

CHAPTER 4 Analysis of Major Transport Corridors

4.1 Introduction and Methodology of Evaluation

In this section, the infrastructure development options, including the improvement of public transport services, were evaluated for each corridor based on the circumstances of land use, urban development, transport conditions and future estimation with tested options. The corridors are identified as the seven major corridors connecting the central area of Colombo and the suburbs, such as Malabe, Galle, Kandy, Negombo, High level road, Horana and Low level road corridors, which are described in Figure 4.1.1.

In the beginning, each corridor is reviewed and summarised in the view of current corridor characteristics such as land use and environment, urban development potential, and transport infrastructures and issues. The following analysis was made based on the assumptions of urban structure with the residence and employment populations along the corridor in the current year and future year of 2035.

Based on the current analysis and urban structure, the transport options such as candidate projects are screened for further analysis by multi-criteria with efficiency, environmental impact, land acquisition and incompatibility of other transport options. Note that Table 4.1.1 shows the comparison table for selection of suitable public transport options with various criteria.

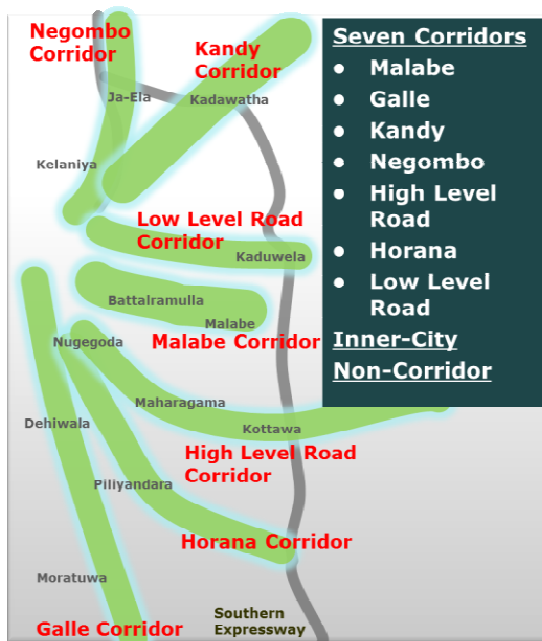


Figure 4.1.1 Target Seven Corridors

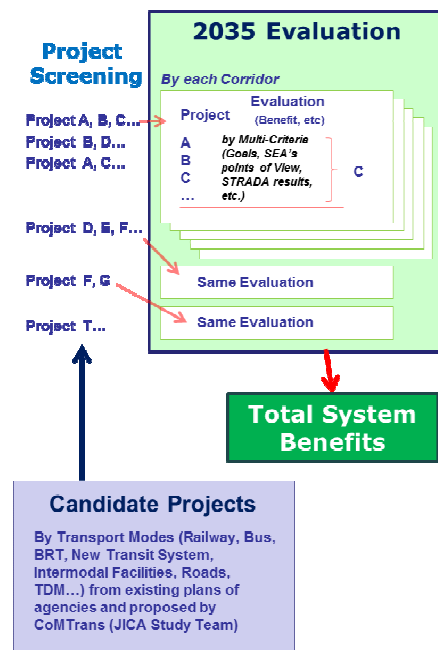


Figure 4.1.2 Process of Corridor Analysis

Table 4.1.1 Comparison of Public Transport Options

System	Bus Priority Lane	BRT	AGT	Monorail	LRT – Ground/Elevated	MRT-Elevated	MRT-Under ground	Moder-nized Railway
Capacity	1-20k	3-20k	4-15k	7-30k	7-30k	18-60k	18-60k	18-40k
Scheduled Speed (km/h)	10-15	15-20	20-30	20-40	20-40	30-40	30-40	30-60
Land Acquisition	not at all	along roads	station & some roads	only major stations	station & some roads	station & some roads	station exit only	Minimum
Stop Spacing (km)	0.3-0.5	0.5-1.0	0.5-1.0	0.5-1.0	0.3-1.0	1.5	1.5	2.0
Initial Cost (mil USD/km)	<0.1	?	30-40	30-40	35-45	45-55	90-100	the
O&M Cost (USD/Car-km) [Car-km / Capacity]	<0.1	1.3 [\$0.03 per pax.]	2.0 [\$0.04 per pax.]	2.5 [\$0.03 per pax.]	4.0 [\$0.04 per pax.]	5.0 [\$0.03 per pax.]	5.0 [\$0.03 per pax.]	5.0 [\$0.03 per pax.]
Daylight Interference	Not at all	Not at all	Pier & Slab	Pier & Beam	Elevated: Pier & Slab Ground: Station only	Pier & Slab	Not at all	Not at all
Aesthetical	Bus stop only	Station only	Pier & Slab	Pier & Beam		Pier & Slab	Not at all	Elevated section only
Suitable Condition	Medium demand corridor; aesthetical concerned area	High demand corridor with wide road; aesthetical concerned area	High demand corridor where land for station is available	High demand corridor where limited land is available	Ground: Aesthetical concerned area. Elevated: Station land is available	Very High demand corridor without aesthetical concern	Very High demand corridor where limited land is available	Longer distance and High demand corridor where there is a railway

Regarding the selected transport option, further evaluation is to be conducted to find the most appropriate option for each corridor by JICA-STRADA, which is the software for transport network analysis with a 4 step model of trip generation/attraction, distribution, modal share and network assignment. This is a network simulation with the selected option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads.

The results are compared by the key performance indicators (KPIs) of the four points to be considered, Economic efficiency, Environmentally friendly, Equity in society and Safety.

Because the transport options are not functioning well and are only provided on each corridor, these options will function when these are linked and formed into a network, thus, only the improvement of the seven corridors is not enough for the urban transport system, there are also the inner city area and the remaining area covered by the planning area of Colombo Metropolitan Area.

The KPIs are set for the measurable indicators for describing the system benefit from the entire transport system development as well as evaluation criteria for selection of transport options. The Figure below shows the idea of the KPIs.

Evaluation indicators in 2035 which were estimated by JICA-STRADA and set for the four criteria are;

Economic efficiency:	Annual net benefit (billion Rs/year of 2035), Network averaged speed (km/h)
Environmentally friendly:	CO2 emission (million ton/year in 2035)
Equity in society:	Accessibility to transit stations (million population)
Safety:	Loss due to accidents (billion Rs./ year of 2035)

Points to be considered	Project Evaluation		Total Benefits, KPI
	MCA with SEA		
Economic Efficiency	Averaged Vehicle Speed, Total Congestion Loss, VOC, Total time in travel, Total cost of transport, Total trips		
Environmental Friendly	Land acquisition, Environmental Impacts		CO2 Emission
Equity among the People	Number of Population of <ul style="list-style-type: none"> • to access Stations (Rail, New Transit, BRT) with in 30 min. • to access Urban Center within 30 min. • Affordable Transport Costs 		
Safety	Risk and cost of accidents per km travelled		

Figure 4.1.3 Key Performance Indicators (KPIs) for the Four Points to be considered

Annual Net Benefit in 2035 is defined as the difference in “total cost” between “Status Quo” and “Options”. The “total cost” is the concept of the sum of “supply cost” and “Infrastructure cost”. The supply cost consists of vehicle operation cost (VOC), travel time cost (TTC) and Operation and maintenance cost. The Infrastructure cost is to be the annual cost, therefore, it is divided by 20 years for the assumptions of life cycle.

Network averaged speed includes both public and private transport for all the Western province trips.

Accessibility to transit stations is estimated by the number of population in areas within 800m from transit stations using the GIS.

4.2 Malabe Corridor

Malabe corridor supports the connection from Colombo central area to Malabe via the Battaramulla with the A0 road. The following characteristics are identified through data collection and analysis under the CoMTrans study.

(1) Characteristics in the view of Land use and the Environment

Malabe corridor has the new administrative and commercial capitals around Battaramulla, and the area population has increased since 2001.

There are aesthetically sensitive areas such as Town Hall and Diyawannawa Lake.

(2) Characteristics in the view of Urban Development Potentials

There are many urban development plans/ projects as indicated in the figure. Therefore, high population growth for both residents and employees around this corridor is expected to be realised in the near future.

Major impacts are expected at the Defence headquarters relocated from fort area, Sethsiriya II for government offices and an IT Park at Malabe with new universities.

The figure shows the location of urban development areas.

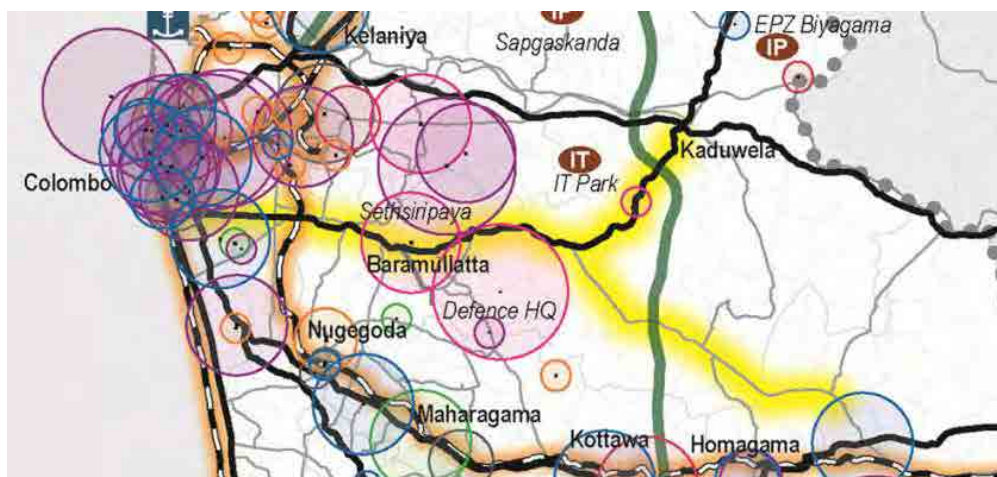


Figure 4.2.1 Urban Development Potentials in Malabe Corridor

(3) Characteristics in the view of Transport Infrastructures and Issues

In the view of current transport infrastructure provision, Malabe corridor does not have a railway line and only has Malabe road (A0). Although there are 10 lanes in the section at the CMC boundary with Parliament road & Kotte road, some other sections are not wide enough such as less than 20m.

The index of current transport conditions of Malabe corridor is summarised in the table (Note: the index value is at the CMC boundary. For travel speed, the section at Rajagiriya is utilised for analysis). It is clear that the over capacity of vehicle traffic on roads and buses are dominant for passenger movement at peak hour.

Issues of current transport conditions are as follows;

- Malabe corridor has the highest modal share of private cars among the seven

corridors.

- In terms of road network, many branch roads are connecting such as New Kandy road, Kotte road, Buthgamuwa road, Pannipitiya road etc., therefore, many private cars and buses are concentrated on one road for entering CMC.

Table 4.2.1 Index of Current Transport Conditions in Malabe Corridor

Index	Value
Peak hour road traffic (pcu)	5,100
Hourly capacity (pcu)	4,400
Peak hour travel speed	14 km/h
Peak hour bus load factor	138%
Peak hour passenger volume	23,500 pax/hour Private: 9,600 Bus: 13,900
Daily bidirectional traffic volume	121,400 vehicles Bus: 4,800

(4) Screening of Possible Options

Under the above situation, possible transport options are examined and evaluated in the screening stage. The results of screening are listed in the table.

Table 4.2.2 Screening Result for Malabe Corridor

Transport Option	Efficiency	Environmental Impact	Land Acquisition	Incompatibility	Selection
Modernized Railway	Not applicable				
MRT-Underground	Demand is not adequate considering cost	Interference of groundwater	Legal issues		
MRT-Elevated		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
LRT		Daylight interference, Aesthetic concern	Land acquisition	BRT, Bus priority	
Monorail		No significant impact	Limited land acquisition	Elevated structures	✓
AGT	Demand is matching with capacity	Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
BRT		No significant impact	Huge land acquisition & re-location	LRT, Bus priority	
Bus Priority	Capacity is not adequate	No significant impact	No significant impact	LRT, BRT	
Road Widening	Capacity is not adequate	Air quality, CO2 emission	Huge land acquisition	BRT	
Expressway Parallel to Malabe Road	Demand is currently matching, but it can be overloaded due to motorization	Air quality, CO2 emission, daylight interference and aesthetic concern	Huge land acquisition but limited re-location		✓

The points of this screening result are summarised as follows;

- Possible maximum total public transport demand in 2035 is estimated at around 20,000 to 30,000 PPHPD (passenger per peak hour per direction), therefore, Modernised railway and MRT (elevated and underground) are not adequate in terms of demand and cost, especially railway is not applicable in the current land use pattern along the corridor.
- In order to meet this demand, LRT, Monorail, AGT and BRT are possible options, but not bus priority. Applying the environmental impact and land acquisition availability, monorail is the most suitable with less land acquisition and daylight interference. Therefore, monorail is the option to be checked further for the network analysis.
- Another possible option is to provide an expressway parallel to Malabe corridor to connect from the centre of Colombo to the Outer Circular Highway (OCH) via Battalamurra and Malabe, even though there would be a heavy environmental impact and land acquisitions. How the network benefits will be expected comparing to the monorail is also tested.

Based on the above discussion, the selected options are listed and tested for the network analysis.

- Monorail system between Fort to Malabe
- Urban expressway in parallel with Malabe Corridor

(5) Evaluation of Selected Options

Quantitative network simulation was conducted utilizing JICA-STRADA for each transport option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads. The table below shows the result of the network simulation.

Table 4.2.3 Evaluation Results for each Development Option

		Status Quo in 2035	Monorail System Fort - Malabe	Urban Expressway Parallel to Malabe Corridor
Economic Efficiency	Annual Net Benefit (billion Rs./year in 2035)	-	94	38
	Network Average Speed (km/h)	7.4	8.2	7.9
Environmentally Friendly	CO ₂ Emission (million tonne/year in 2035)	4.13	4.05	4.21
	Ref. Modal share of Public transport (%)	49.0	50.9	48.3
Equity in Society	Accessibility to Transit Stations (million population)	0.99	1.12	0.99
Safety	Loss due to Accidents (billion Rs./year in 2035)	10.8	10.5	11.1

Note: Definitions are described in the 3.7.1

The above results are summarised and evaluated as follows;

- Regarding the “efficiency”, both options produce greater benefits in comparison to the status quo in 2035; monorail has more beneficial options than urban expressways in terms of annual net benefit. Network speed is improved more than with urban expressway construction.
- In terms of “Environmentally Friendly” and “Safety”, monorail systems provide improvements and expressways are better than status quo.
- Monorail creates more “Accessibility” to transit stations.

In addition to the results described above, land acquisition for expressways is considered as a huge issue. Therefore, the development proposal in Malabe Corridor is a monorail system which runs from Battaramulla/ Malabe to Fort with the stretch of 14.5 km.

It is also proposed that the monorail system should be developed together with Transit Oriented Development (TOD).

The figure below shows the image of the proposed transport development in Malabe Corridor.

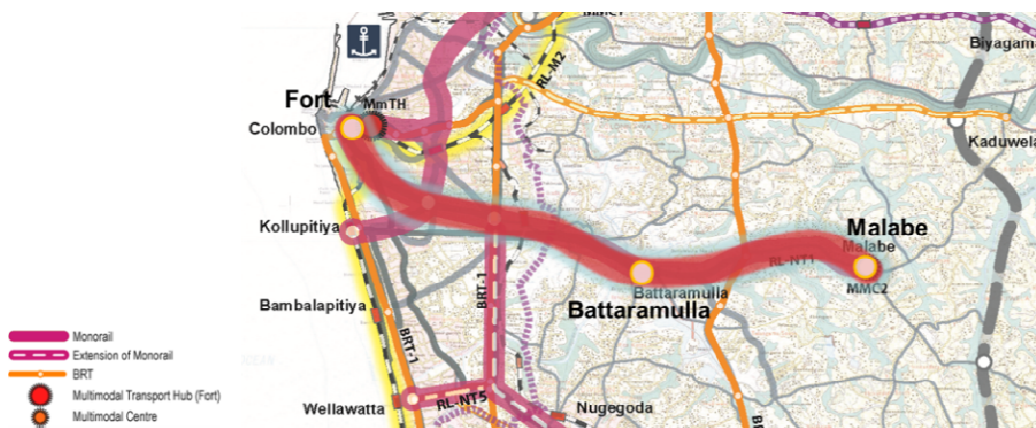


Figure 4.2.2 Proposed Transport Development Options in Malabe Corridor

Note that this figure shows the concept of a development options network. Detailed alignment will be examined and identified in the feasibility study stage.

4.3 Galle Corridor

Galle corridor connects Colombo central area to Kalutara via the Galle road (A02) and the Coast line. The following characteristics are identified through data collections and analysis under the CoMTrans study.

(1) Characteristics in the view of Land use and the Environment

Ribbon development is occurring along the Galle road (A02) with high population density.

There are a series of urban centres such as Bambarapitiya, Dehiwala, Mt. Lavinia, Rathmalana, Moratuwa, Panadura and Kalutara, with universities and colleges. According to the home visit survey, the person trips related to the centre of Colombo are limited in Kalutara in the Western province.

Because of the coast area, there are tourist spots (coastal hotels and restaurants) along the corridor.

