Carbon Net Zero 2050 Roadmap and Strategic Plan

SYNTHESIS REPORT

Sri Lanka
2023

CARBON NET ZERO 2050

ROADMAP AND STRATEGIC PLAN

SRI LANKA

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Carbon Net Zero 2050 Roadmap and Strategic Plan

Ministry of Environment

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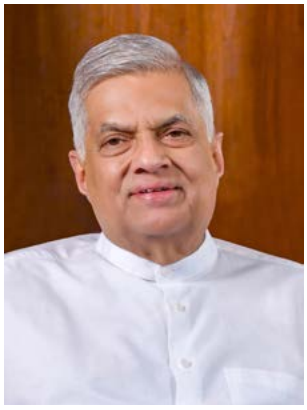

MESSAGE OF THE PRESIDENT OF SRI LANKA

Although Sri Lanka bears very little responsibility for the historical and current climate crisis, emitting only 0.03% of global greenhouse gas emissions, as a country vulnerable to the impacts of climate change, Sri Lanka understands the urgency of ambitious climate action. Sri Lanka has consistently responded to international calls for action on climate change and contributed to these efforts, in line with our capacities and responsibilities under the United Nations Framework Convention on Climate Change.

Sri Lanka recently updated its Nationally Determined Contributions (NDCs) and has further committed to achieve carbon neutrality by 2050. Under this long-term strategy Sri Lanka seeks opportunities for international partnerships to support a sustainable, equitable transition towards a low carbon economy and green recovery, post COVID-19. We believe this would be an opportunity to enable a transition which will have a positive multiplier effect, transforming our whole economy, social and environmental development while paving way for the Climate Prosperity Plan (CPP) for Sri Lanka.

Building on the NDCs, through this Roadmap and Strategic Plan, Sri Lanka is aligning pledges with other development strategies and plans, looking horizontally across sectors and vertically across national and sub-national levels to translate ambition into action and results in reaching net zero emissions. The Roadmap provides projections and recommendations to meet this target, cutting across the six NDC mitigation sectors: Energy, Industry, Transport, Waste Management, Agriculture and Forestry.

The implementation of the Carbon Net Zero 2050 Roadmap and Strategic Plan requires a balanced focus on the process of government coordination and stakeholder engagement as well as considering the issues on just transition, gender, inter-generation, the needs of vulnerable groups, and local community. I take this opportunity to express my sincere gratitude to the Ministry of Environment and all the sectoral agencies for supporting and providing valuable inputs to develop the Carbon Net Zero 2050 Roadmap and Strategic Plan. I would also like to acknowledge and appreciate the support extended by UNDP throughout this process. I believe the successful implementation of this Roadmap requires the mutual understanding and cooperation of all stakeholder agencies. It is imperative that all stakeholders work together in concert to achieve these ambitions, we look forward to everybody's support to make this vision a reality. Finally, I believe that Sri Lanka through the implementation of this Roadmap will sustainably contribute to the temperature goal of the Paris Agreement.

Ranil Wickremesinghe
President of Sri Lanka

ABBREVIATIONS

BAU	Business-As-Usual
CCC	Ceylon Chamber of Commerce
CEB	Ceylon Electricity Board
CPP	Sri Lanka Climate Prosperity Plan
EF	Emission Factor
ESG	Environmental, Social and Governance
FAO	Food and Agriculture Organization of United Nations
GDP	Gross Domestic Product
GHG	Green House Gases
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
KPI	Key Performance Indicators
LP	Liquified Petroleum Gas
LTGEP	Long-Term Generation Expansion Plan
LULUCF	Land Use, Land-use Change and Forestry
MSW	Municipal Solid Waste
NAP	National Adaptation Plan
NDCs	Nationally Determined Contributions
NEAP	National Environment Action Plan
NG	Natural Gas
NSC	National Steering Committee
PMC	Planning and Monitoring Committee
RE	Renewable Energy
SDGs	Sustainable Development Goals
TCFD	Task Force on Climate-related Financial Disclosures
TNC	Third National Communication of Climate Change
TNFD	Task Force on Nature-related Financial Disclosures
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VSSFCW	Vertical Subsurface Flow Constructed Wetland

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BACKGROUND

Emitting around 1.02 CO_{2e} tonnes/per person, Sri Lanka is considered a low-carbon emitting country. However, as economic activities expand, there is also an increasing trend of CO_2 emissions being released and this is a cause for concern.

As a signatory to the Paris Agreement on Climate Change, Sri Lanka has committed to support global efforts to hold the increase in the average global temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels.

Accordingly, Sri Lanka has pledged to achieve net zero carbon status by 2050 in their updated Nationally Determined Contributions (NDCs), which were submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2021. The development of the Carbon Net Zero 2050 Roadmap and Strategic Plan for Sri Lanka is an attempt to set the stage to transition to net zero pathways, proposing climate actions to achieve this national commitment. The proposed climate actions include recommendations to mitigate greenhouse gas (GHG) emissions and increase carbon sequestration and storage, covering the six main thrust sectors as identified in the NDCs: viz Energy, Transport, Industry, Waste, Agriculture, and Forestry.

