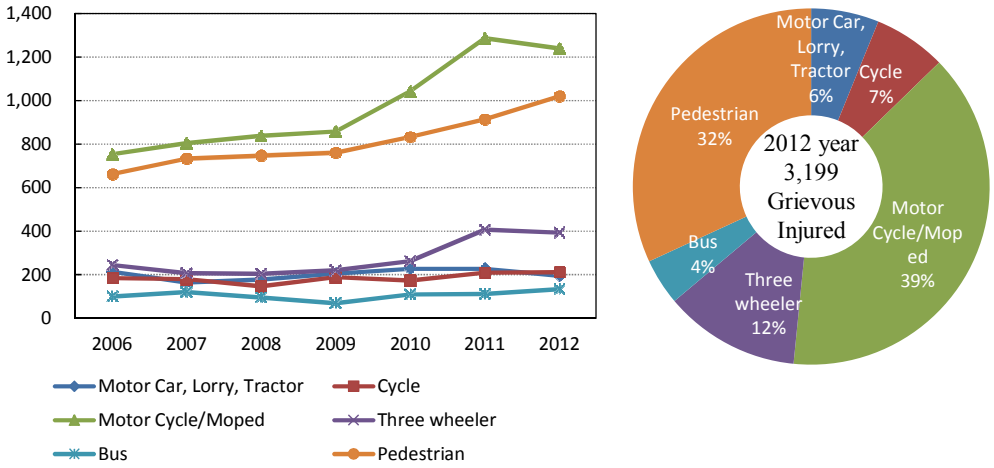


Figure 3.1.3 Grievously Injured by Transport Mode in Western Province

(4) Responsible Offender for Fatal Accidents by Transport Mode

"Responsible for Fatal Accidents" is defined as the driver, rider or pedestrian who is at fault for a fatal accident. Therefore, sometimes the deceased is responsible for the fatal accident. Indeed, 34 percent of the persons responsible for a fatal accident were the fatality.

Figure 3.1.4 shows the offenders in fatal accidents. Motor cars, lorries and tractors amount to 36 percent (the ratio is roughly motor cars 25%: dual purpose vehicles 40%: and lorries 35%). And the number has hovered at around the 350 veh/year level for the last 7 years. Motorcycles/mopeds is the second largest group with 30 percent, and it has been in an increasing trend.

The number of buses involved in fatal accidents has decreased by almost half in the last 7 years. However, as shown in the upper half of Table 3.1.2, the responsible bus driver per registered vehicle is greater than 20 times more than others. Of course, bus drivers are at high risk while they drive long distances. However, the number of responsible per vehicle km for buses is still triple that of all other vehicle types.

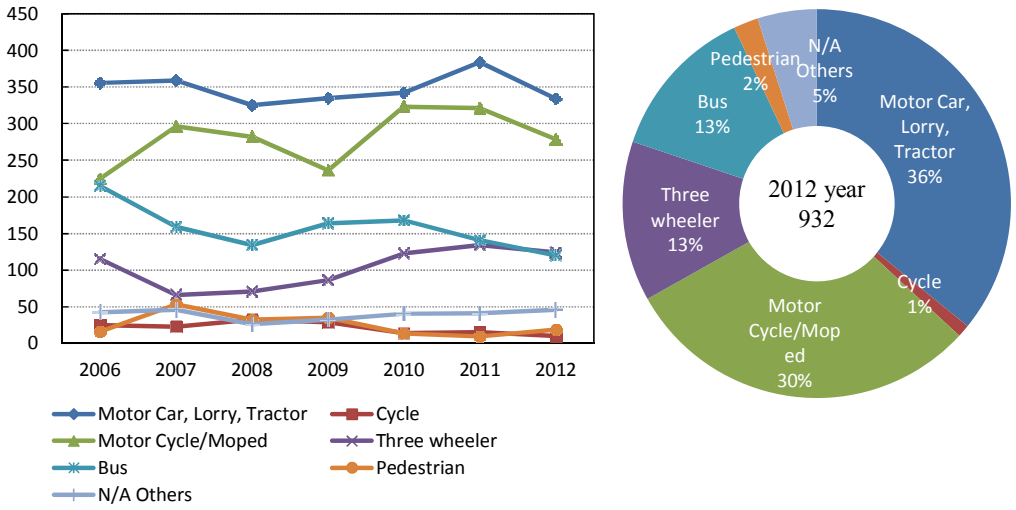


Figure 3.1.4 Responsible for Fatal Accident in Western Province

Table 3.1.2 Responsible by Registered Vehicle and Vehicle Kilometres in Western Province

Year 2011	Registered vehicles	Responsible for Fatal Accidents	Responsible per 1,000 registered vehicles
Omnibuses	7,778	141	18.13
Private Cars	364,197	237	0.65
Goods Transport Vehicles	107,244	147	1.37
Motor Cycles	510,509	321	0.63
Three wheelers	213,177	134	0.63
All vehicle types	1,202,905	980	0.81
Year 2011	Vehicle km Mn.	Responsible for Fatal Accidents	Responsible per Mn. Vehicle km
Private and Public Bus	362	141	0.39
All vehicle types	8,160	1,045	0.13

Sources : Registered vehicles from Divisional Secretariats;
Vehicle km of Private and Public Bus from Central Bank of Sri Lanka, National Transport Commission (http://www.cbsl.gov.lk/pics_n_docs/10_pub/_docs/statistics/other/econ_&_ss_2013_e.pdf) page 124.
Responsible for Fatal Accidents and Vehicle km of all vehicle types from The Study Team

3.1.2 Overview of recent trends in the Whole of Sri Lanka

In the whole of Sri Lanka, the number of pedestrians and motor cycles/mopeds is almost 60 percent of the fatalities. The number of fatalities has decreased from the peak year 2010. However, compared to 2006, the number of pedestrian deaths increased 19 percent and that of motorcycles/mopeds increased 50 percent.

The trends of traffic accidents in the whole of Sri Lanka is shown following, and its tendency is generally similar to that of Western Province.

(1) Number of Accidents and Injured/Fatalities

Figure 3.1.5 shows the number of accidents and injured/fatalities in the whole of Sri Lanka. The total number of traffic accidents continuously increased from 2008 to 2012, and the growth in that period was 41 percent.

The number of fatalities has not changed much for the last seven years. On the other hand, the number of grievously injured persons continuously increased and the increase in the 7 years was 64 percent.

In Table 3.1.3, the number of grievously injured per 100,000 population has also increased by 60 percent. The number of fatalities per 100,000 registered vehicles has decreased, and that of grievously injured remains roughly flat.

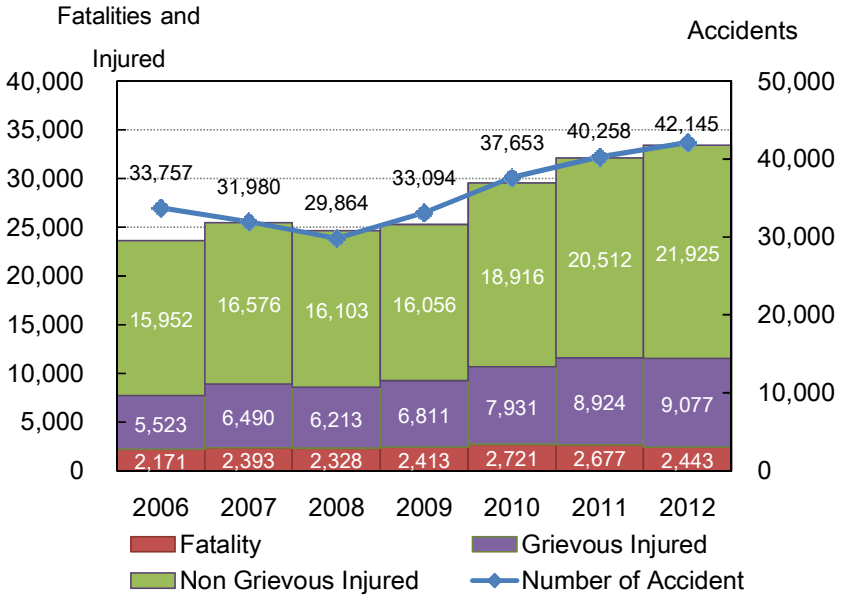


Figure 3.1.5 Number of Accidents and Injured persons in Sri Lanka

Table 3.1.3 Number of Injured/Fatalities by population and registered vehicles in Sri Lanka

Whole of Sri Lanka						
Year	Population	Fatalities per 100,000 population	Grievous Injury per 100,000 population	Registered Vehicles	Fatalities per 100,000 vehicles	Grievous Injury per 100,000 vehicles
2006	19,858,000	11	28	2,827,902	77	195
2007	20,039,000	12	32	3,125,794	77	208
2008	20,217,000	12	31	3,390,993	69	183
2009	20,450,000	12	33	3,595,068	67	189
2010	20,653,000	13	38	3,954,311	69	201
2011	20,869,000	13	43	4,479,732	60	199
2012	20,328,000	12	45	4,877,027	50	186

(2) Number of Fatalities by Transport Mode

Figure 3.1.6 shows the number of fatalities by transport mode. Generally, the most part of the fatalities in traffic accidents are pedestrians and motorcycles/mopeds.

In the whole of Sri Lanka, pedestrians and motorcycle/moped have constituted the highest fatality rate for the last 7 years. In 2012, total fatalities were 2,443 and up to 65 percent of fatalities are pedestrians or motorcycle/moped.

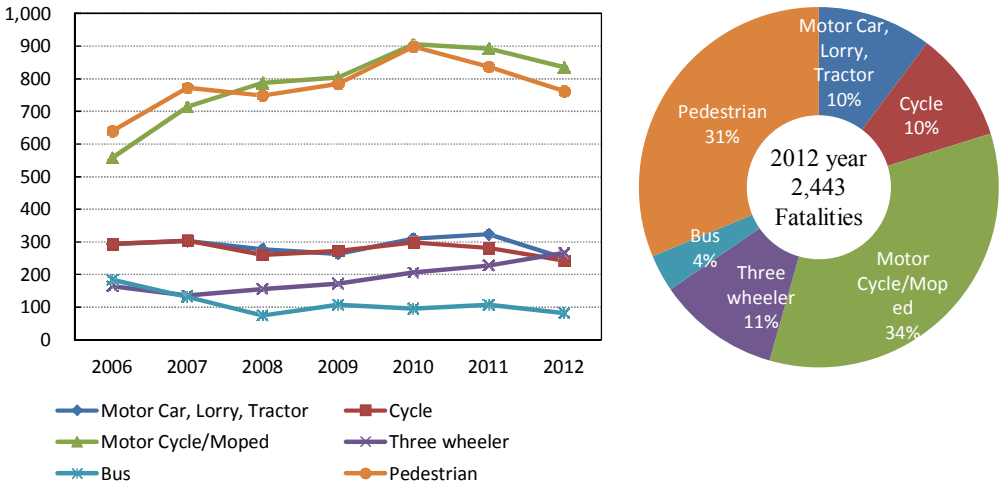


Figure 3.1.6 Fatalities by Transport Mode type in Sri Lanka

(3) Number of Grievously Injured by Transport Mode

As shown in Figure 3.1.7, motorcycles/mopeds are remarkable and growing in the number of grievously injured. Almost half of all grievously injured in 2012 were motorcycle/moped. Compared to the values in 2006, grievously injured motorcycles/mopeds increased 85 percent and that of pedestrians increased 75 percent. Besides, the number of three wheelers also increased 108 percent in the last 7 years.

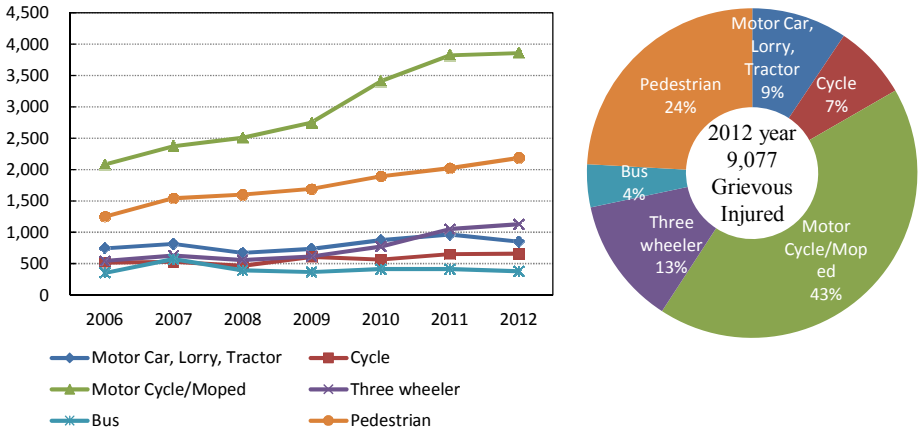


Figure 3.1.7 Grievous Injured by Transport Mode type in Sri Lanka

(4) Responsible Offender for Fatal Accidents by Transport Mode

Figure 3.1.8 shows the offenders in fatal accidents. Motor cars, lorries and tractors amount to 34 percent (the ratio is roughly motor cars 15%: dual purpose vehicles 38%: lorries 41%: and tractors 6 percent). Motorcycles/mopeds are the second largest group with 33 percent, and it has increased 61 percent in the last 7 years.

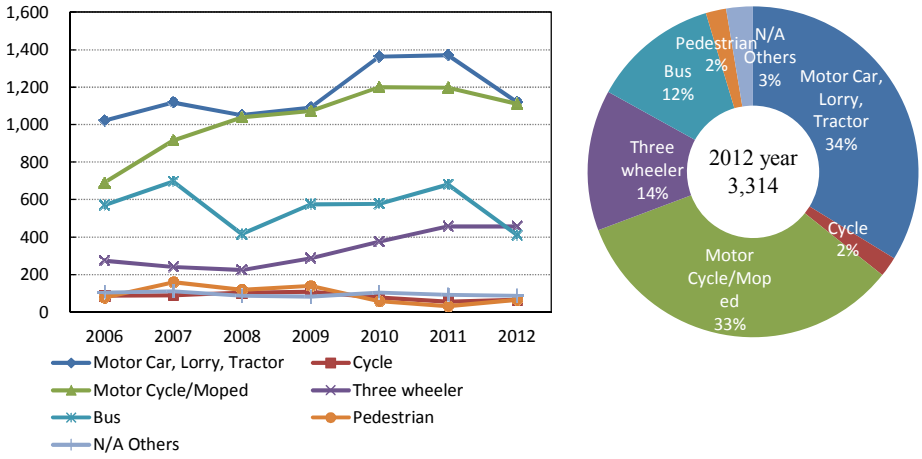


Figure 3.1.8 Responsible for Fatal Accidents by Transport Mode type in Sri Lanka

The number of buses involved in fatal accidents has decreased to almost two thirds the initial level in the last 7 years. However, as shown in the upper half of Table 3.1.2, the responsible bus driver per registered vehicle is greater than 20 times more than others. Of course, bus drivers are at high risk while they drive long distances. However, the number of responsible per vehicle km for buses is still triple that of all other vehicle types.

Table 3.1.4 Responsible by Registered Vehicle and Vehicle Kilometres in Sri Lanka

Year 2011	Registered vehicles	Responsible for Fatal Accidents	Responsible per 1,000 registered vehicles
Omnibuses	14,856	681	45.84
Private Cars	590,047	702	1.19
Goods Transport Vehicles	300,840	668	2.22
Motor Cycles	1,535,683	1,197	0.78
Three wheelers	585,559	456	0.78
Year 2011	Vehicle km Mn.	Responsible for Fatal Accidents	Responsible per Mn. Vehicle km
Bus	1,139	681	0.60
All Others	27,000	3,882	0.14

Sources : Divisional Secretariats, Central Bank of Sri Lanka; National Transport Commission; The Study Team

3.1.3 Comparison with Other Countries

shows the traffic accident data of western pacific and south-east Asian countries (only countries which have population more than a million). The number of road traffic deaths per population and per registered vehicle is comparatively not so high in Sri Lanka, 11th and 10th out of the 16 countries respectively. On the other hand, the ratio of pedestrian deaths out of all traffic accident fatalities is ranked in the top 4. Additionally, the number of pedestrian deaths per population and per registered vehicle is ranked 6th for each.

Table 3.1.5 Comparison with Other Countries

Country	Region	Number of registered vehicles (1,000)	Population (1,000)	Year	Estimated number of road traffic deaths	Estimated road traffic death rate (per 100 000 population)	Estimated road traffic death rate (per 10 000 registered vehicle)	Year	Pedestrian deaths	Number of registered vehicle per 1,000 population	Estimated pedestrian death rate (per 100 000 population)	Estimated pedestrian death rate (per 100 000 registered vehicle)	Pedestrians rate in fatal traffic accident	Year	Gross national income per capita (Atlas method)	Year
Bangladesh	S	1,625	148,692	2010	17,289	11.6	106.4	2010	7,054	11	4.7	0.7	40.8%	2009	700	2010
Republic of Korea	W	19,711	48,184	2010	6,784	14.1	3.4	2010	2,564	409	5.3	2.1	37.8%	2010	19,720	2010
Japan	W	89,871	126,536	2010	6,625	5.2	0.7	2010	2,292	710	1.8	0.8	34.6%	2010	42,050	2010
Sri Lanka	S	4,877	20,328	2012	2,443	12.0	5.0	2012	762	240	3.7	4.9	31.2%	2012	2,260	2010
Singapore	W	946	5,086	2010	259	5.1	2.7	2010	74	186	1.5	19.7	28.5%	2010	39,410	2010
Myanmar	S	2,327	47,963	2011	7,177	15	30.8	2010	1,902	49	4.0	2.1	26.5%	2010	0	2010
Mongolia	W	366	2,756	2010	491	17.8	13.4	2010	123	133	4.5	36.3	25.1%	2010	1,870	2010
China	W	207,061	1,348,932	2010	275,983	20.5	13.3	2010	68,996	154	5.1	0.1	25.0%	2010	4,240	2010
Indonesia	S	72,693	239,871	2010	42,434	17.7	5.8	2010	8,954	303	3.7	0.4	21.1%	2010	2,500	2010
Australia	W	16,061	22,268	2010	1,363	6.1	0.8	2010	174	721	0.8	4.5	12.8%	2010	46,200	2010
Cambodia	W	1,653	14,138	2010	2,431	17.2	14.7	2010	292	117	2.1	7.1	12.0%	2010	750	2010
New Zealand	W	3,227	4,368	2010	398	9.1	1.2	2010	37	739	0.8	22.9	9.3%	2010	29,350	2010
Malaysia	W	20,189	28,401	2010	7,085	25	3.5	2010	645	711	2.3	3.5	9.1%	2010	7,760	2010
India	S	114,952	1,224,614	2009	231,027	18.9	20.1	2010	20,099	94	1.6	0.1	8.7%	2010	1,260	2010
Thailand	S	28,485	69,122	2010	26,312	38.1	9.2	2010	2,052	412	3.0	1.4	7.8%	2010	4,150	2010
Lao People's Democratic Republic	W	1,009	6,201	2010	1,266	20.4	12.5	2010	80	163	1.3	16.1	6.3%	2010	1,010	2010

Source: WHO, *S: South-East Asia, *W: Western Pacific

3.1.4 Detailed Analysis of Fatal Accidents in Western Province

In this sub-section, a detailed analysis of fatalities and those responsible are described. It contributes to understanding by whom, when, where and how the fatal accidents are brought about. Based on the analysis, it becomes possible to suggest adequate countermeasures to improve road safety of the target area.

(1) Fatality by Mode and Age group

Figure 3.1.9 shows fatality by transport mode and age group between 2006 and 2012. Three quarters of pedestrian fatalities concentrate in age group 40 to 80, and it amounts more than 30 percent of all fatalities. More than half motorcycle/moped riders that died in traffic accidents were in the age group between 20 and 40. Young drivers of motor cars, lorries, tractors and elder cyclists also show measurable values. Additionally, 125 children less than 4 years old lost their lives.

The line chart in the graph shows fatalities per 100,000 population by age in 2012. Those 60 years of age and older show a high fatality rate.

Effective Countermeasures: Education for young riders and older pedestrians, improve pedestrian crossings and sidewalks

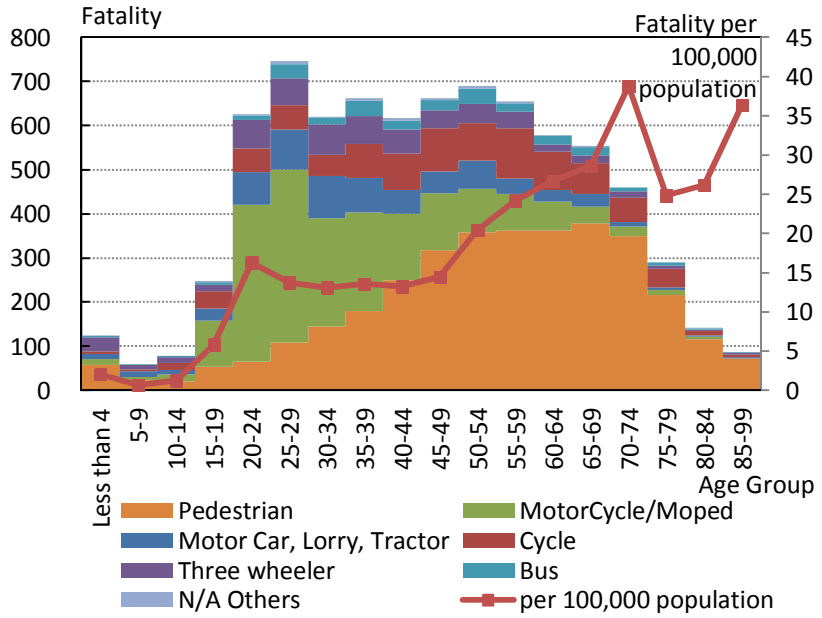


Figure 3.1.9 Fatality by Mode and Age group in Western Province

(2) Individual Responsible by Mode and Age group

Figure 3.1.10 shows the individual responsible for a fatal accident by mode and age group between 2006 and 2012. Generally, young people aged between 20 to 40 show high values. Especially, motor car, lorry, tractor and bus drivers and motorcycle/moped riders between age 20 and 40 cover almost 55 percent.

The number of years from the issue of the first license is shown in Figure 3.1.11. This figure indicates that most fatal accidents are caused by less experienced drivers/riders. The number of individuals that were responsible that did not have a valid license covers 15 percent. Especially, young drivers/riders without valid license are measurable. Almost 40 percent of those responsible had less than 10 years driving experience, and they are concentrated in the age group of 20 to 40. It is required to enforce tighter controls on driving without a license, and to provide a high level of driving education to improve the quality of drivers.

Effective Countermeasures: High level of driving education before issuing license, tight controls on drivers without a license

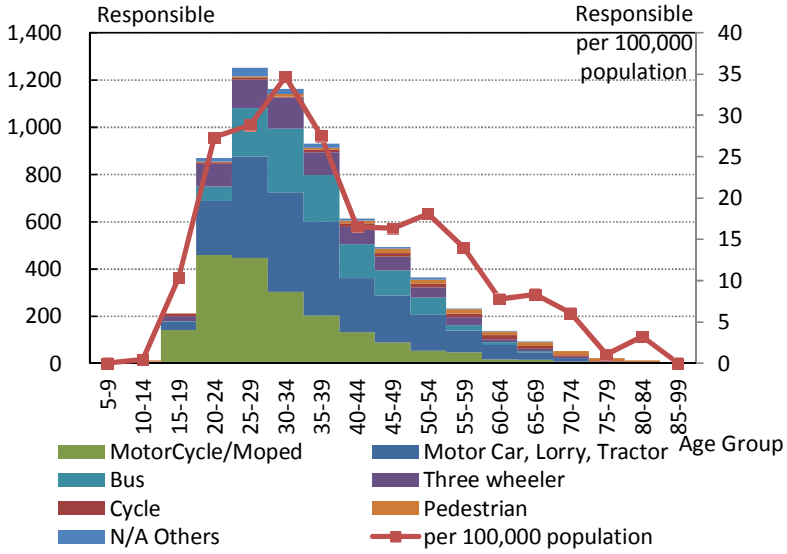


Figure 3.1.10 Individual Responsible by Mode and Age group in Western Province

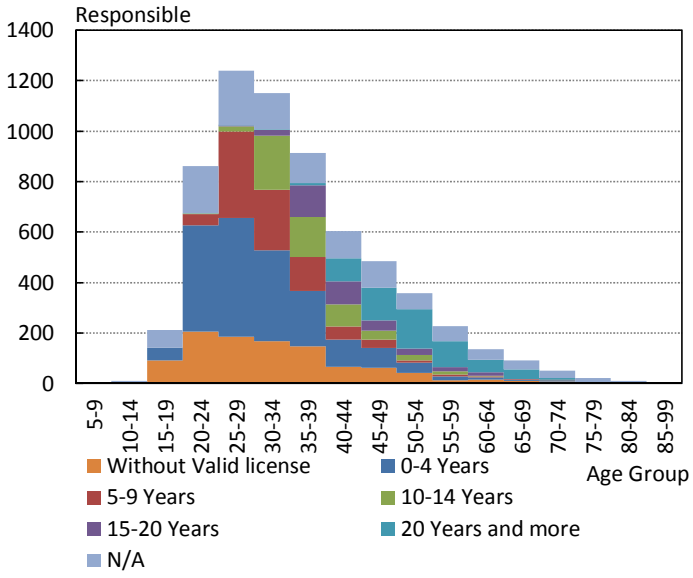


Figure 3.1.11 Individual Responsible by Number of Years since First License and Age Group

(3) Fatal Accidents by Light Condition and Time of day

The peak in Figure 3.1.12 shows the number of fatalities by time of day. As a whole, the number between 16:00 and 23:00 is remarkable, and 44 percent concentrate in this duration. During night time (19:00 – 04:00), 65 percent of fatal accidents happened where there was either no street lighting or improper street lightning. The peak hour of commuting is around 16:00 to 18:00, but the peak hour of fatal accidents is after that, and it is right after sunset. As shown in Figure 3.1.13, pedestrian fatalities between 16:00 and 23:00 are remarkable. That means pedestrians tend to be killed in insufficient light.

Effective Countermeasures: Increase and improve roadside lighting, enforcement of using headlights

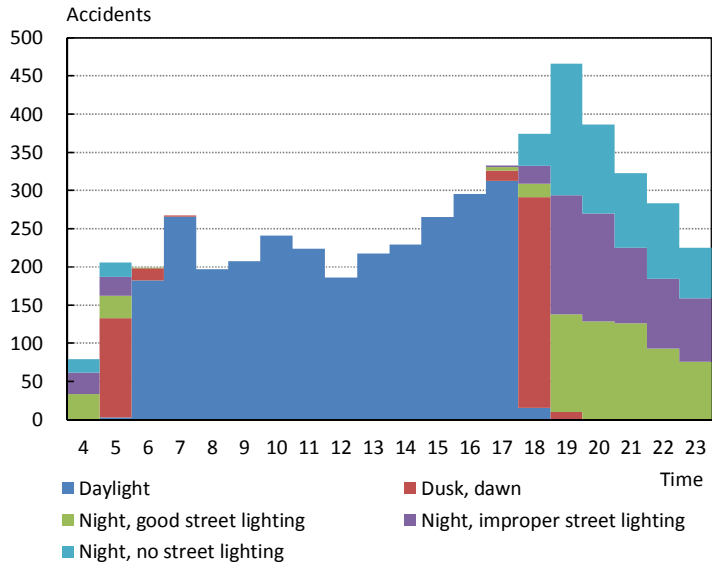


Figure 3.1.12 Fatal Accidents by Time and Light Condition

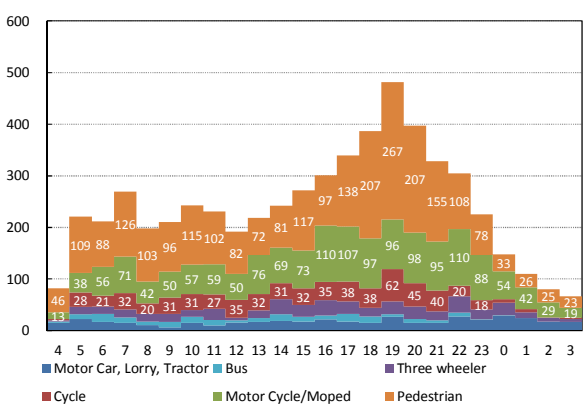


Figure 3.1.13 Fatalities by Mode and Time of day in Western Province

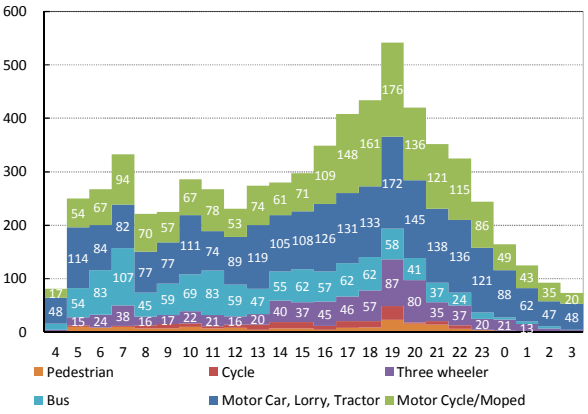


Figure 3.1.14 Individual Responsible for Fatal Accidents by Mode and Time of day in Western Province

(4) Location type and Collision type top 30

Figure 3.1.15 shows location type and human factor of fatal accidents in Western Province between 2006 and 2012. About 70 percent of the accidents happened at a cross roads intersection. The second largest group is T-junctions, and it covers 12 percent. For the human factor, aggressive/negligent driving and speeding covers more than 80 percent of all factors.

Detailed collision types are shown in Table 3.1.6. The collision types are categorised into 88 types in the original database, but only the top 30 are shown here. Cells shaded with blue colour means pedestrian related accidents, and 12 in the top 30 types are related to pedestrians. Most pedestrians are killed while crossing a road (no. 1, 3,6,8,12,14, etc.), and no.1 and 3 amount to more than 1,000.

Other than pedestrians, "Other head on crash", "In conjunction with overtaking" and "Rear-end crash" are remarkable. They are related to aggressive/negligent driving and speeding in Figure 3.1.15. On main corridors, even when there is only one lane each way, drivers try to overtake others by using the opposite lane. That could be one reason why "Other head on crash" and "In conjunction with overtaking" shows such a large value.

Effective countermeasures: improvement of pedestrian crossings and sidewalks, Traffic lights, Centre Medians, Development of fast lane and no-passing zone, Education, Setup speed traps

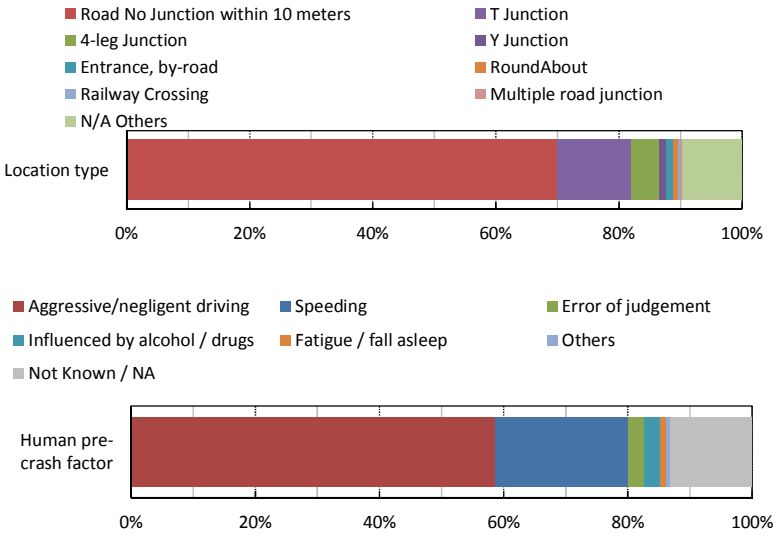


Figure 3.1.15 Location type and Crash type of Fatal Accidents

Table 3.1.6 Detailed Collision type of Fatal Accidents Top 30

	Description	Fatality	
1	With pedestrian entering the road section from the left sidewalk, shoulder etc.	668	11.5%
2	Other head on crash	630	10.9%
3	With pedestrian entering the road section from the right sidewalk, shoulder etc.	369	6.4%
4	In conjunction with overtaking	306	5.3%
5	Rear-end crash hitting a vehicle in position for going straight ahead	304	5.3%
6	With pedestrian staying on the road	255	4.4%
7	Other crashes with pedestrian	237	4.1%
8	With pedestrian entering the road from behind parked car to the left	209	3.6%
9	Crash between cyclist and motor vehicle both going straight ahead in the same directions on the same road without turning off	184	3.2%
10	With pedestrian walking on the left hand side of the road	156	2.7%
11	Vehicle travelling straight ahead leaving the road to the left	148	2.6%
12	With pedestrian entering the road from the left prior to an intersection	143	2.5%
13	Vehicles intersecting without turning off	100	1.7%
14	With pedestrian entering the road from behind parked car to the right	100	1.7%
15	Other crashes with fixed object	100	1.7%
16	Other approaching crashes	97	1.7%
17	Crash between cyclist and motor vehicle going straight ahead in opposite directions on the same road without turning off	92	1.6%
18	Other crashes with cyclists	77	1.3%
19	Vehicle travelling straight ahead leaving the road to the right	76	1.3%
20	With pedestrian entering the road from the left after an intersection	75	1.3%
21	Vehicle turning over and remaining on the road	73	1.3%
22	With passenger falling off vehicle	71	1.2%
23	Overtaking on the right	67	1.2%
24	With pedestrian entering the road from the right prior to an intersection	58	1.0%
25	With pedestrian entering the road from the right after an intersection	55	1.0%
26	With pedestrian walking on the right hand side of the road	54	0.9%
27	Other single crashes	52	0.9%
28	Crash between cyclist and motor vehicle both going in the same direction on the same road and at least one of them turning off in a T, Y, + junction or roundabout	51	0.9%
29	Between vehicle and train	47	0.8%
30	Turning to the right ahead of vehicle going straight ahead in the opposite direction	45	0.8%
	Abbreviations		
	Total	**5789**	

(5) Protection and Injury Severity

The left hand side of Figure 3.1.16 shows the relation between safety belts and injury severity. The number in the figure represents drivers who were injured in traffic accidents. The figure shows safety belts slightly decreased the rate of fatalities and grievous injured in the traffic accidents. The right hand side of Figure 3.1.16 shows the usage rate of safety belts in drivers injured in traffic accidents. The percentage of drivers who wore safety belts when they had accidents has doubled in the last 7 years.

