Initiative for Climate Action Transparency - ICAT

MEASUREMENT, REPORTING AND VERIFICATION PROTOCOL OF TRANSPORT SECTOR IN SRI LANKA

INITIATIVE FOR
Climate Action
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Initiative for Climate Action Transparency - ICAT –

MEASUREMENT, REPORTING AND VERIFICATION FRAMEWORK OF TRANSPORT SECTOR IN SRI LANKA

Deliverable 3-2

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According to the Sri Lankan Nationally Determined Contributions (NDCs) submitted by the Government of Sri Lanka to the United Nations Framework Convention on Climate Change (UNFCCC) in 2016, and the Sri Lanka's Readiness Plan for Implementation of Intended Nationally Determined Contributions (INDCs) in 2016, the establishment of a national MRV(Measuring, Reporting & Verification) system is considered as a national priority. Sri Lanka has also to present the status of achieving the NDC goals in 2020. In this context, Sri Lanka has been looking for assistance from various parties to support the establishment of its national MRV system in the transport sector.

This report on monitoring reporting and verification (MRV) framework of mitigation actions for transport sector in Sri Lanka is the first part of the third deliverable of the assignment on developing a national MRV System for Transport Sector in Sri Lanka under the project Initiative for Climate Action Transparency (ICAT). This report was produced under the direct guidance and supervision of Climate Change Secretariat (CCS) of Ministry of Mahaweli Development and Environment (MMDE), Ministry of Transport and Civil Aviation (MTCA), and UNEP DTU Partnership.

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Sri Lanka.

List of Acronyms

AD	Activity Data
AFOLU	Agriculture, Forestry and Other land Use
BUR	Biennial Update Reports
BAU	Business As Usual
CAGR	Compound Average Growth Rate
CCS	Climate Change Secretariat
CDM	Clean Development Mechanism
CTF	Common Tabular Format
COP	Conference of the Parties
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
EDGAR	Emission Database for Global Atmospheric Research
EF	Emission Factor
GEF	Global Environment Facility
GFEI	Global Fuel Efficiency Initiative
GHG	Greenhouse Gas
IPPU	Industrial Processes and Product Use
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency (Prepared by Japan Weather Association)
LULUCF	Land Use, Land Use Change and Forestry
MMDE	Ministry of Mahaweli Development & Environment
MMWD	Ministry of MegaPolis& Western Development
MoF	Ministry of Finance
MoH	Ministry of Highways
MoPRE	Ministry of Power & Renewable Energy
MoPS	Ministry of Petroleum Resource Development
MTCA	Ministry of Transport & Civil Aviation
MRV	Monitoring, Reporting, and Verification

NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
NTC	National Transport Commission
SNC	Second National Communication
UDA	Urban Development Authority
UNFCCC	United Nations Framework Convention on Climate Change

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1 MONITORING, REPORTING & VERIFICATION PROTOCOL - PASSENGER SHIFT FROM PRIVATE TO PUBLIC (NDC 4.1)

OVERVIEW

This protocol serves as an overview of the monitoring process, a qualitative assessment of the monitored parameters, the organizational structure, the primary responsibilities of the personnel involved in monitoring and QA/QC process.

1.1 Introduction

Mitigation Action - The proposed mitigation action is to shift passengers from private to public transport by introducing light railway transit (LRT) system with park and ride facilities from Malabe to Colombo Fort (Malabe corridor) in Sri Lanka. The LRT line has been designed to construct 17 km long elevated rail track including 16 stations to cover important and major intersections from Malabe to Colombo Fort. Under the proposed LRT system, 25 trains will be deployed for the service and each unit will comprise of four air-conditioned passenger compartments to accommodate 800 passengers. Based on the demand during the peak hours, trains will be operated with a minimum three-minute headway to ensure an efficient and comfortable ride for the passengers. The project is expected to be completed in 2026 and establishes the connectivity between many administrative complexes, commercial hubs and densely populated residential areas of the city.

1.2 Monitoring plan

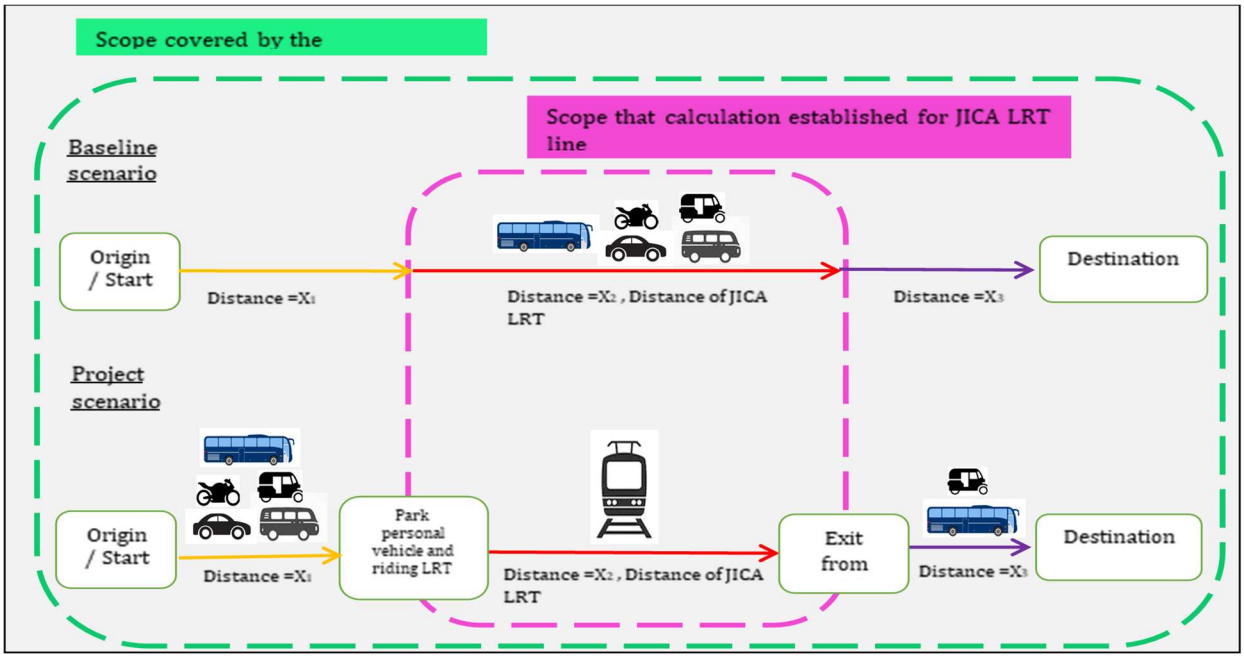

Figure 1.2-1 Monitoring plane

Data monitoring procedure of O & M Company (P1_PRS_OMC)

1.3 Monitoring methodology

Methodology /Tools

ACM0016: Baseline Methodology for Mass Rapid Transit Projects; Version 4.0

Tool,

- "Baseline emissions for modal shift measures in urban passenger transport", Version 01
- "Tool to calculate baseline, project and/or leakage emissions from electricity consumption", Version 01
- "Tool to calculate the emission factor for an electricity system", Version 05

Equations

Equation 1: Base year emission

$$BE_y = \frac{P_y}{P_{SPER}} \sum_p (BE_{p,y} \cdot FEX_{p,y})$$

Equation 1.1: Base year emission per passenger

$$BE_{p,y} = \sum_i BTD_{p,i,y} \times EF_{pkm,i,y} \times 10^{-6}$$

Equation 1. 1. 1: Emission factor per km

$$EF_{KM,i,x} = \left[\sum_n [SFC_{i,n,x} \times NCV_{i,n} \times EF_{CO2,n} + SEC_{i,x} \times EF_{CO2,x}] \times \frac{N_{i,n,x}}{N_{i,x}} \right]$$

Equation 1. 1. 2: Emission factor per passenger km

$$EF_{pkm,i,y} = EF_{KM,i,y} / OC_i$$

Equation 2: Direct project year emission (DPE $_y$)

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EL,j,y} \times (1 + TDL_{j,y})$$

Equation 3: Indirect project year emission

$$IPE_y = \frac{P_y}{P_{SPER}} \sum_p (IPE_{p,y} \cdot FEX_{p,y}) \times 10^{-6}$$

Equation 3.1: Indirect project year per passenger

$$IPE_{p,y} = \sum_i IPTD_{p,i,y} \times EF_{pkm,i,y}$$

Equation 4: Emission reduction

$$ER_y = BE_y - PE_y + LE_y$$

Parameters

1.3.1 Ex-ante parameters (fixed values)

- Specific fuel consumption of vehicle category *i* using fuel type *n* in year *x*
- Net calorific value of fuel *n* used in vehicle category *i*
- Technology improvement factor for vehicle category *i* per year
- Emission factor for fuel type n
- Average occupancy rate of vehicle category *i* in year *x*

1.3.2 Ex-post parameters (regularly monitored values)

- Number of vehicles of category i in year x
- Number of vehicles in vehicle category i using fuel type n in year x
- Total passengers transported by the project LRT per year
- Number of passengers in the time period of the survey (1 week)
- Number of passengers selected in the station sp, in stratum h
- Total number of passengers in the station sp, in stratum h
- Combined margin emission factor for the grid in year y
- Average technical transmission and distribution losses for providing electricity to source j in year y
- Quantity of electricity consumed by the project LRT per year

1.3.3 Parameters to verified/collected one time prior to the monitoring period

- Net calorific value of fuel *n* used in vehicle category *i*
- Technology improvement factor for vehicle category *i* per year
- Emission factor for fuel type n
- Average occupancy rate of vehicle category *i* in year *x*

1.4 Parameter and procedure

Table 1.4-1 Parameter and procedure table

Parameter	Description	Instrument /method	Applied for (baseline, project, leakage)	Procedure
$SFC_{i,n,x}$	Specific fuel consumption of vehicle category *i* using fuel type *n* in year *x*	Default value / Calculate	Baseline & Project indirect	CDM tool 18/ P1_FSRR_CP
NCV $_{i,n}$	Net calorific value of fuel *n* used in vehicle category *i*	Default value / Calculate	Baseline & Project indirect	IPCC/ P1_FSRR_CP
$EF_{CO2,n}$	Emission factor for fuel type n	Default value	Baseline & Project indirect	IPCC
Specific weight for fuel type *x* in the year *y*		Calculate	Baseline & Project indirect	P1_FSRR_CP
IR_i	Technology improvement factor	Default value	Baseline & Project indirect	CDM tool 18
N $_{i,n,x}$	Number of vehicle-kilometers vehicle category *i* using fuel type *n* driven in year *x* or number of vehicles in vehicle category *i* using fuel type *n* in year *x*	Measure survey	Baseline & Project indirect	P1_PRS_OMC
N $_{i,x}$	Number of vehicle-kilometers of category *i* driven in year *x* or number of vehicles of category *i* in year x	Measure survey	Baseline & Project indirect	P1_PRS_OMC
$OC_{i,x}$ or $OC_{B,x}/OC_{T,x}$	Average occupancy rate of vehicle category *i* in year *x* (e.g. Buses (B),	Default value/ Measure	Baseline & Project indirect	CDM tool 18/P1_PRS_OMC

/$OC_{C,x}$/$OC_{MR,x}$	taxis (T), passenger cars (C), motorized rickshaw/bicycle (MR)			
$\mathbf{BTD_{,p,i,y}}$	Baseline trip distance *p* per surveyed passenger using mode *i* in the year *y*	Measure	Baseline	P1_PRS_OMC
$\mathbf{IPTD_{p,y,i}}$	Indirect project trip distance of the surveyed passenger using mode "i"	Measure	Project indirect	P1_PRS_OMC
$\mathbf{n_{lhps}}$	Number of stations *sp* selected in the stratum *h* (3 stratus are created i.e. high, medium and low passenger flow);	Measure survey	Baseline & Project indirect	P1_PRS_OMC
$\mathbf{N_{lhps}}$	Total number of *stations* sp in the stratum *h*	Measure survey	Baseline & Project indirect	P1_PRS_OMC
$\mathbf{n_{ihps}}$	Number of passengers selected in the station *sp*, in stratum *h*	Measure survey	Baseline & Project indirect	P1_PRS_OMC
$\mathbf{N_{ihps}}$	Total number of passengers in the station *sp*, in stratum *h*	Measure survey	Baseline & Project indirect	P1_PRS_OMC
$\mathbf{P_y}$	Total number of passengers in the year *y*	Measure	Baseline & Project indirect	P1_PRS_OMC
$\mathbf{P_{SPER}}$	Number of passengers in the time period of the survey (1 week)	Measure survey	Baseline & Project indirect	P1_PRS_OMC
$\mathbf{EF_{grid,CM}}$	Emission factor for electricity generation in the grid based on combined margin (gCO_2/kWh)	Use calculated national value	Project direct	P2_ER_SLSEA

TDL	Average technical transmission and distribution losses for providing electricity	Use calculated national value	Project direct	P2_ER_SLSEA
$EC_{PJ,y}$	Quantity of electricity consumed by the LRT	Calculate	Project direct	P1_PRS_OMC

1.5 Organization structure and MRV specific responsibilities

Table 1.5-1 Organization structure and MRV specific responsibilities

Parameter description	Tasks	Responsible staff	Procedure	Comment
Specific fuel consumption of vehicle category *i* using fuel type *n* in year *x*	Collect default values and keeping records	Project responsible officer under NDC unit	CDM tool 18/ P1_FSRR_CP	
Net calorific value of fuel *n* used in vehicle category *i*	Collect default values and keeping records	Project responsible officer under NDC unit	IPCC/ P1_FSRR_CP	
Emission factor for fuel type n	Collect default values and keeping records	Project responsible officer under NDC unit	IPCC	
Specific weight for fuel type *x* in the year *y*	Calculate national value and publish on the website	Responsible officer under CEYPETCO	P1_FSRR_CP	Value available in the CEYEPETCO website
Technology improvement factor	Collect default values and keeping records	Project responsible officer under NDC unit	CDM tool 18	Value available under CDM methodological tool 18
Number of vehicle-kilometres vehicle category *i* using fuel type	Conducting a survey, collecting the data and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	

n driven in year *x* or number of vehicles in vehicle category *i* using fuel type *n* in year *x*				
Number of vehicle-kilometers of category *i* driven in year *x* or number of vehicles of category *i* in year x	Conducting a survey, collecting the data and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Average occupancy rate of vehicle category *i* in year *x* (e.g.,buses (B), taxis (T), passenger cars (C), motorized rickshaw/bicycle (MR)	Estimate the average values and reporting it to NDC unit under Transport Ministry (Only onetime)	MRV Focal point at O & M Company	CDM tool 18/P1_PRS_OMC	Calculate default value to specific project only for one time
Baseline trip distance *p* per surveyed passenger using mode *i* in the year *y*	Measuring the values and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Indirect project trip distance of the surveyed passenger using mode "i"	Measuring the values and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Number of stations *sp* selected in the stratum *h* (3 stratus are	Conducting a survey, collecting the data and reporting it to NDC	MRV Focal point at O & M Company	P1_PRS_OMC	

created i.e. high, medium and low passenger flow);	unit under Transport Ministry			
Total number of *stations sp* in the stratum *h*	Conducting a survey, collecting the data and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Number of passengers selected in the station *sp*, in stratum *h*	Conducting a survey, collecting the data and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Total number of passengers in the station *sp*, in stratum *h*	Conducting a survey, collecting the data and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Total number of passengers in the year *y*	Conducting a survey, collecting the data and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Number of passengers in the time period of the survey (1 week)	Conducting a survey, collecting the data and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	
Emission factor for electricity generation in the grid based on combined margin (gCO_2/kWh)	Calculate national value and publish it through national energy balance	Responsible officer under Sustainable Energy Authority	P2_ER_SLSEA	Publicly available. NDC unit can collect it from the "Energy Balance"

