INITIATIVE FOR CLIMATE ACTION TRANSPARENCY - ICAT

MEASUREMENT, REPORTING AND VERIFICATION FRAMEWORK FOR SUSTAINABLE DEVELOPMENT ASSESSMENT OF TRANSPORT SECTOR MITIGATION ACTIONS OF SRI LANKA

Initiative for Climate Action Transparency - ICAT

MEASUREMENT, REPORTING AND VERIFICATION FRAMEWORK FOR ASSESSING SUSTAINABLE DEVELOPMENT IMPACTS OF MITIGATION ACTIONS IN TRANSPORT SECTOR OF SRI LANKA

ClimateSI ,2021

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List of Acronyms

NDC	Nationally Determined Contributions
SDGs	Sustainable Development Goals
ICAT	Initiative for Climate Action Transparency
INDCs	Intended Nationally Determined Contributions
MRV	Measuring, Reporting, and Verifications
GHG	Green House Gas
EST	Environmentally Sustainable Transport

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Executive Summary

Sri Lanka is a developing country that has pledged its commitment to climate action upon signing international agreements such as “the Paris agreement”. Besides, Sri Lanka has also committed to achieving the Sustainable Development Goals while contributing to the global movement of sustainability in addressing environmental, social, and economic aspects. “Measuring, Reporting, and Verification” system to track mitigation actions related to the NDCs of the transport sector was recently developed, and later it was also digitalized under the support of ICAT.

This study proposes an MRV framework to track the Sustainable Development (SD) impacts of selected transport sector mitigation actions. ICAT sustainable development methodology was applied as the framework to develop the SD MRV framework. Several SD impacts, which fall into the environment, social and economic categories, were identified.

Measurement

GHG emissions can be measured using the GHG MRV system developed for the transport sector while several indicators were identified to measure the SD impacts such as respiratory diseases, noise pollution, traffic congestion via a literature survey.

Reporting

Reporting will be done by the entities who were identified as responsible entities to provide the data related to the parameters of the identified indicators.

Verification

Verification can be done at two levels: internal verification by the Ministry of Transport; and third-party verification by the Sustainable Development Council of Sri Lanka

1 Introduction

1.1 Background

Origin of the Sustainable Development Goals

The UN Sustainable Development Goals (SDGs) and the Paris Agreement are two of the most significant policy frameworks of the twenty-first century. Countries have already pledged their Nationally Determined Contributions (NDCs) under the Paris agreement showing how they will reduce the emissions and achieve targets set by the Paris Agreement. Sustainable Development Goals (SDGs) were originated at the UN sustainable development summit in 2015. SDGs comprise 17 main goals and 169 targets. SDGs are said to be a call for all nations to achieve prosperity while saving the planet [1]. Moreover, the 17 Sustainable Development Goals (SDGs) are interconnected and required urgent action by all countries as a global partnership with strategies to enhance health and education, reduce inequality, and inducement of economic growth while tackling climate change. In other words, SDGs are a strong commitment to tackling the most important challenges facing the world today with the support of everyone.

The Paris Agreement, Nationally Determined Contributions in the Sri Lankan Context

Sri Lanka has submitted its first Nationally Determined Contributions (NDCs) to UNFCCC in 2016.NDCs of Sri Lanka were prepared based on the Readiness Plan for the Implementation of the Intended Nationally Determined Contributions (INDCs) 2017-2019 [1].

[1] [Online]. Available: https://www.un.org/sustainabledevelopment/.

NDCs consists of four main areas as follows:

- Mitigation
- Adaptation
- Loss and Damage
- Means of Implementation.

Energy (electricity generation), transport, industry, forest, and waste were identified as the five main sectors under the NDCs of mitigation while health, food security (agriculture, livestock, and fisheries), water and irrigation, coastal and marine, biodiversity, urban infrastructure & human settlement, together with tourism & recreation sectors were considered for adaptation. Minimization and management of possible losses and damages from adverse climate change events were discussed under loss and damage, whereas means of implementation were described considering three main important areas as finance, technology, and capacity building[2]. SDGs can be considered as a platform to study the economic, social and environment benefits of current NDCs.

Sustainable Development Goals in Sri Lankan Context

As a developing country, Sri Lanka has taken considerable initiatives to embed SDGs into the country's policy framework. Sustainable Development Act (2017) establishes the legal framework to implement the SDGs with improved institutional policy coherence. The establishment of the Sustainable Development Council under the act was another important step, and this council formulates SDG related national policies and guides new development projects to integrate SDGs to the project scope[3].

Accessible, timely needed, and reliable disaggregated data are key elements in achieving and monitoring sustainable development goals. To achieve these key elements, Sri Lanka has presented the country's first Voluntary National Review (VNR) in 2018 which was a collaborative and inclusive process, engaged multi-stakeholders [2].

[2] M. o. M. D. a. E. S. Lanka, in *Nationally Determined Contributions*, September 2016.

[3] [Online]. Available: https://www.unescap.org/blog/sdg-implementation-and-budgeting-sri-lanka.

Currently, Sri Lanka is in the process of localizing SDGs. As a part of the process the Sustainable Development Council of Sri Lanka has already mapped an agency framework [3] and a SDG portal [4]. The agency framework includes more than 400 agencies involve in SDG tracking. The SDG portal includes graphs, maps, data tables and meta data relevant to each SDG goal.

However, Sri Lanka has not yet conducted a project level sustainable development assessment for the nationally determined contributions. Therefore, a holistic approach to achieve both NDCs and SGDs is important.

Enhanced Transparency Framework (ETF) and existing MRV systems in Sri Lanka

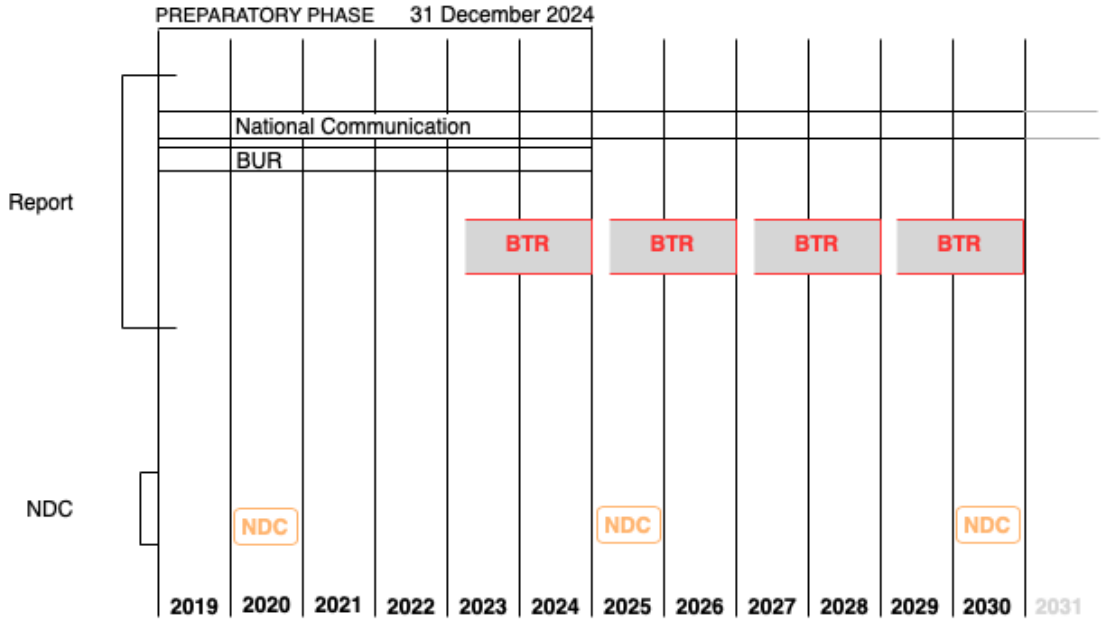

Figure 1: Key elements of an Enhanced Transparency Framework

Source: Maso et al. - 2019, *Unfolding the reporting requirements for Developing Countries under the Paris Agreement's: Enhanced Transparency Framework.*

Enhanced Transparency Framework (ETF) was established by Article 13 of the Paris Agreement. National Communications (NCs), Biennial Update Reports (BURs) and Biennial Transparency Reports (BTR) are the main elements of the ETF.

Regular measurement, reporting and verification are important in achieving timely and successful submission of the above-mentioned elements of ETF.

There are three main MRV (measurement, reporting and verification) types such as GHG emissions, mitigation actions and support. MRVs of GHG emissions conduct at national, organizational, and /or facility level. MRVs of mitigation actions assess the GHG effects and sustainable development effects (environmental, economic, and social) of the mitigation actions and monitor the implementation of mitigation actions. Support MRVs track the status of support received and provided, results, and impacts of support received by the countries. [5].

Out of the three types mentioned above, Sri Lanka has developed a MRV of GHG emissions for the transport sector in 2019 focusing on NDCs of the transport sector. However, the country has not experienced a MRV of mitigation action focusing on sustainable development effects. Therefore, the proposed sustainable development MRV for transport sector complement the existing GHG MRV of transport sector. In formulating the SD MRV framework, analysing linkages of NDCs towards SDGs is important. Therefore, "Initiative for Climate Action Transparency (ICAT)" SD methodology was applied in reaching the following objectives of the deliverable.

1.2 Objectives

The objective of the Initiative for Climate Action Transparency (ICAT)

The Initiative for Climate Action Transparency (ICAT) puts into practice the Paris Agreement's request to strengthen national institutions to meet enhanced transparency requirements. ICAT is a neutral, multi-donor fund designed to improve developing countries' capacity to assess the impacts of their actions to meet their NDCs and bring more outstanding quality, trust, and ambition to climate policies worldwide. ICAT is uniquely positioned as one of the only MRV programs that offer newly developed guidance related to the MRV of policies and actions as well as country capacity-building work. It builds upon the guidance being developed by UDP, WRI, and VCS, and counts on UDP's network of country partners for enhanced engagements. The roles of the implementing partners are to coordinate with the implementing country, and the selected consultants to achieve the objectives of the ICAT project in the implementing country.

The objective of the ICAT project in Sri Lanka

During the first phase of the ICAT project in Sri Lanka, ICAT together with other national entities developed the country's first GHG MRV system for transport sector mitigation actions, and currently, in its second phase, the following operations are carried out.

1) Digitalization of the Transport Sector MRV;
2) Develop a roadmap for the legal framework on MRV in the transport sector;
3) Develop SD MRV system for the Transport sector; and
4) Link the proposed SD MRV with the existing GHG MRV.

The objective of the deliverable

The main objective of the deliverable is to develop an SD MRV framework to track the Sustainable Development (SD) impacts of transport sector mitigation actions.

The output of ICAT project in Sri Lanka – Sustainable Development Assessment of the Transport Sector

i. First draft report on the proposed SD MRV framework for transport sector mitigation actions (based on the desk review); and
ii. Final report on the proposed SD MRV framework for transport sector mitigation actions (submitting after the completion of the validation workshop).

1.3 Scope

This report is the fourth deliverable of the development of the proposed SD MRV framework for the transport sector in Sri Lanka.

1.4 Limitations

Given the intention of linking two MRV systems (SD MRV and GHG MRV), the existing GHG MRV system for the transport sector of Sri Lanka was considered as a foundation for this assessment. Therefore, the assessment was limited to the NDCs, which were selected to develop the GHG MRV system. All possible impacts were identified covering environmental, social, and economical dimensions. However, data required to assess the identified impact were limited. Therefore, surveys will be required to collect more data.

2. Methodology

Overall approach: ICAT sustainable development methodology was applied as a framework for this assessment and was used to identify the relevant SD impacts (indicators) of the mitigation actions. Then, methodologies to assess SD impacts were collected via literature review. After that, institutions were identified to collect and report the data related to the parameters needed, to measure SD impacts under the identified methodology. Data management system and overall institutional arrangement were established based on the data requirements and the responsible agencies to complete the MRV.

ICAT sustainable development methodology consists of four main steps as follows:

i.) Defining the assessment.

ii.) Qualitative assessment.

iii.) Quantitative assessment; and

iv.) Drafting conceptual MRV.

These steps are described in detail below.

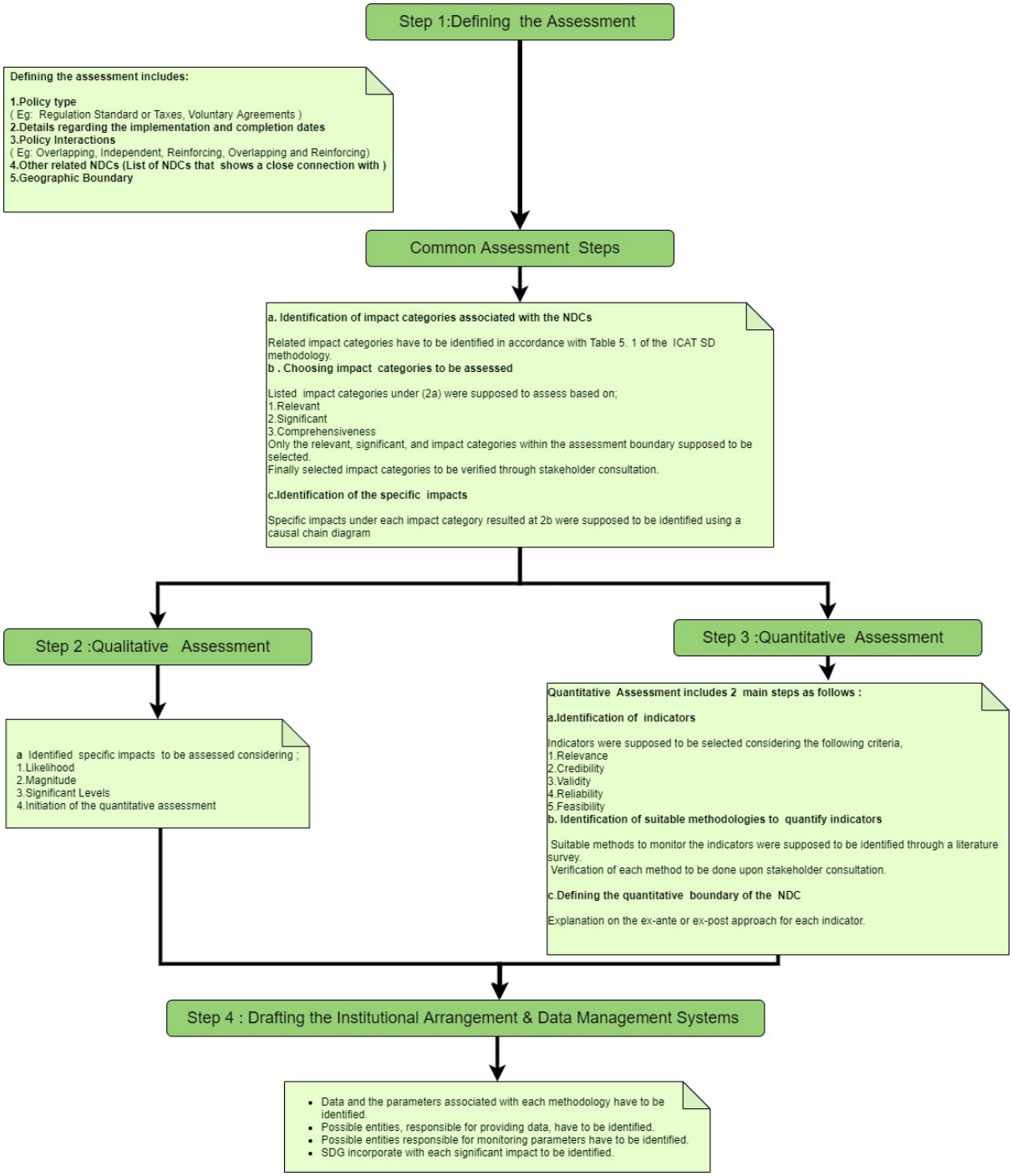

Figure 2: Summary of the Methodology Applied

Source: ClimateSI ,2021

i) Defining the Assessment:

Defining the assessment, by describing the policy (NDC/Sub NDC) at a broader view. This includes the policy type[4] (Eg: regulations and standards, taxes, and charges, voluntary agreements, or actions, etc.), details regarding the implementation and completion, responsible authorities, a basic overview of the policy including policy interactions /relationships.[5] (Eg: overlapping, independent and reinforcing) and the geographic boundary of the policy. Throughout the assessment, general assessment principles such as completeness, consistency and accuracy were well maintained.

Common Steps for Qualitative and Quantitative Assessment:

Following three steps are common for qualitative and quantitative assessment.

a) **Identification of impact categories associated with the NDC:**

All possible impact categories that come under the environmental, social, and economic dimensions were identified at this stage. The group of impact category and impact category were considered in the identification process. The group of impact categories (Eg: employment) and impact categories under each group (Eg: jobs, wages, and worker productivity) considered at the assessment are given in Annex 1[6].

b) **Choose the impact categories to be assessed**:

To ensure a complete and relevant assessment of the impacts resulting from the NDC/mitigation action, impact categories were assessed based on:

- Significance: determining which impact categories are expected to be significantly affected by the policy, either positively or negatively.
- Relevance: determining which impact categories address the intended objective of the policy.

[4] Eleven types of policies were introduced by the ICAT SD methodology, Table 1.1.

[5] Four types of policy interactions /relationships were introduced (independent, overlapping, reinforcing, overlapping and reinforcing) in the ICAT SD methodology, Table 4.3.

[6] Annex 1 was extracted from the table 5.1 of the ICAT SD methodology

- Comprehensiveness: completeness of the assessment including both negative and positive impacts covering environmental, social, and economic dimensions.

c) Identification of specific impacts under each impact category:

There are two different methods to identify specific impacts resulting from a policy or mitigation action. Those methods include a) developing a causal chain and b) a matrix table. In either method, stakeholder consultation, literature review, or expert judgment and comments are important.

ii.) Qualitative Assessment

a) Analyses of the identified specific impacts and completion of the qualitative analyses:

Identified specific impacts will be analysed considering likelihood, magnitude, and significance levels.

Table 1:Different Levels of Likelihood, Magnitude and Significance associate with the assessment

Likelihood of the occurrence of impact	Very Likely - ≥90% Likely <90% and ≥66% Possible <66% and ≥33%, Unlikely <33% and ≥10%, Very Unlikely <10%/
Magnitude of the impact	Major -The change in the impact is (or is expected to be) substantial in size, Moderate- The change in the impact is (or is expected to be) moderate in size (either positive or negative) Minor- The change in the impact category is (or is expected to be) insignificant in size
Significance of the impact	Insignificant - Any impact category that is minor, unlikely, or very unlikely. Significant - Any impact category that is moderate or major

Source: ICAT Sustainable Development Methodology ,2019

Commonly identified impacts include:

Environment:

- Reduction of GHG Emissions.
- Increase/ decrease of respiratory diseases due to the change of pollutants (PM) and increase /decrease air quality.
- Increase /decrease of noise levels.
- Increase /decrease odour level changes
- Increase /decrease waste generation
- Increase/decrease the impact to terrestrial/aquatic eco systems and biodiversity.

Social

- Increase/ decrease quality of life and wellbeing.
- Increase /decrease the traffic congestion.
- Increase/decrease the possible accidents.
- Increase/decrease equal opportunities for both men and women.

Economical

- Creation /loosing of jobs.
- Wages for employees.
- Increase /decrease the operational cost of vehicles.
- New business opportunities

Feasibility of measuring parameters, and in – out jurisdiction boundaries (Eg: air pollution impacted from the LRT during construction is not limited to the assessment boundary Malabe to Pettah (in jurisdiction); it can be affected on other adjacent cities and sometimes the neighbouring countries (out jurisdiction) were discussed at this step of the assessment, and it is an initiation for the quantitative assessment. Figure 3 demonstrates SDGs and associated impact categories.

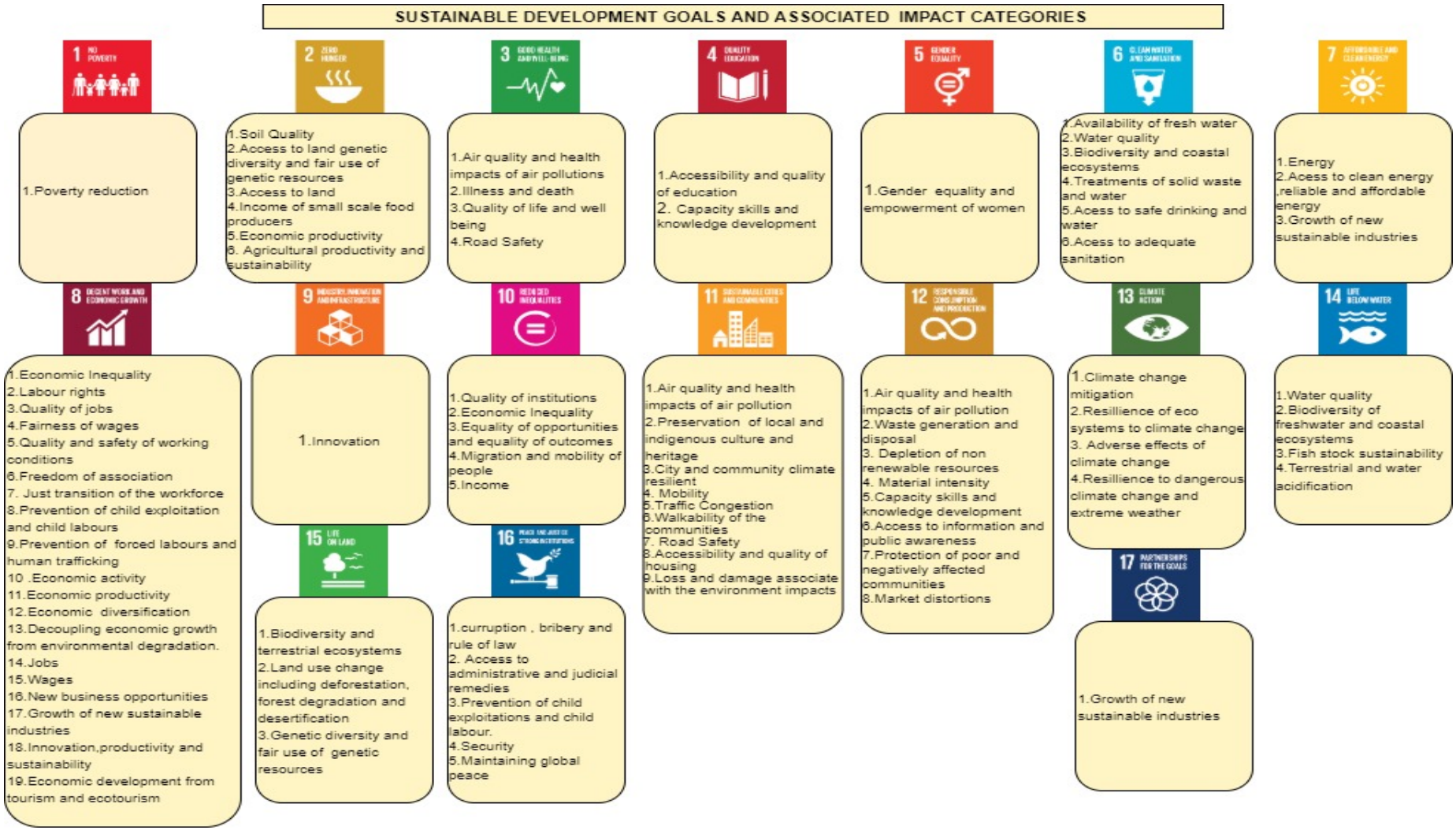

Figure 3: Sustainable Development Goals and Associated Impact Categories

Source: ICAT Sustainable Development Methodology ,2019

iii.) Quantitative Assessment:

Quantitative assessment comprises three main steps as follows:

a) Identification of indicators for specific impacts:

Quantifiable impacts were selected out of the list of impacts identified under the qualitative assessment. Indicators for each quantifiable impact will be identified considering the following criteria given in Table 2.

Table 2: Criteria for indicator selection

Criteria	Description
Relevance	Does the indicator measure what matters as opposed to what is easiest to measure?
Credibility	How trustworthy or believable are the data collected to the intended audiences of the evaluation report?
Validity	Whether a measurement measures what it is supposed to measure.
Reliability	If data on the indicator are collected in the same way from the same source using the same decision rules every time, will the same results be obtained?
Feasibility	Users should avoid trying to measure too much. Users should consider what indicators are already being monitored to limit the costs of data collection. Users should also consider whether the indicator can be measured directly or whether (and how many) parameters are needed to calculate the value of the indicator

Source: ICAT Sustainable Development Methodology ,2019

Commonly identified quantifiable impacts are as follows:

Environment:

- Reduction of GHG Emissions.
- Increase/ decrease of respiratory diseases due to the change of pollutants (PM) and increase/decrease air quality.
- Increase /decrease of noise levels.

Social

- Increase /decrease the traffic congestion.
- Increase/decrease the possible accidents.

Economical

- Creation /loosing of jobs.
- Wages for employees.
- Increase /decrease the operational cost of vehicles.

b) Identification of suitable methodologies to quantify the indicators.

Methodologies required to measure the indicators of selected impacts were collected through a desk review.

Identified methodologies were categorized as given below.

1) Proposed methodologies to quantify the environmental impacts.
2) Proposed methodologies to quantify social impacts.
3) Proposed methodologies to quantify economic impacts.
4) Common methodology for environmental, social and economic impacts.

Proposed methodologies to quantify the environmental impacts.

1. GHG impacts of mitigation actions.

Following methods applied in the GHG MRV system, will be used to quantify GHG impacts of mitigation actions:

- ACM0016: Baseline Methodology for Mass Rapid Transit Projects; Version 4.0.
- JICA Transport / Railway (Passenger) / Electrification Version 2 guideline.
- JICA Transport / Railway (Passenger) / Modal Shift - FIT Version 2.0.
- AMS III.C; emission reductions by electric and hybrid vehicles.
- ICAT transport pricing guidance.
- AM0090, "Modal shift in transportation of cargo from road transportation to water or rail transportation.

2. a) Health impacts of air pollution

All mitigation actions resulted a change of gaseous emissions and other pollutants (e.g., LRT increases emissions during construction and decreases during the implementation) and this change will lead to health impacts (e.g., respiratory diseases). Therefore, it is important to suggest a method to quantify health impacts associated with the air pollution.

Health impacts resulted from the air pollution can be monitored using the following equation. This method was selected over the other methods on health impacts of air pollution, as it focuses on the change of population risk. [6]

$$dHi = \beta XPOPi - dAi \quad (1)$$

Where:

dHi	change in population risk of health effect(i)
β	slope of the dose–response function
POPi	population at-risk of health effect i
dAi	change in level of air pollutant under consideration

Respiratory diseases (Eg: Bronchitis & Asthma) resulted from PM emissions are the main health impact associated with the air pollution. Therefore, PM amounts resulted from the mitigation action, will only be considered as the main pollutant in calculating dAi. Following default relationships given in the methodology can be considered in calculating the ‘‘slope of the dose response function”.

- The total number of yearly cases of chronic bronchitis per 100,000 persons is thus 6.12 * ([PM10]-100).

- The change in daily asthma attacks per asthmatic person is estimated at 0.0326 * ([PM10]-100).

Change in level of air pollutants (PM) can be measured using the methodologies given in the research articles. As such the method suggested by Ferm & Sjöberg.,2015 can be applied in measuring PM emissions associated with the road vehicles and, method suggested by Jeff et al.,2014 for rail.

b) Air Pollution

I. Air pollution associated with road transport.

Air pollutants include particulate matter (PM 2.5, PM10), SOx, NOx and N_2O.As the PM emissions were considered in calculation of health impacts in section 2a above, only the emissions of SOx, NOx and N_2O were proposed to be considered in the air pollution calculations.

Following equation was proposed, to calculate the air pollution resulted from the mitigation actions associated with road transport. [7]. Total emissions including SOx, NOx and N_2O will be considered.

$$Total\ \ Emissions = \sum_{abcd}(EF\ abcd * \ Activity\ abcd\ ) + \sum_b Cold\ b + \ \sum_b Evoporation\ b \quad (2)$$

Where:

EF	emission factor, as mass per unit of activity rate
Activity	activity rate (fuel consumed or distance travelled)
Cold	extra emissions due to cold starts
Evaporation	extra emissions due to evaporation (NMVOCs)
Total emission	gases including SOx, NOx and N_2O
a	fuel type (petrol, diesel, LPG, etc.)
b	vehicle type (passenger car, light-duty truck, bus, etc.)
c	emission control

d road type or vehicle speed

II. Air pollution associated with the train system.

Following two equations were proposed, to calculate the air pollution (SOx, NOx and N_2O) resulted from the mitigation actions associated with fossil fuel – based train system.

To calculate NOx and N_2O:

$$Ei = \sum_m FC_m \times EF_{i,m} \quad (3)$$

Where:

E_i Emissions of pollutant i for the period concerned in the inventory (kg or g)

FC_m Fuel consumption of fuel type m for the period and area considered (tonnes)

EF_i Emission factor of pollutant i for each unit of fuel type m used (kg/tonnes)
m Fuel type (diesel, gas oil)

To calculate SO_2:

$$E_{SO2} = 2 \times \sum_m k_{s,m} \times FC_m \quad (4)$$

Where:

E_{SO2} Emissions of sulphur dioxide for the period concerned in the inventory [kg]

$K_{s,m}$ The sulphur content in the fuel (% by mass).