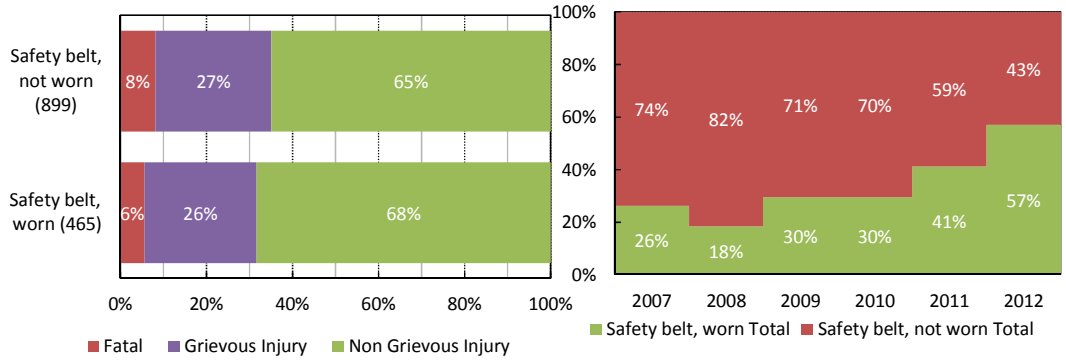


Figure 3.1.16 Relation between Safety belt and Injury Severity and its Usage rate

The left hand side of Figure 3.1.17shows the relation between helmets and injury severity of motorbike riders. The number in the figure represents riders who were injured in traffic accidents. As shown in the figure, wearing helmets decreased the rate of fatalities by 10 percent. The right hand side of Figure 3.1.17 shows the usage rate of helmets by riders injured in traffic accidents. The percentage of wearing helmets has hovered around 90 percent.

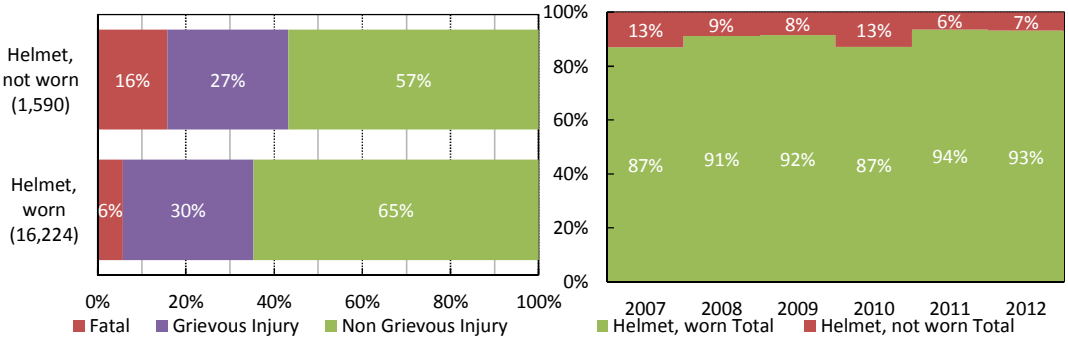


Figure 3.1.17 Relation between Helmets and Injury Severity and its Usage rate

3.1.5 Road Safety for Pedestrians

Figure 3.1.18 shows locations of pedestrian fatal accidents in Western Province in 2012. The heat map is displayed using a kernel density function with radius parameter of 2.5 km.

The accident location points are concentrated around Colombo, Ja-Ela, Wattala, Dehiwala and

Panadura. Especially, 24 percent of the pedestrian fatal accidents are focused in the circle with a radius of 5 km around Colombo, even though the area of the circle is only 2 percent of the area of Western Province.

Locations of accidents differ according to area. For example, in suburban areas of Colombo and on the road to Negombo, "Hit on road without sidewalk" is significant. "Beyond 50m from pedestrian crossing" is distributed evenly across the north half of Western Province, especially near junctions or turns.

As shown in the graph, more than half of the accidents are during crossing. In many divisions, "Beyond 50m from pedestrian crossing" is the highest factor. In Colombo, Kelaniya and Mt.Lavinia, "Within 50m from Pedestrian Crossing" and "On Pedestrian Crossing" shows a measurable value. In Gampaha, Kalutara, Kelaniya and Negombo, fatal accidents which seemed to be caused by lack of a sidewalk cover 20 to 30 percent. In Colombo, more than 10 percent of accidents occurred under the situation that a pedestrian was walking outside of a sidewalk even though there was sidewalk.

Effective countermeasures: improvement of pedestrian crossings and sidewalks in the appropriate locations, installation of road traffic signs warning of pedestrian crossings, installation of traffic lights at intersections in the city area

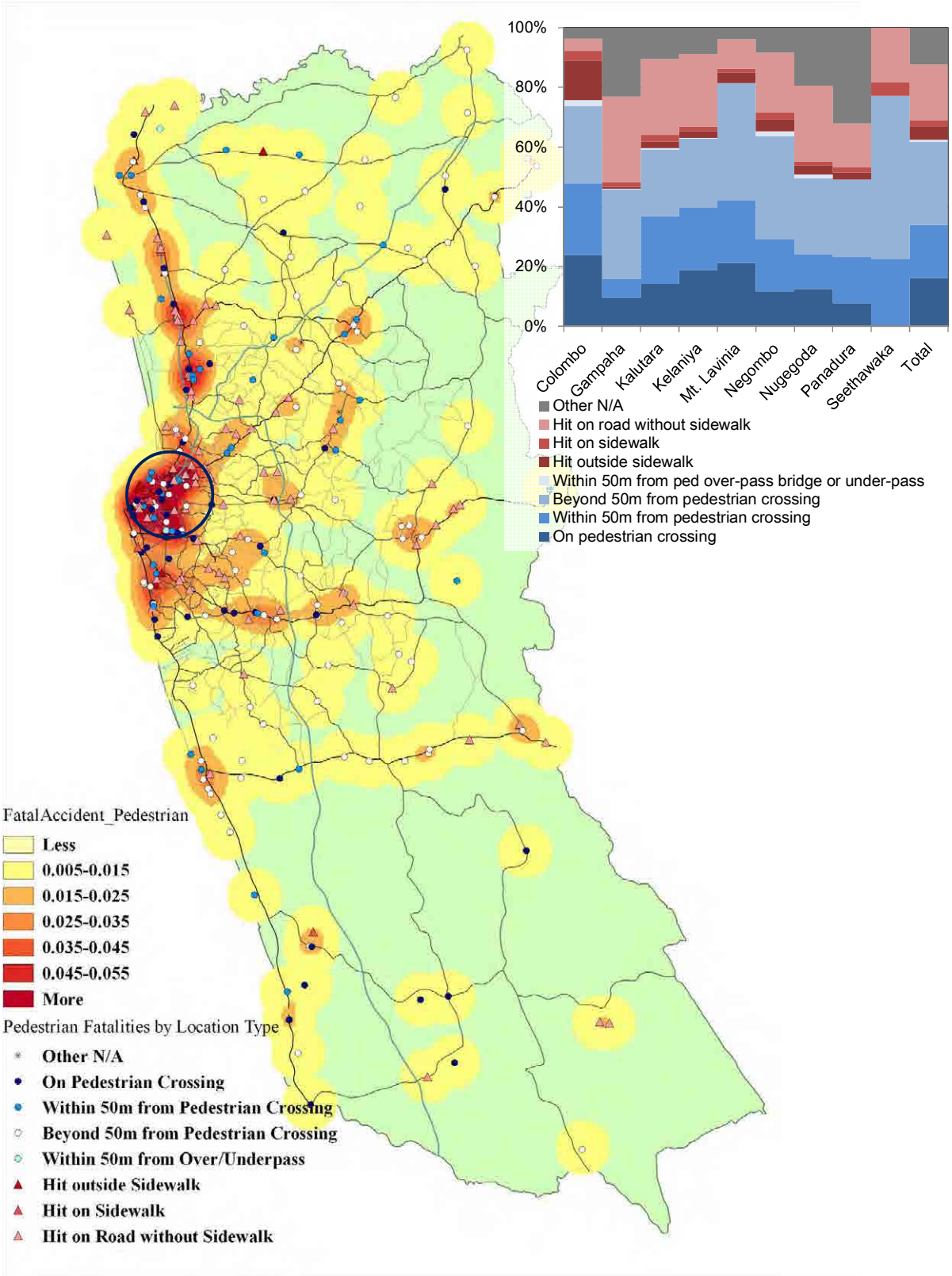


Figure 3.1.18 Location and Heat map of Pedestrian Fatal Accidents in Western Province

3.1.6 Summary of Countermeasures

Based on the above mentioned analysis, countermeasures for traffic accidents in Western Province are proposed in Table 3.1.7.

Table 3.1.7 Countermeasures for Traffic Accidents in Western Province

Category	Objective	Countermeasure
Engineering	Decrease pedestrian accidents on roadside	Improvement of sidewalks
		Guardrails
	Decrease pedestrian accidents when they are crossing a road	Installation of pedestrian crossings
		Traffic light at intersection and pedestrian crossing
		Installation of road traffic signs warning of a pedestrian crossing
	Decrease head on accidents	Installation of Centre Median
	Decrease accidents during overtaking	Introducing Fast lane
		Introducing No-passing zone
	Decrease accidents of motorcycle/bicycle	Installation of motorcycle/bicycle lanes
	Decrease accidents during night time	Increase and improve roadside lights
		Encourage using reflective material
System	Improve the skill of the drivers	Tight controls on drivers without a license
		Improve education before issuing driver's license
		Tightening driver's license examination
	Decrease accidents caused by over speeding	Setup speed traps
	Smoothing traffic flow and reduce blind spots	Prohibit roadside parking
Education	Improve traffic manner of riders and pedestrians	Education for young riders and older pedestrians
		Road safety education in school
	Improve the skill of the drivers	High level of driving education before issuing license
		Education for public transport drivers (Bus, Three wheeler)

CHAPTER 4 Travel Speed Survey

4.1 Introduction

4.1.1 Survey Objectives

The Japan International Cooperation Agency (JICA) and the Ministry of Transport of Sri Lanka agreed to conduct the "Urban Transport System Development Project for Colombo Metropolitan Region and Suburbs" (hereinafter referred to as "the Project") in view to find immediate, short, and long term viable solutions for the transport issues in Colombo Metropolitan Area and the Suburbs in May 2012.

Travel speed is fundamental information for analysing the conditions in the region and this was utilised in formulating the transport master plan of the Colombo Metropolitan Region and Suburbs. In order to identify congestion bottlenecks and their causes the Travel Speed Survey was conducted by utilizing vehicles equipped with a Global Positioning System (GPS) and General Packet Radio Service (GPRS).

4.1.2 Survey Implementation Body

The field survey and data processing were sub-contracted to Geoinformatics International (Private) Limited (hereinafter referred to as "the Sub-consultant") under supervision of Oriental Consultants Co., Ltd. (hereinafter referred to as "the Consultant"), a consulting firm for the Project. The main business of the Sub-Consultant is to provide technological services using geographical information, remotely sensed data and information technology for vehicle tracking and fleet management. Detailed data analysis has been carried out by the Consultant.

4.1.3 Survey Area and Survey Network

The survey area generally covers major arterial roads in the Colombo Metropolitan Area defined in the Main Report. Maps of the surveyed roads are summarised in Figure 4.1.1 and Figure 4.1.2.

4.1.4 Survey Duration

The field survey was conducted for 8 months between January 2013 and August 2013. After the field survey, the data was processed and analysed from February 2013 to February 2014.

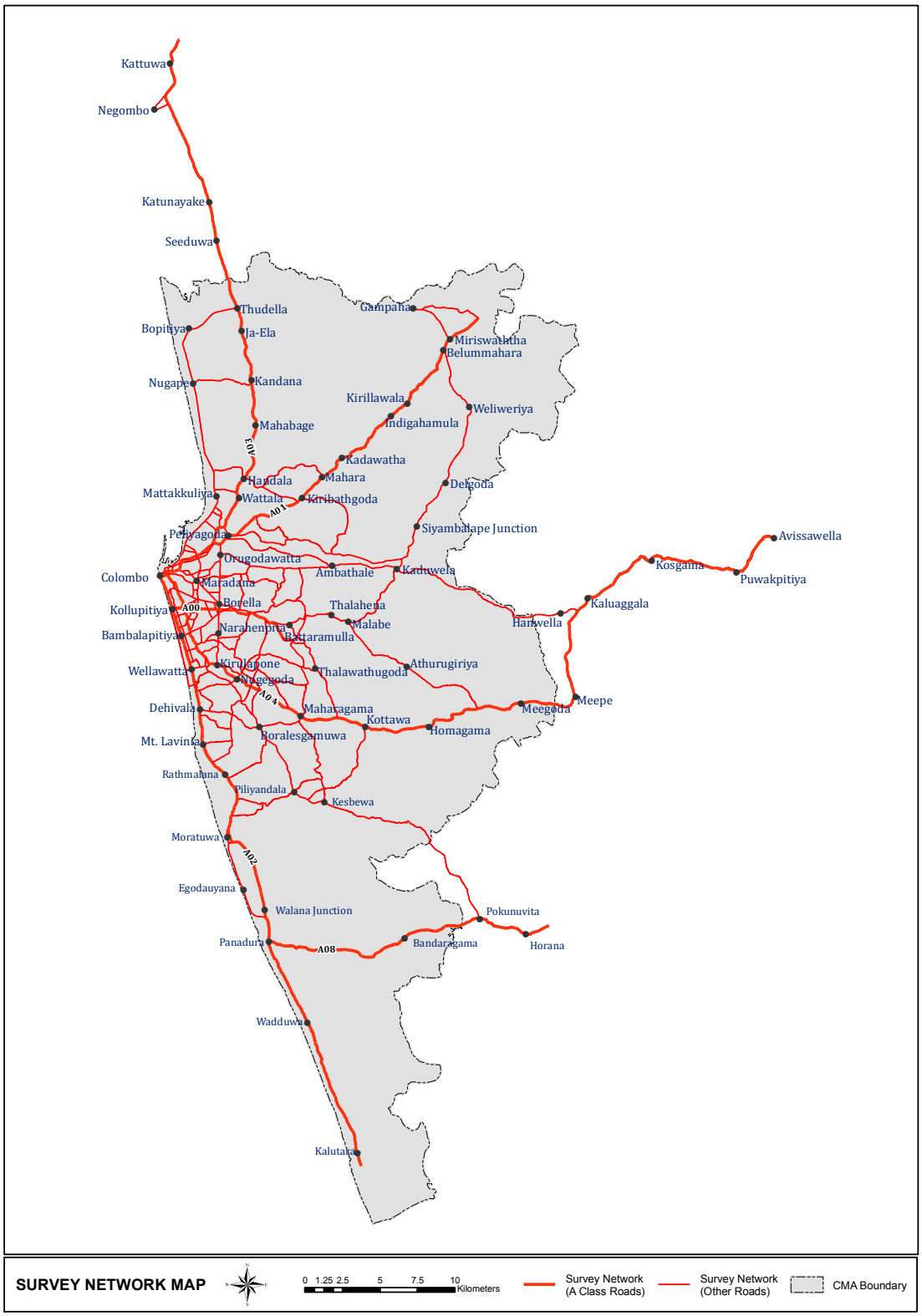


Figure 4.1.1 Whole Survey Network Map

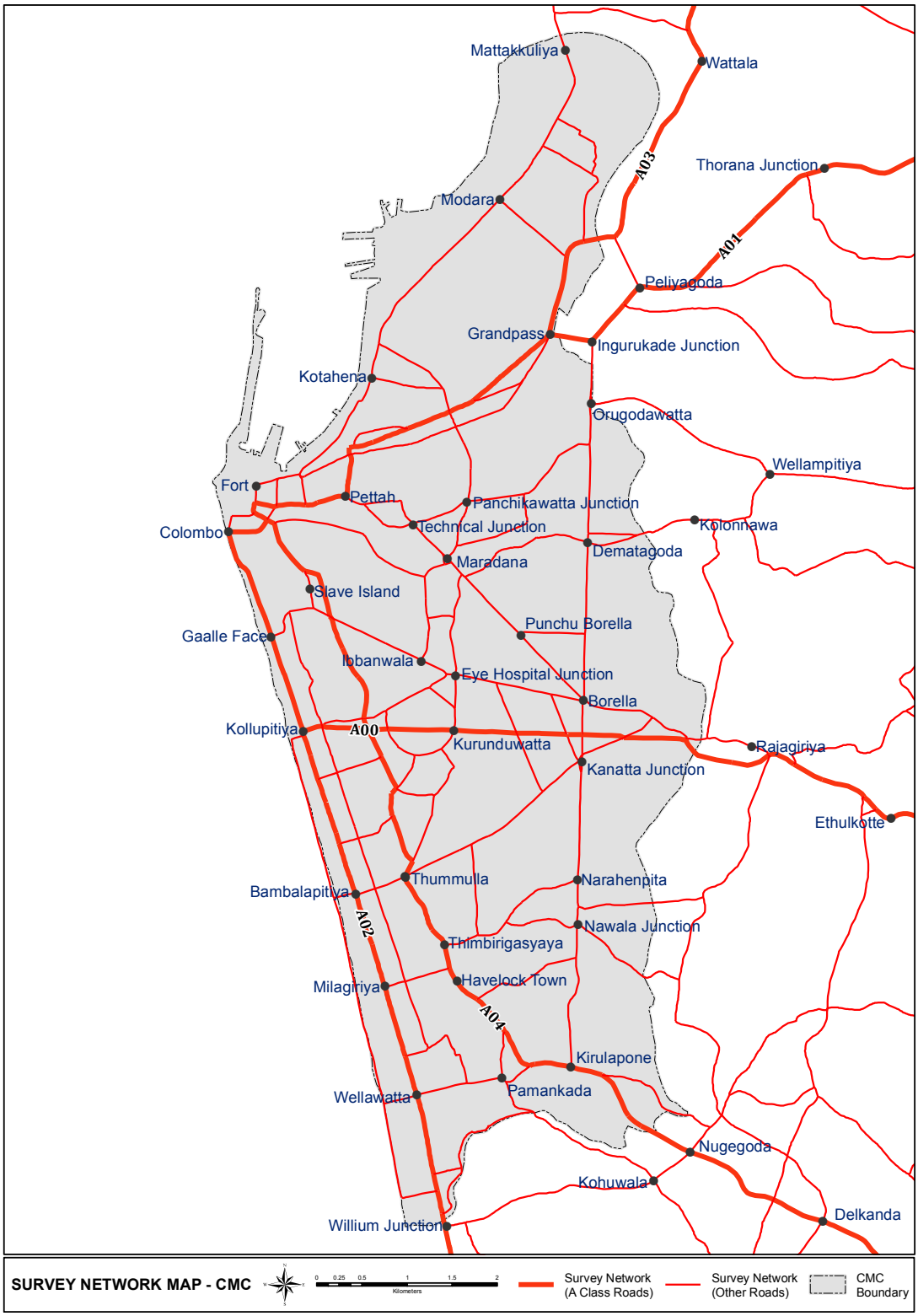


Figure 4.1.2 Survey Network Map around Colombo Municipal Council

4.2 Field Survey

4.2.1 Field Survey Methodology

The survey was conducted with a floating vehicle method to obtain the average vehicle speed on selected roads. The selected roads in the survey areas are separated into sections by major intersections (Each section is shorter than 1km). The positional data of the Survey vehicles is collected with a GPS device at 10 second intervals and the data is submitted to the server through GPRS.

4.2.2 Survey Vehicles and Sample Size

A total of 198 vehicles were used for the survey. Categories of the vehicles are as follows.

Table 4.2.1 Number of Survey Vehicles and Total Survey Hours

Vehicle Category	Number of Vehicles	Total Survey Hours
Car	61	16,160
Van	40	12,000
Crew Cab	12	4,103
Double Cab	13	1,345
Lorry	43	4,893
Bowser	16	3,913
Prime Mover	10	268
Bus	2	180
Motor Bicycle	1	150
Total	198	43,013

Total sample size during the survey period by sections is shown in the following figures.