Average technical transmission and distribution losses for providing electricity	Calculate national value and publish it through national energy balance	Responsible officer under Sustainable Energy Authority	P2_ER_SLSEA	Publicly available. NDC unit can collect it from the "Energy Balance"
Quantity of electricity consumed by the LRT	Collect the values and reporting it to NDC unit under Transport Ministry	MRV Focal point at O & M Company	P1_PRS_OMC	

1.6 Proposed data management system

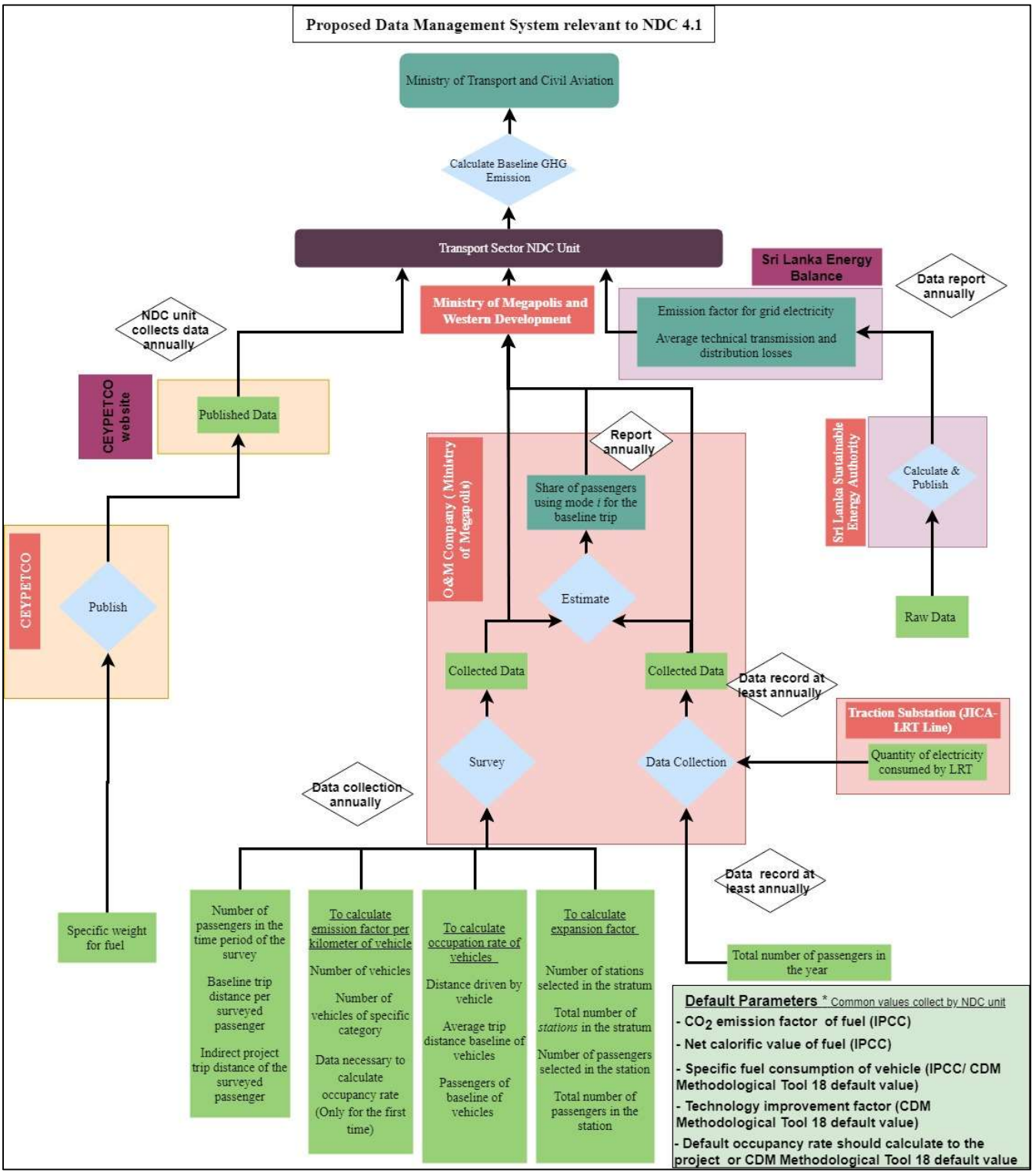

Figure 1.6-1 Proposed data management system

Data requirement

Parameters necessary for baseline and indirect project emissions

Data and parameters not monitored

Data / Parameter table 1

Data / Parameter:	**$SFC_{i,n,x}$**	**$SFC_{i,n,x}$**
Data unit:	Mass or volume units of fuel/km	Mass or volume units of fuel/km
Description:	Specific fuel consumption of vehicle category *i* using fuel type *n* in year *x*	Specific fuel consumption of vehicle category *i* using fuel type *n* in year *x*
Source of data:	In decreasing order of preference: 1. Local measured data (studies, e.g. performed by universities, other institutions or ordered by project proponent); 2. National or international data from studies; 3. IPCC default values for the respective vehicle categories (latest IPCC report) 4. Design data for relevant vehicle categories 5. Globally applicable default values	1. IPCC default values or 2. Globally applicable default values in CDM methodological tool 18 (Baseline emissions for modal shift measures in urban passenger transport)can be used.
Measurement procedures (if any):	The following alternatives are proposed to determine specific fuel consumption (in order of preference). In case one of the alternatives does not provide required values for all categories, the combination of these alternatives can be used and justification for the use of combination should be provided.	**Alternative 3:** latest IPCC default values reported matching the respective vehicle category, age, vehicle origin and technology. **Alternative 5**. Globally applicable default values (See table below).

	Alternative 1: Measurement of fuel consumption data using total data (if available e.g. from bus or taxi companies) or a representative sample for the respective category and fuel type. Sampling per category and fuel should include, as core characteristics, vehicle age and motorization to ensure that the sample is as close as possible to the actual vehicle composition in the urban area(s) of the region for which the baseline is established. Vehicle age and technology (related often to emission standards such as Euro standards) are factors which influence, to a significant extent, the fuel consumption. To be conservative, specific fuel consumptions based on samples shall be based on the lower limit of the uncertainty band at a 95 per cent confidence level. **Alternative 2:** Use of fixed values based on national or international literature. The literature data can either be based on measurements of similar vehicles in comparable surroundings (e.g. from comparable cities of other countries) or may include identifying the vehicle age and technology of average vehicles circulating in the urban area(s) of the region for which the baseline is established and then matching this with the most appropriate IPCC default values. The most important proxy to identify vehicle technologies is the average age of vehicles used in the urban area(s) of the region for which the baseline is established, to determine whether either US, Japanese or European default factors apply or local vehicle	**Table 1 Specific fuel consumption for vehicle category** **Specific fuel consumption** / **Value** / **Unit** Gasoline car (personal car and taxi) / 6 / l/100 km Diesel car (personal car and taxi)) / 5 / l/100 km Motorcycle / 2 / l/100 km

<table>
<tr><td></td><td>manufacturer information can be used (in the case of having a substantial domestic vehicle motor industry or source of origin of vehicle imports).

Alternative 3: latest IPCC default values reported matching the respective vehicle category, age, vehicle origin and technology.

Alternative 4. Design data for relevant vehicle categories.

Alternative 5. Globally applicable default values (See table below).

Table 1 Specific fuel consumption for vehicle category
<table><tr><th>Specific fuel consumption</th><th>Value</th><th>Unit</th></tr><tr><td>Gasoline car (personal car and taxi)</td><td>6</td><td>l/100 km</td></tr><tr><td>Diesel car (personal car and taxi))</td><td>5</td><td>l/100 km</td></tr><tr><td>Motorcycle</td><td>2</td><td>l/100 km</td></tr></table></td><td></td></tr>
<tr><td>Any comment:</td><td></td><td></td></tr>
</table>

Data / Parameter table 2

Data / Parameter:	$\mathbf{N_{i,x}}$	$\mathbf{N_{i,x}}$
Data unit:	VKM or units	VKM or units

Description:	Number of vehicle-kilometers of category *i* driven in year *x* or number of vehicles of category *i* in year *x*	Number of vehicle-kilometers of category *i* driven in year *x* or number of vehicles of category *i* in year *x*
Source of data:	Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used	National Data Or Survey conducted by MRV officer(s) under LRT operation
Measurement procedures (if any):	-	For this option data should be monitored at least annually.
Any comment:	Used for all vehicle categories identified as relevant. In the cases of buses and taxis, informal or illegal units may operate. While estimates on the number of informal units may be available, these are by nature not trustworthy. For both categories it is thus recommended to only include formally registered units. For consistency, it is important that transported passengers are also based on the official records thus not including passenger trips on informal transport. For electrical vehicles fuel type *n* represents electricity	

Data / Parameter table 3

Data / Parameter:	$\mathbf{N_{i,n,x}}$	$\mathbf{N_{i,n,x}}$
Data unit:	VKM or units	VKM or units

Description:	Number of vehicle-kilometres vehicle category *i* using fuel type *n* driven in year *x* or number of vehicles in vehicle category *i* using fuel type *n* in year *x*	Number of vehicle-kilometres vehicle category *i* using fuel type *n* driven in year *x* or number of vehicles in vehicle category *i* using fuel type *n* in year *x*
Source of data:	Municipal transit authorities based on vehicle registration statistics from the respective city or data from vehicle control stations (technical and emission control stations). If no city/municipal data is available, regional data (canton, state) or, as a last option, national data can be used	National Data Or Survey conducted by MRV officer(s) under LRT operation
Measurement procedures (if any):	-	this option data should be monitored at least annually.
Any comment:	Used for all vehicle categories identified as relevant vehicle categories. In the cases of buses and taxis, informal or illegal units may operate. While estimates on the number of informal units may be available, these are by their nature not trustworthy. For both categories it is thus recommended to only include formally registered units. For consistency, it is important that transported passengers are also based on the official records thus not including passenger trips of informal units. For electrical vehicles fuel type *n* represents electricity	

Data / Parameter table 4

Data / Parameter:	**$NCV_{i,n}$**	**$NCV_{i,n}$**

<table>
<tr><td>Data unit:</td><td>Energy/mass or volume units of fuel type n</td><td>Energy/mass or volume units of fuel type n</td></tr>
<tr><td>Description:</td><td>Net calorific value of fuel n used in vehicle category i</td><td>Net calorific value of fuel n used in vehicle category i</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:

Table 3. Data sources and conditions for their usage

<table><tr><th>Data source</th><th>Conditions for using the data source</th></tr><tr><td>(a) National default values</td><td>This source can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)</td></tr><tr><td>(b) IPCC default values at the lower limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td></td></tr></table></td><td>IPCC default values at the lower limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td></tr>
</table>

Measurement procedures (if any):	-	

Monitoring frequency:	For (a): review the appropriateness of the values annually.
	
	For (b): any future revision of the IPCC Guidelines should be taken into account
		(b): any future revision of the IPCC Guidelines should be taken into account

QA/QC procedures:	Verify whether the values under (a) and (b) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a) should have ISO17025 accreditation or demonstrate that they can comply with similar quality standards	
Any comment:	Vehicle owners or operators can buy fuel from a variety of sources (fuel stations). Therefore, in practice it is considered to be simpler to determine the parameter using options (a) or (b)	

Data / Parameter table 5

Data / Parameter:	**IR_i**	**IR_i**
Data unit:	-	-
Description:	Technology improvement factor for vehicle category *i* per year	Technology improvement factor for vehicle category *i* per year

Source of data:	-	
Measurement procedures (if any):	When the tool is used for estimating baseline emissions for individual CDM project activities or Programmes of Activities, the default technology improvement factor is 0.99 for all vehicle categories; When the tool is used for estimating emission for standardized baselines, the technology improvement factor is 1 for the first validity period of standardized baseline. However for subsequent years improvement factor shall be calculated based on historical trend of at least three years	The default technology improvement factor is 0.99 for all vehicle categories;
Any comment:	According to current requirements, standardized baselines need to be updated after its validity expires. The validity of standardized baseline is based on criteria established in the latest approved standard for coverage of data and validity of standardized baseline. For the application during the validity period of standardized baseline from the second version of the standardized baseline, technology improvement factor shall be calculated based on historical trend (minimum three years) of country specific data and used in calculations instead of the technology improvement factor of 1	

Data / Parameter table 6

Data / Parameter:	**$OC_{i,x}$ or $OC_{B,x}/OC_{T,x}/OC_{C,x}/OC_{MR,x}$**	**$OC_{i,x}$ or $OC_{B,x}/OC_{T,x}/OC_{C,x}/OC_{MR,x}$**
Data unit:	Passengers	Passengers

<table>
<tr><td>Description:</td><td>Average occupancy rate of vehicle category i in year x (e.g.,buses (B), taxis (T), passenger cars (C), motorized rickshaws (MR)</td><td>Average occupancy rate of vehicle category i in year x (e.g.,buses (B), taxis (T), passenger cars (C), motorized rickshaws (MR)</td></tr>
<tr><td>Source of data:</td><td>Option 1.Municipal transit authorities or specific studies. Vintage maximum three years.

Option 2. The following default values can be applied:

Table 4. Average occupancy as per vehicle type

<table>
<tr><td></td><td colspan="2">Average occupancy</td><td></td></tr>
<tr><td></td><td>World</td><td>South Asia</td><td>Unit</td></tr>
<tr><td>Car</td><td colspan="2">2</td><td>Person (including the driver)</td></tr>
<tr><td>Taxi</td><td colspan="2">1.1</td><td>Person (excluding the driver)</td></tr>
<tr><td>Motorcycle</td><td colspan="2">1.5</td><td>Person (including the driver)</td></tr>
<tr><td>Bus</td><td>40%</td><td>80%</td><td>Total capacity</td></tr>
</table>

Option 3.