FC_m fuel consumption of fuel m [g].

3. Noise pollution

Noise level of the respective area where mitigation action take place may change after the implementation of the mitigation action. Following equations can be used in predicting noise levels for railways and measuring noise level of road transportation.

a) Measuring noise levels from construction sites -LRT

Following equation can be used to measure the noise levels associated with the construction of LRT.

Noise level of a single noise source in a construction site

$$L=Lw -20\log (r) -8 \text{ dB (A)} \quad (5)$$

L	Noise level at a distance of (m) from the noise sources (dB (A)r=1
Lw	Noise power level of single noise source (dB (A)) in construction
8dB(A)	Noise level at l m from the noise source

Total Noise level of all noise sources in a construction site

$$L= 10\log \left(\frac{10^{L1}}{10} + \frac{10^{L2}}{10} + \cdots \frac{10^{Ln}}{10}\right) \quad (6)$$

L	Combined noise level (dB (A)
L1, L2……Ln	Noise level of each equipment (d B(A))

b) Predicting noise levels for railways

The emission level Lm, E determined at the perpendicular distance of 25 m from the railway line axis at the height of 4m above the terrain.

$$Lm, E = 10 \log[\sum 10^{(0,1.(51+D_{Fz}+D_D+D_L+D_V))}] + D_{Tt} + D_{Br} + D_{Lc} + D_{Ra} \quad (7)$$

Where:

D_{FZ}, D_D, D_L, D_V	Correction for the specific train
D_{Tt}, D_{Br}, D_{Lc}, D_{Ra},	Correction characterizing the railway line
$L_{m,E}$	Emission Levels

c)Measuring the noise level of road transportation.

Pressure of the sound will change according to the noise(vibrations) produce [8]. Therefore, change of the pressure of the sound, can be calculated to represent noise levels, using the following equation. Then the noise level change can be identified by measuring the sound pressure levels in baseline scenario and the project scenario [9].

$$10L_{AeqT} = 10 \log_{10} \left(\frac{1}{T} \sum_{i=1}^{N} 10^{L_{Ai}/10} \right) \quad (8)$$

Where:

N	number of 1-second samples (at least 10)
T	the duration of the measurement interval (in seconds)
LAi	the ith A=weighted sound pressure level (in dB (A))
L_{AeqT}	Sound pressure level

Given methodology is more suitable for the ex-post analysis of the noise level. However, possibility of applying this for the ex-ante analysis depends on the availability of estimated data as a part of a project activity.

Proposed methodologies to quantify the social impacts.

1.Road safety

Rate of occurring accidents and rate of occurring deaths due to accidents may change with the implementation of mitigation actions. Following method can be used to calculate the rate of accidents and rate of deaths associated with the accidents [10]

$$R_D = \frac{D}{N.L.m.365'} \quad (9)$$

$$R_p = \frac{P}{N.L.m.365'} \quad (10)$$

Where:

R_D	Rate of road accidents in the road section
D	Number of all road accidents on the road section over the period of study
N	Average annual daily traffic (vehicles/day)
L	Length of the section under study (km)
m	Account period
R_P	Rate of human death in an accident on the road section under study
P	number of fatalities in road accidents on the road section over the period of study

2.Traffic congestion

Traffic congestion of the respective area, where the mitigation action take place may change with the implementation of the mitigation action. Following steps can be carried out in calculating the traffic congestion [11].

1. Estimate the daily volume of vehicles per lane corresponding to the congested peak hours.
2. Calculate daily vehicle kilometers travelled (DVKT) for each roadway section as the average daily traffic (ADT) of a section of roadway multiplied by the length of that section of roadway.
3. Calculate peak period volume.
4. Determine average freeway speeds during the peak period based on data collected from travel time and speed surveys in corridors.
5. Estimate travel delay is the difference between the amount of time it takes to travel the peak-period vehicle-kilometers at the average speed and at free-flow speeds is termed delay.
6. Calculate daily recurring vehicle-hour delay.

Proposed methodologies to quantify the economic impacts.

Cost and cost savings

Most of the mitigation projects reduce the private vehicle usage and that will reduce the fuel usage. Therefore, fuel cost reduction can be considered as the main indicator for cost and cost savings. Fuel consumption associated with each mitigation action can be calculated as a part of the GHG emission calculations, using following methods.

- ACM0016: Baseline Methodology for Mass Rapid Transit Projects; Version 4.0.
- JICA Transport / Railway (Passenger) / Electrification Version 2 guideline.
- JICA Transport / Railway (Passenger) / Modal Shift - FIT Version 2.0.
- AMS III.C; emission reductions by electric and hybrid vehicles.
- ICAT transport pricing guidance.

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

Following equation can be used to calculate the fuel cost:

Fuel Cost = Fuel Consumption * Unit cost of fuel (11)

All the economic impacts are mitigation action specific. Therefore, a relative improvement of the mitigation action will be calculated using the following common methodology. Data related to other indicators (e.g., jobs, wages) will be collected specific to the mitigation action by conducting surveys.

Common methodology for environmental, social, and economic impacts

Calculating the relative improvement due to the mitigation action.

ICAT SD methodology suggests following equations to calculate the relevant improvement due to mitigation actions. Data associated with environmental, social, and economic indicators such as, amount of waste generated, proportion of women in the labour force, average hourly wages, number of new jobs created, fuel cost or cost savings need to be collected through surveys.

For impact categories where the goal is to increase the indicator value (e.g.: jobs)

$$Relative\ improvement\ (\%) = \frac{Policy\ \ scenario\ impact - Baseline\ scenario\ impact}{Baseline\ scenario\ impact} \quad (12)$$

For impact categories where the goal is to decrease the indicator value (e.g.: air pollution)

$$Relative\ improvement\ (\%) = \frac{Baseline\ \ scenario\ \ impact - Policy\ \ scenario\ impact}{Baseline\ \ scenario\ \ impacts} \quad (13)$$

Where:

Baseline scenario impact	Impacts before implementing the mitigation action
Policy scenario impact	Impacts due to the presence of the mitigation action

c)Defining the quantitative boundary of the assessment (ex – ante & ex -post)

Methods suggested above, can be used for both ex-ante (forward looking) and ex- post (backward looking) approaches. However, most of the mitigation actions associate with the transport sector NDCs are not implemented yet and project specific data are currently not available. Therefore, possibility of applying these methods for the ex-ante analysis depends on the availability of project specific estimated data, literature survey (based on similar projects) and based on appropriate assumptions.

iv) Drafting the institutional arrangement and data management systems

Suitable indicators were selected for the quantifiable specific impacts as explained in the previous steps. Data and the parameters associated with each of the quantifiable indicators were identified and possible entities responsible for providing the data for the identified parameters were mapped.

3. Assessment Outcomes

3.1 Introduce park & ride system.

3.1.1 Outcome of step 01: Defining the Assessment.

Introduce park and ride system is the sub NDC 4.1 of the fourth main NDC, "Shift passengers from private to public transport mode". This can be categorized under the policy type "infrastructure building program" as per the ICAT SD guidance. Introduction of LRT system is one of major project to be implemented under this NDC. Proposed LRT system from "Malabe to Colombo Fort" was selected for this study. As this project is not implemented yet, it will be assessed applying ex -ante (forward -looking) approach.

The overall objective of the project is to create more liveable cities while reaching specific objectives such as mitigating the current traffic congestion at the Malabe corridor, reducing fuel use, air pollution, and providing efficient transport. This sub NDC shows a closer interaction with sub NDC 5.2 "Purchase new rolling stocks for Sri Lanka -railway". The project management unit of JICA will take the main responsibilities of the implementation and maintenance of the project.

Baseline scenario of the assessment: Use of private vehicles to transport passengers from Malabe to Colombo Fort.

Project scenario of the assessment: Use of LRT to transport passengers from Malabe to Colombo Fort.

The route contains 16 stations including IT Park and Pettah station as shown in figure 04.

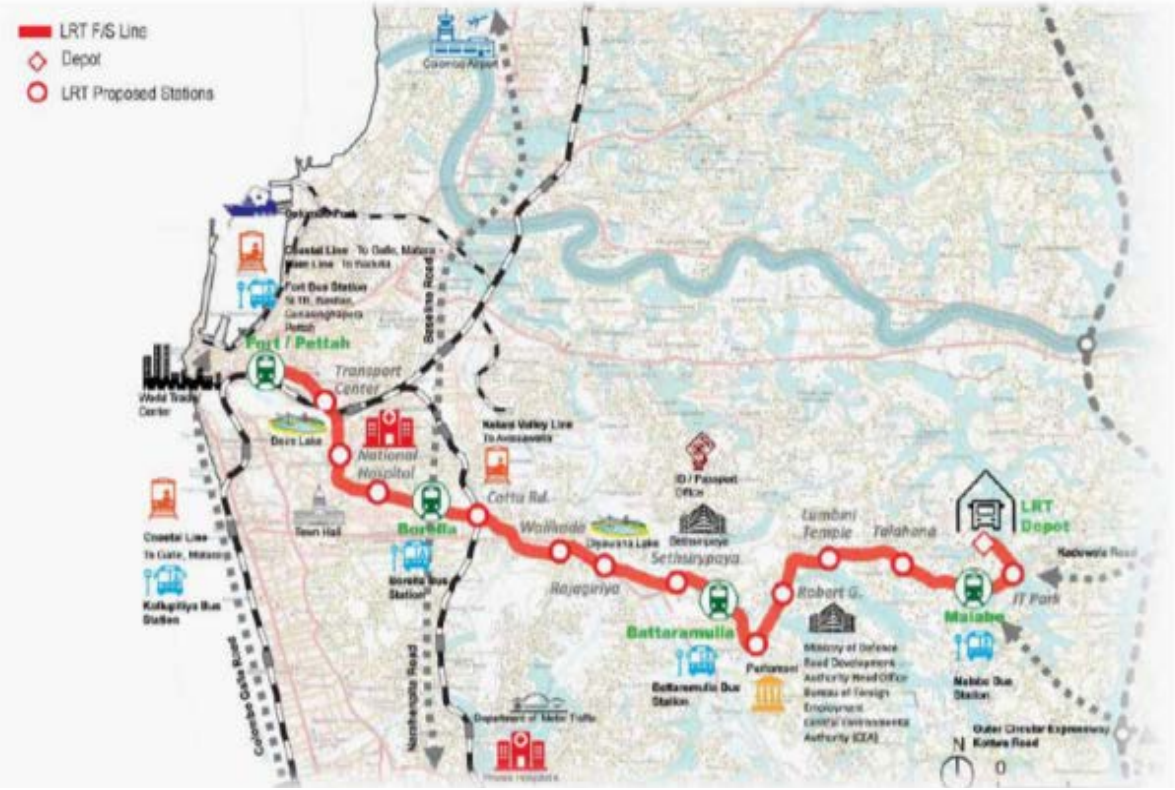

Figure 3:Geographic Boundary of the NDC: Malabe to Colombo Fort

Source: Ministry of Megapolis and Western Development, 2018, *Environmental Impact Assessment for Colombo Light Rain Transit (LRT) Project.*

3.1.2 Outcome of step 02: Qualitative Assessment

2a) Identification of the impact categories associate with NDC.

A wide variety of sustainable development impact categories are associated with the NDC. Impacts categories covering three dimensions of sustainable development were identified by experts from the list of impact categories given in ICAT SD guideline (Annex 1).

2b) Choosing impact categories to be assessed.

Identified impact categories under step 2a were further filtered considering following criteria: relevance, significance, comprehensiveness, and alignment within the assessment boundary. The outcomes of steps 2a & 2b are given in Annex 2-1.

Initial analysis has identified 24 impact categories which are relevant to the selected sub NDS. Out of those only 18 impact categories were chosen for the assessment considering relevance, significance, and the assessment boundary. Selected categories include; climate change mitigation, health impacts of air pollution, odours, waste generation and disposal, biodiversity and terrestrial ecosystems, loss of ecosystem services from air pollution, aesthetic impacts, noise pollution, illness and death, quality of life and well-being, gender equality and empowerment of women, traffic congestion, road safety, jobs, cost reduction, and cost savings, wages, economic activity, and new business opportunities.

2c) Identification of the specific impacts

Specific impacts were identified under each impact category upon drawing causal chains, as shown in figure 05. Nearly 27 specific impacts were identified under each impact category.

2d) Qualitative assessment of the identified specific impacts

Identified specific impacts were assessed against the likelihood of occurring the impact, magnitude of the impact, and significance levels, as shown in table 03.

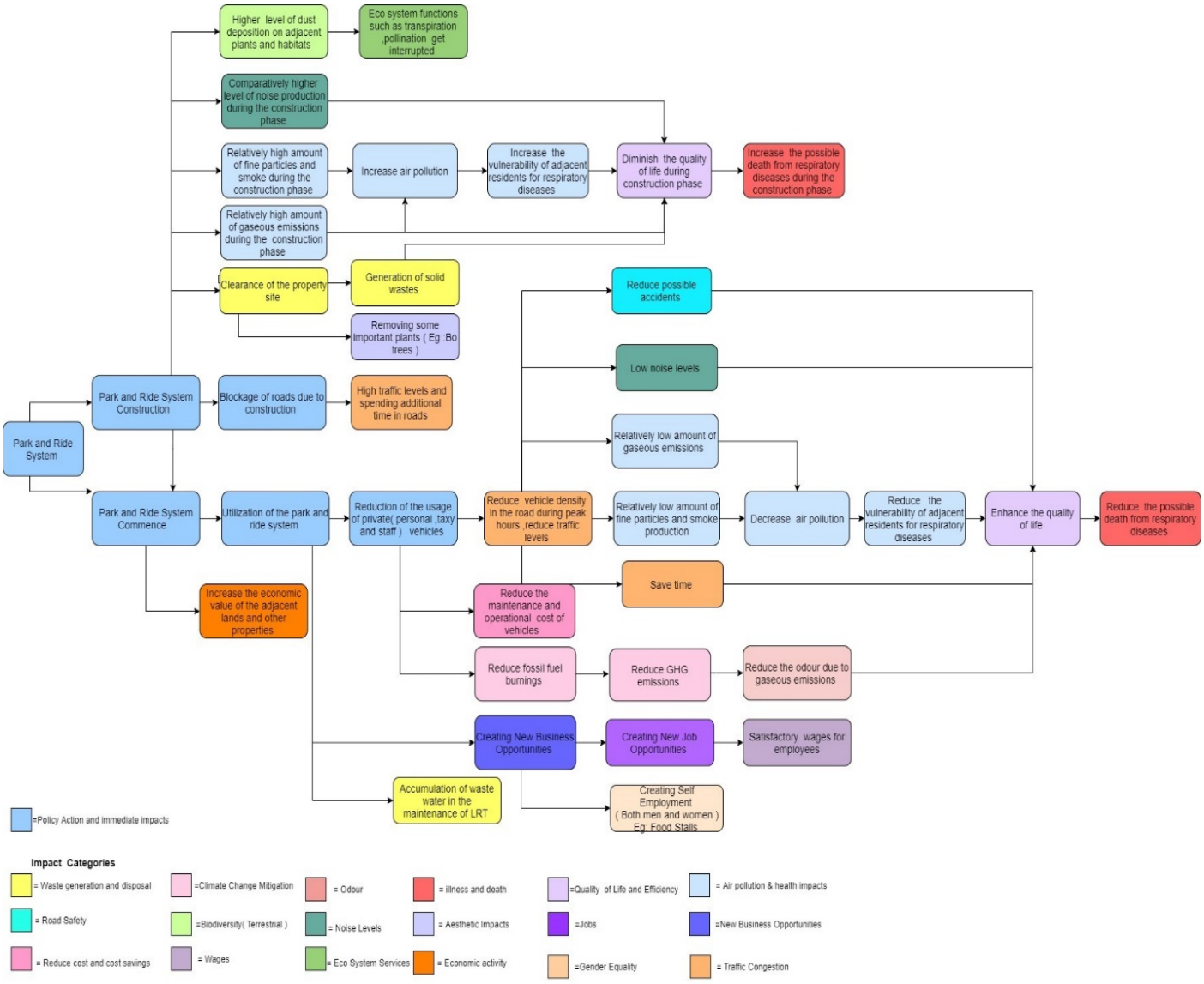

Figure 5: Causal Chain of the Sub NDC 4.1

Source: ClimateSI, 2021

Table 3:Qualitative assessment of the NDC 4.1

Impact* category	Specific impacts identified	Jurisdiction[7] (In/Out)	Qualitative analysis						Defining the boundary for quantitative assessment	
			Likelihood	Magnitude	Positive or negative	Significant	Summary of qualitative assessment results for each impact category	Methods/ sources used in the identification of specific impact	Feasible to quantify	Included in the quantitative assessment boundary
Dimension: Environment										
Climate change mitigation (SDG 13)	Reduction of GHG due to the minimal usage of private vehicles	In/out	Very likely	Major	Positive	Significant	The major positive impact was observed	(Filosa et al., 2017) [12]	Yes	Yes
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Increase the vulnerability of adjacent residents for respiratory diseases due to the high pollutants (PM) during the construction phase of LRT	In	Very likely	Major	Negative	Significant	The major negative impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
	Reduce the vulnerability of adjacent residents for respiratory diseases due to the low pollutants (PM) during the implementation phase of LRT	In	Very likely	Major	Positive	Significant	The major positive impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
	Increase air pollution due to high gaseous emissions	In	Very likely	Major	Negative	Significant	The major negative impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
	Decrease air pollution due to low gaseous emissions.	In	Very likely	Major	Positive	Significant	The major positive impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
Odour	Low level of uncomfortable smell due to the low level of gaseous emissions after the implementation of LRT	In/out	Possible	Moderate	Positive	Significant	A moderate positive impact was observed	(Britneff ,2020) * [14] [15]	No	No
Biodiversity of terrestrial eco systems	Dust from the construction sites deposits on the surface	In	Possible	Major	Negative	Significant	A major negative impact was observed	(Yan,2014) [16]	No	No

[7] In and out of the jurisdiction –
In _of _Jurisdictions impacts relevant for the national mitigation actions
Out-of-jurisdiction impacts may be especially relevant for subnational mitigation actions that have impacts in other subnational regions within the same country (ICAT SD Methodology ,63pg) (applicable for all quantitative tables)

(SDG 15)	of the adjacent plant leaves									
Loss of ecosystem services from air pollution	Reduce the ecosystem services. (Eg: Deposition of dust particles will reduce the ecosystem services such as pollination and physiological processes like transpiration)	In	Possible	Minor	Negative	Insignificant	A minor negative impact was observed	(Ying, 2010) [17]	No	No
Waste generation and disposal (SDG 12)	Site clearance for construction and the accumulation of waste.	In	Very Likely	Major	Negative	Significant	The major negative impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	No	No
	Accumulation of wastewater in maintenance of LRT	In	Very Likely	Major	Negative	Significant	The major negative impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
Noise Pollution	Higher noise levels during the construction	In	Likely	Major	Negative	Significant	The major negative impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
	Lower noise levels after the implementation of LRT	In	Likely	Major	Positive	Significant	The major positive impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
Dimension: Social										
Illness and death (SDG 3)	Increase the possible deaths from respiratory diseases during construction phase.	In	Possible	Minor	Negative	Insignificant	The minor negative impact was observed	(Siribaddana et al., 2019) [18]	No	No
	Reduce the possible deaths from respiratory diseases.	In	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	No	No
Aesthetic Impacts	Removal of Bo trees (Which has a significant religious value) due to construction	In	Very Likely	Major	Negative	Significant	The major negative impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	No	No
Quality of Life and Well Being (SDG 3)	Diminished the quality of life of the adjacent residence during the construction phase of the LRT (Due to higher noise levels, generation of waste, etc)	In	Possible	Major	Negative	Significant	The major negative impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	No	No
	Enhance the quality of life of during the implementation phase. (Due to time savings, low noise levels, low number of accidents ,etc)	In/out	Possible	Major	Positive	Significant	The major positive impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	No	No

Gender equality and empowerment of women (SDG 5)	Opportunities for self-employment (Eg –food stalls) for both men and women	In	Major	Moderate	Positive	Significant	The major moderate impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
Traffic congestion (SDG11)	Traffic levels increase during the construction phase of the LRT	In	likely	Major	Negative	Significant	The major and negative significant impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
	Traffic levels decreases after the implementation of LRT	In	likely	Major	Positive	Significant	The major and positive significant impact was observed	(Environment Impact Assessment of the Colombo Light Railway Transit,2018) [13]	Yes	Yes
Road safety (SDG 3,11)	Reduce possible accidents during peak hours	In	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	Sri Lanka Police,2021 [19]	Yes	Yes
Dimension: Economical										
Wages (SDG 8)	Satisfactory wages for employees	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [13]	Yes	Yes
Jobs (SDG 8)	Create new job opportunities. Loss of job opportunities	In In	Very Likely Very Likely	Moderate Moderate	Positive Negative	Significant Significant	A moderate positive impact was observed. A moderate negative impact was observed	ICAT SD Methodology [13] ICAT SD Methodology [13]	Yes Yes	Yes Yes
Cost and cost savings	Reduce the maintenance and operation cost of private vehicle	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [13]	Yes	Yes
New business opportunities	Create new business opportunities after the implementation of LRT	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [13]	Yes	Yes
Economic activity	Increase the economic value of adjacent lands and other properties	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [13]	No	No

Source: ClimateSI, 2021

3.1.3 Outcome of step 03: Quantitative Assessment

Out of the identified 27 specific impacts (covering environmental, social, and economic dimensions), 15 specific impacts were selected as quantifiable impacts that are within the scope of the assessment.

Table 4: Selection of quantifiable impacts for NDC 4.1

Description	Amount Considered	Reference from the document
Impact categories associate with the NDC	24	Annex 2-1
Number of impact categories chosen for the assessment	18	Annex 2-1 (highlighted in red) Key of the causal chain Table 3-column 1
Qualitative Assessment		
Total number of specific impacts considered under each category	27	Table 3-column 2
Quantitative Assessment		
Quantifiable specific impacts	15	Table 5 -column 2

Source: ClimateSI,2021

3a) Identification of the possible indicators for quantification

Adhering to the guidance given in table 2 of this report and referring to table 5.5 of the ICAT SD methodology, suitable indicators were identified to monitor those specific impacts.

3b) Identification of the possible methodologies /parameters for each indicator

Potential methodologies and related parameters to monitor the indicators were identified upon literature survey. The outcomes of step 3a and 3b are given in table 05.

Table 5:Quantitative assessment of the NDC 4.1

Step 3 a.- Identification of indicators			Step 3b. Identification of suitable methodologies to quantify the indicators	Data collection mechanism	
Impact category	**Specific impacts identified**	**Indicator[8]**	**Proposed methodology.**	**Parameters**	**Relevant entities/reference documents which data can be acquired**
Dimension: Environment					
Climate change mitigation (SDG 13)	Reduction of GHG due to the minimal usage of personal vehicles	Net emissions of greenhouse gases	ACM 0016: Mass Rapid Transit Projects, Version 4.0 will be used as given in the MRV framework for Transport Sector Sri Lanka. **Equation for the Baseline emission:** $BEy = \frac{Py}{PSPER}\sum_{p}(BEp,y \cdot FEXp,y)$ **Equation for the Project emission:** $PEEC,y = \sum_{j} ECPJ,j,y \times EFEL,j,y \times (1 + TDLj,y)$ Emission Reduction= $BEy - PEEC,y$	**Baseline emission:** BE_y Baseline emissions in year y (t CO_2) $BE_{p,y}$ Baseline emissions per surveyed passenger p in year y (t CO_2) $FEX_{p,y}$ Expansion factor for each surveyed passenger p surveyed in year y. (each surveyed passenger has a different expa P_y Total number of passengers in year y P_{SPER} Number of passengers in the time of the survey (1 week) p Surveyed passenger (everyone) y Year of the crediting period **Project emission:** $PE_{EC,y}$ Direct project emissions from electricity consumption in year y (t CO_2) $EC_{PJ,j,y}$ Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/yr) $EF_{EL,j,y}$ Emission factor for electricity generation for source j in year y (tCO_2/MWh)	**Documents** GHG MRV document for transport sector mitigation actions of Sri Lanka **Entities** CEB CEYPETCO CPSTL Ministry of Urban Development, Cost Conservation, Waste Disposal and Community Cleanliness O & M Company of LRT Sri Lanka Sustainable Energy Authority

[8] Indicators were extracted from the table 5.5 of the ICAT sustainable methodology and the indicators marked with * were extracted from the solar PV incentive case study (applicable for all quantitative tables)

				$TDL_{j,y}$ Average technical transmission and distribution losses for providing electricity to source j in year y	
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Reduce or increase respiratory diseases due to low or high number of pollutants (PM)	Proportion of population with diagnosed respiratory diseases.	dHi = βX POPi _ dAi	**Baseline Scenario**: Proportion of population with diagnosed respiratory diseases before implementation of LRT. **Project Scenario:** Proportion of population with diagnosed respiratory diseases after implementation of LRT. (Same equation can be considered in both baseline and project scenarios; Baseline scenario can be considered as zero) dHi — change in population risk of health effect(i) β — slope of the dose–response function POPi — population at-risk of health effect i dAi — change in level of air pollutant under consideration.	**Entities** Central Environment Authority Department of Census and Statistics Vehicle Emission Testing Service
	Reduce or increase air pollution due to the low or high levels of gaseous emissions	Emissions of air pollutants (t/year)	**Baseline Scenario:** $Total\ Emission = \sum_{abcd} (EF\ abcd \times Activity\ abcd) + \sum_{b} Cold\ b + \sum_{b} Evoporation\ b$ **Project Scenario:** Due to the zero tailpipe emissions, gaseous emission in the policy scenario will be considered as zero.	**Baseline Scenario**: Emissions of air pollutants(t/year) (NO_X, N_2O &SO_X) from private vehicles. **Project Scenario:** Emissions of air pollutants (t/year) (NO_X, N_2O &SO_X) from LRT after implementation. EF — Emission factor, as mass per unit of activity rate Activity — activity rate (fuel consumed or distance travelled) Cold — Extra emissions due to cold starts Evaporation — extra emissions due to evaporation (NMVOCs) A — fuel type (petrol, diesel, LPG, etc.)	