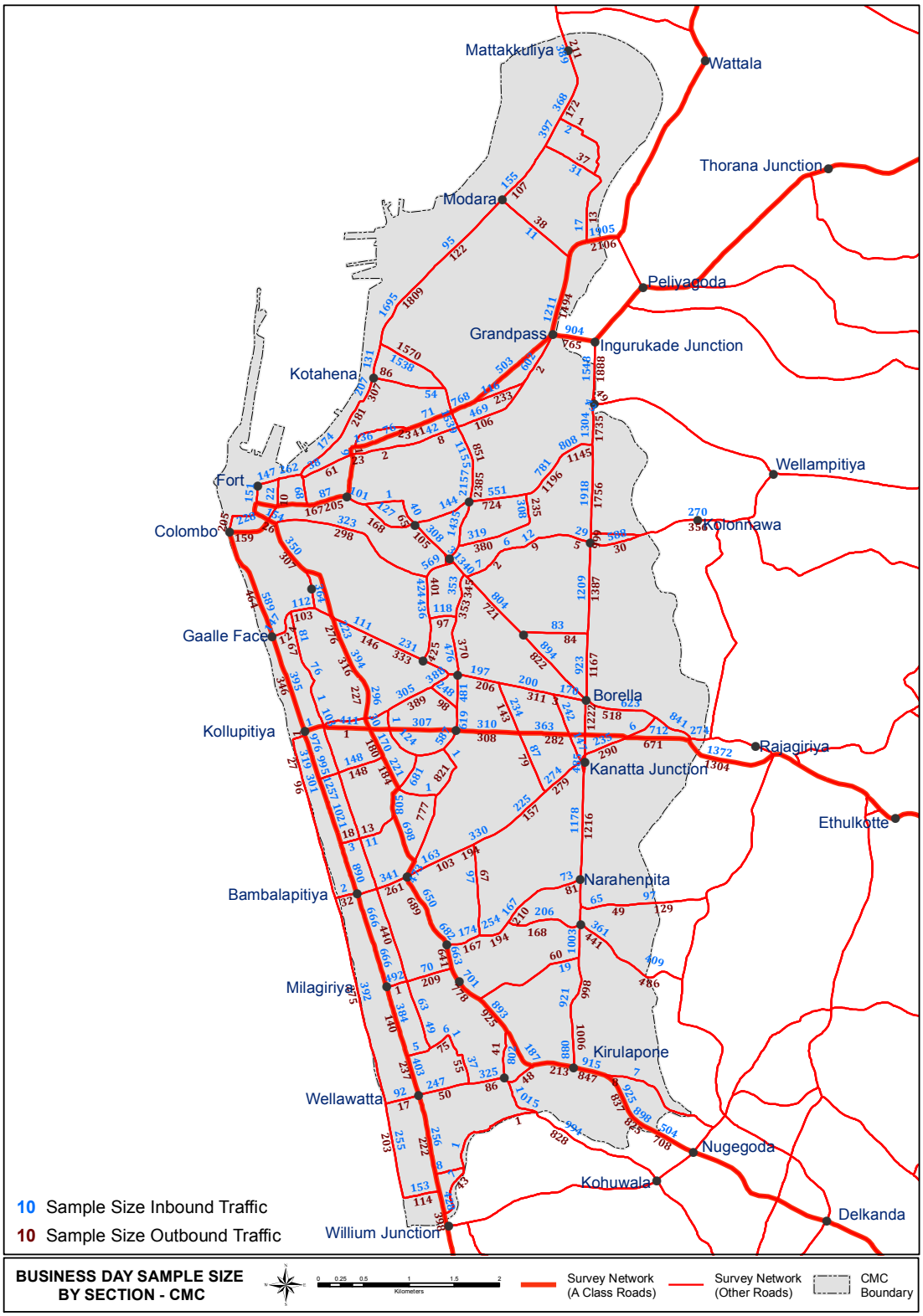


Figure 4.2.1 Business Day Sample Size by Section in CMC

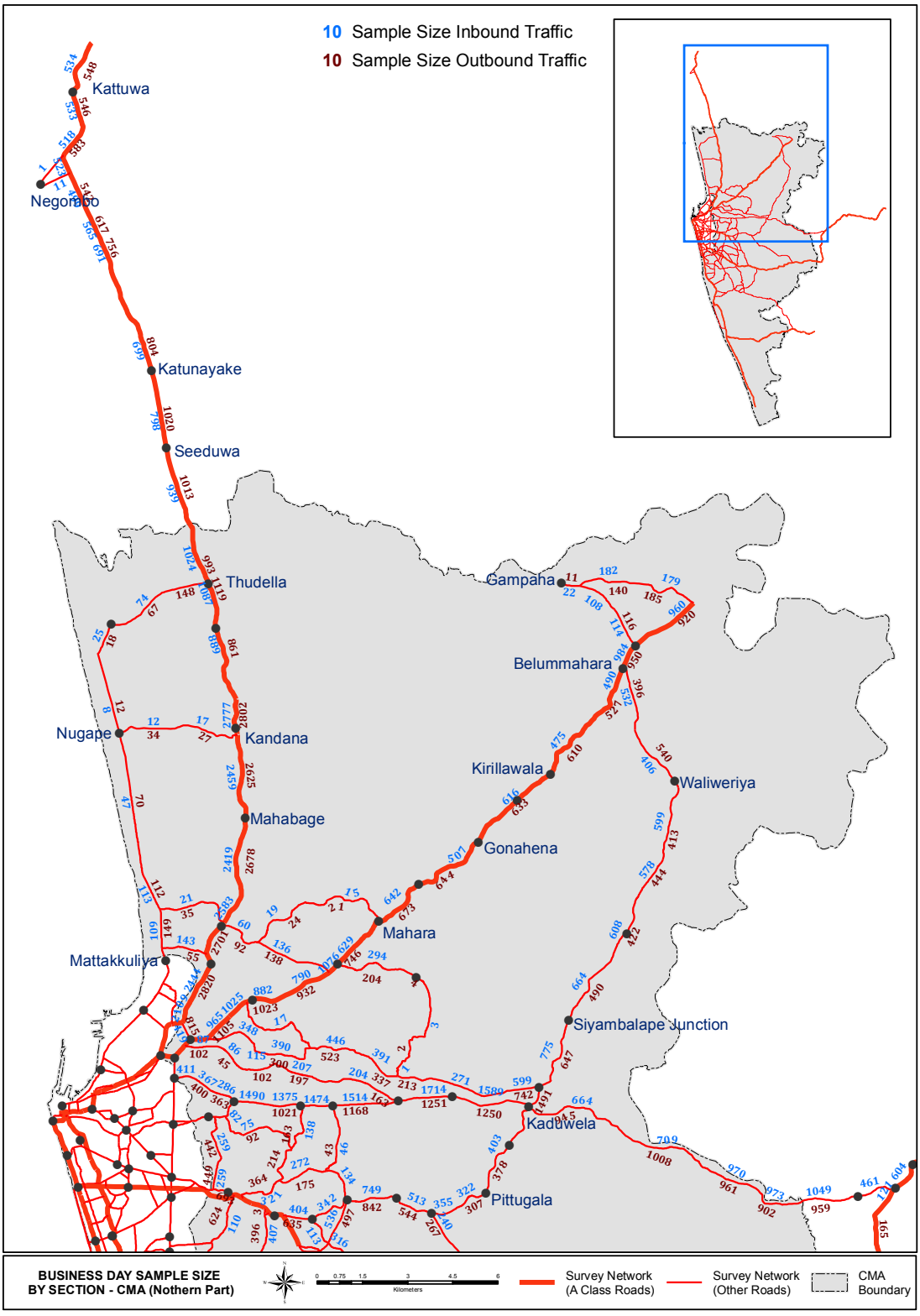


Figure 4.2.2 Business Day Sample Size by Section in the Northern Part of CMA

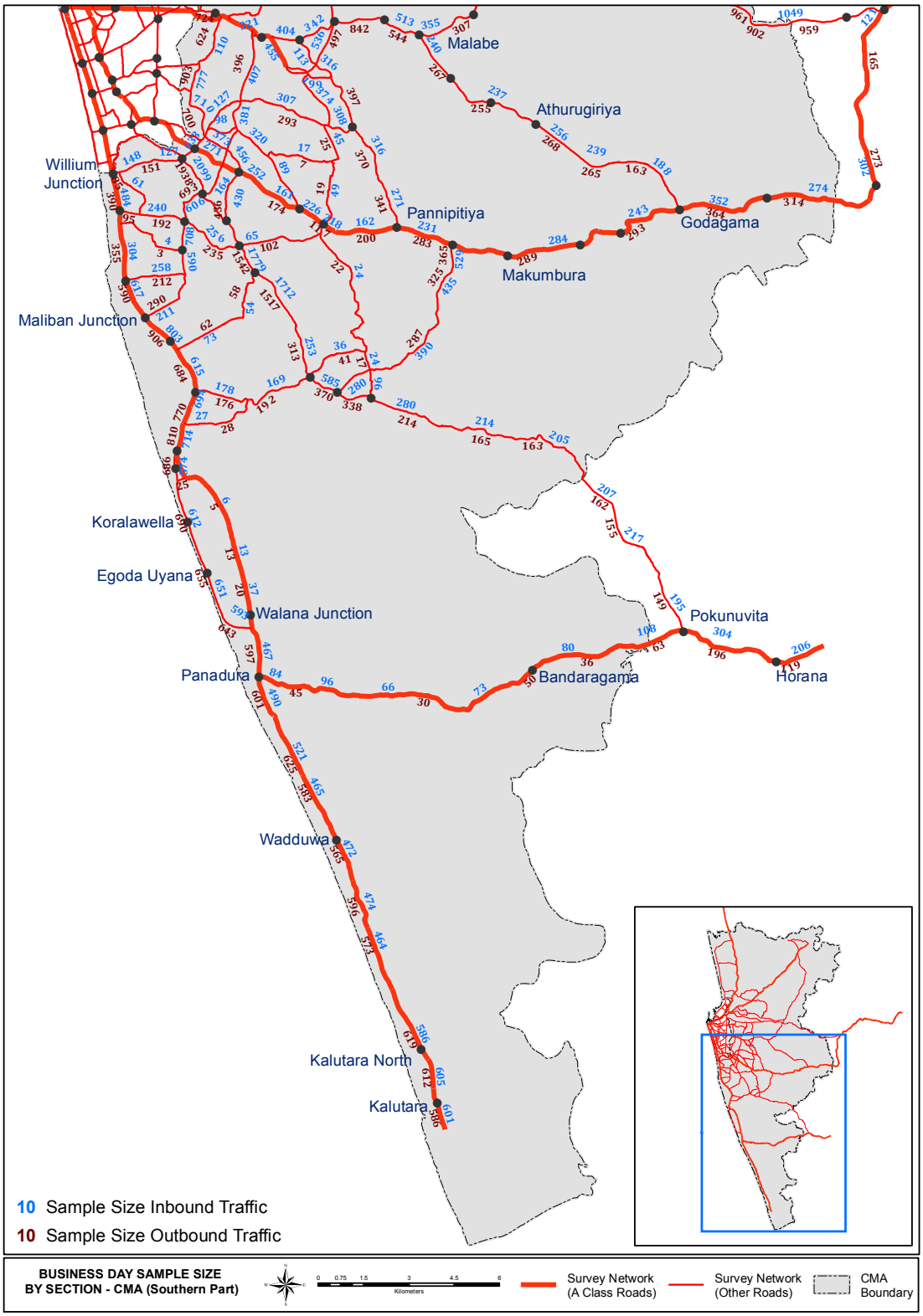


Figure 4.2.3 Business Day Sample Size by Section in the Southern Part of CMA

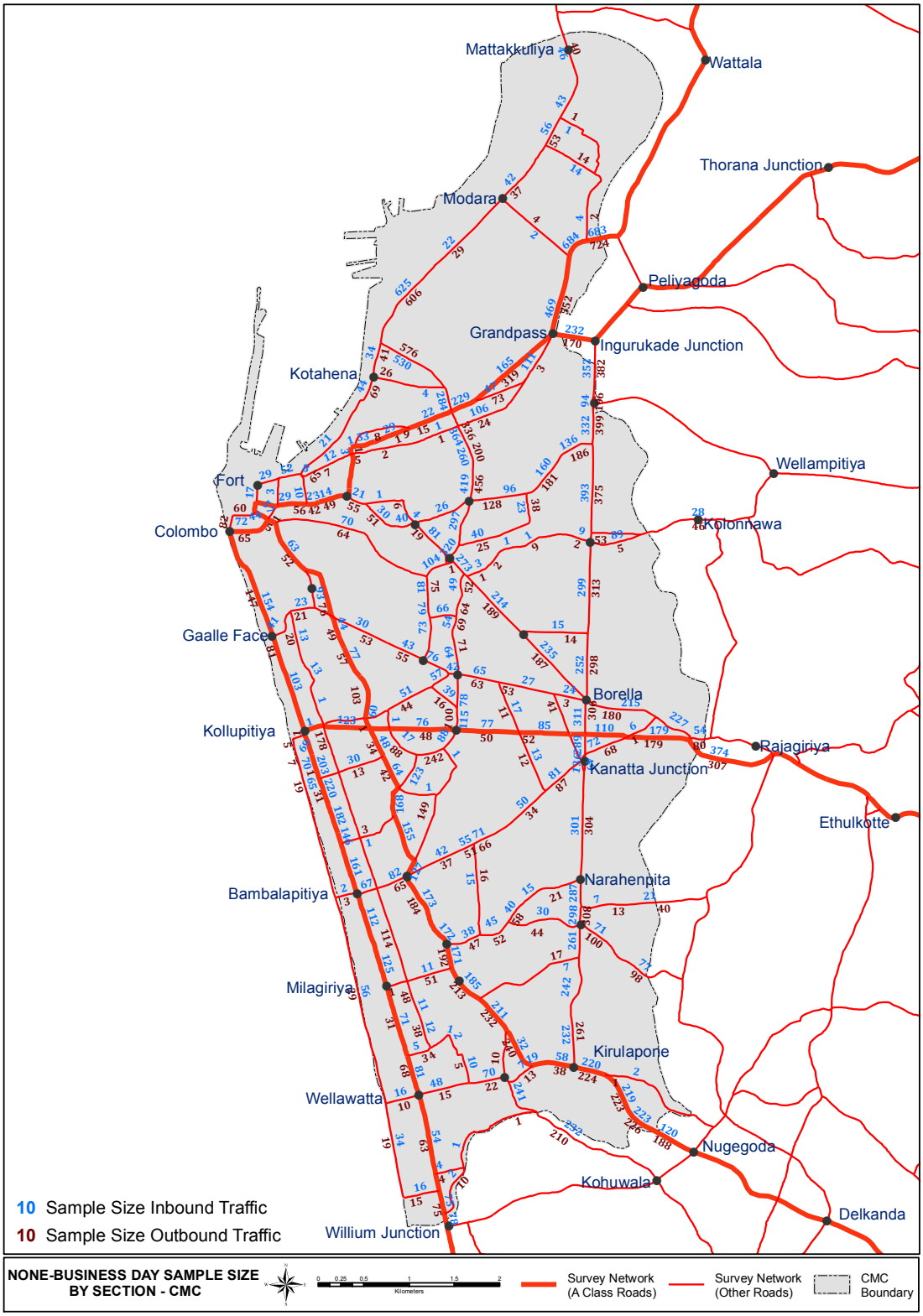


Figure 4.2.4 Non-Business Day Sample Size by Section in CMC

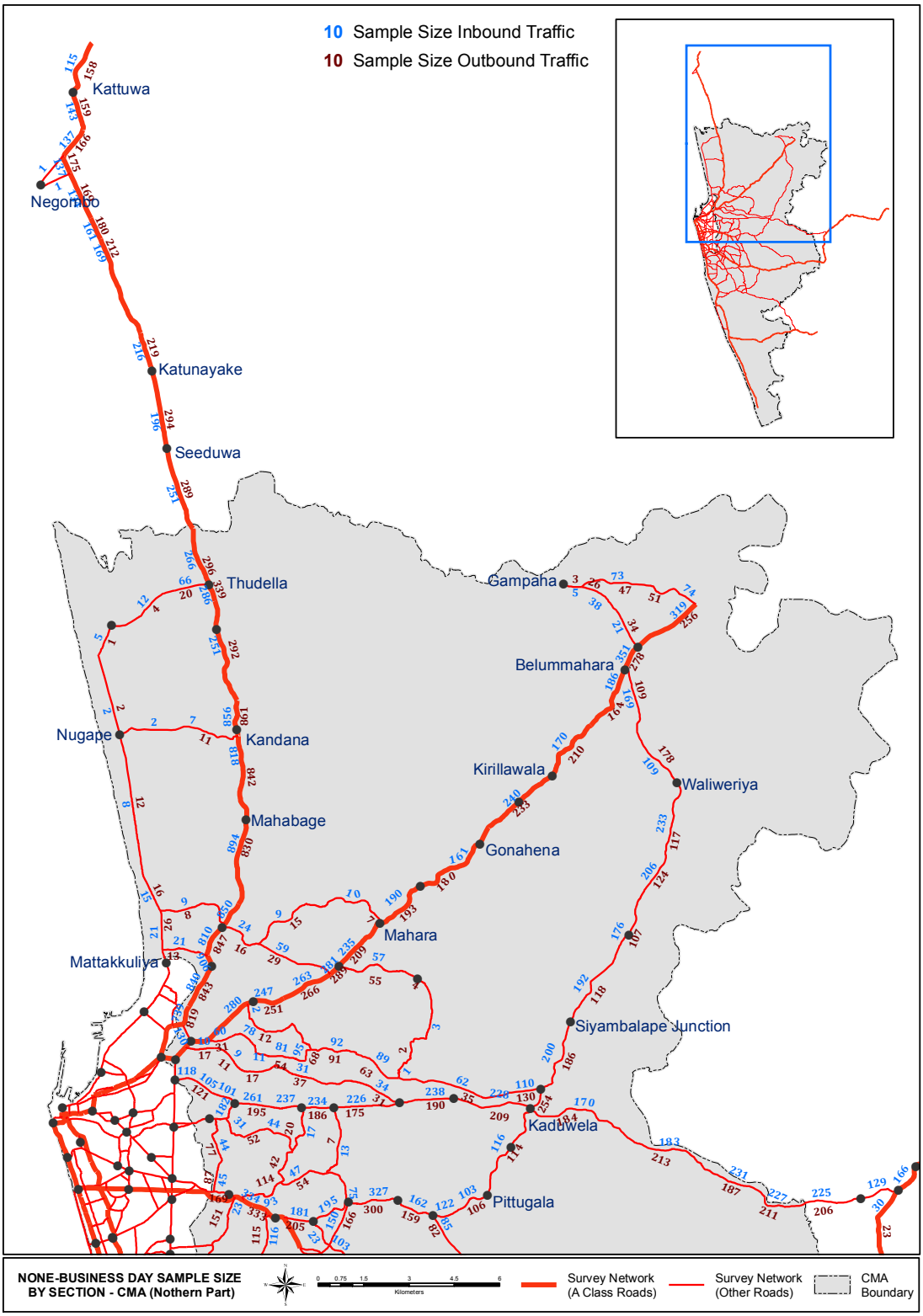


Figure 4.2.5 Non-Business Day Sample Size by Section in the Northern Part of CMA

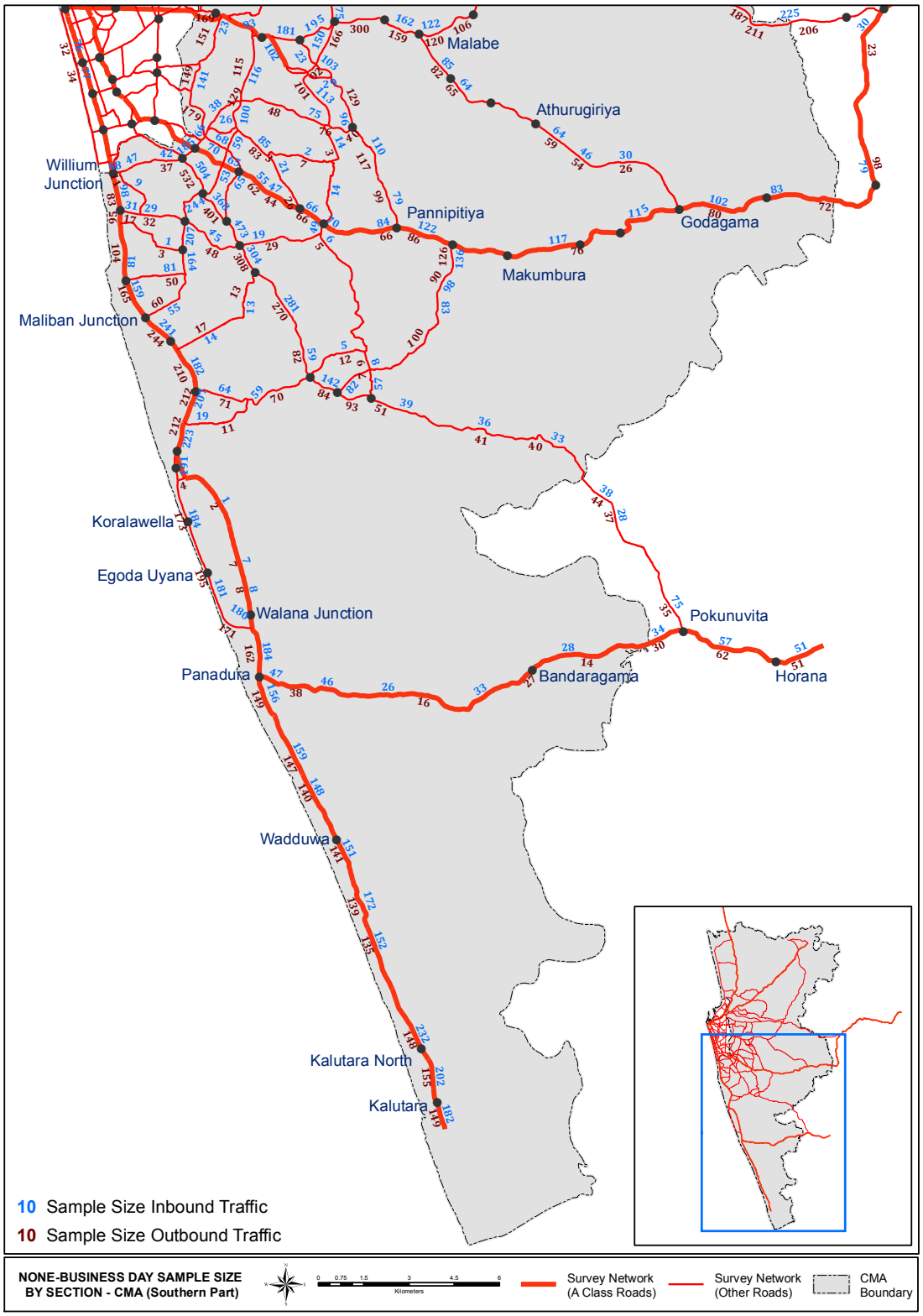


Figure 4.2.6 Non-Business Day Sample Size by Section in the Southern Part of CMA

4.3 Data Analysis

4.3.1 Data Analysis Methodology

(1) Basic Survey Methodology

The Sub-Consultant shall employ a moving observer method by utilizing floating car strategy to observe the average vehicular speed on selected road sections. The roads of the Survey Area (described in the following section) shall be separated into road sections by major intersections. Each road section shall be shorter than 1km. Road sections shall be determined by the Consultant after the contract. Vehicles equipped with a GPS device shall store positional data at 10 second or less intervals. The average travel speed of each road section shall be calculated by the following equation. Travel speed data of the GPS devise shall not be used to estimate travel speed.

$V_a = L_a / (T_{ae} - T_{as})$

Where; V_a: Average travel speed of road section *a*

T_{as}: Time at entering point of road section *a*

T_{ae}: Time at exit point of road section *a*

L_a: Length of Road Section *a*

4.3.2 Business Day Travel Speed

(1) Morning Peak

The three hour period from 6.00 am to 9.00 am was taken as morning peak period in a business day. The inflow travel speed is observed to be less than 20 km/h at many locations inside the CMC, and in the following road segments outside the CMC.

- A01 road from Kiribathgoda to Peliyagoda
- A02 road from Panadura to Wellawatta (except some small segments in Ratmalana to Mt. Lavenia and Rawatawatta to Katubedda)
- B84 road Miriswatta Junction to Piliyandal Junction, Bokundara to Borelasgamuwa, Papiliyana to Pamankada.
- A04 road Kottawa to Havelock Town (except some small segments in Navinna to Delkanda and Pannipitiya to Maharagama).
- A 00 road Rajagiriya to Diyathauyana.
- B47 road from Palan Thuna to Battaramulla.
- B240 road from Thalahena to Koswatta and Godagama to Malabe
- B96 road from Kolonnawa to Orugodawatta.
- AB10 road Kaduwela Junction to Welivita.

The spatial pattern of the travel speed is shown in the following figures.

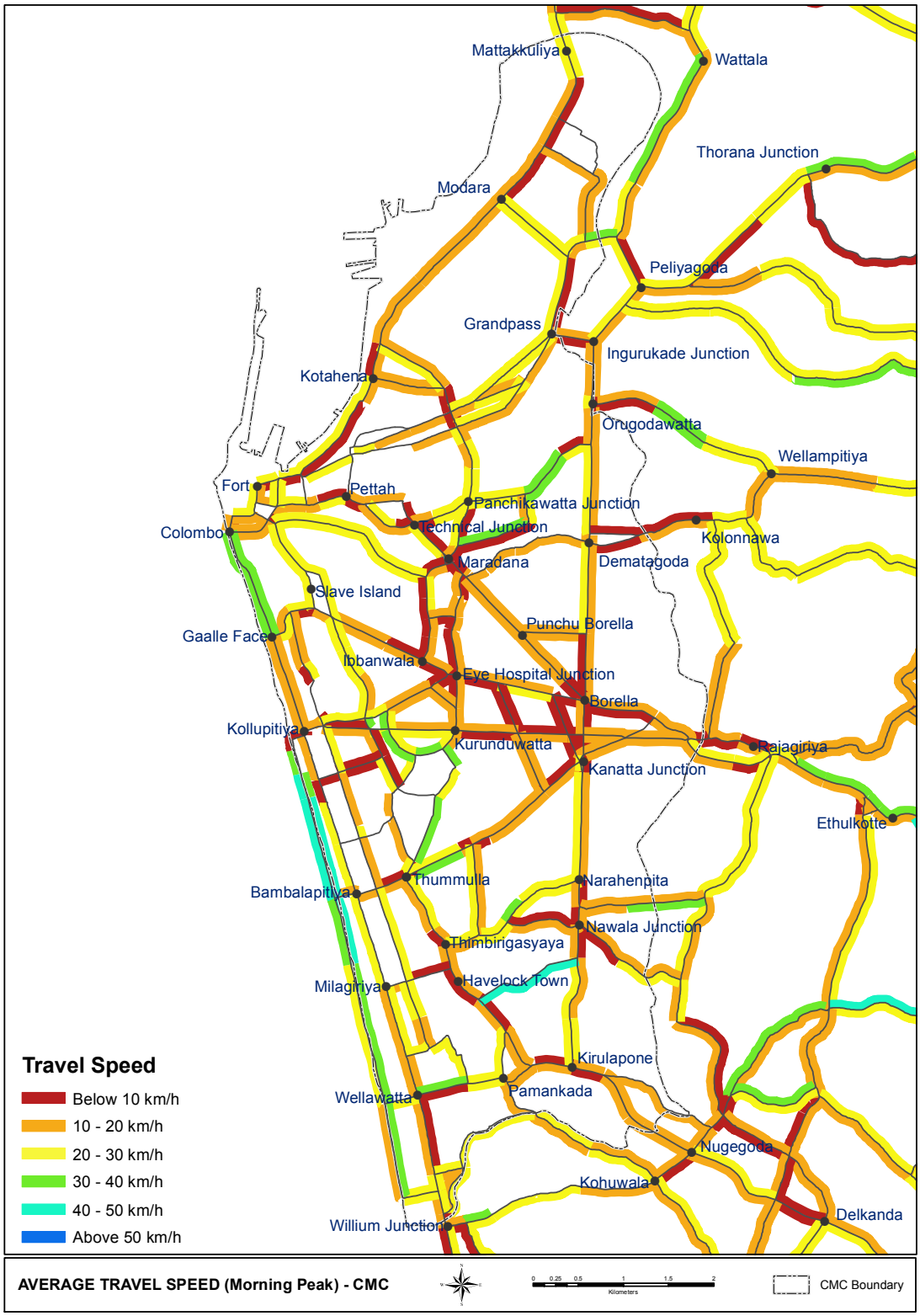


Figure 4.3.1 Business Day Average Travel Speed in Morning Peak in CMA

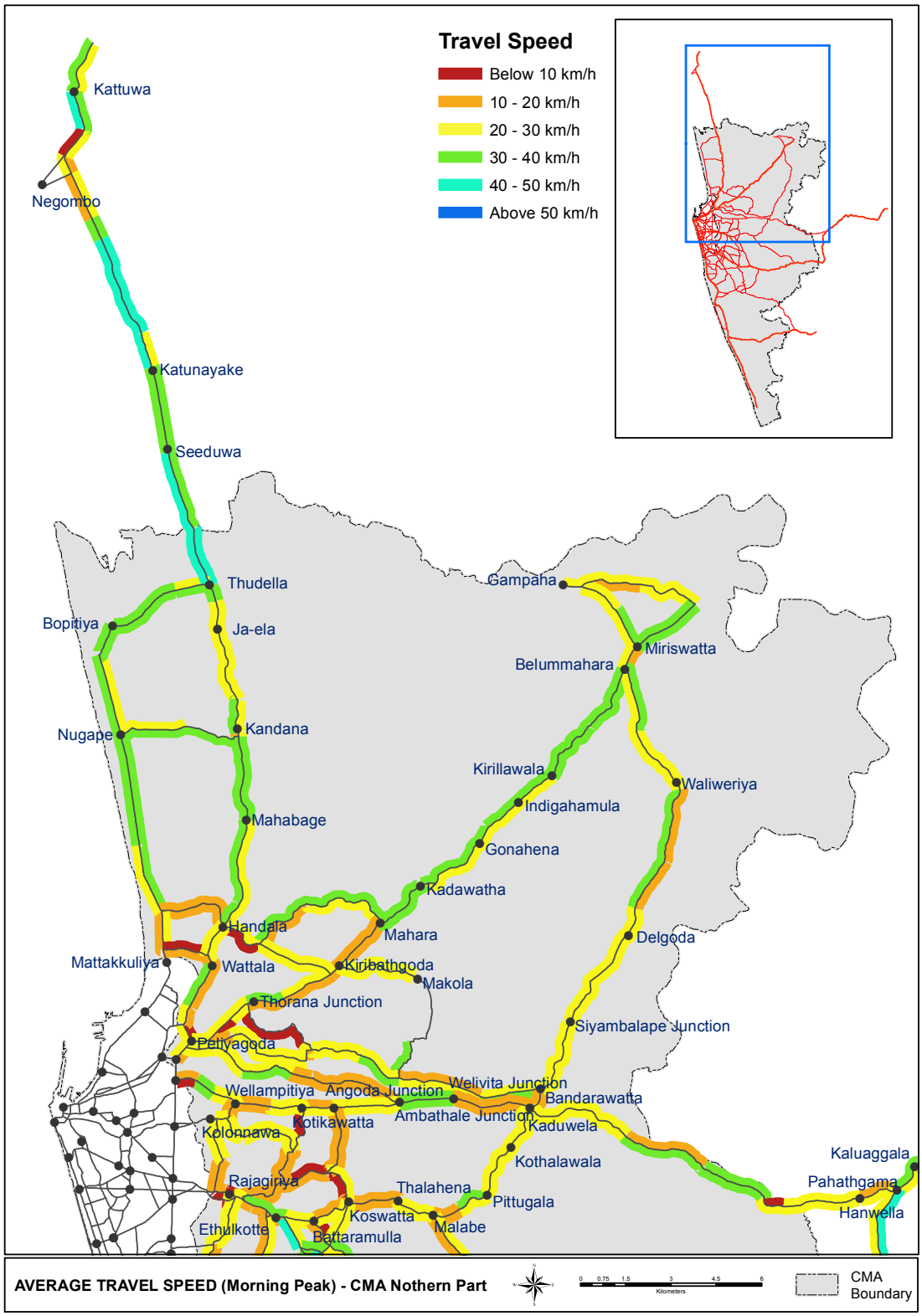


Figure 4.3.2 Business Day Average Travel Speed in Morning Peak in the Northern Part of CMA

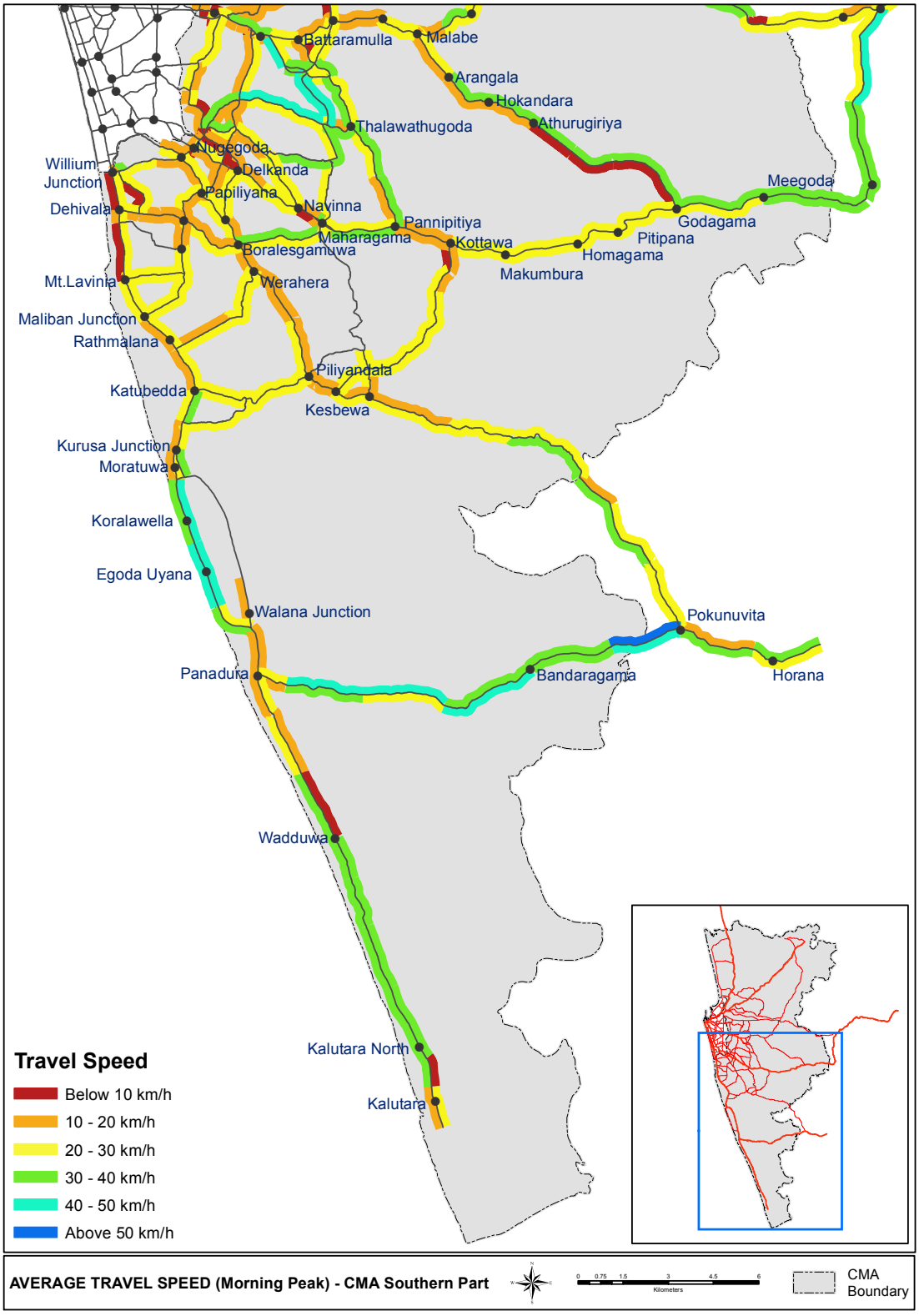


Figure 4.3.3 Business Day Average Travel Speed in Morning Peak in the Sothern Part of CMA

(2) Evening Peak

The three hour period from 4.00 pm to 7.00 pm was taken as evening peak period in a business day. The inflow travel speed is observed to be less than 20 km/h at many locations inside the CMC

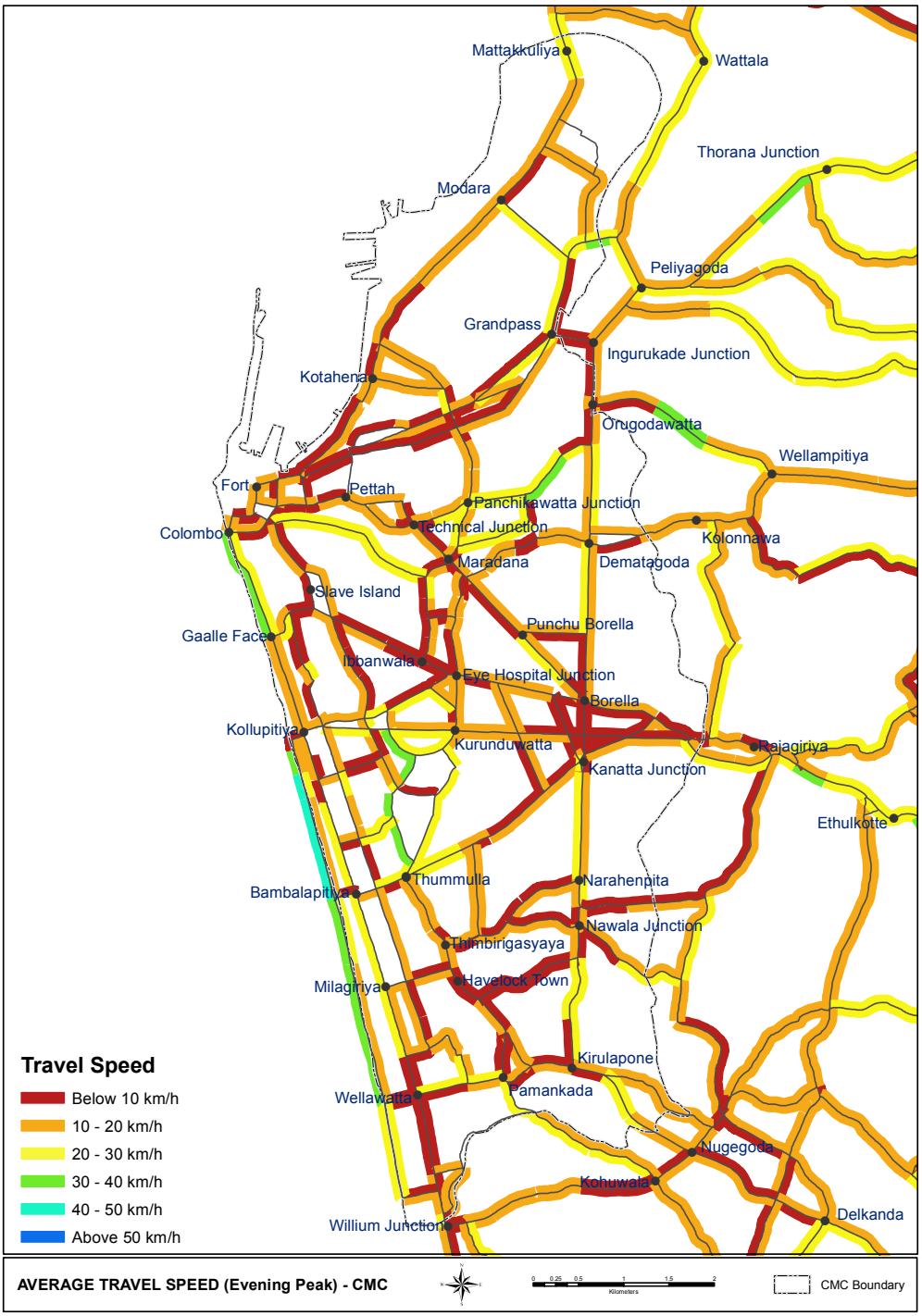


Figure 4.3.4 Business Day Average Travel Speed in Evening Peak in CMC

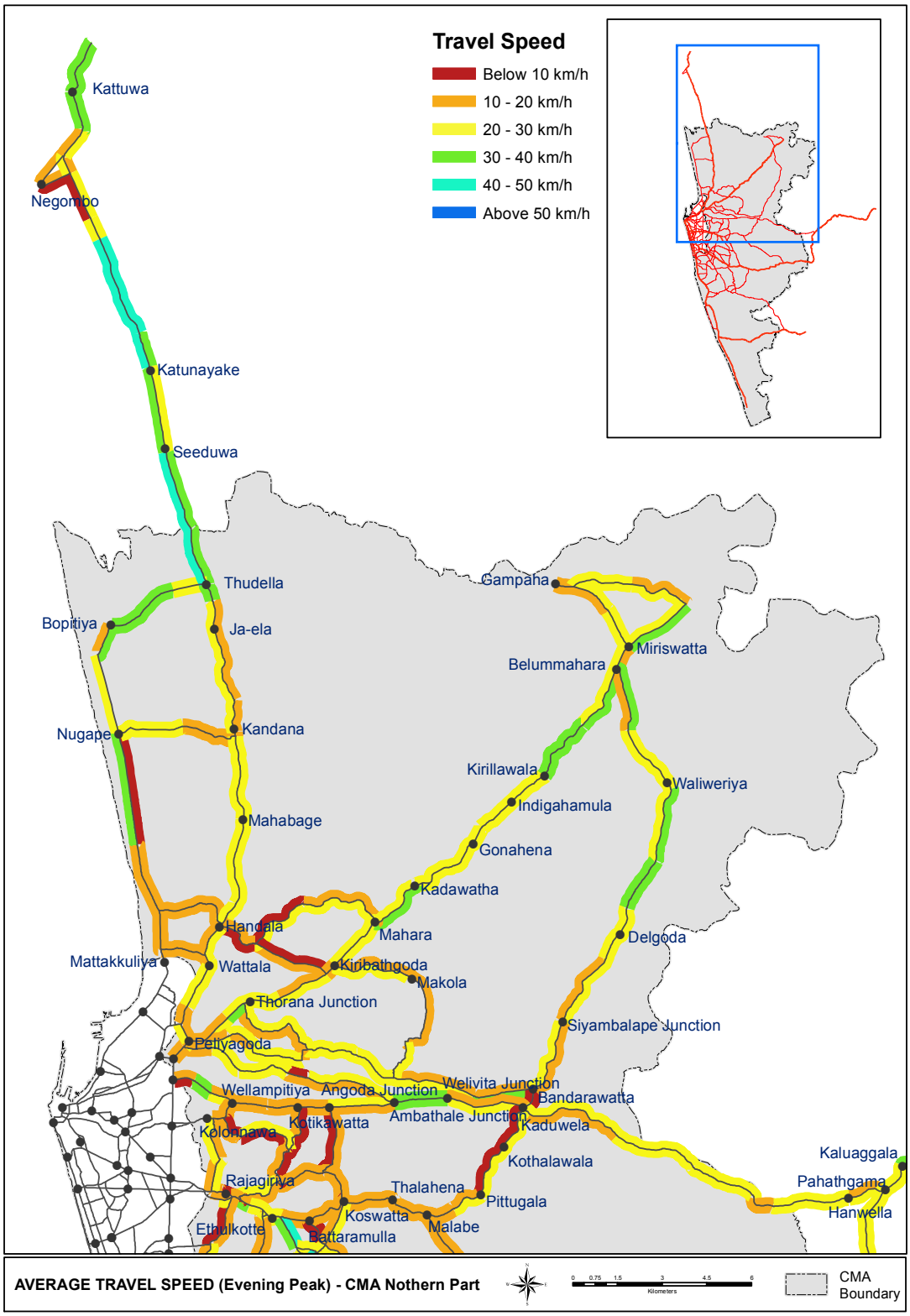


Figure 4.3.5 Business Day Average Travel Speed in Evening Peak in the Northern Part of CMA

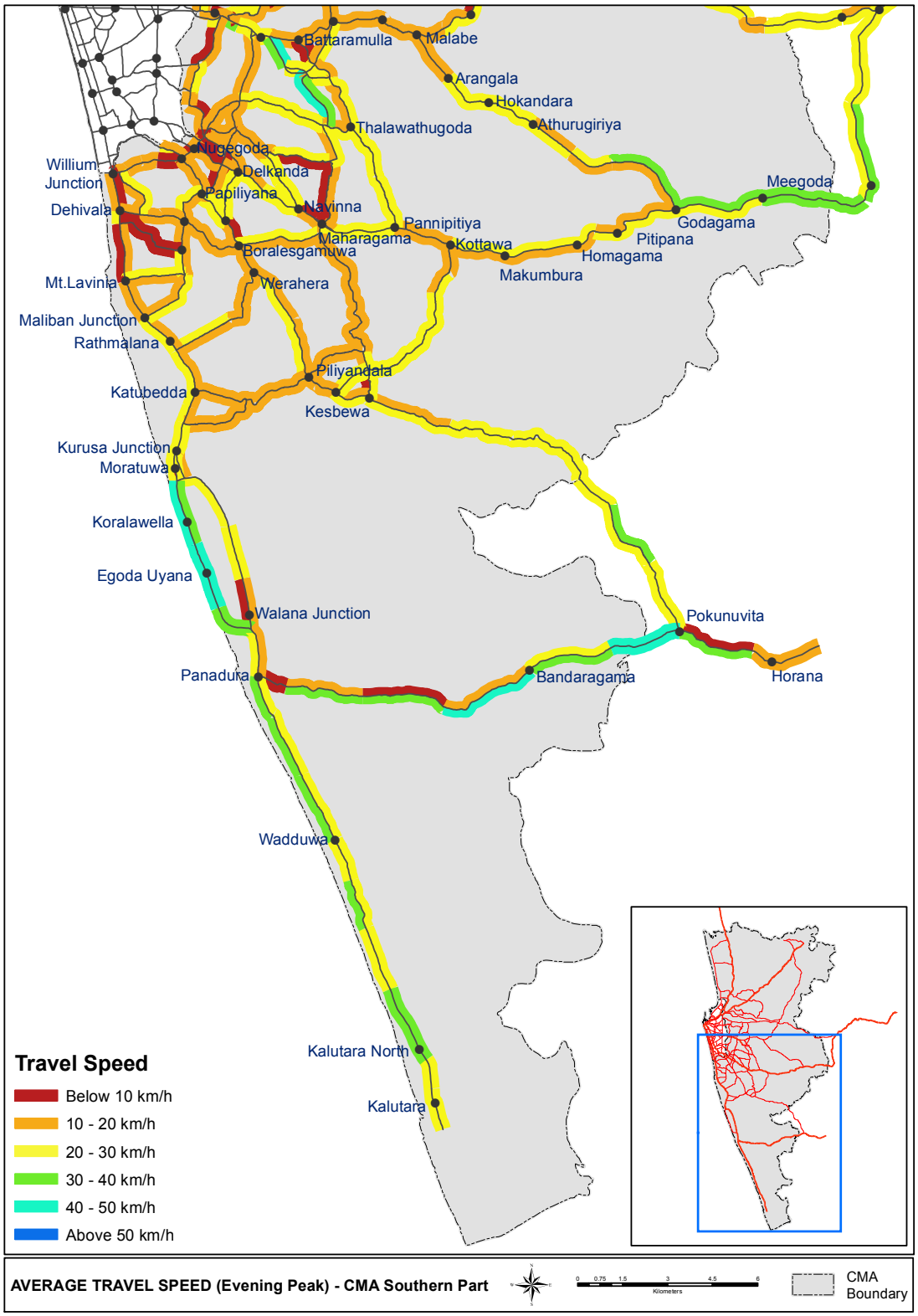


Figure 4.3.6 Business Day Average Travel Speed in Evening Peak in the Southern Part of CMA

4.3.3 Non-Business Day Travel Speed

(1) Morning Peak

The three hour period from 6.00 am to 9.00 am was taken as morning peak period in a non-business day.