Table 4.3.1 Index of Current Transport Conditions in Galle Corridor

Index	Value
Peak hour road traffic (pcu)	2,900
Hourly capacity (pcu)	2,300
Peak hour travel speed	13 km/h
Peak hour bus load factor	101%
Peak hour passenger volume	22,900 pax/hour Private: 5,500 Bus: 9,500 Railway: 7,900
Daily bidirectional traffic volume	67,600 vehicles Bus: 3,790

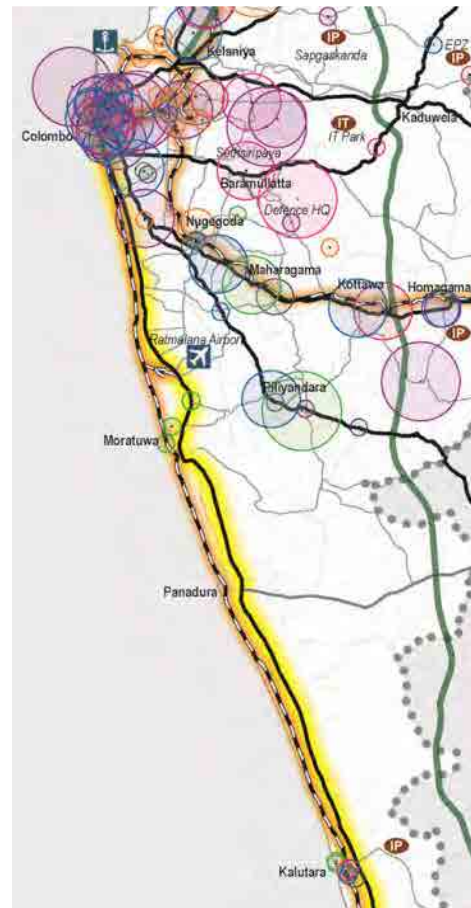


Figure 4.3.1 Urban Development Potentials in Galle Corridor

(2) Characteristics in the view of Urban Development Potentials

There are limited areas around existing urban centres for urban development.

The figure shows the location of urban development areas.

(3) Characteristics in the view of Transport Infrastructures and Issues

In the view of current transport infrastructure provision, Galle corridor has a railway line (Coast Line) which operates 92 trains per day for both directions. Galle road (A02) has 4

lanes at the CMC boundary in the section of Wellawatta – Dehiwala, however some sections are less than 20m wide. Marine drive road is being extended as a 4 lane road from Wellawatta to Dehiwala.

The index of current transport conditions of Galle corridor is summarised in the table (Note: the index value is at the CMC boundary. For travel speed, the section from Wellawatta to Dehiwala is utilised for analysis). Railway and bus covers the passenger movement at peak hour.

Issues of current transport conditions are as follows;

- Galle corridor utilises the railway transport mode and has the highest railway modal share among the seven corridors.
- There is a bottleneck for Galle road at the Dehiwala fly-over section.

(4) Screening of Possible Options

Under the above situation, possible transport options are examined and evaluated in the screening stage. The results of screening are listed in the table.

Table 4.3.2 Screening Result for Galle Corridor

Transport Mode	Efficiency	Environment	Social	Incompatibility	Selection
Modernized Railway	Demand is matching with capacity	Noise	No significant impact		✓
MRT-Underground	Demand is matching with capacity, but cost is higher than modernized railway	Interference of groundwater	Legal issues	Existing Railway	
MRT-Elevated		Daylight interference, Aesthetic concern	Land acquisition	Existing Railway, Elevated structures	
LRT	Demand is matching with capacity	Daylight interference, Aesthetic concern	Land acquisition	Existing Railway, BRT, Bus priority	
Monorail		No significant impact	Limited land acquisition	Existing Railway, Elevated structures	
AGT		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
BRT		No significant impact	Some land acquisition	LRT, Bus priority	✓
Bus Priority	Capacity is not adequate	No significant impact	No significant impact	LRT, BRT	
Road Development [Marine Drive Ex.]	Capacity is not adequate on A02	Air quality, CO2 emission	Huge land acquisition	BRT	✓
Expressway	Demand is currently matching	Air quality, CO2 emission, daylight interference and aesthetic concern	Huge land acquisition		

The points of this screening result are summarised as follows;

- Possible maximum total public transport demand in 2035 is estimated at around

40,000 to 50,000 PPHPD (passenger per peak hour per direction). Therefore, even if the current railway will be modernised and other public transport supported, MRT (elevated and underground) alone is not an acceptable option because of the huge additional investments. Therefore, modernization of the Coast Line railway is the first possible option.

- In order to meet the demand remaining after railway modernization, LRT, Monorail, AGT and BRT are possible options, but not bus priority. Applying the conditions of road infrastructure, a BRT system will be a possible option together with the road development of Marine Drive Extension from Dehiwala to Ratmalana to secure the traffic capacity for Galle road and Marine Drive. Therefore, a BRT system together with the road development is the option to be checked further by network analysis.

Based on the above discussion, the selected options are listed and tested for network analysis.

- Modernization of Coast Railway Line from Fort to Panadura
- BRT system from Fort to Moratuwa together with Marine Drive Extension (Dehiwala – Ratmalana)

(5) Evaluation of Selected Options

A quantitative network simulation was conducted utilizing JICA-STRADA for each transport option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads. The table below shows the result of the network simulation.

Table 4.3.3 Evaluation Results for each Development Option

		Status Quo in 2035	Modernised Railway to Panadura	BRT on A2 to Moratuwa
Economic Efficiency	Annual Net Benefit (billion Rs./year in 2035)	-	51	45
	Network Average Speed (km/h)	7.4	7.7	7.7
Environmentally Friendly	CO ₂ Emission (million tonne/year in 2035)	4.13	4.09	4.09
	Ref. Modal share of Public transport (%)	49.0	50.2	50.6
Equity in Society	Accessibility to Transit Stations (million population)	0.99	0.99	1.11
Safety	Loss due to Accidents (billion Rs./year in 2035)	10.8	10.7	10.7

Note: Definitions are described in 3.7.1

Above results are summarised and evaluated as follows;

Regarding the “efficiency”, both options have benefit in comparison to the status quo in 2035.

In terms of “Environmentally Friendly” and “Safety”, both options ensure the same level of improvement. BRT stations cover more people for improvement of accessibility.

Based on the results described above, both railway modernization and BRT system will be the appropriate options to be implemented. The development proposal in Galle Corridor is as follows;

- Modernization of Coast Railway Line from Fort to Panadura (28 km) as a suburban railway, with electrification, and signal, telecommunication and track improvements
- BRT system from Fort to Moratuwa (20 km) together with Marine Drive extension (Dehiwala-Ratmalana) to secure enough capacity for the traffic volume on Galle road (A02)

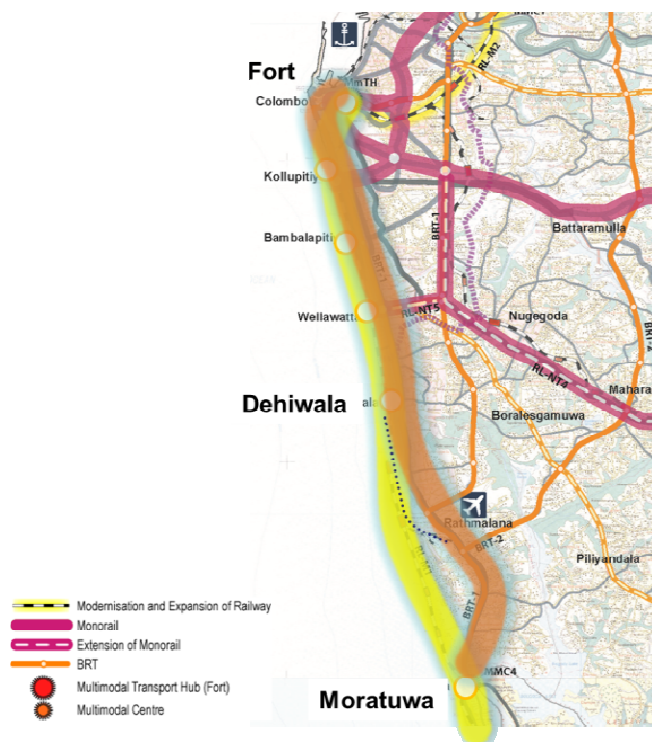


Figure 4.3.2 Proposed Transport Development Options in Galle Corridor

It is also proposed that the multi-modal centre at Moratuwa be established to realise smooth transit between railway, BRT and feeder buses.

The figure shows the image of the proposed transport development in Galle Corridor.

Note that this figure shows the concept of the development option network. Detailed alignment will be examined and identified in the feasibility study stage.

4.4 Kandy Corridor

Kandy corridor connects Colombo central area to Kandy and various areas in the east and north of Sri Lanka with the principal national road A01, as well as the main line of the railway in parallel with A01. The following characteristics are identified through data collection and analysis under the CoMTrans study.

(1) Characteristics in the view of Land use and the Environment

Ribbon development has occurred along the Kandy road (A01), therefore, difficulties regarding resettlements are a concern with the road infrastructure development. In addition, population density is higher along the A01.

There are a series of urban centres along the A01 road and the main line such as;

- Kandy Road based: Kelaniya, Kiribathgoda, Kadawatha
- Rail based: Kelaniya, Ragama, Gampaha

(2) Characteristics in the view of Urban Development Potentials

Currently, due to the CKE being developed, Kelaniya is focused on as the new development area with industrial developments, logistics centre (inland container depot) and commercial markets such as a fish market and vegetable market.

Kadawatha is planned for mixed development because the OCH connects with A01.

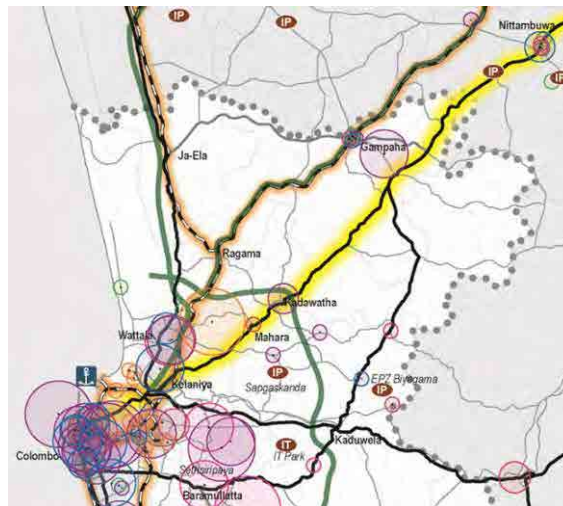


Figure 4.4.1 Urban Development Potentials in Kandy Corridor

The figure shows the location of urban development areas.

(3) Characteristics in the view of Transport Infrastructures and Issues

There are several forms of transport infrastructure developed in the Kandy corridor as follows;

- Railway Main Line, which operates 116 trains per day for both directions.
- Kandy Road (A01) has 6 lanes at the new Kelani bridge section, however, other sections are only 2- 4 lanes.
- OCH will be connected with A01 road at Kadawatha.
- Northern Expressway is now under feasibility study to connect nationwide as part of the national expressway network.
- CKE has been opened and its interchange is located in the Kelaniya area.

Table 4.4.1 Index of Current Transport Conditions in Kandy Corridor

Index	Value
Peak hour road traffic (pcu)	4,400
Hourly capacity (pcu)	3,300
Peak hour travel speed	16 km/h
Peak hour bus load factor	116%
Peak hour passenger volume	37,200 pax/hour Private: 8,700 Bus: 14,100 Railway: 14,400
Daily bidirectional traffic volume	95,200 vehicles Bus: 6,300

The index of current transport conditions of Kandy corridor is summarised in the table (Note: the index value at the CMC boundary). For travel speed, the section at Kelani bridge is utilised for analysis). Passenger based peak hour volume is more than 35,000 passengers per direction with bus and railway supporting its flow.

Issues of current transport conditions are as follows;

- Kandy corridor has the highest passenger volume among the seven corridors by bus and railway modes.
- Kandy road (A01) serves not only urban transport but also inter-provincial passenger and freight traffic.

(4) Screening of Possible Options

Under the above situation, possible transport options are examined and evaluated in the screening stage. The results of the screening are listed in the table.

Table 4.4.2 Screening Result for Kandy Corridor

Transport Mode	Efficiency	Environment	Social	Incompatibility	Selection
Modernized Railway	Demand is matching with capacity	Noise	No significant impact		✓
MRT-Underground	Demand is matching with capacity, but cost is higher than modernized railway	Interference of groundwater	Legal issues	Existing railway	
MRT-Elevated		Daylight interference, Aesthetic concern	Land acquisition	Existing railway, Elevated structures	
LRT	Demand is matching with capacity	Daylight interference, Aesthetic concern	Land acquisition	BRT, Bus priority	
Monorail on A01		No significant impact	Limited land acquisition	Elevated structures	✓
AGT		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
BRT	Capacity is not adequate	No significant impact	Some land acquisition	LRT, Bus priority	✓
Bus Priority		No significant impact	No significant impact	LRT, BRT	
Road Development	Capacity is not adequate	Air quality, CO2 emission	Huge land acquisition	BRT	
Expressway	Planned Northern expressway will be taken for the demands	Air quality, CO2 emission, daylight interference and aesthetic concern	Huge land acquisition		

The points of this screening result are summarised as follows;

- Possible maximum total public transport demand in 2035 is estimated at around 30,000 to 45,000 PPHPD (passenger per peak hour per direction). Therefore, the current railway will be modernised along with other public transport support, because MRT (elevated and underground) is not an acceptable option because of the huge additional investments. Therefore, modernization of the Main Line railway is the first possible option.
- In order to meet the rest of the demand after railway modernization, LRT, Monorail, AGT and BRT are possible options, but not bus priority. Applying the conditions of road infrastructure on A01, a BRT system will be a possible option if the road width is secured for the BRT system (partially, a reversible BRT lane is adequate for the peak hour treatment). Therefore, a BRT system is the option to be checked further in the network analysis. In addition, another option is thought to be the monorail system in case of limited land acquisition condition and adequate financial affordability.

Based on the above discussion, the selected options are listed and tested for network analysis.

- Modernization of Main Railway Line from Fort to Veyangoda

- BRT system on A01 from Fort to Kadawatha
- Monorail system on A01 from Fort to Kadawatha

(5) Evaluation of Selected Options

A quantitative network simulation was conducted utilizing JICA-STRADA for each transport option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads. The table below shows the result of the network simulation.

Table 4.4.3 Evaluation Results for each Development Option

		Status Quo in 2035	Modernised Railway to Veyangoda	Monorail on A01 to Kadawatha	BRT system on A01 to Kadawatha
Economic Efficiency	Annual Net Benefit (billion Rs./year in 2035)	-	48	63	40
	Network Average Speed (km/h)	7.4	7.7	8.0	7.7
Environmentally Friendly	CO ₂ Emission (million tonne/year in 2035)	4.13	4.09	4.09	4.08
	Ref. Modal share of Public transport (%)	49.0	50.1	50.6	50.2
Equity in Society	Accessibility to Transit Stations (million population)	0.99	0.99	1.21	1.14
Safety	Loss due to Accidents (billion Rs./year in 2035)	10.8	10.7	10.6	10.6

Note: Definitions are described in 3.7.1

Above results are summarised and evaluated as follows;

- Regarding the “efficiency”, a simple calculation shows that the monorail system has the highest annual net benefit. However it should be discussed carefully because a monorail system requires a huge investment and should be implemented for enough networks, not only Kandy corridor but others. In this context, the current railway transport infrastructure should be improved first.
- Even the BRT system may have several benefits and give more people access to the transit stations, so that railway modernization and BRT are the adequate options for Kandy corridor.

Based on the results described above, both railway modernization and a BRT system will be the appropriate options to be implemented. The development proposal in Kandy Corridor is as follows;

- Modernization of the Main Line from Fort to Veyangoda (38 km) as a suburban railway with electrification, and signal, telecommunication and track improvements. Note that the Fort-Maradana section should be improved for the track arrangements.
- BRT system from Fort to Kadawatha (16.5 km) including several sections of road widening to secure BRT operation.

- Re-routing of bus service is also proposed to connect railway stations and BRT stations with the surrounding area.

If the BRT system stretches to Kadawatha, the Multi-modal centre will be a future option for connecting the BRT system from the centre of Colombo to Kadawatha with an inter-provincial transport mode used by the expressway network of OCH and the Northern expressway.

The figure shows the image of the proposed transport development in Kandy Corridor.

Note that this figure shows the concept of the development option network. Detailed alignment will be examined and identified in the feasibility study stage.

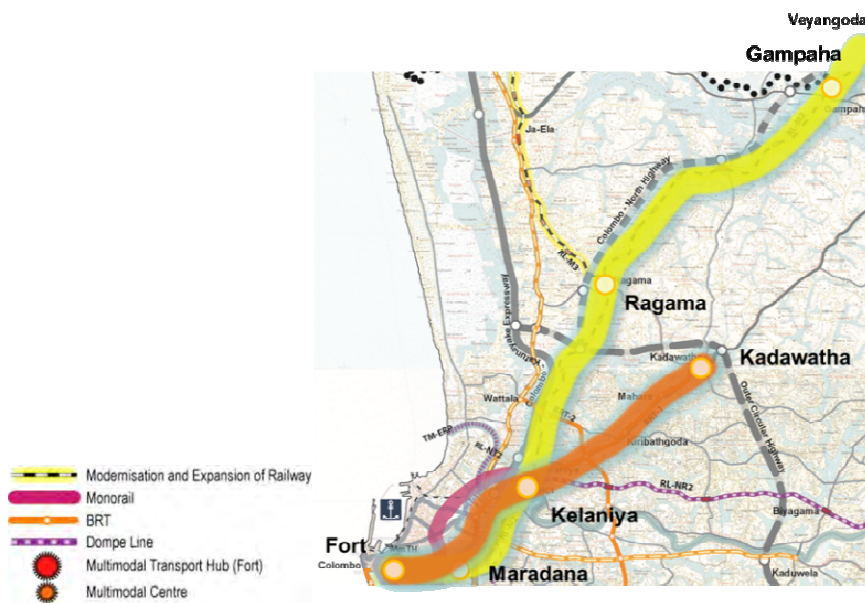


Figure 4.4.2 Proposed Transport Development Options in Kandy Corridor

4.5 Negombo Corridor

Negombo corridor connects Colombo central area to Negombo with the Negombo road (A03) and the Puttalam railway line. The following characteristics are identified through data collection and analysis under the CoMTrans study.