				B vehicle type (passenger car, light-duty truck, bus, etc.) C emission control D road type or vehicle speed	
Waste generation and disposal (SDG 12)	Accumulation of wastewater in maintenance of LRT	Wastewater generated.	Relevant data to be collected upon a site survey. Relative improvement (%) = (Total wastewater collected per day after implementation of LRT -Total wastewater collected per day before implementation of LRT) / Total wastewater collected per day before implementation of LRT. *100% Baseline scenario can be considered as zero.	**Baseline Scenario**: Total wastewater collected per day before implementation of LRT. **Project Scenario:** Total wastewater collected per day after implementation of LRT.	**Entities** O & M Company
Noise Pollution	Increase noise levels during the construction of the LRT	Noise Level (dB)	L=Lw -20log (r) -8 dB (A) In addition, the combined noise level generated. $L = 10\log\left(\frac{10^{L1}}{10} + \frac{10^{L2}}{10} + \cdots \frac{10^{Ln}}{10}\right)$ Baseline scenario can be considered as zero.	**Baseline Scenario**: Noise levels before starting the construction of LRT. **Project Scenario:** Noise levels after starting the construction of LRT. L Noise level at a distance of r (m) from the noise sources (dB (A)) Lw Noise power level of noise source (dB (A)) 8dB(A) Noise level at l m from the noise source L Combined noise level (dB (A)) L1, L2……Ln Noise level of each equipment (d B(A))	**Entities** O & M Company Industrial Technology Institute

	Decrease noise levels in the implementation of the LRT.	Noise Level (dB)	$10L_{AeqT} = 10\log_{10}\left(\frac{1}{T}\sum_{i=1}^{N} 10^{L_{Ai}/10}\right)$	**Baseline Scenario**: Noise levels from private vehicles before the implementation of LRT. **Project Scenario:** Noise levels from LRT after the implementation. (Same equation can be considered in both baseline and project scenarios) N number of 1-second samples (at least 10) T the duration of the measurement interval (in seconds) L_{Ai} the ith A=weighted sound pressure level (in dB(A))	**Entities** Industrial Technology Institute
Dimension: Social					
Gender equality and empowerment of women (SDG 5)	Opportunities for self-employment (Example –Food Stalls) for both men and women	The proportion of the number of women in the labour force.	Relevant data to be collected upon survey. **Equation for relative change:** (The proportion of women in the workforce associated with the LRT after the implementation – The proportion of women in the workforce associated with the LRT before the implementation)/ The proportion of women in the workforce associated with the LRT before the implementation * 100%	**Baseline Scenario:** The proportion of women in the workforce associated with the LRT before the implementation. **Project Scenario:** The proportion of women in the workforce associated with the LRT after the implementation.	**Entities** O & M Company
Traffic Congestion (SDG11)	Traffic levels increase during the construction phase of the LRT	Time lost during transportation.	Applying principal corridors collective assessment for corridors speed plot Travel delay= Amount of time it takes to travel the peak -period vehicle kilometres at the average speed -	**Baseline Scenario:** The time loss of transportation from private vehicles before the construction of LRT. **Project Scenario:** The time loss of transportation from private vehicles during the construction of LRT.	**Entities** Sri Lanka Police

			Amount of time it takes to travel at the free flow speed	Daily vehicles per lane corresponding to the congested peak hours. Daily vehicle kilometres travelled. Length of the roadway Average freeway speeds during the peak period	
	Time savings due to the low traffic levels after the implementation of LRT	Time lost during transportation.	Applying Principal Corridors Collective Assessment for Corridors speed plot Travel delay= Amount of time it takes to travel the peak -period vehicle kilometres at the average speed - Amount of time it takes to travel at the free flow speed	**Baseline Scenario:** The time loss of transportation from private vehicles before the implementation of LRT. **Project Scenario:** The time loss of transportation due to the implementation of LRT. Daily vehicles per lane corresponding to the congested peak hours. Daily vehicle kilometres travelled. Length of the roadway Average freeway speeds during the peak period Average Speed during the peak	**Entities** Sri Lanka Police
Road safety (SDG 3,11)	Reduce possible accidents during peak hours	Number of deaths and injuries from road traffic accident per year	Relevant data to be collected upon traffic audit survey. Rates of the accidents and rate of death due to the accidents can be estimated using the following equations. **Rate of road accidents in the road section under study** $R_D = \frac{D}{N.L.m.365'}$ **Rate of human deaths in an**	**Baseline Scenario:** Number of deaths and injuries from road traffic accidents due to private vehicles **Project Scenario:** Number of deaths and injuries from road traffic accidents due to LRT R_D Rate of road accidents in the road section D Number of all road accidents on the road section over the period of study N Average annual daily traffic (vehicles/day)	**Entities** Sri Lanka Police

			accident on the road section under study $$R_p = \frac{P}{N.L.m.365'}$$ Number of deaths and injuries from road traffic accident per year has to be considered as zero in project scenario	L Length of the section under study (km) m Account period R_P Rate of human death in an accident on the road section under study P number of fatalities in road accidents on the road section over the period of study N Average annual daily traffic (vehicles/day) L Length of the section under study (km) m Account period	
Dimension: Economical					
Wages (SDG 8)	Satisfactory wages for employees	Average hourly wage[9] for employees associate with LRT	Relevant data to be collected upon employer survey. **Equation for relative change:** Average hourly wage of the employee attached to the LRT – Average hourly wage earned by the employees at their previous employment.) / Average hourly wage earned by the employees at their previous employment. *100%	**Baseline Scenario**: Average hourly wage earned by the employees at their previous employment. **Project Scenario:** Average hourly wage of employees attached to the LRT.	**Entities** O & M Company
Jobs (SDG 8)	Create new job opportunities due to LRT.	Number of new jobs created during the construction of LRT. (Temporary jobs)	Relevant data to be collected upon employer survey. Relative improvement (%) = (Number of new jobs created during the	**Temporary Jobs:** **Baseline Scenario**: Number of jobs created before the construction of the LRT. **Project Scenario**: Number of new jobs created during the construction of the LRT.	**Entities** O & M Company

[9] The indicator was extracted from the table 5.5 of the ICAT SD methodology. Average hourly wages of the employees in the transport sector (LRT operation and other modes) will be considered in calculations.

		Number of permanent jobs created during the maintenance of LRT. (Permanent jobs)	construction of the LRT - Number of jobs created before the construction of the LRT.) / Number of jobs created before the construction of the LRT. *100% **Equation for relative change:** (Number of permanent jobs associate with LRT after implementation. – Number of permanent jobs associate with LRT before implementation.)/Number of permanent jobs associated with LRT before implementation *100%	**Permanent jobs:** **Baseline Scenario:** Number of permanent jobs associate with LRT before implementation. **Project Scenario:** Number of permanent jobs associate with LRT after implementation.	
	Loss of jobs opportunities due to the LRT	Number of jobs lost by employees attached to other transport modes.	Relevant data to be collected upon employer survey. **Equation:** (Number of employees working in private (e.g., taxy, staff service, etc) transport modes before implementation of LRT. - Number of employees working in private (e.g., taxy, staff service, etc) transport modes after the implementation of LRT) / Number of employees working in private (e.g., taxy, staff service, etc) transport modes before implementation of LRT * 100%	**Baseline Scenario:** Number of employees working in private (e.g., taxy, staff service, etc) transport modes before implementation of LRT. **Project Scenario** Number of employees working in private (e.g., taxy, staff service, etc) transport modes after the implementation of LRT.	**Entities** Local Authorities Provincial Councils
Cost and cost savings	Savings of the operation cost of privately owned vehicles	Fuel costs or cost savings	Fuel Consumption = $N_{i,n,x}$*$SFC_{i,n,x}$ Fuel Cost =Fuel Consumption * Unit cost of fuel type n	**Baseline Scenario:** Fuel costs to travel from Malabe to Pettah by a private vehicle. **Project Scenario** Electricity cost to travel from Malabe to Pettah by LRT.	**Entities** O & M Company of LRT CPSTL

				$N_{i,n,x}$ Number of vehicle -kilometres vehicle category *i* using fuel type n^2 driven in year *x* (VKM) or number of vehicles in vehicle category *i* using fuel type n^3 in year x (units) $SFC_{i,n,x}$ Specific fuel consumption of vehicle category *i* using fuel type n in year *x* (mass or volume units of fuel/km)	
New business opportunities	Create new business opportunities after the implementation of the LRT	Number of new start-ups /businesses after the implementation of LRT	Relevant data to be collected upon social survey. **Formular will be updated according to the mitigation action as follows:** (New businesses and shops within the area of proposed 16 stations after the implementation f LRT. - Existing businesses and shops within the area of proposed 16 stations.)/ Existing businesses and shops within the area of proposed 16 stations. *100%	**Baseline Scenario** Existing businesses and shops within the area of proposed 16 stations. **Project Scenario:** New businesses and shops within the area of proposed 16 stations after the implementation of LRT.	**Entities** Local Authorities Provincial Councils

Source: ClimateSI,2021

Refer institution wise procedures (deliverable 4.1) for more details on data collection templates.

3.1.4 Outcome of step 04: Institutional arrangement and data management systems

There are 9 institutions involve in the MRV framework of NDC 4.1. Namely the Ceylon Electricity Board (CEB), Ceylon Petroleum Storage Terminal Limited (CPSTL), Ceylon Petroleum Corporation (CEYPETCO), Local Authorities (LA), Sri Lanka Police (SLP), Central Environment Authority (CEA), Department of Census and Statistics (DCS), Vehicle Emission Testing (VET) Service, O & M Company, and Industrial Technology Institute (ITI) are the nine institutions.

All the institutions are responsible for a specific task as shown in table 06.

Table 6: Roles and Responsibilities of the Institutions involve in NDC 4.1.

Institution	Roles and Responsibilities
O & M Company	Collecting and annually reporting the data related to, 1. Noise power levels during construction of LRT. 2. Proportion of women in the workforce. 3. Wastewater generation. 4. Wages of the LRT Employees 5. Jobs created due to LRT 6.Data related to GHG emissions
SLSEA	Measure and report the data on grid emission factor.
Sri Lanka Police	Measuring and reporting data relevant to traffic congestion and road accidents.
CPSTL	Measuring and annually reporting following data 1. Fuel Consumption of Vehicles
CEYPETCO	Measuring and annually reporting the data 1. Sulphur content in the fuel (% by mass) 2. Fuel price 3. Specific fuel consumption of vehicles 4. Density of Fuel
VET	Measuring and annually reporting of data relevant to air pollutions; emission factor as mass per unit of activity rate, extra emissions due to cold starts and extra emissions due to evaporations (NMVOC)
ITI	Measuring and reporting of sound pressure level of road vehicles

CEA	Measuring and annually reporting PM 10 concentration of considered area
DCS	Measuring and annually reporting population at risk of health effect
CEB	Measuring and annually reporting of data relevant to transmission and distribution lost & unit price of electricity.

Data management

Data management process for each indicator is given in figure 06 Proposed Data Management System for NDC4.1. The all indicators which measure, collect, maintain the entry, and reporting frequencies (annually, monthly or etc) are included there. Consolidated data will be annually reported to NDC unit by MRV managers of the respective entities.

Verification

Institutions which are responsible for collecting the data already have an internal verification system. Per the request of the NDC unit of the ministry of transport, institutions will submit the internally verified data. Quality and the accuracy of the data provided, will be verified by the QA & QC team of NDC unit. Quantitative assessment conducted on the SDG impacts of each mitigation action will be verified by the MRV expert committee, appointed by the Ministry of Environment. Verified results will be submitted to the CCS of Ministry of Environment which will be responsible for submitting the results to the UN and SDC depending on the requirement

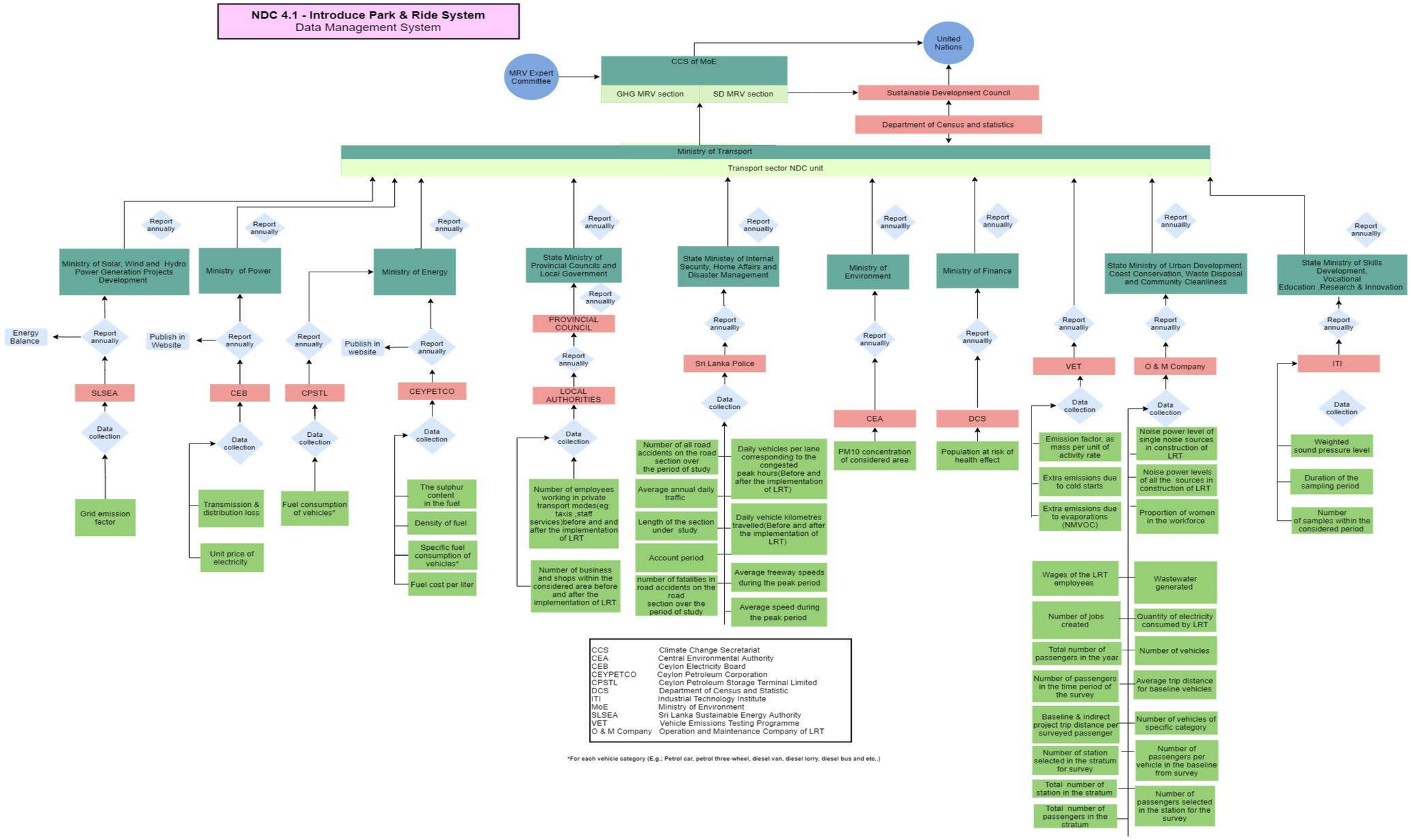

Figure 4:Draft data management system for NDC 4.1

Source: ClimateSI ,2021

3.2 Electrification of the railway system from Veyangoda to Panadura.

3.2.1 Outcome of step 01: Defining the Assessment.

Electrification of the railway system from Veyangoda to Panadura is the sub NDC 5.1 of the fifth main NDC, "Enhance the efficiency and quality of public transport modes". This is a national level policy that was planned to implement in the geographic boundary "Veyangoda – Panadura. It is an "implementation of new technologies, processes or enhancing practices" in policy type. Electrification of the existing railway and the addition of new railway tracks are included in the project. Daily passengers who travel from Veyangoda to Panadura by existing diesel trains, and railway systems will be highly benefited by the electrification of the railway system.

Feasibility studies related to the project is almost completed by now. The project related to the sub -NDC was proposed to start in 2021 and to be completed by 2030.

The overall objective of the sub- NDC is to create more liveable cities while reaching specific objectives such as mitigating the current traffic congestion, reduce fuel use, air pollution, GHG emissions and provide efficient transport by saving time. This sub-NDC shows a close interaction with NDC 8, "Encourage and introduce low emission vehicles such as electric and hybrid".

The Institute of Engineers, Ceylon Electricity Board, Sri Lanka Railways, and Ministry of Transport will take the main responsibilities of the initiation, implementation, and maintenance of the electrification of this railway system.

Baseline scenario of the assessment: Fossil fuel powered train system/ non-electrified railway system from Veyangoda to Panadura.

Project scenario of the assessment: Electrified railway system from Veyangoda to Panadura

Figure 7: Geographic Boundary of the NDC 5.1 - Electrification of the railway from Veyangoda to Panadura, Source: Ministry of Transport and Civil Aviation, 2018, *Pre-feasibility study report for the Colombo Suburban Railway Project*

3.2.2 Outcome of step 02: Qualitative Assessment

2a) Identification of the impact categories associate with NDC.

A wide variety of sustainable development impact categories associated with the NDC, across the three dimensions of environmental, social, and economic were identified by experts, from the list of impact categories given in ICAT SD guideline (Annex 1).

2b) Choosing which impact categories to be assessed.

Identified impact categories under the step 2a were further filtered considering the relevance, significance, comprehensiveness, and alignment within the assessment boundary. The outcome of steps 2a & 2b is given in Annex 2-2.

Out of 17 NDC related impact categories, only 13 impact categories were chosen for the assessment including climate change mitigation, health impacts of air pollution, visibility, odours, biodiversity of terrestrial ecosystems, noise pollution, illness and death, quality of life and well-being, gender equality and empowerment of women, traffic congestion, road safety, economic activities, and jobs.

2c) Identification of the specific impacts

Specific impacts were identified under each of the impact categories upon drawing causal chains as shown in figure 08.

2d) Qualitative assessment of the identified specific impacts

Identified specific impacts were assessed against the likelihood, magnitude, and significance levels as shown in table 07.

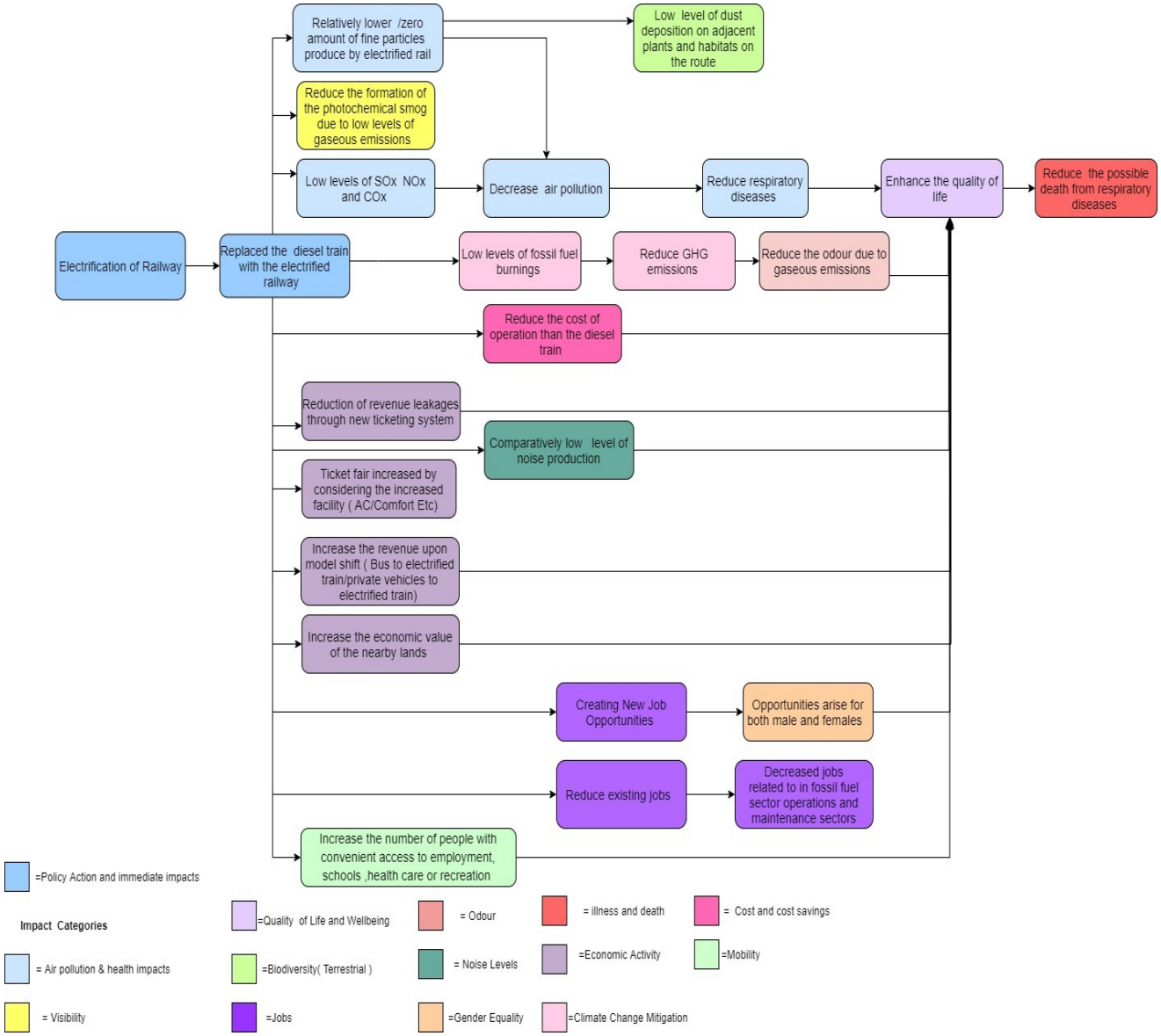

Figure 8: Causal chain diagram for NDC 5.1

Source: ClimateSI,2021

Table 7: Qualitative Assessment of NDC 5.1

Impact* category	Specific impacts identified	Jurisdiction (In or out)	Qualitative analysis						Defining the boundary for quantitative assessment	
			Likelihood	Magnitude	Positive or negative	Significant	Summary of qualitative assessment results for each impact category	Methods/ sources used in the identification of specific impact	Feasible to quantify	Included in the quantitative assessment boundary
Dimension: Environment										
Climate change mitigation (SDG 13)	Reduction of GHG emission by shifting passenger transport mode from fossil fuel powered trains to electrified railway system.	In/out	Very likely	Major	Positive	Significant	A major positive impact was observed	(He & Xu, 2011) [20]	Yes	Yes
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Decrease respiratory diseases due to the low level of pollutants (PM) during the implementation phase of electrified railways	In	Likely	Major	Positive	Significant	The major positive impact was observed	(Abbassi et al., 2013) [21]	Yes	Yes
	Decrease air pollution due to the low level of gaseous emissions	In	Likely	Major	Positive	Significant	The major positive impact was observed	(Abbassi et al., 2013) [21]	Yes	Yes
Visibility	Reduce the formation of photochemical smog (during rain) due to the low levels of gaseous emissions	In	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	(Winterbone, 2015) [22]	No	No
Odour	Low level of uncomfortable smell due to the low level of	In/out	Possible	Moderate	Positive	Significant		(Britneff ,2020) [17]	No	No

	gaseous emissions with the implementation of electrified railway						A moderate positive impact was observed	https://globalnews.ca/news/6517480/rtg-no-risk-smelly-rideau-lrt-station/		
Biodiversity of terrestrial eco systems (SDG 15)	Reduce the deposition of dust from train, on the adjacent plant leaves.	In	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	(Yan,2014) [15]	No	No
Noise Levels	Lower noise levels with the electrification of railway	In	Likely	Major	Positive	Significant	A major positive impact was observed	Pre-feasibility study report for the Colombo Suburban Railway Project,2018 [23]	Yes	Yes
Dimension: Social										
Illness and death (SDG 3)	Decrease the possible deaths from respiratory diseases upon electrified railways	In	Possible	Minor	Positive	Insignificant	The minor positive impact was observed	(Siribaddana et al., 2019) [17]	No	No
Quality of Life and wellbeing. (SDG 3)	Enhance the quality of life (e.g., through reducing respiratory diseases, convenient access to employment, time savings etc.) after the implementation of electrified railway.	In/out	Likely	Major	Positive	Significant	The major positive impact was observed	(Cappa et al., 2019) [24]	No	No
Gender equality and empowerment of women (SDG 5)	Job opportunities for both males and females. (Ex: Inspection officer etc.)	In	Unlikely	Minor	Positive	Insignificant	A minor positive impact was identified.	(http://cs.trains.com/trn/f/111/t/203899.aspx) [25]	Yes	Yes
Mobility (SDG 11)	Increase the number of people with convenient access to employment, schools, health care or recreation	In/out	Very likely	Major	Positive	Significant	A major positive impact was observed	Railway Electrification, Colombo Suburban Railway Project [26] https://www.unescap.org/sites/default/files/9.%20Suburban%20Railway%20Project-Mr.Palitha.pdf	Yes	Yes
Dimension: Economical										

Jobs (SDG 8)	Create new job opportunities. Reduce existing jobs	In In	Likely Possible	Moderate Minor	Positive Negative	Significant Insignificant	A moderate positive impact was observed. A minor negative impact was observed	ICAT SD Methodology [13] ICAT SD Methodology [13]	Yes No	Yes No
Cost and cost savings	Reduce the cost of operation than the diesel train	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	Pre-feasibility study report for the Colombo Suburban Railway Project,2018[23]	Yes	Yes
Economic Activity	Reduction of revenue leakages through the new ticketing system	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	Pre-feasibility study report for the Colombo Suburban Railway Project,2018[23]	Yes	Yes
	Increased net annual profit by ticketing fair increase, considering the increased facilities like (AC Trains, Less travel time, Comfort etc.)	In	Likely	Major	Positive	Significant	The major positive impact was observed	Pre-feasibility study report for the Colombo Suburban Railway Project,2018[23]	No	No (Calculation will be conducted focusing the side of the model)
	Increase the economic value of the nearby lands	In	Possible	Minor	Positive	Insignificant	The minor positive impact was observed	Pre-feasibility study report for the Colombo Suburban Railway Project,2018[23]	No	Yes

Source -ClimateSI,2021

3.2.3. Outcome of step 03: Quantitative Assessment

Out of the 17 specific impacts identified (covering environmental, social, and economic dimensions), 9 specific impacts were selected as quantifiable impacts that are within the scope of the assessment.

Table 8: Selection of quantifiable impacts for NDC 5.1

Description	Amount Considered	Reference from the document
Impact categories associate with the NDC	17	Annex 2-2
Number of impact categories chosen for the assessment	13	Annex 2-2 (highlighted in red) Table 6 -Column 1
Qualitative Assessment		
Total number of specific impacts considered under each category	17	Table 6 -Column 2
Quantitative Assessment		
Quantifiable specific impacts	09	Table 8 -Column 2

Source: ClimateSI ,2021

3a) Identification of the possible indicators for quantification

Adhering to the guidance given in table 2 in this report and referring to table 5.5 of the ICAT SD methodology, suitable indicators were identified to monitor those specific impacts.

3b) Identification of the possible methodologies /parameters for each indicator

Relevant methodologies and parameters to monitor the indicators were identified upon the literature survey. The outcomes of steps 3a and 3b are given in table 09.

Table 9:Qunatitative assessment of the NDC 5.1

Step 3 a)- Identification of Indicators			Step 3b. Identification of suitable methodologies to quantify the indicators	Data collection mechanism	
Impact category	**Specific impacts identified**	**Indicators**	**Proposed Methodology**	**Parameters**	**Relevant entities/reference documents which data can be acquired**
Dimension: Environment					
Climate change mitigation (SDG 13)	Reduction of GHG emission by shifting passenger transport mode from fossil fuel powered trains to electrified railway system	Net emissions of GHGs	**Equation for the baseline scenario** $BE_y = FC_{BL,i,y} \times NCV_i \times EF_{fuel,i}$ $FC_{BL,i,y} = B_{km} \times SFC_{BL,i,y} \times D_i$	**Baseline scenario.** BE_y Baseline emission of year y (t CO_{2eq}) $FC_{BL,i,y}$ Consumption of fuel i associated with the operation of the existing railway in year y (kg) NCV_i Net calorific value of fuel I (TJ/t) $EF_{fuel,i}$ CO_2 emission factor of fuel I (tCO_{2eq}/TJ) B_{km} Annual total trip distance associated with the operation of the existing railway in year y (km) $SFC_{BL,i,y}$ Specific fuel consumption associated with the operation of the existing railway in year y (Liters/km) D_i Density of fuel I (kg/m^3)	**Documents** "Japan International Cooperation Agency's Transport / Railway (Passenger) / Electrification –FIT Version 2 guideline" as given in the MRV Framework for Transport Sector in Sri Lanka. **Entities** Sri Lanka Railways Ceylon Petroleum Storage Terminal Limited SLSEA

			Equation for the policy scenario $PE_y = EC_{PJ,y} \times EF_{elec}$ $EC_{PJ,y} = P_{km} \times SEC_{PJ,y}$ **Emission reduction due to railway electrification** $ER_Y = BE_Y - PE_y$	**Project scenario.** PE_y Project emission of year y (t CO_{2eq}) $EC_{PJ,y}$ Electricity consumption associated with the operation of the project activity in year y (kWh) EF_{elec} CO2 emission factor of the grid electricity (tCO_{2eq}/MWh) P_{km} Annual total trip distance associated with the operation of the project activity in year y (km) $SEC_{PJ,y}$ Specific electricity consumption associated with the operation of the project activity in year y (kWh/km)	

Health impacts of air pollution (SDG3, SDG 11, SDG12)	Decrease respiratory diseases due to the low pollutants (PM) during the implementation phase of electrified railways. Decrease air pollution due to the low level of gaseous emissions	Proportion of population with diagnosed respiratory diseases. Emissions of air pollutants (t/year)	$dH_i = \beta \times POP_i \times dA_i$ **Equation for baseline scenario** $Ei = \sum_m FC_m \times EF_{i,m}$ Emissions of SO_2 may be calculated by means of the following equation:	**Baseline Scenario**: Proportion of population with diagnosed respiratory diseases due to the emissions of diesel train. **Project Scenario:** Proportion of population with diagnosed respiratory diseases after electrifying the railway. (Project scenario can be considered as zero since emission of air pollutants is zero in electrified railway system) dHi change in population risk of health effect(i) β slope of the dose–response function POPi population at-risk of health effect i dAi change in level of air pollutant under consideration **Baseline Scenario**: Emissions of air pollutants(t/year) (NO_X, N_2O &SO_X) from diesel train. **Project Scenario:** Emissions of air pollutants (t/year) (NO_X, N_2O &SO_X) from electrified railway. (Project scenario can be considered as zero since emission of air pollutants is zero in electrified railway system)	**Documents** Research paper from ELSEVIER, External cost of coal-based electricity generation: A tale of Ahmedabad city EMEP/EEA air pollutant emission inventory guidebook 2019 (1.A.3.c Railways - Tier 1 approach) **Entities** Sri Lanka Railways Central Environment Authority Department of Census and Statistics

			$E_{SO2} = 2 \times \sum_m k_{s,m} \times FC_m$	E_i Emissions of pollutant i for the period concerned in the inventory (kg or g) FC_m Fuel consumption of fuel type m for the period and area considered (tonnes) EF_i Emission factor of pollutant i for each unit of fuel type m used (kg/tonnes) m Fuel type (diesel, gas oil) E_{SO2} Emissions of sulphur dioxide for the period concerned in the inventory [kg] $k_{S,m}$ The sulphur content in the fuel (% by mass).	
Noise Pollution	Decreased noise levels after the implementation of electrified railway.	Noise Level reduction	$Lm, E = 10 \log[\sum 10^{(0,1.(51+D_{Fz}+D_D+D_L+ + D_{Tt} + D_{Br} + D_{Lc} + D_{Ra}}$	**Baseline Scenario**: Noise levels from the diesel train **Project Scenario:** Noise levels from the electrified train D_{FZ}, D_D, D_L, D_V Correction for the specific train $D_{Tt}, D_{Br}, D_{Lc}, D_{Ra}$, Correction characterizing the railway line $L_{m,E}$ Emission Levels	**Documents** Research paper from International Journal of Environmental Research and Public Health - Measurement and Prediction of Railway Noise Case Study from Slovakia [27] **Entities** Industrial Technology Institute
Dimension: Social					