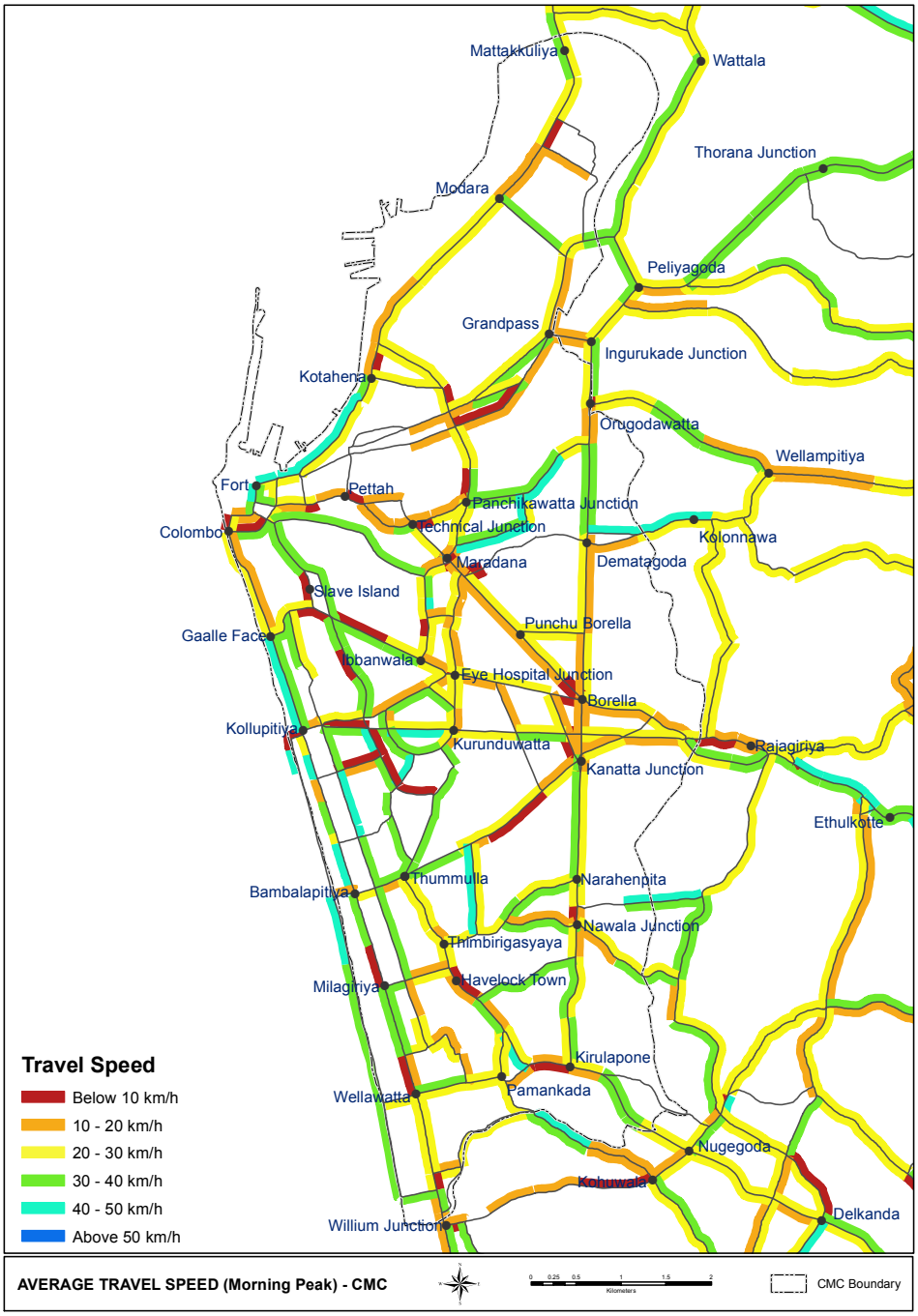


Figure 4.3.7 Non-Business Day Average Travel Speed in Morning Peak in CMA

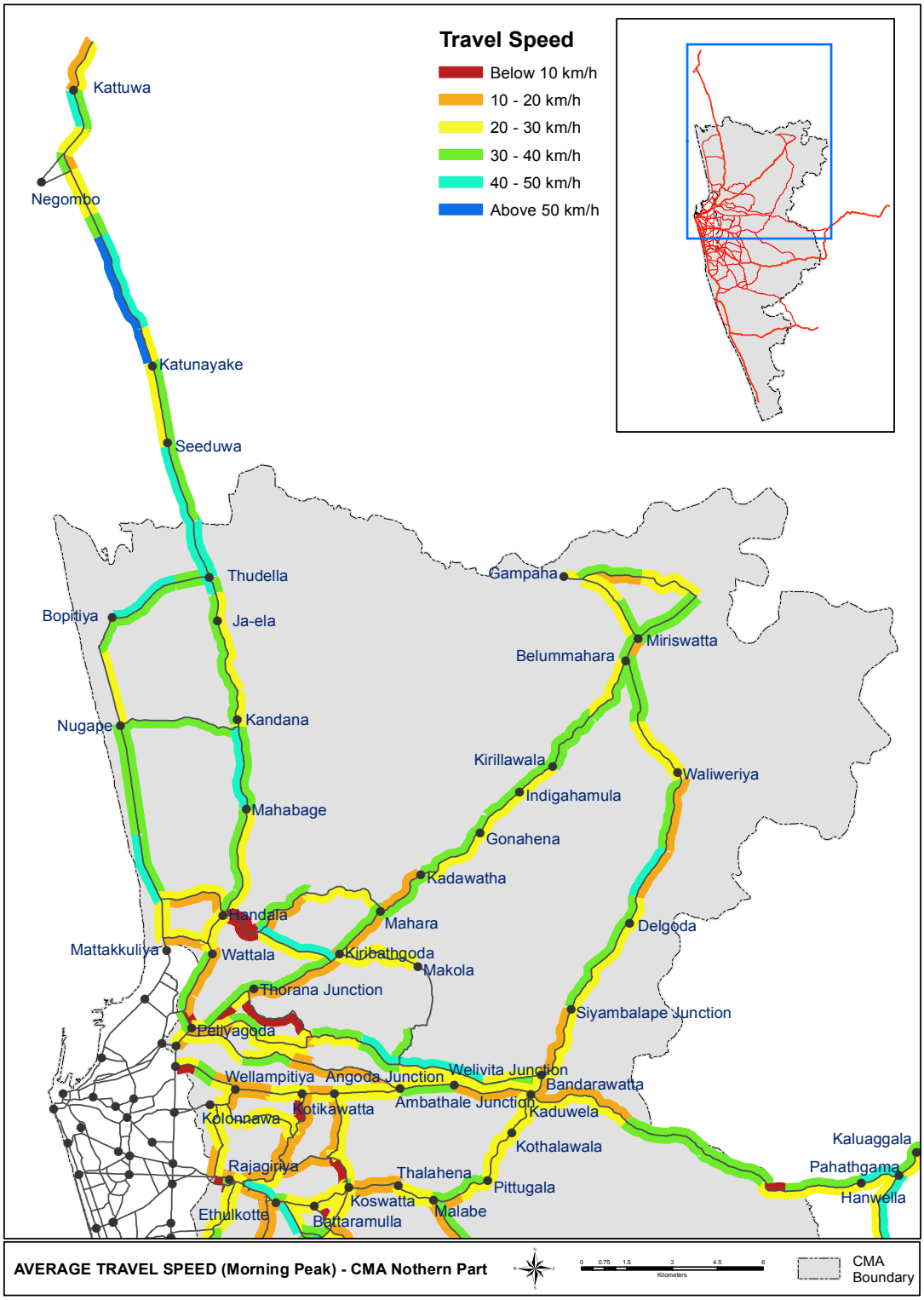


Figure 4.3.8 Non-Business Day Average Travel Speed in Morning Peak in the Northern Part of CMA

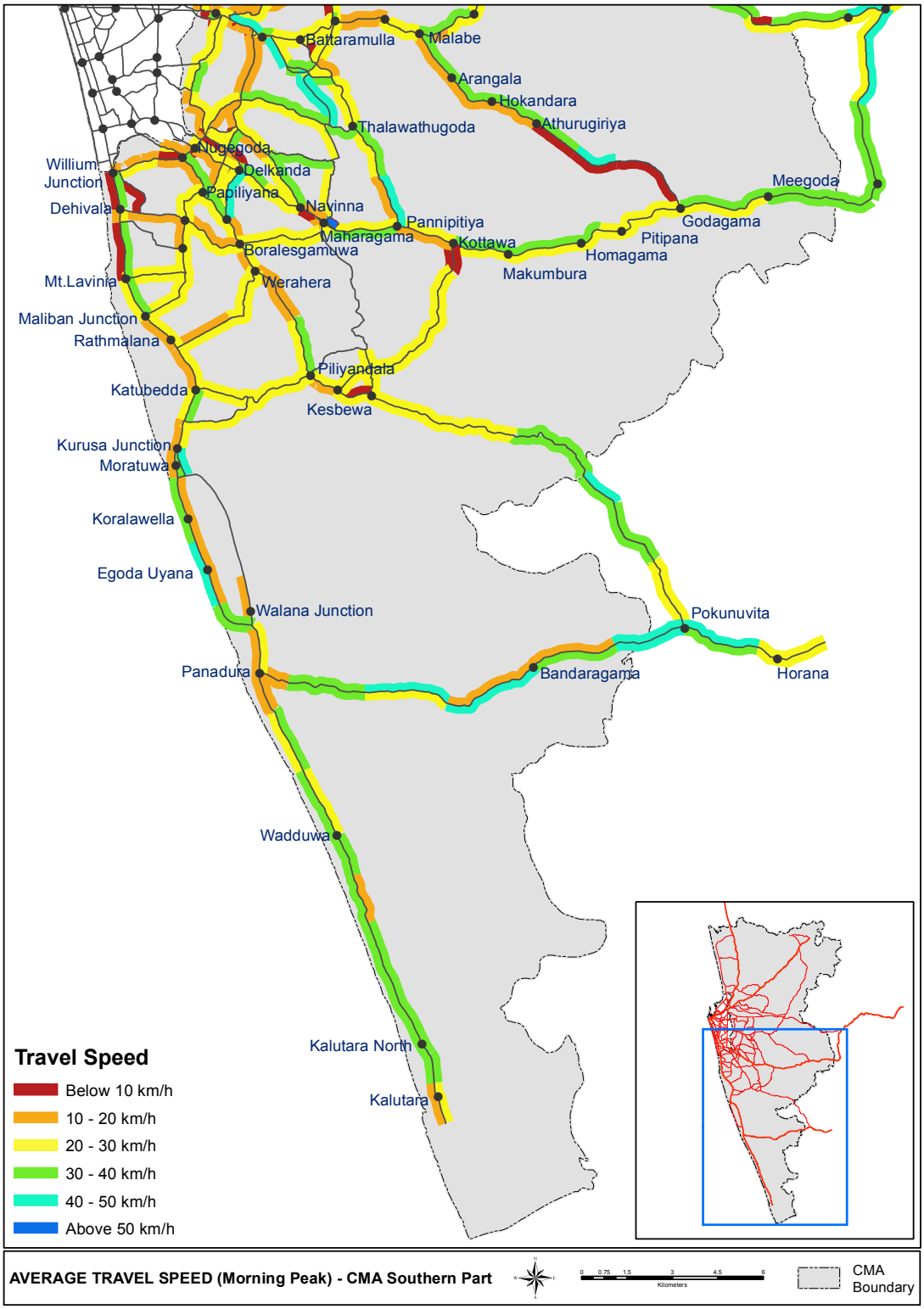


Figure 4.3.9 Non-Business Day Average Travel Speed in Morning Peak in the Sothern Part of CMA

(2) Evening Peak

The three hour period from 4.00 pm to 7.00 pm was taken as evening peak period in a non-business day.

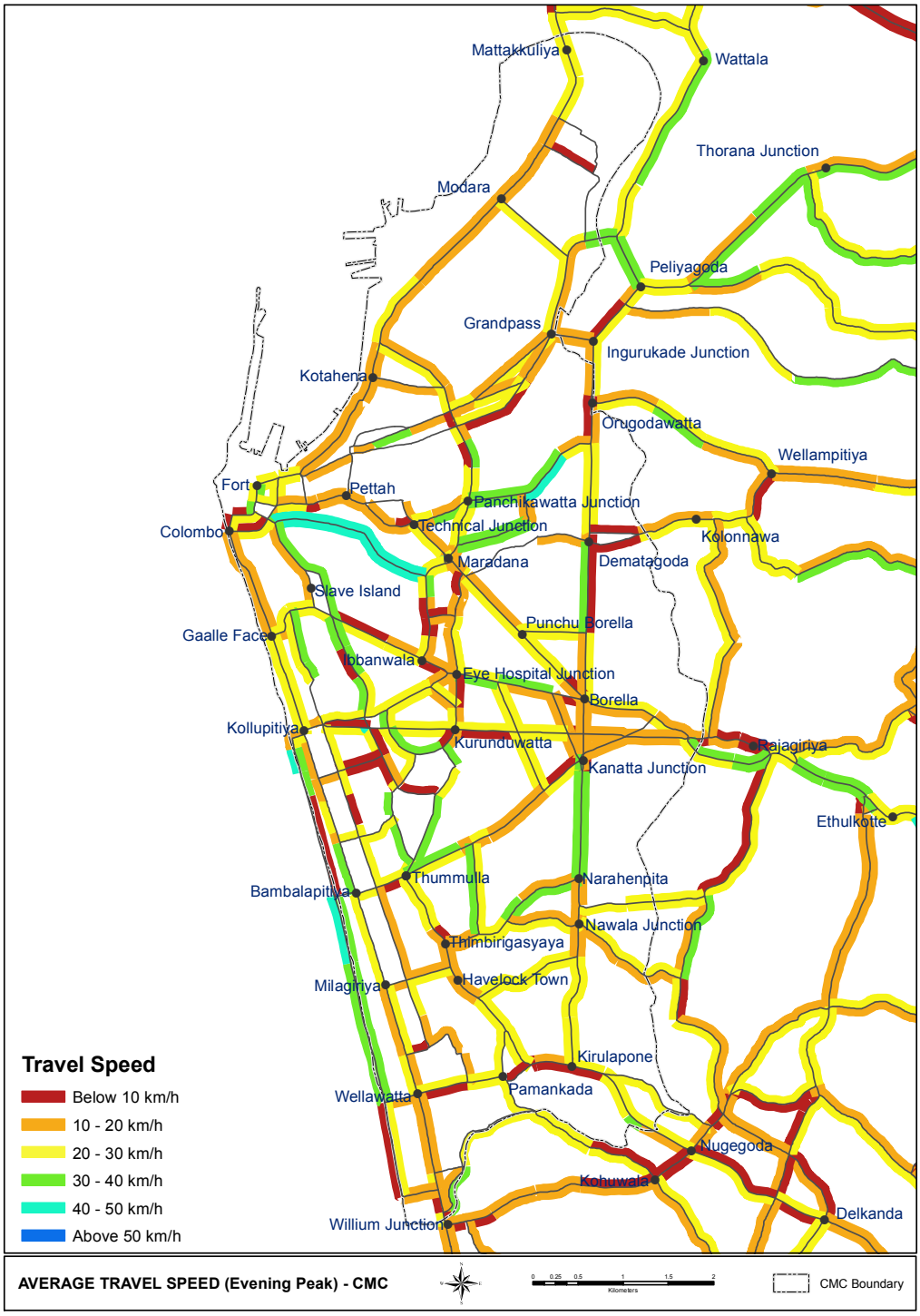


Figure 4.3.10 Non-Business Day Average Travel Speed in Evening Peak in CMC

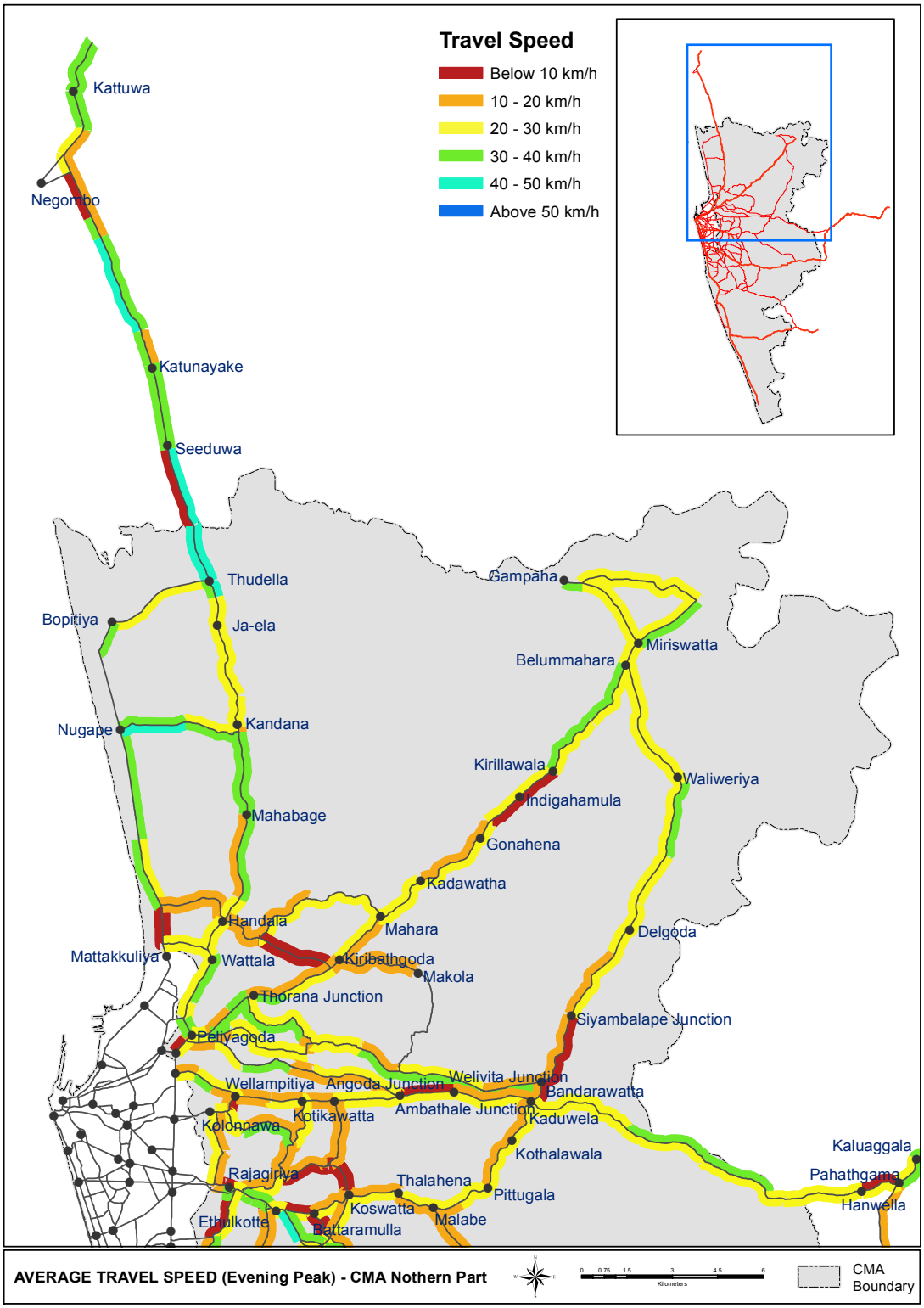


Figure 4.3.11 Non-Business Day Average Travel Speed in Evening Peak in the Northern Part of CMA

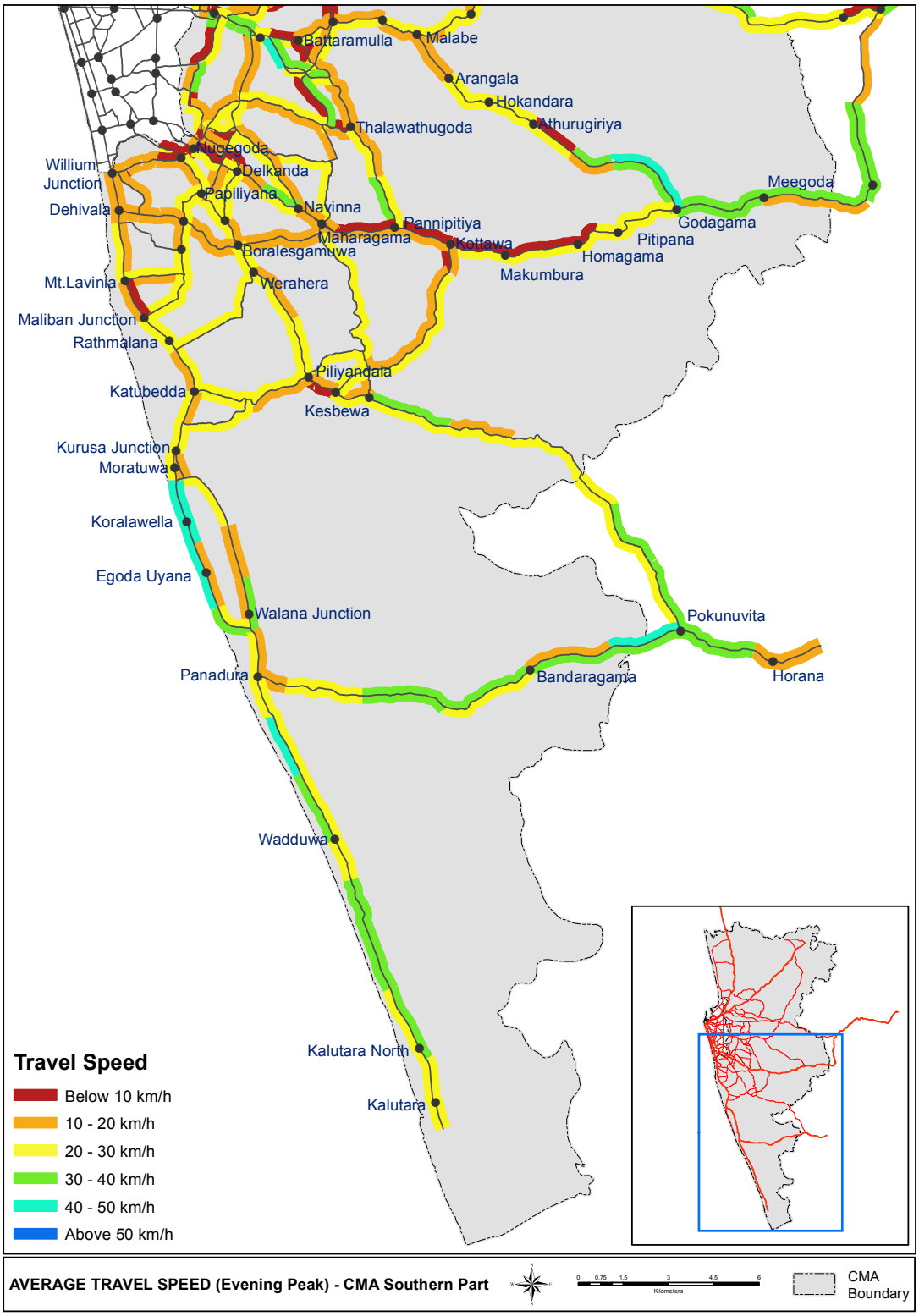


Figure 4.3.12 Non-Business Day Average Travel Speed in Evening Peak in the Southern Part of CMA

4.3.4 Corridor Travel Time Analysis

(1) Hourly average travel time between Lake house junction and Battaramulla junction

Travel Distance Inward 9.59 km

Travel Distance Outward 10.34 km

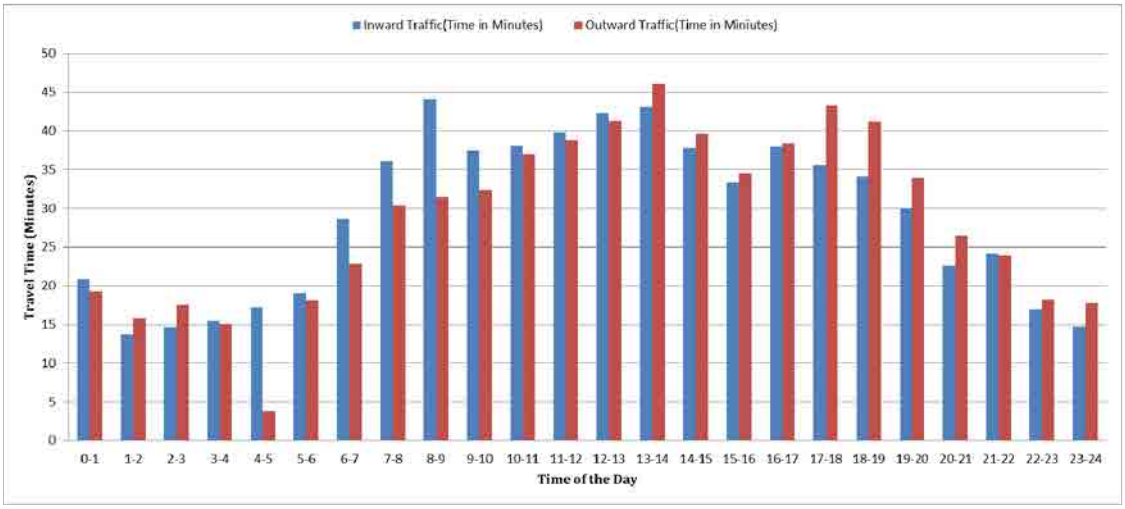


Figure 4.3.13 Hourly Average Travel Time between Lake House and Battaramulla Junction

(2) Hourly average travel time between Lake house junction and Kadawatha junction

Travel Distance Inward 16.10 km

Travel Distance Outward 15.54 km

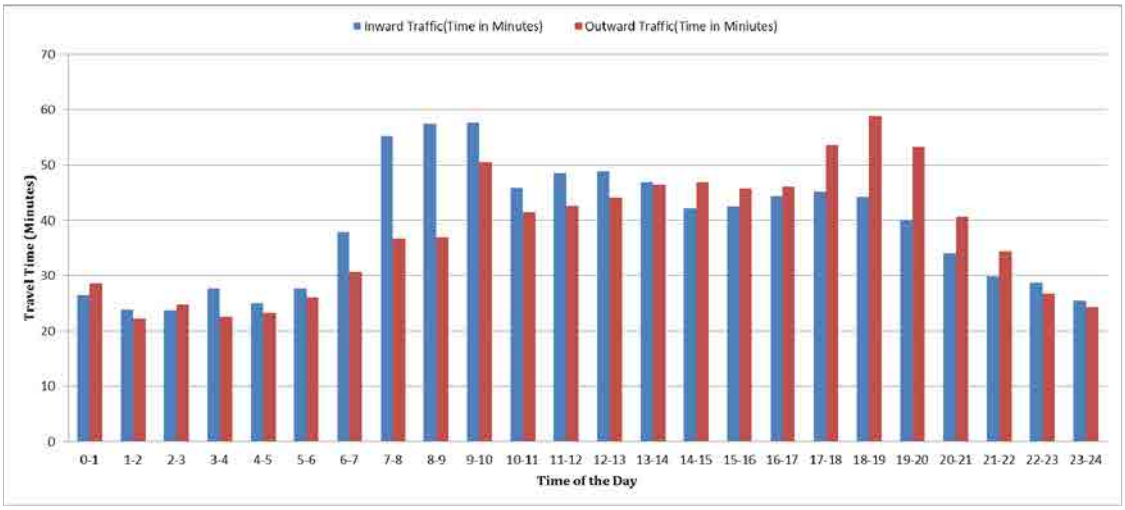


Figure 4.3.14 Hourly average travel time between Lake house junction and Kadawatha junction

(3) Hourly average travel time between Lake house junction and Ja-Ela

Travel Distance Inward 21.87 km

Travel Distance Outward 21.31 km

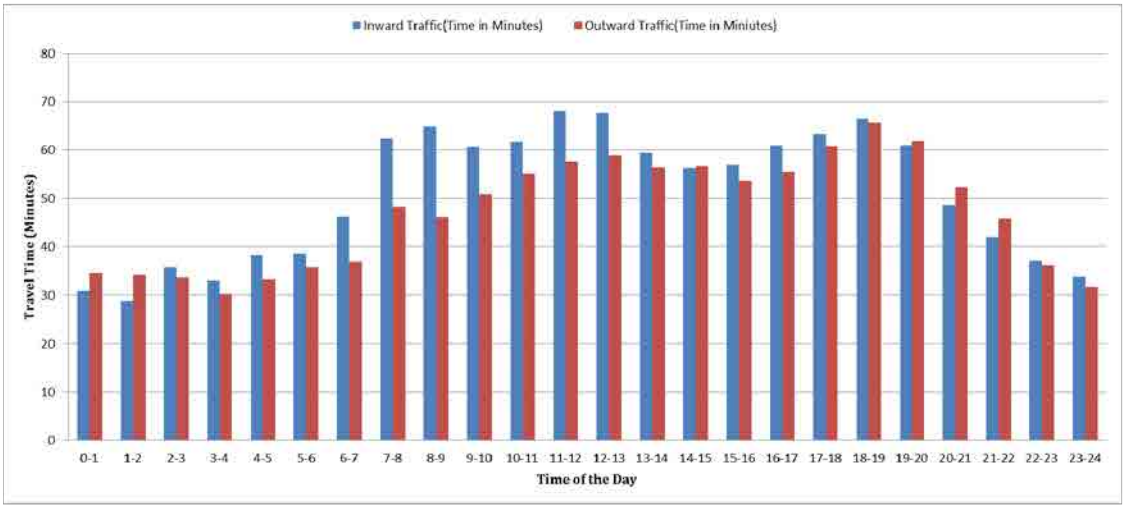


Figure 4.3.15 Hourly average travel time between Lake house junction and Ja-Ela

(4) Hourly average travel time between Lake house junction and Kaduwela (Low Level Road)

Travel Distance Inward 17.04 km

Travel Distance Outward 16.63 km

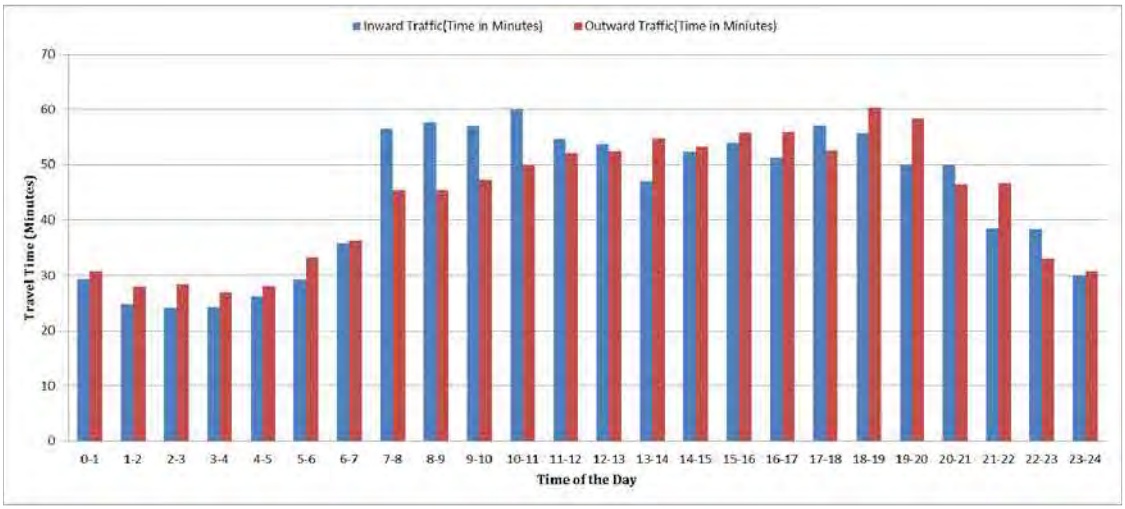


Figure 4.3.16 Hourly average travel time between Lake house junction and Kaduwela (Low Level Road)

(5) Hourly average travel time between Lake house junction and Kottawa (High-level Road)

Travel Distance Inward 18.79 km

Travel Distance Outward 19.09 km

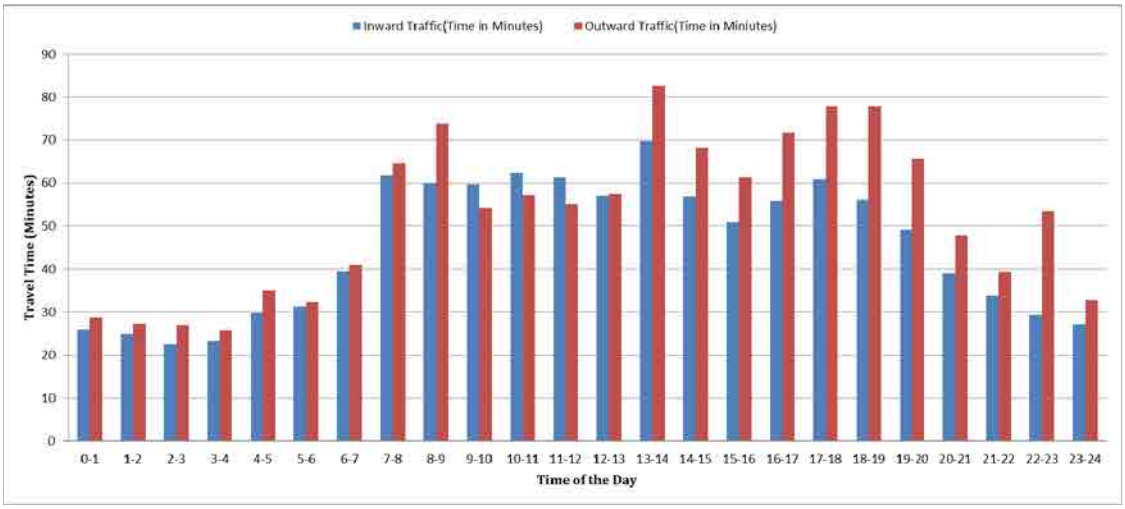


Figure 4.3.17 Hourly average travel time between For Lake house junction and Kottawa (High-level Road)

(6) Hourly average travel time between Lake house junction and Piliyandala

Travel Distance Inward 18.05 km

Travel Distance Outward 18.36 km

Figure 4.3.18 Hourly average travel time between Lake house junction and Piliyandala

(7) Hourly average travel time between Lake house junction and Moratuwa (A2 Road)

Travel Distance Inward 19.57 km

Travel Distance Outward 20.05 km

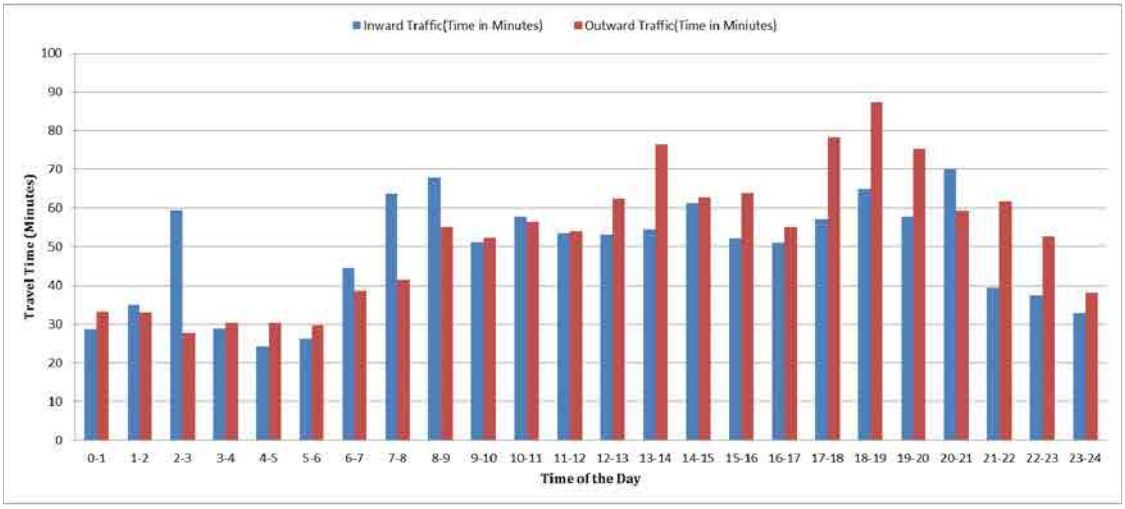


Figure 4.3.19 Hourly average travel time between Lake house junction and Moratuwa (A2 Road)

DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MINISTRY OF TRANSPORT

URBAN TRANSPORT SYSTEM DEVELOPMENT PROJECT FOR COLOMBO METROPOLITAN REGION AND SUBURBS

Technical Report No. 3

Characteristics of Present Transport Demand

AUGUST 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ORIENTAL CONSULTANTS CO., LTD.

