Sustainable Urban Transport Index

Colombo, Sri Lanka

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Introduction

Background and Purpose

The Sustainable Urban Transport Index (SUTI) is an index developed by the UN ESCAP to measure and compare the performance of sustainable urban transport and related sustainable development goads of Asian cities.

The pilot study on selected cities has been focused before deciding in further development, refinement and full-scale application in other Asian cities. Colombo has been selected as one of the pilot cities.

SUTI calculation is based on ten indicators as shown in Table 1

Table 1: The Ten SUTI Indices

1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes
2	Modal share of active and public transport in commuting
3	Convenient access to public transport service
4	Public transport quality and reliability
5	Traffic fatalities per 100.000 inhabitants
6	Affordability – travel costs as share of income
7	Operational costs of the public transport system
8	Investment in public transportation systems
9	Air quality (pm10)
10	Greenhouse gas emissions from transport

Study Area

The study area has been identified as the Western Region (WR) in Sri Lanka. It is the main economic hub of the country as its share of the country's GDP is nearly 42% (3643.2 Billion Rupees out of 8674.2 Billion Rupees in 2013) and nearly 60% attributed to the service sector and more than 30% to the industry sector. It also has recorded the highest per capita income of Rs. 372,814 (approx. USD 2,922) in 2012. It has three administrative districts; Colombo, Gampaha and Kalutara and 33 divisional secretariat divisions. The total land area of the Western Region is 3684 sq. km. Colombo district accounts for the highest urban population in Sri Lanka with 54.6% while Gampaha and Kalutara account for 14.6% and 10.6% respectively.

The population of Western Region was 5.8 million in 2012 spread over a 3,684 sq.km of land area. It is estimated that the total population of the Region will increase to 7.8 million by 2025 with the development anticipated under the Megapolis Structure Plan and it is projected to further increase to 9.1 million in year 2035, with the planned economic growth targets. This development would further increase the transport demand. As the nation's busiest international seaport and airport are located within the area, and expansion of such facilities are also in the pipeline, introduction of structural changes to the transport system is of paramount importance to make the western region a sustainable city with favourable living conditions. The Figure 1 shows the map of the western region which is considered in the study.

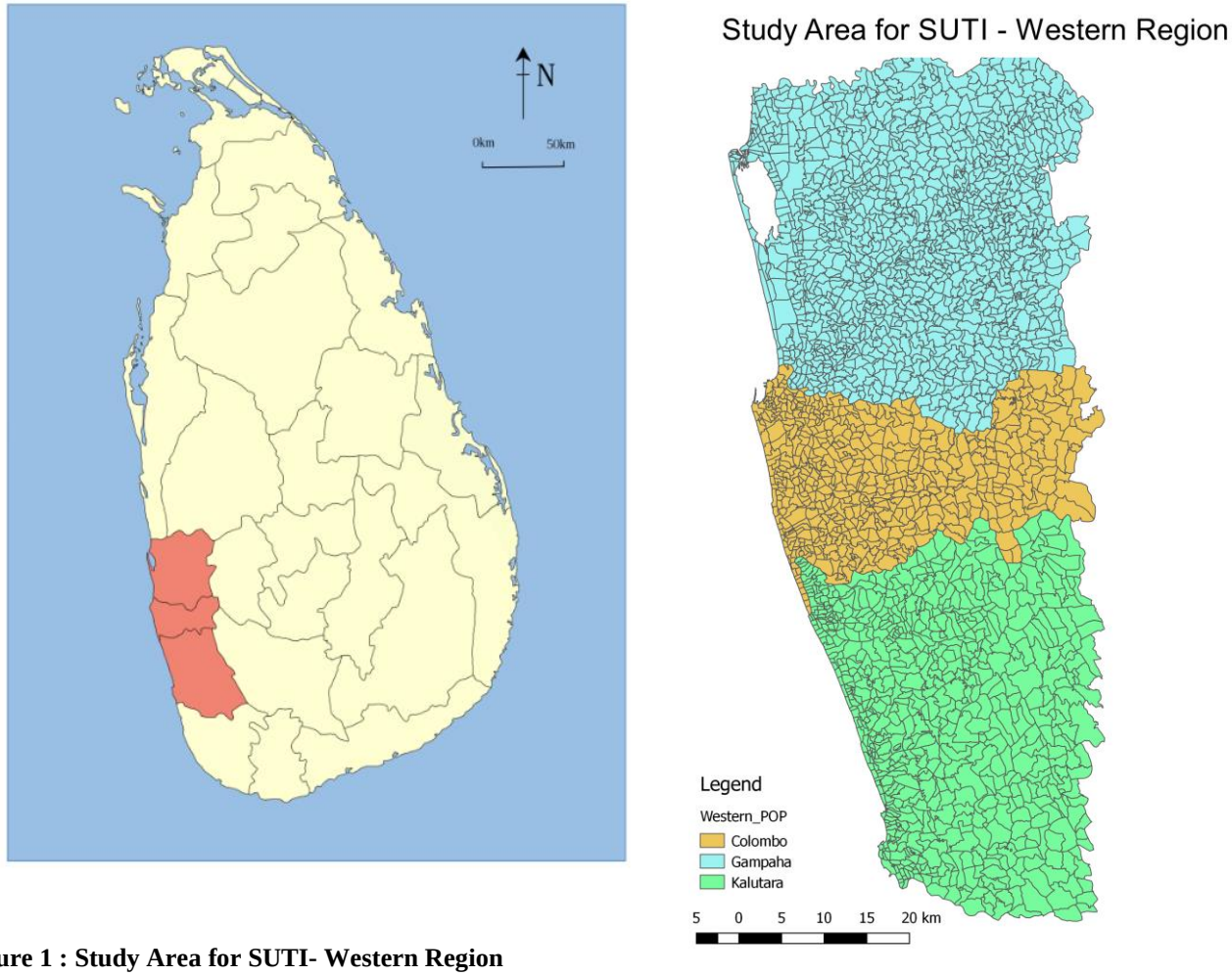

Figure 1 : Study Area for SUTI- Western Region

Existing Transport Master Plans

Western Region Megapolis Transport Master Plan 2016

Western Region Megapolis Plan is the latest Transport Master Plan available for the Western Region developed in 2016 encompassing all aspects of transportation to provide a framework for urban transport development in Western Region up to 2035. The masterplan has been approved by the three secretaries of the ministries of Megapolis and Western Development, Transport & Civil Aviation and Higher Education & Highways who were appointed by the committee to look in to the transport development of the Western Region.

The Transport Master plan has been developed incorporating the Megapolis structure plan developed in 2015/16 looking to the development vision of the Western region. The development priorities have been prepared based on the urgency of the developments to resolve the critical urban transport problems, and based on a logical sequence of implementation in order to maximize the outcomes in achieving the urban mobility objectives. The Megapolis will be implemented as an integrated transport development project, incorporating all modes of transport as well as ensuring sustainability and ease of integration to existing operating conditions and infrastructure. The development plan is set out under 4 categories to assist the authorities to implement it in the most effective manner.

- Public Transport Improvements,
- Road Infrastructure Development,
- Transport Demand Management,
- Environment Sustainable Transport.

Urban Transport System Development Project for Colombo Metropolitan Region and Suburbs 2014 (CoMTrans)

JICA developed the Colombo Urban Transport Survey Project (CoMTrans) from 2012 to 2014 which is a comprehensive transport master plan which identified seven major corridors towards the center of Colombo, with proposed projects to be implemented in short terms, medium terms, and long terms.

The main objectives of the CoMTrans study elaborates on:

- Preparing reliable transport data that can be utilized to evaluate and formulate transport development plans/projects in a scientific manner by conducting an area-wide transport survey.
- Formulating a comprehensive Urban Transport Master Plan for the Colombo Metropolitan Area including the six transport corridors prioritized by the Ministry of Transport with the justification of selected priority/leading projects for short-term, mid- term, and long-term implementation.
- Conducting a feasibility study on the prioritized project under the comprehensive urban transport master plan.

The Strategic Plan for Traffic Management in Colombo Metropolitan Region, 2015

Subsequently, the Ministry of Transport in 2105 did a review of the CoMTrans Master Plan and developed an updated transport master plan. However, both of them were based on the 1998 CMRSP structure plan with updates to accommodate potential growth centres which was then replaced by the Megapolis Transport Master Plan.

Indicator 1: Extent to which Transport Plans Cover Public Transport, Intermodal Facilities and Infrastructure for Active Modes

Relevance	According to sustainable urban transport policy and research it is an essential element in urban sustainable transport planning to provide for alternatives to motorized individual transport. This involves especially public transport, walking, and cycling and includes both networks and nodes/interchange facilities. Urban transport plans should support these modes explicitly and directly by incorporating goals, strategies, physical facilities, services, etc. for them. The indicator refers directly to SDG target 11.2 “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all”. It is also relevant for SDG target 9.1 “Develop quality, reliable, sustainable and resilient infrastructure”.
Definition	The extent to which the city’s most current comprehensive transport or master plan covers the four aspects I) walking networks, II) cycling networks, III) intermodal transfer facilities and IV) expansion of public transport modes
Unit	The extent of coverage is calculated and measured on an ordinal scale from 0 to 16. First, the extent of the coverage in the urban transport plan for each of the four defined aspects I – IV, is reviewed and scored on a 5-step scale: 0) No coverage of the aspect (it is basically ignored) 1) Limited coverage of the aspect (only minor initiatives) 2) Middle coverage of the aspect (some typical initiatives) 3) Extensive coverage of the aspect (several strong initiatives) 4) Leading coverage of the aspect (ambitious, comprehensive, pioneering initiatives) The scores for all four aspects are then added together to provide the overall score (IS(0-4)+ IIS(0-4)+ IIIS(0-4)+ IVS(0-4)), where S(0-4) is score 0-4 for each aspect).
Min and Max values	The lowest possible total score is 0 (=the case that none of the four aspects are covered at all). The highest possible total score is 16 (=the case that a city is a regional leader in all four aspects)

Summary

Table 2: Summary of Indicator 1

Aspects	Explanation	Score
I) Walking networks	Some qualitative goals and some designation in with some budget allocations	2
II) Cycling networks	Some qualitative goals and some designation in with some budget allocations	2
III) Intermodal transfer facilities	The plans have several facilities and project is in progress. Reasonable government funding could be observed	3
IV) Public transport	Plans have extensive approach. Government has an increasing but realistic budget.	4
Total (sum)		11

Methodology

Literature Review on Walking and Cycling Tracks

The indicator is based on a qualitative assessment of the most recent operational transport plans to Western region. Western Region Megapolis Transport Master Plan (WRMTMP) was used as a basic guideline in evaluating indicator requirements. Further Urban Transport System Development Project for Colombo Metropolitan Region and Suburbs (CoMTrans) developed by Japan International Cooperation Agency was also a key input for this indicator.

The CoMTrans master plan suggests developing a pedestrian network as well as a pedestrian bicycle network connecting parks, Beira Lake, wetlands, coastal line and Kelani River. Further, it suggests provision of sidewalks to secure sufficient space for walking trips. The CoMTrans study gives a detailed map of bicycle road networks and pedestrian paths.

When considered the existing situation of walking tracks and cycling tracks, several jogging tracks and green places have been introduced in many parts of greater Colombo and surrounding suburban areas. These were developed as recreational spaces for city dwellers.

