Development of a Multi-Modal Transport Centre for Sustainable Urban Transport
- A Case Study in Colombo Metropolitan Area -

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14th April 2015
Outline

1. Introduction
2. Transport in Colombo Metropolitan Area
3. Preliminary Development Plan of Multi-Modal Transport Centres
4. Impact Analysis
5. Implementation of Multi-Modal Transport Centres (MMC)
6. Conclusion
1. Introduction
Increase of GHG Emission from Developing Countries

- Rapid increase of greenhouse gas emission from developing countries
- Transport sector is a dominant source of GHG emission in developing countries

However...

✓ Financial constraint of the government
✓ Complex and slow administrative procedure
✓ Lack of connection among several public transport modes
✓ Lack of human resources
✓ Political intervention
✓ Complicated land acquisition process
Research Objectives

Potentials of Multi-Modal Centre (MMC) in developing countries

- Railway network in urban areas in some developing countries which is usually not utilized fully
- Intensive bus and paratransit network
- However, those are not managed in an integrated manner

Research Objectives

- to propose a multi-modal transport centre (MMC) development which is affordable, implementable, effective and socially acceptable to alleviate traffic congestion and to reduce emission of GHGs by integrating railway, bus, other public transport services and non-motorized transport
- to conduct a case study taking a railway station in Colombo Metropolitan Area (CMA) as an example to examine economic, financial, social and environmental viabilities
2. Transport in Colombo Metropolitan Area
Colombo Metropolitan Area

- **Western Province**
  - Largest province in Sri Lanka including Colombo and the capital city of Sri Jayewardenepura
  - Population: 5.8 million
  - 3,694km²
  - 44% of National GDP

- **Colombo Metropolitan Area**
  - Population: 3.68 million
  - 996km²

- **Colombo Municipal Council**
  - 0.55 million, 40km²
Road Transport in Colombo

Morning Traffic Congestion

Three Wheeler/ Nano-Taxi

School Traffic
Railway in Colombo

Deteriorated train
Bus Transport in Colombo

Bus Terminal

School Bus
Population Growth Patterns

Population is **increasing** in the areas to the east of CMC, while the growth rate is less in the CMC area.

This can be explained by the changes in land use – in **CMC inner city area** commercial activity is increasing and in the suburbs to the east, residential activity is increasing.
Urban Development Plans/Projects

- Concentration of mixed development projects in Colombo center
- Relocation of government agencies and Defence complex in Battaramulla
Motorization

Unit: 1,000 Passengers per day, Both Direction

Historical data for passenger flow at CMC boundary (1985 – 2013)

Public Transport (Bus and Railway) are losing their modal share.

Private Modes are significantly increasing.

All modes: 2.2%

1985 1995 2004 2013*

Private 26% 33% 33% 42%
Bus 1,061 1,679 1,697 2,066
Rail 1,061 1,679 1,697 2,066

4.2% 58% 1.5%

Average Annual Growth Ratio (AAGR) 1985-2013

Total passengers at CMC boundary at all survey location was 2.1 million passengers per day (both direction). For the comparison purpose, survey locations surveyed in '85, '95 and '04 were selected.
**Rapid Increase of Private Vehicles**

The number of vehicles increased a factor of **2.5 in 12 years**. Motorcycles and 3 wheelers showed significant surge in the number.

*The number of motor vehicles with valid revenue licenses.*

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**Number of Vehicles**

- **Truck**
- **Bus**
- **Car/Van/Pickup**
- **3 Wheelers**
- **Motor Cycles**

**Others**

**AAGR = 8.0%**

**Western Province** (in 1,000)

<table>
<thead>
<tr>
<th>Year</th>
<th>Motorcycles</th>
<th>3 Wheelers</th>
<th>Car/Van/Pickup</th>
<th>Bus</th>
<th>Truck</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td></td>
<td></td>
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<td>200</td>
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<td>2001</td>
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<td>2002</td>
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<td>2006</td>
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<td>2007</td>
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<td>900</td>
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<td>2008</td>
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<td>2009</td>
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<td>2011</td>
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<td>1300</td>
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<tr>
<td>2012</td>
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<td>1400</td>
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</tr>
</tbody>
</table>
Travel Speed (Evening Peak Hour/ Outflow)

5-6PM, Average Travel Speed

Source: Travel Speed Survey by GPS tracking data (2012.12 – 2013.07)
CoMTrans

Legend
Travel Speed
- Below 10 km/h
- 10 - 20 km/h
- 20 - 30 km/h
- 30 - 40 km/h
- 40 - 50 km/h
- Above 50 km/h

CoM Boundary
Estimated Current GHG Emission

CO₂ Emission estimation in the Western Province

- Results of CO₂ emission in 2013 estimated by developed model is almost same as one estimated from fuel consumption data, which is divided proportionally by number of vehicle.