(1) Characteristics in the view of Land use and the Environment

The international airport is located along the corridor and CKE opened in October 2013.

Ribbon development occurred along the Negombo road (A03), therefore, the difficulties of resettlements are a concern regarding the road infrastructure development.

There are some urban centres such as Wattala and Ja-Ela.

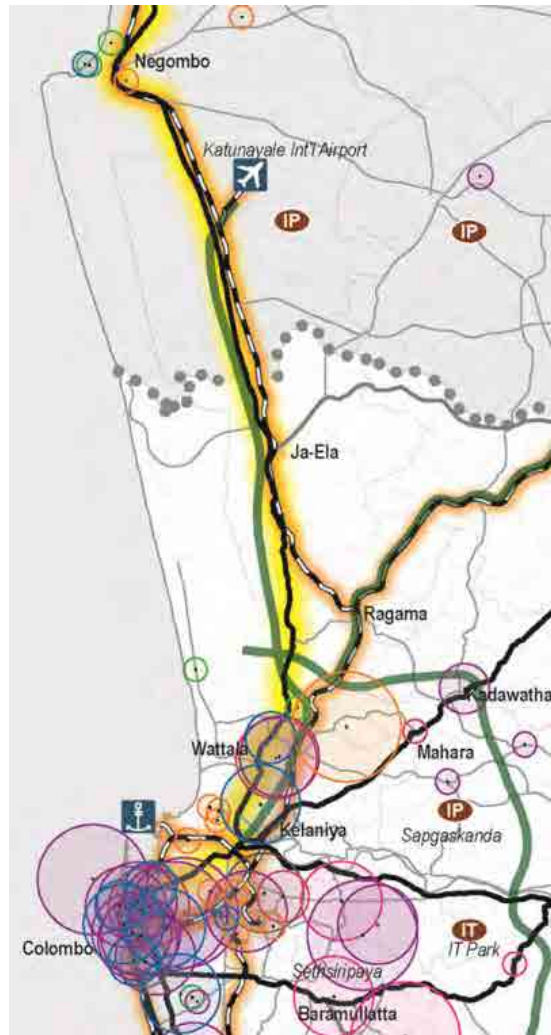


Figure 4.5.1 Urban Development Potentials in Negombo Corridor

Table 4.5.1 Index of Current Transport Conditions in Negombo Corridor

Index	Value
Peak hour road traffic (pcu)	4,000
Hourly capacity (pcu)	4,400
Peak hour travel speed	19 km/h
Peak hour bus load factor	142%
Peak hour passenger volume	33,800 pax/hour Private: 10,000 Bus: 9,400 Railway: 14,400
Daily bidirectional traffic volume	73,300 vehicles Bus: 3,400

(2) Characteristics in the view of Urban Development Potentials

There are industrial developments around the airport.

It is expected that there are some commercial developments around CKE.

(3) Characteristics in the view of Transport Infrastructures and Issues

Puttalam railway line operates 30 trains per day for both directions from Negombo to Ragama station, some railway directly reaches to Fort.

In terms of road transport, CKE opened as the toll expressway with the connection of international airport to Kelani river and the expected extension for crossing the Kelani bridge and port access.

Road traffic is mainly carried on the Negombo road (A03) connecting from Japan Friendship bridge to Negombo with a 4 lane road with only 20m width. It will be connected by OCH in the future.

The index of current transport conditions of Negombo corridor is summarised at the table (Note: the index value is at the CMC boundary. For travel speed, the section at Japan Friendship bridge and Mattakuliya bridge are utilised for analysis). Railway and bus covers the passenger movement at peak hour.

Issues of current transport conditions are as follows;

- Highest number of heavy trucks and trailers are running on A03 among the seven corridors.
- It is assumed that CKE will create impacts on new trip patterns.

(4) Screening of Possible Options

Under the above situation, possible transport options are examined and evaluated in the screening stage. The results of the screening are listed in the table.

Table 4.5.2 Screening Result for Negombo Corridor

Transport Mode	Efficiency	Environment	Social	Incompatibility	Selection
Modernized Railway	Demand is matching with capacity	Noise	No significant impact		✓
MRT-Underground	Demand is matching with capacity, but cost is higher than modernized railway	Interference of groundwater	Legal issues	Existing railway	
MRT-Elevated		Daylight interference, Aesthetic concern	Land acquisition	Existing railway, Elevated structures	
LRT		Daylight interference, Aesthetic concern	Land acquisition	BRT, Bus priority	
Monorail		No significant impact	Limited land acquisition	Elevated structures	
AGT		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
BRT		No significant impact	land acquisition	LRT, Bus priority	
Bus Priority		No significant impact	No significant impact	LRT, BRT	✓
Road Development	Capacity is not adequate	Air quality, CO2 emission	Huge land acquisition	BRT	
Expressway	CKE will be taken the demands	Air quality, CO2 emission, daylight interference and aesthetic concern	Huge land acquisition		

The points of this screening result are summarised as follows;

- Possible maximum total public transport demand in 2035 is estimated at around 30,000 to 45,000 PPHPD (passengers per peak hour per direction). Therefore, the current railway will be modernised along with other public transport support, because MRT (elevated and underground) is not an acceptable option because of the huge additional investments. Therefore, modernization of Puttalam Line railway is the first possible option.
- In order to meet the rest of the demand after railway modernization, LRT, Monorail, AGT, BRT and Bus priority are possible options because of less demand than in other corridors. Applying the current conditions of road infrastructure and land use pattern as well as the consideration of the investment cost, a Bus priority system will be a possible option.

Based on the above discussion, the selected options are listed and tested for the network analysis.

- Modernization of Puttalam Railway Line
- Bus priority system in Negombo road (A03)

(5) Evaluation of Selected Options

A quantitative network simulation was conducted utilizing JICA-STRADA for each transport option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads. The table below shows the result of the network simulation.

Table 4.5.3 Evaluation Results for each Development Option

		Status Quo in 2035	Modernised Railway Puttalam Line	Bus Priority in Negombo Road (A03)
Economic Efficiency	Annual Net Benefit (billion Rs./year in 2035)	-	69	36
	Network Average Speed (km/h)	7.4	7.8	7.7
Environmental Friendly	CO ₂ Emission (million tonne/year of 2035)	4.13	4.06	4.09
	Ref. Modal share of Public transport (%)	49.0	50.5	50.6
Equity in Society	Accessibility to Transit Stations (million population)	0.99	0.99	1.08
Safety	Loss due to Accidents (billion Rs./year in 2035)	10.8	10.6	10.7

Note: Definitions are described in the 3.7.1

Above results are summarised and evaluated as follows;

- Regarding the “efficiency”, both options have some benefit in comparison to the status quo in 2035.
- Even though the bus priority system has less benefit, it can improve all criteria of economic efficiency, environmentally friendly, equity in society and safety, so that it will remain as an option because of less investment cost.

Based on the results described above, both railway modernization and Bus priority system will be the appropriate options to be implemented. The development proposal in Negombo Corridor is as follows;

- Modernization of Puttalam Railway Line from Ragama to Negombo (12.6 km) as a suburban railway connected with the main railway line, with electrification, and signal, telecommunication and track improvements. The airport connection from Katunayake South to the airport terminal, which is 2km long, will also create a more public transport oriented network.
- Bus priority system on Negombo road (A03)

It is also proposed that a BRT open system utilizing CKE will be a more useful connection to Negombo and the airport.

The figure shows the image of the proposed transport development in Negombo Corridor.

Note that this figure shows the concept of the development option network. Detailed alignment will be examined and identified in the feasibility study stage.

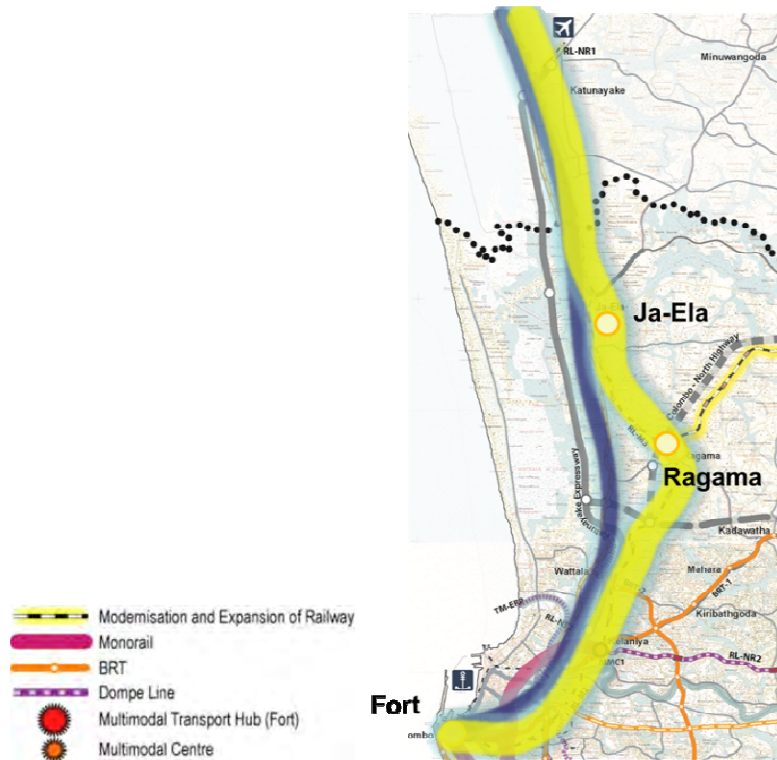


Figure 4.5.2 Proposed Transport Development Options in Negombo Corridor

4.6 High Level Road Corridor

High level road corridor connects the southern part of CMC, Kirulapone to Homagama via Kottawa with the High level road (A04) and the KV line. The following characteristics are identified through data collection and analysis under the CoMTrans study.

(1) Characteristics in the view of Land use and the Environment

Ribbon development has occurred along the high level road (A04), therefore, the difficulties of resettlements are a concern regarding the road infrastructure development along the A04.

There is a series of urban centres such as Nugegoda, Maharagama, Kottawa and Homagama.

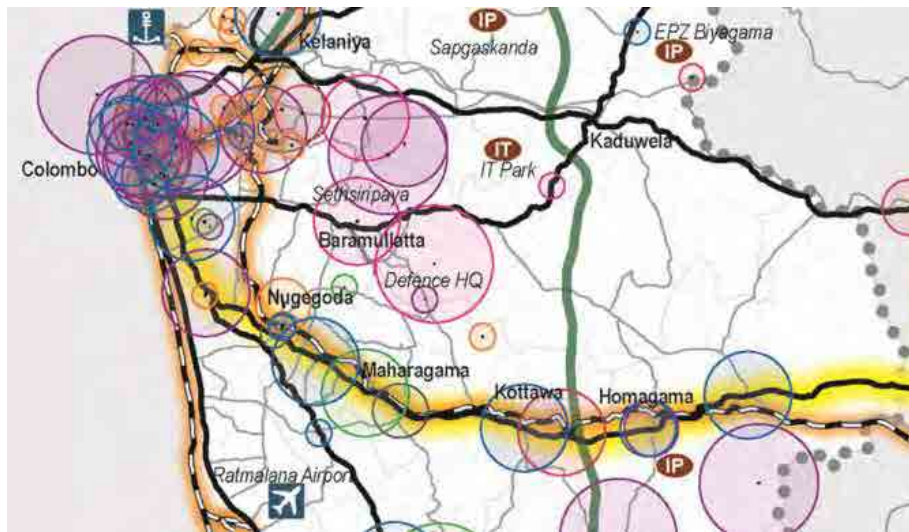


Figure 4.6.1 Urban Development Potentials in High Level Road Corridor

(2) Characteristics in the view of Urban Development Potentials

Under the development of OCH and the Southern expressway, Kottawa is the one potential area for mixed development. UDA plans the 3K project around Kottawa Interchanges.

Several commercial developments are along A04.

(3) Characteristics in the view of Transport Infrastructures and Issues

Regarding public transport services, the KV line operates only 18 trains per day for both directions.

In the case of road infrastructure, High level road (A04) has 4 lanes with 12 to 18m width. It connects to OCH/Southern expressway.

The index of current transport conditions of High Level Road corridor is summarised in the table (Note: the index value is at the CMC boundary. For travel speed, the section at Kirulapone is utilised for analysis). Buses carry the majority of the passenger movement, and railway covers a smaller amount.

Issues regarding the current transport conditions are as follows;

- Low share of railway (KV line) and difficulties of double tracking with concerns regarding land acquisition and resettlements.
- Currently, there is only the one access road (A04) linking CMC to the Southern expressway. Therefore, both urban related traffic and long distance traffic are mixed on the same road.

Table 4.6.1 Index of Current Transport Conditions in High Level Road Corridor

Index	Value
Peak hour road traffic (pcu)	2,000
Hourly capacity (pcu)	2,300
Peak hour travel speed	16 km/h
Peak hour bus load factor	106%
Peak hour passenger volume	15,100 pax/hour Private: 3,700 Bus: 9,900 Railway: 1,500
Daily bidirectional traffic volume	44,100 vehicles Bus: 3,100

(4) Screening of Possible Options

Under the above situation, possible transport options are examined and evaluated in the screening stage. The results of screening are listed in the table.

The points of this screening result are summarised as follows;

- Possible maximum total public transport demand in 2035 is estimated at around 20,000 to 30,000 PPHPD (passengers per peak hour per direction). Therefore, heavy railway and MRT is not adequate for the demand. If the KV line can be improved regarding its operational frequency, this would be one of the options for this corridor. Note that it is limited as single track improvement due to the land acquisition issue.
- In order to meet the demand, LRT, Monorail, AGT and BRT are possible options, but not bus priority. Applying the conditions of road infrastructure and land acquisition issues, BRT and other elevated LRT and AGT would be difficult to construct. In this context, a monorail system is the option to be tested, and there are two possible solutions, one is on the current KV line and the other is on high level road.
- Due to the current condition of long distance trips from the centre of Colombo to the Southern expressway, there is the option to connect by expressway. Therefore, an expressway along the High level road should be investigated.

Table 4.6.2 Screening Result for High Level Road Corridor

Transport Mode	Efficiency	Environment	Social	Incompatibility	Selection
Modernized Railway (single track)	Need to be examined the capacity improvement	Noise	No significant impact		✓
MRT-Underground	Demand is not reached to this mode	Interference of groundwater	Legal issues		
MRT-Elevated		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
LRT	Demand is matching with capacity	Daylight interference, Aesthetic concern	Land acquisition	BRT, Bus priority	
Monorail on KV line on High Level Rd.		No significant impact	Limited land acquisition	Elevated structures	✓
AGT		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
BRT		No significant impact	Some land acquisition	LRT, Bus priority	
Bus Priority	Capacity is not adequate	No significant impact	No significant impact	LRT, BRT	
Road Development	Capacity is not adequate	Air quality, CO2 emission	Huge land acquisition	BRT	
Expressway along High Level Road	Demand is matching	Air quality, CO2 emission, daylight interference and aesthetic concern	Huge land acquisition for road and I/C	Elevated structure on A04	✓

Based on the above discussion, the selected options are listed and tested for the network analysis.

- Modernised railway of KV line with single track
- Monorail system on KV line (Replacement of current KV line)
- Monorail system on High level road
- Urban expressway along High level road to connect with the Southern expressway

(5) Evaluation of Selected Options

A quantitative network simulation was conducted utilizing JICA-STRADA for each transport option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads. The table below shows the result of the network simulation.

Table 4.6.3 Evaluation Results for each Development Option

		Status Quo in 2035	Modernised Railway of KV line (single)	Monorail on KV line	Monorail on High level road	Urban Expressway along High level road
Economic Efficiency	Annual Net Benefit (billion Rs./year in 2035)	-	63	36	100	12
	Network Average Speed (km/h)	7.4	7.8	7.7	8.2	7.7
Environmentally Friendly	CO ₂ Emission (million tonne/year of 2035)	4.13	4.07	4.09	4.05	4.22
	Ref. Modal share of Public transport (%)	49.0	50.0	50.6	50.8	48.1
Equity in Society	Accessibility to Transit Stations (million population)	0.99	0.99	1.08	1.07	0.99
Safety	Loss due to Accidents (billion Rs./year in 2035)	10.8	10.7	10.7	10.5	11.1

Note: Definitions are described in Sub-section 3.7.1

The above results are summarised and evaluated as follows;

- For the evaluation criteria of “economic efficiency”, monorail on the high level road is the most suitable option among them. It also improves the accessibility to transit stations.
- An expressway is estimated to be worse than status quo in terms of CO₂ emission and accidents due to foreseen induced private traffic along the road. In addition, there are difficulties regarding how to develop a 4 lane elevated road on the 4 lane road of the A04 as well as interchanges under current land use condition and patterns.

Based on the results described above, the expressway along the A04 is dropped and will be treated in Horana corridor’s options. The development proposal in the High level road corridor is as follows;

- Monorail System from Borella to Homagama (20km) to connect with the Malabe Monorail System, as well as the connection to Wellawatta for establishment of the monorail network

It is also proposed that the multi-modal centre at Makumbura (near Kottawa) be established to realise smooth transit after development of the monorail system with secured capacity of passenger movement to the urban core centre from feeder buses as well as long distance buses using the OCH and Southern expressway.

The figure shows the image of the proposed transport development in the High level road corridor.