Recently developed Western Region Megapolis Transport Master Plan suggests incorporating walking lanes and cycle lanes as an accessible mode for public transportation. The master plan identifies lack of facilities for pedestrians cause a significant inconvenience to promote walking as a mode of transport. The master plan suggests to provide better facilities for pedestrians by enhancing access to transit services by adding street crossings and providing more amenities at bus stops. Further adding street lighting, sidewalks, curb extensions and ramps are identified as improvement areas when promoting walk as a mode of transport.

According to the WRMTMP there is a proposed project to implement walking and cycling tracks. It will commence in 2017 and will be carried out over a period of 2 years. The estimated cost of this project is 7.09 million US dollars.

Figure 2: Main transport multimodal hub proposed to be constructed at Fort/Pettah

Moreover, the master plan suggests conducting a feasibility study on evaluating cycle lanes in Colombo Metropolitan area. The project is expected to cost approximately 1.42 million US dollars and will be carried out over a period of 2 years. The Figure 3 shows proposed traces for bicycle and motorcycle paths that are to be developed in western region.

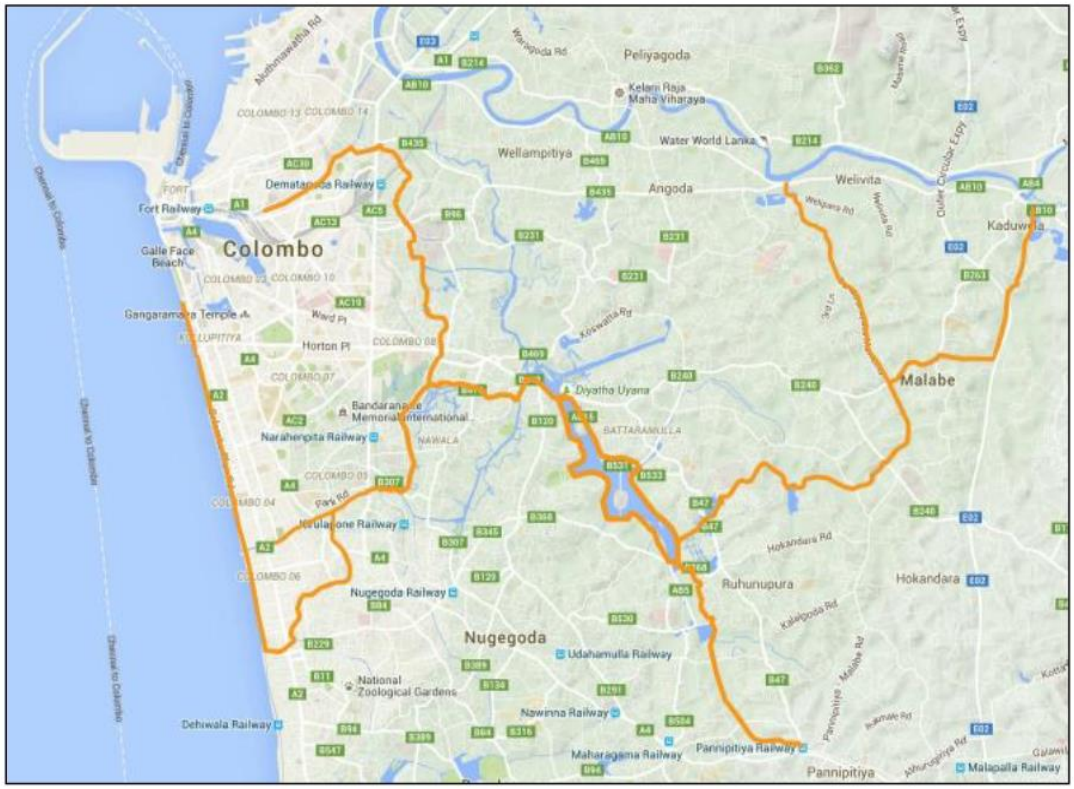

Figure 3: Proposed Bicycle and Motorcycle Paths

Literature Review on Intermodal Transfer Facilities

On the aspect of inter modal transfer facilities, the COMTRANS study and WRMTP both identifies the requirement of a multimodal transport hub. The WRMTP suggest that the main transport multimodal hub should be constructed at Fort/Pettah in Colombo. The project is expected to start in 2017 and planned to be completed within 2 years the estimated cost for the project is 200 million US dollars.

Further the study suggests to develop 6 major multimodal transport centres at Kottawa, Horana, Kadawatha, Kaduwela, Panadura, Negambo and 5 minor multimodal transport centres at Gampaha, Ragama, Moratuwa, Meerigama and Avissawella. The Figure 2 shows the main transport multimodal hub which is proposed to be constructed at Fort/Pettah.

Literature Review on Public Transport

The public transport in Sri Lanka is facilitated through buses and trains. Sri Lanka Railway operates the railway service and there are no private service providers. The passenger bus services are provided by Sri Lanka Transport Board and many private bus owners. Public transportation accounts for around 50% of the model share of transport modes. There is a significant commitment from transport master plans and government budget for operation and improvement of public transportation.

The Western Region Megapolis Transport Master Plan identifies public transportation as one of the main focus for transformation in transportation. The plan proposes improvement of public transport under several development stages. Re-structure and revision of public bus services, modernize and improvement of the quality of buses and services, railway electrification and modernization, introducing a new rapid transit system and introducing a new inland water transport system are some of the initiatives identified. The master plan identifies that existing public transport system should be improved by quality and quantity. Further an increase in investment on public transportation could be observed by analysing the recent government budgets. Figure 4 and Figure 5 shows proposed railway electrification and modernization map for Colombo and proposed rapid transit system network for Colombo Business District respectively.