Note:

Vehicle emission: Estimated based on the fuel consumption of whole Sri Lanka in transportation sector of SLSEA by using the ratio of vehicle registration number in whole Sri Lanka and the Western Province.

Railway emission: Estimated based on the fuel consumption of railway of whole Sri Lanka by using the ratio of travel distance of railway in whole Sri Lanka and the Western Province.

Number of hybrid vehicle: 15,561 (Dec. 2013)
Estimation on Future GHG Emission

GHG emission reductions by low carbon scenario options

- Infrastructure development/improvement: C2 scenario (Intensive public transport system development with ERP) will achieve the lowest emission. (0.93 Mton CO₂ reduction in 2035, 11.3% of BAU_SQ)
- Hybrid Vehicles: 0.38 Mton CO₂ reduction in 2035 from above option results
- Fuel Switch: 0.66 Mton CO₂ reduction in 2035 from above option results
- Bus/Truck regulation enforcement: 0.12 Mton CO₂ reduction in 2035 from above option results

![CO2 emission by Transport Scenario](chart1)

![CO2 reduction by Scenarios](chart2)
Colombo Urban Transport Master Plan (CoMTrans) with JICA

Formulated Urban Transport Master Plan

Urban Centres
- Major Urban Centres
- Urban Centres

Public Transport Network Development
- Modernisation and Expansion of Railway
- Monorail
- Extension of Monorail
- BRT
- Bus Priority Lane
- Dompe Line
- ERP Boundaries
- Multimodal Transport Hub (Fort)
- Multimodal Centres
- Park & Ride / Stobon Plaza

Road Network Development
- Urban Expressway
- 6 Lanes Road Project
- 4 Lanes Road Project
- 2 Lanes Road Project
- On-going or Developed Projects
Colombo Low Carbon Urban Transport Study by the World Bank

Kick-off Workshop

January, 22, 2014

Assessment of GHG emission

Feb. – Sep.

Current GHG Emission
  - Collection of Emission Factors

Low Carbon Options/ Scenario
  - Communication with Stakeholders

Mode Integration Pilot Project


Selection of 2 Pilot Stations
  - Site Analysis
  - Demand/Supply Analysis
  - Layout Design
  - Physical/Institutional Integration

Pre-Feasibility Study

September, 2014

Dissemination Workshop
Ministry of Transport (MOT) is the focal agency for the study.

Stakeholders, who are invited to this workshop, will be consulted individually or at workshops during the course of the study.

Technical Assistance is implemented by the World Bank South Asia Transport Unit, supported by Oriental Consultants Co., Ltd. Global.

Funding is provided by Energy Sector Management Assistance Program (ESMAP), a global knowledge and technical assistance program administered by the World Bank.
3. Preliminary Development Plan of Multi-Modal Transport Centres
Development Concept of MMC Mode Integration

Functions
- Local Bus terminals
- Monorail Station
- BRT Station and Railway Station (Only Applicable for Kelaniya)
- Taxi and 3-Wheeler
- Park & Ride
- Drop-off/Pick-up Area

Public Area
- Terminal Building
  - Waiting Area and Meeting Point
  - Modern Facilities with universal design
- Station Plaza
  - Smooth Access with Station and Parking
Mode Integration Pilot Project

- **Mode integration** between Bus and Railway services will be studied at a station in order to promote public transport for low carbon transport scenario.
- **Physical / Operational Integrations** will be considered.

**Physical Integration**

Relocation of:
- Bus departure/arrival, waiting area, shelters
- Walkways,
- Sings and marking,
- Railway Station facilities/entrance,

Creation of:
- Non-fare box revenue generation facilities
- Drop-off/pick-up area for para-transit modes

etc....