This is the synthesis report of the comprehensive Roadmap and Strategic Plan developed through comprehensive stakeholder consultations and a validation process, paying due attention to the local circumstances and priorities, gender inclusivity and the socio-economic well-being of the community.

APPROACH AND METHODOLOGY

The approach used in the development of the Baseline and Mitigation Scenarios for the Roadmap and Strategic Plan is based on modeling and predicting the GHG emissions from the prioritized activities from each of the six mitigation sectors over the time period 2025 to 2050. The Baseline Scenario was defined as the future scenario, where the activities and related emissions of the unconditional actions in the updated NDCs are extended to the year 2050, continuing current trends in population, economy, technology, and human behavior. The Business-As-Usual (BAU) real Gross Domestic Product (GDP) growth rate of 3.1% is used for the Baseline Scenario, as per the Sri Lanka Climate Prosperity Plan (CPP) published in 2022. The Mitigation Scenario includes appropriate unconditional and conditional mitigation actions identified in the NDCs in each sector, reflecting the best case of actions that are technically, socially, and environmentally feasible. The Mitigation Scenario adopts the projected real GDP growth rate of 4.2% as indicated in the CPP. The estimations reveal that the timely implementation of all the mitigation actions proposed in each sector would lead to carbon net zero emission status by 2050 or before. The Roadmap and Strategic Plan for Sri Lanka is consistent with the national policy environment, which is framed by a number of recent initiatives including the National Climate Change Policy (2012), the National Environment Policy (2022) and the National Environment Action Plan (NEAP) 2022 – 2030, and the Draft Low Carbon Development Strategy for Sri Lanka 2021 - 2030.

SECTOR-WISE PREDICTION OF EMISSIONS FOR THE BASELINE AND MITIGATION SCENARIOS

The situation related to the six major sectors contributing to GHG Emissions, their role in national development, the current status and past trends of GHG emissions were analyzed. The Baseline Scenario for each sector was developed using national-level data from the population prediction model adopted by the UN World Population Prospect 2022, and the real GDP values were adopted as indicated in the CPP (2022). The estimations showed that in the Baseline Scenario, where only the NDC unconditional actions, which do not depend on external inputs such as technology and funding are implemented, there will be a net carbon emission of 23.62 Mt per year by 2050 (resulting from total emissions of 46.03 Mt and carbon sequestration of 22.41 Mt per year).

The sector-wise prediction of GHG emissions for the Baseline Scenario were developed for the 2025 to 2050 period. The overview of the emission predictions for the Baseline scenario is depicted in Figure A.

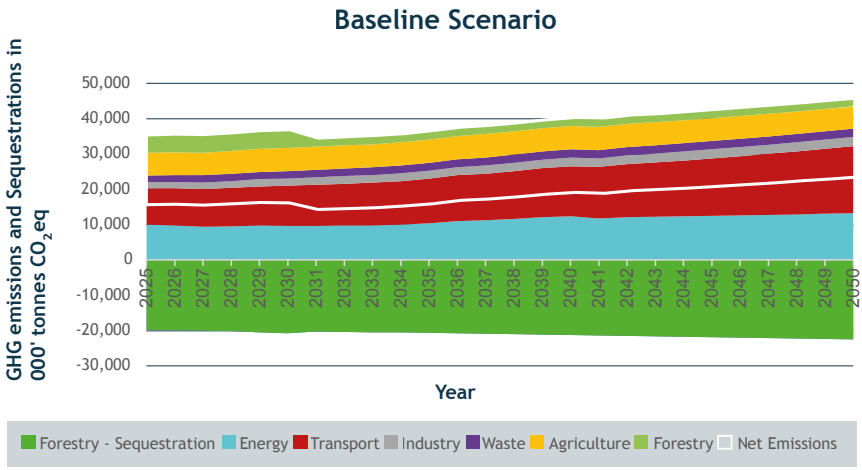

Figure A: The Cumulative Emissions and Sequestration for the Baseline Scenario

Note: Sequestration is indicated as negative values while the Emissions are indicated as positive values

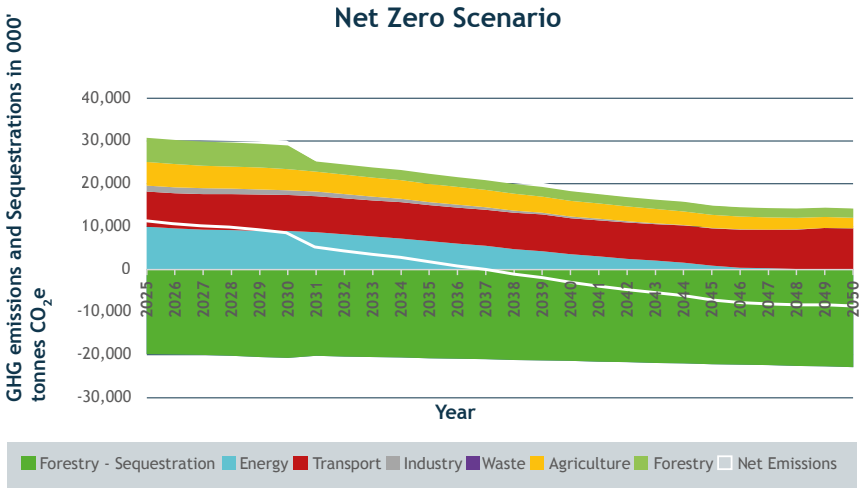

Figure B: Cumulative Emissions and Sequestration for the Mitigation(Net Zero) Scenario