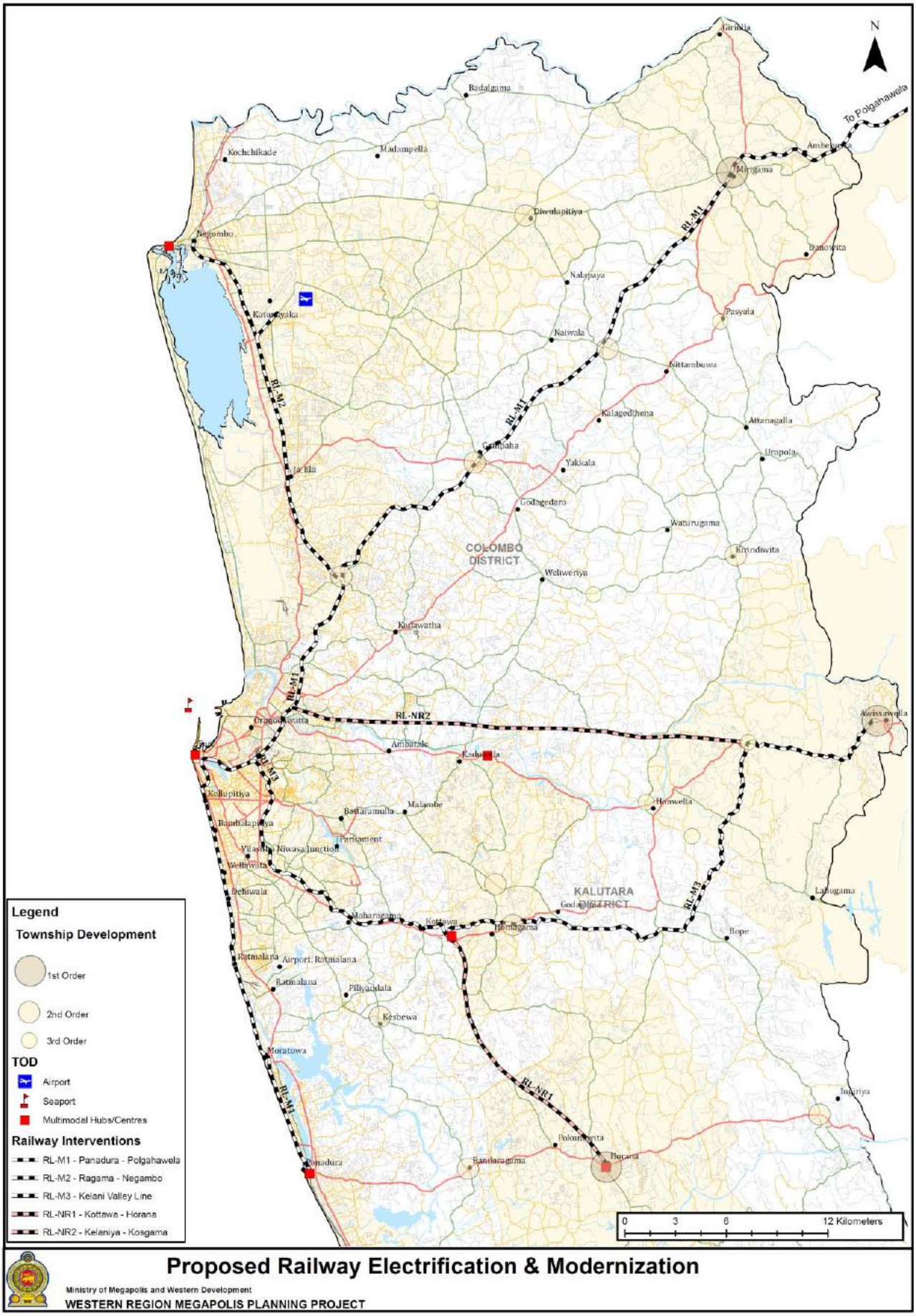

Figure 4: Proposed Railway Electrification and Modernization Map

Source: WRMPPTMP

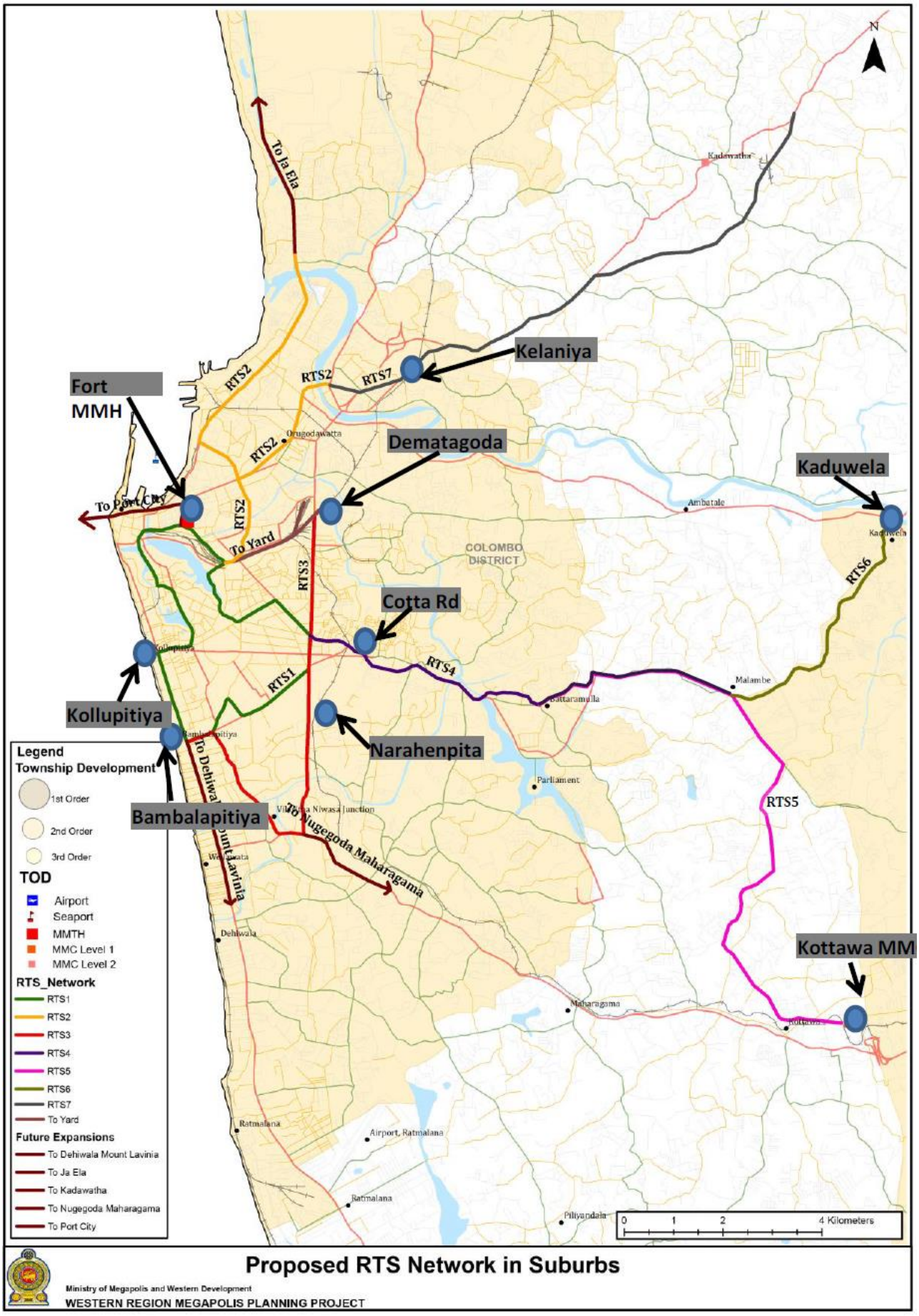

Figure 5: Proposed RTS Network

Source: WRMPPTMP

Indicator 2: Modal Share of Active and Public Transport in Commuting

Relevance	To monitor the modal split is a useful indicator in providing for more sustainable urban transport solutions. The indicator refers to SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all". Active and public transport may be considered as more sustainable transport compared to individual motorized transport. Therefore, the indicator has a focus on increasing the share of these modes. The modal split is most critical for commuting (travel to and from work), as this travel puts the most stress on the urban transport system and the environment. Therefore, the indicator has its focus on commuting. The definition for this indicator is drawn from the ISO 37120 standard set of indicators developed by the Global City Indicators Program (GCIP 2015).
Definition	Percentage of commuting trips using active and public travel modes (= using a travel mode to and from work and education other than a personal motorized vehicle). 'Active transport' means cycling and walking. It does NOT include mopeds or other motorized two-wheelers. 'Public transport' includes public bus, BRT, tram, rail, scheduled ferry. It does NOT include taxi or unofficial motorized para-transit (auto-rickshaw, min-bus, becak, tuk-tuk, etc). 'Personal motorized vehicle' therefore means passenger car, motorcycle, scooter, moped, taxi, and motorized para-transit. For en example of more exact aggregation of data categories see text below.
Unit	Percentage of trips for commuters not by personal motorized vehicle
Min and Max values	The lowest value is 10%; the highest value is 90%.

Summary

Table 3: Summary of Indicator 2

Average number of trips per person by main mode of transport		
(for age group example 15-60 years)		
PURPOSE	**COMMUTING**	
	(WORK AND EDUCATION)	
MODE	**#**	**subtotals**
a. Scheduled bus and minibus	2,478,382	
b. Train, metro, tram	201,069	
c. Ferry		
d. Other public		
e. Public transport	(a+b+c+d)	2,679,451
f. Walking		
g. Bicycle		
h. Active transport	(f+g)	1,109,695
i. Passenger car	280,591	
j. Taxi	431,906	
k. Motorcycle	520,468	
l. Scooter/moped		
m. Para transit (unscheduled)		
n. Other motorized (trucks,etc)		
o. Individual motorized	(i+j+k+l+m+n)	1,232,965
p. Total	(e+h+o)	5,022,111
q. Public and active	(e+h)	3,789,146
r. Modal share of active and public transport		75.45

Methodology

Data Collection

The data was collected by referring to the urban transport system development project for Colombo metropolitan region and suburbs (CoMTrans). The report was compiled in 2014 and data is representative of the existing situation of Western Region. The CoMTrans study team has conducted a home visit survey to collect the latest travel activity information of the residence along with the socio-economic information of the household and individuals by visiting households in the study area the number of trips is analysed by the purpose and by zone. Mode choice is analysed based on the trip tables by mode. The household survey was conducted by covering approximately 44,000 households which represents 3% of the population of Western region.

The Figure6 provides the details about the sample size of household survey. The sampling was based on randomly selecting households from the available lists of addresses in the service area.

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

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

Figure 6: Sample Selection for Household Survey Source: CoMTrans Study

Collected data was verified Using GN division data, vehicle registration data and travel survey data. Figure 7 shows the procedure taken in the survey on validation of home visit survey data

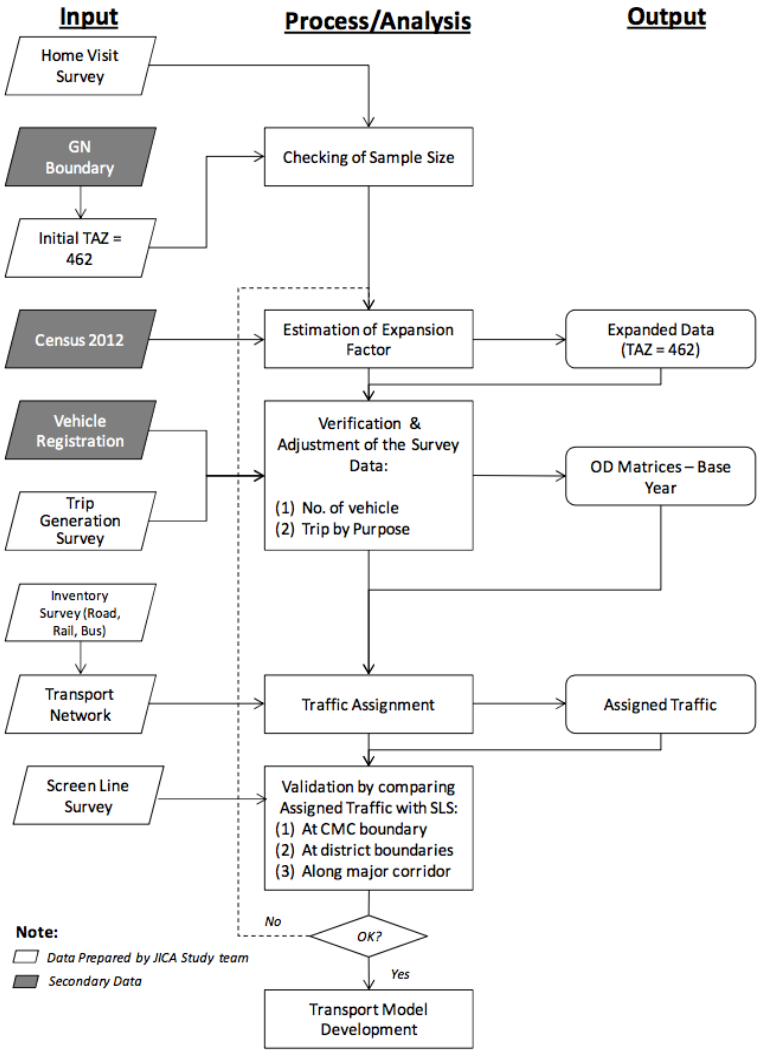

Figure 7: Data Verification Process for Household Survey

Source: CoMTrans Study

Data Analysis

The modes are categorized into 6 major vehicle types as car, motorcycle, three-wheeler, taxi, bus, railway and non-motorized travel (NMT). The non-motorized travel was considered as active transportation while buses and Railway were considered as public transportation while passenger cars motorcycles, three-wheeler and taxi were considered as individual motorized vehicles.

40.4% of total 10 million trips within a day in Western Region is made by public transport. This is when 22% of non-Motorized Transport is also considered as a mode. Figure 8: Modal Share of all trips in Western Region - Data and Illustration Source: CoMTrans Study

Further, it illustrates that the public transport share can be considered as 52% share of the total trips without NMT been considered. Distribution of trips by mode and by purposes of western region is shown in Figure 9: Mode Share by Trip Purpose
Source: CoMTrans Study

The commuting trips considered for the index includes education and work only The Figure 10 illustrates the mode share of commuting trips.

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

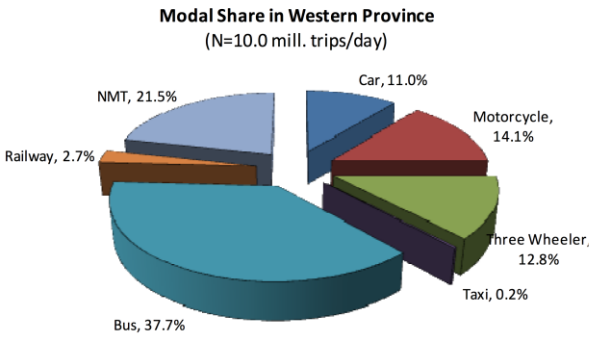

Figure 8: Modal Share of all trips in Western Region - Data and Illustration Source: CoMTrans Study

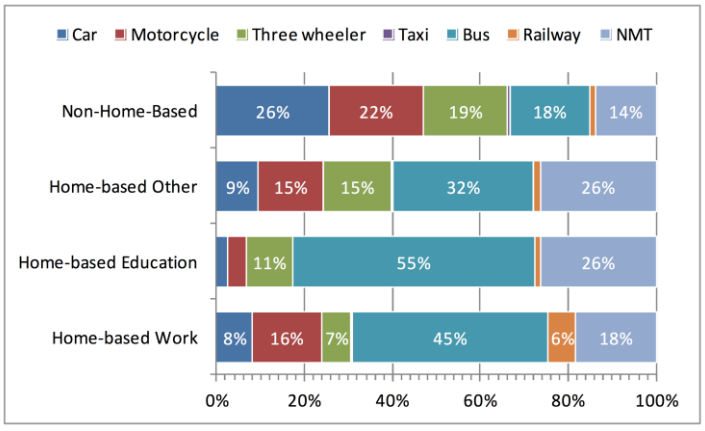

Figure 9: Mode Share by Trip Purpose

Source: CoMTrans Study

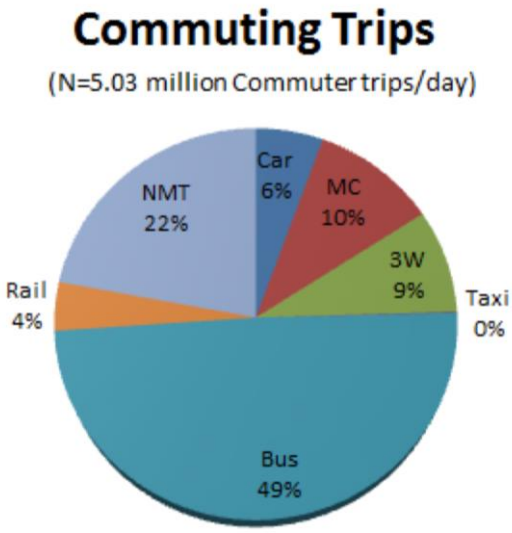

Figure 10: Mode share of Commuting trips

Source: CoMTrans Study

Indicator 3: Convenient Access to Public Transport Service

Relevance	Access to public transport service is a key requirement for equitable access in a sustainable city. Convenient access to sustainable travel modes is the main indicator adopted by the United Nations Social and Economic Council and the United Nations Statistical Commission for monitoring SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all".
Definition	Proportion (percentage) of the population that has convenient access to public transport, defined as living 500 meters or less from a public transport stop with minimum 20-minute service. Public transport is a shared passenger transport service available to the general public, excluding taxis, car pools, hired buses and para-transit (same delimitation as used for public transport in indicator 2. Active transport is not included here) If possible, the measure is measured for the general population as well as for vulnerable groups (women, elderly, and persons with disabilities).
Unit	Percentage of urban population
Min and Max values	Minimum level is 20%; max level is 100% of the urban population. 100% is hardly realistic everywhere, but some cities are close to this target.