**Operational Integration**

Coordination of:
- Fare / ticket integration,
- Coordinated time table and operation hours between bus and railway services,
- Bus route rationalization (feeder services),
- Passenger information provision

etc....
Proposed Candidates for Pilot Stations

Daily Passenger Flow
(Both Direction)

Source: University of Moratuwa (2009)
CoMTrans
Urban Transport Master Plan

Urban Centres
- Major Urban Centres
- Urban Centres

Public Transport Network Development
- Modernisation and Expansion of Railway
- Monorail
- Extension of Monorail
- BRT
- Bus Priority Lane
- Dompe Line
- ERP Boundaries
- Multimodal Transport Hub (Fort)
- Multi Modal Centre (MMC)

Concept of MMC
- Functions:
  - Local Bus terminals
  - Monorail Station
  - BRT Station and Railway Station (Only Applicable for Kelaniya)
  - Taxi and 3-Wheeler
  - Park & Ride
  - Drop-off/Pick-up Area
- Public Area:
  - Terminal Building
    - Waiting Area and Meeting Point
    - Modern Facilities with universal design
  - Station Plaza
    - Smooth Access with Station and Parking

Gampaha
Border of Colombo Metropolitan Area, under developed by UDA

Ragama
Connects Puttalam line to Main Line

Main Line

Coastal Line
Moratuwa
Multimodal Centre (MMC) is proposed with BRT, Railway, Feeder Bus

Panadura
Low density, Less land to be developed as MMC, distance between railway station and bus terminal

Colombo Low Carbon Urban Transport Study
Ministry of Transport
Image of Mode Integration for Bus and Railway Services

JR Kitamoto Station Plaza
- Railway station
- Station square
  - Feeder bus terminal
  - Taxi, Kiss and Ride
  - Open Space, Landscape, Greenery

JR Hitachi Station Plaza
- Commercial Area
- Shelters for bus, taxi users
- Time table board (Bus, Railway)
Situation Analysis on **Ragama Station**  [Main/Puttalam Line]

**Positive Features / Potentials**

**Current Access Mode Share:** Bus 43.7%, Walk 46.7%
- Intersection of Main Line and Puttalam Line
- Sri Lanka Railway’s lands are available.
- Potential for population growth
- **Northern Expressway** will be located nearby the city (Exact alignment: to be confirmed).
- The station is located between Kandy Road and Negombo Road.
- UDA wish to development the city and around the station.
- Ragama Hospital is located nearby the station.

**Negative Features / Constraints**

- Currently, only a small land is used for the bus terminal, and Bus Terminal for Colombo is 300 m away from the station.
- It is necessary to find future bus passengers who use Ragama Station.
• Buses, Cars, and Pedestrians are mixed around the station and the roads.
  ➢ Pedestrian’s safety should be secured.
  ➢ Appropriate bus terminal and circulation should be introduced.

Ragama Station: Existing Condition

Road in front of the Station

Existing Railway Station Building

Existing Bus Stand
(Land surrounding the railway station is used for bus stand)

Bus Stop next to the Station

Railway Facilities

Market

Park

To Kadawatha (Kandy Road)

<Flyover>
Note: The percentage shown in figures above was calculated by dividing the number of daily passengers currently using the candidate stations to the daily trip production from each traffic zone estimated using the data of CoMTrans Home Visit Survey 2013.
Estimation of Travel Demand

1. CoMTrans OD tables developed by JICA STRADA software

2. Identification of 3 types of potential users

3. Estimation of modal shift by 3 types of potential user using CoMTrans mode choice model

<table>
<thead>
<tr>
<th>Station</th>
<th>2013</th>
<th>2035 estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer User estimated by JICA-STRADA (w/o MMC)</td>
<td>825</td>
<td>1,650</td>
</tr>
<tr>
<td>Expected Transfer User (modal shift) by mode integration</td>
<td>230</td>
<td>490</td>
</tr>
</tbody>
</table>
## Requirement for Bus Bay

### Estimated Peak Hour Transfer Passenger (Bus to Rail)

<table>
<thead>
<tr>
<th>Item</th>
<th>Current</th>
<th>2035 est.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Future Transfer User estimated by JICA-STRADA (w/o MMC)</td>
<td>825</td>
<td>1,650</td>
</tr>
<tr>
<td>2. Expected Transfer User (modal shift) by mode integration</td>
<td>230</td>
<td>490</td>
</tr>
</tbody>
</table>

### Peak Hour Bus Operation

<table>
<thead>
<tr>
<th>Station</th>
<th>Current Operation</th>
<th>2035 est.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ragama</td>
<td>25 Buses/hour</td>
<td>50 Buses/hour</td>
</tr>
<tr>
<td></td>
<td>Route: 18</td>
<td></td>
</tr>
</tbody>
</table>

Bus operation is set in accordance with current bus operation (route, frequency), because there are some bus user with the destination around the station.