Mobility (SDG 11)	Increase the number of people with convenient access to employment, schools, health care or recreation	Increase of number of people with convenient access to employment, schools, health care or recreation	Relevant data to be collected upon bilateral meetings with the Sri Lanka Railways. Result can be obtained by simple equation developed as below. $Y = \frac{ab - AB}{AB}$	**Baseline Scenario**: Mobility levels due to the fossil fuel -based train: Number of seated passengers transported in one -trip of diesel train. **Project Scenario:** Mobility levels due to the electrified - train: Number of seated passengers transported in one -trip of electrified train. Y Increase of number of people with convenient access to employment, schools, health care or recreation A No. of seated passengers transported in a one trip by fossil fuel-based train system (one-way) B No of trips per day by fossil fuel-based train system (one-way) a No. of seated passengers transported in a one trip by electrified railway system (one-way) b No of trips per day by electrified railway system (one-way)	**Entities** Sri Lanka Railway
Dimension: Economical					
Jobs (SDG 8)	Create new job opportunities	Number of new jobs created in associated sectors	Relevant data to be collected upon bilateral meetings with the Sri Lanka Railways Relative improvement (%) = (Number of employees in Sri Lanka Railway to operate and maintain trains after introducing	**Baseline Scenario:** Number of employees in Sri Lanka Railway to operate and maintain trains before introducing the electric railway. **Project Scenario:**	**Entities** Sri Lanka Railway

			the electric railway. - Number of employees in Sri Lanka Railway to operate and maintain trains before introducing the electric railway.) / Number of employees in Sri Lanka Railway to operate and maintain trains before introducing the electric railway. *100%	Number of employees in Sri Lanka Railway to operate and maintain trains after introducing the electric railway.	
Cost and cost savings	Reduction of fuel cost	Fuel costs savings	Method used at the GHG Emission calculation was incorporated as follows: Fuel Cost= $B_{km} * SFC_{BL,i,y} * FP$ Electricity Cost = $EC_{PJ,y} * EP$	**Baseline Scenario:** Fuel costs to travel from Malabe to Pettah by the diesel train. **Project Scenario** Cost of electricity to travel from Malabe to Pettah by the electrified train.	**Entities** Sri Lanka Railway Ceylon Petroleum Storage Terminal Limited Ceylon Electricity Board Sri Lanka Sustainable Energy Authority

				B_{km} Annual total trip distance with the operation of the existing railway in year y $SFC_{BL,i,y}$ Specific fuel consumption of fossil fuel powered train (kg/km) FP Fuel Price in LKR per Litre ECPJ, y Electricity consumption associated with the operation of the project activity in year y (kWh) EP Unit Price of electricity in LKR per kWh	
Economic Activity	Reduction of revenue leakages through smart ticketing and seat reservation system	Increased net annual profit by introducing smart ticketing and seat reservation system (GDP)	Relevant data to be collected upon bilateral meetings with the Sri Lanka Railways and surveys. Result can be obtained by simple equation developed as below. $Y = (F + T) - M$	**Baseline Scenario:** Average annual cost spent on the maintenance of ticketing machines and issuing tickets in diesel trains. **Project Scenario** Average annual financial benefit from the reduction of ticket machines and issuing tickets after introducing smart ticketing systems.	**Entities** Sri Lanka Railways **Websites** Colombo suburban railway project [26] https://www.csrp.lk/reip/components/smart-ticketing-and-seat-reservation-system/

				Y Increased net annual profit by introducing smart ticketing and seat reservation system F Average annual financial benefit from reduction of ticketless travel (fraud) T Average annual reduction of ticket production cost M Annual operations and maintenance cost for ticketing machines and other ticketing and reservation channels	
	Increased net annual profit by ticketing fair increase, considering the increased facilities like (AC Trains, Less Travel Time, Comfort etc.)	Increase of net annual profit by ticketing fair increase (GDP)	Relevant data to be collected upon bilateral meetings with the Sri Lanka Railways. Result can be obtained by simple equation developed as below. $Y = I_B \times T$	**Baseline Scenario:** Average annual income by ticket sale in diesel train. **Project Scenario** Average annual income by ticket sale in electrified train Y Increase of net annual profit by ticketing fair increase I_B Average annual income by ticket sale in baseline scenario T % increase of ticket price in project scenario –	**Entities** Sri Lanka Railways **Websites** Colombo suburban railway project [26] https://www.csrp.lk/reip/components/smart-ticketing-and-seat-reservation-system/

Source -ClimateSI,2021

Refer institution wise procedures (deliverable 4.1) for more details on data collection templates.

3.2.4 Outcome of Step 4: Institutional arrangement and data management systems

There are 7 institutions involve in the MRV framework of NDC 5.1. Namely the Ceylon Electricity Board (CEB), Ceylon Petroleum Storage Terminal Limited (CPSTL), Ceylon Petroleum Corporation (CEYPETCO), Sri Lanka Railways (SLR), Central Environment Authority (CEA), Department of Census and Statistics (DCS), and Industrial Technology Institute (ITI) are the seven institutions.

All the institutions are responsible for a specific task as shown in table no 10.

Table 10: Roles and responsibilities of the institutions involve in NDC 5.1

Institution	Roles and Responsibilities
SLR	Collecting and annually reporting the data related to, 1. Fuel consumption 2. Electricity consumption 3. No of seated passengers transported per trip 4. No of trips per day 5. Accident-related data, in specific routes and 6. No of employees in SLR to operate and maintain the trains 7. Operational and maintenance cost for ticketing machines 8. Ticket production cost 9. Annual income by ticket sale 10. Price increasement rate of tickets
SLSEA	Measuring and annually reporting the data 1. Grid emission factor
CPSTL	Measuring and annually reporting following data 1. Net Calorific Value of fuel
ITI	Measuring and reporting of sound pressure level of trains under different characterization of measurement
CEYPETCO	Measuring and annually reporting the data 1. Sulphur content in the fuel (% by mass) 2. Fuel price
CEA	Measuring and annually reporting PM 10 concentration of considered area
DCS	Measuring and annually reporting population at risk of health effect
CEB	Annually reporting the unit price of electricity

Data Management

Data management process for each indicator is given in figure 9. Proposed Data Management System for NDC 5.1. The all indicators which measure, collect, maintain the entry, and reporting frequencies (annually, monthly, or etc.) are included there. Consolidated data will be annually reported to NDC unit by MRV managers of the respective entities.

Verification

Institutions which are responsible for collecting the data already have an internal verification system. Per the request of the NDC unit of the ministry of transport, institutions will submit the internally verified data. Quality and the accuracy of the data provided, will be verified by the QA & QC team of NDC unit. Quantitative assessment conducted on the SDG impacts of each mitigation action will be verified by the MRV expert committee, appointed by the Ministry of Environment. Verified results will be submitted to the CCS of Ministry of Environment which will be responsible for submitting the results to the UN and SDC depending on the requirement.

NDC 5.1 - Electrification of the Railway from Veyangoda to Panadura
Data Management System

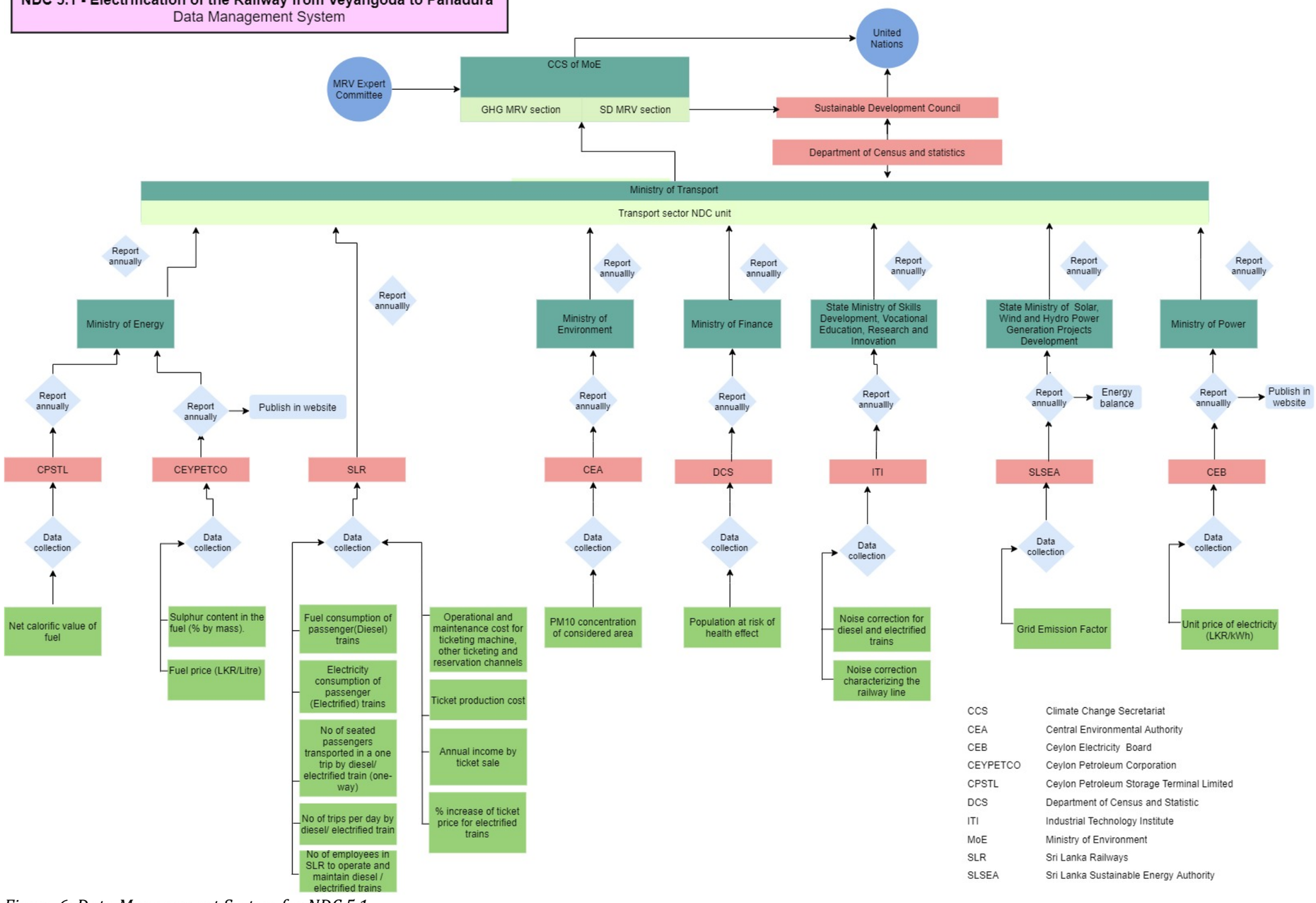

Figure 6: Data Management System for NDC 5.1

Source: ClimateSI ,2021

3.3 Purchase new rolling stocks for Sri Lanka Railway

3.3.1 Outcome of step 01: Defining the Assessment.

Purchase new rolling stocks for Sri Lanka Railway is the sub NDC 5.2 of the fifth main NDC, "Enhance the efficiency and quality of public transport mode". This is a national level policy. Policy type of the sub NDC is, "implementation of new technologies, processes or enhancing practices". Passengers who utilize the Sri Lankan Railway system will get the benefit of it.

The proposed mitigation action is to purchase six power sets for Sri Lanka Railways to improve the public transportation. In the absence of the new rolling stocks, the passengers would have used road transport such as buses, taxi and passenger owned vehicles, etc. The overall objective of the sub NDC is to create more liveable cities while reaching the specific objectives such as mitigating the current traffic congestion, reducing fuel use and air pollution. This sub-NDC shows an interaction with NDC 5.1 "Electrification of Railways".

Sri Lanka Railways and Ministry of Transport share the main responsibilities of the implementation and the maintenance of the new rolling stocks.

Baseline scenario of the assessment: Use of personnel vehicles and buses for travelling.

Project scenario of the assessment: Rail transportation by purchased new rolling stocks.

3.3.2 Outcome of step 02: Qualitative Assessment

2a) Identification of the impact categories associate with NDC.

A wide variety of sustainable development impact categories associate with the NDC, across the three dimensions of environmental, social, and economic were identified by experts from the list of impact categories given in ICAT SD guideline (Annex 1).

2b) Choosing which impact categories to be assessed.

Identified impact categories under the step 2a were further filtered considering the relevance, significance, comprehensiveness, and alignment within the assessment boundary. Outcomes of steps 2a & 2b are given in Annex 2-3.

Out of 17 impact categories, only 12 impact categories were chosen for the assessment including climate change mitigation, health impacts of air pollution, cost and cost savings, visibility, odours, biodiversity and terrestrial ecosystems, noise pollution, illness and death, quality of life and well-being, traffic congestion, road safety and jobs.

2c) Identification of the specific impacts

Specific impacts were identified under each of the impact categories upon drawing causal chains as shown in figure 10.

2d) Qualitative assessment of the identified specific impacts

Identified specific impacts were assessed against the likelihood, magnitude, and significance levels as shown in table 11.

Figure 7:Causal Chain of NDC 5.2

Source: ClimateSI ,2021

Table 11: Qualitative assessment of NDC 5.2

Impact category	Specific impacts identified	Jurisdiction (In/Out)	Qualitative analysis						Defining the boundary for quantitative assessment	
			Likelihood	Magnitude	Positive or negative	Significant	Summary of qualitative assessment results for each impact category	Methods/ sources used in the identification of specific impact	Feasible to quantify	Included in the Quantitative Assessment Boundary
Dimension: Environment										
Climate change mitigation (SDG 13)	Reduction of GHG due to the minimal usage of personal vehicles	In/out	Very likely	Major	Positive	Significant	The major positive impact was observed	(Filosa et al., 2017) [12]	Yes	Yes
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Decrease respiratory diseases due to the low pollutants (PM) following the reduction of road vehicles.	In	Very likely	Major	Positive	Significant	The major positive impact was observed	(Nielson,2011) [27]	Yes	Yes
	Decrease air pollution due to the reduction of private vehicles	In	Very likely	Major	Positive	Significant	The major positive impact was observed	(Nielson,2011) [27]	Yes	Yes
Visibility	Reduce the possibility of the formation of photochemical smog	In	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	(Nielson,2011) [27]	No	No

	due to reduction of private vehicles									
Noise Levels	Reduce the noise levels due to the reduction of private vehicles	In	Possible	Minor	Positive	Insignificant	Minor positive impact was observed	(Nielson,2011) [27]	-	-
Odour	Low level of uncomfortable smell due to the low level of gaseous emissions due to the reduction of road vehicles	In/out	Possible	Moderate	Positive	Significant	A moderate positive impact was observed	(Britneff ,2020) [17] https://globalnews.ca/news/6517480/rtg-no-risk-smelly-rideau-lrt-station/	No	No
Biodiversity of terrestrial eco systems (SDG 15)	Dust deposition on the adjacent trees will be reduced due to the reduction of road vehicles	In	Possible	Moderate	Positive	Significant	A moderate positive impact was observed	(Yan,2014) [15]	No	No
Dimension: Social										
Illness and death (SDG 3)	Decrease the possible deaths from respiratory diseases.	In	Possible	Moderate	Positive	Significant	A moderate positive impact was observed	(Nielson,2011) [27]	No	No
Quality of life and wellbeing. (SDG 3)	Enhance the quality of life through (e.g., reducing respiratory diseases, time savings, job creation, reduce accidents etc.)	In/out	Likely	Major	Positive	Significant	The major positive impact was observed	(Cappa et al., 2019) [24]	No	No

	implementation of new rolling stocks.									
Traffic congestion (SDG11)	Time savings due to the low traffic levels due to the reduction of road vehicles	In	likely	Major	Positive	Significant	The major and positive significant impact was observed	(Nielson,2011) [27]	Yes	Yes
Road safety (SDG 3,11)	Reduce possible accidents during peak hours.	In	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	Sri Lanka Police,2021 [19]	Yes	Yes
Dimension: Economical										
Jobs (SDG 8)	Create new job opportunities in Sri Lanka Railways	In	Possible	Moderate	Positive	Significant	A moderate positive impact was observed	ICAT SD Methodology [13]	Yes	Yes
	Loss of jobs for bus and private vehicle workers	In	Possible	Minor	Negative	Insignificant	A minor negative impact was observed	ICAT SD Methodology [13]	No	No
Cost and cost savings	Reduce the maintenance and operational cost of private vehicles	In	Possible	Moderate	Positive	Significant	A moderate positive impact was observed	ICAT SD Methodology [13]	Yes	Yes

Source: ClimateSI,2021

3.3.3 Outcome of step 03: Quantitative Assessment

Out of the 13 specific impacts identified, (covering environmental, social, and economic dimensions) 7 specific impacts were selected as quantifiable impacts that are within the scope of the assessment.

Table 12: Selection of quantifiable impacts for NDC 5.2

Description	Amount Considered	Reference from the document
Impact categories associate with the NDC	17	Annex 2-3
Number of impact categories chosen for the assessment	12	Annex 2-1 (highlighted in red) Table 9-Column 1
Qualitative Assessment		
Total number of specific impacts considered under each category	14	Table 9-Column 2
Quantitative Assessment		
Quantifiable specific impacts	07	Table11: Column 2

Source: ClimateSI,2021

3a) Identification of the possible indicators for quantification

Adhering to the guidance given in table 2 in this report and table 5.5 of the ICAT SD methodology, suitable indicators were identified to monitor those specific impacts.

3b) Identification of the possible methodologies /parameters for each indicator

Relevant methodologies and parameters to monitor the indicators were identified upon a literature survey. The outcome of steps 3a & 3b is given in table 13.

Table 13: Quantitative assessment of the NDC 5.2

Step 3a. Identification of indicators			Step 3b. Identification of suitable methodologies to quantify the indicators	Data collection mechanism	
Impact category	**Specific impacts identified**	**Indicators**	**Proposed methodology.**	**Parameters**	**Relevant entities/reference documents which data can be acquired**
Climate change mitigation (SDG 13)	Reduction of GHG emission by shifting passenger transport from other transport modes to rail transportation by adding new rolling stocks	Net emissions of GHGs	**Equation for the baseline scenario** $BE_y = \sum (P_y \times BTDP_y \times MS_{j,y} EF_{PKM,i})$ $EF_{PKM,i} = (\frac{EF_{KM,i}}{OR_i})$ **Equation for the policy scenario** $PE_y = FC_{PJ,y} \times NCV_i \times EF_{Fuel,i}$ $FC_{PJ,y} = P_{km} \times SFC_{PJ,y} \times D_i$	**Baseline emission.** BEy — Baseline emission of year y (t CO_{2eq}) P_y — Number of passengers transported by the project in year y $BTDP_y$ — Average trip distance of the passenger of the project activity in year y (km) $MS_{j,y}$ — 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_{2eq}/passenger km) $EF_{KM,i}$ — CO2 emission factor of transport mode i OR_i — Average occupation rate of transport mode i	**Documents** - "Japan International Cooperation Agency's Transport / Railway (Passenger) / Modal Shift - FIT Version 2.0, March 2014 Japan International (Prepared by Japan Weather Association)" as given in the MRV Framework for Transport Sector in Sri Lanka. **Entities** Sri Lanka Railways Ceylon Petroleum Storage Terminal Limited Ministry of Transport Sri Lanka Transport Board National Transport Commission

			Emission reduction $ER_Y = BE_Y - PE_y$	**Project emission.** PE_y Project emission of year y (kg CO_{2eq}) $FC_{PJ,y}$ Consumption of fuel i associated with the operation of the project activity in year y (kg) NCV_i Net calorific value of fuel i (kJ/m^3) $EF_{Fuel,i}$ CO2 emission factor of fuel i P_{km} Total distance travelled. per year by project activity $SFC_{PJ,y}$ Specific fuel consumption associated with the operation of the project activity in year y D_i Density of fuel i	
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Decrease respiratory diseases due to the low pollutants levels due to the reduction of private vehicles.	Proportion of population with diagnosed respiratory diseases.	$dH_i = \beta \times POP_i \times dA_i$	**Baseline Scenario**: Proportion of population with diagnosed respiratory diseases when using private vehicles (Before introducing new rolling stocks) **Project Scenario:** Proportion of population with diagnosed respiratory diseases after introducing new rolling stocks). dHi change in population risk of health effect(i) β slope of the dose–response function POPi population at-risk of health effect i	**Documents** Research paper from ELSEVIER, External cost of coal-based electricity generation: A tale of Ahmedabad city Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories - emissions: energy, road transport EMEP/EEA air pollutant emission inventory guidebook 2019 (1.A.3.c Railways - Tier 1 approach) **Entities** Sri Lanka Railways Central Environment Authority Vehicle Emission Testing Programme Department of Census and Statistics

	Decrease air pollution due to the low level of gaseous emissions.	Emissions of air pollutants (t/year)	**Baseline Scenario: Emissions from road transport** $Total\ Emission = + \sum_{abcd} (\ EF\ abcd \times\ Activity\ abcd\ ) + \sum_{b} Cold\ b + \sum_{b} Evoporation\ b$ **Project Scenario: Emissions from fossil fuel-based train system** Emissions of NOx & N_2O can be calculated from the following equation: $Ei = \sum_m FC_m \times\ EF_{i,m}$ Emissions of SO_2 may be calculated by means of the following equation: $E_{SO2} = 2 \times \sum_m k_{s,m} \times FC_m$	dAi change in level of air pollutant under consideration **Baseline Scenario**: Emissions of air pollutants(t/year) (NO_X, N_2O &SO_X) from private vehicles. **Project Scenario:** Emissions of air pollutants (t/year) (NO_X, N_2O &SO_X) from train after introducing new rolling stocks. EF Emission factor, as mass per unit of activity rate Activity activity rate (fuel consumed or distance travelled) Cold Extra emissions due to cold starts Evaporation extra emissions due to evaporation (NMVOCs) A fuel type (petrol, diesel, LPG, etc.) B vehicle type (passenger car, light-duty truck, bus, etc.) C emission control	

			Reduction of air pollutant emission (Baseline Emission – Project emission)	D road type or vehicle speed E_i Emissions of pollutant i for the period concerned in the inventory (kg or g) FC_m Fuel consumption of fuel type m for the period and area considered (tonnes) EF_i Emission factor of pollutant i for each unit of fuel type m used (kg/tonnes) m Fuel type (diesel, gas oil) E_{SO2} Emissions of sulphur dioxide fo the period concerned in the inventory [kg] $k_{S,m}$ The sulphur content in the fuel by mass).	
Traffic Congestion (SDG11)	Time savings due to the low traffic levels due to the reduction of road vehicles	Time lost during transportation.	Applying principal corridors collective assessment for corridors speed plot Travel delay= Amount of time it takes to travel the peak -period vehicle kilometres at the average speed - Amount of time it takes to travel at the free flow speed	**Baseline Scenario:** The time loss of transportation from private vehicles before introducing rolling stocks. **Project Scenario:** The time loss of transportation from train after inserting rolling stocks. Daily vehicles per lane corresponding to the congested peak hours. Daily vehicle kilometres travelled. Length of the roadway. Average freeway speeds during the peak period Average Speed during the peak	**Documents** 2019 urban mobility report by Texas A&M Transportation Institute (Appendix A: Methodology) **Entities** Sri Lanka Railway Sri Lanka Transport Board Sri Lanka Police

Road safety (SDG 3,11)	Reduce possible accidents during peak hours	Number of deaths and injuries from road traffic accident per year	Relevant data to be collected upon traffic audit survey. Rates of the accidents and rate of death due to the accidents can be calculated using the following equations from conference paper which given as the reference document. **Rate of road accidents in the road section under study** $R_D = \frac{D}{N.L.m.365'}$ **Rate of human deaths in an accident on the road section under study** $R_p = \frac{P}{N.L.m.365'}$	**Baseline Scenario:** Number of deaths and injuries from road traffic accidents due to private vehicles **Project Scenario:** Number of deaths and injuries from road traffic accidents after introducing new rolling stocks. R_D Rate of road accidents in the road section D Number of all road accidents on the road section over the period of study N Average annual daily traffic (vehicles/day) L Length of the section under study (km) m Account period R_P Rate of human death in an accident on the road section under study P number of fatalities in road accidents on the road section over the period of study N Average annual daily traffic (vehicles/day) L Length of the section under study (km) m Account period	**Documents** Conference paper from WLSEVIER, Forecasting of road accident in the DVRE system. **Institutions** Sri Lanka Police

Jobs (SDG 8)	Create new job opportunities	Number of new jobs created in associated sectors	Relevant data to be collected upon bilateral meetings with the Sri Lanka Railways Relative improvement (%) = (Number of employees in Sri Lanka Railway to operate and maintain trains after purchasing new rolling stocks. - Number of employees in Sri Lanka Railway to operate and maintain trains before purchasing new rolling stocks) / Number of employees in Sri Lanka Railway to operate and maintain trains before purchasing new rolling stocks. *100%	**Baseline Scenario:** Number of employees in Sri Lanka Railway to operate and maintain trains before purchasing new rolling stocks. **Project Scenario:** Number of employees in Sri Lanka Railway to operate and maintain trains after purchasing new rolling stocks.	**Entities** Sri Lanka Railway
Cost and cost savings	Savings of the operation cost of the private vehicles	Fuel Cost Savings	Methodology used in GHG emission calculation can be incorporated as follows. **Baseline Scenario:** $FC_{mode} = BE_{mode, Fuel Type} / Emissions\ per\ unit_{Fuel Type}$ $Fuel\ Cost = FC_{mode} * FP$ **Project Scenario** $Fuel\ Cost = P_{km} * SFC_{PJ,i,y} * FP$	**Baseline Scenario:** Fuel costs associate with private vehicle. **Project Scenario** Fuel costs associate with diesel train after introducing rolling stocks. FC_{mode} Fuel Consumption based on the mode BE_{mode} Baseline emission, respective to the mode of vehicle	**Entities** Sri Lanka Railways

				P_{km}	Annual total trip distance with the operation of the existing railway in year y	
				$SFC_{PL,i,y}$	Specific fuel consumption of fossil fuel powered train (kg/km)	
				FP	Fuel Price in LKR per Litre	

Source – ClimateSI, 2021

Refer institution wise procedures (deliverable 4.1) for more details on data collection templates.

3.3.4 Outcome of step 04: Institutional arrangement and data management systems

There are 8 institutions involve in the MRV framework of NDC 5.2. Namely the Ceylon Petroleum Storage Terminal Limited (CPSTL), Ceylon Petroleum Corporation (CEYPETCO), Sri Lanka Railways (SLR), Sri Lanka Police (SLP), Central Environment Authority (CEA), Department of Census and Statistics (DCS), Vehicle Emission Testing (VET) Service, National Transport Commission (NTC).

All the institutions are responsible for a specific task as shown in table 14.

Table 12: Roles and responsibilities of the institutes involve with the NDC 5.2

Institution	Roles and Responsibilities
SLR	Collecting and annually reporting the data related to, 1. Fuel consumption 2. Specific line wise passenger km 3. Specific fuel consumption 5. Accident-related data, in specific routes
Sri Lanka Police	Measuring and reporting data relevant to traffic congestion
CPSTL	Measuring and annually reporting following data 1. Net Calorific Value of fuel
NTC	Measuring and reporting of share of passengers by each transport mode%
CEYPETCO	Measuring and annually reporting the data 1. Sulphur content in the fuel (% by mass) 2. Fuel price
CEA	Measuring and annually reporting PM 10 concentration of considered area
DCS	Measuring and annually reporting population at risk of health effect
VET	Measuring and annually reporting of data relevant to air pollutions; emission factor as mass per unit of activity rate, extra emissions due to cold starts and extra emissions due to evaporations (NMVOC)

Data Management

Data management process for each indicator is given in figure 11. Proposed Data Management System for NDC 5.2. The all indicators which measure, collect, maintain the entry, and reporting frequencies (annually, monthly, or etc.) are included there. Consolidated data will be annually reported to NDC unit by MRV managers of the respective entities.

Verification

Institutions which are responsible for collecting the data already have an internal verification system. Per the request of the NDC unit of the ministry of transport, institutions will submit the internally verified data. Quality and the accuracy of the data provided, will be verified by the QA & QC team of NDC unit. Quantitative assessment conducted on the SDG impacts of each mitigation action will be verified by the MRV expert committee, appointed by the Ministry of Environment. Verified results will be submitted to the CCS of Ministry of Environment which will be responsible for submitting the results to the UN and SDC depending on the requirement.