Note: Sequestration is indicated as negative values while the Emissions are indicated as positive values

The Mitigation (Net Zero) scenario indicating the carbon net zero pathway for Sri Lanka was developed after identifying the feasible mitigation actions for each sector, using NDC actions as an initial step, studying literature, research findings and inputs from stakeholder consultations to go further to achieve further reductions while being conscious of the impacts of such actions on vulnerable groups and maintaining gender equity. The sector-wise and total GHG emissions for the Mitigation (Net Zero) Scenario for the 2025 to 2050 period is presented in Figure B. The results demonstrate that depending on the timely implementation of mitigation actions in the sectors under review, the country will be able to achieve net zero by 2037, and by 2050, there will be a net carbon emission of -7.72 CO_{2e} Mt per year, as the total emissions will be reduced to 14.25 Mt per year, while the expected sequestration would amount to 21.97 Mt per year.

CARBON NET ZERO 2050 ROADMAP AND STRATEGIC PLAN

The Roadmap and Strategic Plan for Sri Lanka provides a series of strategies in five-year intervals from 2025 to 2050 for each of the six mitigation sectors. The estimated GHG emission reduction from the baseline emission level at the end of each five-year period are presented as milestones in progressing towards carbon net zero. The Key Performance Indicators (KPIs) are also included to facilitate the monitoring of the proposed actions. Only emission reductions that can be reasonably estimated using available data and predictive tools were taken into consideration in the calculations. Other actions are also indicated, which would be beneficial but would require data, funding, and technological inputs, to be accounted into the present emission reduction calculations. It is emphasized that more accurate estimations for GHG emissions and carbon sequestration needs to be undertaken to ensure clear, transparent, and understandable estimates, in aligning with the requirements set out in the Paris Agreement.

The actions are proposed to be carried out in the latter part of the 25-year period under consideration, in anticipation of a more stable economy, better attitudes and conservation practices instilled in the population. This Roadmap and Strategic Plan for Sri Lanka is expected to be used as a base document, with the achievement of milestones being monitored through the KPIs for the actions given for each sector. Thus, any significant deviations from the expected outcomes should be dealt with promptly, with corrective actions.

INVESTMENTS TO ACHIEVE CARBON NET ZERO

Detailed calculations of economic benefits achieved by avoided carbon emissions and the cost of implementation of the proposed actions are considered. Recognizing that the country is going through an economic crisis, the proposed activities have been prioritized wherein the additional funding requirement during the initial periods of implementation would be minimum until funds from external sources are secured. This is because it is predicted that the spending on activities that are aimed at carbon emission reduction will have less priority than the spending on essential commodities. Given the rigid nature of the recurrent expenditure of the Government, curtailment of capital expenditure is forecasted to be more likely in the period ahead, limiting the funds required for green infrastructure projects. It is anticipated that the proposed actions, that are mainly focused on attitude and lifestyle changes towards a low carbon future, would be supported through policy initiatives and other supporting incentives very early in the timeline.

The present value of the total investments required to implement the strategic plan of energy (which included electricity and endues thermal energy forms – Liquified Petroleum Gas (LPG) and Biomass), transport, waste, agriculture, and forestry sectors is estimated at Rs 44,137 billion, which, at the present exchange rate amounts to approximately US$ 140 billion. Investment requirements for the industry sector (Industrial Processes and Product Use – IPPU) need to be quantified with the availability of the relevant data. It is acknowledged that the proposed action plan does not include a roadmap to finance the proposed strategic actions.