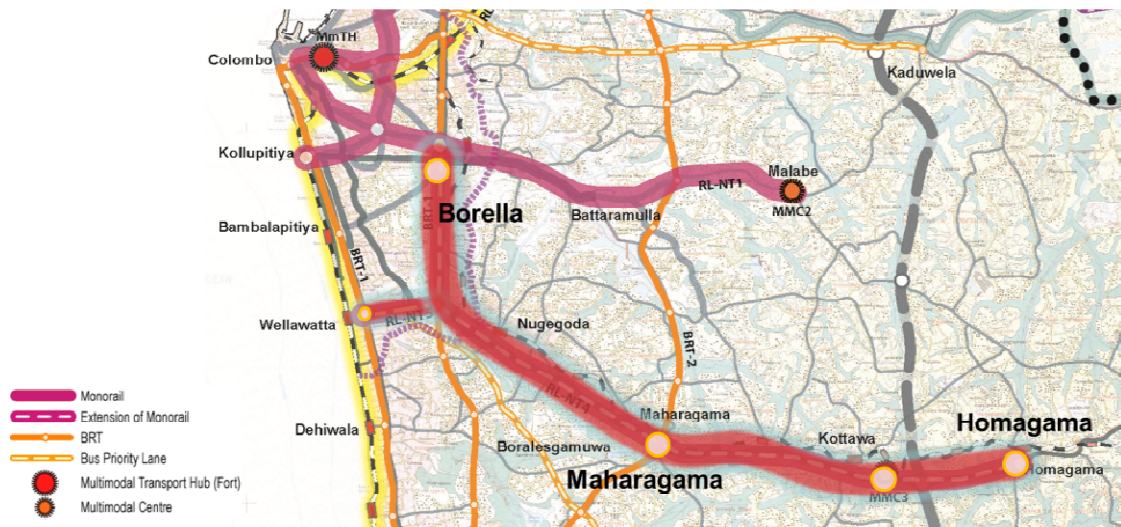


Figure 4.6.2 Proposed Transport Development Options in High Level Road Corridor

Note that this figure shows the concept of the development option network. Detailed alignment will be examined and identified in the feasibility study stage.

4.7 Horana Corridor

Horana corridor connects Colombo central area to Horana via Peliyandara Kalutara with the Horana road (B84). The following characteristics are identified through data collection and analysis under the CoMTrans study.

(1) Characteristics in the view of Land use and the Environment

Ribbon development is occurring along the Horana road (B84)

Along the B84, there are many wet lands.

There are urban centres at Peliyandara.

(2) Characteristics in the view of Urban Development Potentials

There are no foreseen major urban developments along the corridor.

Table 4.7.1 Index of Current Transport Conditions in Horana Corridor

Index	Value
Peak hour road traffic (pcu)	2,200
Hourly capacity (pcu)	2,300
Peak hour travel speed	19 km/h
Peak hour bus load factor	106%
Peak hour passenger volume	11,100 pax/hour Private: 3,700 Bus: 7,400
Daily bidirectional traffic volume	41,300 vehicles Bus: 1,600

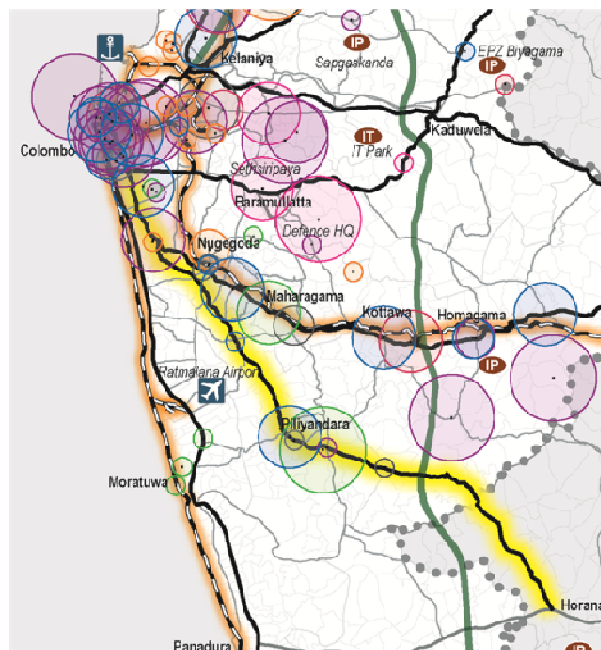


Figure 4.7.1 Urban Development Potentials in Horana Corridor

(3) Characteristics in the view of Transport Infrastructures and Issues

In terms of public transport service, only the bus is operated. There are no railway lines and it would be difficult to develop the railway line in the future due to the land use and conditions along the road.

Horana road (B84) is mainly a 2 lane road with 12m width. Only the section around the CMC boundary has 4 lanes.

The index of current transport conditions of Horana corridor is summarised in the table (Note: the index value is at the CMC boundary. For travel speed, the section at Vilawala is utilised for analysis). Passengers mainly use bus services and private cars.

Issues of current transport conditions are as follows;

- There are only limited spaces for public transport installation, therefore bus service is the only possible option in this corridor.

(4) Screening of Possible Options

Under the above situation, possible transport options are examined and evaluated in the screening stage. The results of the screening are listed in the table.

Table 4.7.2 Screening Result for Horana Corridor

Transport Mode	Efficiency	Environment	Social	Incompatibility	Selection
Modernized Railway	Not applicable				
MRT-Underground	Demand is not reached to this mode	Interference of groundwater	Legal issues		
MRT-Elevated		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
LRT	Demand is not adequate considering costs	Daylight interference, Aesthetic concern	Land acquisition	BRT, Bus priority	
Monorail		No significant impact	Limited land acquisition	Elevated structures	
AGT		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
BRT		No significant impact	Some land acquisition	LRT, Bus priority	
Bus Priority	Demand is matching	No significant impact	No significant impact	LRT, BRT	✓
Road Development	Capacity is not adequate	Air quality, CO2 emission	Huge land acquisition	BRT	
Expressway [via Battaramulla] [via Nugegoda]	Demand is currently matching	Air quality, CO2 emission, daylight interference and aesthetic concern	Huge land acquisition, incase of alignment		✓

The points of this screening result are summarised as follows;

- Possible maximum total public transport demand in 2035 is estimated at around only 10,000 to 15,000 PPHPD (passengers per peak hour per direction). Therefore, railway based options are not adequate based on the demands. There is only the bus priority option.
- Based on the previous discussions regarding the high level road corridor, there are options to connect from the Southern expressway to CMC by an expressway. With the careful consideration of land availability, two options are possible for the route, one is via Battaramulla to connect around Baseline road, the other is via Nugegoda and the

interchange attached to B84 to connect around Kirulapone.

Based on the discussion above, the selected options are listed and tested for network analysis.

- Bus priority system on B84 to Kesbewa
- Urban Expressway (CMC - Battalamura – Kahathuduwa IC of the Southern expressway)
- Urban Expressway (CMC (Kirulapone) – Nugegoda - B84 – Kahathuduwa IC on the Southern expressway)

(5) Evaluation of Selected Options

A quantitative network simulation was conducted utilizing JICA-STRADA for each transport option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads. The table below shows the result of the network simulation.

Table 4.7.3 Evaluation Results for each Development Option

		Status Quo in 2035	Bus Priority on Horana road (B84)	Urban Expressway via Battaramulla	Urban Expressway via Nugegoda
Economic Efficiency	Annual Net Benefit (billion Rs./year of 2035)	-	51	15	38
	Network Average Speed (km/h)	7.4	7.7	7.6	7.8
Environmentally Friendly	CO ₂ Emission (million tonne/year in 2035)	4.13	4.09	4.18	4.21
	Ref. Modal share of Public transport (%)	49.0	50.0	48.3	48.2
Equity in Society	Accessibility to Transit Stations (million population)	0.99	0.99	0.99	0.99
Safety	Loss due to Accidents (billion Rs./year in 2035)	10.8	10.7	11.0	11.1

Note: Definitions are described in 3.7.1

Above results are summarised and evaluated as follows;

- Bus priority system has the “economic efficiency” with low cost investment and produces some improvement.
- An urban expressway will produce some improvement of “economic efficiency”. Other indexes are worse due to the road oriented developments. This means that the reason to invest in this expressway to connect CMC to the Southern expressway and Nugegoda route is that it is more effective than others, maybe because of capturing some traffic related to the B84 road.

Based on the results described above, the development proposal for Horana Corridor is as follows;

- Bus Priority System on Horana road (B84) with bus priority lanes and signalling. This is based on the committed project for road widening to 4 lanes with redesigning. It is also effective if the feeder bus services will be able to connect with the high level road and the monorail stations.
- Urban expressways connect CMC to B84 and to Hahathuduwa IC of the Southern expressway. This helps not only the Horana corridor but also increases the number of long distance trips towards the southern direction from CMC.

The figure shows the image of the proposed transport development in Horana Corridor.

Note that this figure shows the concept of the development option network. Detailed alignment will be examined and identified in the feasibility study stage.

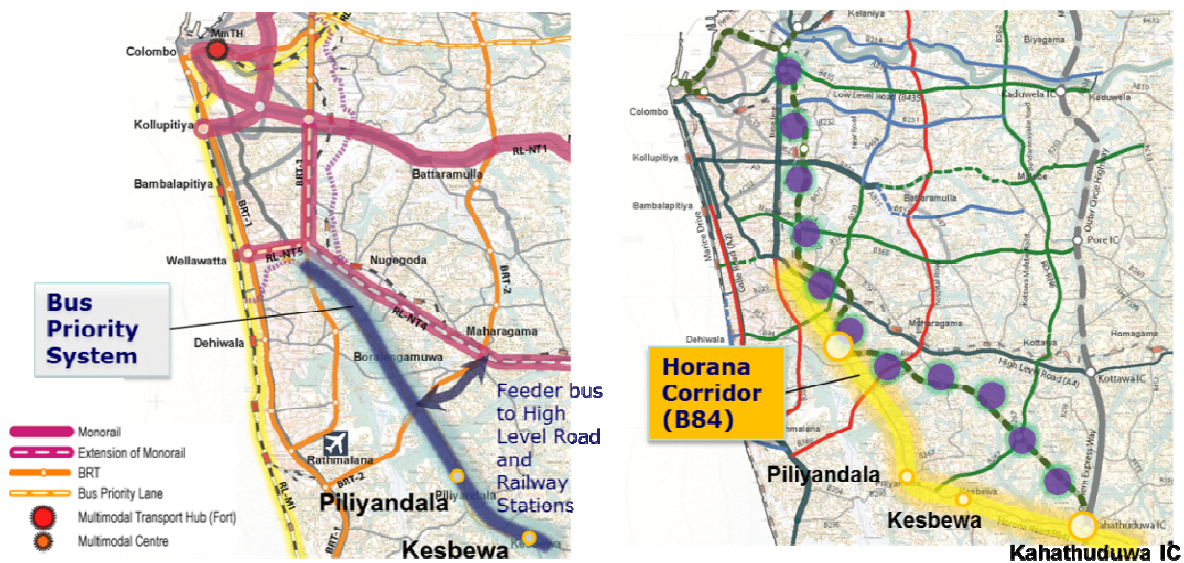


Figure 4.7.2 Proposed Transport Development Options in Horana Corridor

4.8 Low Level Road Corridor

The low level road corridor connects Colombo central area to Avissawella via Kaduwela with the low level road (B435). The following characteristics are identified through data collection and analysis under the CoMTrans study.

(1) Characteristics in the view of Land use and the Environment

Ribbon development has occurred along the low level road (B435) since the early stage of Colombo. Thus the difficulties of resettlement are a concern.

Left bank of Kelani river is at a low elevation.

There are only a few urban centres such as Kaduwela where the new Kandy road passes.

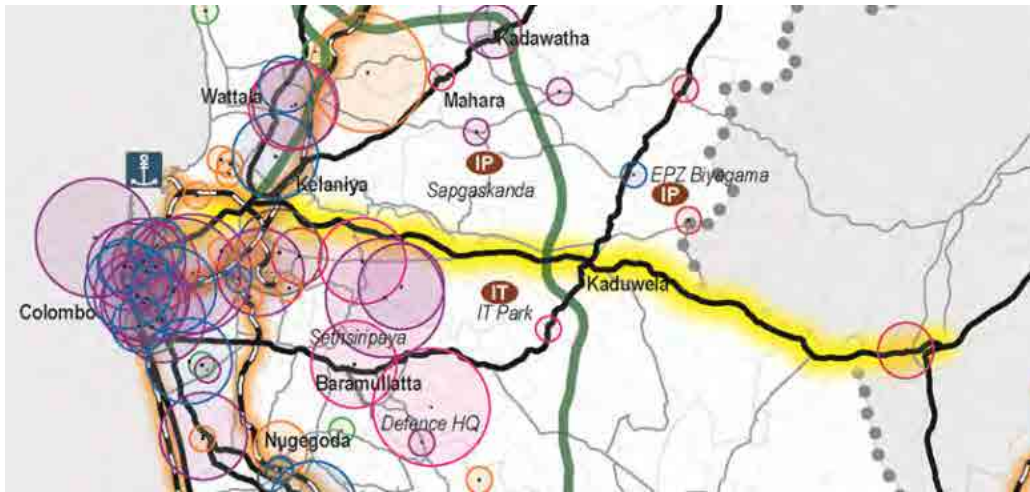


Figure 4.8.1 Urban Development Potentials in Low Level Road Corridor

(2) Characteristics in the view of Urban Development Potentials

Kaduwela is planned for mixed development because the OCH connects with B435.

(3) Characteristics in the view of Transport Infrastructures and Issues

The low level road does not have any railway based public transport.

There is only the low level road (B435), with 2 lanes of only 10 ~ 12m width provided. It will connect with OCH at Kaduwela, which is currently well-known as the new Kandy road passed from A01 to Malabe corridor.

The index of current transport conditions of the Low level road corridor is summarised in the table (Note: the index value is at the CMC boundary. For travel speed, the section at Orugodawatta is utilised for the analysis). Bus is the only public transport service.

Issues of current transport conditions are as follows;

- There are only limited spaces for public transport installation, therefore bus services are the only possible option for this corridor.

Table 4.8.1 Index of Current Transport Conditions in Low Level Road Corridor

Index	Value
Peak hour road traffic (pcu)	2,900
Hourly capacity (pcu)	2,200
Peak hour travel speed	18 km/h
Peak hour bus load factor	171%
Peak hour passenger volume	14,300 pax/hour Private: 6,500 Bus: 7,800
Daily bidirectional traffic volume	70,700 vehicles Bus: 2,400

(4) Screening of Possible Options

Under the above situation, possible transport options are examined and evaluated in the screening stage. The results of the screening are listed in the table.

Table 4.8.2 Screening Result for Low Level Road Corridor

Transport Mode	Efficiency	Environment	Social	Incompatibility	Selection
Modernized Railway	Not applicable				
MRT-Underground	Demand is not reached to this mode	Interference of groundwater	Legal issues		
MRT-Elevated		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
LRT	Demand is not reached to this mode	Daylight interference, Aesthetic concern	Land acquisition	BRT, Bus priority	
Monorail		No significant impact	Land acquisition	Elevated structures	
AGT		Daylight interference, Aesthetic concern	Land acquisition	Elevated structures	
BRT		No significant impact	Land acquisition	LRT, Bus priority	
Bus Priority	Demand is matching	No significant impact	No significant impact	LRT, BRT	✓
Road Development	Capacity is not adequate	Air quality, CO2 emission	Huge land acquisition	BRT	
Expressway	Demand is not reached to this option	Air quality, CO2 emission, daylight interference and aesthetic concern	Huge land acquisition		

The points of this screening result are summarised as follows;

- Possible maximum total public transport demand in 2035 is estimated at around only 10,000 to 15,000 PPHPD (passengers per peak hour per direction). Therefore, railway based options are not adequate based on the demands. There is only the option for bus priority.

Based on the above discussion, the selected options are listed and tested for the network analysis.

- Bus priority system on B435 to Kaduwela

(5) Evaluation of Selected Options

A quantitative network simulation was conducted utilizing JICA-STRADA for each transport option which was then combined with the status quo scenario projection for 2035 for both public transport infrastructure and roads.

The results above are summarised and evaluated as follows;

- The level of improvement is not great, however, most of the indicators are positive and no negative impacts exist.
- Based on the results described above, the development proposal for the Low level road corridor is as follows;
- Bus priority system on the low level road (B435) with priority lanes and signalling. This is based on the committed project for road widening for 4 lanes with redesigning.

This priority lane should be well coordinated with the BRT system on Baseline road.

Table 4.8.3 Evaluation Results for each Development Option

		Status Quo in 2035	Bus Priority on Low Level Road (B435)
Economic Efficiency	Annual Net Benefit (billion Rs./year in 2035)	-	12
	Network Average Speed (km/h)	7.4	7.5
Environmentally Friendly	CO ₂ Emission (million tonne/year in 2035)	4.13	4.12
	Ref. Modal share of Public transport (%)	49.0	49.4
Equity in Society	Accessibility to Transit Stations (million population)	0.99	0.99
Safety	Loss due to Accidents (billion Rs./year in 2035)	10.8	10.8

Note: Definitions are described in the 3.7.1

The figure shows the image of the proposed transport development in High level road corridor.

Note that this figure shows the concept of the development option network. Detailed

alignment will be examined and identified in the feasibility study stage.