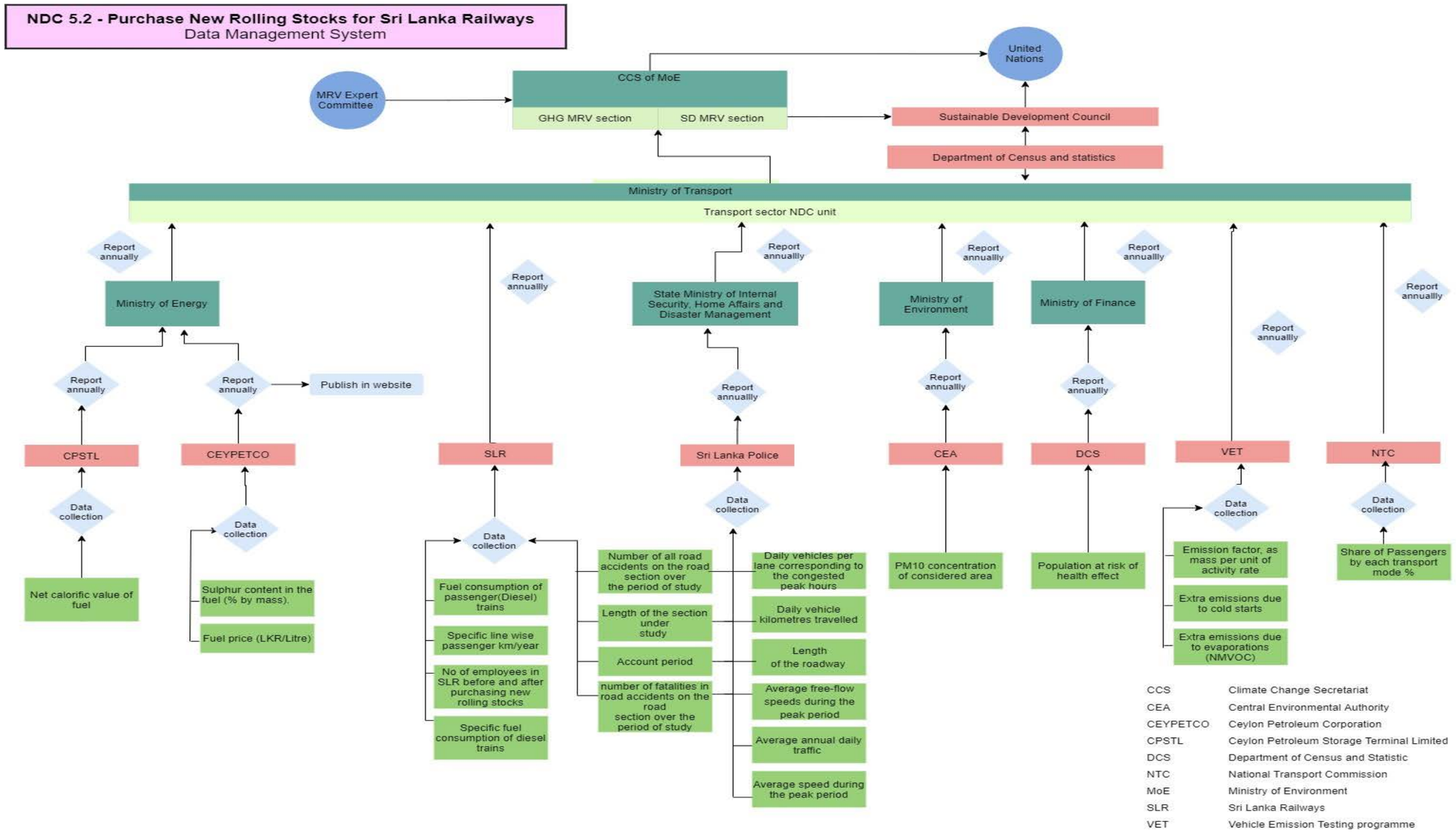

Figure 8:Draft SD MRV Framework for NDC 5.2

Source : ClimateSI,2021

3.4 Introduce electric buses.

3.4.1 Outcome of step 01: Defining the Assessment.

Introduce electric buses is the sub NDC 8.3 of the eighth main NDC, "Encourage and introduce low emission vehicles such as electric and hybrid". Selected project activity under this NDC involves the introduction of 9 electric buses for the public passenger transportation in Colombo region by Sri Lanka Transport Board (SLTB). It is an "implementation of new technologies, processes or enhancing practices" in policy type.

The overall objective of the sub- NDC is to create more liveable cities while reaching specific objectives such as reducing fuel use, air pollution, and noise pollution and providing efficient transport by saving time.

This sub- NDC shows a close interaction with Sub NDC 8.4, "Introduce carbon taxes to promote electric cars" and Sub NDC 5.1, "Electrification of the railway system from Veyangoda to Panadura" as these sub -NDCs share similar objectives.

Ministry of Finance, Ministry of Transport and Sri Lanka Transport Board will take the main responsibilities of the initiation, implementation, and maintenance of the project.

Baseline scenario of the assessment: Public passenger transport from convention diesel buses

Project scenario of the assessment: Public passenger transport from environmentally friendly electric buses

3.4.2 Outcome of step 02: Qualitative Assessment

2a) Identification of the impact categories associate with NDC.

A wide variety of sustainable development impact categories associated with the NDCs, covering three dimensions of environmental, social, and economic were identified from the list of impact categories given in ICAT SD guideline (Annex 1) with the assistance of expert judgement and through literature review.

2b) Choosing which impact categories to be assessed.

Identified impact categories under the step 2a were further filtered considering the relevance, significance, comprehensiveness, and alignment within the assessment boundary. The outcomes of step 2a & 2b are given in annex 2-4

Out of 19 impact categories, only 12 impact categories were chosen for the assessment including climate change mitigation, health impacts of air pollution, odours, biodiversity of terrestrial eco system, noise pollution, illness and death, quality of life and well-being, traffic congestion, cost and cost savings, mobility, jobs and wages.

2c) Identification of the specific impacts

Specific impacts were identified under each of the impact categories upon drawing causal chains as shown in figure 12.

2d) Qualitative assessment of the identified specific impacts

Identified specific impacts were assessed against the likelihood, magnitude, and significance levels as shown in table 15.

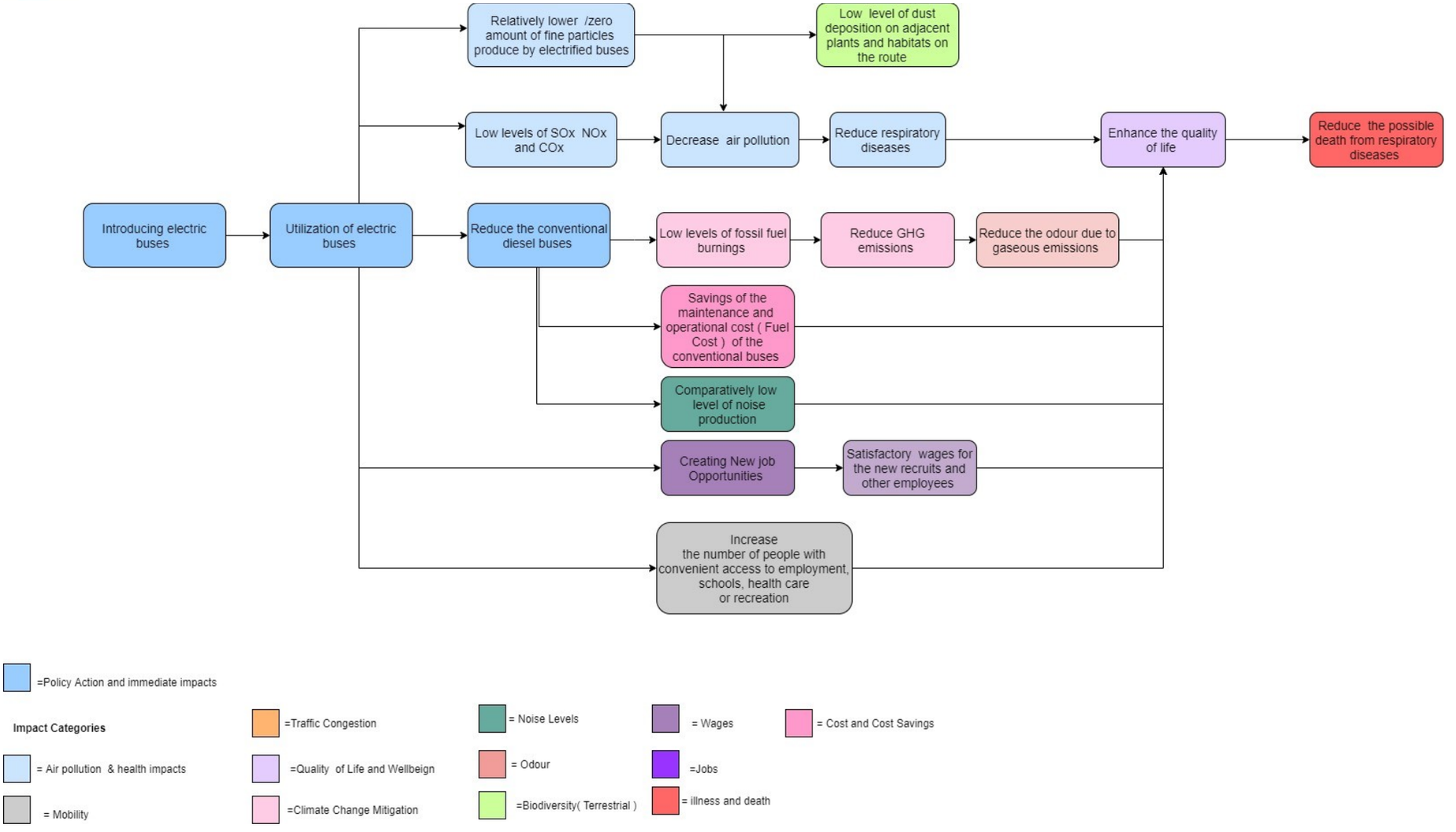

Figure 12: Causal Chain of NDC 8.3

Source: ClimateSI,2021

Table 13:Qualitative assessment of the NDC 8.3

Impact category	Specific impacts identified	In or out of jurisdiction	Qualitative Analysis						Defining the boundary for quantitative assessment	
			Likelihood	Magnitude	Positive or Negative	Significant	Summary of qualitative assessment results for each impact category	Methods/ sources used in the identification of specific impact	Feasible to quantify	Included in the quantitative assessment boundary
Dimension: Environment										
Climate change mitigation (SDG 13)	Reduction of GHG due to the introduction of electric buses	In/out	Very likely	Major	Positive	Significant	The major positive impact was observed	(Filosa et al., 2017) [12]	Yes	Yes
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Decrease respiratory diseases of the adjacent residence due to the low level of pollutants (PM) from electric buses	In	Possible	Major	Positive	Significant	The major positive impact was observed	(Weiss, 2015) [28]	Yes	Yes
	Decrease air pollution due to the low gases emissions from electric buses	In	Possible	Major	Positive	Significant	The major positive impact was observed	(Weiss, 2015) [28]	Yes	Yes
Odour	Low level of smell due to the minimal gaseous emissions from electric buses	In/out	Possible	Moderate	Positive	Significant	A moderate positive impact was observed	(Britneff ,2020) [17]	No	No
Biodiversity of terrestrial eco systems (SDG 15)	Reduce the deposition of dust on the surface of the adjacent plant leaves	In	Possible	Minor	Positive	Insignificant	A moderate positive impact was observed	(Yan,2014) [15]	No	No

Noise Pollution	Lower noise levels after the implementation of electric buses	In	Likely	Major	Positive	Significant	The major positive impact was observed	Expert knowledge	Yes	Yes
Dimension: Social										
Illness and death (SDG 3)	Reduce possible deaths from respiratory diseases	In	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	(Siribaddana et al., 2019) [17]	No	No
Quality of life and well being (SDG 3)	Enhance the quality of life by implementation of electric buses. (due to the reduction of respiratory diseases, easy access to employment etc.)	In/out	Likely	Major	Positive	Significant	The major positive impact was observed	(Cappa et al., 2019) [24]	No	No
Mobility (SDG 11)	Increase the number of people with convenient access to employment, schools, health care or recreation.	In	likely	Major	Positive	Significant	The major and positive significant impact was observed	Expert knowledge	Yes	Yes
Dimension: Economical										
Wages (SDG 8)	Satisfactory wages for new recruits and other employees.	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [13]	Yes	Yes
Jobs (SDG 8)	Create new job opportunities	In	Very Likely	Moderate	Positive	Significant	A moderate positive impact was observed	ICAT SD Methodology [13]	Yes	Yes
Cost and cost Savings	Savings of the maintenance and operational cost of the conventional buses	In	Very Likely	Moderate	Positive	Significant	A moderate positive impact was observed	ICAT SD Methodology [13]	Yes	

Source: ClimateSI, 2021

3.4.3 Outcome of step 3: Quantitative Assessment of the Mitigation Action

Out of the 14 specific impacts identified (covering environmental, social, and economic dimensions), 08 specific impacts were identified as quantifiable specific impacts that are within the scope of the assessment.

Table 16: Selection of quantifiable impacts for NDC 8.3

Description	Amount Considered	Reference from the document
Impact categories associate with the NDC	19	Annex 2-4
Number of impact categories chosen for the assessment	12	Annex 2-4 (highlighted in red) Table 12 -Column 1
Qualitative Assessment		
Total number of specific impacts considered under each category	12	Table 12-Column 2
Quantitative Assessment		
Quantifiable specific impacts	08	Table 14- Column 2

Source: ClimateSI,2021

3a) Identification of the possible indicators for quantification

Adhering to the guidance given in table 2 in this report and referring to table 5.5 of the ICAT SD methodology, suitable indicators were identified to monitor those specific impacts.

3b) Identification of the possible methodologies /parameters for each indicator

Possible methodologies and related parameters to monitor the indicators were identified upon a literature survey. The outcomes of steps 3a & 3b are given in table 17.

Table 17: Quantitative assessment of NDC 8.3

Step 3a. Identification of indicators			Step 3b. Identification of suitable methodologies to quantify the indicators	Data collection mechanism	
Impact category	**Specific impacts identified**	**Indicator**	**Methodology**	**Parameters covered by the survey /Included in the equation**	**Possible entities/reference documents provide/ obtained data**
Environment					
Climate change mitigation (SDG 13)	Reduction of GHG due to the introduction of electric buses	Net emissions of greenhouse gases	Small scale CDM methodology- AMS III.C; emission reductions by electric and hybrid vehicles. **Equation: Policy Scenario** $PE_y = \sum_i EF_{PJ,km,i,y} \times DD_{i,y} \times N_{i,y}$ **Equation: Baseline scenario** $BE_y = \sum_i EF_{BL,km,i} \times DD_{i,y} \times N_{i,y} \times 10^{-6}$	**Baseline scenario** BE_y Total baseline emissions in year y (t CO_2) $EF_{BL,km,i}$ Emission factor for baseline vehicle category i (g CO_2/km) $N_{i,y}$ Number of operational project vehicles in category i in year y $DD_{i,y}$ Annual average distance travelled by the project vehicle category i in the year y (km) **Policy scenario** PE_y Total project emissions in year y (t CO_2) $EF_{PJ,km,i,y}$ Emission factor per kilometre travelled by the project vehicle type i (t CO_2/km) $N_{i,y}$ Number of operational project vehicles in category i in year y $DD_{i,y}$ Annual average distance travelled by the project vehicle category i in the year y (km)	**Documents** GHG MRV document for transport sector mitigation actions of Sri Lanka **Entities** Sri Lanka Transport Board Ceylon Petroleum Storage Terminal Limited Sri Lanka Sustainable Energy Authority Road Passenger Transport Authority National Transport Commission

Health impacts of air pollution (SDG3, SDG 11, SDG12)	Reduce respiratory diseases due to low emissions of pollutants (PM).	Proportion of population with diagnosed respiratory diseases.	dHi = β X POPi _ dAi	**Baseline Scenario**: Proportion of population with diagnosed respiratory diseases when using conventional diesel buses. **Project Scenario:** Proportion of population with diagnosed respiratory diseases after introducing electric buses. dHi change in population risk of health effect(i) β slope of the dose–response function POPi population at-risk of health effect i dAi change in level of air pollutant under consideration	**Entities** Central Environment Authority Vehicle Emission Testing Programme Department of Census and Statistics
	Decrease air pollution due to the low level of gaseous emissions.	Emissions of air pollutants (t/year)	**Baseline scenario** $Total\ Emissions = + \sum_{abcd} (EF\ abcd * Activity\ abcd) + \sum_{b} Cold\ b + \sum_{b} Evoporation\ b$ **Policy scenario** Emissions considered as zero considering the tail pipe emissions	**Baseline scenario** EF Emission factor, as mass per unit of activity rate Activity activity rate (fuel consumed or distance travelled) Cold Extra emissions due to cold starts Evaporation extra emissions due to evaporation (NMVOCs) a fuel type (petrol, diesel, LPG, etc.) b vehicle type (passenger car, light-duty truck, bus, etc.) c emission control d road type or vehicle speed	**Documents** Good practice guidance and uncertainty management in national greenhouse gas inventories

Noise Pollution	Decrease noise levels with the utilization of the electric buses.	Noise Level	$10L_{AeqT} = 10\log_{10}\left(\frac{1}{T}\sum_{i=1}^{N} 10^{L_{Ai}/10}\right)$ Same equation can be used separately in baseline and policy scenario	**Baseline Scenario**: Noise levels associated with the conventional diesel buses. **Project Scenario:** Noise levels associated with the electric buses. N number of 1-second samples (at least 10) T the duration of the measurement interval (in seconds) L_{Ai} the ith A=weighted sound pressure level (in dB(A))	**Entities** Industrial Technology Institute
Dimension: Social					
Mobility (SDG 11)	Increase the number of people with convenient access to employment, schools, health care or recreation.	Number of people or proportion of population with convenient access to employment, schools, health care or recreation	Relevant data to be collected upon bilateral meetings with the Sri Lanka Transport Board. Result can be obtained by simple equation developed as below. $Y = \frac{ab - AB}{AB}$	**Baseline Scenario**: Mobility levels due to the conventional diesel buses: Number of seated passengers transported in one -trip of diesel bus. **Project Scenario:** Mobility levels due to the electric buses: Number of seated passengers transported in one -trip of electric buses. Y Increase of number of people with convenient access to employment, schools, health care or recreation A No. of seated passengers transported in a one trip by fossil fuel-based bus (one-way) B No of trips per day by fossil fuel-based bus (one-way)	**Entities** Sri Lanka Transport Board

				a No. of seated passengers transported in a one trip by electrified buses (one-way) b No of trips per day by electrified bus system (one-way)	
Dimension: Economical					
Wages (SDG 8)	Satisfactory wages for the new recruitments	Average hourly wage for employees associates with electric buses	Relevant data to be collected upon employer survey. **Equation for relative change:** Average hourly wage of the employees attached to SLTB to operate electric buses. – Average hourly wage earned by the employees at their previous employment.) / Average hourly wage earned by the employees at their previous employment. *100%	**Baseline Scenario**: Average hourly wage earned by the employees at their previous employment. **Policy Scenario:** Average hourly wage of the employees attached to SLTB to operate electric buses.	**Entities** Sri Lanka Transport Board Department of Employment and labour National Transport Commission Ministry of Transport
Jobs (SDG 8)	Create new job opportunities	Number of permanent jobs created due to operation and maintenance of electric buses. (Permanent jobs)	Relevant data to be collected upon employer survey. (Number of employees attached to the SLTB after implementing electric buses. – Number of employees attached to the SLTB before implementing electric buses.)/ Number of employees attached to the SLTB before implementing electric buses. *100%	**Baseline Scenario:** Number of employees attached to the SLTB before deploying electric buses. **Policy Scenario:** Number of employees attached to the SLTB after deploying electric buses.	**Entities** Sri Lanka Transport Board

Cost and cost savings	Savings of the maintenance and operational cost of the conventional buses	Fuel costs or cost savings	Method used in GHG emission calculation can be incorporated as follows. Baseline Scenario: $SFC_i * N_{i,y} * DD_{i,y}$ * Unit cost of the fuel Project Scenario: $SEC_{P,J,K,M,I,Y*} N_{i,y} * DD_{i,y}$ * Unit cost of the Electricity	**Baseline Scenario:** Fuel costs associated with the conventional diesel buses. **Project Scenario** Electricity cost associated with the electric buses. SFC_i Specific fuel consumption of baseline vehicle category *i* (g/km) $N_{i,y}$ Number of operational project vehicles in category *i* in year *y* $DD_{i,y}$ Annual average distance travelled by the project vehicle category *i* in the year *y* (km) $SEC_{P,J,K,M,I,Y}$ Specific electricity consumption by project vehicle category *i* per km in year *y* in urban conditions(kWh/km)	**Entities** Sri Lanka Transport Board

Source: ClimateSI,2021

Refer institution wise procedures (deliverable 4.1) for more details on data collection templates.

3.4.4 Outcome of Step 4: Institutional arrangement and data management system

There are 11 institutions involve in the MRV framework of NDC 8.3. Namely the Ceylon Electricity Board (CEB), Ceylon Petroleum Storage Terminal Limited (CPSTL), Ceylon Petroleum Corporation (CEYPETCO), Sri Lanka Transport Board (SLTB), National Transport Board (NTC), Road Passenger Transport Authority (RPTA), Department of Labour (DOL), Central Environment Authority (CEA), Department of Census and Statistics (DCS), Vehicle Emission Testing (VET) Service, and Industrial Technology Institute (ITI) are the eleven institutions.

All the institutions are responsible for a specific task as shown in table 18.

Table 14: Roles and responsibilities of the institutions involve in the NDC 8.3.

Institution	Roles and Responsibilities
SLTB	Measuring, recording and annually reporting following data. 1.Annual average distance travelled by electric buses In the absence of 1, following data will be provided. 1.Total distance travelled by e- buses. 2. Total number of e-bus operated. 3.Number of operated electric buses 4.Specific electricity consumption of electric buses In the absence of 2, following data will be provided. 3.1 Ranges of the buses 3.2 Battery capacity 4.Specific fuel consumption of conventional buses In the absence of the 4, following data will be provided. 4.1 Fuel cost per km
NTC	Measure and report the average hourly wage earned by the employees
RPTA	
Department of Labour	
SLSEA	Measure and report the data on grid emission factor.
CPSTL	Measuring and annually reporting following data 1. Net calorific value of fossil fuel that use in running tanks
CEYPETCO	Measuring and annually reporting the data 1. Unit cost of fuel

	2. Density of Fuel
VET	Measuring and annually reporting of data relevant to air pollutions: 1. Emission factor as mass per unit of activity rate 2. Extra emissions due to cold starts 3. Extra emissions due to evaporations (NMVOC)
ITI	Measuring and reporting of sound pressure level of road vehicles
CEA	Measuring and annually reporting PM 10 concentration of considered area
DCS	Measuring and annually reporting population at risk of health effect
CEB	Measuring and annually reporting of data relevant to transmission and distribution lost & unit price of electricity.

Data management

Data management process for each indicator is given in figure 13. Proposed Data Management System for NDC 8.1. The all indicators which measure, collect, maintain the entry, and reporting frequencies (annually, monthly, or etc.) are included there. Consolidated data will be annually reported to NDC unit by MRV managers of the respective entities.

Verification

Institutions which are responsible for collecting the data already have an internal verification system. Per the request of the NDC unit of the ministry of transport, institutions will submit the internally verified data. Quality and the accuracy of the data provided, will be verified by the QA & QC team of NDC unit. Quantitative assessment conducted on the SDG impacts of each mitigation action will be verified by the MRV expert committee, appointed by the Ministry of Environment. Verified results will be submitted to the CCS of Ministry of Environment which will be responsible for submitting the results to the UN and SDC depending on the requirement.

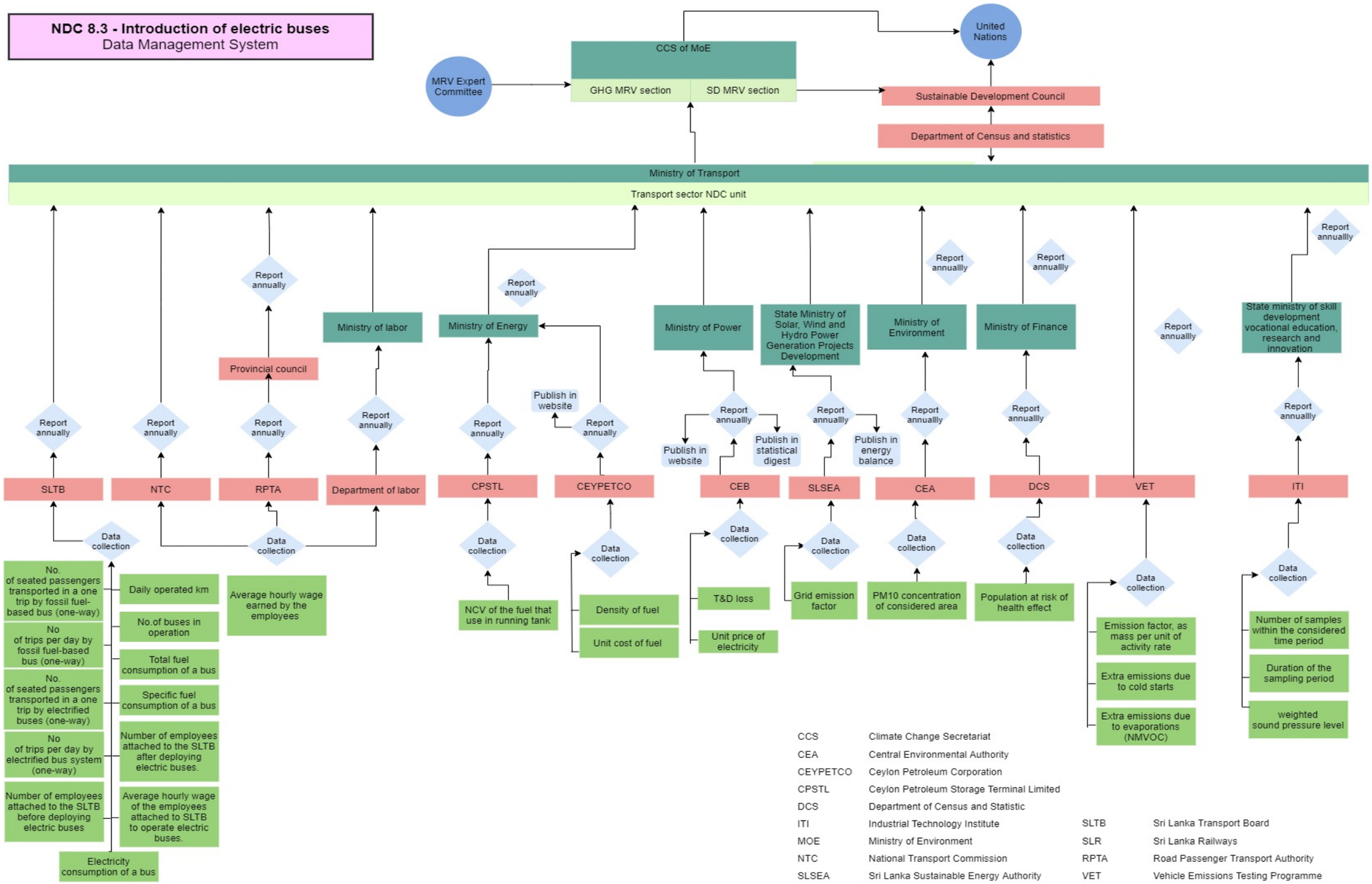

Figure 9:Data Management System for NDC 8.3

Source: ClimateSI ,2021

3.5 Introduction of the carbon tax to promote electric cars.

3.5.1 Outcome of step 01: Defining the Assessment.

Introduction of the carbon tax to promote electric cars is the sub NDC 8.4 of the eighth main NDC, "Encourage and introduce low emission vehicles such as electric and hybrid". This is a national-level policy and "Tax and Charges" in policy type.

The carbon tax has been introduced by the government for conventional diesel and petrol vehicles since 2019 based on the engine capacity, age, and fuel type. The carbon tax does not apply to electric vehicles while all other vehicles must pay. This benefits passengers by reducing the emissions and leading to a quality environment to be exposed.

The overall objective of the sub- NDC is to create more liveable cities while reaching specific objectives such as, reducing fuel use, air pollution, and noise pollution and to provide efficient transport by saving time.

This sub- NDC shows a close interaction with Sub NDC 8.3 "Introduce electric buses" and also with the sub NDC 5.1 "Electrification of the railway system from Veyangoda to Panadura "as all these NDCs share similar objectives.

Department of Motor Traffic plays the key role of implementation and the maintenance of the policy action.

Baseline scenario of the assessment: Share of electric/ hybrid vehicles in the vehicle market without carbon tax

Project scenario of the assessment: Share of electric/ hybrid vehicles in the vehicle market with carbon tax

3.5.2 Outcome of step 02: Qualitative Assessment

2a) Identification of the impact categories associate with NDC.

A wide variety of sustainable development impact categories associated with the NDC, covering three dimensions of environmental, social, and economic were identified from the list of impact categories given in ICAT SD guideline (annex 1) with the assistance of expert judgement and through literature review.

2b) Choosing which impact categories to be assessed.

Identified impact categories under the step 2a were further filtered considering the relevance, significance, comprehensiveness, and alignment within the assessment boundary. The outcomes of steps 2a & 2b are given in Annex 2-5.