Survey of occupancy of individual motorized transport (motorcycles, personal cars, taxis) in the urban area</td><td>1. Measure by O & M Company through

2. Default values are available in the CDM methodological tool 18. (National values are not available)</td></tr>
</table>

	for which the baseline is established. The obtained occupancy rates can be used as default values for these vehicle categories at a country level, as variation in occupancy rates of individual motorized transport used in the urban context is relatively low. Survey of occupancy rates of public transport (bus, light rail, tram, metro, BRTs, etc.) in the urban area for which the standardized baseline is established. If standardized baselines for multiple cities in a country are established, these cities need to be grouped in categories of similar cities (based on population size, population density, etc.) and surveys on occupancy rates of public transport of sample cities need to be conducted. If there is no big variation in occupancy rates of the same mode in the cities of the same category, then surveyed occupancy rates of public transport can be used as defaults for the rest of the cities in the same category	
Measurement procedures (if any):	Based on visual occupation studies for all vehicle categories. For buses the occupation rate is based on boarding-alighting studies, electronic smart tickets or on visual occupation studies with expansion factors for routes served to determine the average occupation rate along the entire route. As an alternative for buses, the occupancy rate can be based on average trip distance of bus passengers, total passengers and total distance driven by buses.	For the JICA LRT project, data available in the "Preparatory Survey on the Project for Establishment of New Light Rail Transit System in Colombo 2018"

	For taxis (including motorized rickshaws), the driver should not be counted	
Any comment:	-	

Data / Parameter table 7

Data / Parameter:	**$EF_{CO2,n}$**	**$EF_{CO2,n}$**
Data unit:	g CO2/J	g CO2/J
Description:	Emission factor for fuel type n	Emission factor for fuel type n
Source of data:	The following data sources may be used, if the relevant conditions apply: **Table 5. Data sources and conditions for their usage** **Data source** / **Conditions for using the data** (a) National default values — This source can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances) (b) IPCC default values at the lower limit of the uncertainty at a 95	IPCC default values at the lower limit of the uncertainty at a 95 per cent confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories

	per cent confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories		
	Note: In case biofuels or biofuel blends are used, the CO*2* emission factor for the share of biofuels used as pure or in blends is equal to zero		
Measurement procedures (if any):	-		
Monitoring frequency:	For (a): review the appropriateness of the values annually. For (b): Latest available IPCC Guidelines should be taken into account	Latest available IPCC Guidelines should be taken into account	
QA/QC procedures:	-		
Any comment:	-		

Data and parameters monitored

Data / Parameter table 8

Data / Parameter	P_y
Unit	Passengers
Description	Total passengers transported by the project LRT per year

Source of data	MRV officer(s) under LRT operation
Measurement methods and procedures	The system for determining passenger numbers has not yet been defined.
Monitoring frequency	Continuously, aggregated at least annually
QA/QC procedures	Checked with ticket sales (average fare and income from ticket)
Purpose of data	Calculation of baseline and project emissions
Additional comment	

Data / Parameter table 9

Data / Parameter	P_{SPER}
Unit	Passengers
Description	Number of passengers in the time period of the survey (1 week)
Source of data	Survey conducted by MRV officer(s) under LRT operation
Measurement methods and procedures	Survey
Monitoring frequency	at least annually
QA/QC procedures	See Annex xxx for the survey design
Purpose of data	Calculation of baseline emission
Additional comment	

Data / Parameter table 10

Data / Parameter	n_{ihps} , N_{ihps}
Unit	Passengers
Description	Number of passengers selected in the station *sp*, in stratum *h*

	Total number of passengers in the station *sp*, in stratum *h*
Source of data	Survey conducted by MRV officer(s) under LRT operation
Measurement methods and procedures	Survey
Monitoring frequency	at least annually
QA/QC procedures	See Annex xxx for the survey design
Purpose of data	Calculation of baseline emission
Additional comment	

Parameters necessary for direct project emissions

Data and parameters monitored

Data / Parameter table 11

Data / parameter:	**$EF_{grid,CM,y}$**	**$EF_{grid,CM,y}$**
Data unit:	tCO_2/MWh	tCO_2/MWh
Description:	Combined margin emission factor for the grid in year *y*	Combined margin emission factor for the grid in year *y*
Source of data:	Calculate the combined margin emission factor, using the procedures in the latest approved version of the .Tool to calculate the emission factor for an electricity system.	Sri Lanka Energy Balance by Sri Lanka Sustainable Energy Authority
Measurement procedures (if any):	As per the .Tool to calculate the emission factor for an electricity system.	Tool to calculate the emission factor for an electricity system.
Monitoring frequency:	As per the .Tool to calculate the emission factor for an electricity system.	Latest available grid emission factor should be taken into account (Annually need to check for the value)
QA/QC procedures:	As per the .Tool to calculate the emission factor for an electricity system.	
Any comment:	Only applicable to scenarios A and C (cases C.I and C.III)	

Data / Parameter table 12

Data / parameter:	**$TDL_{j,y}$ and $TDL_{k,y}$ and $TDL_{l,y}$**	**$TDL_{j,y}$**
Data unit:	-	
Description:	Average technical transmission and distribution losses for providing electricity to source *j*, *k* or *l* in year *y*	Average technical transmission and distribution losses for providing electricity to source *j* in year *y*

Source of data:	In case of scenario B and scenario C, case C.II, assume $TDL_{j/k/l,y} = 0$ as a simplification. In case of other scenarios (scenario A and scenario C, cases C.I and C.III), choose one of the following options: • Use recent, accurate and reliable data available within the host country; • Use as default values of 20% for (a) project or leakage electricity consumption sources; (b) baseline electricity consumption sources if the electricity consumption by all project and leakage electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies is larger than the electricity consumption of all baseline electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies. • Use as default values of 3% for (a) baseline electricity consumption sources; (b) project and leakage electricity consumption sources if the electricity consumption by all project and leakage electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies is smaller than the electricity consumption of all baseline electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies.	Sri Lanka Energy Balance by Sri Lanka Sustainable Energy Authority
Measurement procedures (if any):	For a): $TDL_{j/k/l,y}$ should be estimated for the distribution and transmission networks of the electricity grid of the same voltage as the connection where the proposed CDM project activity is connected to. The technical	The distribution losses can either be calculated by the project participants or be based on references from utilities, network operators or other official documentation.

	distribution losses should not contain other types of grid losses (e.g. commercial losses/theft). The distribution losses can either be calculated by the project participants or be based on references from utilities, network operators or other official documentation.	
Monitoring frequency:	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.	Annually. In the absence of data from the relevant year, most recent figures should be used,
QA/QC procedures:		
Any comment:		

Data / Parameter table 13

Data / Parameter:	**$EC_{PJ,y}$**
Data unit:	MWh
Description:	Quantity of electricity consumed by the project LRT per year
Source of data:	LRT operator(s) in transaction substation
Measurement procedures (if any):	Based on electronic meters and electric bills
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	Control with electricity invoices. Data is controlled with train-km and estimated energy consumption per train-km
Any comment:	Used to calculate together with the emission factor grid the DPE as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption".

2 MONITORING, REPORTING & VERIFICATION PROTOCOL -Railway Electrification

(NDC 5.1)

OVERVIEW

This protocol serves as an overview of the monitoring process, a qualitative assessment of the monitored parameters, the organizational structure, the primary responsibilities of the personnel involved in monitoring and QA/QC process.

2.1 Introduction

Mitigation Action - The proposed mitigation action involves the electrification of Veyangoda to Panadura railway line with 64 km which covers both main line and coastal line. Currently around 44 million passengers are carried by the existing diesel powered railway system annually. After improving the railway system, this number of passengers will use electric train.

2.2 Monitoring plan

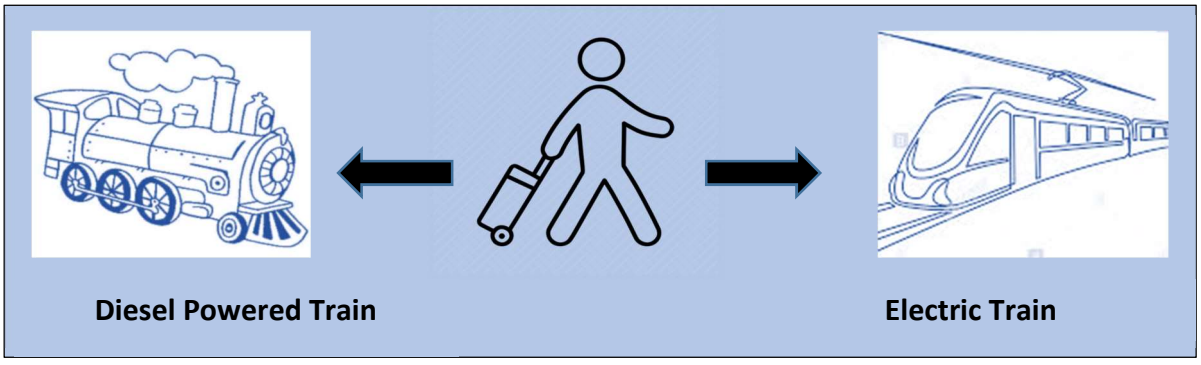

Figure 2.2-1 Monitoring plan

P2 and P3 Procedures will be applied to monitor and report the relevant parameters.

2.3 Monitoring methodology

Relevant methodology and equation

Baseline emission

$$BE_y = FC_{BL,i,y} * NCV_i * EF_{fuel,i}$$

Project emission

$$PE_y = EC_{pJ,y} * EF_{elec}$$

Table 2.3-1 Parameter description table

Parameter	Description	Unit
$FC_{BL,i,y}$	Consumption of fuel i associated with the operation of the existing railway in year y	t/year
$EF_{fuel,i}$	CO_2 emission factor of fuel i	t-CO_2/TJ
NCV_i	Net calorific value of fuel i	TJ/t
$EC_{PJ,y}$	Electricity consumption associated with the operation of the project activity in year y	MWh/year
EF_{elec}	CO_2 emission factor of the grid electricity	t-CO_2/MWh

2.3.1 Ex-ante parameters (fixed values)

- CO_2 emission factor of fuel i
- Net calorific value of fuel i
- CO_2 emission factor of the grid electricity

2.3.2 Ex-post parameters (regularly monitored values)

- Consumption of fuel i associated with the operation of the existing passenger railway
- Electricity consumption associated with the operation of the electrified train

2.3.3 Parameters to verified/collected one time prior to the monitoring period

The MRV focal point at the SLR and MRV officer at Transport NDC unit shall verify the above fixed values and regularly monitored values.

2.4 Parameter and procedure

Table 2.4-1 Parameter and procedure description table

Parameter	Description	Instrument /method	Applied for (baseline, project, leakage)	Procedure
$FC_{BL,i,y}$	Consumption of fuel i associated with the operation of the existing railway in year y	Annex 01	Baseline	P1_ER_SLR
$EF_{fuel,i}$	CO_2 emission factor of fuel i	Annex 02	Baseline	P2_ER_SLSEA
NCV_i	Net calorific value of fuel i	Annex 02	Baseline	P2_ER_SLSEA
$EC_{PJ,y}$	Electricity consumption associated with the operation of the project activity in year y	Annex 01	Project	P1_ER_SLR
EF_{elec}	CO_2 emission factor of the grid electricity	Annex 02	Project	P2_ER_SLSEA

2.5 Organization structure and MRV specific responsibilities

Table 2.5-1 Organization structure and MRV specific responsibilities

Tasks	Responsible staff	Procedure	Comment
Recording and reporting of Fuel consumption	MRV Focal point at SLR	P1_ER_SLR	
Recording and reporting of electricity consumption	MRV Focal point at SLR	P1_ER_SLR	
Recording the fixed value of parameter	MRV officer at Transport NDC unit	P2_ER_SLSEA	Go through relevant website

2.6 Proposed Data Management System

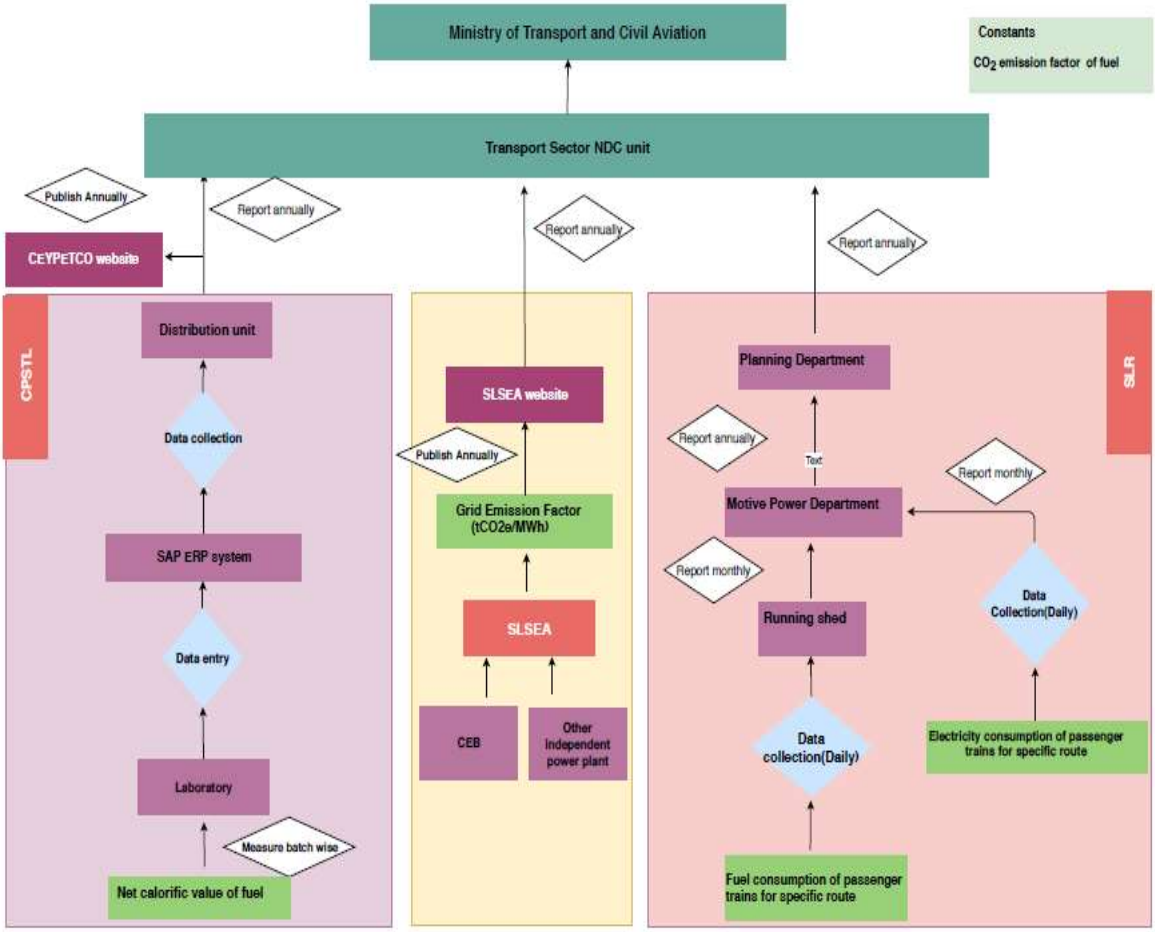

Figure 2.6-1 Proposed Data Management System for NDC 5.1

2.7 Annex

2.7.1 Annex 01: Sri Lanka Railway

Data / Parameter:	$FC_{BL,i,x}$	$FC_{BL,i,x}$
Data unit:	liter or m^3	liter
Description:	Amount of fuel *i* consumed by the existing diesel powered railway in year *y*	Amount of fuel i consumed by the existing diesel powered railway in year y
Source of data:	Historical data from the project participants	Historical data from SLR
Measurement procedures (if any):	-	Purchase receipt of the fuel
Monitoring Frequency:	Daily, summed for a year	Annually
QA/QC procedures:		
Any comment:	-	Currently this data is not available. Therefore value was calculated based on specific fuel consumption of diesel power power set, trip distance per annum.

Data / Parameter:	$EC_{PJ,y}$	$EC_{PJ,y}$
Data unit:	MWh	MWh
Description:	Amount of electricity consumed by the electrified railway in year *y*	Amount of electricity consumed by the electrified railway in year y
Source of data:	Actual data from the project participants	A planned value
Monitoring Frequency:	Daily, summed for a year	Annually
QA/QC procedures:		
Measurement procedures (if any):	-	A monitored value of Electric meter
Any comment:	-	Currently this data is not available. Therefore value was calculated based on specific electricity consumption and annual total trip distance

2.7.2 Annex 02 – CPSTL, SLSEA and IPCC

Data / Parameter:	$EF_{fuel,i}$	$EF_{fuel,i}$
Data unit:	t CO_2/ TJ	t CO_2/ TJ
Description:	CO_2 emission factor of fuel *i*	
Source of data:	The following data sources may be used : a) Values provided by the fuel supplier in invoices b) Measurements by the project participant c) Regional or national default values d) IPCC default value	IPCC default value
Measurement procedures (if any):	Measurements should be undertaken in line with national or international fuel standards	
Any comment:	If the fuel supplier provides the CO_2 emission factor on the invoice and the value is based on measurements for this	

Data / Parameter:	NCV_i	NCV_i
Data unit:	TJ/t	TJ/t
Description:	Average net calorific value of fuel *i*	
Source of data:	The following data sources may be used : a. Values provided by the fuel supplier in invoices b. Measurements by the project participant c. Regional or national default values d. IPCC default value	National default value provided by CPSTL
Measurement procedures (if any):	For a) and b): Measurements should be undertaken in line with national or international fuel standards	
Any comment:	QA/QC procedures: Verify that the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values out of this range, collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards	

Data / Parameter:	EF_{elec}	EF_{elec}
Data unit:	t CO_2/ MWh	t CO_2/ MWh
Description:	CO_2 emission factor for Grid connected electricity	
Source of data:	The following data sources may be used : a) Values provided by the fuel supplier in invoices b) Measurements by the project participant c) Regional or national default values d) IPCC default value	Country specific grid emission factor published in SLSEA
Measurement procedures (if any):	Measurements should be undertaken in line with national or international fuel standards	
Any comment:	If the fuel supplier provides the CO_2 emission factor on the invoice and the value is based on measurements for this specific fuel, this CO_2 factor should be used.	