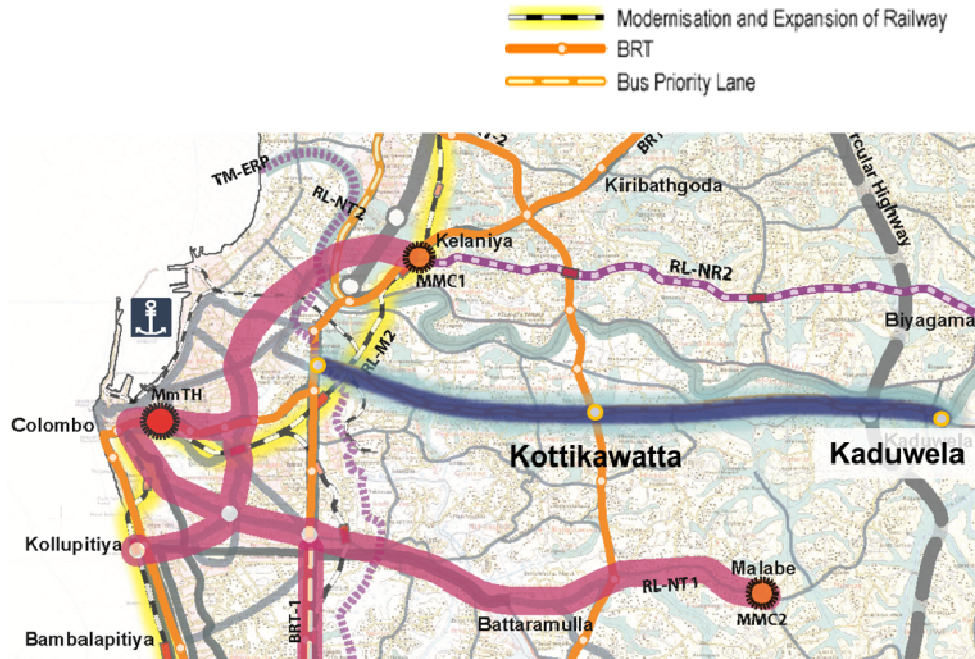


Figure 4.8.2 Proposed Transport Development Options in Low Level Road Corridor

4.9 Summary of Development Options for the Seven Corridors

Through the discussions on each corridor analysis, the table shows the summary of the development options for the seven corridors. Note that these are results on a corridor basis so that it should be discussed in the view of network enhancement, especially the public transport network, such as monorail network, railway network and BRT network to link closely.

Table 4.9.1 Summary of Development Options for the Seven Corridors

Corridor/Area	Development Options in 2035		
	Monorail	Railway	BRT/Bus/Roads
Malabe	Monorail	-	-
Galle	-	Modernized	BRT [w/ Marine drive Extension]
Seven Corridors	Kandy	Modernized	BRT
	Negombo	Modernized	Bus priority
	High Level Road	Monorail	-
	Horana	-	Bus priority U. Expressway [via Nugegoda]
	Low Level Road	-	Bus priority

CHAPTER 5 Phasing of Urban Transport Projects

5.1 Points Considered for Prioritisation

The policy measures listed above can be regarded as a long list of projects to improve the transport situation. Among these policy measures, in general the following policy measures are planned to be implemented in the short term.

(1) Extensive Public Transport Network Development

It is essential to develop an extensive network of high quality public transport to alleviate traffic congestion in the Colombo metropolitan area; otherwise, people would shift from public transport to private modes and would bring about more serious traffic congestion.

(2) Rehabilitation and Repair of the Existing Transport Facilities

Rehabilitation and repair the existing transport facilities are regarded as short-term measures since it is usually economical to make the most use of the existing infrastructure and it is required for securing safety.

(3) Development of Flyovers and Underpasses at Bottleneck Intersections

Traffic congestion often occurs at intersections in the urbanised area where traffic capacity is reduced compared to a single road section since various traffic flows share the traffic capacity of the intersections. One of countermeasures to alleviate traffic congestion at intersections is to provide grade separation facilities such as flyovers and underpasses.

(4) Missing Link of Expressway Network

Colombo Natunayake Expressway has been operating since November 2013 and the Outer Circular Highway, Kottawa - Kaduwela section was recently opened to the public in March 2014. Elevated roads around the new Kelaniya bridge with connection to CKE will be developed in the short-term. If the end of the elevated road is located in the middle of the city centre, it is anticipated that it would cause serious traffic congestion at that exit point. From the transport engineering and planning point of view, a dead end should not be in the city centre but the expressway link should be extended to the south and should be connected to the OCH or Southern Expressway to distribute traffic flows to various destinations. Furthermore these expressway developments would not serve the southern part of the CMC thus they should cover the southern part of CMC to promote spatial equity among the districts.

(5) Logical Sequential Order of Infrastructure Development

Transport facilities are usually composed of networks. Road and railway networks consist of several links in sequence. When developing a new road or railway line, logically the sequence of development is starting from the end of the road or the railway line, when it is long and has to be divided into several phases for development.

(6) Soft Measures

Soft measures such as improvement of regulation regarding public transport operation, improvement of management of public transport operation, establishment of technical standards, establishment of road network master plan and education on traffic safety and so forth are relatively easy to implement in terms of budget and time.

(7) Traffic Control

Traffic control, including traffic signal installation can be implemented in the short term for certain areas to smooth traffic flows at intersections. An area wide traffic control system would be the system for the city centre. Extension of the traffic signal system will be implemented in the following phase.

(8) Transport Demand Management

Transport demand management aims to control transport demand by various policy measures. This includes car traffic restraint schemes such as road pricing in congested areas. Electric Road Pricing (ERP) has already been implemented in Singapore and London. A prerequisite for employing car traffic restraints is quality public transport systems. Since car traffic restraint schemes force car drivers and passengers to shift from private car use to public modes of transport, if there is no reasonable public transport system, people are reluctant to switch their modes. In terms of timing, these policy measures can be taken after the public transport system is developed extensively.

(9) Initial Prioritisation of Urban Transport Projects

According to the criteria and conditions mentioned above, the projects are tentatively divided into three phases; namely, short-term, intermediate-term and long-term development plans. This phasing shall be reviewed after the evaluation is made and budget constraints are also taken into consideration.

5.2 Urban Transport System Development Scenarios

5.2.1 Preparation of Urban Transport System Development Scenarios

The base case scenario and three urban transport system development scenarios are prepared to compare the advantages and disadvantages of each development scenario.

- Base Case Scenario
- Intensive public transport system development scenario
- Mixed public transport and road network development scenario
- Intensive road network development scenario

The base case scenario includes the transport system development identified in the corridor analysis. Obviously the improvements consist of the selected option for each radial corridor. The other three cases include other facilities including transport facilities and services in the circumferential direction as well.

In addition, transport demand management (hereinafter referred to as “TDM”) such as electric road pricing can be included as an option to reduce traffic congestion on the road network and to promote a modal shift from the private mode of transport to public transport.

5.2.2 Preparation of Public Transport Network and Road Network

The guiding principal for formulating a public transport network is to prepare a congestion free public transport network as much as possible to promote public transport use. Public modes of transport for a congestion-free network include 1) Railway 2) Monorail 3) Bus Rapid Transit.

(1) Alternatives for Public Transport Network

BRT is proposed on the roads with three lanes per direction. Those roads include Base Line Road, Galle road together with Marine Drive and Duplication road. It is proposed to develop the Middle Ring road with 3 lanes per direction to prepare for future development of BRT.

Heavy rail basically focus on the rehabilitation and improvement of the existing railway system except for the short-distance airport access and Dompe freight line.

In other areas and corridors where wide road space is not available, development of an elevated rail-based transit system is planned. Major components of this category include the Fort-Malabe corridor, High level road corridor and north –south corridor in the city centre.

(2) Alternatives for Road Network

The expressway network is formulated taking on-going road development projects and connection with the existing expressways such as the southern expressway as well as the outer circular highway into account. This includes connection between the southern expressway and the CKE and Pore - Malabe - Borella connection. The port access road is an extension of the elevated road connecting to CKE and is also included in the expressway network.

The arterial road development scenario includes those for supporting public transport and major and minor arterial road development is proposed to formulate neighbourhood units in suburban areas.

Alternatives for the transport network are prepared by combining projects in public transport as well as the road network taking budget constraints into consideration. An intensive public transport system development scenario consists of more public transport options compared to that of an intensive road network development scenario as indicated in Table 5.2.1. The most appropriate development scenarios will be selected based on the evaluation of the transport system development scenarios and then the urban transport master plan will be formulated.

Table 5.2.1 Alternatives for Transport System Development Scenario

Sub Transport Sector	Project ID	Project Name	Transport System Development Scenario						Note
			A1	A2	B1	B2	C1	C2	
			Intensive Highway Development	Intensive Highway Development & TDM	Combined Public Transport and Highway Development	Combined Public Transport and Highway Development & TDM	Public Transport Intensive	intensive Public Transport Development & TDM	
TDM	TM-ERP	Electric Road Pricing (CMC)	-	√	-	√	-	√	
BRT	BRT-1	Fort-(Galle Road)-Moratuwa	√	√	√	√	√	√	
	BRT-1	Kelaniya-Fort-(Galle Road)-Wellawatta-Kirillapone-(Baseline)	√	√	√	√	√	√	
	BRT-1	Kelaniya-(Kandy Road)-Kadawata	-	-	√	√	√	√	
	BRT-2	Middle Ring Road	√	√	√	√	√	√	
	BRT-2	BRT Base Line Extension	-	-	√	√	√	√	
	BRT-2	BRT Moratuwa Extension	-	-	√	√	√	√	
Monorail	RT-NT1	Battaramulla Line(East West Line)	√	√	√	√	√	√	
	RT-NT2	North - South Line	√	√	√	√	√	√	
	RT-NT3 and 4	Borella-Kirillapone-Homagama	-	-	-	-	√	√	
	RT-NT5	Kirillapone – Wellawatta	-	-	-	-	√	√	
Railway	RL-M1 to M5	Electrification , Signal improvement, Procurement of Electric Cars	-	-	√	√	√	√	
	RL-NR2	Dompe Line	-	-	-	-	√	√	Private investment
Arterial Roads	RD-RN3	Base Line Extension	√	√	√	√	√	√	required for BRT
	RD-RN4	Marine Drive Extension	√	√	√	√	√	√	required for BRT
	RD-RN2	Middle Ring Road	√	√	√	√	√	√	required for BRT

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Sub Transport Sector	Project ID	Project Name	Transport System Development Scenario						Note
			A1	A2	B1	B2	C1	C2	
			Intensive Highway Development	Intensive Highway Development & TDM	Combined Public Transport and Highway Development	Combined Public Transport and Highway Development & TDM	Public Transport Intensive	intensive Public Transport Development & TDM	
	RD-RN1, 5,6,7and 8	Major Arterial Roads	4 lanes	4 lanes	2 lanes	2 lanes	2 lanes	2 lanes	
	RD-RN9, 10	Minor Arterial Roads	√	√	√	√	√	√	
Urban Express ways	RD-EX1	Kelani-Borella-Kirillapone-	√	√	√	√	√	√	
	RD-EX2	Pore-Malabe-Borella	√	√	-	-	-	-	
	RD-EX3	Port Access	√	√	√	√	√	√	Port access is prerequisite for direct ramp to Fort MmTH
	RD-EX4	Direct Ramp to Fort MmTH	-	-	√	√	√	√	required for connecting to Intercity Bus Terminal in MmTH

Note: √ indicates the project is included in the development scenario. – indicates that the project is not included in the scenario.

CHAPTER 6 Evaluation of Urban Transport Development Scenarios

6.1 Evaluation of Urban Transport Development Scenarios

Four urban transport system development scenarios were evaluated to find the most appropriate option for long term transport system development for the CMA.

The Base case scenario consists of the modes of transport selected as a most suitable mode for each corridor in the corridor analysis. In the evaluation of the Base case scenario, the total network capacity is examined for the year 2035. The Base case scenario focuses on enhancement of seven transport radial corridors but not as much focus is put on places that have lower priority such as roads in the circumferential direction. Since it is expected that the urbanised area will expand outward from the city centre, it examines overall sufficiency of the transport network capacity against increasing transport demand. Comparison of simulation results between Base Case and Case C2 clearly indicates the significant traffic flows on the circumferential roads and traffic demand will be distributed more evenly in Case 2. If ring roads are developed the traffic demand on Base Line road could be reduced as illustrated in Figure 6.1.1.

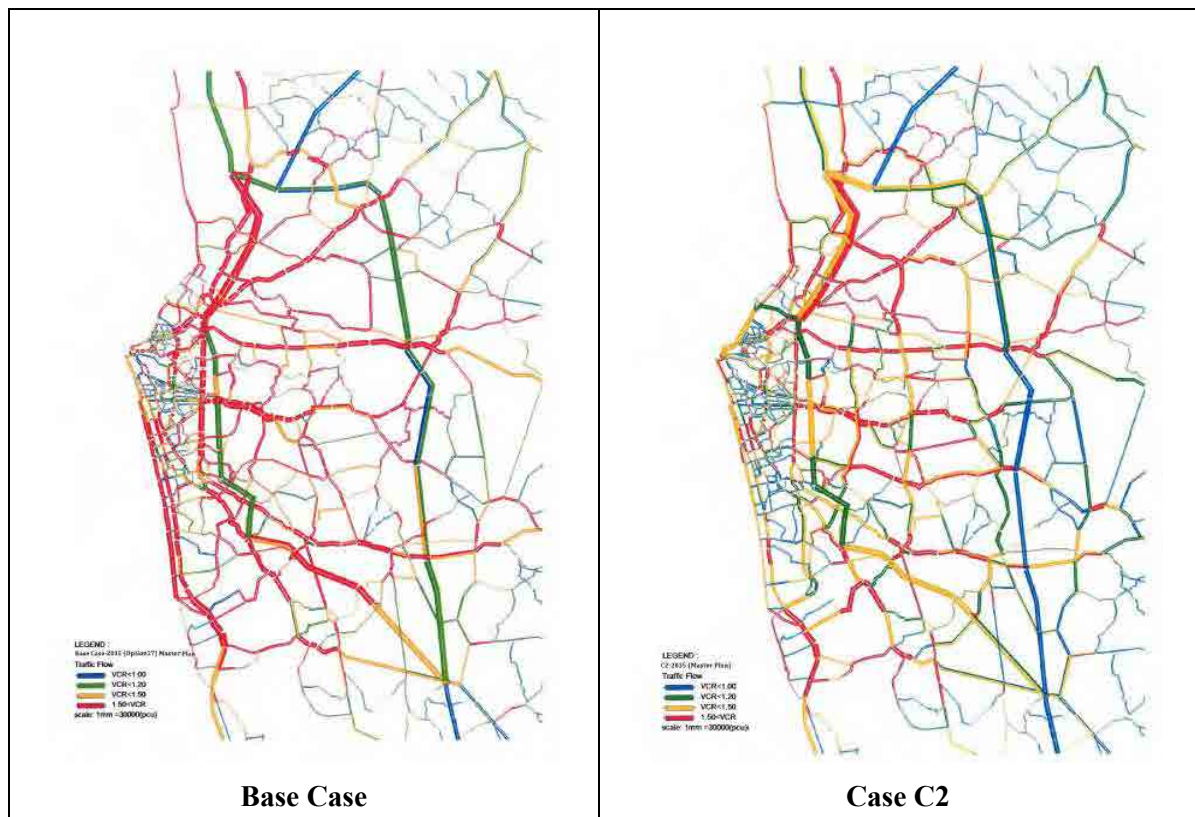


Figure 6.1.1 Comparison of Base Case and Development Scenario C2 in 2035

Alternative transport system development scenarios were prepared to analyse the future direction of the transport network; to determine whether an intensive road network is appropriate for the Colombo metropolitan area or a public transport network should be developed intensively to meet the future transport demand. Consequently, an intensive highway development scenario and intensive public transport development scenario were prepared and compared. The advantages and disadvantages of each development scenario were examined from various aspects.

In addition, if these cases will not be able to alleviate traffic congestion, a further option is also studied. Employment of transport demand management is this option and it includes car traffic restraint schemes such as ERP.

- 1) Base Case
- 2) Intensive Highway Network Development Scenario
- 3) Mixed Highway and Public Transport Development Scenario
- 4) Intensive Public Transport System development Scenario

Performance of each transport system development scenario is evaluated from the following aspects.

- 1) Efficiency: Economic Internal rate of Return EIRR and NPV(net Present Value)
- 2) Equity: Service area of quality public transport (railway, monorail and BRT)
- 3) Environmentally Friendly: Global Warming: Emission of CO₂
- 4) Traffic Safety: Economic loss due to traffic accidents

Traffic simulation results indicate that the transport network capacity is not sufficient in the Base case transport system development scenario. The transport capacity in the radial corridors does not have a significant problem regarding shortage of capacity based on the corridor analysis that examined the required increase in capacity. However, shortage of transport capacity in suburban areas is observed.

Then the performances of the three transport system development scenarios were compared as shown in Figure 6.1.2, Figure 6.1.3, Figure 6.1.4, Figure 6.1.5, Figure 6.1.6 and Figure 6.1.7. The intensive public transport system development scenario indicates better performance compared to the intensive highway development scenario. Thus it is recommended to develop the public transport system intensively to formulate future transport systems for the Colombo metropolitan area. However, even if the public transport system is developed intensively, a shift to private modes of transport is inevitable due to the increase in household income and increase in car ownership. As a result, the public transport share would not increase significantly; and it would not be easy to alleviate traffic congestion.

To deal with this problem, transport demand should be controlled. By employing traffic restraint schemes such as ERP, the traffic flows into the city centre could be reduced in peak hours and this would lead to a shift to public transport. This can be observed by comparing Case C1 and Case C2. Traffic congestion would be alleviated with TDM as illustrated in Figure 6.1.6 and public transport demand would increase by shifting from private modes to public modes as shown in Figure 6.1.3. If the public transport system is developed intensively and, furthermore, transport demand management (TDM) is also employed, the projected performances of the transport system indicate that it will be better than without TDM.