Out of 12 impact categories, only 11 impact categories were chosen for the assessment including climate change mitigation, health impacts of air pollution, odours, visibility, biodiversity, and terrestrial ecosystems, noise pollution, quality of life and well-being, innovation, jobs, and economic activity.

2c) Identification of the specific impacts

Specific impacts were identified under each of the impact categories upon drawing causal chains as shown in figure 14.

2d) Qualitative assessment of the identified specific impacts

Identified specific impacts were assessed against the likelihood, magnitude, and significance levels as shown in table 19.

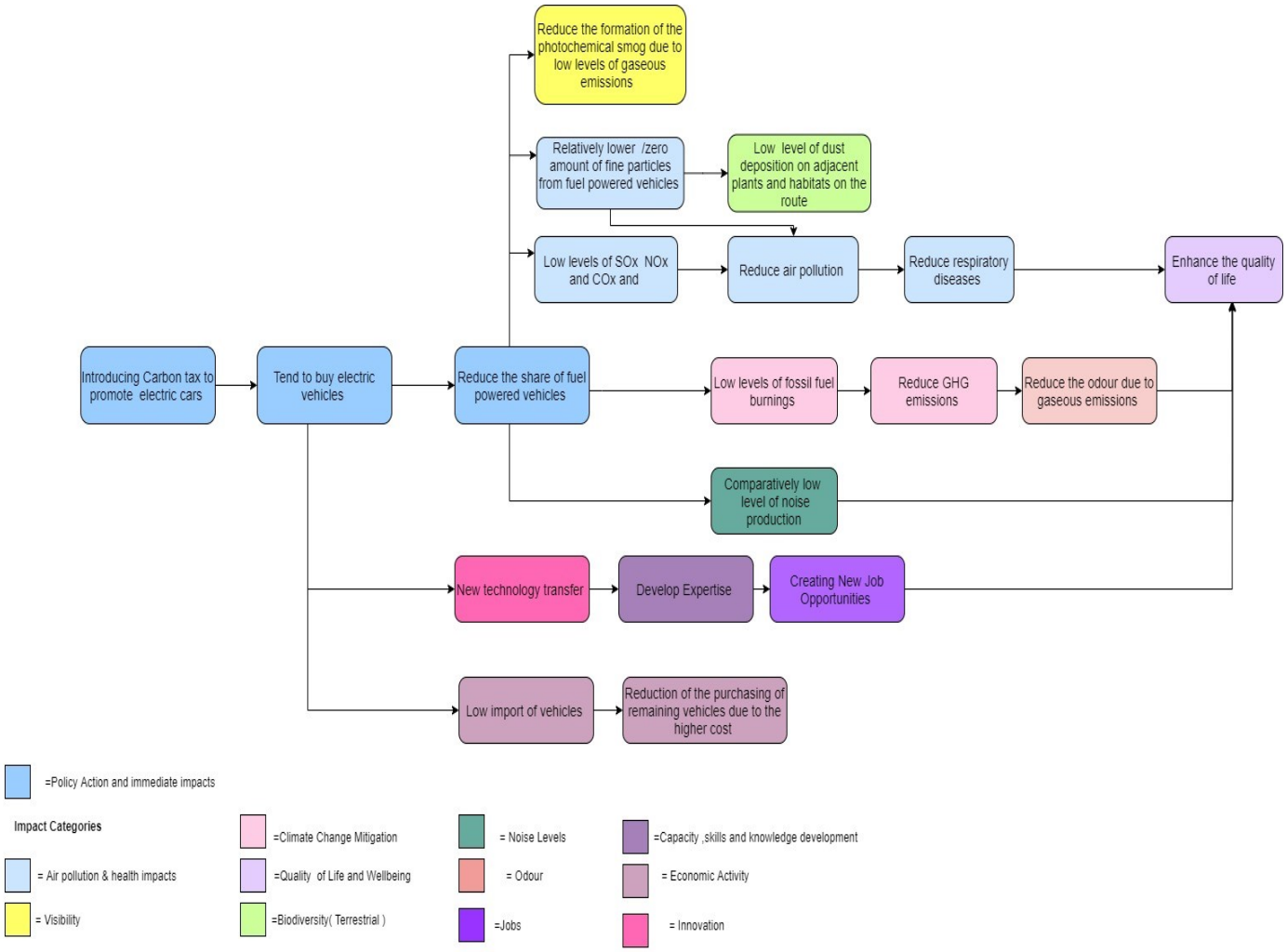

Figure 10:Causal Chain of NDC 8.4,

Source: ClimateSI,2021

Table 15:Qualitative assessment of NDC 8.4

Impact category	Specific impacts identified	In or out of jurisdiction	Qualitative Analysis						Defining the boundary for quantitative assessment	
			Likelihood	Magnitude	Positive or Negative	Significant	Summary of qualitative assessment results for each impact category	Methods/ sources used in the identification of specific impact	Feasible to quantify	Included in the quantitative assessment boundary
Dimension: Environment										
Climate change mitigation (SDG 13)	Reduction of GHG due to the reduction of the share of fuel powered vehicles	In/out	Very likely	Major	Positive	Significant	The major positive impact was observed	(Filosa et al., 2017) [12]	Yes	Yes
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Reduce respiratory diseases due to the low level of pollutants (PM)	In	Very likely	Major	Positive	Significant	The major positive impact was observed	Expert Knowledge	Yes	Yes
	Decrease air pollution due to the low level of gaseous emissions	In	Very likely	Major	Positive	Significant	The major positive impact was observed	Expert Knowledge	Yes	Yes
Biodiversity of terrestrial Eco Systems	Reduce the deposition of dust on the adjacent plants	In	Possible	Minor	Positive	Insignificant	A minor positive	(Yan,2014) [14]	No	No

(SDG 15)	and habitats, from diesel vehicles						impact was observed			
Visibility	Reduce the possibility of forming photochemical fog due to the minimal emissions of gases	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	Experts Knowledge	No	No
Odour	Reduce odour due to the low levels of emissions	In	Likely	Major	Positive	Significant	The major positive impact was observed	Experts Knowledge	No	No
Noise Pollution	Lower noise levels with the utilization of electric vehicles	In	Likely	Major	Positive	Significant	The major positive impact was observed	(Jacyna,2017) [29]	Yes	Yes
Dimension: Social										
Quality of Life and well being (SDG 3)	Enhance the quality of life through (e.g., reducing respiratory diseases, reduce noise levels etc) upon the increasing the share of electric vehicles	In/out	Likely	Major	Positive	Significant	The major positive impact was observed	(Cappa et al., 2019) [24]	No	No
Dimension: Economical										

Jobs (SDG 8)	Create new job opportunities due to the development of expertise.	In	Likely	Minor	Positive	Significant	A minor positive impact was observed	ICAT SD Methodology [17]	Yes	Yes
Capacity skills and knowledge development	Develop Expertise	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [17]	No	No
Economic activity	Low imports of vehicles	In	Very Likely	Major	Negative	Significant	The major negative impact was observed	ICAT SD Methodology [17]	Yes	Yes
	Reduction of the purchasing of remaining vehicles due to the higher cost	In	Very Likely	Major	Negative	Significant	The major negative impact was observed	ICAT SD Methodology [17]	No	No
Innovation (SDG 8,9)	New Technology Transfer	In /Out	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [17]	No	No

Source: ClimateSI ,2021

3.5.3 Outcome of step 3: Quantitative Assessment

Out of the 13 specific impacts (covering environmental, social, and economic dimension) identified 06 specific impacts were identified as quantifiable parameters that are within the scope of the assessment.

Table 20: Selection of quantifiable impacts for NDC 8.4

Description	Amount Considered	Reference from the document
Impact categories associate with the NDC	12	Annex 2-5
Number of impact categories chosen for the assessment	11	Annex 2-5 (highlighted in red) Table 15 -Column 1
Qualitative Assessment		
Total number of specific impacts considered under each category	13	Table15 -Column 2
Quantitative Assessment		
Quantifiable specific impacts	06	Table 17: column 2

Source: ClimateSI, 2021

3a) Identification of the possible indicators for quantification

Adhering to the guidance given in table 1 in this report and referring to table 5.5 of the ICAT SD methodology, suitable indicators were identified to monitor those specific impacts.

3b) Identification of the possible methodologies /parameters for each indicator

Possible methodologies and related parameters to monitor the indicators were identified upon a literature survey.

The outcomes of the step 3a & 3b are given in table 21.

Table 21: Quantitative assessment of the NDC 8.4

Step 3 a)- Identification of indicators			Step 3b. Identification of suitable methodologies to quantify the indicators	Data collection mechanism	
Impact category	**Specific impacts identified**	**Indicator**	**Methodology**	**Parameters covered by the survey /Included in the equation**	**Possible entities/reference documents provide/ obtained data**
Dimension: Environment					
Climate change mitigation (SDG 13)	Reduction of GHG due to the reduction of the share of fuel powered vehicles	Net emissions of greenhouse gases	ICAT Transport Pricing Guidance **Baseline scenario** $\boldsymbol{BE\ i}_{,,}\ in\ CO2\ emissions\ (t\ CO2) = [F,\boldsymbol{j},\boldsymbol{y}\ in\ energy\ units\ (TJ)]\ x\ [\boldsymbol{EFi}\ (t\ CO2\ per\ TJ)]$ **Project scenario** GHG impact = (market share) x (annual new vehicle sale) x (per km emissions reduction) x (average lifetime km per vehicle)	**Baseline scenario key indicators** $\boldsymbol{FC_{i,j,y}}$ Total fuel energy i (from gasoline / diesel / electricity) used per mode j of passenger transport (road / rail) in year y $\boldsymbol{EFi}$ Emission factor for fuel i (tCO_2/TJ)	**Documents** GHG MRV document for transport sector mitigation actions of Sri Lanka **Entities** Department of motor traffic Vehicle Emission Testing Programme Ceylon Petroleum Corporation
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Reduce respiratory diseases due to low emissions of pollutants (PM).	Proportion of population with diagnosed respiratory diseases.	dHi = β X POPi _ dAi	**Baseline Scenario**: Proportion of population with diagnosed respiratory diseases before enforcing carbon tax. **Project Scenario:** Proportion of population with diagnosed respiratory diseases after enforcing carbon tax.	**Entities** Central Environment Authority Vehicle Emission Testing Programme Department of Census and Statistics

	Decrease the air pollution due to the low level of gaseous emissions	Emissions of air pollutants (t/year)	**Baseline scenario indicator** $Total\ Emissions = \sum_{abcd} (EF\ abcd * Activity\ abcd) + \sum_{b} Cold\ b + \sum_{b} Evoporation\ b$ **Policy scenario indicator** Due to the zero tailpipe emissions, gaseous emission in the policy scenario will be considered as zero.	dHi change in population risk of health effect(i) β slope of the dose–response function POPi population at-risk of health effect i dAi change in level of air pollutant under consideration **Baseline Scenario**: Emissions of air pollutants(t/year) (NO_X, N_2O &SO_X) from fuel-based vehicles before enforcing carbon tax. **Project Scenario:** Emissions of air pollutants (t/year) (NO_X, N_2O &SO_X) after enforcing carbon tax **Baseline scenario indicator**	**Documents** Good practice guidance and uncertainty management in national greenhouse gas inventories

				EF Emission factor, as mass per unit of activity rate Activity activity rate (fuel consumed or distance travelled) Cold Extra emissions due to cold starts Evaporation extra emissions due to evaporation (NMVOCs) a fuel type (petrol, diesel, LPG, etc.) b vehicle type (passenger car, light-duty truck, bus, etc.) c emission control d road type or vehicle speed	
Noise Pollution	Decrease noise levels with the utilization of electric vehicles.	Noise Level	$LAeqt = 10\log 10(1/T)\sum_{I=1}^{N} 10^{L\mu/10}$	**Baseline Scenario**: Noise levels of diesel vehicles before enforcing carbon tax. **Project Scenario:** Noise levels of remaining diesel vehicles before enforcing carbon tax. N number of 1-second samples (at least 10) T the duration of the measurement interval (in seconds) L_{Ai} the ith A=weighted sound pressure level (in dB(A))	**Entities** Industrial Technology Institute
Dimension: Economical					
Jobs (SDG 8)	Create new job opportunities	Number of new jobs created in	Relevant data to be collected upon employer survey.	**Baseline Scenario:** Number of employees in automobile sector who are specialized in electric vehicles before enforcing carbon tax. **Policy Scenario:**	**Entities** Department of Employment and Labour

		associated sectors (Permanent jobs)	(Number of employees in automobile sector who are specialized in electric vehicles after enforcing carbon tax. – Number of employees in automobile sector who are specialized in electric vehicles before enforcing carbon tax)/ Number of employees in automobile sector who are specialized in electric vehicles before enforcing carbon tax*100%	Number of employees in automobile sector who are specialized in electric vehicles after enforcing carbon tax.	
Economic activity	Low imports of conventional vehicles after the enforcement of carbon tax	Total vehicle imports	(Annual total vehicle imports before enforcing carbon tax. – Annual total vehicle imports after enforcing carbon tax.)/ Annual total vehicle imports before enforcing carbon tax. *100%	**Baseline Scenario:** Annual total vehicle imports before enforcing carbon tax. **Policy Scenario:** Annual total vehicle imports after enforcing carbon tax.	**Entities** Sri Lanka Customs

Source: ClimateSI,2021

Refer institution wise procedures (deliverable 4.1) for more details on data collection templates.

3.5.4 Outcome of step 4: Institutional arrangement and data management systems.

There are 11institutions involve in the MRV framework of NDC 8.4. Namely the Ceylon Electricity Board (CEB), Ceylon Petroleum Storage Terminal Limited (CPSTL), Ceylon Petroleum Corporation (CEYPETCO), Vehicle Importers Association, Department of Motor Traffic (MOT), Sri Lanka Customs (SLC), Department of Labour (DOL), Central Environment Authority (CEA), Department of Census and Statistics (DCS), Vehicle Emission Testing (VET) Service, and Industrial Technology Institute (ITI) are the eleven institutions.

All the institutions are responsible for a specific task as shown in table 22.

Table 16:Roles and responsibilities of the institutes involve in NDC 8.4.

Institution	Roles and Responsibilities
DMT	DMT collect most of the data that are necessary for the calculation. Type, age, fuel type, engine capacity and specific fuel/electricity consumption are some of the data should be collected through DMT. Other than that total number of vehicles registering per year should also collect. DMT should always be cautious about updates of carbon taxes
SLSEA	Measure and report the data on grid emission factor.
CPSTL	Measuring and annually reporting following data 1. Net calorific value of fuel
CEYPETCO	Measuring and annually reporting the data 1. Specific fuel consumption of vehicles 2. Density of Fuel
VET	Measuring and annually reporting of data relevant to air pollutions; 1. Emission factor as mass per unit of activity rate 2. Extra emissions due to cold starts 3. Extra emissions due to evaporations (NMVOC) 4. Distance travelled in vehicle km
ITI	Measuring and reporting of sound pressure level of road vehicles
CEA	Measuring and annually reporting PM 10 concentration of considered area
DCS	Measuring and annually reporting population at risk of health effect
CEB	Measuring and annually reporting of data relevant to transmission and distribution lost.
SLC	Measuring and annually reporting of Cost, Insurance and Freight (CIF) price and annual total vehicle imports
Department of Labour	Measuring and annually reporting, Number of employees in automobile sector who are specialized in electric vehicles

Data management

Data management process for each indicator is given in figure15. Proposed Data Management System for NDC 8.4. The all indicators which measure, collect, maintain the entry, and reporting frequencies (annually, monthly, or etc.) are included there. Consolidated data will be annually reported to NDC unit by MRV managers of the respective entities.

Verification

Institutions which are responsible for collecting the data already have an internal verification system. Per the request of the NDC unit of the ministry of transport, institutions will submit the internally verified data. Quality and the accuracy of the data provided, will be verified by the QA & QC team of NDC unit. Quantitative assessment conducted on the SDG impacts of each mitigation action will be verified by the MRV expert committee, appointed by the Ministry of Environment. Verified results will be submitted to the CCS of Ministry of Environment which will be responsible for submitting the results to the UN and SDC depending on the requirement.

8.4 Introduction of carbon tax to promote electric cars
Data Management System

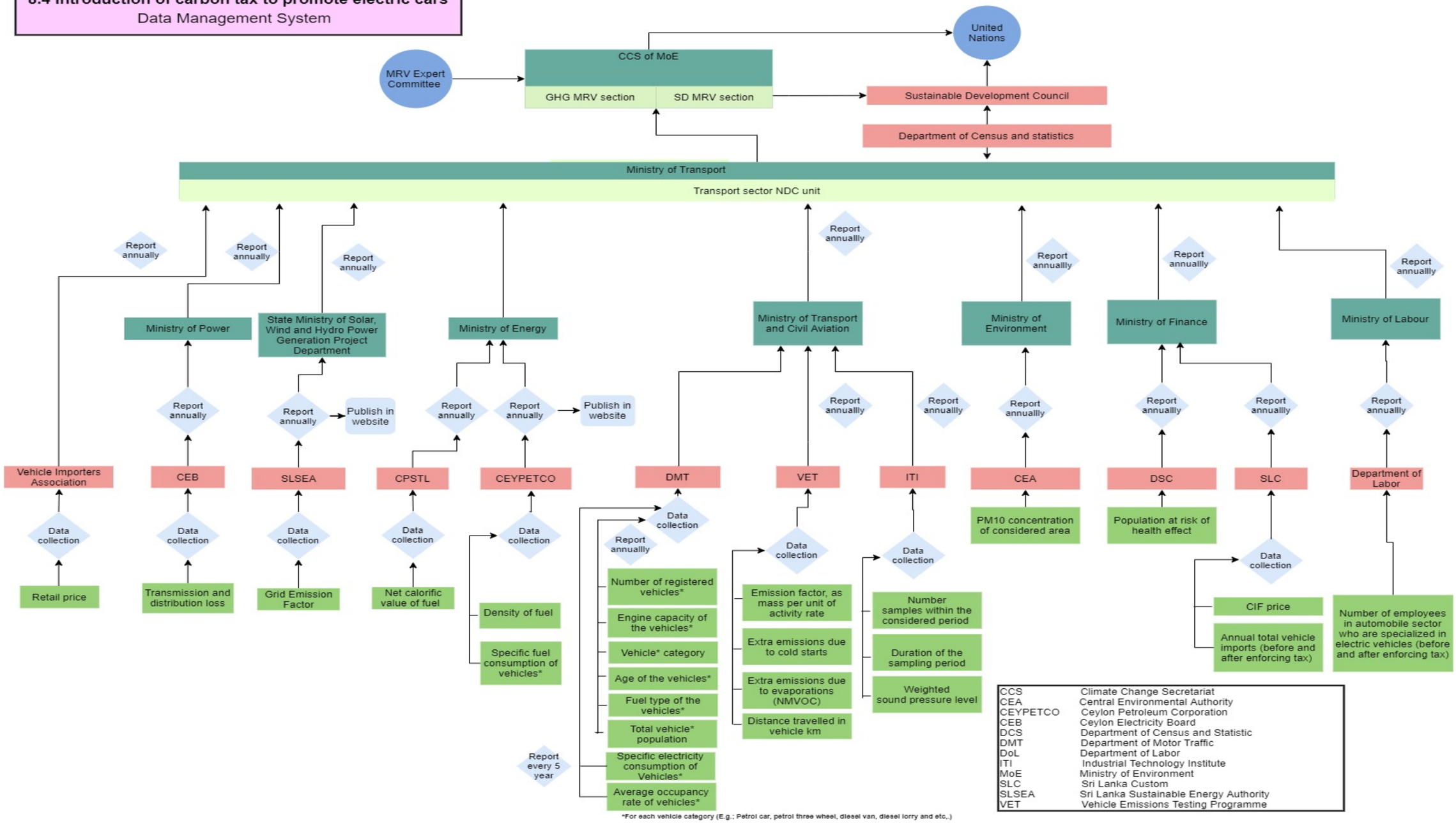

Figure 15: Data Management System of NDC 8.4

Source: ClimateSI,2021

3.6 Transport Heavy Loads by Railways

3.6.1 Outcome of step 01: Defining the Assessment.

Transport of heavy loads by railway is the sub NDC 9.4 of the ninth main NDC "Reduce traffic congestion to reduce GHG emissions". This sub NDC falls into the policy type "implementation of new technologies, processes, or enhancing practices".

Shifting transportation of petroleum products from road to rail is one of many projects under this NDC. Aviation fuel transportation from Kollonnawa to Katunayake considered for this study. As this is already implemented analysis will be done by applying an ex-post (backward looking) approach.

The overall objective of the sub- NDC is to create more liveable cities while mitigating the current traffic congestion, reduce fuel use, air pollution and noise pollution and provide efficient transport by saving time. This sub-NDC shows a close interaction with all other NDCs too.

Sri Lanka Railway, Ceylon Petroleum Storage Terminal Limited will take the main responsibilities of the implementation and maintenance of the project.

Baseline scenario of the assessment: Transportation of aviation fuel from bowsers

Project scenario of the assessment: Transportation of aviation fuel from the train

Figure 16: Geographic boundary for NDC 9.4

Source: http://earth.google.com

3.6.2 Outcome of step 02: Qualitative Assessment

2a) Identification of the impact categories associate with NDC.

A wide variety of sustainable development impact categories associated with the NDC, across the three dimensions of environmental, social, and economic were identified.

2b) Choosing which impact categories to be assessed.

Identified impact categories under the step 2a were further filtered considering the relevance, significance, comprehensiveness, and alignment within the assessment boundary. The outcomes of step 2a & 2b are given in Annex 2-6.

Altogether 11 impact categories were chosen including climate change mitigation, health impacts of air pollution, visibility, odours, noise pollution, illness and death, jobs, quality of life and wellbeing, traffic congestion, road safety, and wages.

2c) Identification of the specific impacts

Specific impacts were identified under each of the impact categories upon drawing causal chains as shown in figure 17.

2d) Qualitative assessment of the identified specific impacts

Identified specific impacts were assessed against the likelihood, magnitude, and significance levels as shown in table 23.

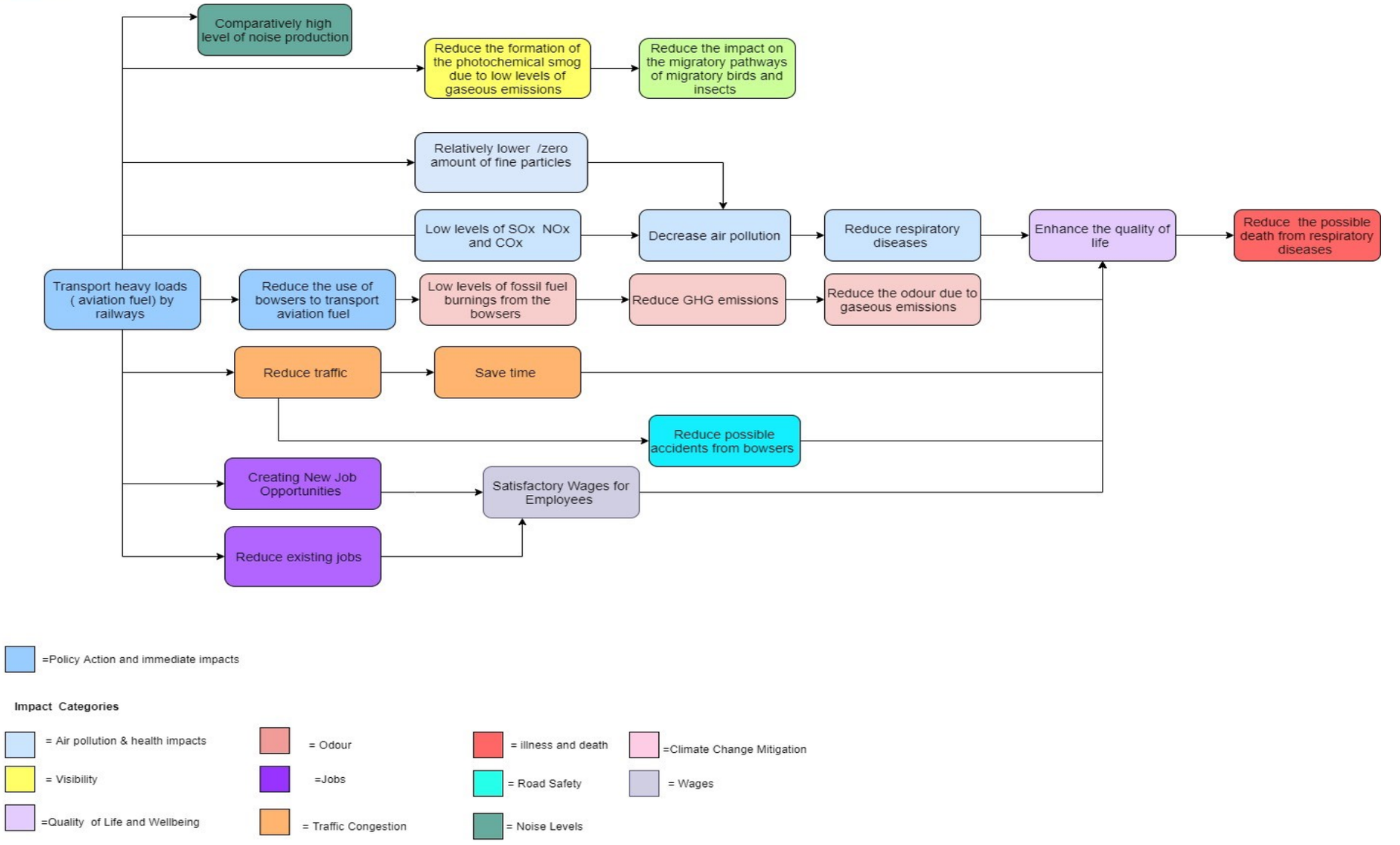

Figure 17: Causal Chain diagram for NDC 9.4

Source: ClimateSI,2021

Table 23: Qualitative assessment of the NDC 9.4

Impact category	Specific impacts identified	Jurisdiction (In/Out)	Qualitative Analysis						Defining the Boundary for Quantitative Assessment	
			Likelihood	Magnitude	Positive or Negative	Significant	Summary of qualitative assessment results for each impact category	Methods/ sources used in the identification of specific impact	Feasible to Quantify	Included in the quantitative assessment boundary
Dimension: Environment										
Climate change mitigation (SDG 13)	Reduction of GHG due to the transportation of heavy loads by railways	In/out	Very likely	Major	Positive	Significant	The major positive impact was observed	(Filosa et al., 2017) [12]	Yes	Yes
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Reduce respiratory diseases of the adjacent residence due to low pollutants (PM) emissions	In	Very likely	Major	Positive	Significant	The major positive impact was observed	Expert Knowledge	Yes	Yes
	Decrease air pollution due to the low level of gaseous emissions	In	Very likely	Major	Positive	Significant	The major positive impact was observed	Expert Knowledge	Yes	Yes
Visibility	A low level of emissions reduces the chances of	In/out	Likely	Minor	Positive	Insignificant	A minor positive impact was observed	Expert Knowledge	No	No

	creating a photochemical smog									
Odour	Low level of uncomfortable smell produces from trains with compared bowsers	In/out	Possible	Minor	Positive	Insignificant	A minor positive impact was observed	Expert Knowledge	No	No
Noise Pollution	Increase higher noise levels upon the transportation of train	In	Likely	Major	Negative	Significant	The major negative impact was observed	Expert Knowledge	Yes	Yes
Dimension: Social										
Illness and death (SDG 3)	Decrease possible deaths from respiratory diseases	In	Very Likely	Minor	Positive	Insignificant	The minor positive impact was observed	(Jang et al., 2012) [31]	No	No
Quality of Life and Well Being (SDG 3)	Enhance the quality of life by (e.g., reducing respiratory diseases and traffic levels.)	In/out	Likely	Major	Positive	Significant	The major positive impact was observed	(Cappa et al., 2019) [24]	No	No
Traffic congestion (SDG11)	Traffic levels decreased due to the allocation of the train instead of bowsers	In	likely	Major	Positive	Significant	Major and a positive impact was observed	(https://www.strata.org/pdf/2017/pipelines.pdf) [32]	Yes	Yes
Road safety (SDG 3,11)	Reduce possible accidents associate with bowsers	In	Possible	Minor	Positive	Insignificant	The minor positive impact was observed (Over the years	Sri Lanka Police,2021 [19]	Yes	Yes

							least number of accidents were reported as collapses of oil bowsers)			
Dimension: Economical										
Wages (SDG 8)	Satisfactory wages for employees	In	Very Likely	Major	Positive	Significant	The major positive impact was observed	ICAT SD Methodology [17]	Yes	Yes
Jobs (SDG 8)	Create new job opportunities	In	Unlikely	Minor	Positive	Insignificant	The minor positive impact was observed	ICAT SD Methodology [17]	No	No
	Loss of jobs	In	Unlikely	Minor	Negative	Insignificant	The minor negative impact was identified	ICAT SD Methodology [17]	No	No

Source: ClimateSI, 2021

3.6.3 Outcome of step 3: Quantitative Assessment

Out of the 13 specific impacts 07 specific impacts were identified as quantifiable parameters that are within the scope of the assessment.