### Min. Requirement of Nos. of Bus Bay

**Operational Requirements**
- Arrival: 3 min. /bus/bay
- Departure: 10 min. /bus/bay

<table>
<thead>
<tr>
<th>Arrival</th>
<th>Departure</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Bus bays</td>
<td>8 Bus bays</td>
</tr>
</tbody>
</table>
Preliminary Layout Option 2 (1.5 ha)

**Proposed Bus Terminal**
- Arrival: 4 bays
- Departure: 8 bays

**Bus Arrival Area 1**
- (from Northern Direction): 1 bay

**Bus Arrival Area 2**
- (from Eastern Direction / Kadawatha, etc.): 2 bays

**Bus Arrival Area 3**
- (from Western Direction / Colombo, etc.): 1 bay

**Bus Departure Area**
- (to all directions; 8 bays)

**Parking**
- Car Parking: 58 lots
- Bike Parking: 45 lots

**Proposed Station**
- West - Station Building: Main Ticket Gate, Station Office, Waiting Room
- East Entrance: Ticket Gate

**Pedestrian Deck**
- For Safe Transfer

**Commercial Facilities**
- Shopping Mall
- Shops / Kiosks with Public Plaza

**Image of Shops**
(Reference: Floating Market at Pettah)
### Comparison of Development Options

<table>
<thead>
<tr>
<th>Bus Bay</th>
<th>Arr.: 4 bays / Dep.: 7 bays</th>
<th>Arr.: 4 bays / Dep.: 8 bays</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transfer Distance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus Arr. &gt; Station: 40 - 60 m</td>
<td>Bus Arr. &gt; Station: 50 - 75 m</td>
<td></td>
</tr>
<tr>
<td>Station &gt; Bus Dep.: 60 - 85 m</td>
<td>Station &gt; Bus Dep.: 70 - 100 m</td>
<td></td>
</tr>
<tr>
<td>Taxi Bay &gt; Station: 100 m</td>
<td>Taxi Bay &gt; Station: 60 m</td>
<td></td>
</tr>
</tbody>
</table>

| Other Features | (+) Shorter transfer distance | (+) Minimum land area with maximum usage |
|               | (+) Main railway station facilities: east side, close to the existing market and hospital | (+) Main railway station facilities: west side, close to proposed commercial facility and bus terminal |
|               | (+) More parking space | (+) Minimum damage to the existing railway land and facilities. |
# Construction Cost  (Preliminary Estimation)

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit Cost (USD/m(^2))</th>
<th>Option 1 (1.8 ha)</th>
<th>Option 2 (1.5 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Floor</td>
<td>Floor Area (m(^2))</td>
<td>Estimated Cost (USD)</td>
</tr>
<tr>
<td>Pavement</td>
<td></td>
<td>15,920</td>
<td><strong>1,153,700</strong></td>
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<tr>
<td></td>
<td></td>
<td>4,850</td>
<td>485,000</td>
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<tr>
<td></td>
<td>50</td>
<td>3,730</td>
<td>186,500</td>
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<td></td>
<td>50</td>
<td>840</td>
<td>42,000</td>
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<tr>
<td></td>
<td>70</td>
<td>5,760</td>
<td>403,200</td>
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<tr>
<td></td>
<td>50</td>
<td>740</td>
<td>37,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,060</td>
<td><strong>9,459,000</strong></td>
</tr>
<tr>
<td></td>
<td>1,800</td>
<td>2 (GF+1F)</td>
<td>1,818,000</td>
</tr>
<tr>
<td></td>
<td>1,800</td>
<td>1(1F)</td>
<td>306,000</td>
</tr>
<tr>
<td></td>
<td>1,500</td>
<td>1</td>
<td>1,275,000</td>
</tr>
<tr>
<td></td>
<td>1,200</td>
<td>1,030</td>
<td><strong>1,236,000</strong></td>
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<tr>
<td></td>
<td>400</td>
<td>520</td>
<td><strong>208,000</strong></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>18,980</td>
<td><strong>5,996,700</strong></td>
</tr>
<tr>
<td>Commercial Building*1</td>
<td>2,000</td>
<td>4</td>
<td>6,060,000</td>
</tr>
<tr>
<td>TOTAL incl. com. Bldg.*</td>
<td></td>
<td>22,010</td>
<td><strong>12,056,700</strong></td>
</tr>
</tbody>
</table>

*1 Commercial Building: Foot print area is 757.5m\(^2\) (Option 1) and 575.0m\(^2\) (Option 2).