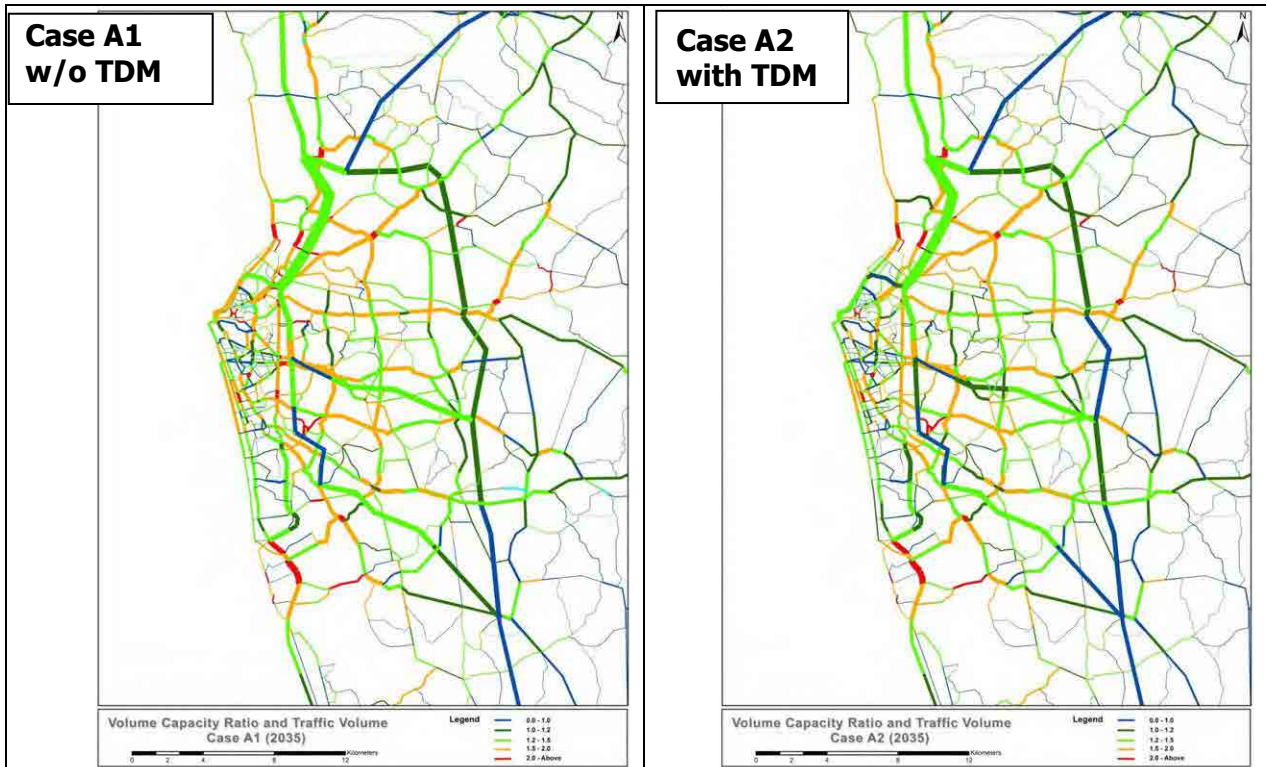


Figure 6.1.2 V/C for Simulation of Cases A1 and A2 in 2035

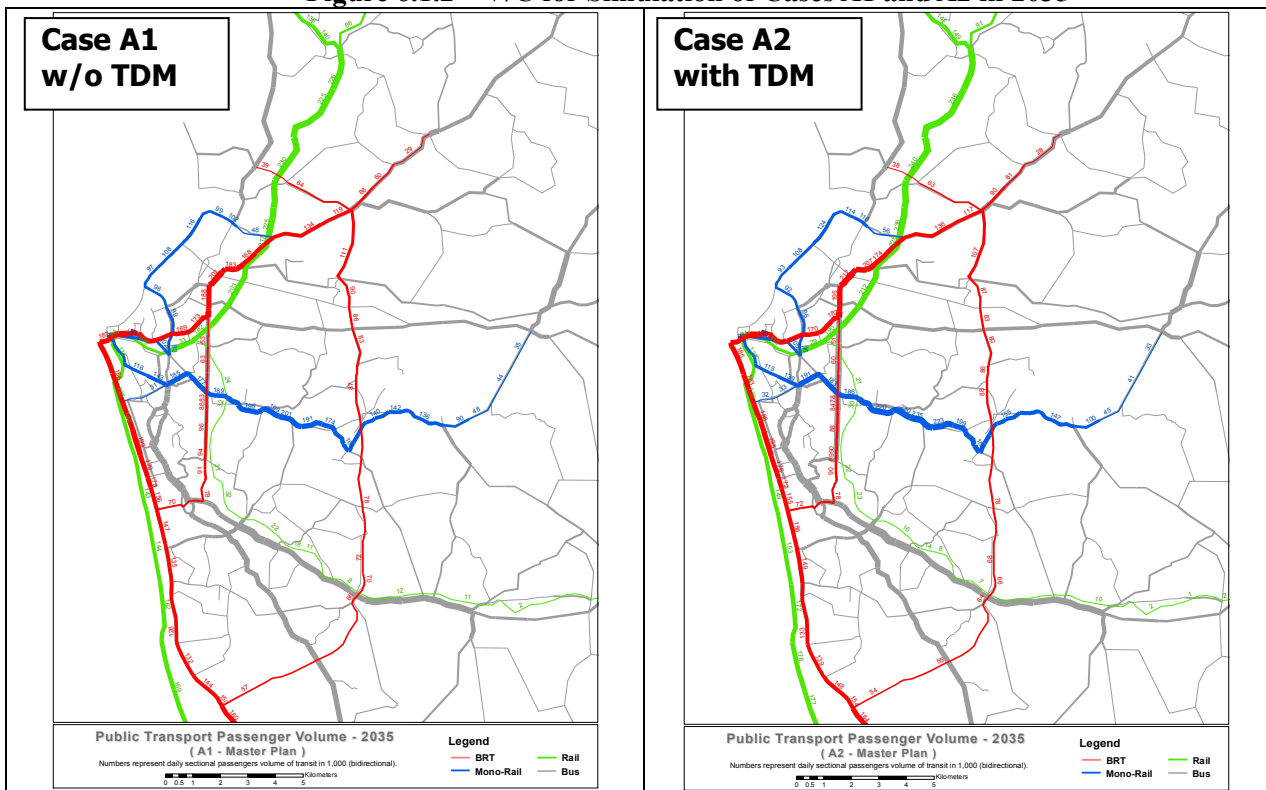


Figure 6.1.3 Passenger Demand on Public Transport of Cases A1 and A2 in 2035

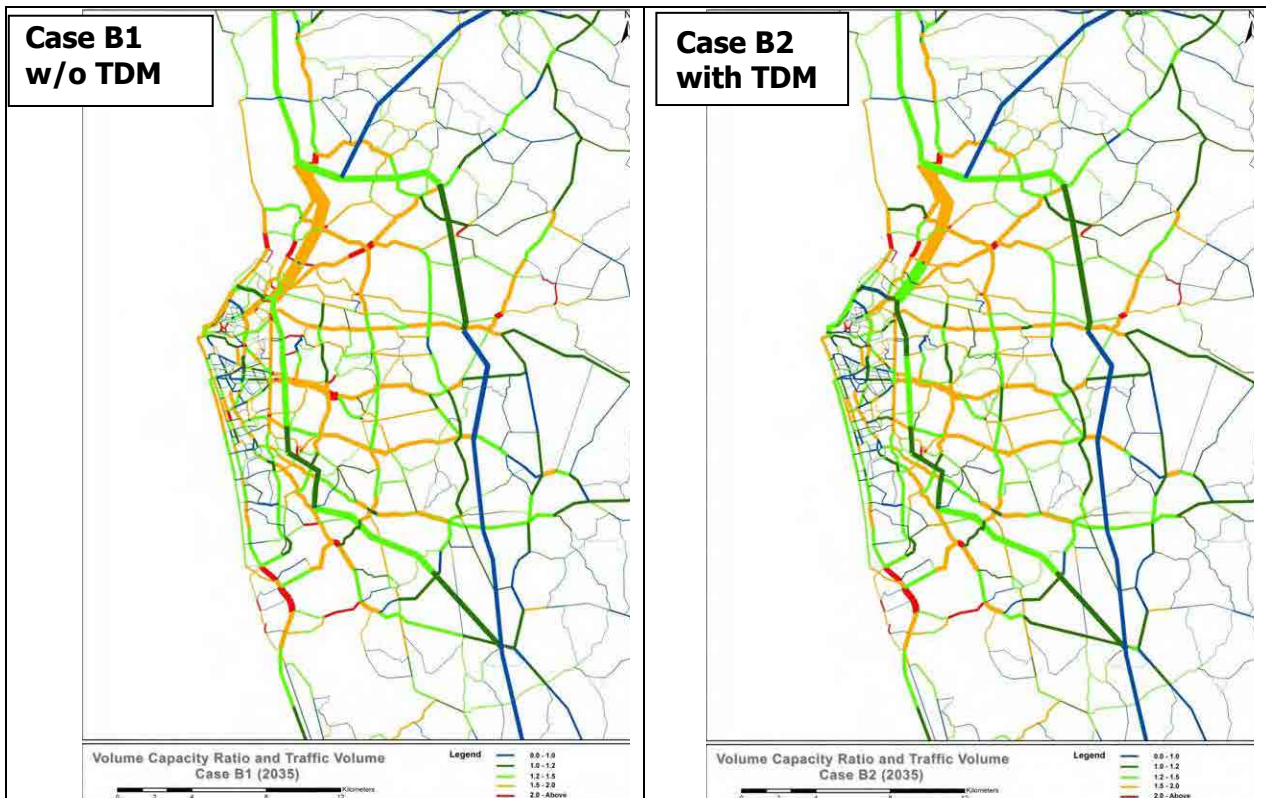


Figure 6.1.4 V/C for Simulation of Cases B1 and B2 in 2035

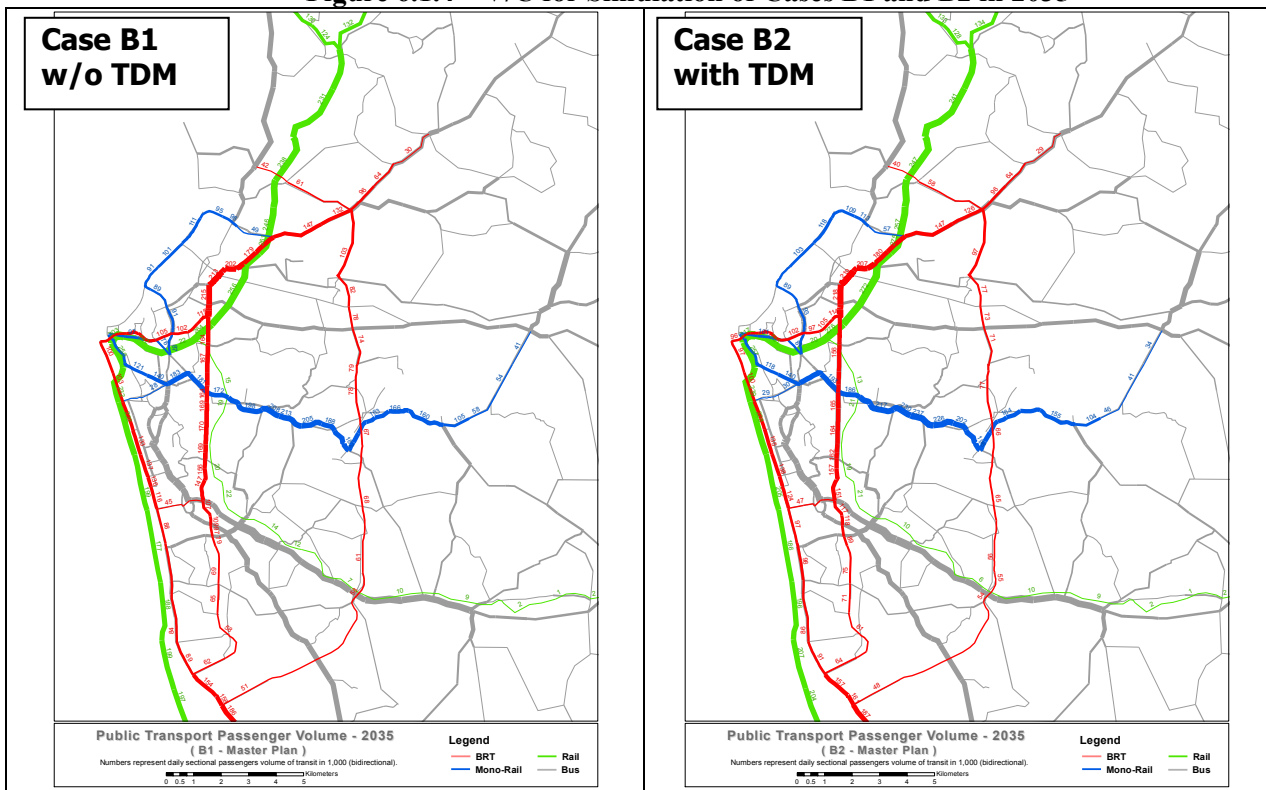


Figure 6.1.5 Passenger Demand on Public Transport of Cases B1 and B2 in 2035

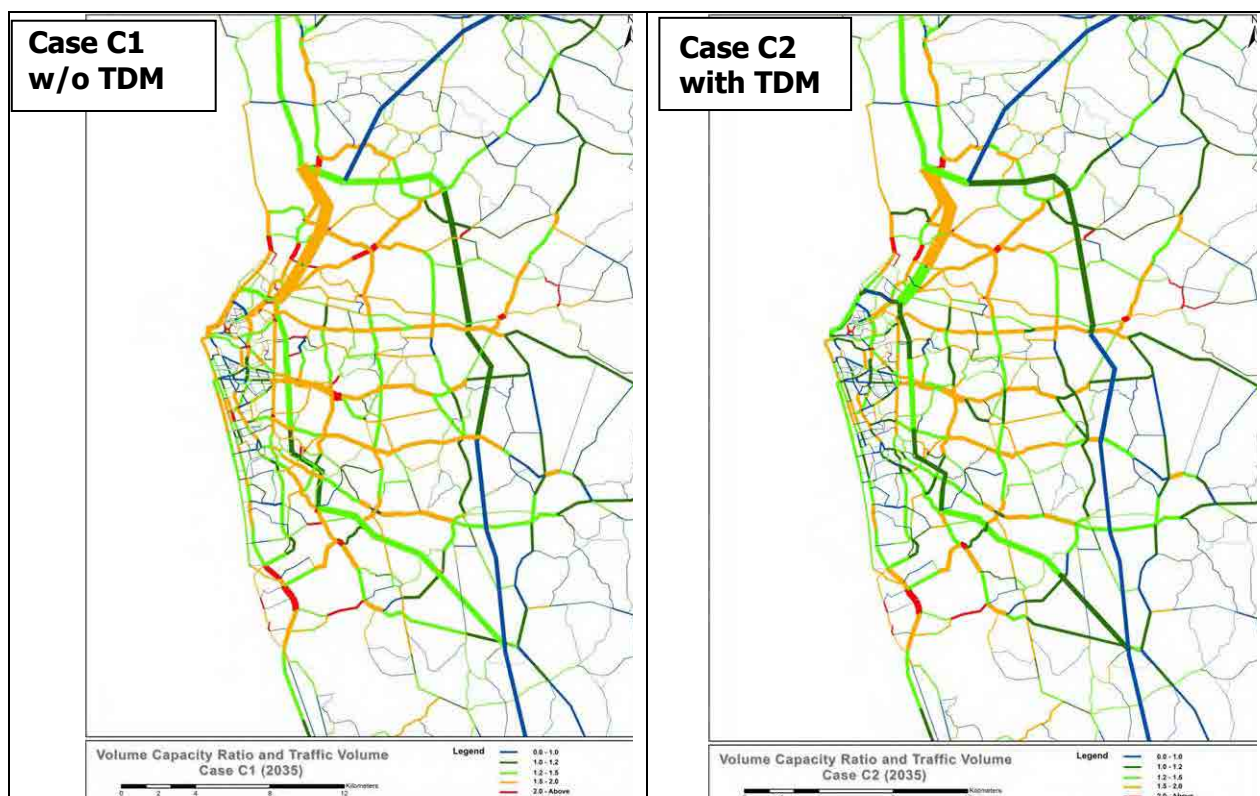


Figure 6.1.6 V/C for Simulation of Cases C1 and C2 in 2035

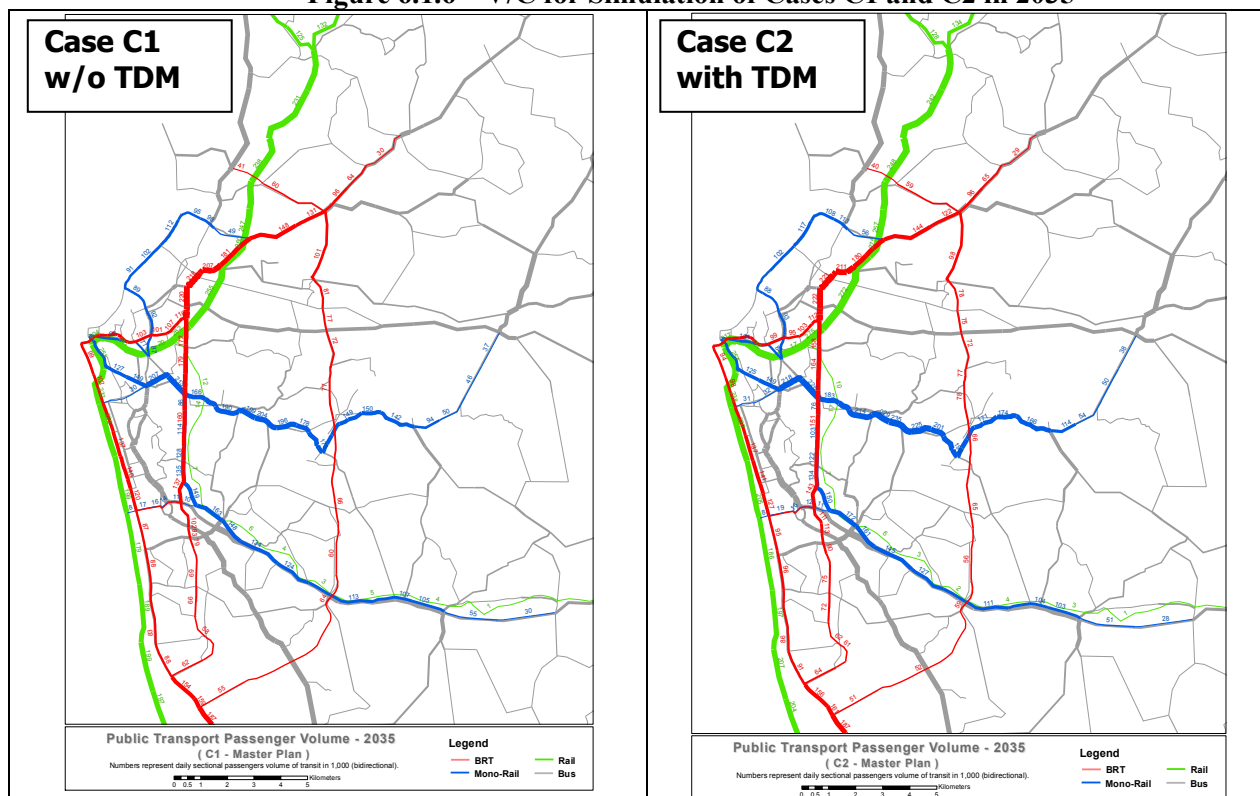


Figure 6.1.7 Passenger Demand on Public Transport of Cases C1 and C2 in 2035

In conclusion, for the urban transport system development scenario it is recommended to develop the public transport system extensively and at the same time employ TDM to promote the shift to public transport.