Table 24: Selection of quantifiable impacts for NDC 9.4

	Amount Considered	Reference from the document
Impact categories associate with the NDC	32	Annex 2-1
Number of impact categories chosen for the assessment	11	Annex 2-1 (highlighted in red) Table 18 -Column 1
Qualitative Assessment		
Total number of specific impacts considered under each category	13	Table 18-Column 2
Quantitative Assessment		
Quantifiable specific impacts	07	Table 20 -Column 3

Source: ClimateSI, 2021

3a) Identification of the possible indicators for quantification

Adhering to the guidance given in table 2 in this report and referring to table 5.5 of the ICAT SD methodology, suitable indicators were identified to monitor those specific impacts.

3b) Identification of the possible methodologies /parameters for each indicator

Possible methodologies and related parameters to monitor the indicators were identified upon a literature survey. Outcomes of the step 3a & 3b are given in table 25.

Table 25: Quantitative assessment of NDC 9.4

Step 3a. Identification of Indicators			Step 3b. Identification of suitable methodologies to quantify the indicators	Data collection mechanism	
Impact category	**Specific impacts identified**	**Indicator**	**Methodology**	**Parameters covered by the survey /Included in the equation**	**Possible entities/reference documents provide/ obtained data**
Climate change mitigation (SDG 13)	Reduction of GHG due to the transportation of heavy loads by railways instead of bowsers	Net emissions of greenhouse gases	Methodology AM 0090 version 01.1.0" Modal shift in transportation of cargo from road transportation to water or rail transportation can be used to quantify the GHG effects as given in the GHG MRV for transport sector. **Baseline scenario:** $BE_y = T_y \cdot AD \cdot EF_{BL} \cdot 10^{-6}$ **Policy scenario:** $PE_y = (PE_{FC,y} + PE_{EC,y}) \cdot F_{RT,PJ,y} + PE_{CR,y}$	**Baseline scenario:** T_y Amount of cargo transported by the project transportation mode in year *y* (tonne) AD Distance of the baseline trip route (km) EF_{BL} Baseline emission factor for transportation of cargo (gCO_2 per tonne.km) **Project scenario:** $PE_{FC,y}$ Project emissions from fossil fuel combustion in the project activity in year *y* (tCO_2) $PE_{EC,y}$ Project emissions from electricity consumption in the project activity in year *y* (tCO_2) $F_{RT,PJ,y}$ The factor to account for non-empty return trips in the project scenario in year *y* (fraction) $PE_{CR,y}$ Project emissions from transportation of cargo in complementary routes in trucks in year *y* (tCO_2)	**Documents** GHG MRV document for transport sector mitigation actions of Sri Lanka **Entities** Sri Lanka Railways Ceylon Petroleum Storage Terminal Limited
Health impacts of air pollution (SDG3, SDG 11, SDG12)	Reduce respiratory diseases due to low emissions of pollutants (PM).	Proportion of population with diagnosed respiratory diseases.	dHi = βX POPi _ dAi	**Baseline Scenario**: Proportion of population with diagnosed respiratory diseases when transporting fuel by railway. **Project Scenario:** Proportion of population with diagnosed respiratory diseases when transporting fuel by bowsers.	**Entities** Central Environment Authority Vehicle Emission Testing Programme Sri Lanka Railway Department of Census and Statistics **Documents** Good practice guidance and uncertainty management in national greenhouse gas inventories

	Decrease air pollution due to the low emissions of gases.	Emissions of air pollutants (t/year)	**Baseline Scenario -Emissions from bowsers** $Total\ Emissions = \sum_{abcd} (EF\ abcd * Activity\ abcd) + \sum_{b} Cold\ b + \sum_{b} Evoporation\ b$ **Project Scenario -Emissions from train** NO_X, N_2O $Ei = \sum_{m} FC_m \times EF_{i,m}$ SO_X $E_{SO2} = 2 \times \sum_{m} k_{s,m} \times FC_m$	dHi change in population risk of health effect(i) β slope of the dose–response function POPi population at-risk of health effect i dAi change in level of air pollutant under consideration **Baseline Scenario**: Emissions of air pollutants(t/year) (NO_X, N_2O &SO_X) from bowsers. **Project Scenario:** Emissions of air pollutants (t/year) (NO_X, N_2O &SO_X) from train. **Baseline scenario** EF Emission factor, as mass per unit of activity rate Activity activity rate (fuel consumed or distance travelled) Cold Extra emissions due to cold starts Evaporation extra emissions due to evaporation (NMVOCs) a fuel type (petrol, diesel, LPG, etc.) b vehicle type (passenger car, light-duty truck, bus, etc.) c emission control d road type or vehicle speed **Project scenario** E_i Emissions of pollutant i for the period concerned in the inventory (kg or g) FC_m Fuel consumption of fuel type m for the period and area considered (tonnes) EF_i Emission factor of pollutant i for each unit of fuel type m used (kg/tonnes) m Fuel type (diesel, gas oil) E_{SO2} Emissions of sulphur dioxide for the period concerned in the inventory [kg]	

				$k_{S,m}$ The sulphur content in the fuel (% by mass).	
Noise Pollution	Increase higher noise levels upon the transportation of train	Noise Level	Noise Level $LAeqt = 10\log 10(1/T)\sum_{I=1}^{N} 10^{L\mu/10}$	**Baseline Scenario**: Noise levels associated with bowsers. **Project Scenario:** Noise levels associated with the train. N number of 1-second samples (at least 10) T the duration of the measurement interval (in seconds) L_{Ai} the ith A=weighted sound pressure level (in dB(A))	**Entities** Industrial Technology Institute
Traffic Congestion (SDG11)	Increase time Savings	Time lost during transportation.	Applying principal corridors collective assessment for corridors speed plot Travel delay= Amount of time it takes to travel the peak -period vehicle kilometres at the average speed - Amount of time it takes to travel at the free flow speed	**Baseline Scenario:** The time loss of transportation associate with the fuel transporting bowsers. **Project Scenario:** The time loss of transportation associate with the fuel transportation through train Daily vehicles per lane corresponding to the congested peak hours. Daily vehicle kilometres travelled. Length of the roadway Average freeway speeds during the peak period Average Speed during the peak	**Entities** Sri Lanka Police
Road safety (SDG 3,11)	Reduce accidents by shifting mode of transportation from bowsers to train.	Number of deaths and injuries from road traffic accident per year	Relevant data to be collected upon traffic audit survey. Rates of the accidents and rate of death due to the accidents can be calculated using the following equations from conference paper which given as the reference document. **Rate of road accidents in the road section** under study	R_D Rate of road accidents in the road section D Number of all road accidents on the road section over the period of study N Average annual daily traffic (vehicles/day) L Length of the section under study (km) m Account period **Baseline Scenario:** Number of deaths and injuries from road traffic accidents due to bowsers. **Project Scenario:** Number of deaths and injuries from road traffic accidents due to the transportation of fuel by train	**Documents** Conference paper from ELSEVIER, Forecasting of road accident in the DVRE system. **Institutions** Sri Lanka Police

			$R_D = \frac{D}{N.L.m.365'}$ **Rate of human deaths in an accident on the road section under study** $R_p = \frac{P}{N.L.m.365'}$	R_P Rate of human death in an accident on the road section under study P number of fatalities in road accidents on the road section over the period of study N Average annual daily traffic (vehicles/day) L Length of the section under study (km) m Account period	
Wages (SDG 8)	Satisfactory Wages for employees	Average hourly wage for an employee engaged in aviation fuel transport through train.	Relevant data to be collected upon employer survey. **Equation:** (Average hourly wage for an employee engaged in aviation fuel transport through train- Average hourly wage for an employee engaged in aviation fuel transport through bowser) / Average hourly wage for an employee engaged in aviation fuel transport through bowser *100%	**Baseline scenario:** Average hourly wage for an employee engaged in aviation fuel transport through bowser. **Policy scenario:** Average hourly wage for an employee engaged in aviation fuel transport through train.	**Entities** Sri Lanka Railway Department of Employment and labour Ceylon Petroleum Storage Terminals Limited

Source: ClimateSI, 2021

3.6.4 Outcome of step 4: Institutional arrangement and data management systems

There are 8 institutions involve in the MRV framework of NDC 9.4. Namely the Ceylon Electricity Board (CEB), Ceylon Petroleum Storage Terminal Limited (CPSTL), Ceylon Petroleum Corporation (CEYPETCO), Local Authorities (LA), Sri Lanka Police (SLP), Central Environment Authority (CEA), Department of Census and Statistics (DCS), Vehicle Emission Testing (VET) Service, O & M Company and Industrial Technology Institute (ITI) are the nine institutions.

All the institutions are responsible for a specific task as shown in table 26.

Table 26: Roles and responsibilities of the institutions involve in NDC 9.4.

Institution	Roles and Responsibilities
SLR	Collecting and annually reporting the data related to, 1.Amount & type of cargo transported in specific route. 2.Cargo train kilometer. 3. Fuel consumption of specific freight trains for a specific route 4.Wages of employees 5. Measuring and reporting data relevant to traffic congestion and accidents during the project scenario (when transporting fuel through rail).
Sri Lanka Police	Measuring and reporting data relevant to traffic congestion and road accidents.
CPSTL	Measuring and annually reporting following data 1.Amount of cargo transported through bowsers (in specific route) 2.Fuel consumption from bowsers 3.NCVs of fuel 4.Wages of the employees 5.Trip distance
CEYPETCO	Measuring and annually reporting the data 1.Sulphur content in the fuel (% by mass) 2.Density of Fuel
VET	Measuring and annually reporting of data relevant to air pollutions; emission factor as mass per unit of activity rate, extra emissions due to cold starts and extra emissions due to evaporations (NMVOC)
ITI	Measuring and reporting of sound pressure level of road vehicles
CEA	Measuring and annually reporting PM 10 concentration of considered area
DCS	Measuring and annually reporting population at risk of health effect

Data management

Data management process for each indicator is given in figure 18. Proposed Data Management System for NDC 9.4. The all indicators which measure, collect, maintain the entry, and reporting frequencies (annually, monthly, or etc.) are included there. Consolidated data will be annually reported to NDC unit by MRV managers of the respective entities.

Verification

Institutions which are responsible for collecting the data already have an internal verification system. Per the request of the NDC unit of the ministry of transport, institutions will submit the internally verified data. Quality and the accuracy of the data provided, will be verified by the QA & QC team of NDC unit. Quantitative assessment conducted on the SDG impacts of each mitigation action will be verified by the MRV expert committee, appointed by the Ministry of Environment. Verified results will be submitted to the CCS of Ministry of Environment which will be responsible for submitting the results to the UN and SDC depending on the requirement.

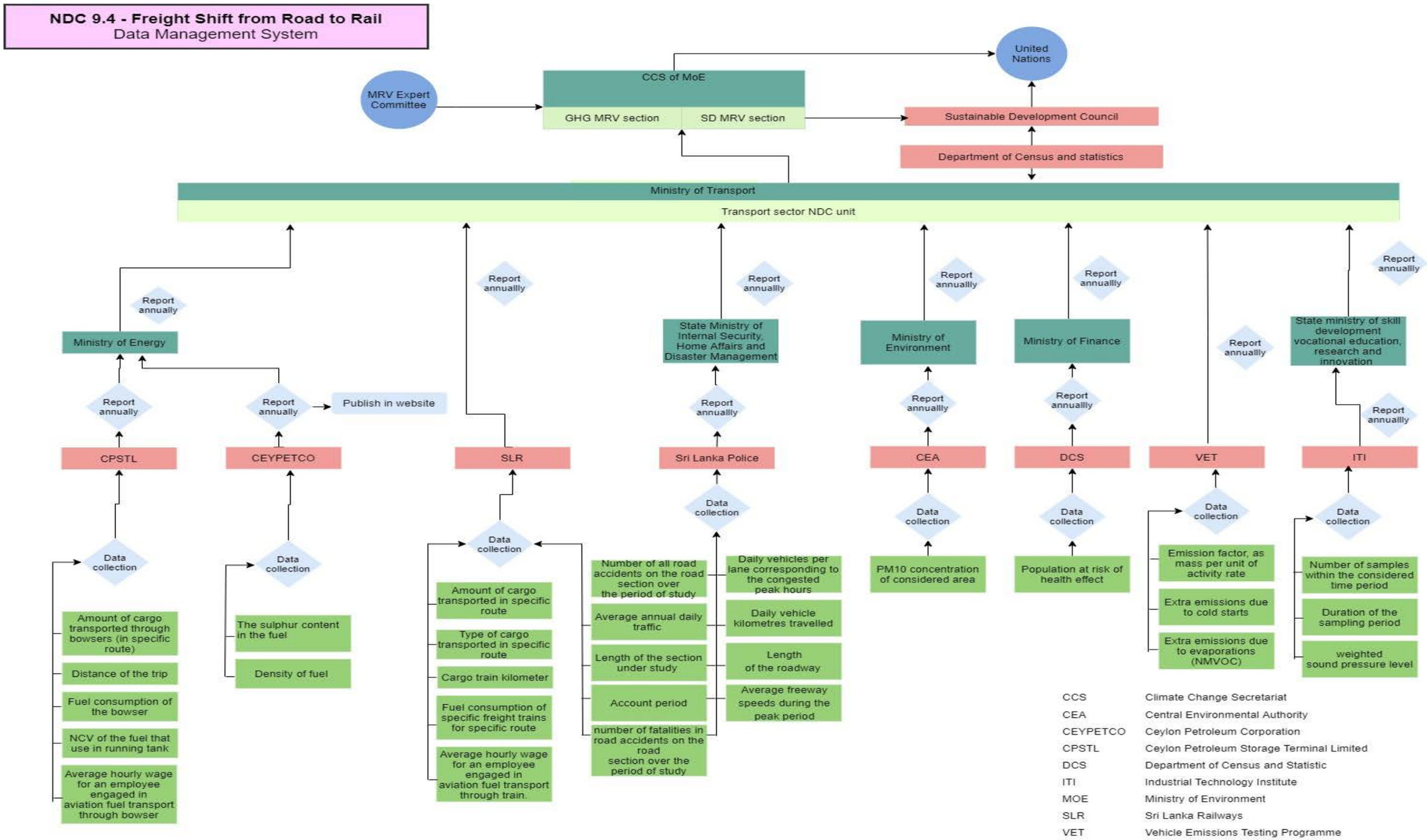

Figure 18: Data management system for NDC 9.4

ClimateSI,2021

4.Proposed national institutional arrangement for transport sector SD MRV framework in Sri Lanka

Existing institutional arrangement in accessing sustainable development impacts of transport sector mitigation actions.

Development of a robust institutional structure which encompasses relevant institutions with clearly demarcated roles and responsibilities is essential for an effective implementation of any MRV system. When developing the institutional arrangement for transport sector SD MRV in Sri Lanka, it is important to understand the existing governance structure and the reporting agencies. The proposed institutional arrangement is based on the existing system with necessary improvements. Existing institutions can be considered under three main categories as follows:

- Existing institutional arrangements in transport sector
- Existing institutional arrangement in climate change related sectors
- Existing institutional arrangement in sustainable development goals

Existing institutional arrangements in transport sector

Institutional arrangement of the Sri Lankan transport sector was comparatively fragmented. However, the Ministry of Transport (MOT) has the overall responsibility in developing policies and projects in the transport sector. Ministry of Transport has one state ministry named as "State Ministry of Vehicle Regulations, Bus Transport Services, Train Compartments and Motor Car Industry."

National Transport Commission, National Council on Road Safety and Department of Sri Lanka Railways are the main statutory institutions and departments function under the Ministry of Transport. Lakdiva Engineering Ltd, Sri Lanka Transport Board, National Transport Medical Institute and the Department of motor traffic are the statutory bodies function under the state ministry. Apart from the ministry, the state ministry and the institutions mentioned above, ministries such as the Ministry of Highways and Ministry of Public Services, Provincial Councils and Local Government also directly involved in the Sri Lankan Transport Sector.

Existing institutional arrangement in climate change related sectors

Ministry of Environment (MOE) is the main responsible entity of the environment and climate related issues and operations of the country. Meantime the Ministry of Environment is the national focal point for UNFCCC. The Central Environment Authority, The Climate Change Secretariat and the Sri Lanka Climate Fund are the main entities comes under the Ministry of Environment.

The Climate Change Secretariat is the operational focal point for climate change related operations in Sri Lanka and responsible for developing relevant policies and programmes to monitor the impacts of national climate responses. The Climate Change Secretariat includes, three main cross functional committees including the inter- agency committee on climate change, the national expert committee on climate change mitigation and the national expert committee on climate change adaptation.

The Sri Lanka Climate Fund (SLCF) is a government owned private company which is established to achieve low carbon and climate resilient. This company promotes the private sector investment for mitigating and adapting to climate change in a commercially sustainable way.

The Central Environment Authority (CEA) of Sri Lanka was established on 12th August 1981, under the provision of the National Environmental Act No :47 of 1980. CEA together with its governing ministry, Ministry of Environment (MOE) fulfil the objective of integrating environmental matters in country's development. The CEA was given many regulatory powers under the National Environment (Amendment) acts No:56 of 1988 and No: 53 of 2000. The CEA provides many services including issuing environmental protection licensing, conducting EIAs /IEEs, providing environmental recommendations, conducting information and laboratory services, scheduled waste management licensing and handle public complaints related to the environment.

Existing institutional arrangement in sustainable development goals

There are two main institutions involve in assessing the sustainable development goals in Sri Lanka. Out of the two, the Sustainable Development Council (SDC) is the key government entity responsible of monitoring and evaluation of the achievement of SDGs as a country. Meantime SDC is the designated body to report to United Nations on the progress of SDGs. The council has five main powers as follows:

a) Formulate and Review.

Work together with all the nine provincial councils and cabinet ministers in the process of formulating and reviewing national policies.

b) Issue guidelines

The council has the authority to issue guidelines relating to sustainable development for all parties including ministries, provincial councils and in new development projects.

c) Identify

Identify sustainable development standards, mechanisms and ecological footprint indicators.

d) Promote Sustainable Development

Promote Sustainable Development through key areas including the research, development, innovation, education, and awareness.

e) Introduce and follow up

Introducing and following up on the methodologies, audit mechanisms on sustainable development.

The council is maintaining an SDG portal and it has nearly 400 government agencies to monitor the SDG targets. The department of census and statistics is one of the key institutions from the identified 400 agencies.

Department of Census and Statistics is a combination of two units, the statistic section and the census section which functioned separately under the Donoughmore Constitution. These separate entities were brought under one department and named as the "Department of Census, Statistics and Planning with the emergence of the Soulbury Constitution in 1947.The department was renamed as the "Department of Census and Statistics by a gazette notification of 18th, May 1948. The DCS maintain the

relevant data and statistics on nine main subjects' areas including agriculture, computer literacy, education, health, industry, inflation and prices, trade, income and expenditure, labour force, national accounts, gender statistics, population, poverty, and public employment.

Currently, Department of Census and Statistics is contributing to the monitoring of the sustainable development goals by providing the baseline data to monitor the SDG indicators. Apart from that, the Department has developed an open access indicator framework for SDG monitoring.

5.2 Proposed national institutional set up for SD MRV to track the sustainable impacts of transport sector mitigation actions.

With a basic knowledge of the existing institutional structure in climate change area, the transport sector of the country and the sustainable development, the institutional arrangement for the transport sector SD MRV implementation is developed as presented in the figure 19.

Roles and responsibilities of the institutions

1.Ministry of Environment (MOE)

As the national focal point to UNFCCC, Ministry of Environment is responsible for reporting the progress of NDC implementation to the UNFCCC through CCS.

2. MRV Sections in the Climate Change Secretariat (CCS)

Climate Change Secretariat is the operational focal point which is responsible to report the status of achieving the NDCs. There is a proposed GHG MRV section functioning under the climate change secretariat. This was proposed as a part of the GHG MRV of transport sector mitigation actions and the GHG MRV system is referring to the emission reduction calculation associated with the GHG emissions. Parallel to that, another MRV section under the climate change secretariate was proposed as "SD MRV". This MRV section will be referring to the environment, social and economic impacts of mitigation actions.

SD MRV section of the Ministry of Environment will also report to the Sustainable Development Council of Sri Lanka. Eventually the Sustainable Development Council will incorporate the project level sustainable impacts to the country's SDG achievement and report to the United Nations (UN).

3.MRV Expert Committee

There is an existing MRV expert committee for GHG MRV system and this includes several sectoral experts. The same expert committee was proposed to work as an external verifier for the SD MRV system. Main roles and responsibilities of the MRV Expert Committee on Sustainable Development Assessment as follows:

- Verification of the sustainable impact assessment calculations conducted by the NDC unit.
- Provide necessary guidance and feedback to sectoral NDC units on quantifying the sustainable impact.
- Make recommendations for improving the process for data collection.
- Provide recommendation on suitable methodologies to access the sustainable impacts.
- Establishing systems and procedures for the verification of reported impacts of NDCs.

4. Transport Sector NDC Unit

The transport sector NDC unit was proposed as a part of the GHG MRV, and it is comprised of a trained staff and necessary infrastructure. There is an existing set of roles and responsibilities for GHG MRV, and the following roles and responsibilities will be assigned transport sector NDC unit with the focus of sustainable development assessment.

- Coordination of the flow of information from individual institution and ministries for a collective assessment of environment, social and economic impacts of policies, strategies, and actions.

- Calculation of Sustainable impacts of transport sector policies, strategies, and actions.
- Quality assurance and quality control of data.
- Identification of all institutions that will be involved in data collection.
- Allocate responsibilities for all institutions ensuring that there is a clear lead for each institution for sustainability monitoring and establish an institutional level formal approval process.
- Develop and monitor a time frame and schedule for the preparation and submission of necessary data including specific dates for deliverables.
- Documenting systematically, as appropriate, all the assumptions, data and methods used
- Store and safe keep of data and calculations

Other related institutions of the proposed SD MRV institutional framework

1.Ceylon Electricity Board (CEB)

The Ceylon Electricity Board (CEB) was established on 1st November 1969 under the Parliament Act No. 17 of 1969 as a corporate body. The CEB is authorized to generate, transmit and distribute electrical energy, to reach all categories of consumers and collect the revenue. The obligation of the CEB is to make the optimal use of the resources through the application of pragmatic and time-tested managerial methods.

2. Ceylon Petroleum Cooperation (CEYPETCO)

The Ceylon Petroleum Corporation was set up as a state enterprise by Act. No. 28 of 1961 in parliament and further amendments carried out subsequently. It is governed by Ministry of Energy. The main objectives of Ceylon Petroleum Corporation are to carry on business as an importer, exporter, seller, supplier, and distributor of Petroleum products. To carry on business of exploring for the exploiting, producing, and refining of Petroleum and to carry on any such business as may be incidental or conducive to the attainment of the objectives.

3.Ceylon Petroleum Storage Terminal Limited (CPSTL)

CPSTL is an entity which govern by the Ministry of Energy. Further, CPSTL is a Company duly incorporated under the companies Act No. 17 of 1982 in terms of Section 2 (1) of the conversion of Public Corporations or Government owned business undertakings into Public Companies Act No.23 of 1987, owns the Common User Facility (CUF) consisting of Oil Terminals, Storage Facilities, Pipelines, and the Bowser Fleet, more fully described in the Government Gazette extraordinary bearing No. 1310-8 dated 13th October 2003.

4.Department of Labour (DOL)

The Department of Labour was established under the Indian Immigrant Labour Ordinance No. 01 of 1923. The main function of the department is to implement the legislations to empower the security and welfare of Labour Force.

5. Industrial Technology Institute (ITI)

The Industrial Technology Institute is a wholly owned institute of the Government of Sri Lanka and functions under the jurisdiction of State Ministry of Skills Development, Vocational Education, Research, and Innovation. A statutory board incorporated on the 1st of April 1998, under the Science and Technology Development Act No. 11 of 1994, the Industrial Technology Institute (ITI) is the successor to the Ceylon Institute of Scientific and Industrial Research (CISIR). The institute has grown steadily over the past sixty years from a humble beginning in 1955 (as CISIR) and has expanded continuously to boast of skills and expertise from a myriad of different scientific disciplines. The Science and Technology Development Act No.11 of 1994 that came into effect on 01 April 1998 describe mandate of ITI. The objective of the Technology Institute shall be to elevate the level of technology in Sri Lanka to the level required or rapid industrialization.

6.National Transport Commission (NTC)

In 1991, NTC was introduced to regulate inter provincial bus services and established regional transport authorities (Road Transport Authorities) to regulate intra bus services under 13 constitutions. At present each province has their own RPTA.

7. State Ministry of Urban Development, Coast Conservation, Waste Disposal and Community Cleanliness (O & M Company)

O & M Company will be responsible for operational and management performance of the LRT. In consideration of that, the MRV system should be established complementing the O & M Company of JICA – LRT system. Since O & M Company is a proposed entity, it does not have attributed mandatory functions. However, it is recommended that the urban railway be managed by another legislative system from the national railway in Sri Lanka. A new act for JICA – LRT system in the process of establishing by PMU under MMWD.

8. Sri Lanka Customs

In the year 1806 Sri Lanka Customs established with enacting the Custom Ordinance. Current Sri Lanka Custom is under Ministry of Finance and Mass Media which responsible for collection of revenue, prevention of revenue leakages and other frauds, facilitation of legitimate trade, collection of import and export data to provide statistics and finally cooperation and coordination with other government departments and stakeholders in respect of imports and exports.

To calculate retail price of the vehicle, the cost, insurance and freight (CIF) value data which collected from Sri Lanka Custom is very important. Vehicle retail price can be calculated using the CIF data as well as taxes from custom and profit kept by the vehicle importer from vehicle importer association.

9. Sri Lanka Police

The Police Department was established on 03 September 1866 with the view of providing an organized service to the public during the British administration according to the Police Ordinance No. 16 of 1865. Since then, for about 154 years, the Sri Lanka Police is committed to discharging the significant responsibility of establishing and maintaining the law and order of the country. Sri Lanka Police is vested with the responsibility of establishing social security by affirming the security of every aspect of public life. Control and prevention of crimes, prevention of drug menace, controlling corruption, traffic control, protection of the environment, making relief to people in disaster situations, and providing VIP security are the main tasks included in the scope of the police.

10. Sri Lanka Railways (SLR)

Sri Lanka Railways (SLR) is the key internal institute responsible for implementing this NDC. This is a government department functioning under Ministry of Transport. It is the only rail transport provider of the country. It has established through railway Ordinance which is commenced in 1902. Sri Lanka Railways Authority Act (No.60 of 1993) was enacted since 15th of December 1993. Act was repealed in February 2005 as Sri Lanka Railways Authority (Repeal) Act, No.3 of 2005.

11. Sri Lanka Transport Board (SLTB)

Sri Lanka introduced first public transport service from Colombo to Chilaw. In 1958 Central Transport Board (CTB) was established. Around 2,500 buses were operated under CTB. Two decades after introducing CTB, nine regional boards were introduced. Political influences, poor management and heavy losses failed the regional companies. Therefore, in 1979 private sector was invited to invest in transport sector. Just one year after introducing private buses, around 5,000 buses were operated without proper mechanism. Therefore, Peoplized bus companies were established. Due to various reasons, Peoplized companies were integrated into regional transport companies. After that SLTB was reconstituted by Sri Lanka Transport Board Act No 25 in 2005.

12.Vehicle Emission Testing Program (VET)

The Ministry of Environment has gazetted regulations specifying mobile air emission standards, fuel standards and vehicle specification standards for importation, under section standards for importation, under section 32 of the National environment Act No. 47 of 1980, which were effective from 1st July 2003. These regulations stipulate that the Commissioner of Motor Traffic (CMT) is responsible for the enforcement of mobile air emission standards through authorization of accredited garages for the purpose of testing and certifying air emission levels of any motor vehicle. To give appropriate authority to the CMT, to implement this activity, regulations are to be gazette under Section 19, 202 and 237 of the Motor Traffic Act no. 21 of 1981.

13. Sri Lanka Sustainable Energy Authority (SLSEA)

The Sri Lanka Sustainable Energy Authority (SLSEA) was established on 1st October 2007 for the necessity of having a liable institution to drive Sri Lanka toward a new level of sustainability in energy generation and usage. The SLSEA is responsible for enacting the Sri Lanka Sustainable Energy Authority Act No. 35 of 2007.

Data quality management process of SD MRV system

A process to ensure that data are properly collected, handled, processed, used, and maintained at all stages is a key to a reliable MRV system to improve transparency, consistency, comparability, completeness, and accuracy of the system. Therefore, the transport sector SD MRV system encompasses the quality Assurance (QA) and quality control (QC) measures. According to the ICAT sustainable development methodology, it is important maintain a minimum uncertainty level in sustainability assessment. Therefore, establishing a quality control (QC) and a quality assurance (QA) is important.

Data quality control will be done by the QA/QC team at the “transport sector NDC unit”, which was proposed under the GHG MRV system. However, a different focus will be maintained when assessing QA/QC of the sustainable assessment by adhering to the following steps.

1. Assess and rely on the existing QA process of the data collection of the specific institution -As most of the data are originally collected for the purposes other than sustainable development impact calculations many institutions already have a process to ensure the quality of data. If the QA/ QC team is satisfied with the existing QA process they can rely on that. However, if the QA associated with activity data is inadequate then the team must go for other methods of QA listed below.