URBAN TRANSPORT SYSTEM
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CHAPTER 1 Introduction

1.1 Background

The transport demand in Colombo Metropolitan Area has increased remarkably over the past few years. The speed of vehicle flow has declined resulting in higher vehicle operating cost for vehicle owners and environmental deterioration to the entire community. These impacts negatively affect not only the economic development in the Colombo Metropolitan Area, but also that of the country. The Colombo Metropolitan Area and suburbs therefore require improvement and development of the transport system to tackle the increasing transport demand. As the largest metropolitan area in Sri Lanka, the population of Colombo and its suburbs with 5.84 million inhabitants (2012) is expected to increase to 8.4 million by 2030. Further to the traffic congestion caused by the anticipated increasing demand, less utilisation of high occupancy vehicles, a lack of facilities for pedestrians and bus passengers, insufficient capacity of public transport and poor enforcement of traffic rules aggravate the situation.

To cope with the anticipating transport demand and related problems, the Ministry of Transport with technical support from Japan International Cooperation Agency (JICA) initiated the Urban Transport System Development Project for Colombo Metropolitan Region and Suburbs (CoMTrans) to prepare reliable transport data that can be utilised as a basis for evaluating transport development plans/projects in a scientific manner so that a comprehensive urban transport master plan can eventually be formulated.

Within the above context, a number of transport surveys were conducted to obtain various data, which are person trip movements and vehicle movement patterns. The survey results were used to understand the current traffic situation, to develop models, to analyse overall public transport performance and individual issues, and to collect detailed data required for future Transport planning.

1) Home Visit Survey (HVS)
2) Cordon Line Survey (CLS)
3) Screen Line Survey (SLS)
4) Trip Generation Survey (TGS)
5) Truck OD Interview Survey (TODIS)
6) Travel Speed Survey (TSS)
7) Trip Generation Survey (TGS)
8) Stated Preference (SP) Survey

How the results of these transport surveys are utilised in the process of Master Plan formulation in this study is depicted in Figure 1.1.1.

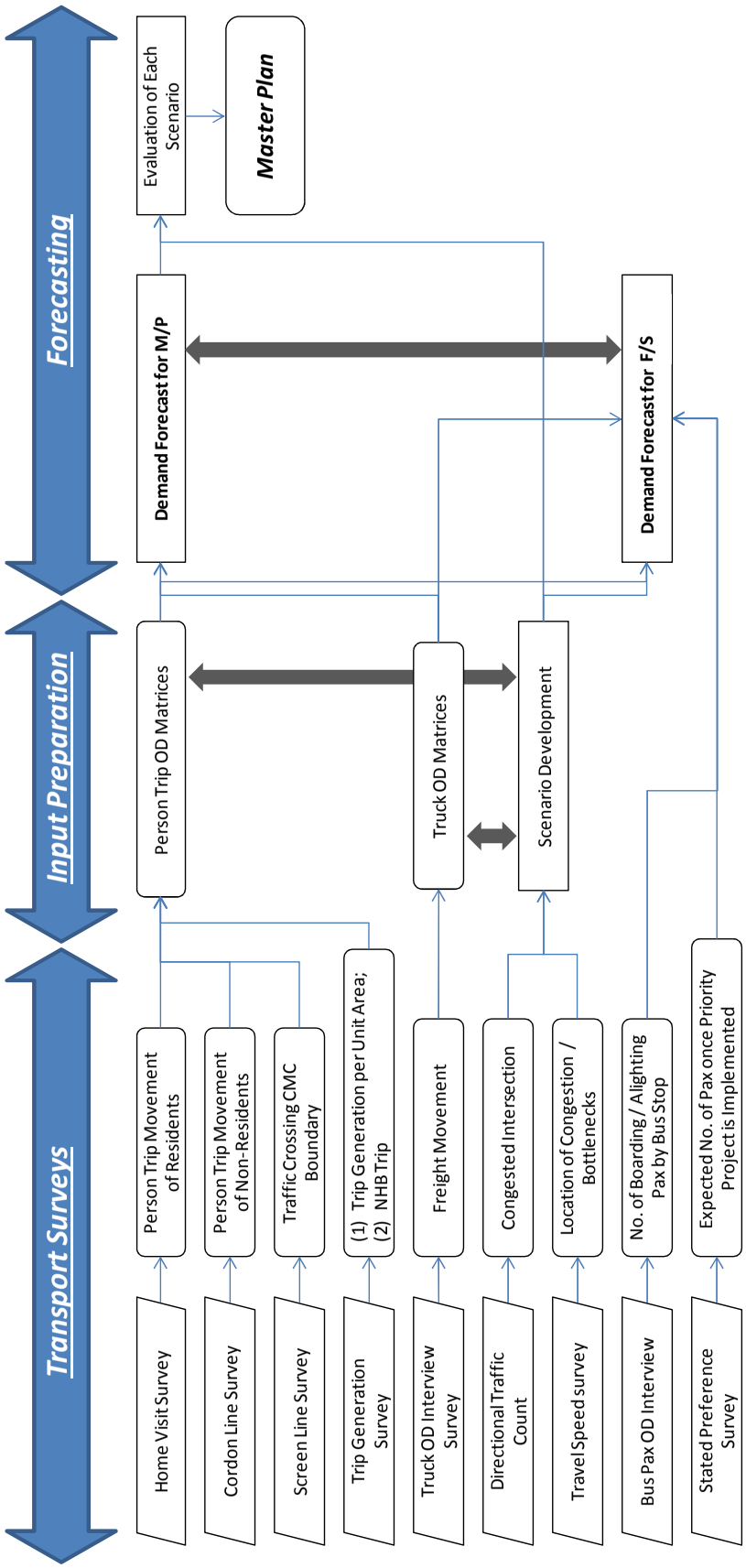


Figure 1.1.1 Overall Framework of Transport Surveys in the Process of Master Plan Formulation

1.2 Survey Objectives and Methods

Out of the transport surveys conducted under the CoMTrans project, only the result of five transport surveys are presented in this report in which most parts are covered by the Home Visit Survey (HVS).

1.2.1 Home Visit Survey (HVS)

In the HVS, CoMTrans Study Team collects the latest travel activity information of the residents along with the socioeconomic information of the household and individuals by visiting households in the Study area. This information is mainly used for analysis of the present OD matrices and for transport model building for the whole study area. The number of trips is analysed by purpose and by zone. Trip distribution is analysed based on the origin/destination information obtained by the survey. Modal choice is also analysed based on trip tables by mode. This survey is the base of the transport demand model building, and the interrelationship between the HVS and findings from other surveys related to traffic volume are of particular importance within the framework of the transport demand model.

This was the first time ever that HVS, a large scale and comprehensive transport survey, was carried out in Sri Lanka.

1.2.2 Cordon Line Survey (CLS)

The HVS collects trip information of the residents in the Western Province. On the other hand, there are many non-resident trips within the Western Province. The Cordon Line Survey was conducted to collect non-resident trip information regarding coming into and going out from the Western Province. The data obtained from the Cordon Line survey is utilised to complement the OD trip information of the residents, which is being collected through the Home Visit Survey.

To collect the non-resident trip information, the Cordon Line Survey was conducted with passengers or drivers coming into and going out from the Western Province for 4 modes of transport, which are Private vehicles, Buses, Railways and Airplanes at several cordon lines. The data obtained will be utilised as a basic database for developing transport demand forecast models.

1.2.3 Screen Line Survey (SLS)

The main objective of this survey is to verify the present OD matrices which are estimated based on the results of the Home Visit Survey and Cordon Line Survey. Also by observing the traffic volume at some of the previous survey locations such as the boundary of the Colombo Municipality, the annual growth rate can be understood and used to analyse the current traffic problems in each corridor.

1.2.4 Truck OD Interview Survey (TODIS)

The main objective of the Truck OD Interview Survey is to understand the current freight vehicle trip information regarding their origin and destination, such as export processing zones (EPZs), industrial estates (IEs), ports, and container terminals. The data obtained will be used for the freight transport travel demand forecast.

1.2.5 Trip Generation Survey (TGS)

The main objective of this survey is to obtain the trip generation rate per unit area, per employee and so forth of selected facility types. The trip rates will be used for the travel demand forecast, especially for Non-Home-Based trips, which were not fully captured in the Home Visit Survey.

1.3 Outline of Home Visit Survey (HVS)

1.3.1 Survey Coverage and Sample Size

The HVS survey covers the entire Western Province, which includes three districts; namely, Colombo District, Gampaha District, and Kalutara District, having 2,496 GN divisions in total.

Originally, the target sampling ratio was set at 3.0% of the population of the Survey area and the sample size was estimated to be approximately 44,000 households. This number was calculated using the population and average household size published respectively in the preliminary report of the Census of Population and Housing 2012 and the Household Income and Expenditure Survey 2009.

Table 1.3.1 Estimation of Target Sample Size

Category	Colombo District	Gampaha District	Kalutara District	Total
Population*1	2,309,809	2,294,641	1,217,260	5,821,710
Sampling rate	3%	3%	3%	3%
Average household size*2	4.0	4.0	4.0	4.0
Approx. households to be surveyed	17,500	17,300	9,200	44,000

Source: *1-Census of Population and Housing 2012, Department of Census and Statistics
*2-Household Income and Expenditure Survey 2009, Department of Census and Statistics

1.3.2 Sampling Method

To obtain the representative household sample, sample households were randomly selected from available lists of addresses in the survey area during which attention was given to ensure fair spatial distribution of the samples across the survey zone.

Previous experiences indicated that for this kind of comprehensive survey, a number of selected respondents refused to take part. In this respect, in our sampling work we prepared around 4% in which the reserved sample for replacement is 1% (or 5 households for every 20 households).

During the survey preparation stage, several lists of address were obtained from different institutions for selection of sampled households. After evaluation and on-site verification of the addresses from those sources, it was decided to utilise the "Election Registration List 2011" provided by the Department of Election.

A summary of advantages and disadvantages of the available sources of the addresses is given in Table 1.3.2.

Table 1.3.2 Advantages and Disadvantages of Available Address Lists from Different Institutions

Category	Advantage	Disadvantage	Conclusion
Department of Elections	- Availability of names of household members aged 18 years and older enables verification whether the Surveyor conducts her/his work properly; - Sufficient detail of address to locate which GN division the household belongs; - Availability of recent list produced in 2011.	- There are cases where the name of the former occupants remain on the list; i.e. registration is not fully done when address changes.	- Suitable for the HVS survey.
Ceylon Electricity Board	- Availability of name of customer and address; - Information on electricity consumption of household, which is correlated with household income, enables us to control distribution of income from the sample.	- Name of customer and house number are not updated despite data in 2012; - Incomplete address which makes it very difficult to identify GN Division; - Obtained addresses in the list do not cover all sections of the Survey area.	- Difficulty in identifying GN division poses a big problem for sampling work. Additionally, incomplete address and not updated name is a big obstacle for finding households to be surveyed.
Lanka Electricity Company			
Department of Census and Statistics	- Exact name and address with location on sketch map is helpful for surveyors to find the house; - GN division available.	- Highly confidential; - The address must be recorded by hand, so it needs a lot of time considering the sample size.	- Due to time constraint, it was not possible to record the address list.

1.3.3 Survey Method

The survey was conducted through the delivery/collection of survey forms method. Surveyors are required to first find the location of the sampled household and then explain about the survey objective and how to fill in the forms to the respondents. Surveyors leave the survey forms, and re-visit the household to collect the completed survey forms after the designated survey date with prior agreement from respondents.

The surveyors were requested to visit the selected households again for data verification if necessary.

1.3.4 Survey Form Design

(1) Form-1: Household Information (One form for each household)

Information on the socio-economic background of the household including address, level of income and expenditure, private motor vehicle ownership, duration of stay, and number of household members. In addition, this form is utilised to inquire about respondents' opinions/preferences regarding urban transportation in general through the choice method.

(2) Form-2a:Household Member Information (One form for each household member)

The socio-economic background of individual members of the households including cost of transportation, address of work place/school, types of work place, monthly income, transportation cost subsidy from the work place and information regarding ordinary commuting trips to work place/school are collected.

(3) Form-2b: Information regarding Previous Housing Location (Only for those who have moved during the last five years)

Information about moving and previous housing, reason for moving, preference for moving and ordinary commuting trips to work place/school before moving are collected.

(4) Form-3: Trip Information (For each household member)

Information about the trips of each member of the household including origin and destination, trip purpose, mode of transport, transfer point, departure and arrival time are collected.

1.3.5 HVS Zoning System

Table 1.3.3 shows the relationship between administrative divisions and the HVS survey zones.

For coding purposes, the survey zones are prepared for both inside and outside of the Survey area. Inside the Survey area, the survey zones are exactly the same as GN Divisions. The only exceptions are made for two GN divisions, i.e. Thimbigirigasyaya GN Division and Kurundawatta GN Division, since they are comparatively large in size and they are located in Colombo Municipality Council. As a result, Thimbigirigasyaya GN Division and Kurundawatta GN Division are further divided into 2 and 4 survey zones respectively (Figure 1.3.2). Outside of the Survey area, the zones are larger in size which varies according to their distance from the survey zones.

The Zone Code, assigned for each survey zone, is prepared in 7-digits, starting with a 2-digit District code, 2-digit DS code, and 3-digit GN code as used by the Department of Census and Statistics. Results of the surveys are compiled in the database according to this zone code system and then integrated into GIS for subsequent analysis. The typical zone code numbering system is shown in Figure 1.3.3.

Table 1.3.3 Relationship between Administrative Division and Survey Zone System

	Name of Province	Name of District	No. of DS Divisions	No. of GN Divisions	No. of Survey Zones	Survey Zone Level
Study Area	Western	Colombo	13	557	561	GN Division
		Gampaha	13	1177	1177	GN Division
		Kalutara	14	762	762	GN Division
Outside Study Area	North Western	Kurunegala	30	-	30	DS Division
		Puttalam	16	-	16	DS Division
	Central	Kandy	20	-	1	District
		Matale	11	-	1	District
		Nuwara Eliya	5	-	1	District
	Sabaragamuva	Kegalle	11	-	11	DS Division
		Ratnapura	17	-	17	DS Division
	Southern	Galle	18	-	18	DS Division
		Hambantota	11	-	1	District
		Matara	16	-	1	District
	Northern	Jaffna	14		1	District
		Mannar	5	-	1	District
		Vavuniya	4	-	1	District
		Mullaitivu	5	-	1	District
		Kilinochchi	4	-	1	District
	North Central	Anuradhapura	22	-	1	District
		Polonnaruwa	7	-	1	District
	Eastern	Batticaloa	12	-	1	District
		Ampara	19	-	1	District
		Tricomalee	11	-	1	District
	Uva	Badulla	15	-	1	District
		Moneragala	11	-	1	District
	Airports				3	Special zones
	Port				1	Special zones
	Total No. of Survey Zones				**2613**	

Source: **C**ensus Codes of Administrative Divisions Sri Lanka 2001, Department of Census and Statistics

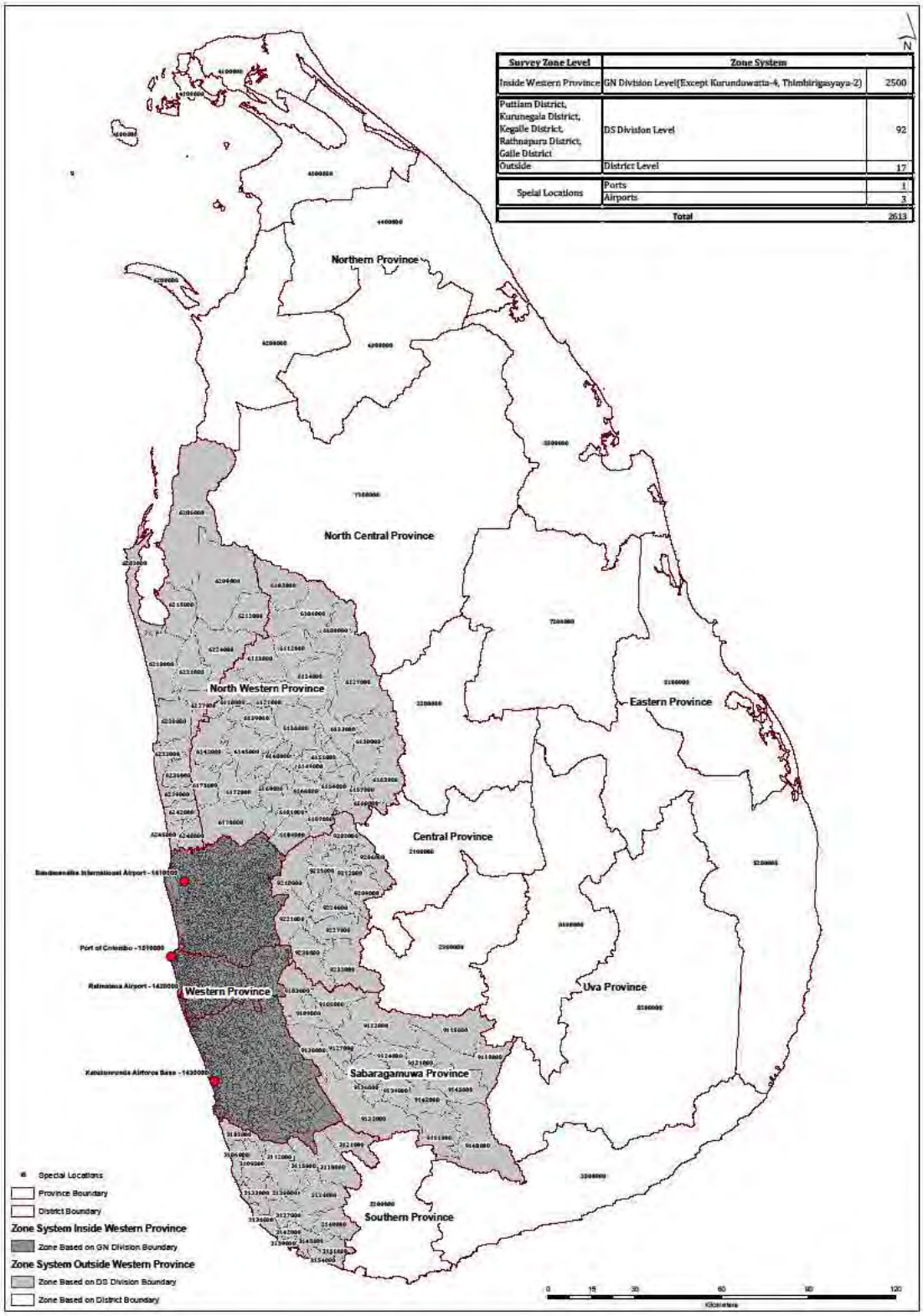


Figure 1.3.1 Map of HVS Survey Zones

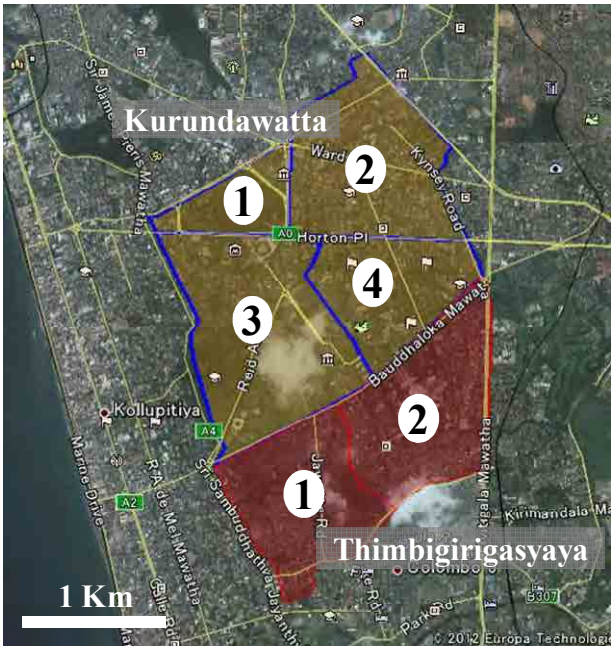


Figure 1.3.2 HVS Survey Zones inside Kurunduwatta and Thimbirigasyaya GN Divisions

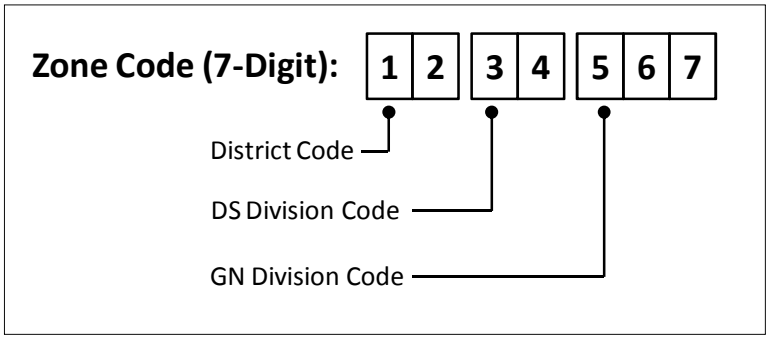


Figure 1.3.3 Zone Code System

1.4 Organizational Implementation of HVS

1.4.1 Organizational Structure

The survey organization is presented in Figure 1.4.1. The survey team is headed by the Chief Supervisor who is responsible for the whole implementation of the survey. The actual interviews with the households have been conducted by surveyors recruited by the local consultant. All survey management and control activities were done at the CoMTrans project provided by the Study team.

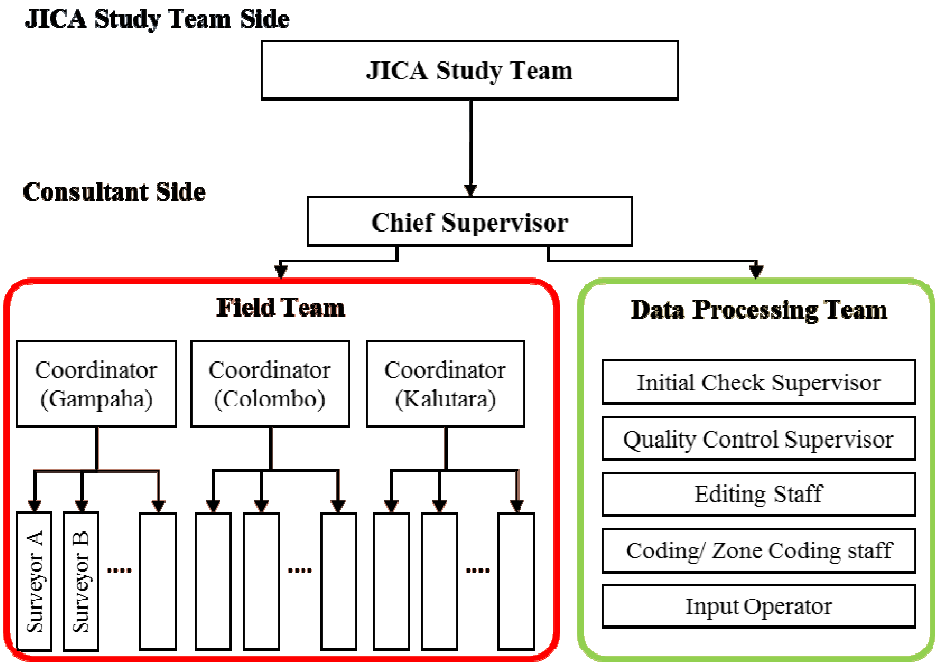


Figure 1.4.1 Survey Organization

1.4.2 Flow of Survey Activities

The overall procedure which includes all major activities of the survey is presented in Figure 1.4.2.

1.4.3 Survey Administration and Public Relations

The following table shows some problems that occurred during the survey implementation and the corresponding countermeasures / actions undertaken by the Study team are presented in Table 1.4.1

1.4.4 Quality Control Measures

To maximise the accuracy of information recorded in the forms, quality control measures have been put into practice as shown in Figure 1.4.3.

Before the commencement of the survey implementation, a Surveyors' Manual, Supervisor Manual, and Data Processing Manual were carefully prepared as guidance for the survey personnel. Training of the survey personnel was conducted under observation of the Study team to ensure that the instructions were correctly delivered to the survey personnel in accordance with the manuals. Once the survey was implemented, the collected survey forms have been brought to head office so that a supervisor can check for correctness, completeness and consistency before proceeding. This manual checking is being done in three steps: Initial Check supervisor, Quality Control supervisor, and Editing staff. These works are closely supervised and monitored by the Study team. After manually checking, the information from the survey forms was input into a database system, and at this stage again, the checking is done by computer program. To minimise typing mistakes done by Data Entry operators, data input is done twice by different

operators and then matching of the two data sets was conducted. After the matching, logical check by computer program is started. Because correcting logical errors is a critical work, the Study team carefully supervises the work.

Understanding that constant supervision and monitoring by the Study Team is crucial for the data quality, arrangements were made to provide the same office space for both the Study team and the local consultant.

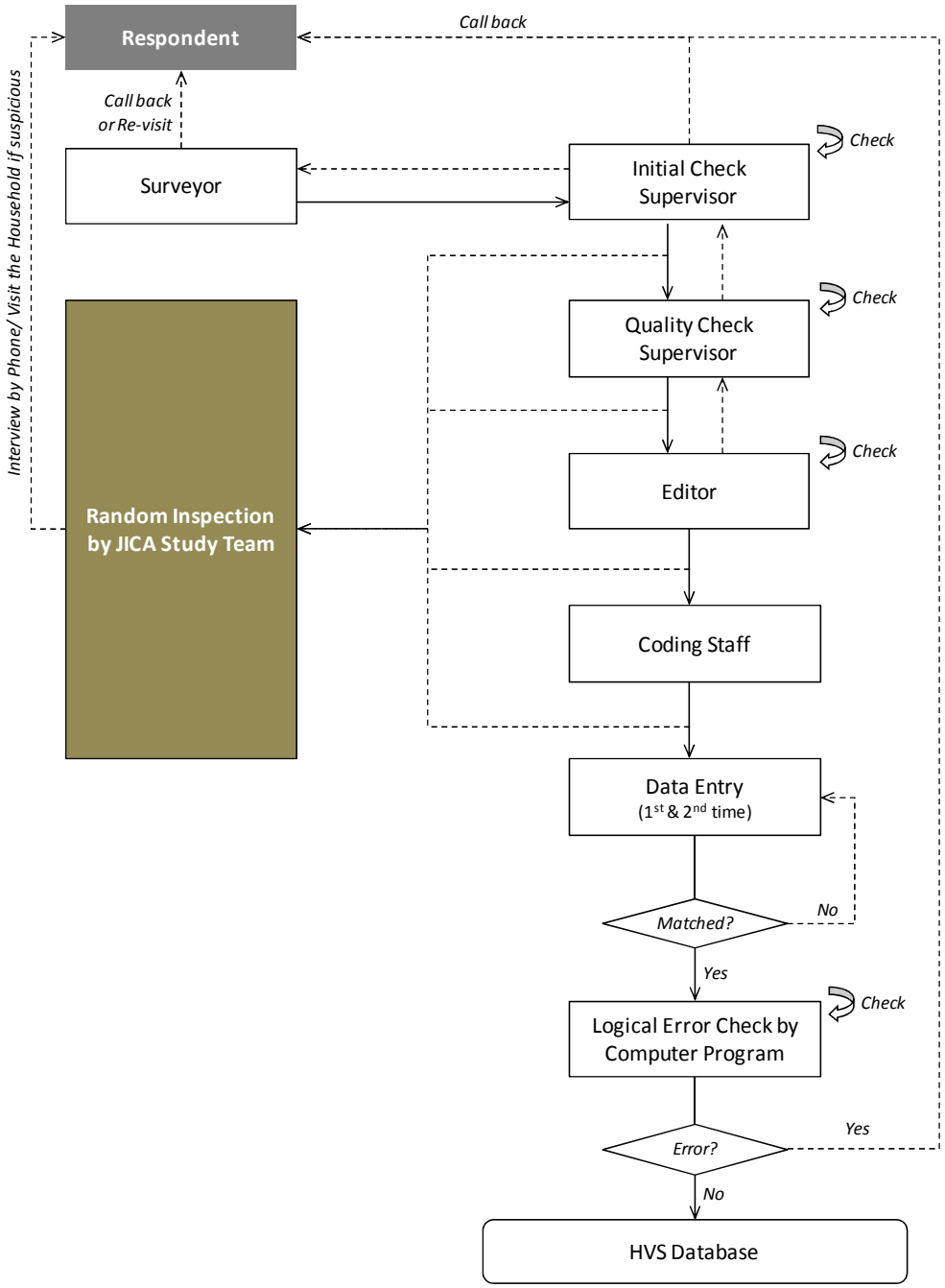


Figure 1.4.2 Overall Work Flow of the HVS

Table 1.4.1 Problems and Countermeasures

Problem	Countermeasure / Solution
Some respondents have rejected filling in the form.	Public announcement through workshops, awareness programs, and mass media including TV, radio, newspaper advertisement, posters, and press releases by JICA were utilised.
Muslim community in Colombo and Kalutara districts, particularly in the DS Divisions listed below have collectively refused to participate in the survey due to various reasons. Kalutara District: Beruwela, Panadura, Kalutara, and Bandaragama. Colombo District: Colombo, Thimbirigasyaya, and Dehiwela.	The Ministry of Transport, Department of Muslim Religious and Cultural Affairs has agreed to request for coordination from Religious or Community leaders of the area concerned in order to disseminate this information to the citizens after praying time on Friday and ask for their participation.
There was a strike held by teachers on 4th December, 2012 and there was a reduction in the number of students attending Colombo schools during the week before school holidays.	To collect trip information under the ordinary degree of traffic congestion, distribution of forms has been suspended during the strike.
It has been found that some surveyors cheated and filled the forms in by themselves without visiting the household to be surveyed.	By inspection/verification of the survey results on site by the Study team, disqualified surveyors were removed and the collected forms were dropped.
Some surveyors were observed as impolite and showed a lack of adequate explanation for the survey objective.	The Study team has directly made phone calls to the surveyors one by one in order to remind them to maintain the survey quality and check the level of understanding.