Table 6.1.1 Evaluation of Urban Transport System Development Scenarios

Evaluation Item	A1	A2	B1	B2	C1	C2
	Intensive Highway Development	Intensive Highway Development & TDM	Combined Public Transport and Highway Development	Combined Public Transport and Highway Development & TDM	Intensive Public Transport	Intensive Public Transport Development & TDM
Economic Internal Rate of Return (%)	19.7%	21.2%	19.3%	22.7%	19.1%	22.9%
Net Present Value (billion Rs.)	622	765	564	779	541	797
Population in the Public Transport Service Area ¹⁾	1.26 million people		1.36 million people		1.40 million people	
Reduction of CO ₂ Emission (million ton)	11.5	11.3	11.3	11.2	11.3	11.0
Reduction of Loss due to Traffic accidents (billion Rs.) ²⁾	12.1	11.9	11.8	11.7	11.9	11.5
Overall Evaluation	B-	B+	B-	A-	B-	A

Note:

1) Public transport service area is defined as the area within an 800 meter radius from railway stations and BRT shelters.

2) Loss due to traffic accidents is discounted 12%.

Source: CoMTrans Estimate

CHAPTER 7 Strategies for Urban Transport System Development

The strategies for developing Urban Transport Systems in the Colombo Metropolitan Area can be divided into two stages; the first set includes the strategies that are developed at the planning stage and those strategies should be taken into consideration when planning urban transport systems and land use. The other strategies are those related to project implementation.

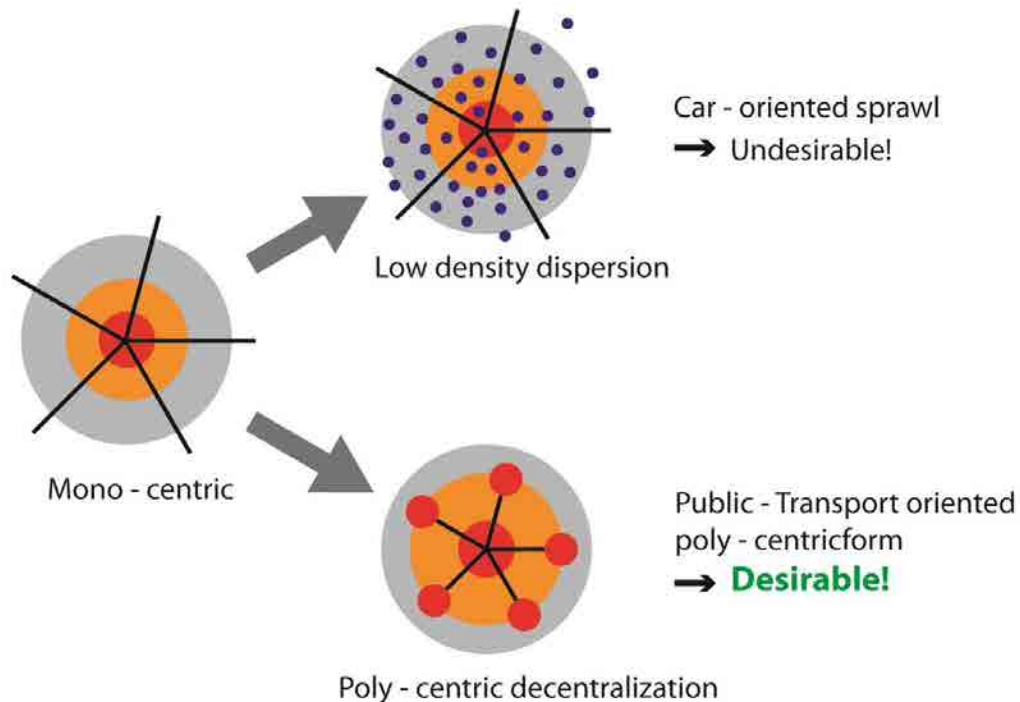
7.1 Strategies for Integration with Urban Planning

7.1.1 Centre Development for Mass Transit Systems

Urban structure and transport systems should be integrated. For instance, a highway oriented transport network is suitable for low-density land use which can be seen in the suburbs of the United States. In contrast, a mass transit system is appropriate for high-density urban land use.

As mentioned in 5.2.1 as one of the planning issues, sub-centre development is one way to deal with traffic concentration in the city centre. In order to develop the sub centres, strong transport linkage is required between the city centre of Colombo and the sub centres. Mass transit systems should be installed between these centres to support the travel needs of the people and goods. Conceptually, to support the viability of public transport systems, it is preferable that a city grows compactly in a form of poly-centric decentralization.

Guided urban development is essential to develop cities that will be consistent with urban transport systems. In this regard, metropolitan-wide urban land use planning is also required.



Source: Shigeru Morichi and Surya Raj Acharya Editors; Transport Development in Asian Megacities A New Perspective, 2013

Figure 7.1.1 Spatial Patterns and Suitable Transport Options

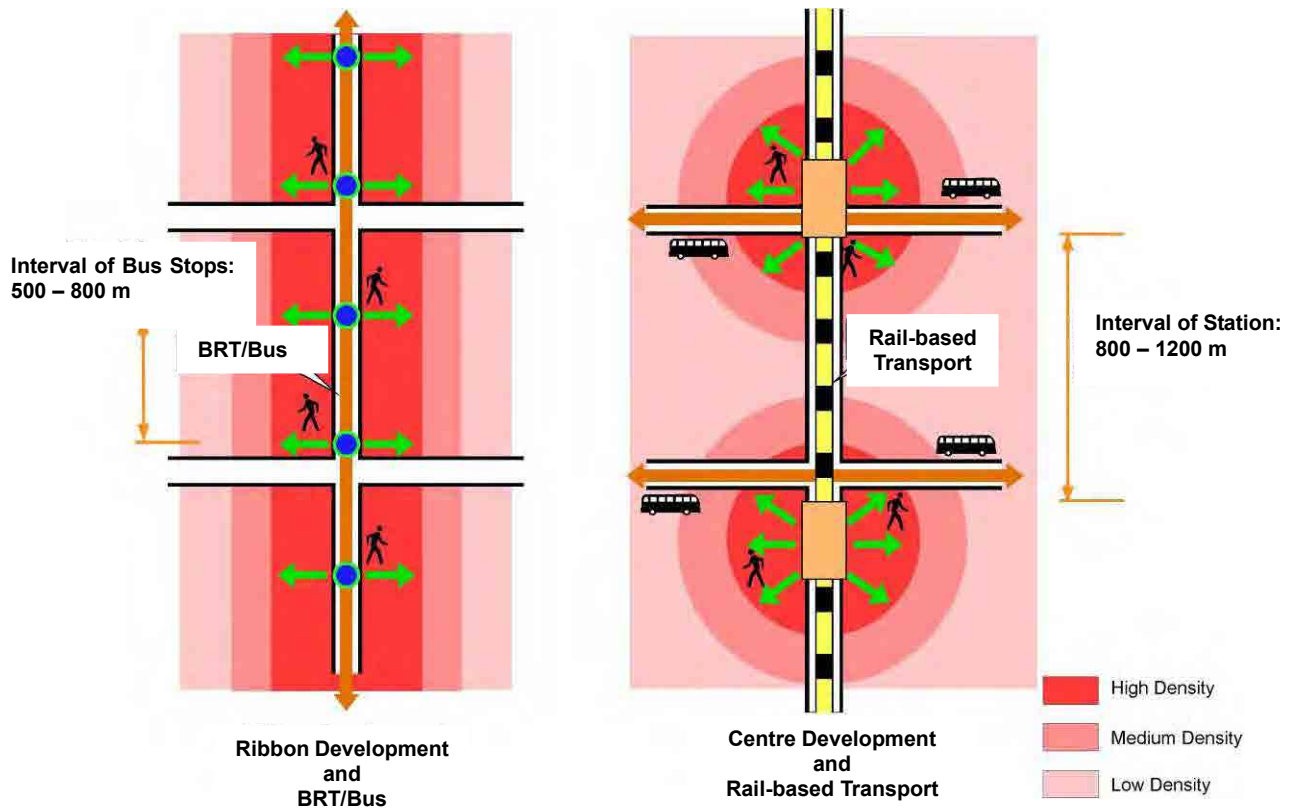
7.1.2 Development of Public Transport Systems to be Synchronised with Urban Development

The Colombo Metropolitan area has expanded outward from the city centre. In suburban areas the population density has not been high and travel demand is not high in the area. In the future, as urbanisation continues, travel demand would increase and then mass transit systems might be required.

Mass transit systems should be developed in accordance with urban development. Travel demand along the corridor should be monitored to determine the development timing of the mass transit system. This phased development should be taken into account in particular for the BRT system to be developed along the planned Middle Ring road in the suburban area.

7.1.3 Transit Oriented Development (TOD)

To make mass transit systems viable, high density urban development in the areas surrounding rail-based transit system stations is preferable. In the city centre, high-rise office buildings and commercial facilities, such as shopping malls within walking distance from a station are desirable to increase passenger demand on the transit system. In suburban areas, high rise apartments near stations are a preferable form of land use for the mass transit system. To materialise these developments, high floor ratios should be promoted in the urban development plan. On the other hand, outside of the area surrounding the station, the floor area ratios should be limited to prevent high density urban development.



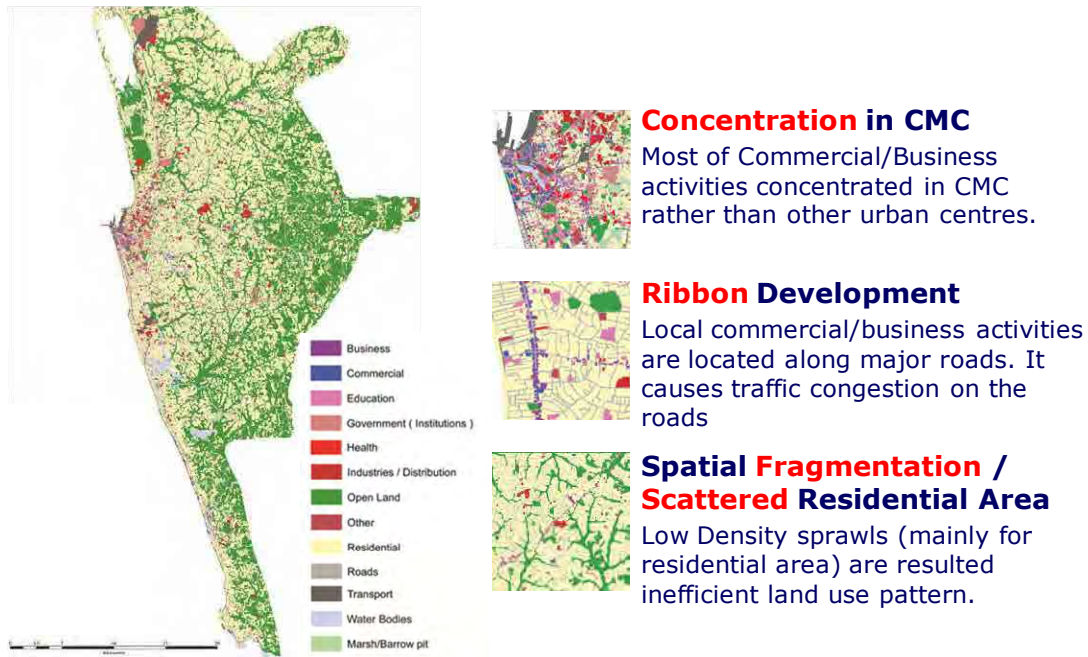
Source: CoMTrans Study Team

Figure 7.1.2 Transit Oriented Development

The CoMTrans land use survey found the following issues in the Colombo Metropolitan Area as described in Sub section 2.2.3 Urban Development Characteristics.

- Ribbon development along the major roads and
- Spatial fragmentation/scattered residential areas.

The urban transport master plan should take into consideration urban development structures.



Source: CoMTrans Land Use Survey, 2013

Figure 7.1.3 Present Land Use Patterns and Issues

Therefore, CoMTrans proposes that the integration of urban development with urban transport systems is of utmost importance. The strategy for the integration includes sub-centre development as illustrated in Figure 7.1.4 and Transit Oriented Development as in Figure 7.1.5.

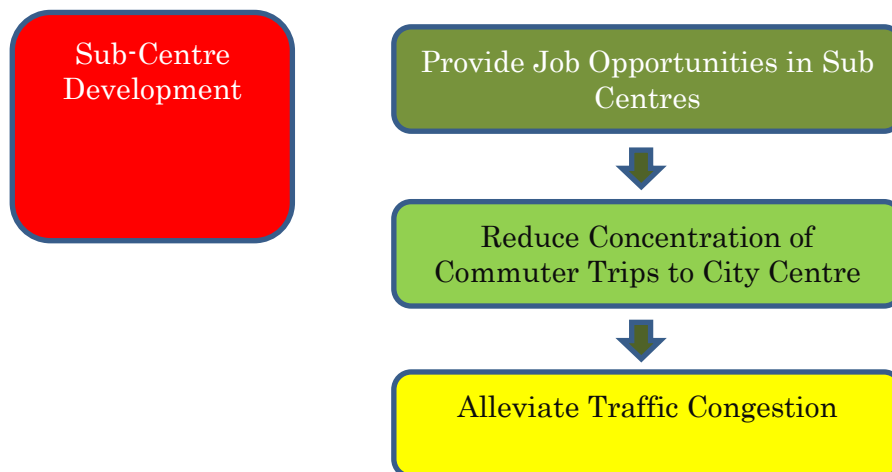


Figure 7.1.4 Integration of Urban Development and Transport Systems: Sub-Centre

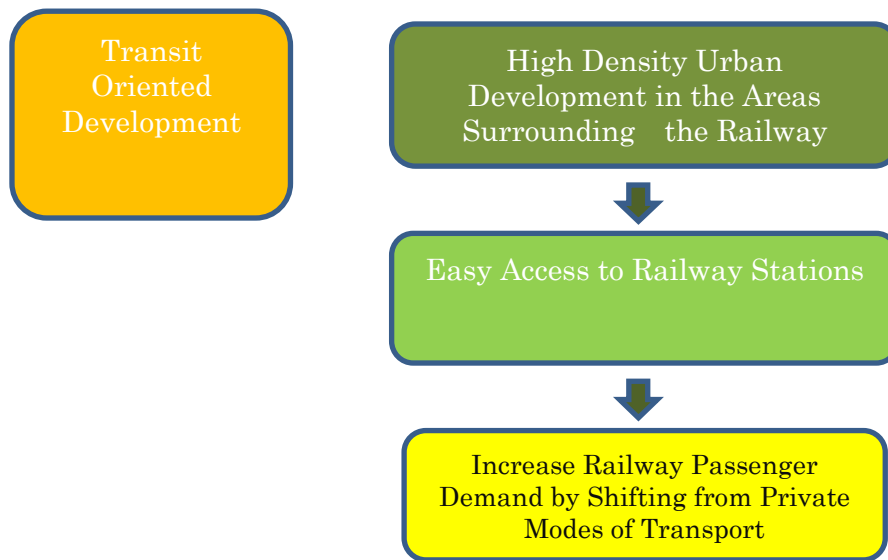


Figure 7.1.5 Integration of Urban Development and Transport Systems: Transit Oriented Development

7.2 Strategies for Transport Planning

7.2.1 Development of Extensive Public Transport Networks

Public transport systems at a higher level of service should be developed in the form of networks so that people can reach their destinations within the system. A higher level of public transport service means a congestion free transport system; namely, heavy railway, medium-size transit systems and bus rapid transit (BRT).

A public transport network should consist of several trunk lines with feeder services and it should cover as wide an area as possible.

7.2.2 Application of Transport Demand Management (TDM) and Car Traffic Restraint Scheme

Transport demand management (TDM) is necessary to alleviate traffic congestion in the CBD because new road construction, or even road widening is very difficult in the CBD and will be limited due to physical constraints such as availability of land for the roads. Road pricing is a scheme to alleviate traffic congestion by charging vehicles entering congested areas in the city centre and it also raises funds for developing and improving the urban transport systems. Improvement of public transport is prerequisite for employing TDM.

7.3 Strategies in Project Implementation

7.3.1 Public-Private Partnership:

This system reduces the government investment for transport infrastructure development, which is replaced by private sector funding and encourages the participation of private organizations for operation and maintenance. It is common that urban highways are developed under BOT (Build Operate Transfer) schemes or PPP (Public Private Partnership) schemes in many cities, thus when urban expressways are developed, the private sector should be encouraged to participate in the form of BOT or PPP. However public transport system development is usually difficult to finance by only the private sector. In most common cases, public transport fares are regulated by the government at low levels since the government should provide means of transport for group C households (monthly income: less than 40,000). Therefore it seems difficult to make public transport projects financially profitable merely with passenger fare revenue. In many countries common practice for financing public transport is to provide infrastructure by the public sector and provide operation by the private sector.