2. Comparison with independently complied data sources -

Many of the sustainable development impact related transport sector data, are compiled by various organizations and local universities. Comparison can be done by similar statistics published by those entities.

3. Comparison with samples -

Sustainable development impacts of any sector is a devolved subject. Some of the required data are collected by provincial level institutions like provincial councils and local authorities and other associations. These data sets can be used as samples provide the opportunity to check the reasonableness of national data.

4. Trend check - Activity data can be compared with the data from the previous years. Activity data are normally showing consistent change from year to year. Therefore, if there are major changes those data should be further investigated. Calculation related QC will be done by the MRV Expert committee. The committee will check the duplication of inputs, unit conversion errors, or calculation errors.

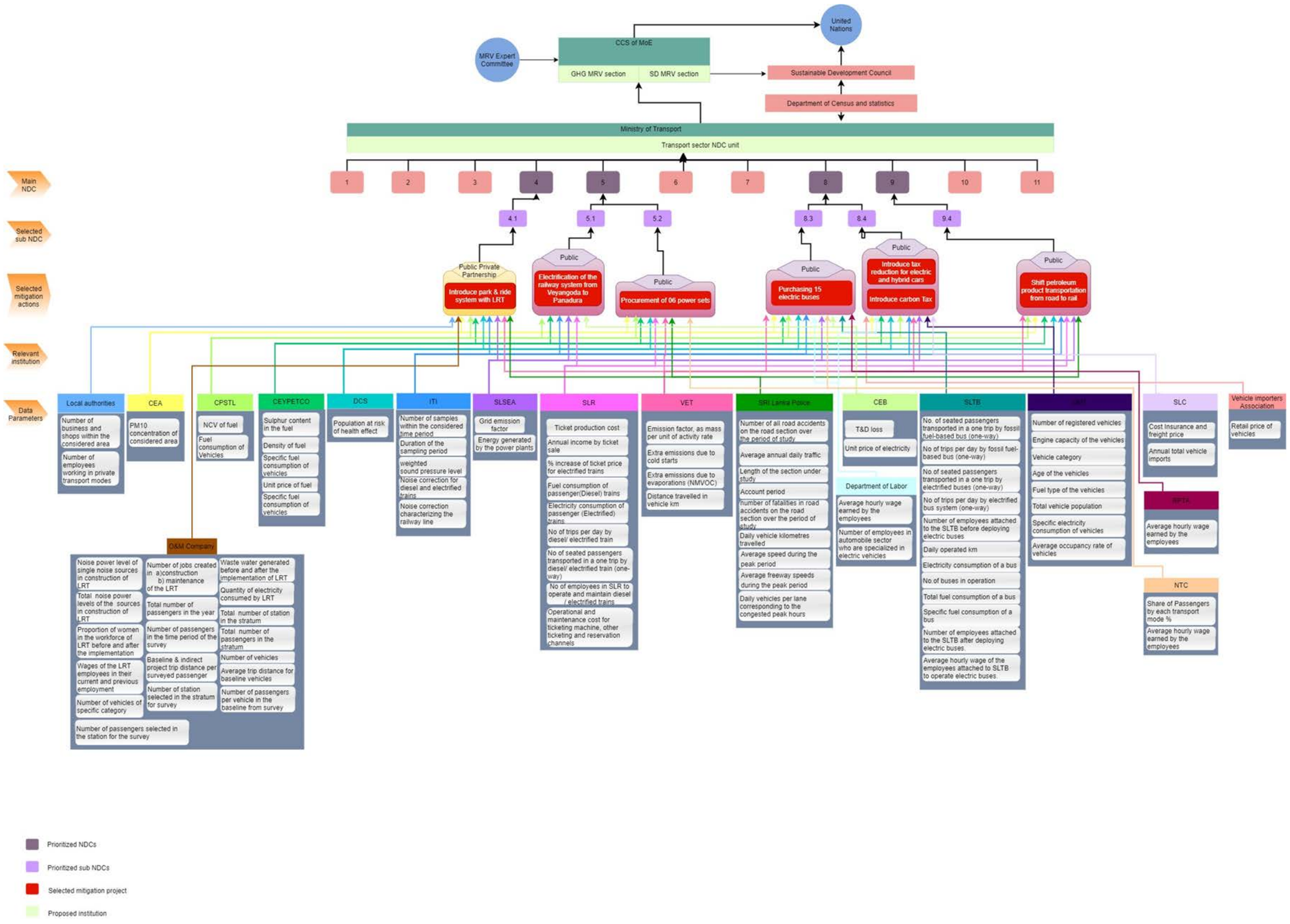

Figure 11: Proposed Institutional Framework for the SD MRV system

Recommendation

Sri Lanka is currently in the stage of localizing SDG indicators to measure SDGs at sector level, and has already mapped those with the relevant authorities, entities responsible for monitoring the localized UN indicators for SDGs. However, a clear institutional framework for SDG tracking is yet to be developed even though the Sustainable Development Council of Sri Lanka is actively engaged in SDGs work. However, there is no system in place to measure, report and verify SD impacts of mitigation actions in Sri Lanka. Therefore, the implementation of a SD MRV system to track SD impacts of mitigation actions under NDCs would be a timely needed requirement. In this scenario, it is very much important in selecting the correct indicators for monitoring SD impacts of mitigation actions, and their targets to integrate with the national level achievement of SDGs.

This report established SD MRV framework to track SD impacts of mitigation actions under Transport sector NDCs. The Project level SD impact analyses were a comprehensive assessment that incorporated many impacts. In this regard, identification of the indicators representing each specific impact category is one of the most critical steps. The assessment has revealed that all transport sector NDCs are interrelated to contribute to many SDGs. The absence of methodologies to quantify the given impacts turned out to be a challenge. However, appropriate methodologies were identified upon the desk review of peer-reviewed journal articles and documented in the report.

The SD MRV framework was established based on the parameters in the identified methodologies to measure SD impacts of mitigation actions. Type of data needed, data providing entities, data reporting entities, verification entities, data management system, and institutional arrangement were identified and formulated into the SD MRV system established.

Many institutions were identified to be in the drafted SD MRV framework. These institutions will collect respective data as explained in the procedures. However, there's no existing legal mandate up to date in collecting institutional data, therefore it is recommended to established a legal arrangement (eg: signing MOUs with respective

institutions) for institutions in the SD MRV. To sustain the proper functioning and efficiency of the SD MRV system it is recommended to integrate this to the digitalized GHG MRV and it is also recommend to integrate existing digital data collecting systems of respective institutions to the digitalized MRV system.

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-Annexes-

Annex 1 Impact Categories

Dimension	Groups of impact categories	Impact categories
Environmental impacts	Air	1. Climate change mitigation
		2. Ozone depletion
		3. Health impacts of air pollution
		4. Visibility
		5. Odours (CO)
	Water	6. Availability of freshwater
		7. Water quality
		8. Biodiversity of freshwater and coastal ecosystems
		9. Fish stocks sustainability
	Land	10. Biodiversity of terrestrial ecosystems
		11. Land-use change, including deforestation, forest degradation, and desertification
		12. Soil quality
	Waste	13. Waste generation and disposal
		14. Treatment of solid waste and wastewater
	Other/cross-cutting	15. The resilience of ecosystems to climate change
		16. Adverse effects of climate change
		17. Energy
		18. Depletion of non-renewable resources
		19. Material intensity
		20. Toxic chemicals released to air, water, and soil
		21. Genetic diversity and fair use of genetic resources
		22. Terrestrial and water acidification
		23. Infrastructure damage from acid gases and acid deposition
		24. Loss of ecosystem services from air pollution
		25. Nuclear radiation
		26. Noise pollution
		27. Aesthetic impacts
Social impacts	Health and well-being	28. Accessibility and quality of health care
		29. Hunger, nutrition, and food security
		30. Illness and death
		31. Access to safe drinking water
		32. Access to adequate sanitation
		33. Access to clean, reliable, and affordable energy

		34. Access to land
		35. Liveability and an adequate standard of living
		36. Quality of life and well-being
	Education and culture	37. Accessibility and quality of education
		38. Capacity, skills, and knowledge development
		39. Climate change education, public awareness, capacity-building, and research
		40. Preservation of local and indigenous culture and heritage
	Institutions and laws	41. Quality of institutions
		42. Corruption, bribery, and rule of law
		43. Public participation in policy-making processes
		44. Access to information and public awareness
		45. Compensation for victims of pollution
		46. Access to administrative and judicial remedies
		47. Protection of environmental defenders
		48. Freedom of expression
	Welfare and equality	49. Poverty reduction
		50. Economic inequality
		51. Equality of opportunities and equality of outcomes
		52. Protection of poor and negatively affected communities
		53. Removal of social disparities
		54. Climate justice and distribution of climate impacts on different groups
		55. Gender equality and empowerment of women
		56. Racial equality
		57. Indigenous rights
		58. Youth participation and intergenerational equity
		59. The income of small-scale food producers
		60. Migration and mobility of people
	Labour conditions	61. Labour rights
		62. Quality of jobs
		63. Fairness of wages
		64. Quality and safety of working conditions
		65. Freedom of association
		66. Just transition of the workforce
		67. Prevention of child exploitation and child labor
		68. Prevention of forced labor and human trafficking
	Communities	69. City and community climate resilience

		70. Mobility
		71. Traffic congestion
		72. Walkability of communities
		73. Road safety
		74. Community/rural development
		75. Accessibility and quality of housing
	Peace and security	76. Resilience to dangerous climate change and extreme weather events
		77. Security
		78. Maintaining global peace
Economic impacts	Overall economic activity	79. Economic activity
		80. Economic productivity
		81. Economic diversification
		82. Decoupling economic growth from environmental degradation
		83. Jobs
	Employment	84. Wages
		85. Worker productivity
		86. New business opportunities

(#) Taken from Table 5.1 ICAT SD Guidance)

Annex 2 -1 Impacts associate with NDC 4.1 LRT and choosing which impact categories to be assessed (In each of the annex impacts that are highlighted in maroon were chosen for the next step.)						
Step 2a: Identification of the Impact Categories Associate with the NDC			**Step 2b: Choosing which impact categories to be assessed**			
Dimension	**Groups of impact categories**	**Impact categories**	**Relevant**	**Significance**	**Included in the assessment boundary**	**The rationale for determination of relevance and significance**
Environmental Impacts	Air	1. Climate change mitigation	Yes	Yes	Yes	The NDC is expected to significantly reduce GHG emissions
		2. Ozone depletion	Yes	No	No	The NDC does not significantly reduce ozone depletion in the local context.
		3. Health impacts of air pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce the air pollutant and thereby reduce the associated respiratory diseases.
		4. Odours	Yes	Yes	Yes	The NDC is expected to significantly reduce associated odours
	Land	5. Biodiversity of terrestrial ecosystems	Yes	Yes	Yes	The NDC is expected to significantly increase the impacts (E.g.: deposition of dust on leaves,)
		6. Loss of ecosystem services from air pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce important ecosystem services
		7. Land-use change, including deforestation, forest degradation, and desertification	Yes	No	Yes	The NDC is not significantly reduced or change an identified forest or a protected area.
	Waste	8. Waste generation and disposal	Yes	Yes	Yes	The NDC is expected to significantly increase the amount of waste generated during the construction phase of the project
	Other cross cuttings	9. Noise pollution	Yes	Yes	Yes	The NDC is expected to significantly increase the noise levels during the construction
		10. Aesthetic impacts	Yes	Yes	Yes	The NDC is expected to increase the impacts on the (nature views of heritage structures)
Social Impacts	Health and well-being	11. Illness and death	Yes	Yes	Yes	The NDC is expected to decrease /increase the illnesses and deaths depending on the different phases of the mitigation action
		12. Quality of life and well-being	Yes	Yes	Yes	The NDC is expected to significantly increase/decrease the quality of life depending on the different phases of the mitigation action
	Institutions and laws	13. Compensation for victims of pollution	Yes	Yes	No	The NDC is expected to significantly increase the pollution levels during the construction phase. However, it is not within the boundary of the assessment
	Welfare and equality	14. Gender equality and empowerment of women	Yes	Yes	Yes	The NDC increases the potential job opportunities significantly
	Labour conditions	15. Labour rights	Yes	Yes	No	The NDC does not significantly have an impact on labour rights
		16. Quality and safety of working conditions	Yes	Yes	No	The NDC is not significantly d of assuring the quality and safety of new recruitments.
	Communities	17. Traffic congestion	Yes	Yes	Yes	The NDC is expected to significantly increase /reduce the traffic levels depending on the several phases of the mitigation action
		18. Road Safety	Yes	Yes	Yes	The NDC will potentially reduce the possible accidents by reducing vehicle density during peak hours
		19. Community/rural development	Yes	Yes	No	The NDC is significantly developing the infrastructure associate with LRT, however, the geographic boundary of the assessment “Malabe to Pettah” is already a developed area

	Employment	20. Wages	Yes	Yes	Yes	The NDC is significantly increasing potential job opportunities thereby it is important to pay sufficient /fair enough wages for new employees
		21. Jobs	Yes	Yes	Yes	The NDC is significantly in increasing potential job opportunities.
		22. Cost and cost savings	Yes	Yes	Yes	The NDC is significantly increasing potential savings
		23. New business opportunities	Yes	Yes	Yes	The NDC is significantly increasing potential new business opportunities
		24. Economic activity	Yes	Yes	Yes	The NDC will potentially increase the economic value of adjacent lands and other properties

(Source: ClimateSI 2021)

Annex 2 -2 Impacts associate with NDC 5.1 Electrification of the railway and choosing which impact categories to be assessed						
Step 2a: Identification of the Impact Categories Associate with the NDC			**Step 2b: Choosing which impact categories to be assessed**			
Dimension	**Groups of impact categories**	**Impact categories**	**Relevant**	**Significance**	**Included in the assessment boundary**	**The rationale for determination of relevance and significance**
Environmental impacts	Air	1. Climate change mitigation	Yes	Yes	Yes	The NDC is expected to significantly reduce GHG emissions
		2. Ozone depletion	Yes	No	No	The NDC does not significantly reduce ozone depletion in the local context.
		3. Health impacts of air pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce associated respiratory diseases
		4. Visibility	Yes	Yes	Yes	The NDC is expected to significantly increase visibility levels.
		5. Odours (CO)	Yes	Yes	Yes	The NDC is expected to significantly reduce do odours associated with the diesel train
	Land	6. Biodiversity of terrestrial ecosystems	Yes	Yes	Yes	The NDC is expected to reduce the dust and smoke emissions from the diesel train therefore the deposition of dust on adjacent flora is reducing
	Other cross cuttings	7. Loss of ecosystem services from air pollution	Yes	Yes	No	The NDC is expected to facilitate the ecosystem services by reducing the influence over the ecosystem services. However, it's going to be negligible.
		8. Noise pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce the noise levels compared to the diesel train
	Health and well-being	9. Illness and death	Yes	Yes	Yes	The NDC is expected to significantly reduce the air pollution levels thereby the respiratory diseases and eventually the possibility of death
		10. Quality of life and well-being	Yes	Yes	Yes	The NDC is expected to significantly increase the quality of life and well-being by introducing electrified railways
	Welfare and equality	11. Gender equality and empowerment of women	Yes	Yes	Yes	The NDC is expected to significantly increase job opportunities and thereby it will increase opportunities for both men and women.
	Communities	12. Traffic congestion	Yes	Yes	Yes	The NDC is expected to significantly reduce the traffic levels.
		13. Road safety	Yes	Yes	Yes	The NDC is expected to significantly increase road safety by reducing the traffic levels upon reducing vehicles at peak hours.

		14. Community/rural development	Yes	Yes	No	The NDC is expected to increase the infrastructure, however, the geographic boundary of the project Panadura to Veyangoda is an already developed suburb of Colombo. Therefore, this impact was not considered.
Economic impacts	Overall economic activity	15. Economic activity	Yes	Yes	Yes	The NDC is expected to increase the property value of adjacent lands and other properties.
		16. Jobs	Yes	Yes	Yes	The NDC is expected to create new job opportunities in maintenance and also in technical assistance.
	New Businesses	17. New business opportunities	Yes	No	No	The NDC is not clearly in increasing new business opportunities.

(Source: ClimateSI 2021)

Annex 2 -3 Impacts associate with NDC 5.2 Purchasing new rolling stocks and choosing which impact categories to be assessed						
Step 2a: Identification of the Impact Categories Associate with the NDC			**Step 2b: Choosing which impact categories to be assessed**			
Dimension	**Groups of impact categories**	**Impact categories**	**Relevant**	**Significance**	**Included in the assessment boundary**	**The rationale for determination of relevance and significance**
Environmental impacts	Air	1. Climate change mitigation	Yes	Yes	Yes	The NDC is expected to significantly reduce GHG emissions
		2. Ozone depletion	Yes	No	No	The NDC does not significantly reduce ozone depletion in the local context.
		3. Health impacts of air pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce associated respiratory diseases
		4. Visibility	Yes	Yes	Yes	The NDC is expected to significantly increase visibility levels.
		5. Odours (CO)	Yes	No	Yes	The NDC is expected to significantly reduce odours s associated with the diesel train
	Land	6. Biodiversity of terrestrial ecosystems	Yes	Yes	Yes	The NDC is expected to reduce the dust and smoke emissions after inserting new rolling stocks.
	Other cross cuttings	7. Loss of ecosystem services from air pollution	Yes	Yes	No	The NDC is expected to facilitate the ecosystem services by reducing the influence over the ecosystem services. However, it's going to be negligible.
		8. Noise pollution	Yes	No	No	The NDC is expected to maintain the associated noise levels more or less at the same level
	Health and well-being	9. Illness and death	Yes	Yes	Yes	The NDC is expected to significantly reduce the air pollution levels thereby the respiratory diseases and eventually the possibility of death
		10. Quality of life and well-being	Yes	Yes	Yes	The NDC is expected to significantly increase the quality of life and wellbeing by reducing the possible respiratory diseases and effective journey
	Welfare and equality	11. Gender equality and empowerment of women	Yes	Yes	Yes	The NDC is expected to significantly increase the job opportunities in inserting the rolling stocks and maintenance.
	Communities	12. Traffic congestion	Yes	Yes	Yes	The NDC is expected to significantly reduce the traffic levels.
		13. Road safety	Yes	Yes	Yes	The NDC is expected to significantly increase road safety by reducing the traffic levels upon reducing vehicles at peak hours.
		14. Community/rural development	Yes	Yes	No	The NDC is expected to increase the efficiency of the rail and not mainly the adjacent infrastructure

Economic impacts	Overall economic activity	15. Economic activity	Yes	No	No	The NDC is expected to increase the efficiency of the rail and not specifically the economic valuation of the other adjacent properties.
		16. Jobs	Yes	Yes	Yes	The NDC is expected to create new job opportunities in maintenance and also in technical assistance.
	New Businesses	17. New business opportunities	Yes	No	No	The NDC is not clearly in increasing new business opportunities.

(Source: ClimateSI 2021)

Annex 2 -4 Impacts associate with NDC 8.3 Introducing electric buses and choosing which impact categories to be assessed						
Step 2a: Identification of the Impact Categories Associate with the NDC			**Step 2b: Choosing which impact categories to be assessed**			
Dimension	**Groups of impact categories**	**Impact categories**	**Relevant**	**Significance**	**Included in the assessment boundary**	**The rationale for determination of relevance and significance**
Environmental impacts	Air	1. Climate change mitigation	Yes	Yes	Yes	The NDC is expected to significantly reduce GHG emissions
		2. Ozone depletion	Yes	No	No	The NDC does not significantly reduce ozone depletion in the local context.
		3. Health impacts of air pollution	Yes	Yes	Yes	The NDC is expected to significantly decrease the air pollution and reduce the associated health impacts
		4. Visibility	Yes	Yes	Yes	The NDC is expected to significantly reduce gaseous emissions released from buses therefore it will increase the level of visibility
		5. Odours (CO)	Yes	No	Yes	The NDC is expected to significantly reduce gaseous emissions released from buses, reduce the unbearable odours during peak hours.
	Land	6. Biodiversity of terrestrial ecosystems	Yes	No	Yes	The NDC is expected to significantly reduce the deposition of dust on the adjacent terrestrial plants.
		7. Soil quality	Yes	No	No	The NDC is expected to reduce the potential oil leakage of the diesel buses (However this impact can be considered as negligible)
	Other/cross-cutting	8. Terrestrial and water acidification	Yes	No	No	The NDC is expected to reduce the potential oil leakages and emission contamination of the diesel buses and thereby reduce the water and terrestrial acidification. (However, this impact can be considered as negligible)
		9. Infrastructure damage from acid gases and acid deposition	Yes	No	No	The NDC is expected to reduce the potential oil leakages and emission contamination of the diesel buses and thereby reduce the water and terrestrial acidification and eventually possible acid gases and acid deposition. (However, this impact can be considered as negligible)
		10. Loss of ecosystem services from air pollution	Yes	No	No	The NDC is expected to reduce the deposition of dust on the adjacent terrestrial plants, thereby ensure the progress of the ecosystem services. (However, this impact can be considered as negligible)

		11. Noise pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce noise levels associated with diesel buses.
	Health and well-being	12. Illness and death	Yes	Yes	Yes	The NDC is expected to significantly reduce associated health impacts and thereby reduce the potential risk of death and illness.
		13. Quality of life and well-being	Yes	Yes	Yes	The NDC is expected to significantly increase the quality of life by reducing the potential risk of death and illness.
	Communities	14. Mobility	Yes	Yes	Yes	The NDC is expected to significantly increase the availability of electric buses than the diesel buses thereby the mobility increase.
		15. Traffic congestion	Yes	Yes	Yes	The NDC is expected to reduce the potential traffic congestion by reducing the usage of private own vehicles.
		16. Road safety	Yes	No	No	The NDC is expected to reduce the potential accidents by reducing the usage of private own vehicles. (However, this impact can be considered as negligible)
Economic impacts	Overall economic activity	17. Economic activity	Yes	Yes	Yes	The NDC is expected to significantly reduce the ownership and the maintenance cost of private vehicles
	Employment	18. Jobs	Yes	Yes	Yes	The NDC is expected to significantly increase the jobs such as inception officers and for maintenance
		19. Wages	Yes	Yes	Yes	The NDC is expected to significantly increase the fair number of wages for the employees.

(Source: ClimateSI 2021)

Annex 2 -5 Impacts associate with NDC 8.4 Introducing carbon tax to promote electric cars and choosing which impact categories to be assessed						
Step 2a: Identification of the Impact Categories Associate with the NDC			**Step 2b: Choosing which impact categories to be assessed**			
Dimension	**Groups of impact categories**	**Impact categories**	**Relevant**	**Significance**	**Included in the assessment boundary**	**The rationale for determination of relevance and significance**
Environmental impacts	Air	1. Climate change mitigation	Yes	Yes	Yes	The NDC is expected to significantly reduce GHG emissions
		2. Ozone depletion	Yes	No	No	The NDC does not significantly reduce ozone depletion in the local context.
		3. Health impacts of air pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce emissions and thereby the related respiratory diseases.
		4. Visibility	Yes	Yes	Yes	The NDC is expected to significantly reduce emissions and thereby the potential possibility of producing photochemical smog
		5. Odours (CO)	Yes	Yes	Yes	The NDC is expected to significantly reduce emissions and thereby the related odours
	Other/cross-cutting	6. Terrestrial and water acidification	Yes	Yes	Yes	The NDC is expected to significantly reduce potential emissions and leakages, thereby reducing potential contamination and acidification.
		7. Noise pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce the noise levels associated with diesel vehicles.
Social impacts	Health and well- being	8. Quality of life and well-being	Yes	Yes	Yes	The NDC is expected to significantly increase the quality of life and well being
	Education and culture	9. Capacity, skills, and knowledge development (SDGs 4, 12)	Yes	Yes	Yes	The NDC is expected to significantly increase in the relevant field
Economic impacts	Overall economic activity	10. Economic activity	Yes	Yes	Yes	The NDC is expected to significantly decrease the imports and thereby the economic activity
	Employment	11. Jobs	Yes	Yes	Yes	The NDC is expected to significantly increase the potential jobs
	Business and Technology	12. Innovation (SDGs 8, 9)	Yes	Yes	Yes	The NDC is expected to significantly increase potential technology experts

(Source: ClimateSI 2021)

Annex 2 -6 Impacts associate with NDC 9.4 Transporting heavy loads by railway and choosing which impact categories to be assessed						
Step 2a: Identification of the Impact Categories Associate with the NDC			**Step 2b: Choosing which impact categories to be assessed**			
Dimension	**Groups of impact categories**	**Impact categories**	**Relevant**	**Significance**	**Included in the assessment boundary**	**The rationale for determination of relevance and significance**
Environmental impacts	Air	1. Climate change mitigation	Yes	Yes	Yes	The NDC is expected to significantly reduce GHG emissions by replacing bowsers with train
		2. Ozone depletion	Yes	No	No	The NDC does not significantly reduce ozone depletion in the local context.
		3. Health impacts of air pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce the air pollutant and thereby reduce the associated respiratory diseases.
		4. Visibility	Yes	Yes	Yes	The NDC is expected to reduce potential photochemical smog formulation and thereby the visibility increase
		5. Odours	Yes	Yes	Yes	The NDC is expected to significantly reduce associated odours after shifting to trains.
	Water	6. Water quality	Yes	No	No	The NDC does not significantly reduce the associate water quality upon shifting to trains.
		7. Biodiversity of freshwater and coastal ecosystems	Yes	No	No	The NDC does not expected to significantly reduce the impacts (Eg: deposition of dust on leaves, oil contamination of bowsers with aquatic bodies) on terrestrial and freshwater ecosystem.
		8. Fish stocks sustainability	Yes	No	No	The NDC does not significantly impacted on the fish stock sustainability.
	Land	9. Biodiversity of terrestrial ecosystems	Yes	Yes	Yes	The NDC is expected to significantly reduce the impacts (Eg: deposition of dust on leaves, Interruption of migratory routes, and the routes of insects such as butterflies, moths won't get interrupted compared to the transportation of bowsers upon transporting oil through the train.
		10. Soil quality	Yes	No	No	The NDC does not expected to significantly reduce the contamination of oil leakages with soil upon shifting transportation to trains
	Other cross-cutting	11. Energy	Yes	No	No	The NDC does not significantly preserved energy in the local context
		12. Depletion of non-renewable resources	Yes	No	No	The NDC does not significantly limit the depletion of non-renewable sources in the local context
		13. Infrastructure damage from acid gases and acid deposition	Yes	No	No	The NDC does not significantly damaged infrastructure at direct a context.
		14. Loss of ecosystem services from air pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce the loss of ecosystem services due to air pollutants
		15. Noise pollution	Yes	Yes	Yes	The NDC is expected to significantly reduce the noise levels associated with transportation
	Health and well being	16. Illness and death	Yes	Yes	Yes	The NDC is expected to significantly reduce the deaths associated with asthma and other respiratory diseases
		17. Access to safe drinking water	Yes	No	No	The NDC does not significantly increase access to safe drinking water

Social impacts		18. Access to adequate sanitation	Yes	No	No	The NDC does not significantly increase the access to the adequate sanitation
		19. Livability and an adequate standard of living	Yes	No	No	The NDC does not significantly increase the liveability and adequate standard of living
		20. Quality of life and well-being	Yes	Yes	Yes	The NDC is significantly increase the quality of life and well –being upon reducing traffic levels and respiratory diseases
	Institutions and laws	21. Compensation for victims of pollution	Yes	No	No	The NDC d contributes to introducing the air pollution levels and the pollution associated with other ecosystems. Therefore, NDC's contribution to providing compensation for victims of pollution going to be negligible.
	Welfare and equality	22. Protection of poor and negatively affected communities	Yes	No	No	The NDC does not significantly reduce the noise levels, air pollution levels associate with transportation thereby it protects vulnerable communities.
		23. Gender equality and empowerment of women	Yes	No	No	The NDC does not significantly increase job opportunities for both men and women.
	Labour conditions	24. Quality of jobs	Yes	Yes	Yes	The NDC will potentially increase the jobs upon transportation of oil through railways. Satisfactory levels of the workers may change depending on the job description
		25. Quality and safety of working conditions	Yes	Yes	Yes	The NDC will potentially increase the jobs upon transportation of oil through railways. Suitable safety precautions to be maintained to achieve a safe and quality working environment
	Communities	26. Mobility	Yes	No	No	The NDC is not significantly impacted on the mobility levels
		27. Traffic congestion	Yes	Yes	Yes	The NDC will potentially reduce the traffic levels upon transportation of oil through the train
		28. Walkability of communities	Yes	No	No	The NDC is not significantly impacted on the walkability of communities
		29. Road safety	Yes	Yes	Yes	The NDC will potentially reduce the possible accidents associated with bowsers upon, transporting oil through the train
	Employment	30. Jobs	Yes	Yes	Yes	The NDC will potentially increase the jobs upon transportation of oil through railways.
		31. Wages	Yes	Yes	Yes	The NDC will potentially increase the jobs and thereby wages to be paid for the workers
	Other related impacts	32. New business opportunities	Yes	No	No	The NDC is not significantly impacted on the new business opportunities

(Source: ClimateSI 2021)