RECOMMENDATIONS

- Attention needs to be given to alternative financing options rather than depending solely on domestic budgetary allocations. It is recommended that green financing options available locally and internationally should be explored to fund investments needed to achieve the desired outcomes.
- The Central Bank of Sri Lanka has already prepared the Green Finance Taxonomy for the banking sector as part of the actions defined under the Roadmap for Sustainable Finance in Sri Lanka. The taxonomy was developed with the aim of enabling financial market actors to raise capital for green activities in local and international markets. Therefore, seeking concessional or priority-based funding for zero carbon projects from the banking sector could be considered as a potential financing option going forward.
- Implementation of the actions proposed to achieve carbon net zero involves a whole-of-government and whole-of-society approach.
- Further comprehensive investigation of each of the actions proposed in the Roadmap and Strategic Plan should be carried out to identify the viability and priority levels for implementation. This prioritization needs to consider the technology readiness level in the local context, the enabling environment including policy, regulatory and institutional setup, data, human resources and cost factors. This should also be supported by a sound evaluation and prioritization methodology with localized criteria and an indicator framework.
- To ensure sustainable growth, investing in research and development is vital. This will advance adoption of new technologies in all sectors, such as green hydrogen technologies, in the energy, transport and industrial sectors, leading to increased efficiency, cost-effectiveness, and safety, while minimizing carbon emissions, this will in turn further attract innovation and drive industry expansion.
- The Roadmap and Strategic Plan for Sri Lanka needs to be regularly updated with new, reliable data as available in the future. Towards this the government should encourage an open dialogue with all stakeholders and monitor the achievement of the KPIs on a regular basis, at least biennially.
- The strategies and actions proposed in the Roadmap and Strategic Plan will need to be internalized into the sectoral development plans of the relevant institutions.

SECTION 1: INTRODUCTION

1.1 Development Challenges and Global Disclosures

The 2030 Agenda for Sustainable Development (and the Sustainable Development Goals - SDGs), and the Paris Agreement on Climate Change (and the Nationally Determined Contributions – NDCs) could be considered the most significant development commitments in implementation at present. The 2030 Agenda provides a framework for collective action to be implemented by all countries and all stakeholders to address global development challenges and achieve a more resilient and sustainable future for all. One critical element in implementation is the localization of the SDGs, through which national interests, priorities and country specific circumstances should be considered when mainstreaming SDGs. The Paris Agreement is a binding agreement, bringing nations together to combat climate change and adapt to its effects through their NDCs which are meant to reflect an increasing level of ambition to meet climate commitments. Specifically, the Paris Agreement sets forth an overarching goal to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. Further, to reach these ambitious goals, mobilization and provision of financial resources, a new technology framework and enhanced capacity-building is to be put in place to support developing countries.

1.2 The Progression and Trends

Although a majority of United Nations (UN) member countries are signatories to both the 2030 Agenda and the Paris Agreement, recent assessments outline that the anticipated progress has not been achieved, and the challenges ahead would be more severe. In fact, the challenges are further exemplified with the unprecedented COVID-19 pandemic. The Human Development Report 2020 emphasizes that COVID-19 is not just a health issue, but a human development crisis impacting the economy and the society. The Sustainable Development Goals (SDGs) Report 2021 emphasizes that progress was already off track prior to the COVID-19 pandemic, and global crises are further threatening decades of development gains, pushing progress on the SDGs even further off track.

The most alarming trends are associated with GHG emissions, global warming, and climate change. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) shows that total net anthropogenic GHG emissions have continued to rise during the period 2010 to 2019, and it is likely that warming will exceed 1.5 °C during the 21st century and would make it harder to limit warming below 2 °C. However, to avoid the worst of climate impacts, modelling suggests that the global net zero CO_2 emission targets need to be reached in the early 2050s limiting warming to 1.5 °C with no or limited overshoot, and by the early 2070s warming could be limited to 2 °C. These pathways also include deeper reductions in other GHG emissions. Further, they involve rapid and, in most cases, immediate, GHG emission reductions in all sectors. Thus, realizing the temperature goals of the Paris Agreement demands the global economy to transition to net zero pathways by 2050.

1.3 National Commitments to Climate Change

As a signatory to both the 2030 Agenda and the Paris Agreement, Sri Lanka has committed to support global efforts to achieve sustainable development, limiting global temperature rise to safer limits, and to building resilient societies to face inevitable climate change impacts. The draft National Policy and Strategy on Sustainable Development sets a policy goal related to SDG 13, Climate Action, as "Commitments on climate change are achieved, while ensuring adaptation to and mitigation of climate change impacts". Further, national commitments on climate change are elaborated more comprehensively under the mandate of the Paris Agreement. The updated NDCs reflect a more ambitious, quantified, and robust assessment of the mitigation potential and adaptation measures for the next decade (2021-2030) informed by up-to-date analysis, improved information and data, and an extensive stakeholder consultation process. Another key initiative taken by the government in relation to climate change is the launching of the National Adaptation Plan (NAP) 2016 - 2025, covering nine key vulnerable sectors, in alignment with the NDCs.

The mitigation actions presented in the updated NDCs reflect improved target setting in six sectors; energy (power: electricity generation and end-use), transport, industry, waste, forestry, and agriculture (including livestock). The enhanced ambitions includes reducing GHG emissions by 14.5% (4% unconditional and 10.5% conditional) and increasing forest cover to 32% by 2030, with respect to the BAU scenario (2021). To realize this ambitious target, Sri Lanka further committed to:

- Achieve 70% renewable energy in electricity generation by 2030,
- Achieve Carbon Neutrality by 2050 in electricity generation, and,
- No further capacity addition of coal power plants.