3 MONITORING, REPORTING & VERIFICATION PROTOCOL – Purchasing new rolling stocks

(NDC-5.2)

OVERVIEW

This protocol serves as an overview of the monitoring process, a qualitative assessment of the monitored parameters, the organizational structure, the primary responsibilities of the personnel involved in monitoring and QA/QC process.

3.1 Introduction

Mitigation Action - The proposed mitigation action is to purchase **six power sets** for Sri Lanka Railway to improve the public transportation. Currently around seventy- seven power set are operated under Sri Lanka Railway.

3.2 Monitoring plan

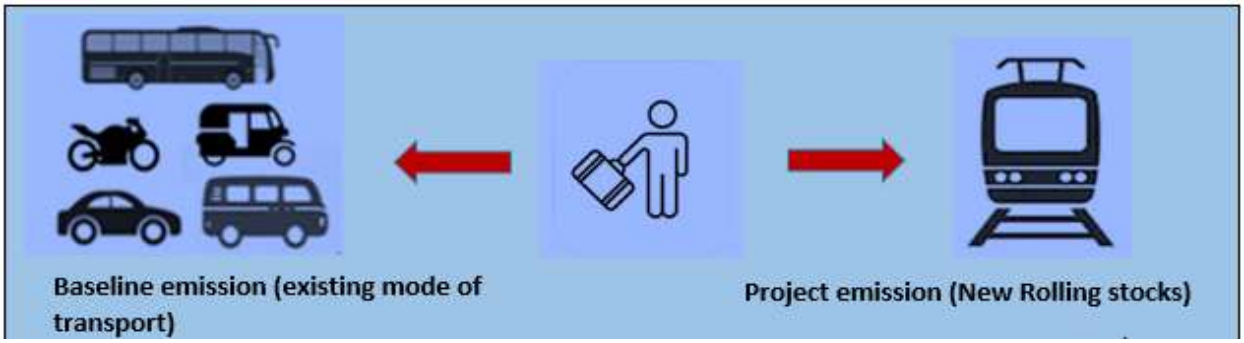

Figure 3.2-1 Monitoring plan

P5_PNRS_SLR and P4_PNRS_NTC Procedures are applied to monitor and report the relevant parameters.

3.3 Monitoring methodology

Relevant methodology and equation

Project Emission

$$PE_y = FC_{PJ,y} * NCV_i * EF_{fuel,i}$$

Baseline Emission

$$BE_y = (P_y * BTDP_y * MS_{i,y} * EF_{PKM,i})$$

Table 3.3-1 parameter description table

Parameter	Description	Unit
P_y	Number of passengers transported by the project in year y	Passenger/ year
$BTDP_y$	Average trip distance of the passenger of the project activity in year y	km
$MS_{i,y}$	Share of passengers by transport mode i in the baseline scenario in year y	%
$EF_{PKM,i}$	CO_2 emission factor per passenger kilometer for transport mode i	t-CO_2/ passenger-km
$FC_{PJ,i,y}$	Consumption of fuel i associated with the operation of the project activity in year y	t / year
NCV_i	Net calorific value (NCV) of fuel i	TJ/t
$EF_{fuel,i}$	CO_2 emission factor of fuel i	t-CO_2/TJ

3.3.1 Ex-ante parameters (fixed values)

- CO_2 emission factor of fuel i
- CO_2 emission factor per passenger kilometer for transport mode i

3.3.2 Ex-post parameters (regularly monitored values)

- Consumption of fuel i associated with the operation of the project activity in year y
- Share of passengers by transport mode i in the baseline scenario in year y
- Number of passengers transported by the project in year y
- Average trip distance of the passenger of the project activity in year y
- Net calorific value of fuel i

3.3.3 Parameters to verified/collected one time prior to the monitoring period

The MRV focal point at the SLR, NTC, CPSTL and MRV officer at Transport NDC unit shall verify the above fixed values and regularly monitored values.

3.4 Parameter and procedure

Table 3.4-1 Parameter and procedure table

Parameter	Description	Instrument/ method	Applied for (baseline, project, leakage)	Procedure
$\mathbf{P_y}$	Number of passengers transported by the project in year y	Annex 01	Baseline	P1_PNRS_SLR
$\mathbf{BTDP_y}$	Average trip distance of the passenger of the project activity in year y	Annex 01	Baseline	P1_PNRS_SLR
$\mathbf{MS_{i,y}}$	Share of passengers by transport mode i in the baseline scenario in year y	Annex 02	Baseline	P2_PNRS_NTC
$\mathbf{EF_{PKM,i}}$	CO_2 emission factor per passenger kilometer for transport mode i		Baseline	
$\mathbf{FC_{PJ,i,y}}$	Consumption of fuel i associated with the operation of the project activity in year y	Annex 01	Project	P1_PNRS_SLR
$\mathbf{NCV_i}$	Net calorific value of fuel i		Project	P1_FSRR_CPSTL
$\mathbf{EF_{fuel,i}}$	CO_2 emission factor of fuel i		Project	

3.5 Organization structure and MRV specific responsibilities

Table 3.5-1 Organization structure and MRV specific responsibilities

Tasks	Responsible staff	Procedure	Comment
Recording and reporting of Fuel consumption, passenger volume and trip distance related data	MRV Focal point at SLR	P1_PNRS_SLR	
Recording and reporting of share of passengers by each transport mode	MRV Focal point at NTC	P2_PNRS_NTC	
Recording and reporting of NCV value	MRV Focal point at CPSTL	P1_FSRR_CPSTL	
Recording and reporting fixed value	MRV officer at Transport NDC unit		Go through relevant website, guidelines and standard

3.6 Proposed Data Management System

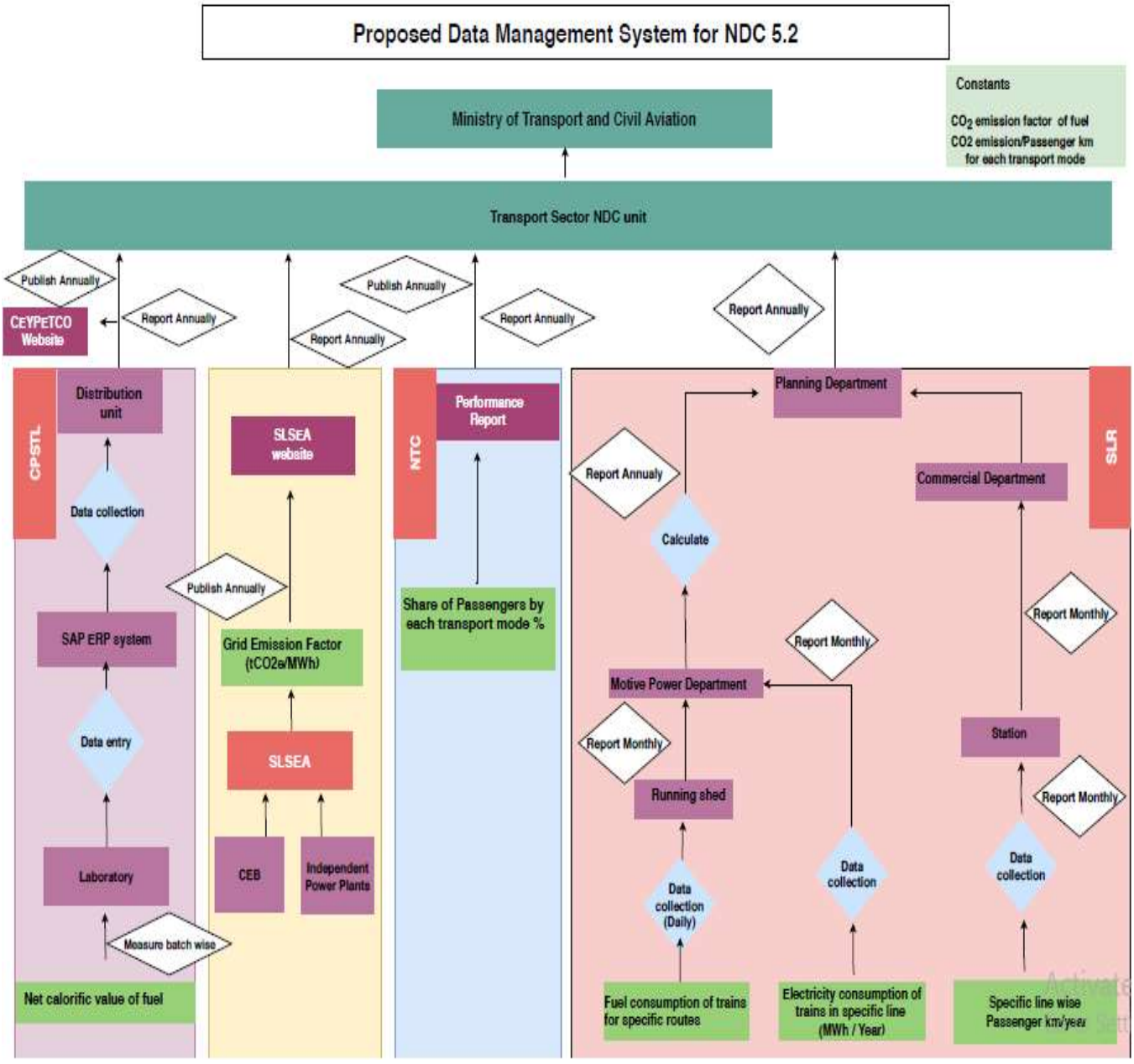

Figure 3.6-1 Proposed Data Management System

3.7 Annex

3.7.1 Annex 01: Sri Lanka Railway

Data / Parameter:	**$FC_{PJ,i,y}$**	**$FC_{PJ,i,y}$**
Data unit:	t / year	t / year
Description:	Consumption of fuel i associated with the operation of the project activity in year y	Amount of fuel i consumed by the existing diesel powered railway in year y
Source of data:	Data from the project participants	Historical data from SLR
Measurement procedures (if any):	-	Purchase receipt of the fuel
Monitoring Frequency:	Daily, summed for a year	Annually
QA/QC procedures:		
Any comment:	-	Currently this data is not available. Therefore value was calculated based on specific fuel consumption of diesel power power set, trip distance per annum.

Data / Parameter:	**P_y**	**P_y**
Data unit:	Passenger/ year	Passenger/ year
Description:	Number of passengers transported by the project in year y	Number of passengers transported by the project in year y
Source of data:	Actual data from the project participants	A planned value
Monitoring Frequency:	Daily, summed for a year	Annually
QA/QC procedures:		
Measurement procedures (if any):	-	
Any comment:	-	Currently this data is not available. Therefore value was calculated based on Average number of passengers transported by carriage

Data / Parameter:	$BTDP_y$	$BTDP_y$
Data unit:	Km/ year	t CO_2/ TJ
Description:	Average trip distance of the passenger of the project activity in year y	
Source of data:	Actual data from the project participants	A planned value
Monitoring Frequency:	Daily, summed for a year	Annually
QA/QC procedures:		
Measurement procedures (if any):		
Any comment:		Currently this data is not available. Therefore calculation was carried out by considering total length covered by Sri Lanka Railway and total number of carriages

3.7.2 Annex 02: NTC

Data / Parameter:	$MS_{i,y}$	$MS_{i,y}$
Data unit:	Km/ year	Km/ year
Description:	Share of passengers by transport mode i in the baseline scenario in year y	
Source of data:	Actual data from the project participants	"Transport statistics" published by National Transport Commission.
Monitoring Frequency:	Daily, summed for a year	Annually
QA/QC procedures:		
Measurement procedures (if any):		
Any comment:		

4 MONITORING, REPORTING & VERIFICATION PROTOCOL- INTRODUCTION OF ELECTRIC BUSES (NDC 8.3)

OVERVIEW

This protocol serves as an overview of the monitoring process, a qualitative assessment of the monitored parameters, the organizational structure, the primary responsibilities of the personnel involved in monitoring and QA/QC process.

4.1 Introduction

Mitigation option: Introducing electric buses

4.2 Monitoring plan

Conventional diesel buses

Number of seats:

Specific fuel consumption: 0.29 L/km

Emission factor: 765.93 gCO_2/km

Fuel Cost per km: 21.13

Electric buses

Number of seats: Up to 41+1

Specific electricity consumption: 1.22 kWh/km

Emission factor: 767.03 gCO_2/km

Fuel Cost per km:

Figure 4.2-1 Monitoring plan

4.3 Monitoring methodology

Methodology /Tools

Small scale methodology, AMS III.C; emission reductions by electric and hybrid vehicles

Tool to calculate project or leakage CO2 emissions from fossil fuel combustion

Equations

Equation 01
Baseline Emission

$$BE_y = \sum_i EF_{BL,km,i} \times DD_{i,y} \times N_{i,y} \times 10^{-6}$$

Equation 02
Baseline emission

$$EF_{BL,km,i} = SFC_i \times NCV_{BL,i} \times EF_{BL,i} \times IR^t$$

OR

$$BE_y = \sum_i EF_{BL,km,i} \times \frac{EC_{PJ,i,y}}{SEC_{PJ,km,i,y}} \times 10^{-6}$$

Equation 03
Project emission

$$PE_y = \sum_i EF_{PJ,km,i,y} \times DD_{i,y} \times$$

OR

$$PE_y = \sum_i EF_{PJ,km,i,y} \times \frac{EC_{PJ,i,y}}{SEC_{PJ,km,i,y}}$$

Equation 04
Emission factor for project vehicle

$$EF_{PJ,km,i,y} = \sum_i SEC_{PJ,km,i,y} \times EF_{elect,y}/(1 - TDL_y) \times 10^{-3} + \sum_i SFC_{PJ,km,i,y} \times NCV_{PJ,i} \times EF_{PJ,i} \times 10^{-6}$$

Equation 05
Emission reduction

$$ER_y = BE_y - PE_y - LE_y$$

Parameters

Table 4.3-1 parameter table

Data requirement	
Annual average distance travelled by project vehicle category *i* in the year *y* (km)	$DD_{i,y}$
Number of operational project vehicles in category *i* in year *y*	$N_{i,y}$
Specific fuel consumption of baseline vehicle category *i* (g/km)	SFC_i
Specific electricity consumption by project vehicle category *i* per km in year *y* in urban conditions (kWh/km)	$SEC_{PJ,km,i,y}$
Technology improvement factor for baseline vehicle in year *t*	IR^t
Emission factor of fossil fuel consumed by baseline vehicle category *i* (g CO_2/J)	$EF_{BL,i}$
Net calorific value of fossil fuel consumed by baseline vehicle category *I* (J/g)	$NCV_{BL,i}$
CO_2 emission factor of electricity consumed by project vehicle category *i* in year *y* (kg CO_2/kWh)	$EF_{elect,y}$
Average technical transmission and distribution losses for providing electricity in the year *y*	TDL_y
The electricity consumed for charging project vehicles category i at the charging stations/points in year y (kWh)	$EC_{PJ,i,y}$
Emission factor for baseline vehicle category i (g CO2/km)	$EF_{BL,km,i}$
Emission factor per kilometer travelled by the project vehicle type *i* (t CO_2/km)	$EF_{PJ,km,i,y}$