Summary

Table 4: Summary of Indicator 3

Parameter	**Number**
Train Stations	101
Bus Stations	1235
Population at 500m Proximity	
for bus stations	2,179,418
for train Stations	396,087
Total population	5,851,130
% within 500m buffer zone	44%

Methodology

Introduction to Public Transport Operations in Western region

In Sri Lanka, major public transport modes are passenger bus service and train service. Bus stations along bus routes give access to public buses. Most of the public bus services are owned by private service providers who usually owns 1 to 2 buses operating on a route. The Western province transport authority is responsible for regulating intra provincial private bus service. Table 5 gives summary on public bus service in Western province.

Table 5: Bus Service in Western Region

Object	Amount
Total Route amount	433
Permitted number of Busses in WP	6,448
Daily Operated amount of buses - approximately	5,620
Mileage per Day approximately	950,000km
Number of trips per day approximately	48,000
Number of Passengers per day approximately	3,800,000
Number of Bus stands	1,235

The Western Region is being covered by four train lines operated by Sri Lanka Railway. Total of 531 km of rail network covers the Western Region with 61 train stations allowing access for train services. Table 6 gives details about railway operations in Western Region

Table 6: Train Service in Western Region

Operational Line	Railway Operation	Distance (km)	Average traveltime	Speed (km/hr)
Kelani Valley Line	Slow to Avissawella	60.81	2:15	27.03
	Slow to Padukka	36.24	1:35	22.89
Puttalam Line	Slow to Chilaw	46.3	1:35	29.24
	Slow to Negambo	39.2	1:25	27.67
Costal Line	Slow to Ambalangoda	60.24	2:00	30.12
	Slow to Panadura	26.21	0:50	31.45
	Express	60.24	1:20	45.18
Main line	Slow to Aluthgama	59.3	1:40	35.58
	Slow to Veyangoda	23.53	1:10	24.77
	Express	59.3	1:10	50.83
	Inter Provincial	59.3	0:57	62.42

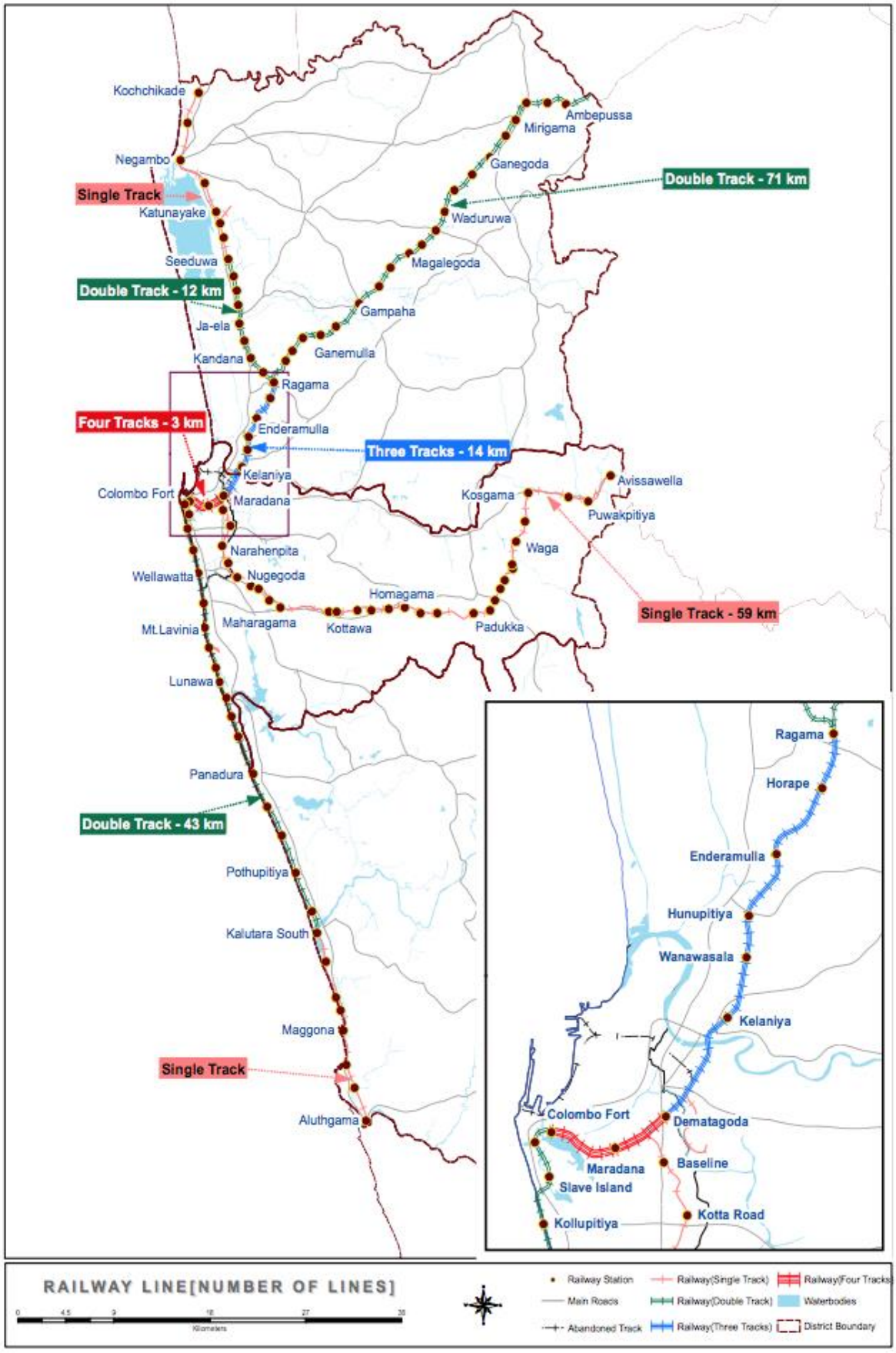

Figure 11:Railway Lines of Western Region

(Ref: CoMTrans Study)

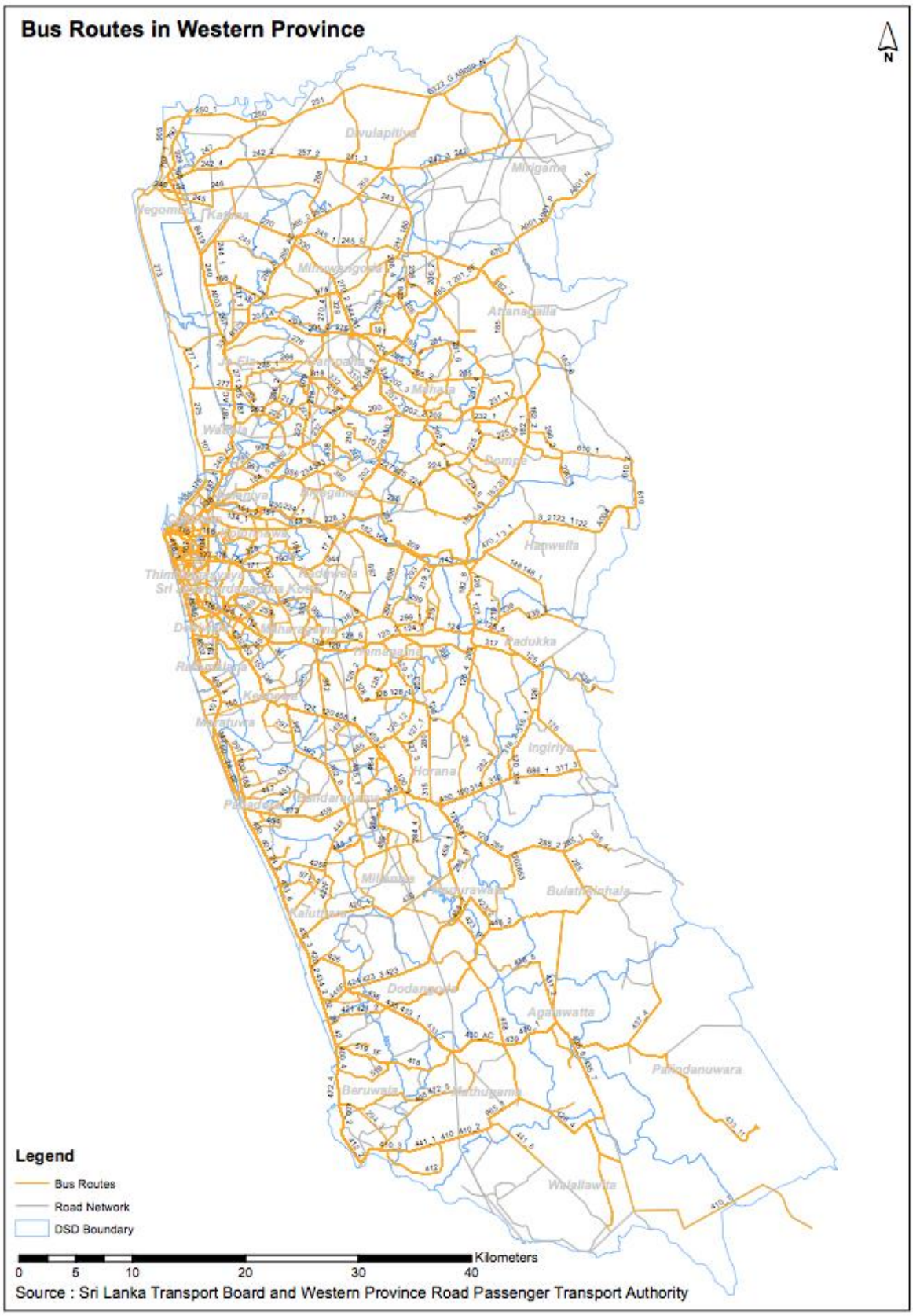

Figure 12:Bus Routes of Western Region

(Ref: CoMTrans Study)

Data collection and analysis

The indicator required to identify the percentage of population living closer to 500m walking distance or 20-minute service to public transportation station. In order to find the population living at 500m buffer zones to public transport stations it is required to find population density augmented into finer control areas. For this requirement, population census data of 2012 was clustered into Grama Niladari Divisions (GND), which is the smallest administrative unit of the country. Number of people lived in each GND was distributed spatially on the area of the GND and a population density for each GND division was derived. It was assumed that population was equally distributed throughout the whole area of the GND. (*See Figure 14)*