7.3.2 Introduction of a Value-Capture System for Public Transport Development

The rail-based transport is not disturbed by ordinary traffic and the mode can provide fast speed and large passenger capacity transport service. Railway passengers enjoy the railway service for travelling in the urban areas. In addition, railway service can increase sales of department stores, and shopping malls near stations and promote the values of land and housing along the railway corridor. However the railway company is not able to gain all the value added accrued from the railway development. Since a rail-based transport system requires a huge initial investment, the methodology of cost recovery should be considered through value capture of development. In the case of private railway companies in Japan, they develop housing areas along the railway corridor. After they provide new railway service, the land value increases and they sell the housing at a higher price and profit from the real estate business. They are also starting retail businesses as well by building shopping malls at the terminal stations. From this kind of commercial business they can profit in addition to passenger transport service. To support rail-based transit development projects financially it is recommended to take this kind of business model into consideration as illustrated in Figure 7.3.1.

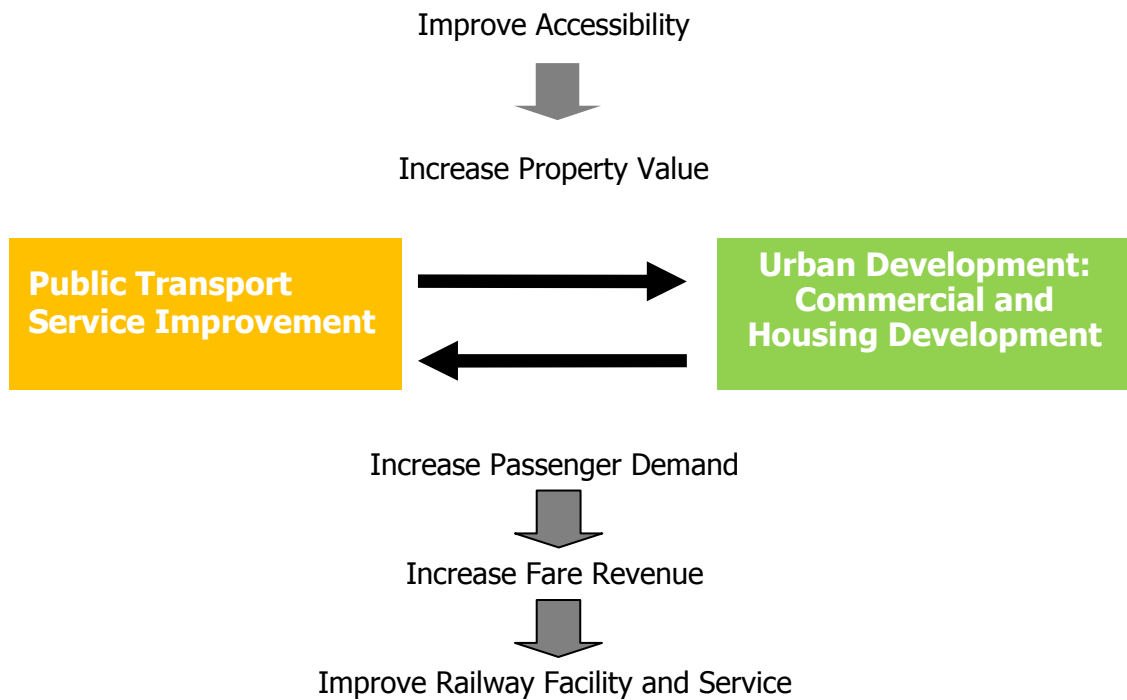


Figure 7.3.1 Value Capture Mechanism for Public Transport Development

7.3.3 Land Readjustment Methodology

To achieve an effective urban structure, new implementation methods should be introduced in Sri Lanka. Especially, the structure requires high capacity roads, therefore, land acquisition is necessary. There are 2 examples described below that can be considered for the implementation.

Land Re-adjustment

This is a typical method that is used in Japan's urban development to create a comfortable residential area. It is illustrated in Figure 7.3.2.

An irregular-shaped plot is re-plotted into a rectangular shape by reducing the site area. The reduced site area is provided for roads and sometimes parks or community facilities, and part of the land is sold to cover expenses to compensate for the cost for road construction and improvement. Then all lands are re-plotted and roads can be constructed. Although each land owner lost a part of the land, the land owners will gain more value since the land value will be increased as the road condition becomes much better than before.

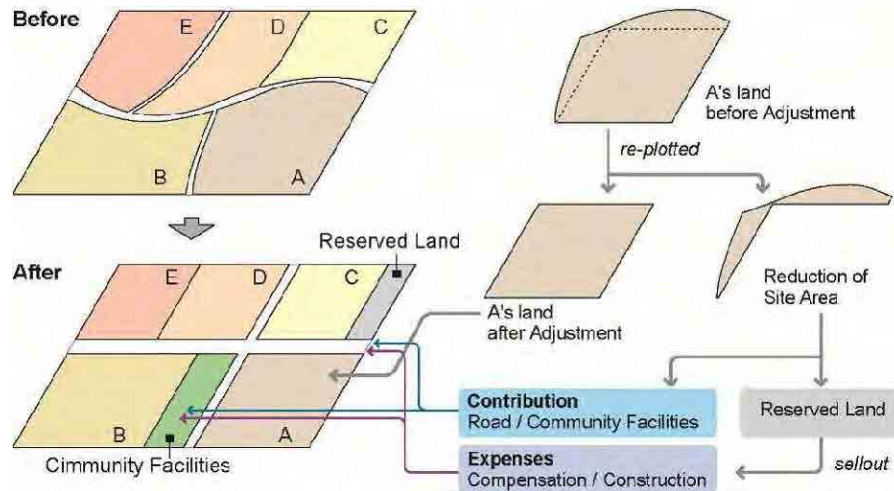


Figure 7.3.2 Conceptual Method of Land Re-plotting

Urban Renewal Project

This is also a typical method in the Japanese context to create urban centres with a commercial or business district. Figure 7.3.3 illustrates the simplified method of urban renewal.

Land owners can be organising an urban renewal association. Often a developer coordinates to organise the association and the government is also involved. The lands are unified and shared with the owners and the developer. A part of the land is provided for public purposes, mainly roads. Thus, a building is constructed and all the members gain profits by allocating the floors.

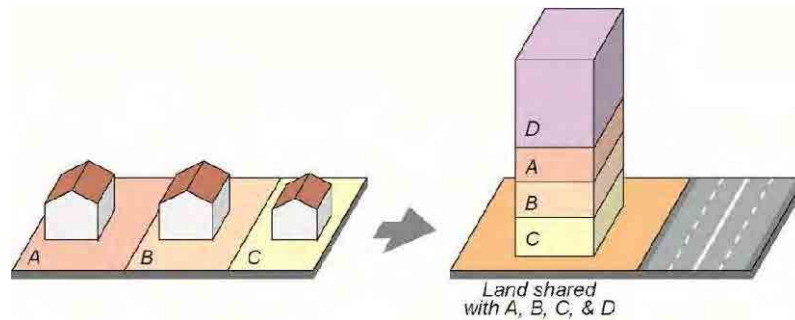


Figure 7.3.3 Conceptual Method of Urban Renewal

Actually, there is a practice of this kind of urban renewal method in the Slave Island Project by UDA and the private sector. A plot of land is being developed and some of the land owners are allocated floors in a newly built building.

Although the above mentioned 2 methods are just hypothetical examples, they could guide to some potential method for implementation. In order to carry this out, collaboration between the communities, land owners, the private sector such as developers, and the public sector such as the local government is required. They are still challenging methods for the Sri Lankan context. However, implementation methods are essential and should be recommended in order to achieve the Master Plan.

CHAPTER 8 Inter-City Transport Systems

Transport systems are divided into Inter-city transport systems and urban transport systems. Inter-city transport systems provide transport services between cities. Before discussing urban transport system development, development of inter-city transport systems is described.

8.1 Inter-city Passenger Transport Systems

Currently, inter-city bus services are concentrated in Pettah bus terminals and most of the city bus services are also departing from and arriving at the Pettah bus terminals. Around 7400 intra provincial buses depart from and arrive at Pettah and some 3300 inter-provincial buses leave and arrive at Pettah. The number of passengers departing from Pettah bus terminal is estimated to be about 38,000 passengers per day for intercity bus services and some 14,000 passengers per day for intracity bus services. This concentration of bus operation causes traffic congestion in the Pettah area. On the other hand, the majority of inter-city railway passengers depart from and arrive at the Fort railway station. In terms of inter-regional passenger movement, the Fort and Pettah areas are the hubs of the inter-regional transport systems. People travelling from the northern part, eastern part and southern part of the country can change their mode of transport at these transport hubs. The Multi-modal transport hub is an interchange point of inter-regional transport and intra-regional transport as shown in Figure 8.1.1.

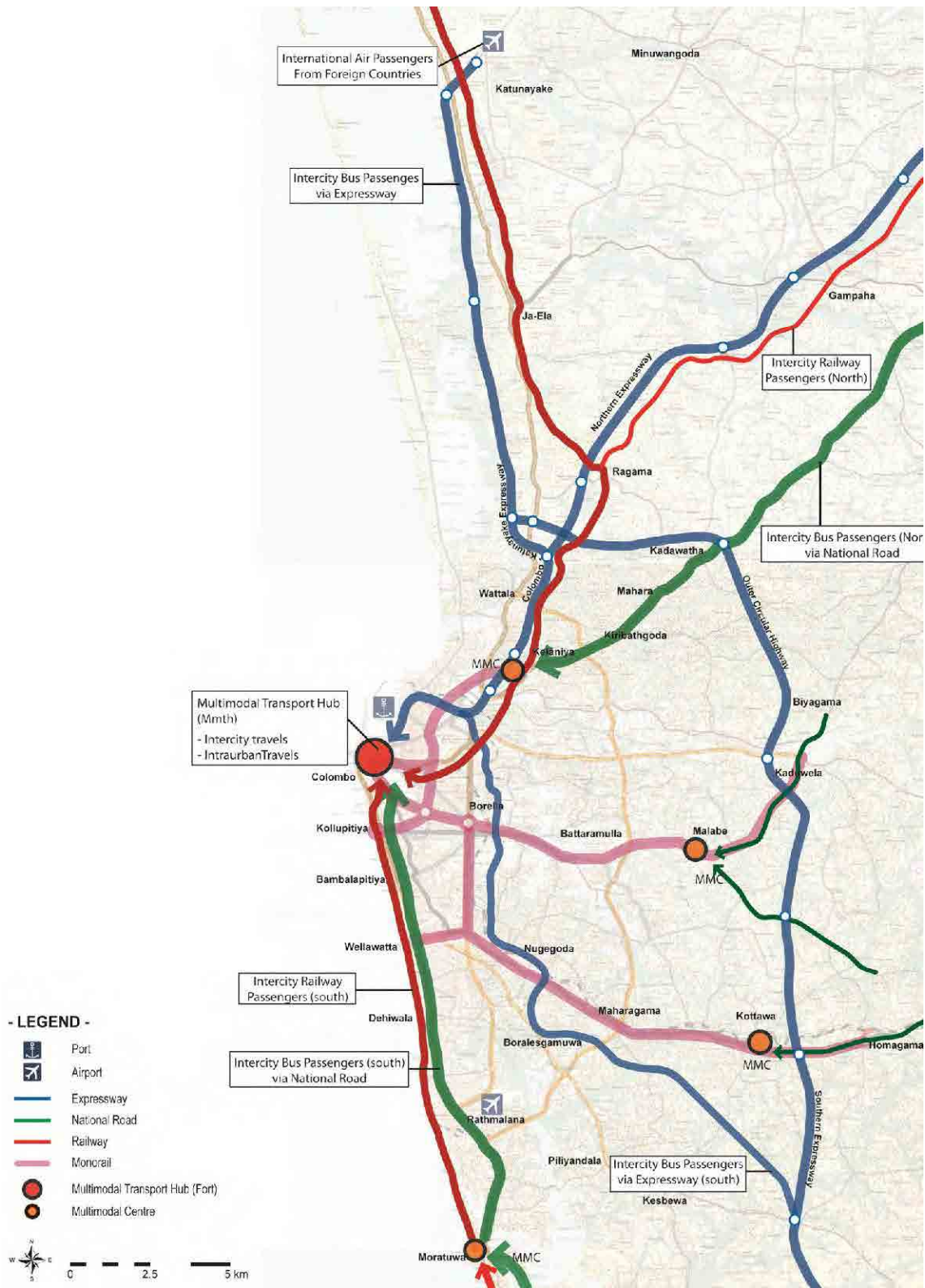


Figure 8.1.1 Inter-city Passenger Public Transport Systems

The intercity passenger public transport system is connected with the urban transport systems at the Multi-modal Transport Hubs and Multi Modal Centres. Passengers from outside of the metropolitan area transfer at these transport nodes and go to final destinations by urban transport systems in the metropolitan area as shown in Figure 8.1.2.

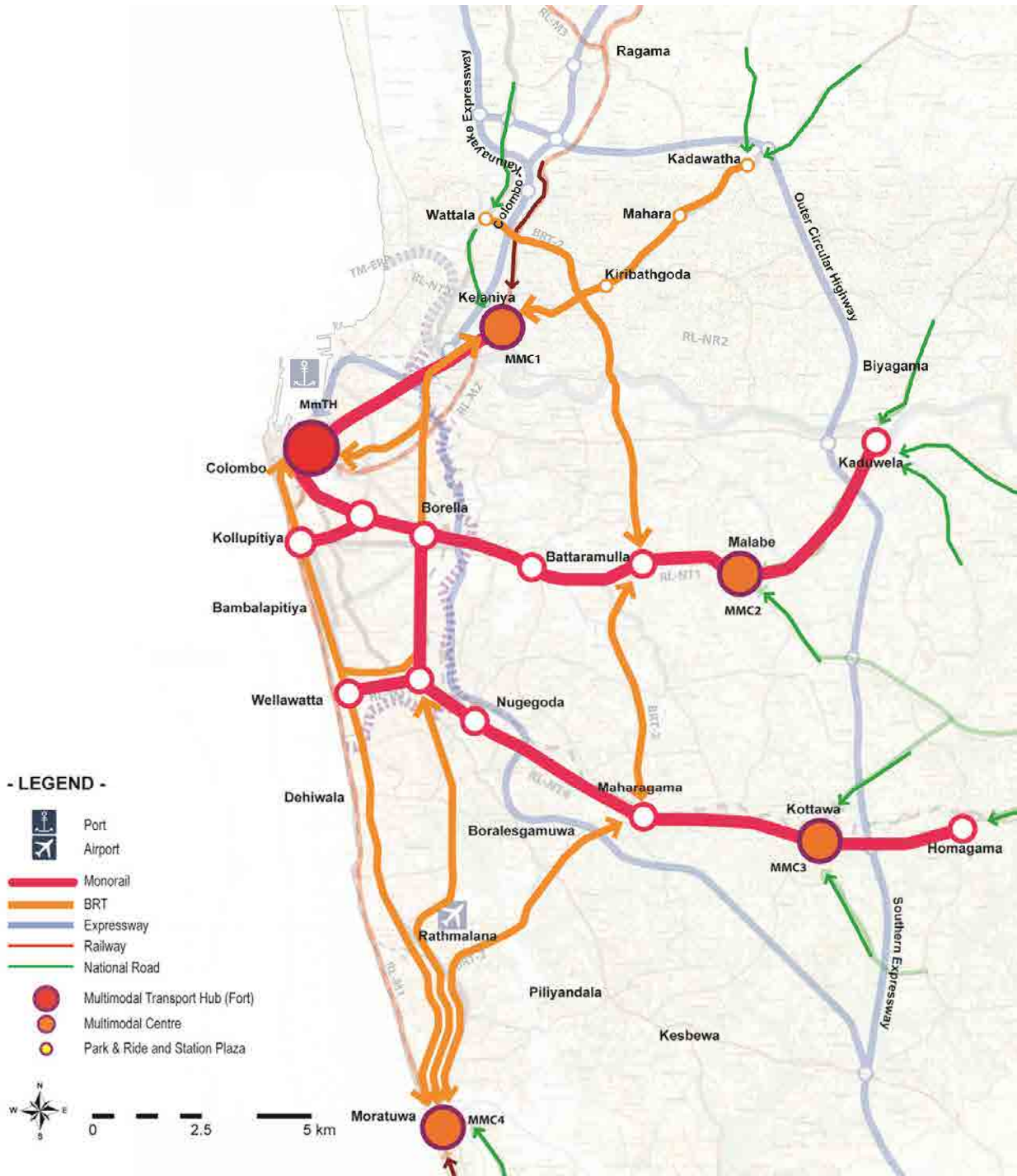


Figure 8.1.2 Urban Passenger Public Transport Systems

8.2 Inter-city Cargo Transport Systems

Major inter-city cargo trip demands are to/from Colombo port. According to the Truck OD interview survey at Colombo port, the destination of trucks are Puttalam District 27%, Gampaha District 23%, CMC 17% and Colombo District 12% thus 50% of the destinations are located in the north. The other major cargo flows are generated and attracted in industrial estates and EPZs. At present, heavy vehicles to/from Colombo port are passing through the northern part of CMC and this causes traffic congestion in the city centre. To reduce the burden of cargo traffic flows in the city centre, a truck ban in daytime is a countermeasure and the other way is provision of direct access to the port by an expressway network. If the Port Access road would be inter-connected with the inter-regional expressway network, the port-related cargo could be easily transported to outside of the region. Trucks can avoid passing through the business district and thus they would not disturb traffic flows in the city centre.