4.4 Parameter and procedure

Table 4.4-1 Parameter and procedure

Parameter	Description	Instrument	Applied for (Baseline/Project)	Procedure (P1,P2)
SFC_i	Specific fuel consumption of baseline vehicle category *i* (g/km)	Calculate	Baseline	P1
IR^t	Technology improvement factor for baseline vehicle in year *t*	Default	Baseline	Methodology
$EF_{BL,i}$	Emission factor of fossil fuel consumed by baseline vehicle category *i* (g CO_2/J)	Default	Baseline	IPCC

$NCV_{BL,i}$	Net calorific value of fossil fuel consumed by baseline vehicle category *I* (J/g)	Calculate	Baseline	P1_FSRR_CPSTL
$EF_{BL,km,i}$	Emission factor for baseline vehicle category i (g CO2/km)	Calculate	Baseline	NDC unit
$EF_{elect,y}$	CO_2 emission factor of electricity consumed by project vehicle category *i* in year *y* (kg CO_2/kWh)	Calculate	Project	P2_ER_SLSEA
TDL_y	Average technical transmission and distribution losses for providing electricity in the year *y*	Calculate	Project	P2_ER_SLSEA
$EF_{PJ,km,i,y}$	Emission factor per kilometer travelled by the project vehicle type *i* (t CO_2/km)	Calculate	Project	NDC unit
$DD_{i,y}$	Annual average distance travelled by project vehicle category *i* in the year *y* (km)	Calculate	Baseline & Project	P1_IEV_SLTB
$N_{i,y}$	Number of operational project vehicles in category *i* in year *y*	Measure	Baseline & Project	P1_IEV_SLTB
$EC_{PJ,i,y}$	The electricity consumed for charging project vehicles category i at the charging stations/points in year y (kWh)	Measure	Baseline & Project	P1_IEV_SLTB
$SEC_{PJ,km,i,y}$	Specific electricity consumption by project vehicle category *i* per km in year *y* in urban conditions (kWh/km)	Calculate	Baseline & Project	P1_IEV_SLTB

4.5 Organization structure and MRV specific responsibilities

Table 4.5-1 Organization structure and MRV specific responsibilities

Tasks	Responsible staff			Procedure	Comment
	Measure	**Report**	**Verify**		
Sri Lanka Transport Board (SLTB)					
Number of e-buses	Head of depot	Planning division	MRV manager	P1_IEV_SLTB	
Total distance travelled by e-buses	Head of depot	Planning division	MRV manager	P1_IEV_SLTB	
Number of diesel buses	Head of depot	Planning division	MRV manager	P1_IEV_SLTB	
Total distance travelled by diesel buses	Head of depot	Planning division	MRV manager	P1_IEV_SLTB	
Total electricity consumption of e-buses	Head of depot	Planning division	MRV manager	P1_IEV_SLTB	
Total fuel consumption of buses	Head of depot	Planning division	MRV manager	P1_IEV_SLTB	
Ceylon Petroleum Storage Terminals Limited (CPSTL)					
Net calorific value of fossil fuel consumed by baseline vehicle category I ($NCV_{BL,i}$)	Head Laboratory	Head of the information & technology unit	MRV manager	P1_FSRR_CPSTL	
Density of fuel consumed by baseline vehicle category I	Head Laboratory	Head of the information & technology unit	MRV manager	P1_FSRR_CPSTL	
Sri Lanka Sustainable Energy Authority (SLSEA)					
CO_2 emission factor of electricity consumed by project vehicle category i in year y ($EF_{elect,y}$)			MRV manager		
Average technical transmission and distribution losses for providing electricity in the year y (TDL_y)			MRV manager		

4.6 Proposed data management

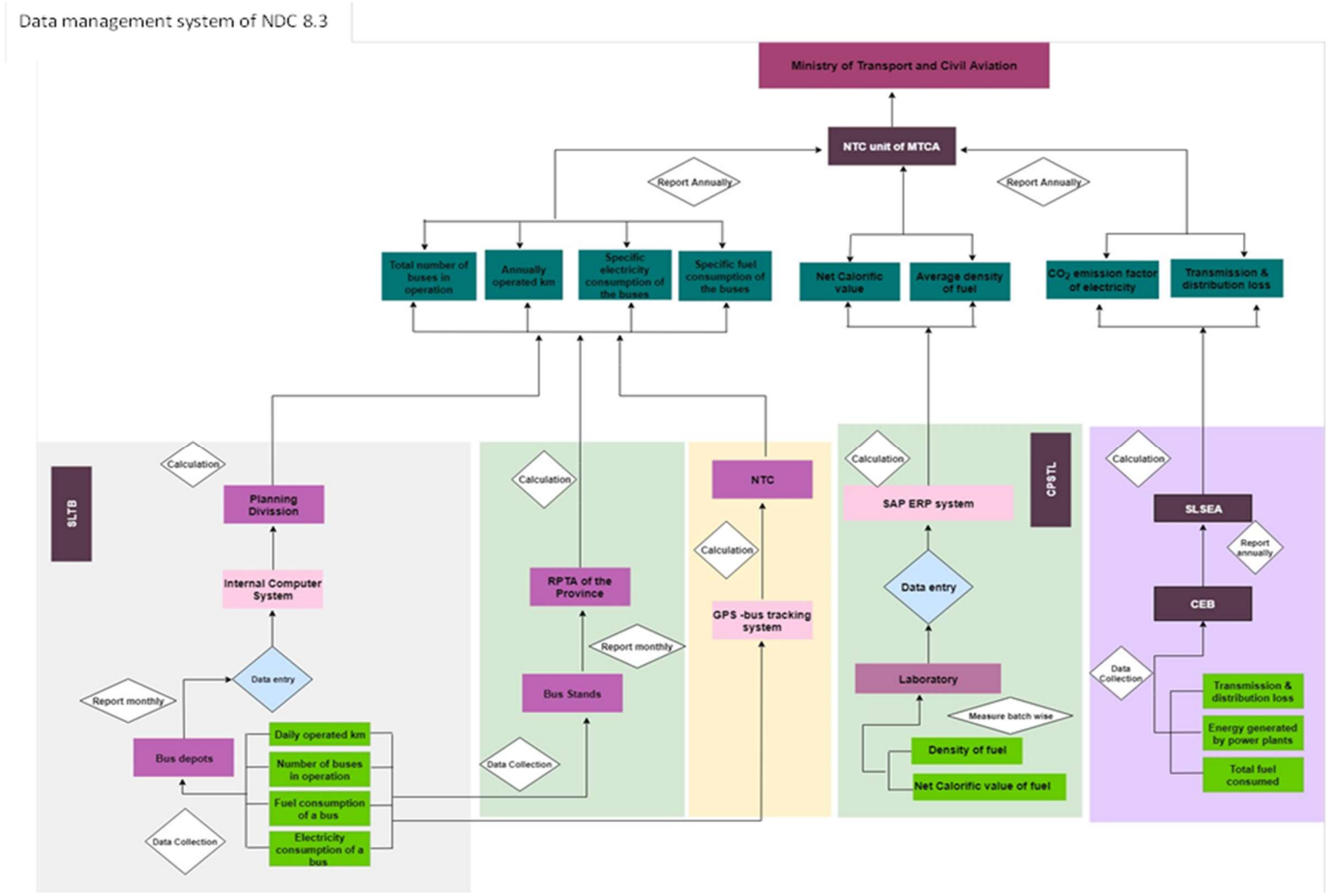

Figure 4.6-1 Proposed data management

Data required from SLTB

Data / Parameter:	$DD_{i,y}$
Data unit:	*km*
Description:	*Annual average distance driven by project vehicle* i *in year* y *(km/yr)*
Source of data:	*Measurement*
Measurement procedures (if any):	*Measure the annual average distance driven by the project vehicles through:* *Option (A): monitoring of all vehicles* *or* *Option (B): representative sample survey of vehicles for each vehicle category. Sample vehicles shall be chosen in accordance with the latest version of the "Guidelines for sampling and surveys for CDM project activities and programme of activities" using a 90 per cent confidence interval and +/- 10 per cent precision to determine the sample size. The lower bound of 95 per cent confidence interval shall be used as the annual distance travelled*
Any comment:	-

Data / Parameter:	$SFC_{PJ,km,i,y}$
Data unit:	*g/km*
Description:	*Specific fossil fuel consumption per km per project vehicle category* i *in year* y
Source of data:	*Measurement*

Measurement procedures (if any):	*Measure the specific fossil fuel consumption through:* *Option (A): monitor consumption of all project vehicles* *or* *Option (B): measure the amount of fossil fuels consumed per km travelled for a representative sample of each vehicle category. Sample vehicles shall be chosen in accordance with the latest version of the "Guidelines for sampling and surveys for CDM project activities and programme of activities" using a 90 per cent confidence interval and +/- 10 per cent precision to determine the sample size. The upper bound of 95 per cent confidence interval shall be used for the specific fuel/electricity consumed.* *Cross-checked against vehicle specifications (g/km) for urban conditions provided by the manufacturers and use the highest of the two values*
Any comment:	-

Data / Parameter:	$N_{i,y}$
Data unit:	-
Description:	*Number of project vehicle in operation in year* y
Source of data:	
Measurement procedures (if any):	*Establish the number of the project vehicles in operation through:* *Option (A): based on annual sales records or official data on registered project vehicles cross-checked against the results from a representative sample survey vehicles to determine the percentage of vehicles in use* *or* *Option (B): based on annual sales records or official data for registered project vehicles, multiplied by the default factor* 0.9^t*, where* t *is year counter for the number of years since the vehicle was introduced (for example: if* n *vehicles are sold in year 1, in year 2 the number of vehicles still in operation are assumed to be equal to* n**0.9, and in year 3,* n**0.9*^{2}*, etc.)*
Any comment:	-

Data / parameter:	$EC_{PJ,i,y}$
Data unit:	kWh
Description:	Electricity consumed by the project vehicles of type *i* in year *y*
Source of data:	Electric charging records at the electricity charging station
Measurement procedures (if any):	
Any comment:	The electric charging records will be crosschecked by driver logs or invoices from electricity filling station

Data / Parameter:	$SEC_{PJ,km,i,y}$
Data unit:	*kWh/km*
Description:	*Specific electricity consumption per km per project vehicle category* i *in year* y
Source of data:	*Measurement*
Measurement procedures (if any):	*Measure the specific electricity consumption through:* *Option (A): monitor electricity consumption of all project vehicles* *or* *Option (B): measure the amount of electricity consumed per km travelled for a representative sample of each vehicle category. Sample vehicles shall be chosen in accordance with the latest version of the "Guidelines for sampling and surveys for CDM project activities and programme of activities" using a 90 per cent confidence interval and +/- 10 per cent precision to determine the sample size. The upper bound of 95 per cent confidence interval shall be used for the specific fuel/electricity consumed.* *Cross-checked against vehicle specifications (kWh/km) for urban conditions provided by the manufacturers and use the highest of the two values*
Any comment:	-

Data required from SLSEA

Data / Parameter:	***EF_{elect}***
Data unit:	*kg CO_2/kWh*
Description:	*CO_2 emission factor of electricity used by project vehicle*
Source of data:	*Measurement*
Measurement procedures (if any):	*As per procedures of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*
Any comment:	-

Data / Parameter:	TDL_y
Data unit:	*percentage*
Description:	*Average technical transmission and distribution losses for providing electricity in the year* y
Source of data:	
Measurement procedures (if any):	*As per the procedures of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"*
Any comment:	-

Data required from CPSTL

Data / Parameter:	$NCV_{BL,i}$, $NCV_{PJ,i}$
Data unit:	*J/g*
Description:	*Net calorific value of fuel* i
Source of data:	
Measurement procedures (if any):	*Country specific data or IPCC default value*
Any comment:	-

5 MONITORING, REPORTING & VERIFICATION PROTOCOL - INTRODUCTION OF NEW ELECTRIC AND HYBRID VEHICLES _ TAX

(NDC 8.4)

OVERVIEW

This protocol serves as an overview of the monitoring process, a qualitative assessment of the monitored parameters, the organizational structure, the primary responsibilities of the personnel involved in monitoring and QA/QC process.

5.1 Introduction

Mitigation action: The mitigation action is to improve the road transport by introducing new electric and hybrid vehicles to vehicle fleet by implementing carbon tax/ excise duty tax, which is applicable only for hybrids vehicles, petrol and diesel-powered motor vehicles. The proposed carbon tax is calculated based on the fuel type, engine capacity and age of the vehicles. And the proposed excise duty tax is calculated based on the fuel type, engine capacity of the vehicles.

In the absence of the proposed mitigation action, the conventional petrol and diesel-powered motor vehicles would have dominated the vehicle market. The mitigation action aims to increase the share of electric vehicles in the vehicle market.

5.2 Monitoring plan

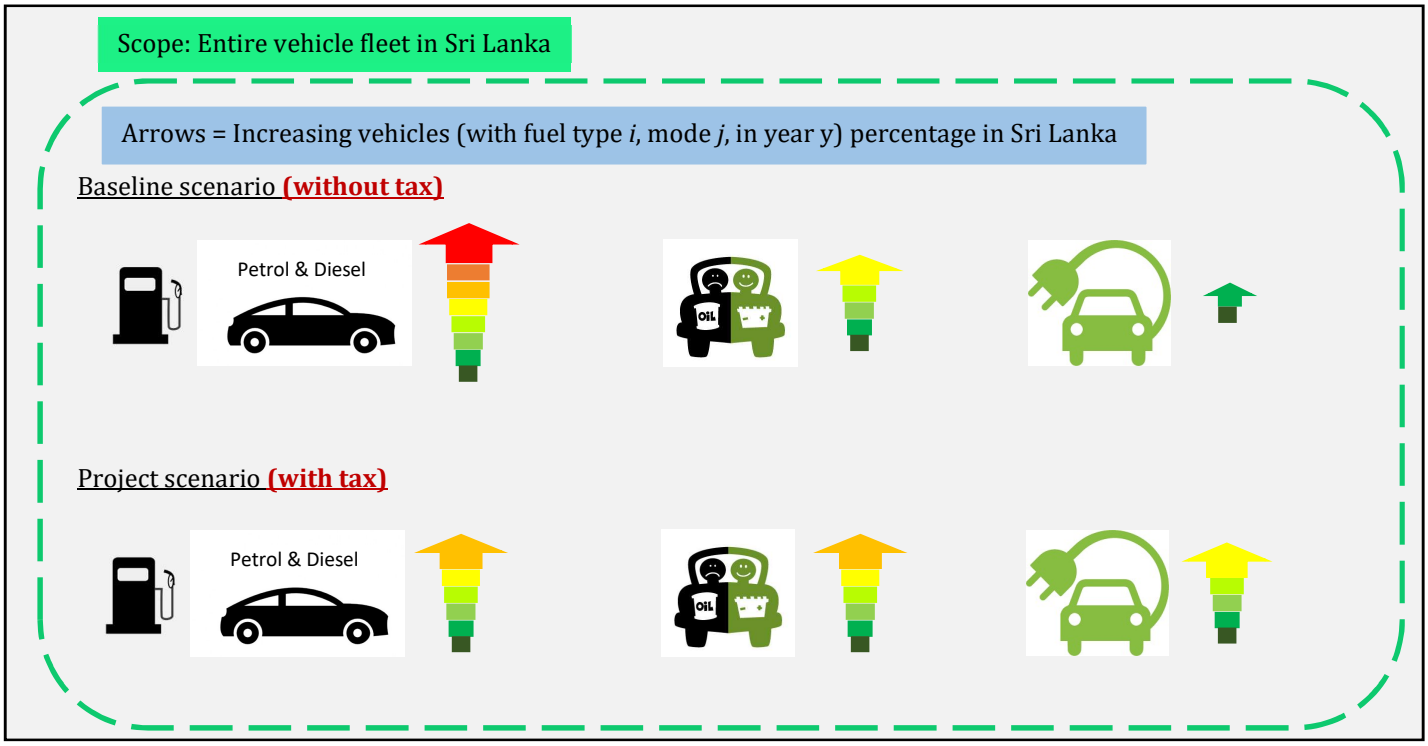

Figure 5.2-1 Summary of project activity

- P6_INEHV_DMT - Data collection and management procedure for Department of Motor Traffic
- P11_INEHV_VET - Data collection and management procedure for Vehicle Emission Testing
- P7_INEHV_SLC - Data collection and management procedure for Sri Lanka Customs
- P3_ER_SLSEA - Data collection and management procedure for Sri Lanka Sustainable Energy Authority
- P9_FSRR_CPSTL - Data collection and management procedure for Ceylon Petroleum Storage Terminal Limited