The location of bus stations and train stations were collected from Google Maps by accessing Google Maps via Google Places Application Programming Interface. *(See Figure 13).* The collected spatial data was analysed by open source geo-spatial analysis software (QGIS 18.2) and buffer zones for each public transport station was identified. Then the total population living within the buffer zones were calculated by the software following the spatial clustering theories. *(See Figure 13)*

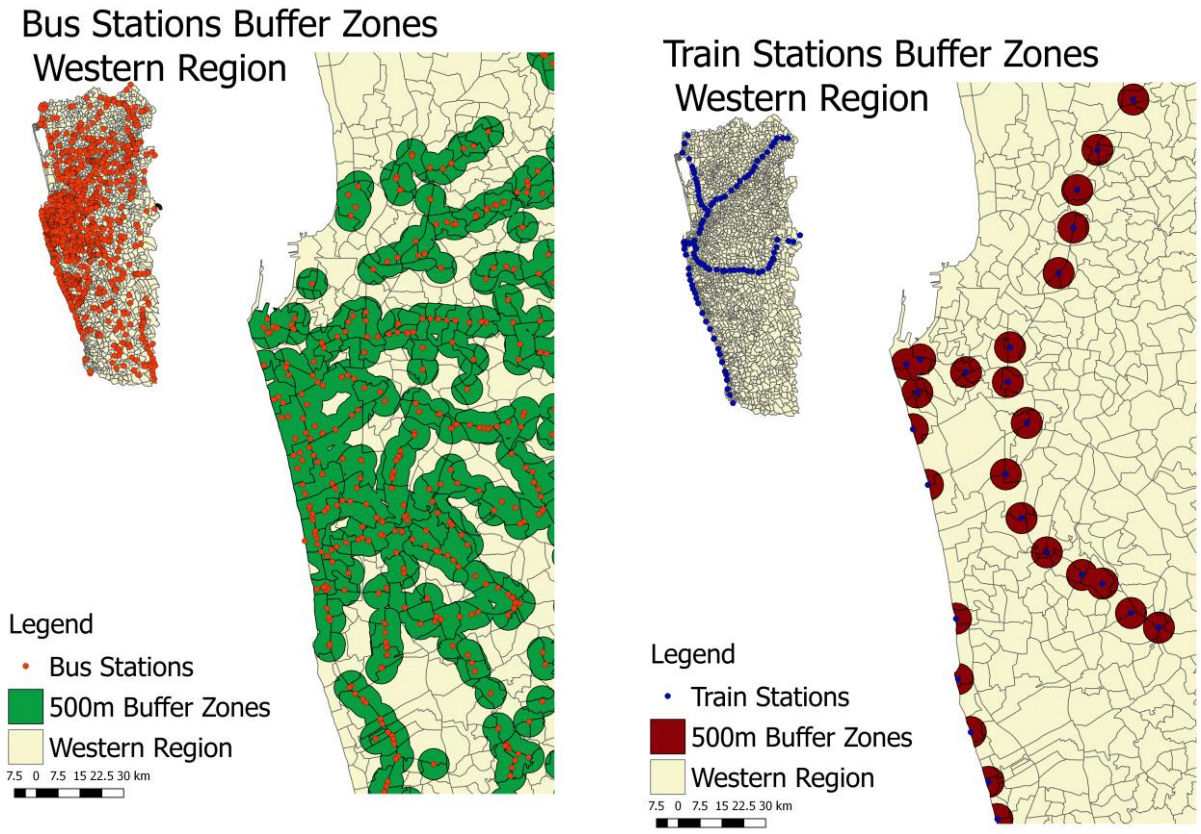

Figure 13: 500m Buffer Zones for Train Stations and Bus Stations of Western Region

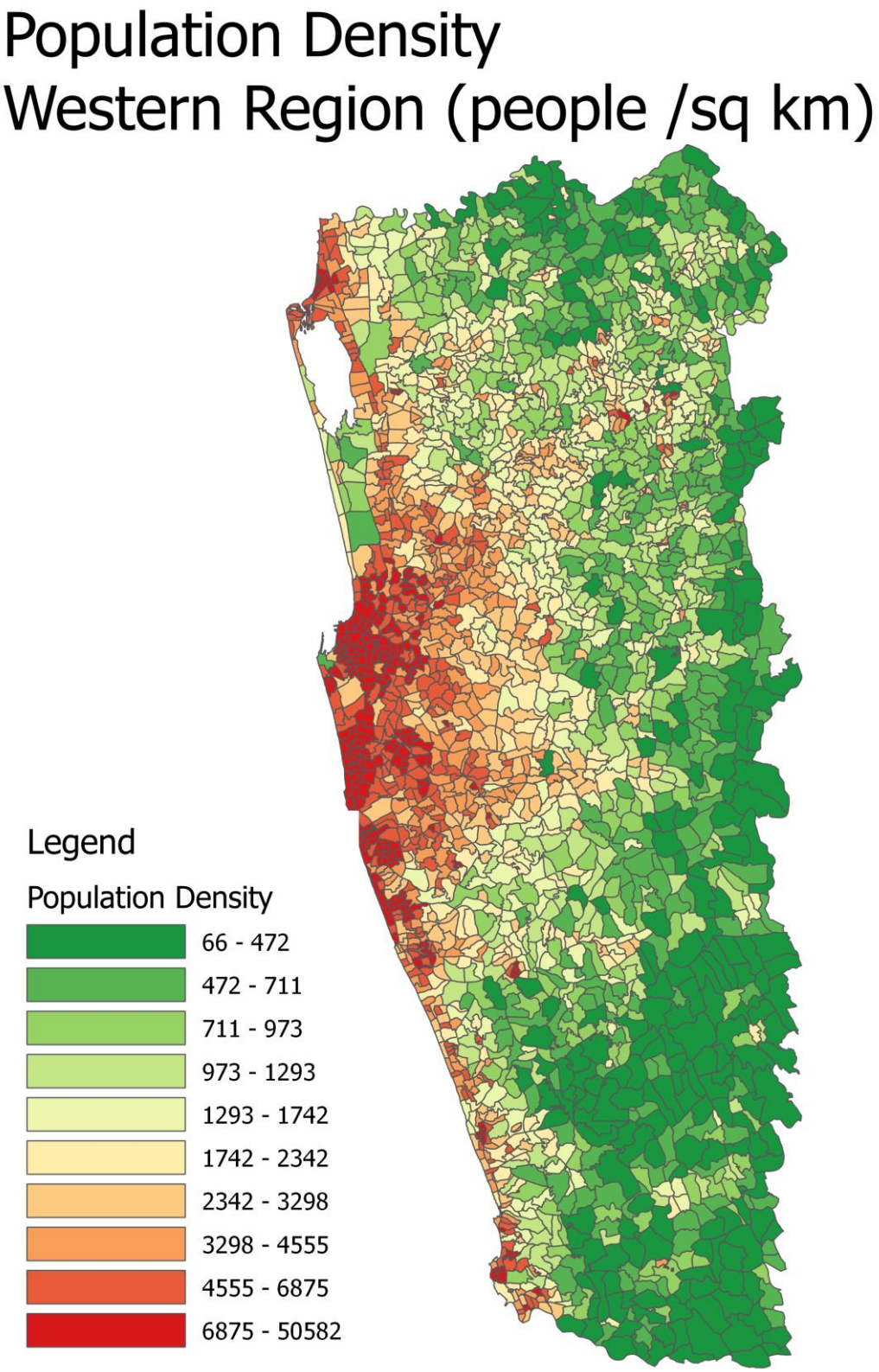

Figure 14:Population Density of Western Region

Indicator 4: Public Transport Quality and Reliability

Relevance	The indicator is relevant in support of SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all" and SDG target 9.1 "Develop quality, reliable, sustainable and resilient infrastructure". Providing high quality service in urban public transport (PT) is essential for attracting passengers and limiting individual motorized transport in the long term. High share in public transport modes supports urban sustainability including the economy. Both objective and subjective indicators can be used to measure PT quality and reliability. The user's positive subjective experience of the service is critical for people's desire to choose public transport. Monitoring the subjective user satisfaction is therefore becoming a widespread approach among urban public transport companies in the world using satisfaction surveys. Reliability and predictability are important aspects of the perceived quality of the public transport system.
Definition	The degree to which passengers of the public transport system are satisfied with the quality of service while using the different modes of public transport
Unit	Overall share of satisfied customers as percentage of all public transport users (%) based on a survey.
Min and Max values	30 is the expected minimum, 95 the expected maximum

Summary

Table 7: Summary of Indicator 4

Mode	Total Responses	Negative	Positive	Neither	Satisfied %
Satisfied with Quality and reliability of Bus service	394,350	296,133	23,854	74,363	6.05%
Satisfied with Quality and reliability of Train service	645,300	398,928	33,624	212,748	5.21%
Public Transport Quality and Reliability (Weighted)					**6%**

Minimum value of 30 is used in the calculation

Methodology

The indicator requires to identify how passengers are satisfied with the existing public transport system. It is required to carry out a survey on this regard. Household survey carried out by CoMTrans study team was used. The survey has extended to 35,850 households to get responses which represent 3% of the population of Western region. For the analysis 8,680 respondents who use public transport systems were used and analyzed the data

Survey was comprised of questions which ask to evaluate the public transport services from a qualitative approach. The survey was conducted to cover train service and Bus service which are the main public transport modes of western region. Following Questions were asked for each transport mode.

(a) Frequency of bus operation is not sufficient thus waiting time is long
(b) Buses are often delayed due to traffic congestion
(c) It is not comfortable since it is hot on buses without air condition
(d) It is too expensive if we get on air-conditioned buses
(e) It is not comfortable because buses are dirty on board
(f) It is not comfortable because it is overcrowded on buses
(g) Bus routes are limited thus bus passengers need several transfers
(h) Security on buses are not fully guaranteed
(i) It is not convenient because of long waiting when it has few passengers
(j) It is not convenient because of bus frequency reduces during the night
(k) It is not comfortable because behavior of bus conductor and staff are not well
(l) Frequency of train operation is not sufficient thus waiting time is long
(m) It is not comfortable since it is hot on trains without air condition
(n) It is not comfortable because trains are dirty on board
(o) It is not comfortable because it is overcrowded on trains
(p) Security on trains are not fully guaranteed
(q) It is not convenient because of railway frequency reduces during the night
(r) It is not convenient because connection of railway and bus are not well organized

The responses for each question were recorded on a six-point scale as;

1. Strongly Agree
2. Agree
3. Neither
4. Disagree
5. Strongly Disagree
8. I don’t know
9. Unknown

The aggregated data was averaged by taking “Disagree” and “Strongly Disagree” responses as the satisfied responses. Then overall average of satisfaction was calculated by averaging the satisfied responses for each transport mode. Satisfied percentage on quality and reliability of public transport was derived by taking the weighted average of satisfied responses of bus quality and reliability and train quality and reliability. Table 7 shows the results.