Further, Sri Lanka has pledged to achieve economy-wide Net Zero Carbon status by 2050. Thus, the Carbon Net Zero 2050 Roadmap and Strategic Plan for Sri Lanka attempts to create an avenue towards a just transition to net-zero pathways.

1.4 Overview of the Carbon Net Zero 2050 Roadmap and Strategic Plan

1.4.1 Scope and Objectives

The Roadmap and Strategic Plan presents a comprehensive pathway to reducing GHG emissions and increasing carbon sinks. In line with the NDCs and the NAP, the mitigation activities are presented targeting six sectors, namely energy (electricity), transport, industry, waste, agriculture, and forestry. The Roadmap and Strategic Plan is formulated to be robust, amenable, and easy to implement across the administrative structure of Sri Lanka with the acceptance of all concerned stakeholders on its effective and meaningful implementation.

1.4.2 General Methodology

The development of Roadmap and Strategic Plan for Sri Lanka followed an inclusive stakeholder consultation process, covering all the respective sectors. The current status of GHG emissions and the related policy background in Sri Lanka was studied, with feasible strategies and actions to minimize emissions and increase carbon sequestration in the period from 2025 to 2050 proposed through a review of literature, discussions and consultations. The Roadmap and Strategic Plan builds on the updated NDC Implementation Plan which indicates the past trends and predictions up to 2030. However, the actions in the updated NDCs were reviewed to carry forward only the activities that could be reasonably justified as feasible, and a few other strategies and actions were proposed to achieve carbon net zero by 2050. The social impacts that could arise due to the implementation of the proposed actions were analyzed, and corrective action was proposed to assure social and gender equity and inclusivity across the strategies and actions. An analysis was also carried out to review the economic viability of the proposed actions with respect to the value of avoided carbon.

1.4.3 Overview of the Carbon Net Zero 2050 Roadmap and Strategic Plan

- *The Baseline Scenario*

The current situation related to the six major sectors contributing to GHG Emissions, their role in national development, the current status and past trends of GHG emissions were analyzed. The Baseline Scenario for each sector was developed using national-level data from the population prediction model adopted by the UN World Population Prospect 2022, and the real GDP values were adopted as indicated in the CPP. The estimations showed that in the Baseline Scenario, where only the NDC unconditional actions are implemented, which do not depend on external inputs such as technology and funding, there will be a net carbon emission of 23.62 CO_{2e} Mt per year by 2050 (resulting from total emissions of 46.03 Mt and carbon sequestration of 22.41 Mt per year). Table 1.1 presents the GHG emissions under each sector, and the carbon sequestration of the baseline.

Table 1.1: Baseline GHG emissions and carbon sequestration in 2050.

Sector	GHG Emissions in 2050 (million tonnes CO_{2e} per year)	Carbon Sequestration in 2050 (million tonnes CO_{2e} per year)
Energy Sector (Excluding fuel used in Transport and Industry)	13.25	-
Transport	19.01	-
Industry	2.58	-
Waste	2.33	-
Agriculture	6.32	-
Forestry	2.54	22.41
Total	46.03	22.41
Net Emissions	23.62 million tonnes CO_{2e} in 2030	

- *The Mitigation (Net Zero) Scenario*

To achieve carbon net zero by the year 2050, feasible sector-wise strategies and actions for emission reduction and increasing sequestration or trapping of carbon were studied in detail, in consultation with the stakeholders. This also included a thorough review of literature to identify available innovative technologies and methods used locally and overseas. This is done to achieve the maximum possible reduction in emissions in each sector, while maximizing the economic and social development of the country. The GHG emissions for the 2025 to 2050 period, the Best-Case scenario, also referred to as the Mitigation (Net Zero) Scenario, was predicted after identifying the feasible mitigation actions for each sector, building on the NDC actions as an initial step. The predicted scenario is based on an extensive literature review, research findings, and inputs from stakeholder consultations to achieve further reductions while accounting for potential impacts to vulnerable groups, including women. Table 1.2 presents the GHG emissions under each sector, and the carbon sequestration of the carbon Net Zero scenario.

Table 1.2: GHG emissions and carbon sequestration in 2050 - Carbon Net Zero scenario.

Sector	GHG Emissions in 2050		Carbon Sequestration in 2050	
	GHG emission (million tonnes CO_{2e} per year)	% Reduction	Amount (million tonnes CO_{2e} per year)	% Increase
Energy Sector (Excluding fuel used in Transport and Industry)	0.00	100%	-	
Transport	9.58	49.6%	-	
Industry	0.012	99.5%	-	
Waste	0.00172	99.9%	-	
Agriculture	2.48	60.8%	-	
Forestry	2.18	14.2%	21.97	(1.96%)
Total	14.25	69.0%	21.97	(1.96%)
Net Emissions	(7.72) million tonnes CO_{2e} in 2030			

The calculations showed that in the Mitigation (Net Zero) Scenario, where the proposed mitigation actions are implemented, by 2050, the country will be able to achieve Net Zero by 2037, and by 2050, there will be a net carbon emission of -7.72 CO_{2e} Mt per year, as the total emissions will be reduced to 14.25 Mt per year, while the expected sequestration would amount to 21.97 Mt per year.