5.3 Data monitoring procedure

Methodology /Tools
ICAT Transport Pricing Guidance (2018) Tools, ➢ "Baseline emissions for modal shift measures in urban passenger transport", Version 01

Equations	
Equation 1: Base year emission	$\boldsymbol{BE_{i,j,y}}$ *in* CO_2 *emissions* $(t\ CO_2) = [\boldsymbol{FC_{i,j,y}}$ *in energy units* $(TJ)] \times [\boldsymbol{EF_i}\ (t\ CO_2\ per\ TJ)]$
Equation 1.1: Total fuel consumption	$Total\ fuel\ consumption\ FC_{i,j,y}\ in\ volume\ units(litres) = d_{i,j,y}(in\ VKT) \times SFC_{i,j,y}(in\ litre\ per\ VKT)$
Equation 1. 2: Fuel energy use	$F_{i,j,y} in\ energy\ units(TJ) = FC_{i,j,y} in\ volume\ units(litre) \times \rho_i \times NCV_i \div 10^9$
Equation 2.1: Discount rate (Only for carbon tax calculation)	$NPV = \frac{F}{\ }$
Equation 2.2: Tax rebate	Average value of tax rebates = (Previous carbon tax - New carbon tax)/ Retail price
Equation 2.3: Market share	Market Share (percentage - point change) = (beta) x (average rebate value)
Equation 2.4 Emission reduction	Per km emissions reduction = GHG emissions of fuel car per PKM -GHG emissions of electric car per PKM

Equation 2.4.1 Passenger kilometers	$PKM_{i,car,y} = \sum_i d_{i,car,y}\ (in\ VKT) \times I_{car,y}\ (in\ persons\ per\ vehicle)$
Equation 2.4.2 Base year emission per passenger kilometers	$BEpkm_{i,j,y}\ in\ CO_2\ emissions(kg\ CO_2) per\ passenger\ kilometre = BE_{i,j,y}(kg\ CO_2) \div PKM_{i,j,y}$
Equation 2 GHG impact	GHG impact = (market share) x (annual new vehicle sale) x (per km emissions reduction) x (average lifetime km per vehicle)

5.3.1 Ex-ante parameters (fixed values)

- Average (per VKT) number of persons travelling in same vehicle (with mode *j* in year *y*) Net calorific value of fuel *n* used in vehicle category *i*
- Specific fuel consumption. Average consumption per VKT in municipal, regional or national fleet (with fuel type *i*, mode *j*, in year *y*)
- Density of fuel type *i*
- Net calorific value of fuel type *i*
- Emission factor for gasoline fuel
- Emission factor for diesel fuel
- Beta value
- Taxes for the fuel type i engine capacity c age x vehicles
- Average vehicle lifespan (with fuel type *i*, mode *j*, in year *y*).

5.3.2 Ex-post parameters (regularly monitored values)

- Combined margin emission factor for the grid in year *y* Number of vehicles in vehicle category *i* using fuel type *n* in year *x*
- Retail price of vehicle with engine capacity c fuel type i
- Annual new vehicle sales (with fuel type *i*, mode *j*, in year *y*)

5.3.3 Parameters to verified/collected one time prior to the monitoring period

- Density of fuel type *i*
- Net calorific value of fuel type *i*
- Emission factor for gasoline fuel
- Emission factor for diesel fuel
- Beta value

5.4 Parameter and procedure

Table 5.4-1 Parameter and procedure

Parameter	Description	Instrument /method	Applied for (baseline, project, leakage)	Procedure
$l_{j,y}$	Average (per VKT) number of persons travelling in same vehicle (with mode *j* in year *y*)	Default value/ Measure	Baseline & Project	CDM tool 18/ P6_INEHV_DMT
$sfc_{i,j,y}$	Specific fuel consumption. Average consumption per VKT in municipal, regional or national fleet (with fuel type *i*, mode *j*, in year *y*).	Default value / Calculate	Baseline & Project	CDM tool 18/ P9_FSRR_CP
ρ_i	Density of fuel type *i*	Use calculated national value	Baseline & Project	P9_FSRR_CP
NCV_i	Net calorific value of fuel type *i*	Default value/Use calculated national value	Baseline & Project	IPCC/ P9_FSRR_CP
$EF_{gasoline}$	Emission factor for gasoline fuel	Default value	Baseline & Project	IPCC
EF_{diesel}	Emission factor for diesel fuel	Default value	Baseline & Project	IPCC
Beta value	Beta value of Market Share	Default value	Project	ICAT Transport Pricing Guidance
$EF_{grid,CM,y}$	Combined margin emission factor for the grid in year *y*	Use calculated national value	Baseline & Project	P3_ER_SLSEA
Retail price	Retail price of vehicle with engine capacity c fuel type i	Estimated value	Project	Vehicle retailers
Carbon Tax	Taxes for the fuel type i engine capacity c age x vehicles	Default value	Project	P6_INEHV_DMT
Excise duty Tax	Taxes for the fuel type i engine capacity c vehicles	Default value	Project	P7_INEHV_SLC

Annual new vehicle sales	Annual new vehicle sales (with fuel type *i*, mode *j*, in year *y*)	National value	Project	P6_INEHV_DMT
d $_{i,j,y}$	Vehicle kilometres travelled (with fuel type *i*, mode *j*, in year *y*)	Measure	Baseline & Project	P11_INEHV_VET
Vehicle lifespan	Average vehicle lifespan (for fuel type *i*, mode *j*, in year *y*)	Default value	Baseline & Project	IPCC

5.5 Organization structure and MRV specific responsibilities

Table 5.5-1 Organization structure and MRV specific responsibilities table

Parameter description	Tasks	Responsible staff	Procedure	Comment
Average (per VKT) number of persons travelling in same vehicle (with mode *j* in year *y*)	Collect default values and keeping records	MRV Focal point at DMT	CDM tool 18/ P6_INEHV_DMT	
Specific fuel consumption. Average consumption per VKT in municipal, regional or national fleet (with fuel type *i*, mode *j*, in year *y*).	Collect default values and keeping records	NDC unit under Ministry from MRV Focal point at CPSTL	CDM tool 18/ P9_FSRR_CPSTL	
Density of fuel type *i*	Calculate national value and publish on the website	MRV Focal point at CPSTL	P9_FSRR_CPSTL	Value available in the CEYEPETCO website
Net calorific value of fuel type *i*	Calculate national value	MRV Focal point at CPSTL	IPCC/ 91_FSRR_CPSTL	
Emission factor for gasoline fuel	Collect default values and keeping records	Project responsible	IPCC	

		officer under NDC unit		
Emission factor for diesel fuel	Collect default values and keeping records	Project responsible officer under NDC unit	IPCC	
Beta value of Market Share	Collect default values and keeping records	Project responsible officer under NDC unit	ICAT Transport Pricing Guidance	
Combined margin emission factor for the grid in year *y*	Calculate national value	MRV Focal point at SLSEA	P3_ER_SLSEA	
Retail price of vehicle with engine capacity c fuel type i	Estimate the values or collect values	Project responsible officer under NDC unit	Vehicle retailers	
Taxes for the fuel type i engine capacity c age x vehicles	Collect default values and keeping records	MRV Focal point at DMT	P6_INEHV_DMT	Carbon Tax
Taxes for the fuel type i engine capacity c vehicles	Collect default values and keeping records	MRV Focal point at SLC	P7_INEHV_SLC	Excise duty tax
Annual new vehicle sales (with fuel type *i*, mode *j*, in year *y*)	Calculate values and keeping records	MRV Focal point at DMT	P6_INEHV_DMT	
Vehicle kilometres travelled (with fuel type *i*, mode *j*, in year *y*)	Calculate values and keeping records	MRV Focal point at VET	P11_INEHV_VET	
Average vehicle lifespan (for fuel type *i*, mode *j*, in year *y*)	Collect default values and keeping records	Project responsible officer under NDC unit	IPCC	