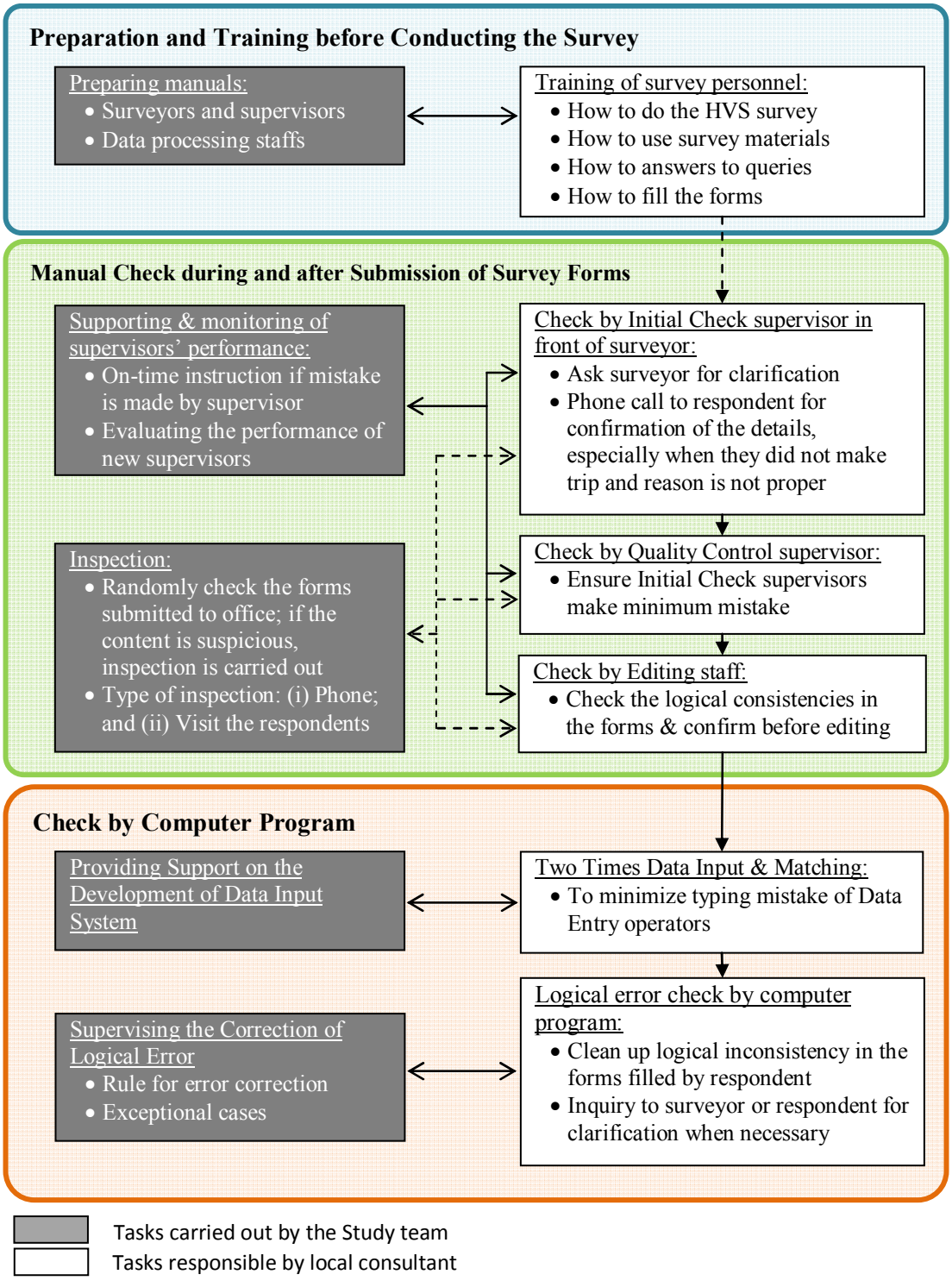


Figure 1.4.3 Quality Control Procedure

1.5 Samples Collected by HVS

HVS activities were originally scheduled for about five months from November 2012 to April 2013. However, the survey had experienced substantial delay before it ended in August 2013.

The actual achievement after data processing and error checking was eventually 35,850 households or 81.5% of the target sample size. Figure 1.5.1 shows the spatial distribution of the effective sample.

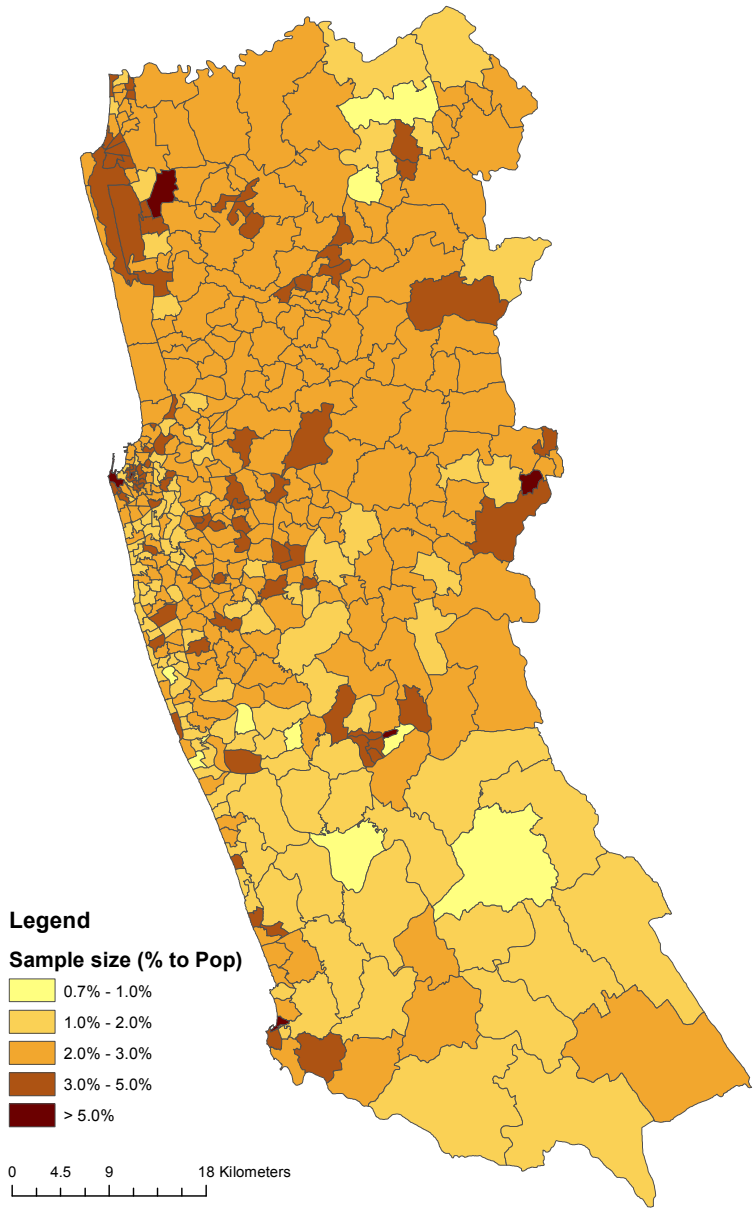


Figure 1.5.1 Spatial Distribution of Effective Sample

1.6 Premise of the Analysis of HVS Data

1.6.1 Definition of a Trip

A trip is defined as "the movement of a person from an origin to a destination with a purpose". The concept of a trip is presented below.

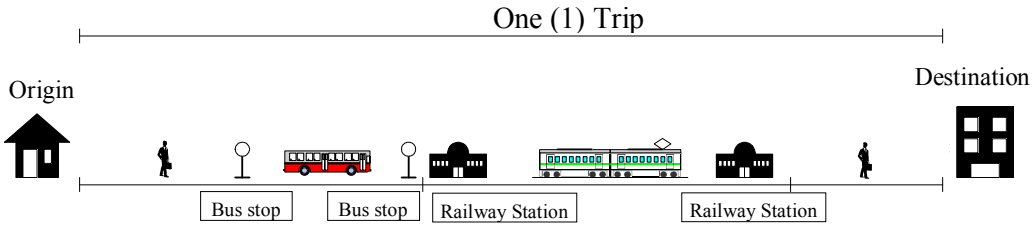


Figure 1.6.1 Concept of a Trip

The following is an example of a one-day movement of Mr. A in which five trips are produced. Further explanations with illustrated examples are given in Appendix 1.

- 1st Trip; In the morning, Mr. A went to his office (his work place) from his home.
- 2nd Trip; In the afternoon, he visited a company for a business meeting at the other office building.
- 3rd Trip; After the meeting, he went back to his office (his work place).
- 4th Trip; In the early evening, he left his work place for shopping at a supermarket.
- 5th Trip; After the shopping, he went home.

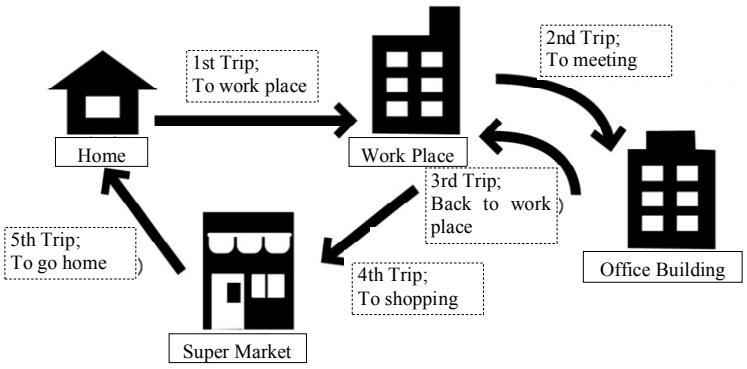


Figure 1.6.2 Example of One Day's Movement and Number of Trips

1.6.2 Scope of the Analysis

Trips made inside the study area are classified into those of residents and non-residents. The HVS covers residents of the study area; hence, the analysis is made only for residents of the study area whose comprehensive trip information is available.

For non-residents, however, their trip information is limited only to those obtained from the Cordon Line Survey. Note, however, that trip information of the non-residents was reflected in the OD tables for transport modelling.

Also focus was given to the fact that HVS was conducted to include household members aged 5 years old and above.

1.6.3 Zone System of Analysis

The zone system for the analysis is classified as follows.

Table 1.6.1 Zone System for Traffic Analysis within the Study Area

Classification	No. of Zones	Purpose
Macro zone block	19	For analysing traffic characteristics and movement in a macro block (block matrix) and illustrating the analysis result
Large zone	40	For analysing traffic characteristics at a large zone level and illustrating the analysis result
Medium zone	119	For analysing traffic characteristics at a medium zone level and illustrating the analysis result
Small zone (or Traffic Analysis Zone[1])	462	For developing transport models and conducting traffic assignment

1.6.4 Transport Mode and Its Integration

There are two ways to define a trip by their classification: linked trip and unlinked trip. The former is an entire movement of a person from an origin to a destination with a single purpose, while the latter is a part of the former segregated by transport mode. In other words, a linked trip is a chain of unlinked trips by different individual transport modes.

In the analysis hereafter, the term “trip”, unless otherwise specified, only refers to a “linked trip”.

[1] Traffic Analysis Zone (TAZ): a unit of geography which varies in size and is commonly used in conventional transport planning models. In this study, Western Province is divided into 462TAZs, in which 59 TAZs are in CMC and 403TAZs are in the rest of the province. In CMC, one TAZ is constructed by one GN division, except for Kurundawatta and Thimbirigasyaya GN divisions where sub-dividing into 4 and 2 TAZs respectively were necessary due to their large sizes. Outside of CMC, one TAZ is constructed by one or more GN divisions based on the demographical characteristics and potential of the area in the planning.

Hence, to determine a transport mode used by an individual for his/her trip, a representative transport mode is assumed. In this respect, it is necessary to determine the priority among various transport modes used within one trip. In this study, the priority was defined based on the following considerations:

- Public mode has a higher priority than private mode; and
- Line-haul mode has a higher priority than feeder mode.

Table 1.6.2 Priority of Representative Transport Mode and Integrated Transport Mode

No.	Transport Mode	Mode Priority	Integrated Transport Mode			
			7 Modes		3 Modes	
1	Walking only	18	7	NMT	3	NMT
2	Walking to/from bus stop/railway station	17	7	NMT	3	NMT
3	Bicycle	15	7	NMT	3	NMT
4	Motorcycle	14	2	Motorcycle	1	Private Transport
5	Three Wheeler (Private use)	13	3	Three Wheeler	1	Private Transport
6	Car/Jeep/Van	11	1	Car	1	Private Transport
7	Pick Up	12	1	Car	1	Private Transport
8	Three Wheeler (Hired)	10	3	Three Wheeler	1	Private Transport
9	Taxi (Car/Van)	8	4	Taxi	1	Private Transport
10	Taxi (Nano)	9	4	Taxi	1	Private Transport
11	Employee Transport	7	5	Bus	2	Public Transport
12	Staff Service	5	5	Bus	2	Public Transport
13	School Bus/Van	6	5	Bus	2	Public Transport
14	Non A/C Bus (Private)	4	5	Bus	2	Public Transport
15	Non A/C Bus (SLTB)	3	5	Bus	2	Public Transport
16	A/C Bus	2	5	Bus	2	Public Transport
17	Railway	1	6	Railway	2	Public Transport
18	Others	16	5	NMT	2	NMT

Note: NMT = Non-motorised transport

CHAPTER 2 HVS Data Processing

2.1 General

Home Visit Survey data is an important basis for transport model development. Therefore, it is necessary to conduct data validation to ensure that the data is proper for the modelling. The procedure taken in this study is presented below.

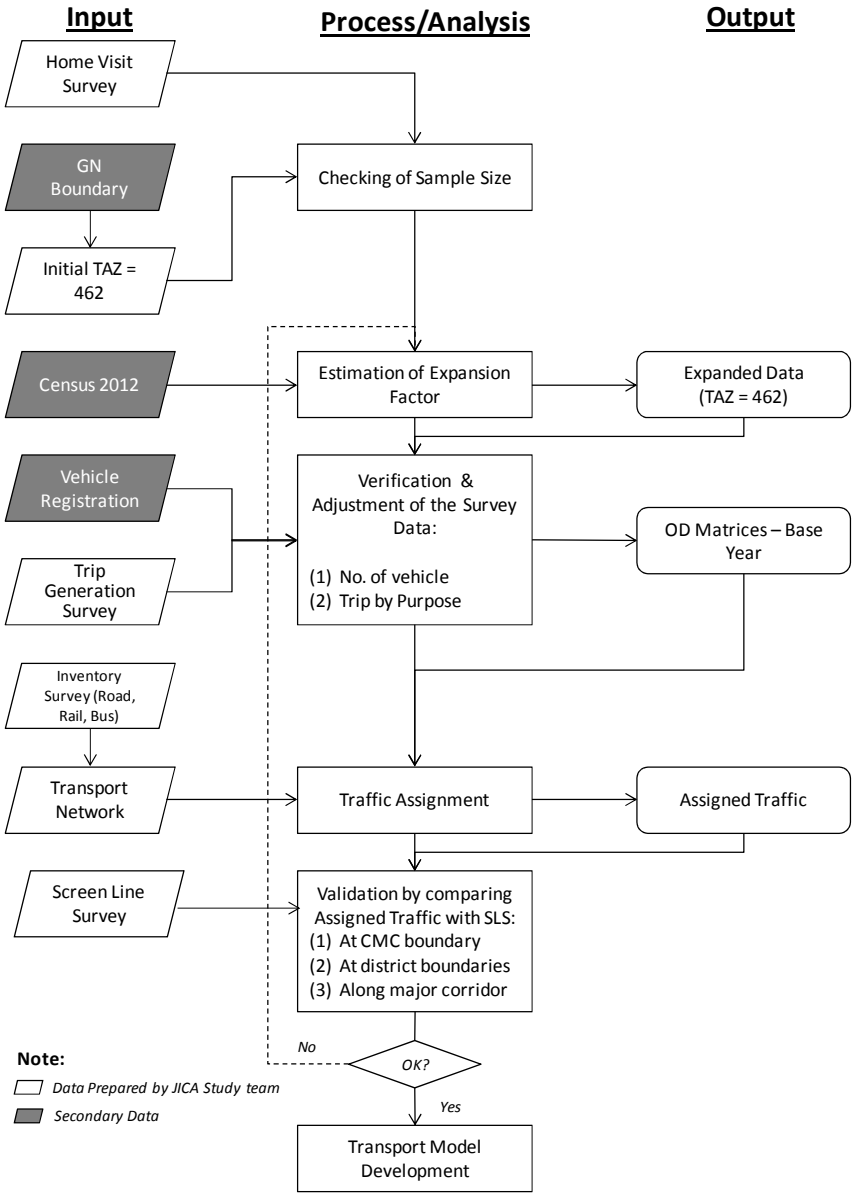


Figure 2.1.1 Procedure for Validation of HVS Data

2.2 Problems Observed after First Data Aggregation

There was a sample bias of household by income level as the data was over-represented by the households with monthly income below Rs. 40,000, the group C given on the survey form. Because household income strongly influences the trip making patterns (e.g. trip frequency, trip purpose, transport mode, etc.), the total number of trips could be under estimated unless correct data adjustment is made.

In addition, it was observed that trips which are made on a regular basis such as commuting trips were well recorded on the survey forms; however, other trip purposes which maybe thought as less important by certain respondents were not fully captured.

2.3 Attempts for Verification of the Survey Data

2.3.1 Report from the Field

Household lists given to the surveyors were prepared using random sampling techniques based on the election registration data. Nevertheless, surveyors encountered refusal from some households. The majority of these households belong to the group A (monthly income: Rs 80,000 and more). The main reasons for rejection were that they could not find time to fill in the comprehensive survey forms or they do not want to reveal the information pertaining to their personal households and trips.

2.3.2 Investigation on Vehicle Ownership

The total number of vehicles in Western Province was estimated using HVS data and compared with the statistics of registered vehicle. It shows that the estimated number of private cars and motorcycles respectively represents 53% and 77% of the registered vehicles. This indicates that the share of Group C households is too high.

To solve this problem, the statistics of registered vehicles were used to correct the sample bias in which the proportion of income was adjusted without changing the total number of households.

2.3.3 Comparison with Result of Trip Generation Survey

After the adjustment of the share of household income, the trip by purpose was estimated and compared with the result of the trip generation survey. The comparison shows a notable difference for non-commuting trips; therefore, the correction was made by using data from the trip generation survey. Initial OD matrices were prepared at this stage.

2.3.4 Comparison with Screen Line Survey Result

The initial OD matrices were used to conduct traffic assignment. The assigned traffic at certain observation points along the CMC boundary was compared with the screen line survey results. The assigned traffic volume and real traffic count should be close enough otherwise the adjustment from the earlier steps were repeated.

2.4 Result of Correction of Sample Bias

The estimated number of households, population, and trips before and after adjustment are shown in Table 2.4.1.

Table 2.4.1 Survey Data before and after Adjustment

Items	Before Adjustment			After Adjustment		
	Group C	Group B	Group A	Group C	Group B	Group A
No. of Households (‘000)	1,111	270	74	1,017	323	116
Population (5 yrs. old and above) (‘000)	3,903	1,130	308	3,571	1,350	481
No. of Trips (‘000)	5,822	2,420	1,006	6,160	2,697	1,233

CHAPTER 3 Demographic and Household Features

3.1 Population

3.1.1 Population by Gender and Age Group

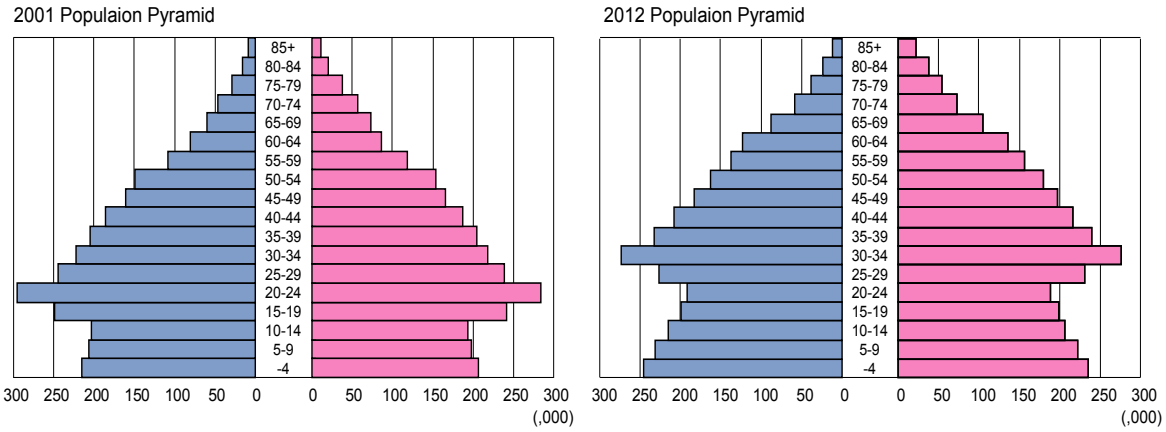
Population 2012 was estimated based on the Population Census 2001, Statistics on Vital Events 2000-2010 and the registered number of Live Births and Deaths of Usual Residents by district from 2000 to 2007.

The 5-year age group populations in 2001 and 2012 are shown in Table 3.1.1, and Population Pyramids in 2001 and 2012 are shown in Figure 3.1.1.

Table 3.1.1 Population by Sex and 5-year Age Group of Western Province

Population	2001 Census			2012 Estimation		
Age Group	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
Less than 4	214,669	205,959	420,628	246,027	235,435	481,462
5-9	206,153	197,097	403,250	231,906	223,027	454,933
10-14	203,570	192,537	396,107	214,386	205,915	420,301
15-19	249,063	240,969	490,032	198,305	198,601	396,906
20-24	296,307	284,486	580,793	191,065	189,242	380,307
25-29	243,825	238,584	482,409	227,127	231,172	458,299
30-34	222,523	218,354	440,877	273,075	277,091	550,166
35-39	204,606	205,221	409,827	232,004	240,385	472,389
40-44	185,462	187,408	372,870	207,224	216,659	423,883
45-49	160,929	164,649	325,578	182,153	197,099	379,252
50-54	148,519	152,883	301,402	162,076	180,019	342,095
55-59	108,798	117,788	226,586	136,980	156,143	293,123
60-64	79,783	86,971	166,754	122,136	136,028	258,164
65-69	60,545	72,803	133,348	87,405	104,846	192,251
70-74	46,404	57,317	103,721	58,267	73,137	131,404
75-79	29,825	38,399	68,224	37,915	54,723	92,638
80-84	16,330	21,053	37,383	23,522	37,617	61,139
85 and over	9,085	12,323	21,408	11,675	21,328	33,003
Total	2,686,396	2,694,801	5,381,197	2,843,248	2,978,467	5,821,715

Note: Populations by age group in 2012 are estimated by CoMTrans Study Team
Source: Census of Population and Housing 2001 and 2012, Department of Census and Statistics



Note: Populations by age group in 2012 are estimated by CoMTrans Study Team
Source: Census of Population and Housing 2001 and 2012, Department of Census and Statistics

Figure 3.1.1 Population Pyramids of Western Province (2001 and 2012)

3.1.2 Population by Social Status

Table 3.1.2 and Figure 3.1.2 show the population by social status group. The majority of males are workers while the majority of females are housewives. Share of male and female students are about the same.

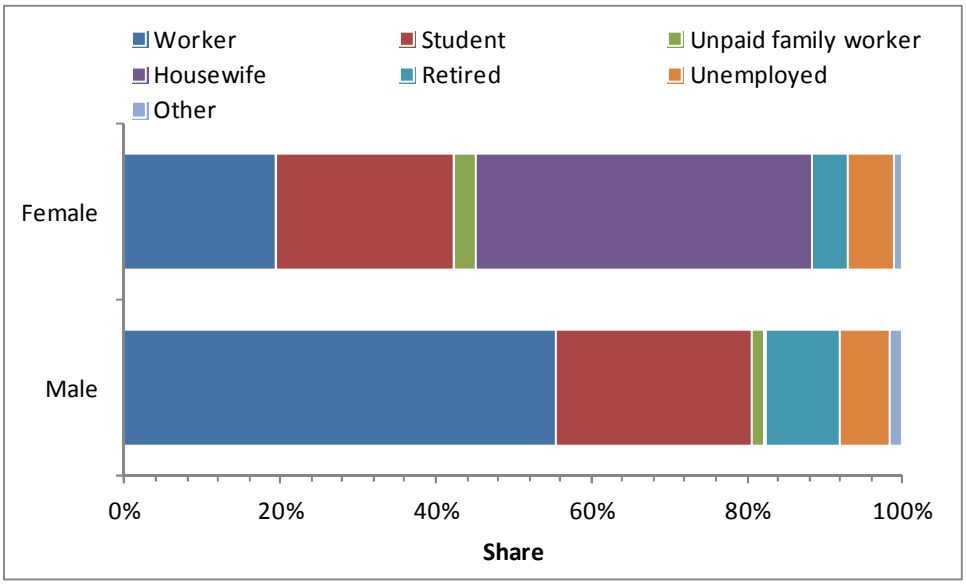


Figure 3.1.2 Share of Population by Social Group

Table 3.1.2 Distribution of Population by Social Status

No.	Social Status	Social Group	Population (5yr and above)	Share
1	Working (Full Time)	Worker	1,513	28.0%
2	Working (Part Time)		463	8.6%
3	Kindergarten	Student	18	0.3%
4	Student (grade 1-5)		447	8.3%
5	Student (grade 6-8)		294	5.4%
6	Student (grade 9-10)		180	3.3%
7	Student (O/L)		128	2.4%
8	Student (A/L)		151	2.8%
9	Student (Graduate)		46	0.9%
10	Student (P. Grad.)		1	0.0%
11	Student (PhD)		0	0.0%
12	Other Students		30	0.6%
13	Unpaid family worker	Unpaid family worker	122	2.3%
14	Housewife	Housewife	1,224	22.7%
15	Retired	Retired	376	7.0%
16	Unemployed	Unemployed	336	6.2%
17	Other	Other	74	1.4%
	Total		5,402	100%

3.2 Household

3.2.1 Household Income

Table 3.2.1 shows the estimated number of households by monthly income. Almost 70% of the households earn less than Rs. 40,000 per month and 22% belong to Rs. 40,000 – 79,999. Less than 10% of the households in Western province earn Rs. 80,000 or more.

3.2.2 Household Expenditure

Table 3.2.2 shows the estimated number of households in the Western province by monthly expenditure. Around 82% of the households spend less than Rs. 40,000 per month.

Table 3.2.1 Number of Households by Monthly Income

No.	Monthly Household Income	Households ('000)	Share
1	< Rs.40,000	1017	69.8%
2	Rs.40,000 - Rs.79,999	323	22.2%
3	Rs.80,000 - Rs.119,999	73	5.0%
4	Rs.120,000 - Rs.159,999	21	1.4%
5	Rs.160,000 - Rs.199,999	8	0.6%
6	Rs.200,000 - Rs.299,999	7	0.5%
7	Rs.300,000 - Rs.399,999	3	0.2%
8	Rs.400,000 -	1	0.1%
9	Unknown	3	0.2%
	Total	1,456	100.0%

Table 3.2.2 Number of Households by Monthly Expenditure

No.	Monthly Household Income	Households ('000)	Share
1	< Rs.40,000	1192	81.9%
2	Rs.40,000 - Rs.79,999	207	14.3%
3	Rs.80,000 - Rs.119,999	36	2.5%
4	Rs.120,000 - Rs.159,999	8	0.6%
5	Rs.160,000 - Rs.199,999	5	0.3%
6	Rs.200,000 - Rs.299,999	3	0.2%
7	Rs.300,000 - Rs.399,999	1	0.1%
8	Rs.400,000 -	0	0.0%
9	Unknown	3	0.2%
	Total	1,456	100.0%

3.2.3 Transport Expenditure

Figure 3.2.1 depicts the composition of monthly household transport expenditure by income group. As expected, the general trend is that Group C households spend less and Group A households spend more on monthly transport. As much as 69% of Group C households (i.e. households with income less than Rs. 40,000) spend no more than Rs. 4,000 on transport, while

only 33% and 13% of Group B (Rs. 40,000 – Rs. 79,999) and Group A households (Rs. 80,000 and above), spend Rs 4,000 or less on transport. It is interesting to note that for the Group B, 27% of the households spend more than Rs. 8,000 which is more than 10% of their household income. For the Group A, almost 50% spend over Rs. 10,000 for transport.

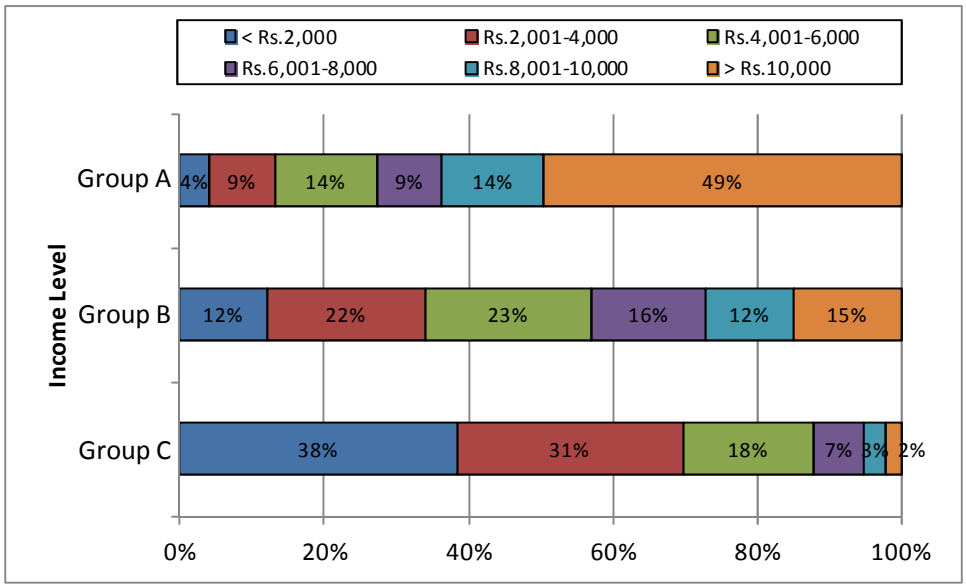


Figure 3.2.1 Distribution of Household Monthly Transport Cost by Income Group

The average monthly transport cost of Group C, Group B and Group A are Rs. 3,584, Rs. 6,998 and Rs. 14,929 respectively. The transport cost of the Group B households is almost double that of the Group C ones; transport cost of the Group A households is as high as 4 times that of the Group C. On average, 14%, 16%, and 17% of the total household expenditure of group C, group B, and group A, respectively, are spent on the transport cost.

Table 3.2.3 Average Household Transport Cost and its Ratio to Total Expenditure

Household Income Group	Average Household Monthly Expenditures (Rs./month)	Average Household Monthly Transport Cost (Rs./month)	Ratio of Transport Cost to Total Expenditures
Group C	26,307	3,584	14%
Group B	43,303	6,998	16%
Group A	88,432	14,929	17%

3.2.4 Vehicle Ownership

In subsequent analysis, household income is classified into 3 major groups: Group C, Group B, and Group A.

In general, vehicle ownership of the household is closely correlated with household income. It is

observed that the percentage of car-owning households increases proportionately with income. In contrast, the percentage of motorcycle-owning households shows a gradual decrease when income is Rs. 80,000 and beyond.

Based on this analysis, the three income groups are classified which will be used throughout the remaining chapters of this report:

- Group C: Less than Rs. 40,000 per month;
- Group B: Rs. 40,000 – Rs. 79,000 per month;
- Group A: Rs. 80,000 per month or more.

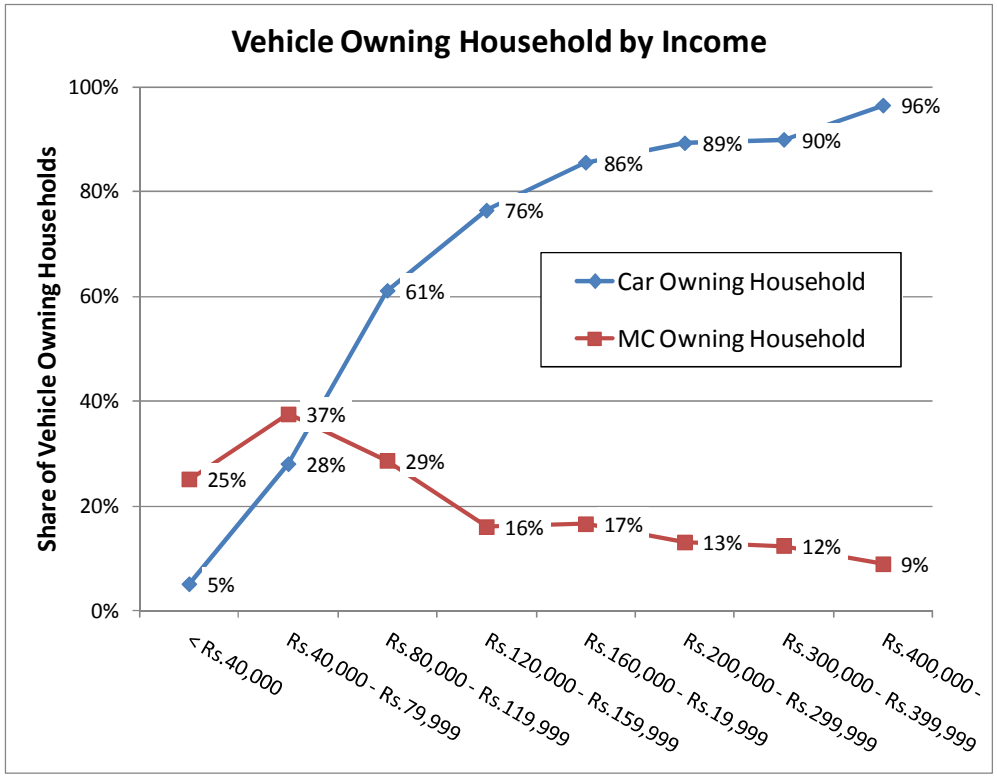


Figure 3.2.2 Distribution of Vehicle Owning Households by Income

CHAPTER 4 Trip Purpose based on HVS

4.1 Trip Purpose Composition

It is estimated that around 10 million trips are made by residents in Western Province. Trip purpose composition is shown in Figure 4.1.1.

Aside from "To home" trips, the "To work", "Private matters" and "Education" trips are the major purposes and the share of these trips are 19%, 19% and 13% respectively. Compared to the major trip purposes, "Business, "Shopping" and "Other" trips respectively present only 4%, 3% and 3%.

It should be noted that the share of the trips made for the purpose of "Private matters" is as high as "To work" trips. Table 4.1.1 provides the detail about from and to where private matter trips are made by showing the facility types at origin and at destination. This basic analysis shows that the majority of the private matter trips are made for sending children to school since 52% of the trips start from homes and 47% end at educational facilities.