Table 8: Public Transport Reliability Analysis from Household Survey

(Source: CoMTrans Study)

Question	Variable	Dissatisfied			Satisfied				Total responces	Negative	Possitive	**Satisfied %**
		1. Strongly Agree	*2. Agree*	*3. Neither*	*4. Disagree*	*5. Strongly Disagree*	*8. I don't know*	*9. Unknown*				
(a) Frequency of bus operation is not sufficient thus waiting time is long	Bus_notSuff	3641	3384	766	536	88	185	80	8680	7025	624	**7.19%**
(b) Buses are often delayed due to traffic congestion	Bus_delay	3023	3959	940	452	76	173	57	8680	6982	528	**6.08%**
(c) It is not comfortable since it is hot on buses without air condition	Bus_not_confor	2369	3530	1548	678	100	356	99	8680	5899	778	**8.96%**
(d) It is too expensive if we get on air-conditioned buses	Expensive_air	3069	3789	1060	232	72	359	99	8680	6858	304	**3.50%**
(e) It is not comfortable because buses are dirty on board	Bus_dirty	2008	3083	1904	1029	136	397	123	8680	5091	1165	**13.42%**
(f) It is not comfortable because it is overcrowded on buses	Bus_overcrowd	3639	3687	738	256	64	197	99	8680	7326	320	**3.69%**
(g) Bus routes are limited thus bus passengers need several transfers	Bus_roots_limit	2105	3240	1660	886	164	489	136	8680	5345	1050	**12.10%**
(h) Security on buses are not fully guaranteed	Bus_no_secure	2447	3597	1550	412	89	455	130	8680	6044	501	**5.77%**
(i) It is not convenient because of long waiting when it has few passengers	Bus_long_waiting	3554	3792	746	212	78	217	81	8680	7346	290	**3.34%**
(j) It is not convenient because of bus frequency reduces during the night	Bus_frq_low_night	3956	3456	675	178	64	264	87	8680	7412	242	**2.79%**
(k) It is not comfortable because behavior of bus conductor and staff are not well	Behavior_bus_con	2710	3368	1341	410	100	390	361	8680	6078	510	**5.88%**
Total		32521	38885	12928	5281	1031	3482	1352	95480	71406	6312	**6.61%**

Question	Variable	Dissatisfied			Satisfied				Total responces	Negative	Possitive	**Satisfied %**
		1. Strongly Agree	*2. Agree*	*3. Neither*	*4. Disagree*	*5. Strongly Disagree*	*8. I don't know*	*9. Unknown*				
(l) Frequency of train operation is not suffcient thus waiting time is long	Train_opera	1498	2284	1064	198	56	3402	178	8680	3782	254	**2.93%**
(m) It is not comfortable since it is hot on trains without air condition	Train_unconfort	927	1874	1620	454	83	3534	188	8680	2801	537	**6.19%**
(n) It is not comfortable because trains are dirty on board	Train_dirty	909	1777	1658	552	86	3493	205	8680	2686	638	**7.35%**
(o) It is not comfortable because it is overcrowded on trains	Train_owercrowd	1466	2250	1132	200	41	3404	187	8680	3716	241	**2.78%**
(p) Security on trains are not fully guaranteed	Train_not_secure	1203	2037	1388	263	72	3493	224	8680	3240	335	**3.86%**
(q) It is not convenient because of railway frequency reduces during the night	Train_fre_low_night	1432	2225	1122	149	53	3488	211	8680	3657	202	**2.33%**
(r) It is not convenient because connection of railway and bus are not well organised	connec_rail_not_org	1465	2231	1064	123	66	3394	337	8680	3696	189	**2.18%**
Total		8900	14678	9048	1939	457	24208	1530	60760	23578	2396	**3.94%**

Limitations

The data available to determine the indicator was not satisfactory. The questions used in data collection are negative expressions which resulted in most respondents to agree on negative expressions. Further, positives such as fare level which is considerably low has not been considered. Therefore, in future work it is suggested to carry out a consumer survey based on direct evaluation framework based survey and analyse data.

Indicator 5: Traffic Fatalities per 100,000 Inhabitants

Relevance	Traffic accidents are a leading cause of death among younger population groups in some countries and are therefore a critical element in public health. The number of fatalities also indirectly indicates the (far more frequently occurring) injuries, as well as substantial health and material costs. Almost half of all traffic fatalities occur in cities. The indicator 5 is the same as the main one adopted for monitoring SDG target 3.6 'By 2020, halve the number of global deaths and injuries from road traffic accidents'.
Definition	Fatalities in traffic (road; rail, etc.) in the urban areas per 100.000 inhabitants. As defined by the WHO, a death counts as related to a traffic accident if it occurs within 30 days after the accident.
Unit	Number of persons killed per 100,000 inhabitants
Min and Max values	The minimum level is set to zero fatal accidents while the max is 35 per year. While zero may not seem as an immediately realistic level to achieve, it is increasingly used as a long-term goal among transport authorities around the world and therefore a meaningful lower yardstick.

Summary

Table 9: Summary of Indicator 5

Fatalities 2016	**Number**
Fatalities at road transport	804
Fatalities at rail transport	70
Total Fatalities	1,002
Inhabitants	5,851,130
Fatalities/100,000 inh	15

Methodology

The indicator requires traffic fatalities in study area as a quotient of 100,000 inhabitants. In Sri Lanka there are two major modes of transportation as road transportation and rail transportation. Hence fatalities should be identified in accordance to each transport mode.

Table 10 illustrates traffic fatalities belonging to road transport and rail transport. In data collection traffic fatalities belong to 2015 and 2016 were considered and 2016 data was selected as it is the most recent data available. Integration of 2015 and 2016 data enabled to ensure that outliers would not exist. The major source of fatality data was traffic police headquarters. Final report of 2012 census data was used together population data. *(See table 10).*

Table 10: Analysis on Annual Fatalities

Fatalities by Type	**2015**	**2016**	**Source**
Road transport			
Pedestrians	311	330	Traffic Police Head Quarters
Motorcyclists	242	269	Traffic Police Head Quarters
Motor Vehicle Drivers	55	57	Traffic Police Head Quarters
Passengers	101	83	Traffic Police Head Quarters
Cyclists	58	61	Traffic Police Head Quarters
Other	7	4	Traffic Police Head Quarters
Fatalities at road transport (western region)	774	804	
Rail transport	2015	2016	
Falling down from trains	3	1	SLR Performance report 2015
Throwing stones to trains	0	3	SLR Performance report 2015
Derailments	0	0	SLR Performance report 2015
Vehicle class at crossings	11	14	SLR Performance report 2015
Suicides and careless behaviour	161	180	SLR Performance report 2015
Fatalities at rail transport (All island)	175	198	
Fatalities at rail transport (Adjusted to Western Region)	62	70	SLR Performance report 2015
Total Fatalities	949	1002	
Inhabitants	5,851,130	5,851,130	Department of census and statistics – 2012 Final report
Fatalities/100,000 inh	**14**	**15**	

Limitations

The major limitation faced in data collection for this indicator is, fatality data available for rail transport represents the whole Island. It was not possible to gather data classified after location from Sri Lanka Railway. Therefore, all island value was adjusted by taking the weighted number of fatalities based on the length of railway km in Colombo. Further population data used in data connection is an estimate to the Colombo population of 2016 by referring to the population growth rate.

Table 11: Railway Length

Railway Line	Length
All Island	1508
Western Region	531

Indicator 6: Affordability – Travel Costs as Share of Income

Relevance	Transport costs represent a significant share of the household budget, especially for low income households. High travel costs can also increase the costs of labour to business. Affordability is a commonly recognized feature of a sustainable transport system. The indicator will be helpful in support of the SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all".
Definition	Cost of a monthly network-wide public transport ticket covering all main modes in the city, compared to mean monthly income for the poorest quartile of the population of the city.
Unit	Percentage of monthly income
Min and Max values	The minimum (worst) value is 35 percent of income to uses public transport. The maximum (best) value is 3.5 percent

Summary

Table 12: Summary of Indicator 6

Services	Number of Passengers	Market shares (estimated)	Revenue from Passenger	Monthly cost (60 tickets)	Weighted monthly cost	Year
Sri Lanka Railway	136,050,000	3.31	39.44	2,366.4	78.44	2016
Sri Lanka Transport Board	1,018,687,813	24.82	31.44	1,886.4	468.21	2015
Private Bus Companies	2,949,535,000	71.86	31.44	1,886.4	1,355.66	2015
Total	4,104,272,813				1,902.31	
Mean household income, 2nd decile, 2015					14,843.00	2016
Weighted transport cost/Monthly Income %					**12.82**	

Methodology

The indicator requires identifying transport ticket cost as a percentage of monthly income. The mean monthly income for the 2nd decile of the population should be considered. The annual ridership is selected as the indicator which defines the market share of the public transportation. The selection could be justifiable as it represents the public demand for each public transportation mode data was acquired by referring to the National Transport Statistics and performance reports of Sri Lanka and transport board and Sri Lanka Railway

The basis to identify the monthly cost of a ticket was the revenue generated by each of these transportation modes maybe revenue per passenger of Sri Lanka transport board was selected as the average revenue generated by a bus passenger. The revenue generated by a railway passenger was identified from performance indicators of Sri Lanka Railway performance reports. From the obtained data, monthly cost of public transportation for each mode was identified by assuming that a passenger would take two tickets per day which totals up to 60 tickets per month. Ticket price was considered as the average revenue generated by a passenger. After finding the monthly cost of public transportation weighted monthly cost of public transportation was found by weighing the monthly cost of each transport mode by its market share.

The mean household income for the 2nd decile income group was taken as the mean household income. The data was obtained by referring to the household income and expenditure survey conducted by department of census and statistics

Limitations

The major drawback identified in collecting data for this indicator was unavailability of required data for Western Region. Data for average revenue generated by passenger was available as a value averaged to Sri Lanka in national transport statistics report. Therefore, that value was considered when calculating public transport affordability in Western Region.

Average revenue generated by a passenger was considered as a parameter because there was no flat rate of fares available for any of the public transport modes. The fare system is staggered with reference to the distance. Therefore, by using average ticket price would be an erroneous estimate for the indicator.

Annual ridership data for each transport mode was available as a total for Sri Lanka. Annual ridership data was considered as a parameter to determine the market share of each transport mode. Therefore, market share of public transport modes in western region was assumed as similar to that of Sri Lanka.

Indicator 7: Operational Costs of the Public Transport System

Relevance	The operational costs of the public transport system are critical for the ability of a city to provide affordable, efficient and competitive transport services. In this indicator the operational costs are compared to the revenue generated from fares to reflect the financial sustainability of the public transport service. The indicator relates to SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all".
Definition	Ratio of fare revenue to operating costs for public transport systems ('Fare box ratio')
Unit	Percentage of operational costs recovered by fares
Min and Max values	Min value is that only 22% of cost is recovered. Max is recovery rate of 175 % A high value (more than 100% up to 175%) reflects a good financial sustainability. Very low numbers, close to 22%, indicates financial unsustainability with a need for extensive subsides from local or central government.

Summary

Table 13: Summary of Indicator 7

Services	Annual Ridership	Market shares (estimated)	Fare Revenues	Transport Operating expenses	Fare box ratio
Sri Lanka Railway	136,050,000	3%	6,334,600,000	14,048,760,000	45%
Sri Lanka Transport Board	1,018,687,813	25%	35,824,591,470	38,575,335,518	93%
Private Bus Companies	2,949,535,000	72%	92,733,380,400	96,279,512,800	96%
Total	**4,104,272,813**	**100%**		**Weighted**	**93.76%**

Methodology

The indicator requires identifying the fare box ratio or the ratio of fare revenue to operating costs of public transport systems. In determining indicator, three parameters required to be identified which include market share of each public transport mode, fare revenue generated by each transport mode and transport operating expenses of each transport mode.