5.6 Proposed data management

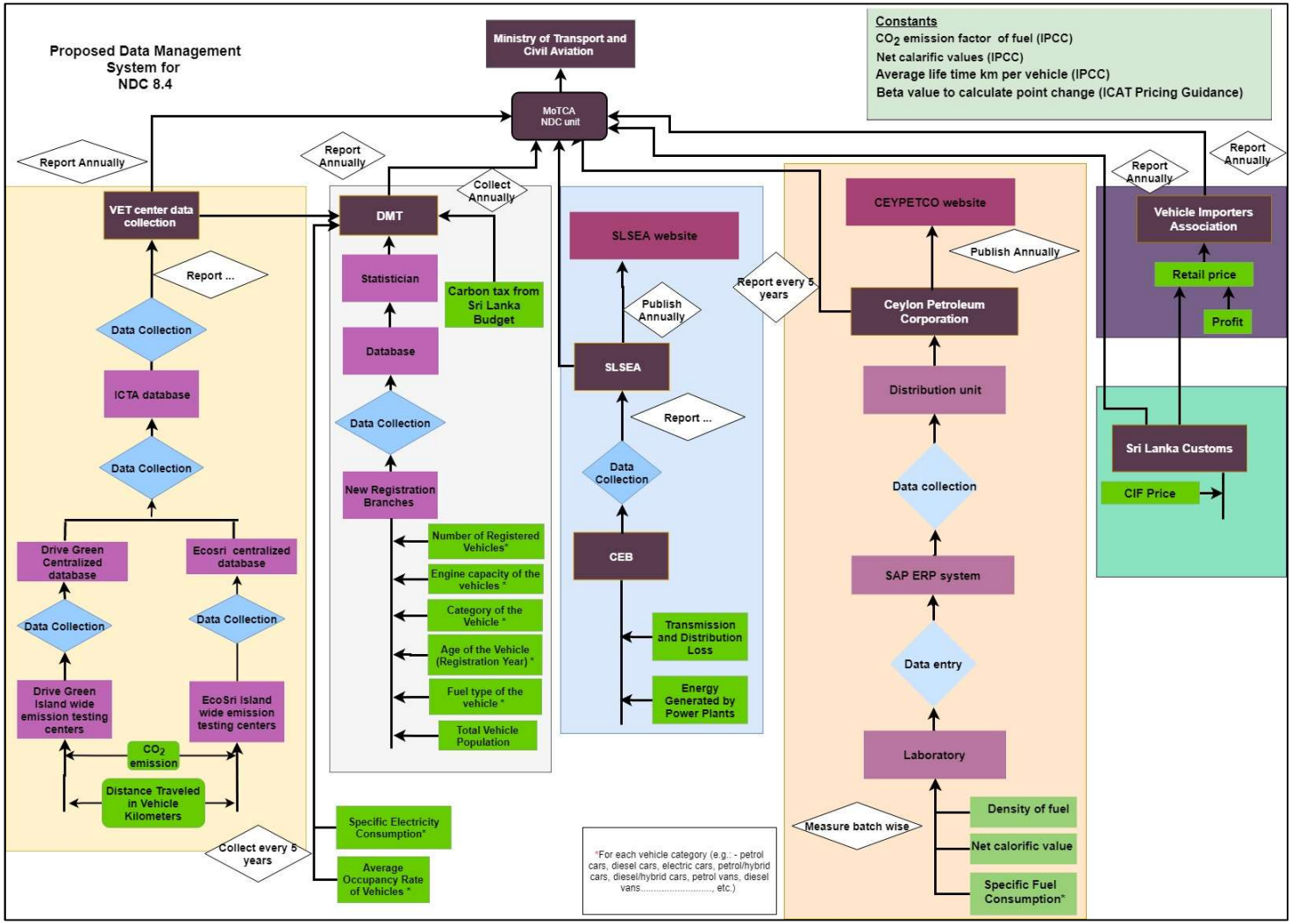

Figure 5.6-1 Proposed data management system for carbon tax

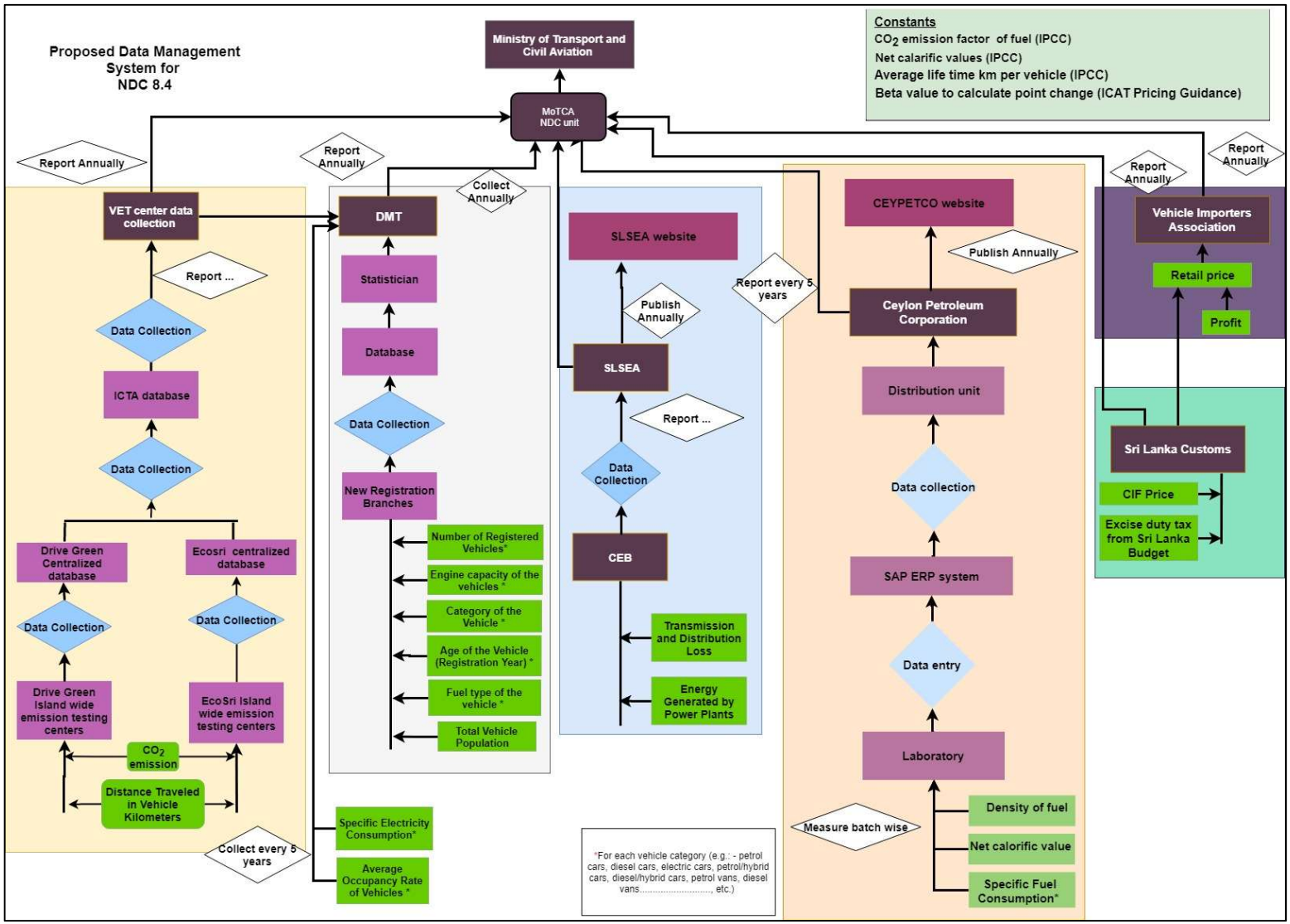

Figure 5.6-2 Proposed data management system for excise duty tax

Parameters necessary for baseline

Data and parameters not monitored

Data / Parameter table 1

Data / Parameter:	$l_{j,y}$	$l_{j,y}$
Data unit:	Persons per vehicle	Persons per vehicle
Description:	Average (per VKT) number of persons travelling in same vehicle (with mode *j* in year *y*). *(only needed for estimation of PKM)*	Average (per VKT) number of persons travelling in same vehicle (with mode *j* in year *y*). *(only needed for estimation of PKM)*
Source of data:	Municipal, regional or national statistics or studies (from transit authorities) □ Municipal, regional or national data collection process or surveys □ Supra-regional default value (e.g., for continent). Else global default value: 2 persons, including the driver (UNFCCC 2014)	1. National data form DMT 2. Default data (CDM TOOL18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport Version 01.0)
Measurement procedures (if any):	Measured/ estimated/ modelled	
Monitoring frequency	Every 5 years	Latest available updates should be taken into account
Any comment:		

Data / Parameter table 2

Data / Parameter:	$sfc_{i,j,y}$	$sfc_{i,j,y}$
Data unit:	Litre per VKT	Litre per VKT

Description:	Specific fuel consumption. Average consumption per VKT in municipal, regional or national fleet (with fuel type *i*, mode *j*, in year *y*).	Specific fuel consumption. Average consumption per VKT in municipal, regional or national fleet (with fuel type *i*, mode *j*, in year *y*).
Source of data:	Municipal, regional or national statistics or studies (from transit authorities) □ Municipal, regional or national data collection process or surveys (e.g., from manufacturers) □ Supra-regional default values (e.g., for continent). Else, global default value for gasoline consumption of gasoline cars: 10 litres per 100 km (assumption by the authors	1. National data from CPSTL 2. Default values CDM TOOL18 Methodological tool: Baseline emissions for modal shift measures in urban passenger transport Version 01.0 - for diesel and petrol cars - electric vehicles Fuel Economy of Light Duty Vehicles in Sri Lanka _the Baseline (2015) prepared by Dr. Thusitha Sugathapala - hybrid cars
Measurement procedures (if any):	Measured/ estimated/ modelled	
Monitoring frequency	Every 5 years	Latest available updates should be taken into account
Any comment:		

Data / Parameter table 3

Data / Parameter:	ρ_i	ρ_i
Data unit:	kg/m^3	kg/m^3

Description:	Density of fuel type *i*	Density of fuel type *i*
Source of data:	In order of priority: □ National energy statistics □ Reliable international sources □ Default values. Diesel: 835 kg/m3 at 15 deg C (Directive 1998/69/EC)26. Gasoline: 720 kg/m3 at 15 deg C (NOAA).27	1. National data from CPSTL 2. IPCC 2006 Default values
Measurement procedures (if any):	Measured	
Monitoring frequency	Every 5 years	Latest available updates should be taken into account
Any comment:		

Data / Parameter table 4

Data / Parameter:	NCV_i	NCV_i
Data unit:	TJ/Gg	TJ/Gg
Description:	Net calorific value of fuel type *i*	Net calorific value of fuel type *i*
Source of data:	In order of priority: □ National energy statistics □ Reliable international sources □ Default values. Diesel: 43.0 TJ/Gg, Gasoline: 44.3 TJ/Gg (both IPCC 2006, Vol. 2 Ch. 1 Table 1.2)	3. National data from CPSTL 4. IPCC 2006 Default values
Measurement procedures (if any):	Measured	

Monitoring frequency :	Every 5 years	Latest available updates should be taken into account
Any comment:		

Data / Parameter table 5

Data / Parameter:	***EF*$_{gasoline}$**	***EF*$_{gasoline}$**
Data unit:	tCO_2/TJ	tCO_2/TJ
Description:	Emission factor for gasoline fuel	Emission factor for gasoline fuel
Source of data:	National energy or environmental statistics □ National fuel providers; for example refineries and/or fuel importers, based on their measurements □ Global default values. Gasoline: 69,300 kgCO2/TJ, Diesel: 74,100 kgCO2/TJ (both IPCC 2006, Vol. 2 Ch. 3 Table 3.2.1)	1. Global default values 2. IPCC 2006 default values for CO_2 , CH_4 and N_2O
Measurement procedures (if any):	Measured	
Monitoring frequency :	Every 5 years	Latest available updates should be taken into account
Any comment:	-	

Data / Parameter table 6

Data / Parameter:	***EF*$_{diesel}$**	***EF*$_{diesel}$**
Data unit:	tCO_2/TJ	tCO_2/TJ
Description:	Emission factor for diesel fuel	Emission factor for diesel fuel
Source of data:	National energy or environmental statistics □ National fuel providers; for example refineries and/or fuel importers, based on their measurements □ Global default values. Gasoline: 69,300 kgCO2/TJ, Diesel: 74,100 kgCO2/TJ (both IPCC 2006, Vol. 2 Ch. 3 Table 3.2.1)	1. Global default values 2. IPCC 2006 default values for CO_2, CH_4 and N_2O
Measurement procedures (if any):	Measured	
Monitoring frequency :	Every 5 years	Latest available updates should be taken into account
Any comment:	-	

Data / Parameter table 7

Data / Parameter	Beta value
Unit	
Description	Beta value
Source of data	Default value from ICAT Transport Pricing Guidance
Measurement methods and procedures	
Monitoring frequency	Latest available updates should be taken into account
QA/QC procedures	

Purpose of data	Calculate GHG impact
Additional comment	

Data and parameters monitored

Data / Parameter table 8

Data / parameter:	$EF_{grid,CM,y}$
Data unit:	tCO_2/MWh
Description:	Combined margin emission factor for the grid in year *y*
Source of data:	Sri Lanka Energy Balance by Sri Lanka Sustainable Energy Authority
Measurement procedures (if any):	
Monitoring frequency:	Latest available grid emission factor should be taken into account (Annually need to check for the value)
QA/QC procedures:	
Any comment:	

Data / Parameter table 9

Data / Parameter	Retail price of the eligible vehicle models
Unit	Sri Lankan Rupees (SLR)
Description	Retail price of vehicle with engine capacity c fuel type i
Source of data	Vehicle retailers
Measurement methods and procedures	.
Monitoring frequency	At least annually
Additional comment	

Data / Parameter table 10

Data / Parameter	1. Carbon taxes 2. Excise duty taxes
Unit	SLR

Description	1. Taxes for the fuel type i engine capacity c age x vehicles 2. Taxes for the fuel type i engine capacity c vehicles
Source of data	Sri Lanka budget, Gazettes, Ministry of Finance
Measurement methods and procedures	1. DMT collect updates about carbon tax 2. SLC collect updates about excise duty tax
Monitoring frequency	At least annually
QA/QC procedures	
Purpose of data	
Additional comment	

Data / Parameter table 11

Data / parameter:	Annual new vehicle sales
Data unit:	Number of vehicles
Description:	Annual new vehicle sales (with fuel type *i*, mode *j*, in year *y*).
Source of data:	Department of Motor Traffics
Measurement procedures (if any):	
Monitoring frequency:	Annually
QA/QC procedures:	
Any comment:	

Data / Parameter table 12

Data / Parameter:	$d_{i,j,y}$	$d_{i,j,y}$
Data unit:	VKT	VKT
Description:	Vehicle kilometres travelled (with fuel type *i*, mode *j*, in year *y*).	Vehicle kilometres travelled (with fuel type *i*, mode *j*, in year *y*).

Source of data:	Municipal, regional or national statistics or studies (from transit authorities) Municipal, regional or national data collection process or surveys (traffic counting, odometer reading, appropriate vehicle stock data)	National statistics (VET) - VKT for diesel, petrol and hybrid vehicles IPCC_AR5 Annex III : Technology-specific Cost and Performance Parameters - Electric vehicles
Measurement procedures (if any):		
Monitoring frequency		Average VKT calculate using data base of VET - Annually
Any comment:		

Data / Parameter table 13

Data / Parameter:	Vehicle lifespan
Data unit:	years
Description:	Average vehicle lifespan (for fuel type *i*, mode *j*, in year *y*).
Source of data:	IPCC_AR5Annex III : Technology-specific Cost and Performance Parameters - default value
Measurement procedures (if any):	
Monitoring frequency:	Latest available updates should be taken into account
QA/QC procedures:	
Any comment:	

6 MONITORING, REPORTING & VERIFICATION PROTOCOL -Freight shift from road to rail

(NDC 9.4)

OVERVIEW

This protocol serves as an overview of the monitoring process, a qualitative assessment of the monitored parameters, the organizational structure, the primary responsibilities of the personnel involved in monitoring and QA/QC process.

6.1 Introduction

Mitigation option: Freight shift from road to rail

6.2 Monitoring plan

Bowsers

Capacity: 33,000 L

Fuel economy: 0.02 L/tkm

Emission factor: 43.67 gCO_2/tkm

Wagons

Capacity of a wagon: 45,400 L

Number of wagons per train: 8

Total capacity of a train: 363 KL

Fuel economy: 0.005 L/tkm

Emission factor: 13.14 gCO_2/tkm

Figure 6.2-1 Monitoring plan

6.3 Monitoring methodology

Methodology /Tools

AM0090 version 01.1.0, "Modal shift in transportation of cargo from road transportation to water or rail transportation"

Tool to calculate project or leakage CO2 emissions from fossil fuel combustion

Equations

Equation 01
Baseline Emission

$$BE_y = T_y \cdot AD \cdot EF_{BL} \cdot 10^{-6}$$

Equation 02
Baseline emission factor

$$EF_{BL} = \frac{\sum_i FC_{BL,i,x} \cdot NCV_{i,x} \cdot EF_{CO2,i,x} \cdot F_{RT,BL}}{T_x \cdot AD}$$

Equation 03
Factor to account for non-empty return

$$F_{RT,BL} = \frac{T_x \cdot AD}{T_x \cdot AD + T_{RT,x} \cdot RTD_x}$$

Equation 04
Project emission

$$PE_y = \left(PE_{FC,y} + PE_{EC,y}\right) \cdot F_{RT,PJ,y} + PE_{CR,y}$$

Equation 05
CO2 emission coefficient

$$COEF_{i,} = w_{C,,y} \times 44/12$$

or

$$COEF_{i,y} = NCV_{i,y} \text{ X } EF_{CO2i,y}$$

or

$$COEF_{i,} = w_{C,,y} \times \rho_{i,y} \times 44/12$$

Parameters

Table 6.3-1 monitored and not monitored parameters table

Not monitored	
Distance of the baseline trip route (km)	AD
Amount of fuel i consumed by the trucks in year x (liter or m^3)	$FC_{BL,i,x}$
Average net calorific value of fuel i consumed by the trucks in year x (GJ per liter or m^3)	$NCV_{i,x}$
CO_2 emission factor of fuel i consumed by the trucks in year x (g CO_2/GJ)	$EF_{CO2,i,x}$
Amount of cargo transported in trucks in year x (tonne)	T_x
Amount of cargo transported in trucks in the return trips in year x (tonne)	$T_{RT,x}$
Distance of the return trip route in year x (km)	RTD_x
Monitored	
Amount of cargo transported by the project transportation mode in year y (tonne)	T_y
weighted average mass fraction of carbon in fuel type i in year y (tC/mass unit of the fuel)	$w_{C,i,y}$
weighted average net calorific value of the fuel type i in year y (GJ/mass unit)	$NCV_{i,y}$

weighted average CO_2 emission factor of fuel type *I* in year *y* (tCO_2/GJ)	$EF_{CO2i,y}$
Quantity of fuel type i combusted in process j during the year y (mass or volume unit/yr)	$FC_{i,j,y}$
weighted average density of fuel type *i* in year *y* (mass unit/volume unit of the fuel)	□

6.4 Parameter and procedure

Table 6.4-1 Parameter and procedure table

Parameter	Description	Instrument	Applied for (Baseline/project)	Procedure (P1,P2)
T_y	Amount of cargo transported by the project transportation mode in year *y* (tonne)	Measured	Baseline	P2_FSRR_SLR
AD	Distance of the baseline trip route (km)	Measured	Baseline	P9_FSRR_CPSTL
$FC_{BL,i,x}$	Amount of fuel *i* consumed by the trucks in year *x* (liter or m^3)	Measured	Baseline	P9_FSRR_CPSTL
$NCV_{i,x}$	Average net calorific value of fuel *i* consumed by the trucks in year *x* (GJ per liter or m^3)	Measured	Baseline	P9_FSRR_CPSTL
$EF_{CO2,i,x}$	CO_2 emission factor of fuel *i* consumed by the trucks in year *x* (g CO_2/GJ)	Default	Baseline	
T_x	Amount of cargo transported in trucks in year *x* (tonne)	Measured	Baseline	P9_FSRR_CPSTL
$T_{RT,x}$	Amount of cargo transported in trucks in the return trips in year *x* (tonne)	Measured	Baseline	P9_FSRR_CPSTL
RTD_x	Distance of the return trip route in year *x* (km)	Measured	Baseline	P9_FSRR_CPSTL

$w_{C,i,y}$	weighted average mass fraction of carbon in fuel type i in year y (tC/mass unit of the fuel)	Calculated	Project	
$NCV_{i,y}$	weighted average net calorific value of the fuel type *i* in year *y* (GJ/mass unit)	Calculated	Project	
$EF_{CO2i,y}$	weighted average CO_2 emission factor of fuel type *I* in year *y* (tCO_2/GJ)	Calculated	Project	
$FC_{i,j,y}$	Quantity of fuel type i combusted in process j during the year y (mass or volume unit/yr)	Measured	Project	P2_FSRR_SLR
$\rho_{i,y}$	weighted average density of fuel type *i* in year *y* (mass unit/volume unit of the fuel)	Measured	Project	P9