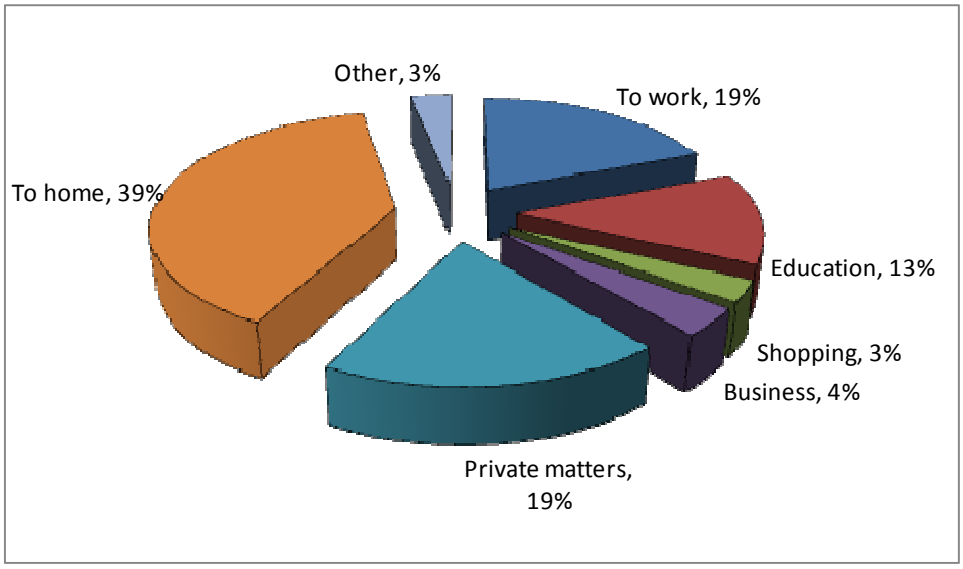


Figure 4.1.1 Trip Purpose Composition in Western Province

Table 4.1.1 Facility Types at Origin and Destination of Private Matter Trips

No.	Facility Type	Trip ('000)		Share	
		Origin	Destination	Origin	Destination
1	Residence, dormitory	983	139	52%	7%
2	Government, public office	80	114	4%	6%
3	Business office, private company	134	106	7%	6%
4	Educational facility	385	899	20%	47%
5	Religious facility	16	70	1%	4%
6	Medical facility	41	154	2%	8%
7	Accommodation, entertainment facility	47	18	0%	1%
8	Restaurant	5	16	0%	1%
9	Retail, Traditional market	23	67	1%	4%
10	Supermarket	13	22	1%	1%
11	Shopping mall, shopping plaza	21	33	1%	2%
12	Grocery market	12	30	1%	2%
13	Factory	23	11	1%	1%
14	Warehouse, storage facility	3	3	0%	0%
15	Transport, communication facility	104	69	5%	4%
16	Supply, disposal facility	3	7	0%	0%
17	Recreational, sport facility	5	16	0%	1%
18	Park, natural environmental area, etc.	2	5	0%	0%
19	Agricultural, forestry and fishery areas	4	5	0%	0%
20	Construction site	20	14	1%	1%
21	Other	20	103	1%	5%
22	Unknown	3	3	0%	0%
	TOTAL	1,904	1,904	100%	100%

4.2 Home Based Purpose

To make it suitable for subsequent analyses and the approach used in the demand forecasting, the "original" trip presented for the above purposes were rearranged respectively into seven and four so-called home-based purposes depending on the type of origin and destination of trips.

Hereafter, analyses by purpose will be done by using these home-based purposes except for certain cases in which the "original".

Table 4.2.1 Trip by Purpose in Western Province (Home-based Purpose)

No.	7 Home-based Purpose	4 Home-based Purpose	No. of Trips ('000)	Share
1	Home to Work	Home-based Work	1,350	13%
2	Work to Home		1,344	13%
3	Home to Education	Home-based Education	1,174	12%
4	Education to Home		1,151	11%
5	Home to Other	Home-based Other	1,458	15%
6	Other to Home		1,415	14%
7	Non-Home-Based	Non-Home-Based	2,154	21%
	Total		10,045	100%

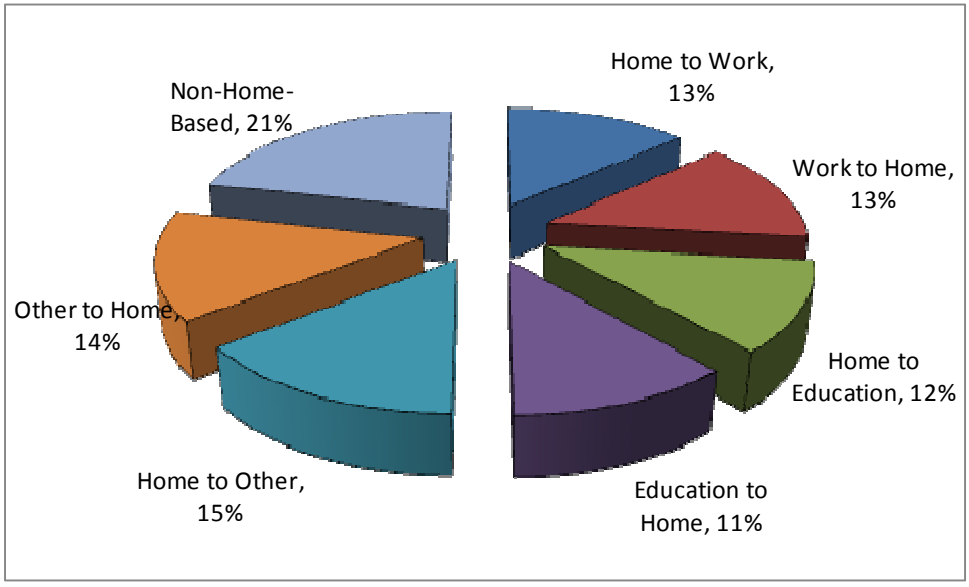


Figure 4.2.1 Trip Purpose Composition in Western Province (Home-based Purpose)

4.3 Trip Purpose by Region

Figure 4.3.1 presents tip purpose comparison between CMC, CMA, and the suburban area at trip origin.

In CMC, the majority of trips made are for the purposes of non-home-based, work to home, education to home, and other to home implying that most work places, education institutions, and other facilities that are concentrated in CMC attract many residents from outside of the city. At the CMA level, however, there is almost a balance between home to work and work to home, home to education and education to home, and home to other and other to home. This means

that residents of CMA commute to their work place or educational institution or travel to other facilities located within CMA.

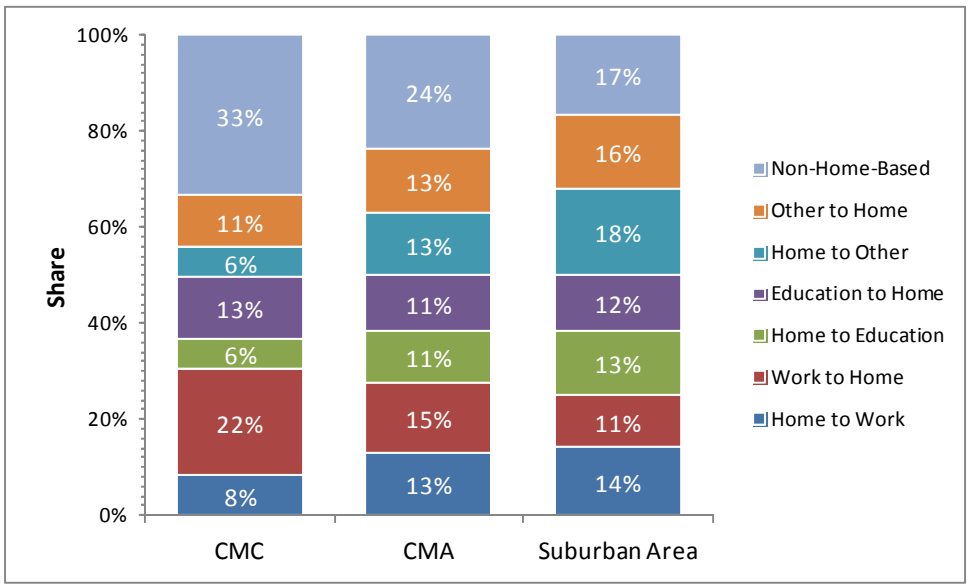


Figure 4.3.1 Trip Purpose Comparison at Trip Origin

4.4 Trip Purpose by Socio-economic Group

4.4.1 By Gender

Males make more home-based work and non-home-based trips than females do. However, the portion of trip for home-based education and home-based other purposes are high for females.

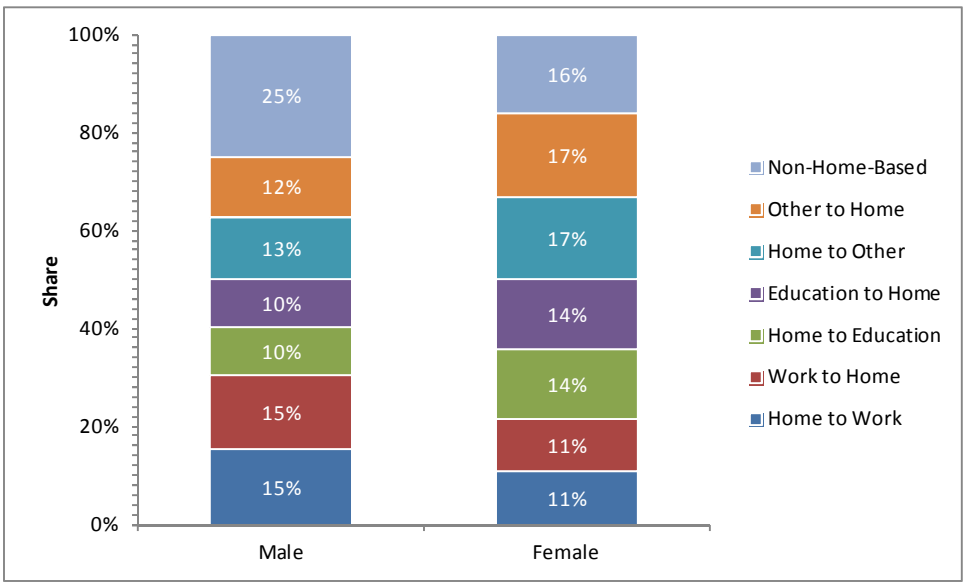


Figure 4.4.1 Trip Purpose Composition by Gender in Western Province

4.4.2 By Age Group

For age groups below 20 years old, trips are dominated by home-based education (home to education and education to home) purpose. Except for the age between 20 and 30 years old, home-based work (home to work and work to home) trips from the age of 30 to 60 years old show no significant difference, but this trip purpose drops drastically after 60 years old as the retired population dominate the group. Home-based other trips grow as the age increases.

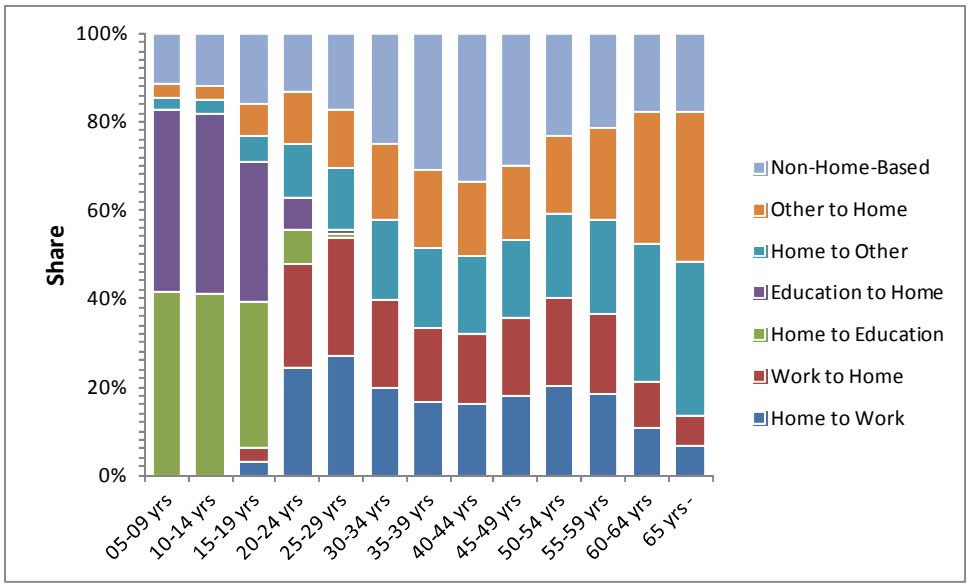


Figure 4.4.2 Trip Purpose Composition by Age Group in Western Province

4.4.3 By Social Status Group

The shares of home to work and work to home trips for workers and home to education and education to home trips for students are dominant.

Trips made by housewives, retired, unemployed, other, and unpaid family worker groups are mainly dominated by home to other and other to home purposes.

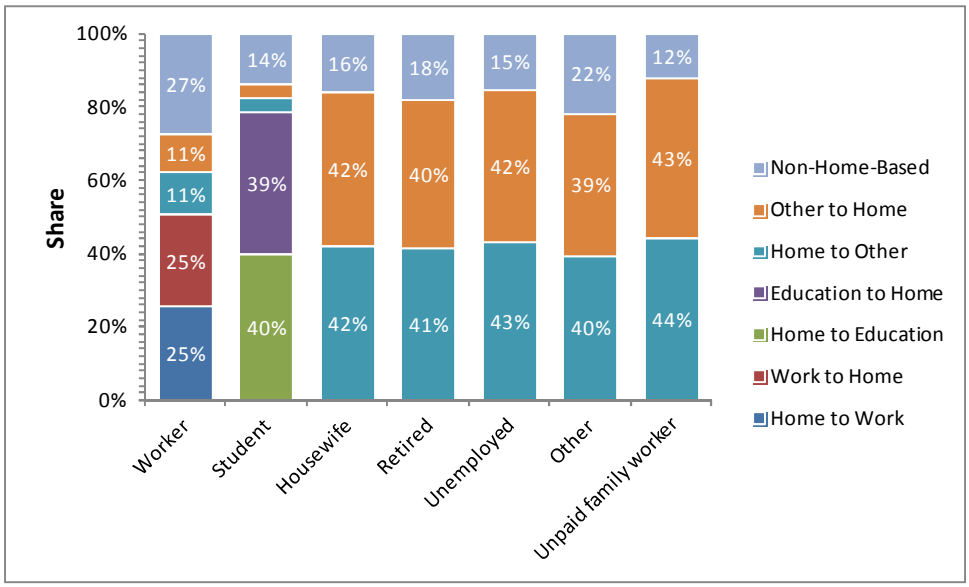


Figure 4.4.3 Trip Purpose Composition by Social Status Group in Western Province

4.4.4 By Income Level

Out of 10 million trips made every day by residents of Western Province, the trips belonging to Group C, Group B, and Group A residents are 61%, 27%, and 12% respectively.

Figure 4.4.4 depicts that the share of non-home-based trips increases proportionately with the household income level.

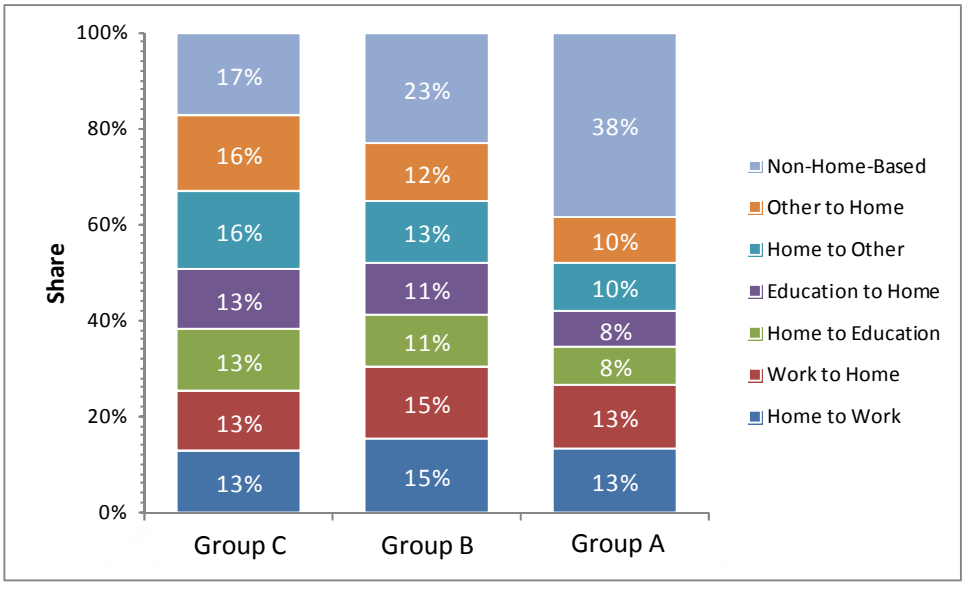
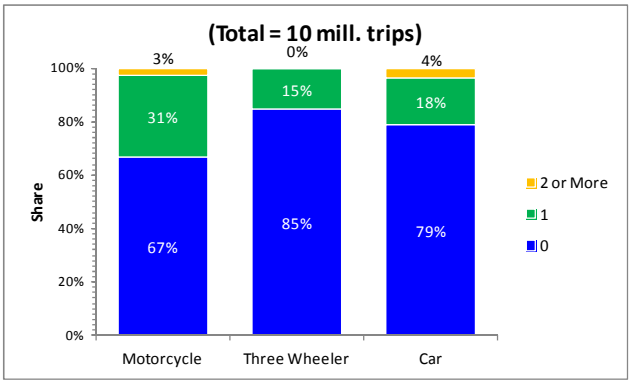


Figure 4.4.4 Trip Purpose Composition by Household Income Level in Western Province

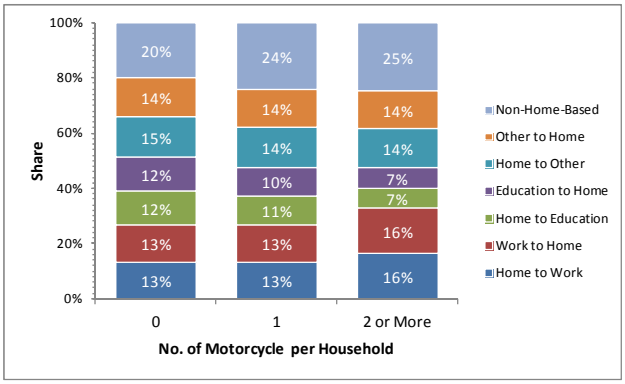
4.4.5 By Vehicle Ownership

Among all trip purposes, non-home-based trips noticeably increase with the number of vehicles owned by the household. This trend is moderate among motorcycle owning households, and it becomes considerable among car owning households.

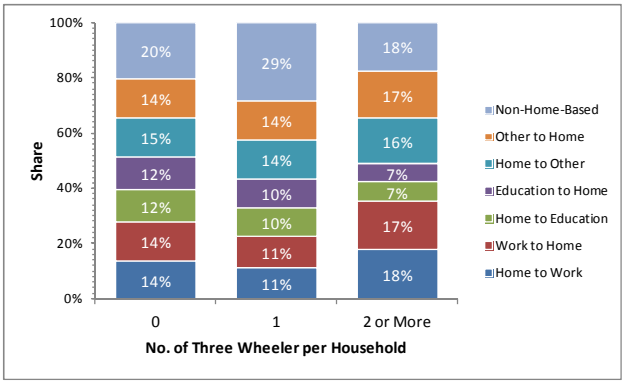
As for the three-wheeler owing households, the sample of households having 2 or more three-wheelers is very small. Nevertheless, there is an increase of non-home-based trips comparing households without three-wheelers to those having one three-wheeler.



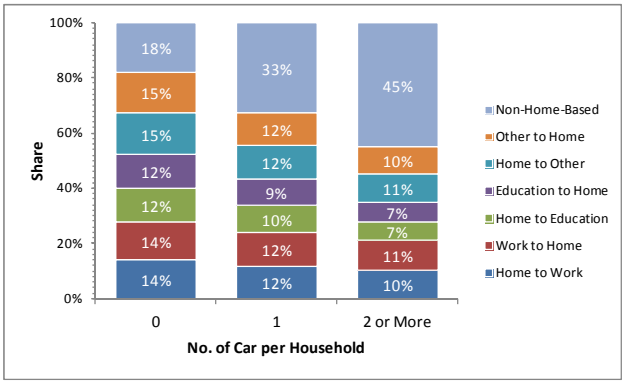
(a) Share of Trips by Household Vehicle Ownership



(b) Trip Purpose Composition by Motorcycle Ownership



(b) Trip Purpose Composition by Three Wheeler Ownership



(b) Trip Purpose Composition by Car Ownership

Figure 4.4.5 Trip Purpose Composition by Household Vehicle Ownership

CHAPTER 5 Trip Production based on HVS

5.1 Total Trips Produced

It is estimated that around 10 million trips are made every day by residents from the 1.46 million households of the study area. About 1.8 million trips are produced with an origin in CMC among which about 1.1 million trips are intra-city trips. Over 1.4 million trips are made between CMC and the rest of Western Province; the majority are trips between CMC and the rest of Colombo District.

Table 5.1.1 Number of Trips Made

Region (Trip Origin)	Trips per Weekday ('000)		
	NMT	Other Modes	Total
CMC	275	1,566	1,840
CMA	1,263	5,679	6,942
Western Province	2,160	7,885	10,045

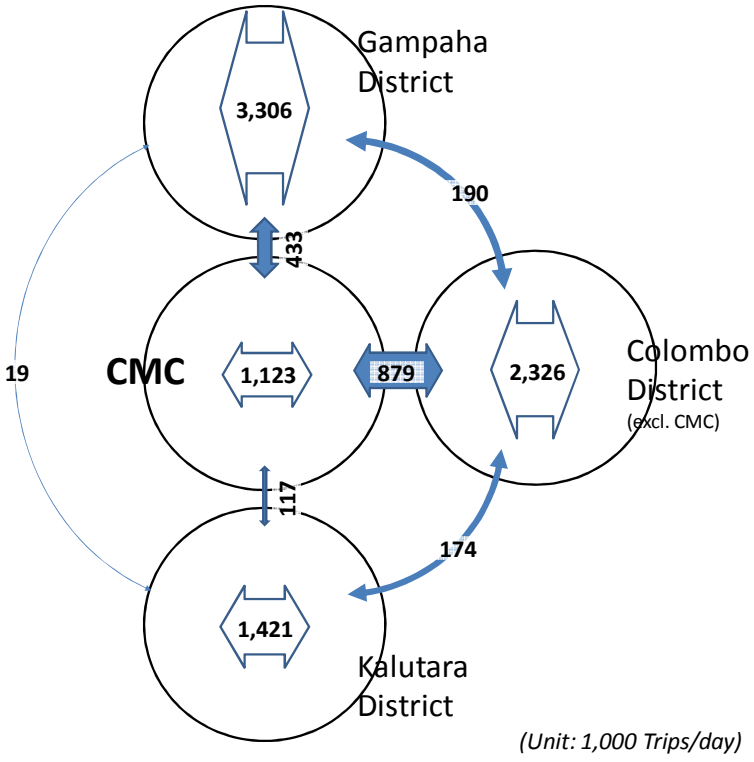


Figure 5.1.1 Movement of Residents in the Study Area

5.2 Trip Production Rate

Trip production rate is an important indicator to understand travel behaviour of the residents in the study area and it is also used for measuring future trip production. Trip production rate, defined as the average number of trips made per resident per weekday, is characterised by two indicators: gross trip rate and net trip rate. Gross trip rate is calculated by dividing the total number of trips per weekday by the number of residents aged 5 years or older whereas net trip rate is calculated by dividing the total number of trips per weekday by the number of residents aged 5 years or older who made a trip.

Trip rate and out-going ratio by residential location obtained from CoMTrans Home Visit Survey 2013 is presented in Table 5.2.1. It shows that the out-going ratio is relatively low in Western Province where only 64.5% of the residents are estimated to make a trip on a given weekday. There is only a small difference between the out-going ratio of CMA and that of the suburban areas; however, their trip rates are notably different.

Table 5.2.1 Out-going Ratio and Trip Production Rate by Region

	Region	Out-going Ratio	Gross Trip Rate	Net Trip Rate
Residential Area	CMC	64.9%	1.81	2.79
	CMA	65.2%	1.92	2.95
	Suburban	63.3%	1.77	2.80
	Western Province	64.5%	1.87	2.90
Trip Origin Location	CMC	-	3.51	5.41
	CMA	-	2.00	3.07
	Suburban	-	1.63	2.58
	Western Province	-	1.87	2.90

5.3 Trip Production Rate by Socio-economic Group

5.3.1 By Gender and Age Group

Trip making behaviour of males and females in the Western Province differ significantly. On average, the out-going ratio and trip rate per weekday of males are 77% and 2.35, while that of females are 53% and 1.43 respectively.

The following figure reveals the decline of the out-going ratio and trip rate of females as age increases. It is interesting to note that both males and females have equally high out-going ratios and trip rates when the age is below 20 years, the school-attending age.

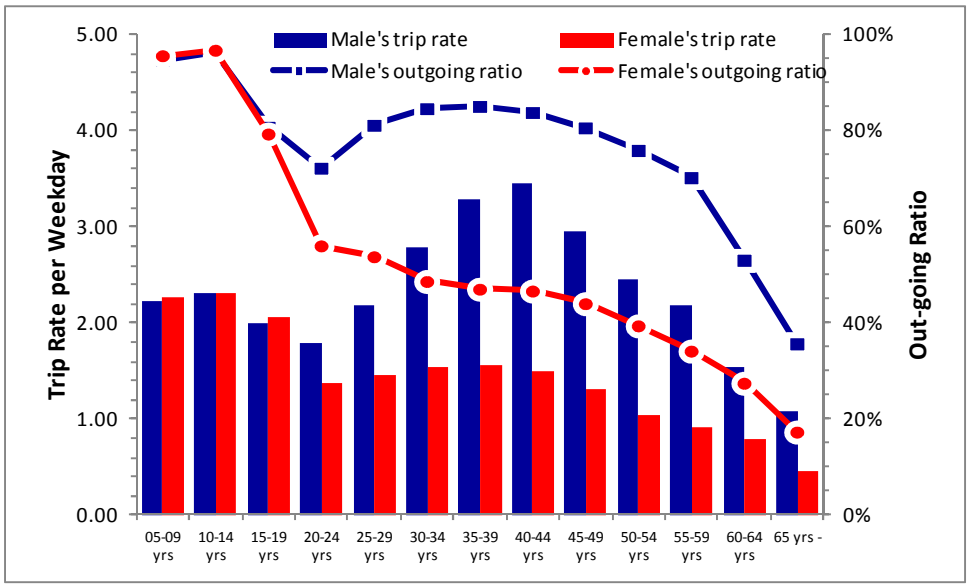


Figure 5.3.1 Out-going Ratio and Trip Rate by Age Group and Gender in Western Province

5.3.2 By Household Income

It is estimated that around 10 million trips are generated every day from 1.46 million households in the Western Province in which 71%, 22% and 7% belong to Group C, Group B and Group A households respectively.

Trip making behaviours, which are characterised by trip production rate and choice of transport mode, are significantly influenced by levels of income. It is observed that trip rate and out-going ratio increase proportionately with the household income level.

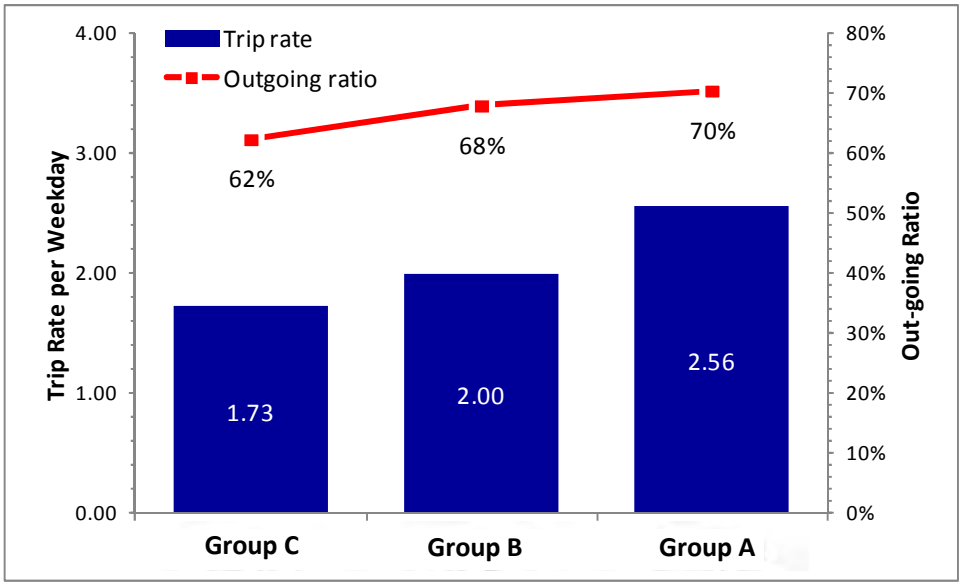
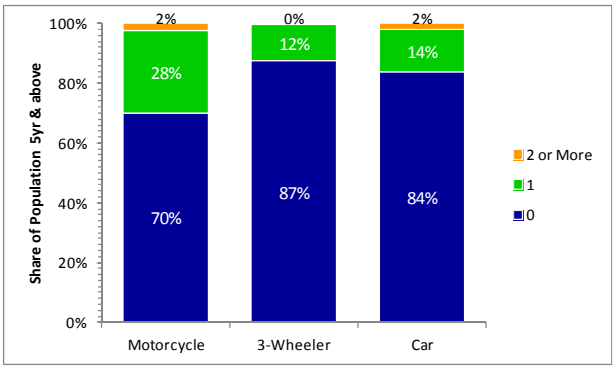


Figure 5.3.2 Out-going Ratio and Trip Rate by Income Group in Western Province

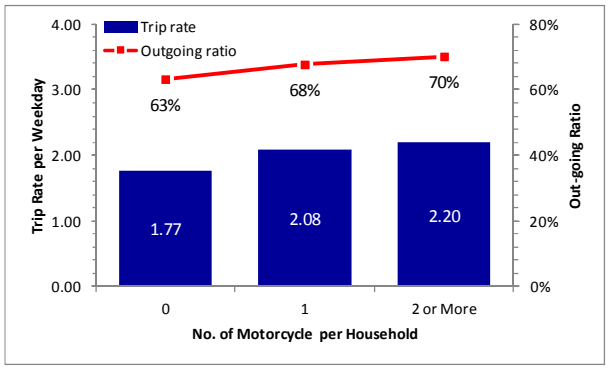
5.3.3 By Vehicle Ownership

Out-going ratio and trip rate by vehicle ownership is shown below in which three types of vehicles namely motorcycles, three wheelers, and cars are taken into consideration.

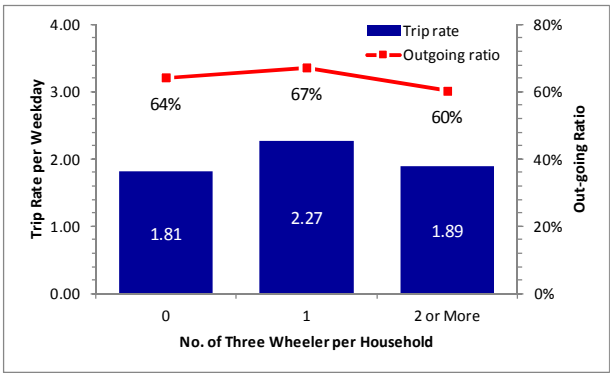
The figure generally depicts that individual members of the household made more trips when the household owned more vehicles. This trend is prevailing for members of car owning households. It is worth noting that the decline of trip rate and out-going ratio among those whose households own two or more three-wheelers may not be correct because the number of samples was too small to represent this category.



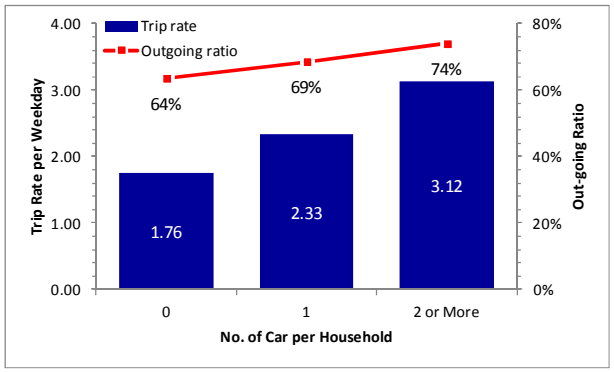
(a) Population Distribution by Number of Vehicles Owned



(b) Out-going Ratio and Trip Rate by Number of Motorcycles



(c) Out-going Ratio and Trip Rate by Number of Three Wheelers



(d) Out-going Ratio and Trip Rate by Number of Cars

Figure 5.3.3 Out-going Ratio and Trip Rate by Vehicle Ownership in Western Province

5.3.4 By Social Status

Out-going ratio and trip production rate vary depending on social status. Relatively high outgoing ratios and trip production rates are found in students and workers. These groups are the leading trip makers as they commute on a daily basis. On the other hand, other social status groups have much lower out-going ratios and trip production.

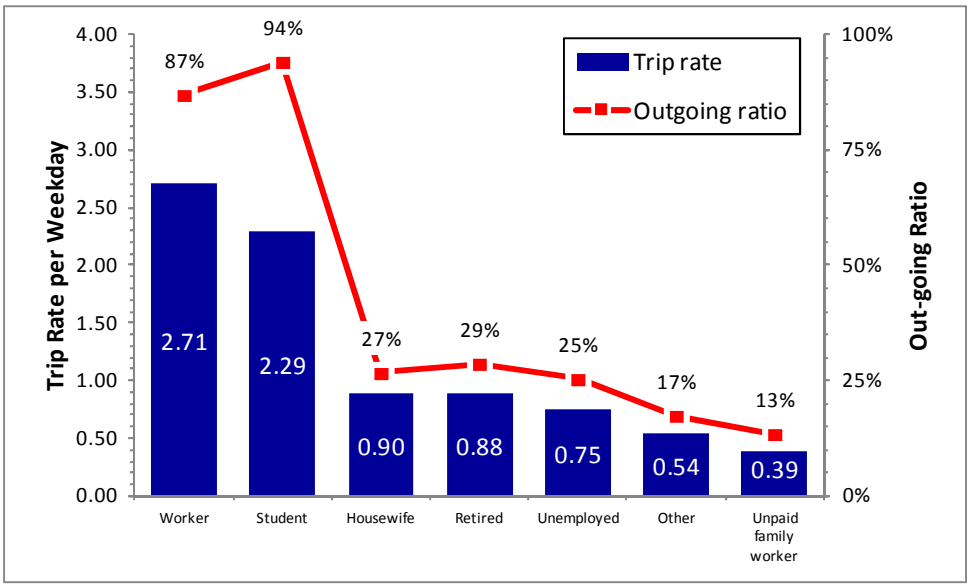


Figure 5.3.4 Out-going Ratio and Trip Rate by Social Status Group in Western Province

5.4 Trip Production Rate by Trip Purpose

Based on the breakdown of trip rate by purpose shown in Figure 5.4.1, non-home-based purpose has the highest trip rate. The next one is home to other followed by other to home, home to work, work to home, home to education and education to home.