The gender and social impacts of the proposed actions were studied and corrective action to eliminate any biases against vulnerable groups were also suggested.

- *Investments to Achieve Carbon Net Zero Target*

To achieve carbon net zero status in Sri Lanka, a variety of mitigation options have been proposed for each sector. Detailed calculations of economic benefits achieved by avoided carbon emissions and the cost of implementation of the proposed actions were conducted. The present value of the total investments required to implement the strategic plan for energy, transport, waste, agriculture, and forestry sectors is estimated at Rs 44,137 billion, which, at the present exchange rate amounts to approximately US$ 140 billion.

SECTION 2: THE CONTEXT

2.1 National Circumstances

Sri Lanka is classified as a lower-middle-income country and its economy is largely dependent on the service sector (59.7% of the GDP), followed by the industrial sector (26.2%), and the agriculture sector (8.4%), according to Ministry of Economic Policies and Plan Implementation (2021). In 2020, CO_2 emissions per capita for Sri Lanka had reached a value of 0.996 tonnes through a gradual increase from a value as low as 0.22 tonnes of CO_2 per capita in 1990 (World Bank, 2020). Even though Sri Lanka is considered a low-carbon emitting country compared to many other countries in the world, this trend of increasing CO_2 emission is cause for concern. Key sectors that contribute to GHG emissions include energy, transport, industry, waste, agriculture, and forestry, which are considered in the mitigation NDCs.

According to the Third National Communication of Climate Change in Sri Lanka (TNC), excluding Land Use, Land-use Change and Forestry (LULUCF), as at 2010, out of a total of 22.08 Mt CO_{2e} emissions, the energy sector including transport contributed 64.1% and the agriculture sector contributed 29.5%, while waste and IPPU sectors contributed 4.4% and 2%, respectively. When LULUCF emissions are also included, the profile changes to nearly 50% (49.3%) emissions coming from the LULUCF sector, 32.5% from the energy sector, and 15% from the agriculture sector, while the waste and IPPU contributions are reduced to 2.2% and 1% respectively. The transport sector is one of the major GHG emitting sectors in Sri Lanka, and its GHG emissions (7.2 $MtCO_2e$) accounted for 51% of the total GHG emissions from the energy sector in 2010.

Women are still under-represented in the climate change decision-making processes in Sri Lanka, as well as in many other parts of the world. Gender inequality and inequity are a cross-cutting theme affecting development programmes. Climate change impacts are disproportionately affecting women. In certain gender-based studies, failure to achieve the set targets has been attributed to women's limited access to timely weather forecast information, limited availability of options for crop and livelihood diversification, lack of independent sources of income, access to credit or financial institutions for better investment, and low decision-making power to apply adaptation.

2.2 Overview of the Policy, Governance, and Institutional Environment

In response to emerging development and climate change challenges, Sri Lanka has taken several steps, including the establishment of institutional arrangements for a coordination focal point to the UNFCCC and the introduction of national development and sectoral policies, strategies, and actions, in line with the global efforts under the 2030 Agenda and the Paris Agreement. These strategic interventions seek to mainstream climate change into key sectors such as energy, urban planning, waste, transport, industry, coastal and marine, forestry, water, health, tourism and recreation, biodiversity, agriculture, livestock, and fisheries. Some of these sectors have already integrated climate change risks and commitments.

The national focal point to the UNFCCC is the Ministry of Environment. Specifically, the Climate Change Secretariat, a specialized division within the ministry, was established in 2008, to coordinate climate action in Sri Lanka. This includes liaison with the vertical donor funds such as the Green Climate Fund and Adaptation Fund. The Climate Change Secretariat has established an Inter-Agency Committee on Climate Change as well as National Expert Committees on climate change adaptation and mitigation.

In the case of NDC implementation, an inter-agency National Steering Committee (NSC) was established. The NSC is chaired by the Secretary to the Ministry of Environment and has representation from secretaries of line ministries in charge of the NDC sectors. Further, the NSC has representation from and closely coordinate with other key agencies such as the Ministry of Finance, National Planning Department, Department of Fiscal Policy, and the National Council for Sustainable Development. The NSC is responsible for overseeing the NDC implementation progress, facilitating adequate inter-agency cooperation on actions that require collaboration between multiple agencies, ensuring policy coherence, preventing the duplication of efforts, and for presenting practical solutions to implementation barriers. At the operational level, each NDC sector has a Planning and Monitoring Committee (PMC). These PMCs will include the relevant heads of the departments and/or institutions. The 10-year NDC implementation and monitoring plans will be supported by the above PMCs, and these plans are to be fully integrated into development plans for each sector/line ministry. The institutional and governance framework for the operationalization of the proposed Roadmap and Strategic Plan could be built on that of NDCs.