The market share of public transport mode was identified by referring to the annual ridership on each public transport mode. In train services are operated by Sri Lanka Railway. Public bus transportation is divided among Sri Lanka Transport Board and private bus companies. The ridership on each of these transport modes could be found from National Transport Statistics report. Fare revenue and transport operating costs for Sri Lanka Railway and Sri Lanka Transport Board could be obtained from annual performance reports of each state-owned organizations. Thus, calculating fare-box ratio for each of these transport modes could be done directly.

When looked at the private bus companies, it could be observed that there are many bus owners operating with one or two buses. Therefore, due to the large number of service providers available in the country it was not possible to obtain revenue data or operating cost data for this transportation mode. Hence an estimation was based on following assumptions. In order to identify the estimated cost of operation, estimated number of operated kilometres by private bus companies and total operation cost per kilometre was considered. Data was obtained from National transport statistics report (see table 14)

Table 14: Private Bus Owners Estimated Cost of Operation

Number of Operated km	Total operation cost per km	Estimated Cost of Operation
1,012,190,000.00	95.12	96,279,512,800.00

To estimate the total fare revenue generated by private bus owners the number of served passengers by them throughout the year was considered. In Sri Lanka, the public bus service fares and private bus service fare are maintained at equal rates to provide equally competitive public bus service in the country. Therefore, it could be assumed that revenue generated by passenger for private bus service and public bus service or to be similar. Depending on that assumption average revenue generated from a passenger by Sri Lanka transport board was used as an equivalent to that of private bus companies. (see table 15)

Table 15: Private Bus Owners Estimated Revenue from Operation

Number of Passengers	Revenue from Passenger	Estimated Revenue from Operations
2,949,535,000.00	31.44	92,733,380,400.00

Limitations

Major drawback found in this calculation was unavailability of data for western region. Sri Lanka Transport Board, National Transport Commission and Sri Lanka Railway provides reports which include data required for calculation of the indicator. Therefore, indicators were calculated covering the whole Sri Lanka.

Unavailability of provincially classified data is a major concern regarding this indicator. In the calculation process, it was assumed that there is no significant difference in fare-box ratio with reference to provincially classified data and considering Sri Lanka as a whole.

Indicator 8: Investment in Public Transportation Systems

Relevance	Investment in public transport is a relevant indicator to monitor efforts to promote sustainable urban mobility and to help shift passengers from individual to public modes. In general, it is considered more sustainable to direct investments towards public transport rather than only incremental extensions of the road network for individual transport. Relates to SDG target 11.2 "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all".
Definition	Share of all transport investments made by the city that is directed to public transport. The investments are likely to vary from year to year in a pattern that may be sensitive to the profile of individual projects. The value is therefore averaged over a period of five years.
Unit	Percentage of transport investment spending (running five-year average).
Min and Max values	Min value is 0 used for public transport; max value is 50% The Min-Max is informed by data from the UITP 'Millennium Cities Database' (UITP 2001). In this database values from 12 to 85% occur. However, these are annual values that are likely to even out when observed as average over five years. In some years a city may dedicate more than 50% of all its transport investments to public transport but within a five-year average this would more rarely be the case.

Summary

Table 16: Summary of Indicator 8

Year	Total Transport Investment (LKR)	Direct Investments on Public transport (LKR)	Share
2012	195,033,000,000	46,938,000,000	24.07%
2013	176,226,000,000	43,826,000,000	24.87%
2014	210,404,000,000	72,677,000,000	34.54%
2015	290,919,000,000	63,446,000,000	21.81%
2016	262,992,000,000	54,702,000,000	20.80%
Average	227,114,800,000	56,317,800,000	24.80%

Methodology

The indicator requires to identify the percentage of direct investment in public transport out of total transport investment spending. It was a challenge to identify direct investment on public transportation. The data was obtained by referring to annual reports and national budget performance reports published by Ministry of Finance. The investment components were identified for last 5 years and average was taken.

For the calculation, data was collected from 2012 to 2016. In Sri Lanka, government investment on transportation was directed via several Ministries the Table 15 indicates actual spending by each ministry which can be considered as total government investment on transportation sector. *See Table 17*

Table 17: Actual expenditure of transport aligned ministries

Year	2012		2013		2014	2015	2016
Ministry	**Recurrent (Million LKR)**	**Capital (Million LKR)**	**Recurrent (Million LKR)**	**Capital (Million LKR)**	**Total (Million LKR)**	**Total (Million LKR)**	**Total (Million LKR)**
Ministry of Higher Education and Highways						222,136	195,600
Ministry of Transport and Civil Aviation					-	68,783	67,392
Ministry of Transport	15,844	32,010	18,746	25,876	76,337	-	-
Highways, Ports and Shipping	196	146,682	263	130,836	133,304	-	-
Private Transport Services	235	66	432	73	763	-	-
Total	16,275	178,758	19,441	156,785	210,404	290,919	262,992

In order to identify the direct investment on public transportation the investment component on maintenance of public transportation systems were considered. Data was collected by referring to the annual report of Ministry of Finance (See *Table 18)*

Table 18: Direct Expenditure on Public Transportation

Major Thrust Areas	2012 (Million LKR)	2013 (Million LKR)	2014 (Million LKR)	2015 (Million LKR)	2016 (Million LKR)
Service Delivery	16,079	19,177	26,506	28,737	32,815
Improvement of Bus Services	227	412	150	161	49
Bus Fleet Augmentation	579	898	1,877	2,633	4,530
Reconstruction of Rail Tracks	2,662	3,042	3,117	2,686	2,676
Construction of Rail Lines	15,045	14,586	32,144	24,600	13,451
Rail Fleet Improvement	8,758	3,944	5,405	419	-
Installation of Signalling & Telecommunication Systems	3,588	1,767	3,478	4,210	1,181
Direct Investment on Public transport	46,938	43,826	72,677	63,446	54,702

Limitations

It was a challenge to identify total investment on transportation sector and direct investment on public transportation at the provincial level. Therefore, investment details of Sri Lankan government as a whole were used in calculating the indicator. Due to this unavailability of data there could be an over/under estimate of the indicator. Therefore, it is suggested that the calculation be adjusted for provincial values.

Indicator 9: Air Quality (PM10)

Relevance	Air pollution including particulate matter (PM) poses health risks for humans. More than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed the World Health Organization limit values. Particulate matter has been adopted by the United Nations Social and Economic Council and the UN Statistical Commission as indicator to monitor SDG Target 11.6 'By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management'. Traffic is a major source of air pollution in cities causing significant health problems as well as impairing visibility and affecting ecosystems and agriculture. Motor vehicles are among the main contributors to PM pollution. The UN Habitat mentions PM concentrations as a useful indicator for estimating effects of sustainable transport policies in cities.
Definition	Annual mean levels of fine particulate matter (PM10) in the air (population weighted) compared to the health threshold. [for PM2.5 as alternative, see text]
Unit	Micrograms per cubic meter (µg/m3).
Min and Max values	Min value (worst) is 150; max value (best) is 10 (for PM10)

Summary

Table 19: Summary of Indicator 9

Parameter	Value
Average PM10	46

Methodology

Data was obtained by referring to air quality tests which were conducted at several locations of the Western Region. The average value of the obtained data was considered as the PM10 value. The tests were conducted by Industrial Technology Institute, Colombo 7.

Table 20: Collected sample of Air quality PM10 levels

	Location	**Cordinates**	**PM10**
1	At a location closes to the Site Office, China Harbour Engineering Company Ltd, Port, Colombo	06°56'8.99"N 79°50'24.28"E	52
2	At a location within the premises of the Museum & Chaithya of Port Authority, Colombo.	06056’18.5” N 079 50’31.2”E	32
3	At a location close to the Port Authority Office, Galle face, Colombo	06055’15.1” N 079 50’44.1”E	37
4	At a location within the premises of the old parliament building, close to the entrance.	06°55'50.24"N 79°50'33.36"E	28
5	At a location in front of the fort railway station, Pettah, Colombo	06°56'1.73"N 79°51'1.54"E	71
6	A location close to the 2000 roundabout, inside the Colombo port.	06°56'34.97"N 79°50'23.70"E	54
7	At open space (ground) in front of “Agamathi Vidyalaya” at Blumendal Road. Duration –From 23:00 hours, 15th June to 05:00 hours, 17th June 2017.	6°57'27.36"N, 79°52'5.66"E	47
8	At the premises of Roadside Store, Supplies section belongs to Sri Lanka Ports Authority. (In front of St.Anthoni’s Church) Duration –From 15:00 hours, 14th June to 18:00 hours, 15th June 2017.	6°56'54.94"N, 79°51'25.31"E	40
9	At the premises of “Sri Sambodhi Chaithya” belongs to Sri Lanka Ports Authority. Duration –From 11:00 hours, 19th June to 16:00 hours, 20th June 2017.	6°56'18.03"N, 79°50'30.88"E	32
10	Within the premises of the Museum & Chaithya of Port Authority, Colombo 01.Duration –From 11:00 hours, 17th March to 15:00 hours, 18th March 2017.	6°55'51.68"N, 79°50'33.25"E	37
11	Close to the Port Authority Office, Galle face, Colombo. In front of Gale Face Hotel Duration –From 20:00 hours, 18th March to 21:00 hours, 19th March 2017.	6°55'14.82"N, 79°50'44.12"E	58
12	Within the premises of the old parliament building, close to the main entrance to the building. Duration –From 17:00 hours, 22nd March to 18:00 hours, 23rd March 2017	6°56'18.23"N, 79°50'31.14"E	72
13	In front of the fort railway station, Colombo 11. (Near the Air Quality Monitoring station operated by CEA. Duration –From 14:00 hours, 13th March to 16:00 hours, 14th March 2017.	6°56'12.21"N, 79°50'25.17"E	38
	Average (PM10)		**46**

The following map show the locations in which PM10 data was available.