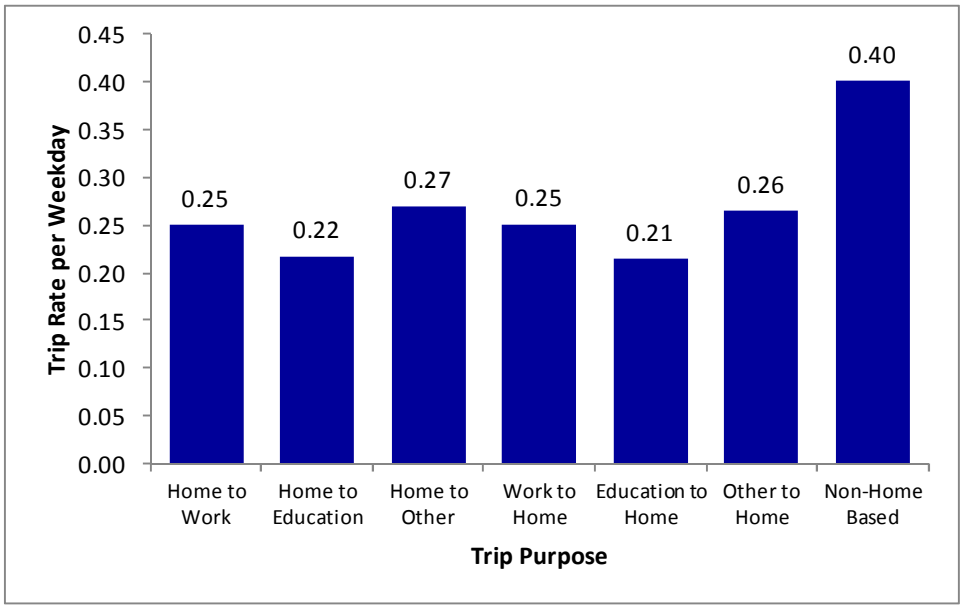


Figure 5.4.1 Trip Rate by Trip Purpose in Western Province

5.4.1 By Gender

Males have higher trip rates than females because they make significantly more trips for the purpose of home to work, work to home, and non-home-based.

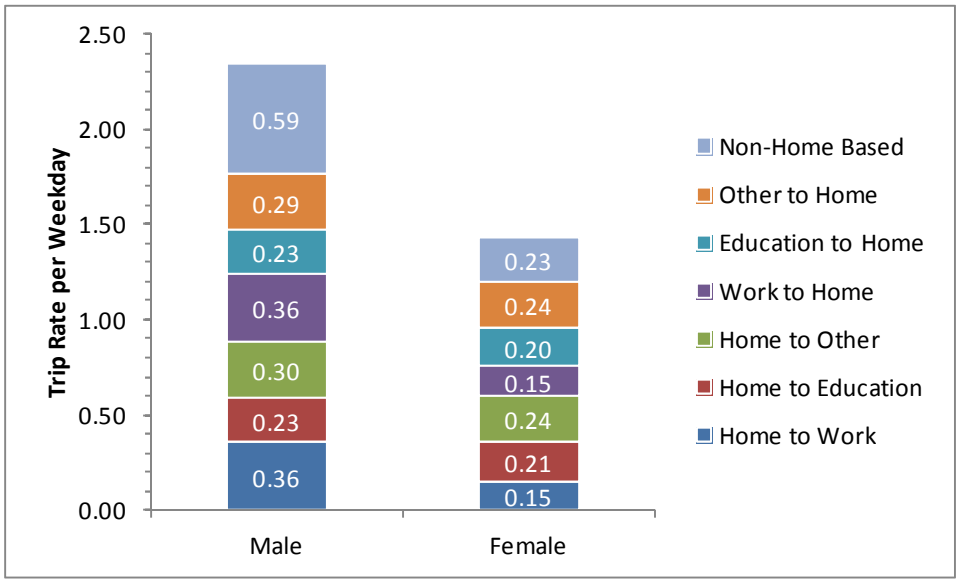


Figure 5.4.2 Trip Rate by Trip Purpose by Gender in Western Province

5.4.2 By Age Group

When the age is below 20 years, the major trips are made for home to education and education to home purposes. For older age groups, home to work, home to other, work to home, other to home, and non-home-based purposes have significant shares in the trip rates.

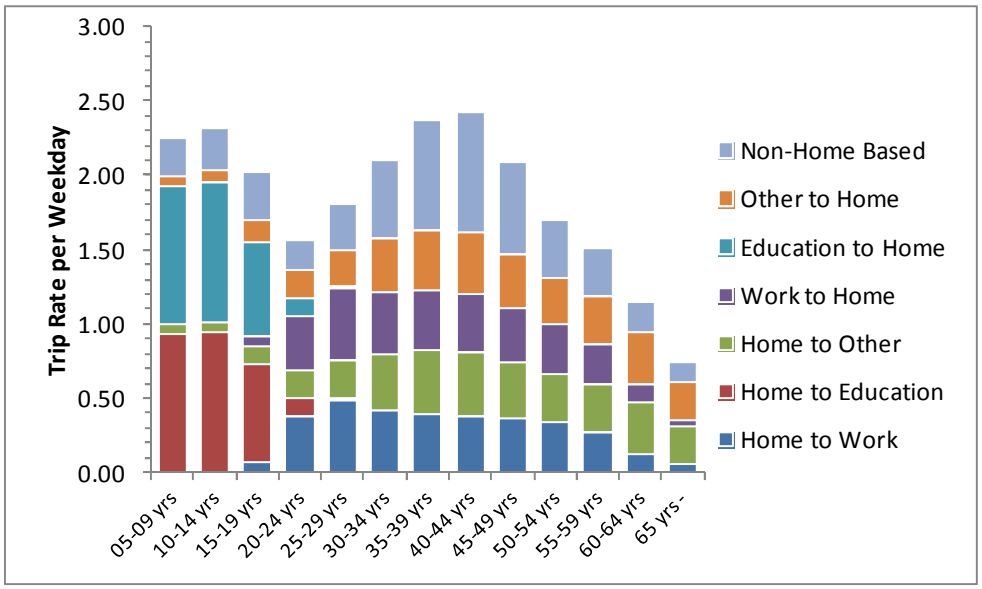


Figure 5.4.3 Trip Rate by Trip Purpose by Age Group in Western Province

5.4.3 By Household Income Level

As household income increases, it is observed that trip rates for the purpose of home to work, work to home, and non-home-based also noticeably increase.

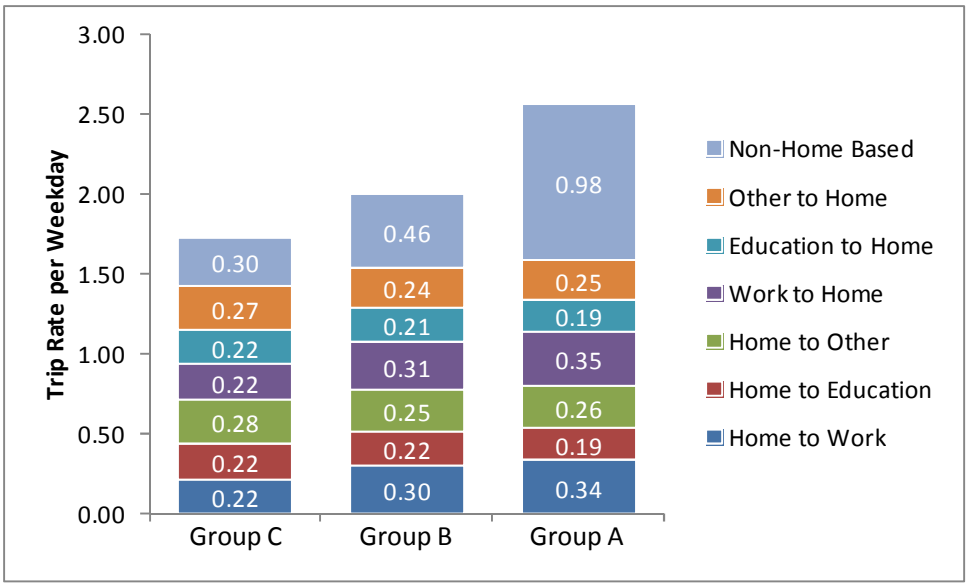


Figure 5.4.4 Trip Rate by Trip Purpose by Income Level in Western Province

5.4.4 By Social Status

Trip production rate for each social status varies according to trip purposes. For workers, higher trip rates are for home to work, work to home and non-home-based, while for students, higher trip

rates are home to education and education to home. For the remaining social status groups, trip rates consist mainly of home to other, other to home, and a small portion of non-home-based purposes.

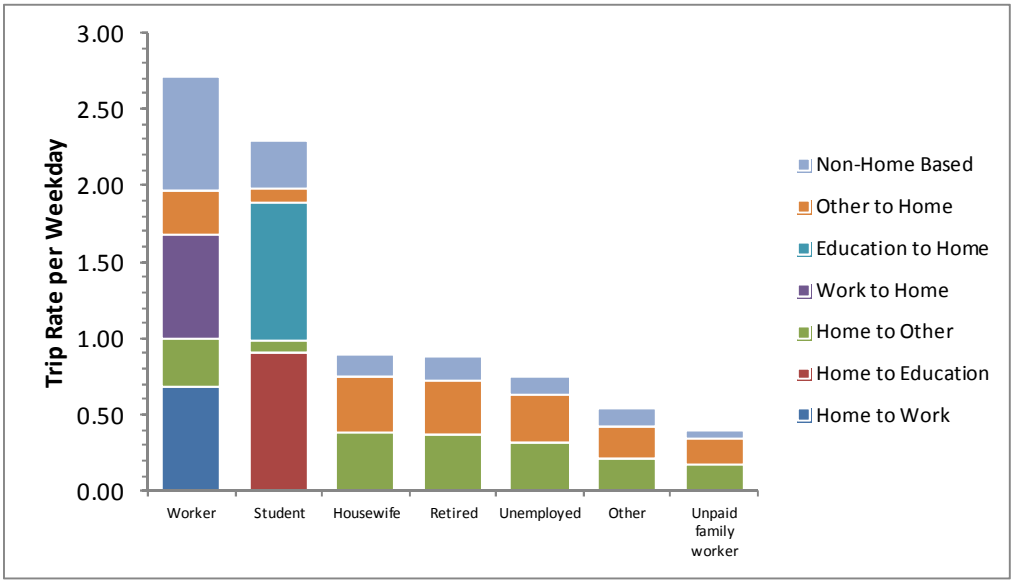


Figure 5.4.5 Trip Rate by Trip Purpose by Social Status Group in Western Province

CHAPTER 6 Transport Mode based on HVS

6.1 Modal Share

6.1.1 Modal Share in Western Province

Around 38% of all trips are made by private modes including cars, motorcycles, three wheelers and taxis while approximately 40% of trips are made by bus and railway. The remaining 22% of trips are made by non-motorised modes of transport.

Bus plays a vital role in daily movements of Western Province's residents as it carries almost half of all motorised trips. In contrast, the railway has extremely low modal share given the low coverage of the railway network comparing to the bus network.

Table 6.1.1 Modal Share in Western Province

No.	Mode of Transport	All Modes		Excluding NMT	
		Trips ('000)	Share	Trips ('000)	Share
1	Car	1,100	11.0%	1,100	14.0%
2	Motorcycle	1,413	14.1%	1,413	17.9%
3	Three Wheeler	1,286	12.8%	1,286	16.3%
4	Taxi	25	0.2%	25	0.3%
5	Bus	3,792	37.7%	3,792	48.1%
6	Railway	269	2.7%	269	3.4%
7	NMT	2,160	21.5%	-	-
Total		10,045	100.0%	7,885	100.0%

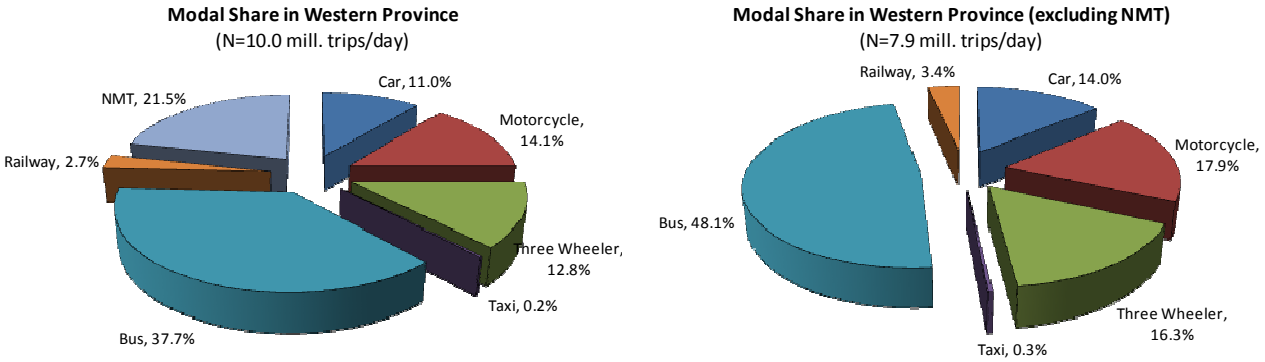


Figure 6.1.1 Modal Share in Western Province

6.1.2 Mode Transfer for Public Transport Users

In general, requiring transfers reduces ridership of public transport. While 74% of bus trips do not require any transfer between transport modes, only 26% of railway trips have this pattern. On average, bus users make 0.31 transfers per trip whereas railway users make 1.06 transfers per trip, more than three fold higher. Furthermore, bus service is highly accessible on foot as walking accounts for more than 90% of the access mode and egress mode of bus trips. Accessibility of the railway, however, relies on not only walking but also on other modes, particularly bus.

This analysis gives an implication that buses not only cover the study area widely, but also operate as trunk lines. Moreover, as long as the connection between bus and railway is not well organised, the issue of transferring remains a strong impedance for traveling by train.

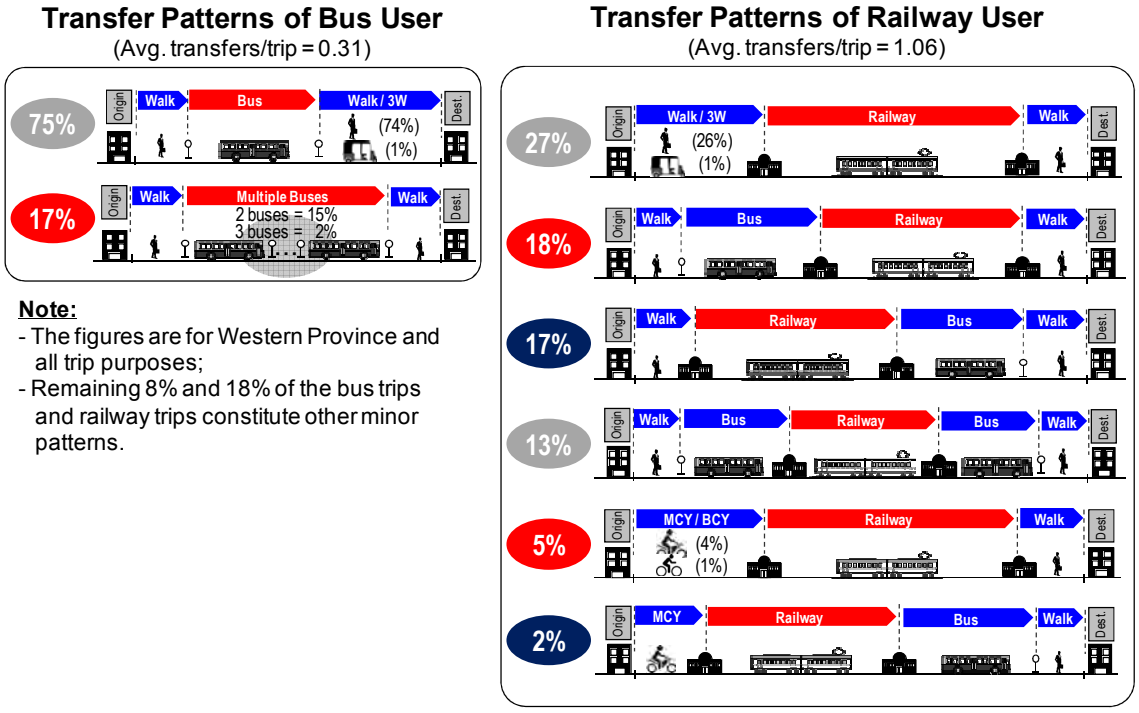


Figure 6.1.2 Major Patterns of Mode Transfer for Bus Users and Railway Users

6.1.3 Access and Egress Mode of Railway

Walking and bus constitutes 49% and 38% of the access mode and 51% and 40% of the egress mode respectively. Apart from these two major modes, motorcycle, three wheeler, bicycle, car and taxi form the remaining share of access and egress mode for the railway.

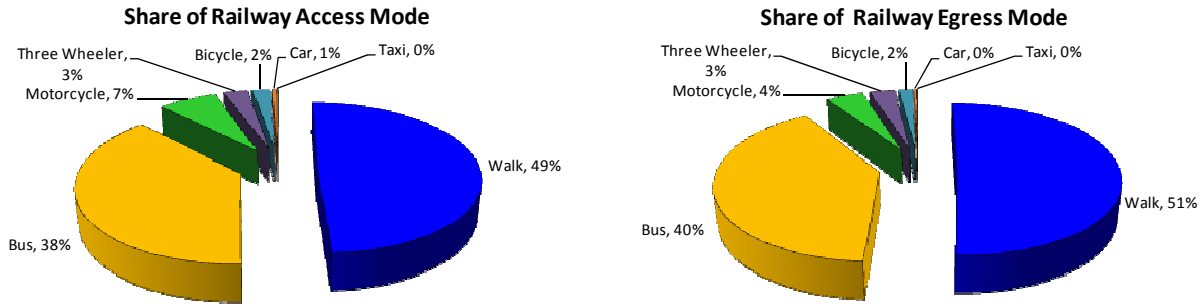


Figure 6.1.3 Access and Egress Modal Share for Railway

6.2 Modal Share by Socio-economic Group

6.2.1 By Gender

The modal share differs according to gender. Males largely depend on private transport modes such as cars and motorcycles, especially dependency on motorcycles is substantially stronger than for females. Meanwhile, females rely more on bus and non-motorised transport modes such as walking and bicycles.

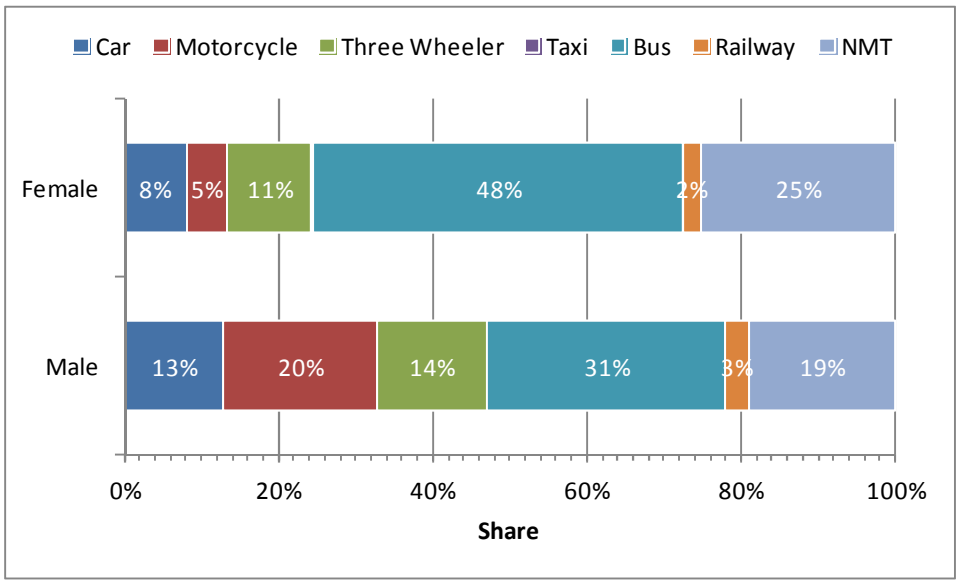


Figure 6.2.1 Modal Share by Gender in Western Province

6.2.2 By Age Group

Bus is dominant in all age groups. Modal shares of car and motorcycle gradually increase when

the age is between 25 to 45 years old. Car share become stagnant after 45 years old, but motorcycle share reduces.

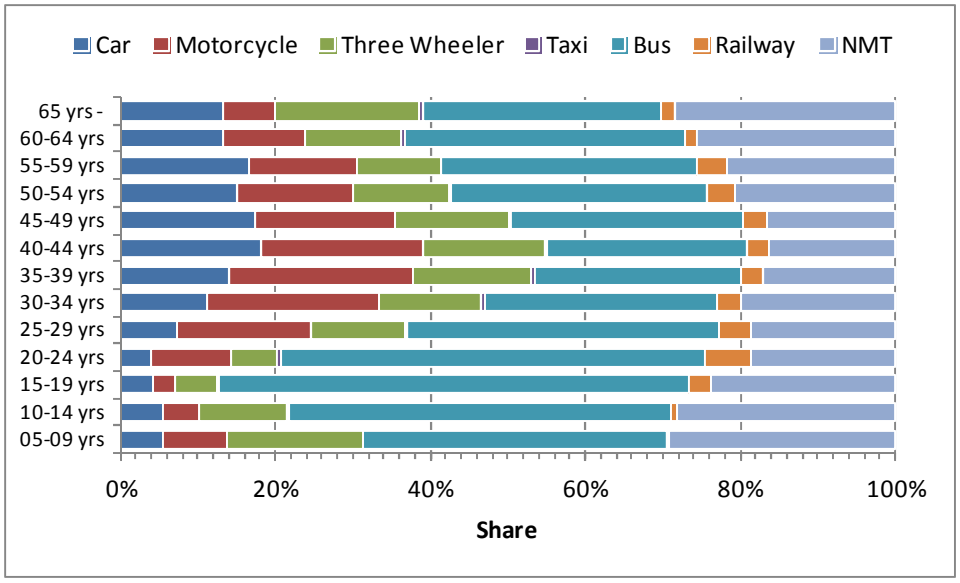


Figure 6.2.2 Modal Share by Age Group in Western Province

6.2.3 By Social Group

Again bus is the dominant mode for all social groups, and students have the highest rate of dependency on bus. Those who use private vehicles the most are workers, followed by retired and other groups. Meanwhile, housewives have the highest share of the non-motorised transport, the second mode after bus.

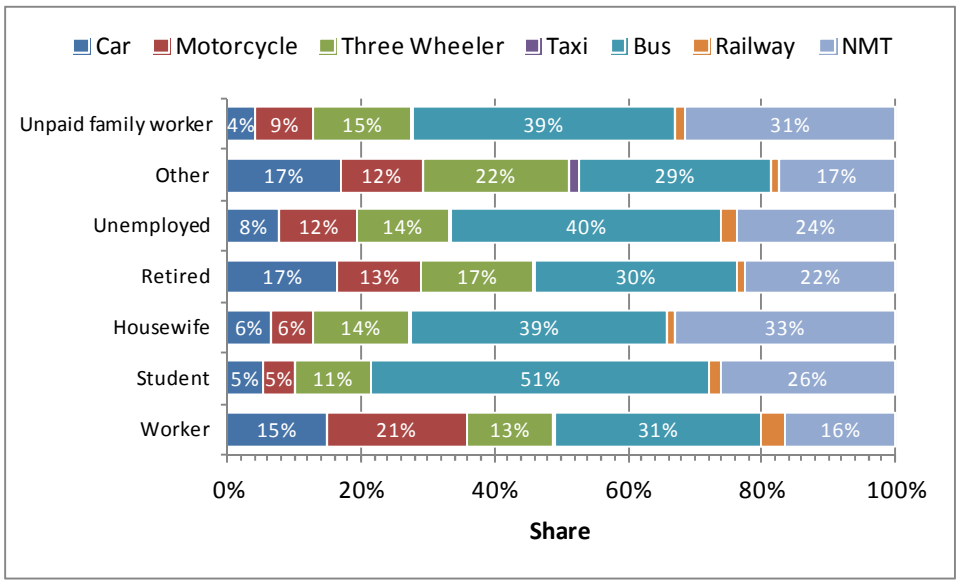


Figure 6.2.3 Modal Share by Social Group in Western Province

6.2.4 By Income

Modal share is significantly influenced by household income. Residents of Group A are more car dependent as almost half of their trips are made by car. Only a few of them use a non-motorised mode of transport (6%) compared to the Group C (28%). On the other hand, modal shares of bus transport are considerably high in all income groups.

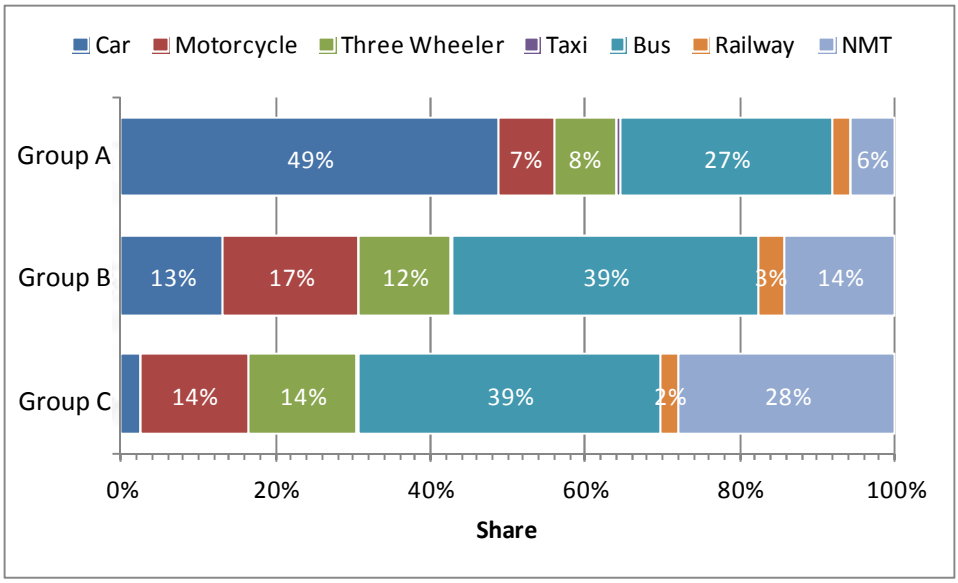


Figure 6.2.4 Modal Share by Income Level in Western Province

6.3 Modal Share by Trip Purpose

6.3.1 All Purposes

Modal share varies according to trip purpose. For almost every trip purpose, bus is always the dominant mode. More than half of the home-based education trips and almost half of the home-based work trips are made by bus. Modal share of three wheeler and motorcycle is about the same for home-based other trips. For non-home based trips, private modes, including car and motorcycle, are the leading ones.

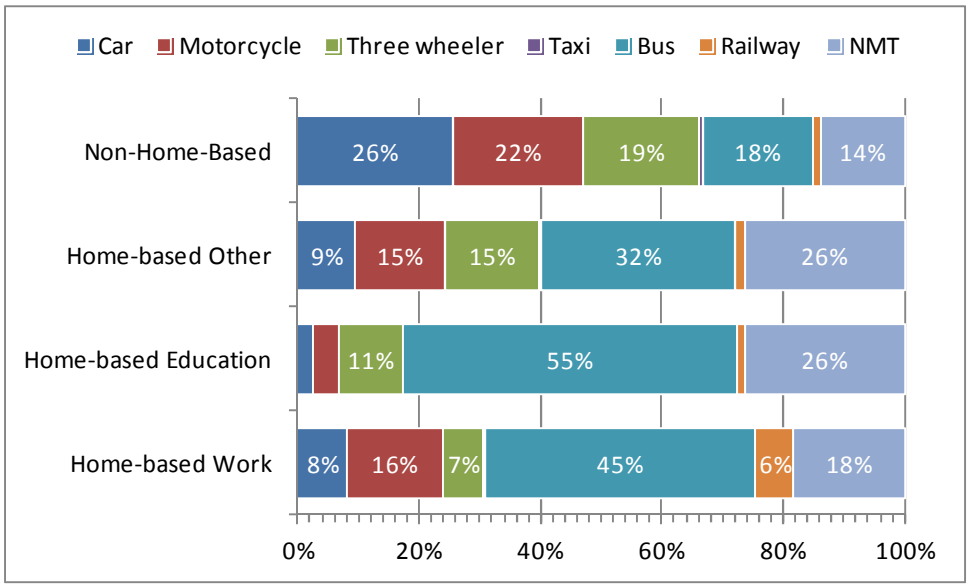
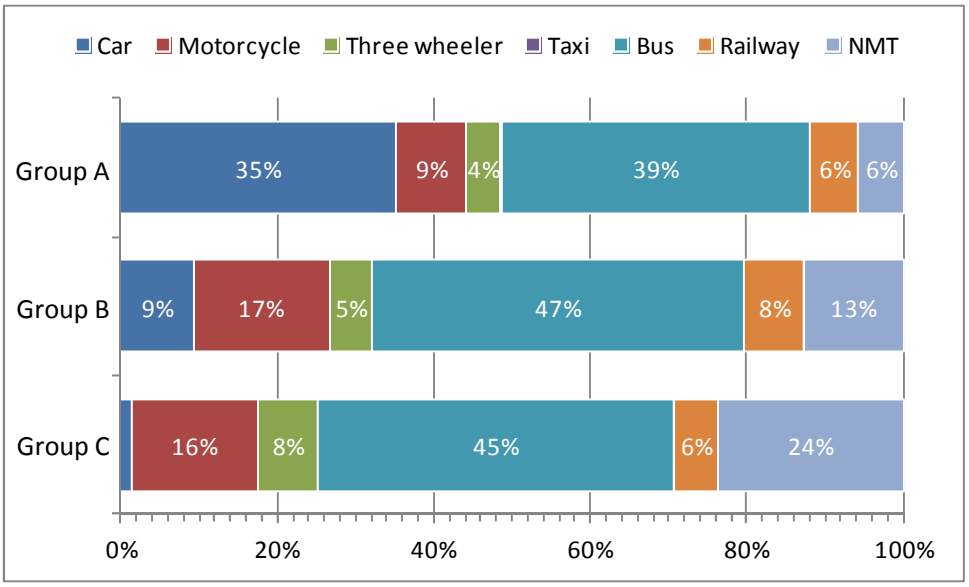


Figure 6.3.1 Modal Share by Trip Purpose in Western Province

6.3.2 Commuting to Workplace

While bus is the dominant mode for commuting to the workplace, car, motorcycle and non-motorised mode of transport are the second main modes for Group A, Group B, and Group C workers respectively. The difference in the share of motorcycle is rather small across the income groups, but that of car is significant.



Note: Group C: monthly income less than Rs. 40,000 / Group B: Rs.40,000 – 79,999 / Group A: Rs. 80,000 and more

Figure 6.3.2 Modal Share by Income Group for Commuting to Workplace

6.3.3 Commuting to Educational Institution

For students at the grade of G.C.E A-Level and below, the use of school bus/van and private car increase proportionately with household income. Students who attend tertiary education are highly dependent on bus regardless of their household income. Growing use of cars is observed among these groups as income increases.

a) No. of Home to Education Trips by Income Level by Grade

b) Modal Share by Grade – Group C

c) Modal Share by Grade – Group B

d) Modal Share by Grade – Group A

Note: Group C: monthly income less than Rs. 40,000 / Group B: Rs.40,000 – 79,999 / Group A: Rs. 80,000 and more

Figure 6.3.3 Modal Share of Home to Education Trips by Grade for Group C, B, and A

6.4 Modal Share by Region

Bus remains the dominant mode regardless of the region as it shares over 30% of the trips produced. The highest share of car is observed for trips produced in CMC whereas the highest share of motorcycle and NMT are in the suburban areas.

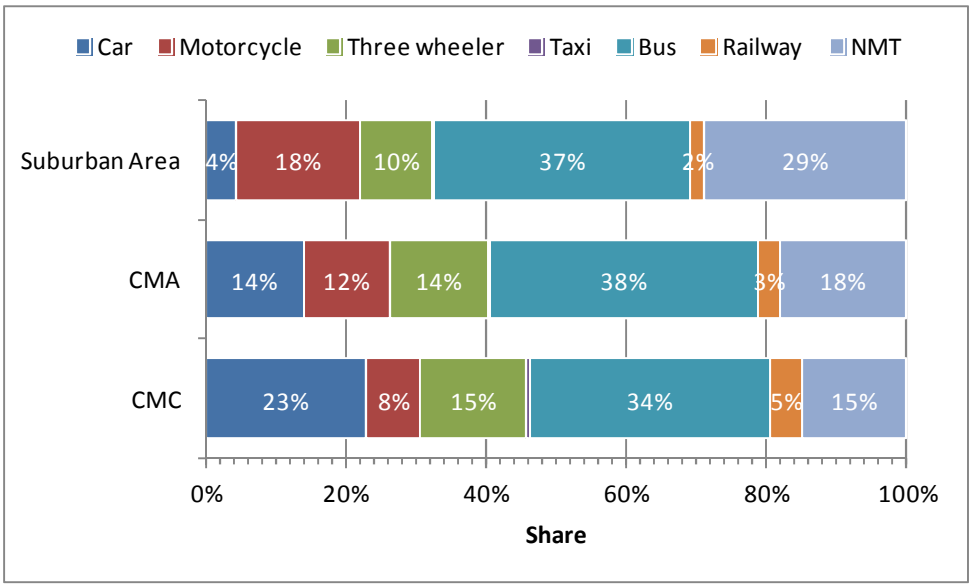


Figure 6.4.1 Modal Share by Region