6.5 Organization structure and MRV specific responsibilities

Table 6.5-1 Organization structure and MRV specific responsibilities table

Tasks	Responsible staff			Procedure	Comment
	Measure	**Report**	**Verify**		
Ceylon Petroleum Storage Terminals Limited (CPSTL)					
Distance of the baseline trip route (*AD*)	N/A	Head of the information & technology unit	MRV manager	P9_FSRR_CPSTL	
Amount of fuel *i* consumed by the trucks in year *x* ($FC_{BL,i,x}$)	Manager Distribution	Head of the information & technology unit	MRV manager	P9_FSRR_CPSTL	
Average net calorific value of fuel *i* consumed by the trucks in year *x* ($NCV_{i,x}$)	Head Laboratory	Head of the information & technology unit	MRV manager	P9_FSRR_CPSTL	
Amount of cargo transported in trucks in year *x* (T_x)	Manager Distribution	Head of the information & technology unit	MRV manager	P9_FSRR_CPSTL	
Amount of cargo transported in trucks in	Manager Distributio	Head of the information	MRV manager	P9_FSRR_CPSTL	

the return trips in year ($T_{RT,x}$)	n	& technology unit			
Distance of the return trip route in year x (RTD_x)		Head of the information & technology unit	MRV manager	P9_FSRR_CPS TL	
weighted average density of fuel type i in year y($\rho_{i,y}$)	Head Laboratory	Head of the information & technology unit		P9_FSRR_CPS TL	
Sri Lanka Railways (SLR)					
Quantity of fuel type i combusted in process j during the year y ($FC_{i,j,y}$)	Head running shed	Director Planning	MRV manager	P2_FSRR_SLR	
Amount of cargo transported by train in year y (T_y)	Chief Wagon Controller	Director Planning	MRV manager	P2_FSRR_SLR	
The origin and destination point and transportation route of the cargo transported by train in year y(OD_y)	Head running shed	Director Planning	MRV manager	P2_FSRR_SLR	
Type of cargo transported by the project transportation mode in year y (C_{ty})	Chief Wagon Controller	Director Planning	MRV manager	P2_FSRR_SLR	

6.6 Proposed data management system

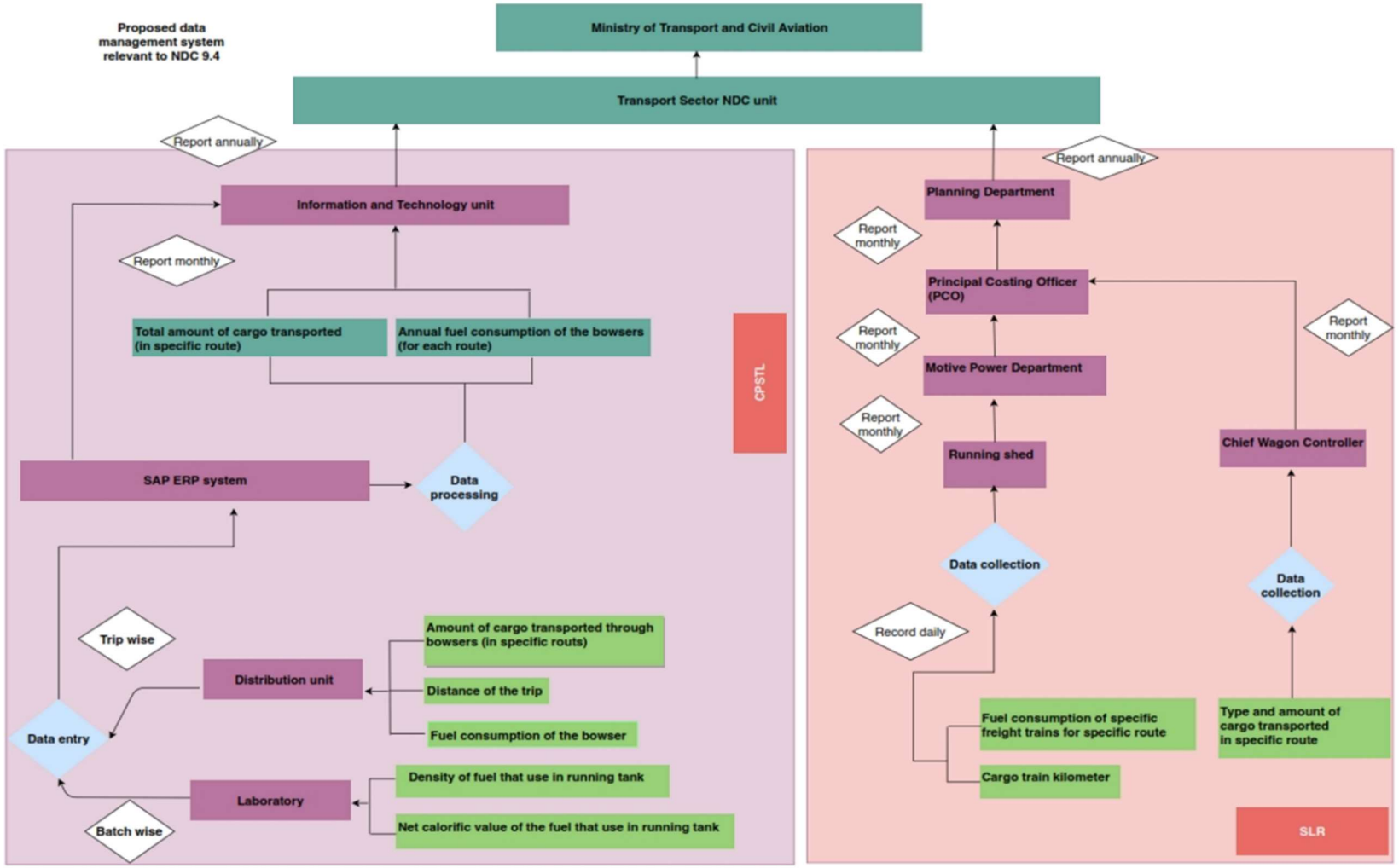

Figure 6.6-1 Proposed data management system

6.7 Annex

Data requirement from CPSTL

Data / Parameter:	$FC_{BL,i,x}$	$FC_{BL,i,x}$
Data unit:	liter or m^3	liter
Description:	Amount of fuel *i* consumed by the trucks in year *x*	Amount of diesel consumed by the bowsers in year 2010
Source of data:	Historical data from the project participants	Historical data from CPSTL
Measurement procedures (if any):	-	
Any comment:	-	Currently this data is not available. Therefore value was calculated based on average fuel economy of most commonly used bowser, trip distance and the number of trips travelled per annum.

Data / Parameter:	AD	AD
Data unit:	Km	Km
Description:	Distance of the baseline trip route (km)	Distance from Kolonnawa terminal to Katunayake bulk depot
Source of data:	Historical data or measurement from the project participants	CPSTL data base
Measurement procedures (if any):	-	
Any comment:	-	

Data / Parameter:	T_x	T_x
Data unit:	tonne	tonne
Description:	Amount of cargo transported in trucks in year *x*	Amount of aviation fuel transported in bowsers in year 2010
Source of data:	Historical data from the project participants	CPSTL data base
Measurement procedures (if any):	-	
Any comment:	-	

Data / Parameter:	$T_{RT,x}$	$T_{RT,x}$
Data unit:	tonne	tonne
Description:	Amount of cargo transported in trucks in the return trips in year *x*	Amount of cargo transported in bowsers in the return trips in year 2010
Source of data:	Historical data from the project participants	
Measurement procedures (if any):	-	
Any comment:	-	All are empty return trips

Data / Parameter:	RTD_x	RTD_x
Data unit:	km	km
Description:	Distance of the return trip route in year *x*	Distance from Katunayaka bulk depot to Kollonnawa main terminal
Source of data:	Historical data from the project participants	
Measurement procedures (if any):	-	
Any comment:	In many cases, RTDx will be the same as AD, where the trucks take the same route in the return trip. However, in cases where the trucks take different route (diversion) in the return trip, the RTDx is the actual length of the return trip	

Monitoring parameters

Data / Parameter:	PTM_y	PTM_y
Data unit:		

Description:	The project transportation mode in year *y*	The project transportation mode in year 2010
Source of data:	Onsite records by project participants	
Measurement procedures (if any):	The project participants will record the mode of transportation in each trip. The verifying DOE will check the records for confirmation.	CPSTL record the mode of transportation in each trip
Monitoring frequency:	Each trip	Each trip
QA/QC procedures:	-	
Any comment:	The project transportation mode (either ships, barges or rail) in year *y* should be the same project transportation as defined in the CDM-PDD at the validation of the project activity This monitored parameter is required in order to comply with the following applicability condition: • The project transportation mode is defined in the CDM-PDD at the validation of the project activity and no change of transportation mode is allowed thereafter	

Data /	***NCVi,y***	***NCVi,y***
Data unit:	GJ per mass or volume unit (e.g. GJ/m^3, GJ/ton)	GJ per mass
Description:	Weighted average net calorific value of fuel type *i* in year *y*	Weighted average net calorific value of diesel in year

<table>
<tr><td>Data / parameter:
Data unit:
Description:
Source of data:

Measurement procedures (if any):

Monitoring frequency:

QA/QC procedur

Any comment:</td><td>The following data sources may be used if the relevant conditions apply:

<table><tr><th>Data source</th><th>Conditions for using the data source</th></tr><tr><td>(a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source if the carbon fraction of the fuel is not provided (Option A)</td></tr><tr><td>(b) Measurements by the project participants</td><td>If (a) is not available</td></tr><tr><td>(c) Regional or national default values</td><td>If (a) is not available.

These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances)</td></tr><tr><td>(d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If (a) is not available</td></tr></table></td><td>d) IPCC default values</td></tr>
<tr><td>Measurement procedures (if any):</td><td>For (a) and (b): Measurements should be undertaken in line with national or international fuel standards</td><td></td></tr>
<tr><td>Monitoring frequency:</td><td>For (a) and (b): The NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated.</td><td></td></tr>
<tr><td>QA/QC procedures:</td><td>Verify if the values under (a), (b) and (c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (a), (b) or (c) should have ISO17025 accreditation or justify that they can comply with similar quality standards</td><td></td></tr>
<tr><td>Any comment:</td><td>Applicable where Option B is used</td><td></td></tr>
</table>

Data requirement from Sri Lanka Railways

Data / Parameter:	OD_y	OD_y
Data unit:		
Description:	The origin and destination point and transportation route of the cargo transported by the project transportation mode in year *y*	Railway route from Kolonnawa main terminal to Katunayaka bulk depot
Source of data:	Onsite records by project participants	SLR
Measurement procedures (if any):	The project participants will record the origin and destination point and transportation route in each trip. The verifying DOE will check the records for confirmation	
Monitoring frequency:	Each trip	
QA/QC procedures:	-	
Any comment:	The origin and destination point and the transportation routes of the cargo transported by the project transportation mode in year *y* should be the same origin and destination points and transportation route as defined in the CDM-PDD at the validation of the project activity. This monitored parameter is required in order to comply with the following applicability condition: • The cargo is transported from the same origin (point A) to the same destination (point B) throughout the whole crediting period. These two points and transportation routes are defined in the CDM-PDD at the validation of the project activity and are fixed along the crediting period	

Data / Parameter:	CT_y	CT_y
Data unit:		
Description:	Type of cargo transported by the project transportation mode in year *y*	Petroleum product transportation via train
Source of data:	Onsite records by project participants	SLR
Measurement procedures (if any):	The project participants will record the type of cargo transported by the project transportation mode in each trip. The verifying DOE will check the records for confirmation.	
Monitoring frequency:	Each trip	Each trip
QA/QC procedures:	-	
Any comment:	The cargo type transported in year *y* should be the same type as defined in the CDM-PDD at the validation of the project activity. This monitored parameter is required in order to comply with the following applicability condition: • Both in the baseline and project activity, only one type of cargo, owned by the project participants, is transported and no mix of cargo is permitted (this condition does not apply to the return trip cargo). The cargo type of the project activity is defined in the CDM-PDD at the validation of the project activity and is fixed along the crediting period	

Data / Parameter:	T_y	T_y
Data unit:	tonne	tonne
Description:	Amount of cargo transported by the project transportation mode in year *y*	Amount of petroleum product transported by rail in year 2010
Source of data:	Onsite measurements by project participants	SLR
Measurement procedures (if any):	The amount of cargo transported under the CDM project by the project transportation mode shall be measured at the point of origin using weight scales. The amount shall be crosschecked with the cargo received at destination	Amount of petroleum product transported via train is measured at the Kolonnawa main terminal by CPSTL and records are available in their data base. These amounts are also reported to Chief Wagon Controller of SLR
Monitoring frequency:	Daily, summed for a year	Record daily
QA/QC procedures:	-	

Any comment:	The project participants shall estimate the T_y to be used for *ex ante* calculation in the CDM-PDD and for the investment analysis and document in the PDD. The sensitivity analysis shall be performed as per the procedure in the combined tool. Changes to the value of T_y during the crediting period as compared to the *ex -ante* estimate (e.g. by more than 10%) represent a change to the project design document and the relevant procedures shall apply	

Data / Parameter:	$T_{RT,y}$	$T_{RT,y}$
Data unit:	tonne	tonne
Description:	Amount of cargo transported by the project transportation mode in the return trips in year *y*	Amount of cargo transported by train in the return trips in year 2010
Source of data:	Onsite measurements by project participants	Onsite measurements by SLR
Measurement procedures (if any):	The amount of cargo transported by the project transportation mode in the return trips shall be measured at the point of origin using weight scales. The amount shall be crosschecked with the cargo received at destination	

Monitoring frequency:	Daily, summed for a year	Daily
QA/QC procedures:	-	
Any comment:	The project participants shall estimate the $T_{RT,y}$ to be used for *ex ante* calculation in the CDM-PDD and for the investment analysis and document in the PDD. The sensitivity analysis shall be performed as per the procedure in the combined tool. Changes to the value of $T_{RT,y}$ during the crediting period as compared to the *ex-ante* estimate (e.g. by more than 10%) represent a change to the project design document and the relevant procedures shall apply.	Return oil wagons are empty

Data / parameter:	***FCi,j,y***	***FCi,j,y***
Data unit:	Mass or volume unit per year (e.g. ton/yr or m^3/yr)	m^3/yr
Description:	Quantity of fuel type *i* combusted in process *j* during the year *y*	Quantity of diesel combusted for
Source of data:	Onsite measurements	SLR
Measurement procedures (if any):	• Use either mass or volume meters. In cases where fuel is supplied from small daily tanks, rulers can be used to determine mass or volume of the fuel consumed, with the following conditions: The ruler gauge must be part of the daily tank and calibrated at least once a year and have a book of control for recording the measurements (on a daily basis or per shift); • Accessories such as transducers, sonar and piezo electronic devices are accepted if they are properly calibrated with the ruler gauge and receiving a reasonable maintenance; • In case of daily tanks with pre-heaters for heavy oil, the calibration will be made with the system at typical operational conditions	
Monitoring frequency:	Continuously	
QA/QC procedures:	The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records	

Any comments	Project activities or PoAs, where end users of the subsystems or measures are households/communities/small and medium enterprises (SMEs), faced with data gaps due to meter failure or other reasons unforeseen, may estimate the quantity of fuel, using one of the following options, provided the gap period does not exceed 30 consecutive days within six consecutive months: • The purchased fuel/energy invoices/bills, where the purchased fuel can be identified specifically for the CDM project; • The energy produced by the equipment, adjusted by efficiency. Efficiency of the equipment is determined using the 'Methodological tool: Determining the baseline efficiency of thermal or electric energy generation systems', and energy produced is measured directly or calculated based on operation hours; • The highest value of the parameter for the same calendar period of the previous years; • The fuel consumption of a representative sample of the first batch1 of project devices. It may be assumed that the fuel consumption measured in a representative sample of the first batch of project devices apply to all subsequent batches	Fuel consumption of each engine is measured by 'running sheds'. But fuel combustion for petroleum products (cargo) transportation is not recorded separately. In the absence of data, value was calculated based on the average fuel consumption of mostly used engines to transport 500 tonnes.