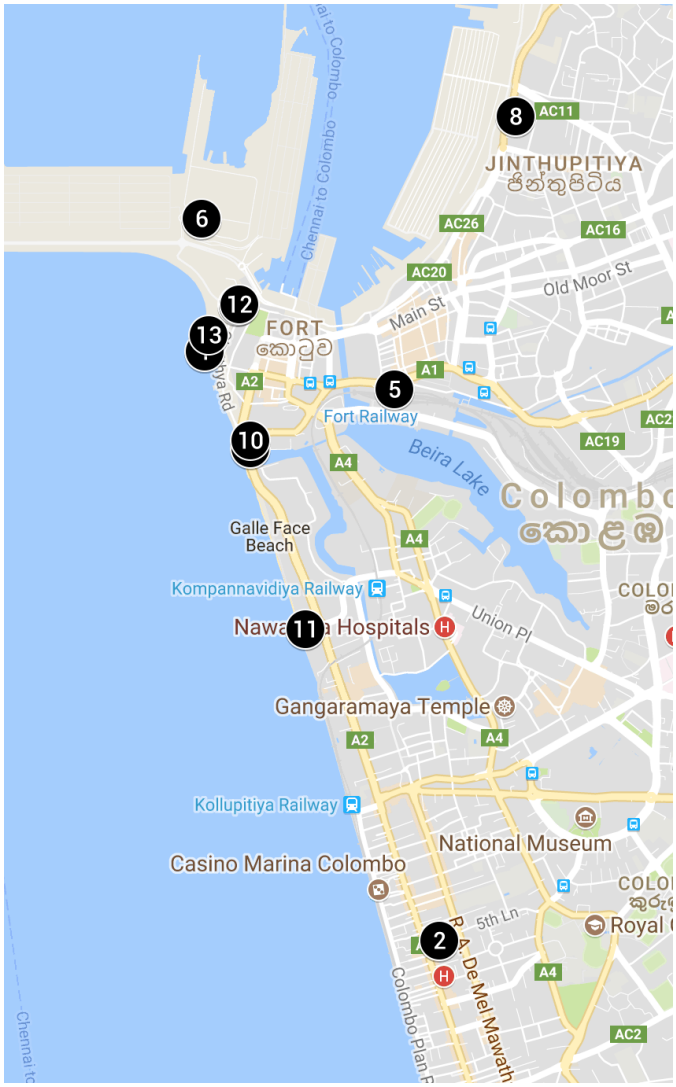

Figure 15: Air Quality Test Locations

All requested parameters for ambient Air Quality were measured by using state of the art mobile ambient air quality monitoring station that includes sensitive automated equipment with USEPA approved reference methodologies. Those methods are recommended for Ambient Air Quality monitoring by National Environmental (Ambient Air Quality) regulations published in Gazette Extraordinary No 1562/22, dated 15th August 2008, under the provisions of section 32 of the National Environmental Act No 47 of 1980. Details of relevant methodologies are given below.

Table 21: Methodology used for Air quality PM10 testing

Parameter	Method	Description	Equipment
Suspended Particulate Matter aerodynamic Diameter less than 10 µm (PM10)	Beta ray Attenuation Method	USEPA Ref Number EQPM-RFPS-0706-162 LDL - 4.0 µg/m3	Sprint BAM particulate monitor Ecotech, Australia. (Manufactured in USA)

Limitations

In Sri Lanka, there are no facilities available to measure air quality data throughout the year. The research institute (Industrial Technology Institute) has conducted tests as per the requirement of its clients. The experiments were conducted by using a mobile ambient air quality monitoring station. Therefore, collecting a data set with annual variation of air quality is not possible.

The mean value of PM10 was obtained by averaging the experimental values which were taken on different times of the year 2017. Therefore, the obtained average PM10 value cannot represent the air quality of western region as data was available only to several locations of Colombo.

It was suggested to take the average PM10 value without adjusted to the population at the surrounding area. The possibility of occurring errors in the final value is higher when it is weighted by population. As many locations of the data collection were closer to coastal belt the average value of PM10 is prone to variation with time and space due to inward and out ward winds.

Indicator 10: Greenhouse Gas Emissions (CO2eq tons/year)

Relevance	Man-made emissions of CO2 and other greenhouse gasses are causing global warming and climate change. Transport contributes worldwide to around one quarter of the global energy related CO2 emissions. A major proportion of this contribution is emitted in cities. The indicator Is highly relevant for SDG 13 'Take urgent action to combat climate change and its impacts', even if this goal does not directly specify GHG targets for the urban level.
Definition	CO2 equivalent emissions from transport by urban residents per annum per capita.
Unit	Ton CO2 equivalent emitted/capita/year
Min and Max values	Min. value (worst) is 2.5 ton; Max value (best) is 0

Summary

Table 22: Summary of Indicator 10

Fuel	Consumption (kilo litres)	Conversion factor (kg/l)	Emissions tons/year
Petrol 90 Octane	494,783	2.272	1,124,147
Petrol 95 Octane	94,232	2.272	214,095
Auto Diesel	846,575	2.676	2,265,435
Super Diesel	40,983	2.676	109,671
Total			3,713,347
Population			**5,851,130**
Emission / Capita			**0.63**

Methodology

The indicator requires to identify carbon dioxide equivalent emissions from transportation by urban and residents per annum per capita. When considering the Sri Lankan transport sector, fuel consumption is the major source of emissions. Petrol and diesel are the major fuel consumption while kerosene consumption for transportation is negligible. To collect data for the indicator it was possible to acquire annual fuel sales of Colombo, Gampaha and Kaluthara districts which were released from commercial fuel stations. *(See Table 23).* In Sri Lanka, fuel stations are operated by privet dealers under the full regulation of Ceylon Petroleum Corporation. Data was collected from report on Sri Lanka energy balance 2015 published by Sri Lanka Sustainable Energy Authority

Table 23: Annual Fuel Consumption for Transportation in Western Region

District	Petrol 90 Octane (kl)	Petrol 95 Octane (kl)	Auto Diesel (kl)	Super Diesel (kl)
Colombo	255156	68208	468177	28397
Gampaha	174709	20163	283794	10395
Kaluthara	64918	5861	94604	2191
	494783	94232	846575	40983

The estimated population data was obtained from Census Report 2012. Conversion factor equivalent CO2 emissions from fossil fuel is obtained by referring to the SUTI Calculation guideline provided by UNESCAP

Results and Discussion

The obtained results from SUTU data sheets are as follows

Table 24: Percentage result for each indicator

	C1 RESULT SPIDER DIAGRAM	Value
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	68.75
2	Modal share of active and public transport in commuting	81.81
3	Convenient access to public transport service	30.00*
4	Public transport quality and reliability	0.15
5	Traffic fatalities per 100.000 inhabitants	57.14
6	Affordability – travel costs as part of income	70.41
7	Operational costs of the public transport system	46.90
8	Investment in public transportation systems	49.60
9	Air quality (pm10)	74.29
10	Greenhouse gas emissions from transport	77.09

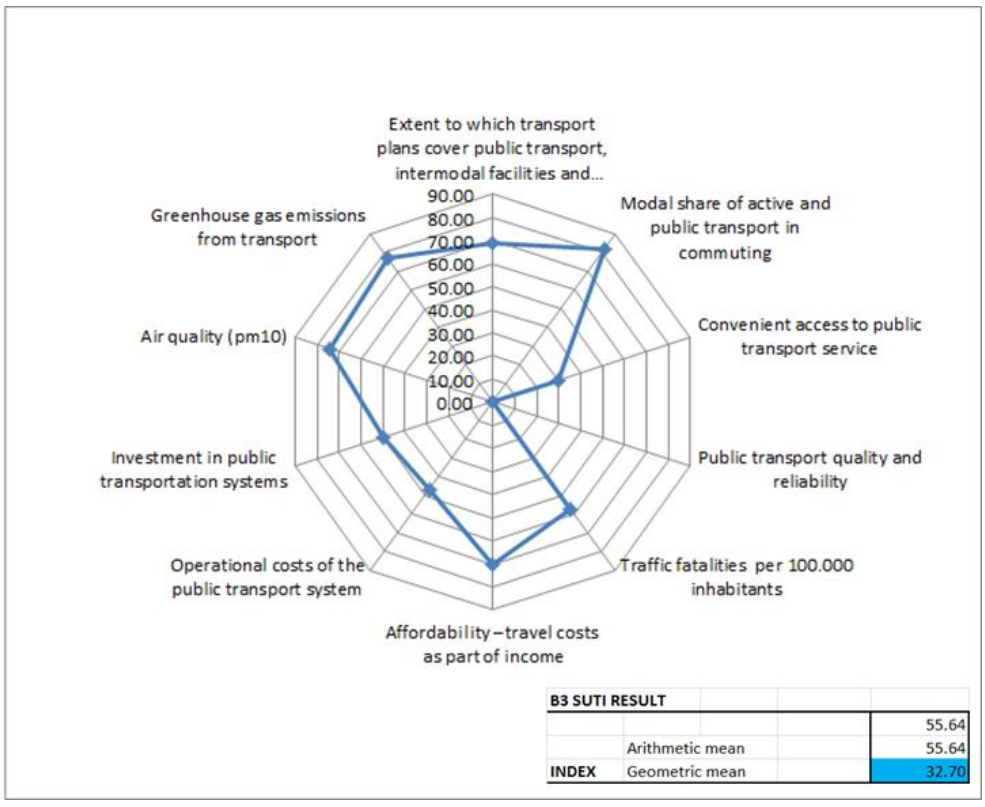

Figure 16: SUTI Spider Diagram

An arithmetic mean of 55.64 and a geometric mean score of 32.70 have been obtained from the SUTI index for the Western Region in Sri Lanka. The challengers for the development of the SUTI index has been with available of data as in temporal where the data is not available in the same time

periods. Therefore, some assumptions had to be made. Secondly, the spatial challenge that data unavailability in the same geographical areas which required assumptions to be made.

SUTI for the Western Region in Sri Lanka verifies what has been identified in previous and current masterplans. It shows that following areas can be improved as shown in Figure 17 to increase the SUTI index.

1. Public transport quality and reliability
2. Convenient access to public transport services
3. Investment in public transportation systems
4. Operational costs of the public transport systems

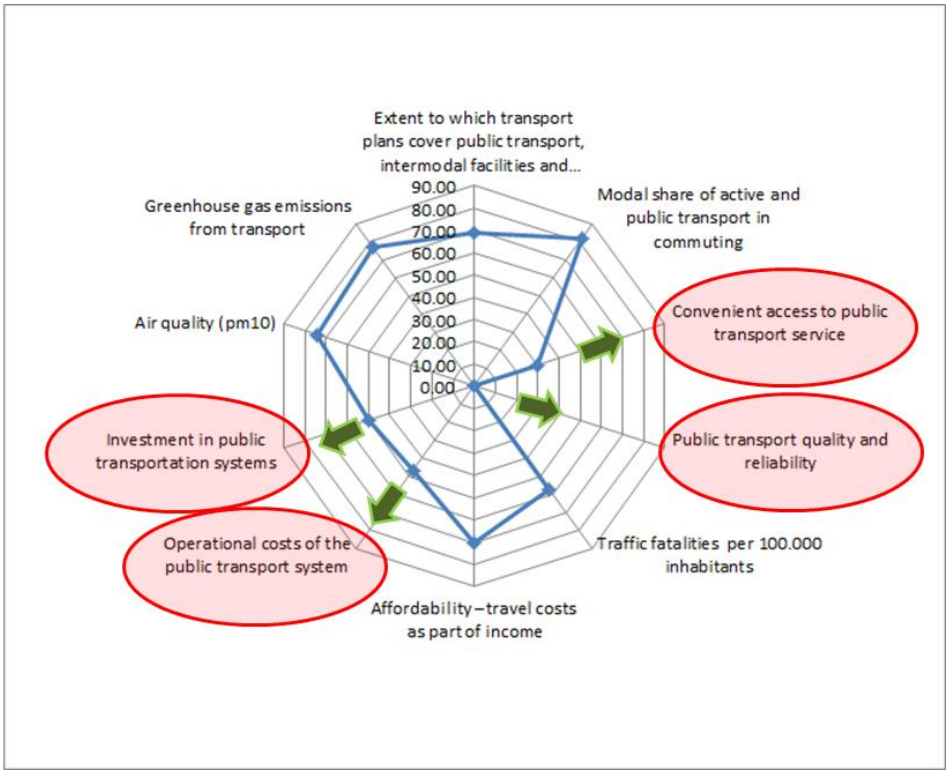

Figure 17: SUTI Spider Diagram Analysed

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