*2 Shops / Kiosks: is located at east area, which can provide the 53 shops (Option 1) and 21 shops (4m x 4m).
Bird View of Proposed MMC at Ragama Station
4. Impact Analysis
Economic Benefits of MMC

- Savings of Travel Time Cost (TTC) due to the reduction of access distance to Ragama Station for passengers from the western area by providing the new entrance of the railway station on the western side
- Savings of Travel Time Cost (TTC) due to the reduction of transfer time at Ragama Station
- Savings of Vehicle Operation Cost (VOC) due to modal shift to public transport
## Cost and Benefit of MMCs

<table>
<thead>
<tr>
<th>Costs</th>
<th>6.0 mil. USD (Option 1)</th>
<th>12.1 incl. commercial building</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.3 mil. USD (Option 2)</td>
<td>9.9 incl. commercial building</td>
</tr>
</tbody>
</table>

### Benefits

**Quantitative benefits for Economic Analysis**

- Reduction of Vehicle Operation Cost (VOC) by Modal shift from private modes of transport
- Reduction of Transfer Time by mode integration facilities

**Reduction of CO\(_2\) emission**

18,000 ton-CO\(_2\) (equivalent to 52,137 trees)

For 20 years (2015-2035), calculated by the vehicle-km for modal shifted passengers’ due to MMC development, Carbon sequestration rate by tree: 17.5kg-CO\(_2\)/year (Kottamba Tree)

CO\(_2\) abatement with MMC at Ragama stations is 294 USD/ton-CO\(_2\)

**Others**

Profit of commercial facilities, Increase of land value, Reduction of traffic accidents, Improvement of landscape, Provision of urban amenities, Provision of evacuation site in case of a disaster ...

### Economic Analysis Results (EIRR)

- 17.4 % (Option 1)
- 18.6 % (Option 2)
5. Implementation of MMCs
7. Implementation of MMC: Mode Integration for Bus and Railway Services

**Operational Elements**

- **Smooth Transfer**
  - Coordinated Time Table between Bus and Railway
  - Common Tickets with IC-Card (NFC), Automatic-Vending Machine

- **Safety**
  - CCTV operation

- **Comfortable**
  - Passenger Information System (Operation Status, Routes, Time Table...)

- **Attractive**
  - Discount Ticket for mode integration
  - Kiosk, shops’ opening hours in accordance with operation hours

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NFC: Near Field Communication, CCTV: Surveillance Camera
8. Implementation of MMC

Institutional Arrangements

- **Bus Terminal**
- **Shopping Mall**
- **Station Building**
- **Open Space**

**Existing Model**

- Design of Transport Facilities (Service Standard) Supervised by **MOT**
- Investment by **Private Sector**
- Developed by **MOT/SLR**
- Developed by **MODUD/UDA**

**Integrated Development with Surrounding Area** by **MODUD/UDA**

**Land Sub-division** is not preferable.
5. Conclusions and Acknowledgements
Conclusions

- Conceptual development of MMC in urban areas in developing countries
- Proposal of proto-type MMC taking Ragama station as an example
- Methodological development in estimating demand and benefit of MMC
- Economic viability of MMC projects (EIRR of 18.6%)
- Significant reduction of CO2 (18,000 t-CO2)
- CO2 abatement with MMC at Ragama stations is 294 USD/ton-CO2
- Proposal on operational and institutional arrangements

Future Research

- Mechanism to enhance cross-sector government coordination
- Detail financial scheme to implement project by PPP
Acknowledgements

This paper is based on experience with the “Colombo Low Carbon Urban Transport Study” by the World Bank and the Ministry of Transport, Sri Lanka. The authors would like to express their gratitude to all the officers of the World Bank, the Ministry of Transport, other Sri Lankan government agencies and the Japan International Cooperation Agency involved in the Study; Dr. Thusitha Sugathapala, Director General of Sustainable Energy Authority; Professor J.M.S.J. Bandara, University of Moratuwa; and all the team members of the Study.