2.3 Introduction to the Sectors

2.3.1 Overview

The selection of sectors in the preparation of the Roadmap and Strategic Plan is fundamentally based on the scope of the interventions initiated by the government in addressing climate change, particularly related to the mitigation of GHGs. Accordingly, the following macro-sectors of the economy have been selected. A brief introduction to each of these sectors together with the GHG emissions are presented in the following sub-sections:

- Energy (Electricity (Power)) – which covers the national grid electricity generation.
- Transport – which covers the ground transport modes (both road and rail).
- Industry - industry energy use (both electricity and thermal energy) emissions and IPPUs.
- Waste – both solid waste and wastewater.
- Agriculture – including livestock sector.
- Forestry – both GHG emissions and sequestration covering forests, trees outside forests and the blue-carbon sector.

2.3.2 Energy Sector

Sri Lanka's primary energy supply was predominantly from biomass (65%) and petroleum (27%) in the early 1980s. Due to changes in living standards, biomass requirement gradually reduced, and the petroleum requirement gradually increased. The Sri Lanka Energy Balance published by the Sri Lanka Sustainable Energy Authority in 2019 outlines that the total energy requirement of the country was 509.6 Petajoule (PJ) in 2019, and the primary energy supply mainly consisted of 223.8 PJ of Petroleum, 169.0 PJ of biomass, and 58.7 PJ of coal. Accordingly, 55.4% of the total energy consumption is from imported fossil fuels, and the remainder are from indigenous resources. Here, biomass comes in different forms such as fuel wood, municipal waste, industrial waste, and agricultural waste. On the energy demand side, the main sectors of energy demand are industry (29.5%), transport (32.1%) and household, commercial and others (38.4%).

As per the TNC, the GHG emissions in the electricity generation sector in the base year of 2010 was 3,334.43 CO_{2e} Gg/yr, which is 1.62 times that of the year 2000, indicating a compound annual average growth rate of 4.9%. The government's recent declaration of a 70% renewable energy

(RE) target by 2030 with no capacity addition of coal power plants has also helped to streamline the emissions management aspects of the net zero carbon development. The present Long-Term Generation Expansion Plan (LTGEP) of the Ceylon Electricity Board (CEB) considers achieving 70% RE by 2030 and maintaining 70% RE beyond 2030 as its base case. Energy conservation through Demand Side Management is also considered one of the potential areas of reducing electricity demand and thus reducing the emissions in the sector.

2.3.3 Transport Sector

Road transport is the dominant mode of mobility, with 94% passenger transportations and 98% of freight transportation. The National Transport Statistics published by the National Transport Commission in 2022 shows that the demand for passenger transportation peaked in 2019 at roughly 231.5 billion passenger-km, but due to travel limitations brought on by the COVID-19 pandemic, the demand fell to 185.5 billion passenger-km in 2020. This reduction was also associated with passengers moving away from public transport. In 2021, this recovered to 191.8 billion passenger-km. In 2019, the public transport modes (buses and railways) had a total modal share of 40.6%, while it was only 36.3% in 2020 and 33.0% in 2021.

The transport sector is the main consumer of imported petroleum fuels. For example, in year 2020, the total petroleum demand was 154.8 PJ, within which the demand for the transport sector was 121.3 PJ (78.4%). The transport sector accounts for 21% of total GHG emissions, road transport accounts for three-quarters of transport emissions, while road transport also accounts for 15% of total CO_2 emissions.

2.3.4 Industry Sector

The industry sector contributed to a significant proportion of employment, substantially reducing unemployment and poverty levels. The sector, which accounted for less than 10% of employment in 1971, increased to 28% in 2018. By 2019, 1,470,287 persons were found to be engaged in the industry sector, with a majority (1,392,704) engaged in manufacturing. Similarly, by 2019, there were 22,212 industrial establishments, which engages 5 or more persons, and manufacturing is the largest segment, accounting for 18,186 establishments (81.9%). According to the 2022 Annual Report of the Central Bank of Sri Lanka , the industry sector is the second largest contributor to the GDP with 27.5% at constant (2015) market prices. The two main manufacturing sub-sectors that contribute to the national income are the manufacture of food and beverages, and tobacco products (44.3%) and the manufacture of textiles, wearing apparel, and leather related products (26.1%), with a combined contribution of over 70%. In addition to the formal establishments in the industry sector, informal and unregistered establishments play an important role through the provision of employment, production of goods and services, and the generation of income.

As per the Sri Lanka Energy Balance, in 2020, the annual energy demand in the industry sector was 111.7 PJ. 76.9% of this energy demand was covered by biomass, 14.3% by electricity, 6.8% via petroleum, and the remaining 2.0% with coal.

In the industry sectors, chemical and physical processes that transform materials release a significant amount of GHGs, such as CO_2, CH_4, and N_2O. Additionally, HFCs and PFCs often are considered possible sources of emissions in the IPPU sector. Mainly cement, ceramics, lime, glass, chemicals, metal, solvent applications, surface coatings, wood preservative applications, spirit manufacturing and fluorinate compounds have all been considered as sub-sectors under the IPPU sector to calculate emissions.

2.3.5 Waste Sector

The waste categories such as Municipal Solid Waste (MSW), domestic wastewater, industrial wastewater, chemical sludge, biological sludge, and sewage emit GHGs like CO_2, CH_4, and N_2O into the environment through various activities of the waste management sector. GHG emissions in the waste sector are generated from different treatment and disposal routes such as MSW disposal, wastewater treatment and disposal (both industrial and domestic), sewage treatment and discharge, and chemical and biological sludge.

The NEAP 2022-2030, other related publications and information available with government agencies outline that the total amount of MSW generation in Sri Lanka ranges from 8,000 to 9,000 t/day, with a per capita waste generation ranging from 0.2 kg/person/day in rural areas, to 0.85 kg/person/day in urban areas. About 60% of the waste generated in Western Province is collected by local authorities , while in other provinces it is about 25%. In the Western Province, about 10% of the collected waste is recycled, 15% is composted and the remainder is transferred to solid waste dump sites . In other provinces, less than 5% is composted, about 7.5% is recycled and the balance is transferred to solid waste dump sites.

2.3.6 Agriculture Sector

Agricultural land covers approximately 2.6 million hectares or roughly 42% of Sri Lanka's total land area. A majority of the land used for food production is owned by about 1.65 million smallholder farmers. With average landholdings totaling less than 2 hectares, smallholder farmers are in charge of almost 80% of Sri Lanka's total annual crop production. The agricultural area in Sri Lanka has increased gradually in the past decade. With the end of the internal conflict, previously inaccessible territories have been converted into productive cropland. According to statistics from the Food and Agriculture Organization of United Nations (FAO), from 2003 to 2013, rice-harvested areas increased by 30.4% (911,440 to 1,188,230 hectares), while maize-harvested areas more than doubled (27,060 to 67,720 hectares). During the same timeframe, pastureland has not increased significantly, and shifting cultivation (chena) declined, due in part to limited land availability. Home gardens, which contribute to household-level food security in rural Sri Lanka, cover a substantial 14.8% of the total land area. These changing patterns of land use, coupled with the strict enforcement of anti-deforestation laws, have resulted in a decreasing in deforestation over the past decade.

Agriculture accounts for 25.1% (4.71 million tonnes CO_2e) of the country's total GHG emissions. Out of this, GHG emissions from cropland (mostly rice cultivation and cultivation of organic soils) account for 69.5% of total emissions, while the livestock sector (especially enteric fermentation) accounts for 30.5 %.

Livestock populations with ruminants emit methane due to the anaerobic digestive process in the forestomaches (fermentation). Milk production from the dairy cow sector in Sri Lanka emits about 2.3 million tons of CO_2e. The emission profile of milk is dominated by methane (93.2 %), while N_2O and CO_2 make up 1.6 % and 5.2 % of the entire emissions, respectively. Approximately 88% of the emissions from the management of stored manure arise from methane produced by the rumination of cows and 5% of CO_2 emissions are related to feed production, transport, and processing contribute a further 5% to total emissions. Ruminants could produce 250 to 500 liters of methane per day subject to various animal and feed-related factors. That would cause about a 12% loss of the dietary energy within the ration as methane. In Sri Lanka, cattle and buffaloes are the most abundant livestock groups, while sheep, goats, and swine make up a smaller proportion.

2.3.7 Forestry Sector

Sri Lanka's forest cover (which was 29.15% of land area in 2015) is comprised of dense forest, open and sparse forest, savannah, and mangroves. This natural vegetation displays diversity and distribution across Sri Lanka's three climatic zones; wet, dry, and intermediate. Furthermore, the forest-like home gardens and plantations of spices, rubber, timber, and more, also occupy a considerable land extent providing carbon benefits. Sri Lanka is unique in South Asia for its high biodiversity per unit area, and the large extent of high-canopy home gardens. However, over time, forest cover has declined. Some forest cover has been cleared to make way for agriculture and plantations, and recently for larger infrastructure projects (dams, roads, human settlements, etc.,). According to the updated NDCs (2021-2030), 18,000 hectares of new forests will be established by 2030 while the existing natural forests and forest plantations will be better protected.

2.4 Past GHG Emission Trends in Each Sector (2010 - 2021)

The historical data for the GHG emissions are reported in the Sri Lanka National Communications submitted to the UNFCCC as an obligation under the Paris agreement. Table 2.1 gives the sector wise summary of GHG emissions for the year 2010 reported in TNC.

Table 2.1: Summary of national emissions for the year 2010

Sector	GHG Emissions/Removals ('000 MT)					
	CO_2 emissions	CO_2 Removals	CH_4	N_2O	HFCs	Total
Energy	12,810.00		950.46	393.70		14,154.16
IPPU	435.59				12.98	448.57
Agriculture	340.45		2,860.62	3,304.60		6,505.67
Waste	122.78		527.94	325.50		976.22
LULUCF-emissions	21,342.40		112.77	4.96		21,460.13
LULUCF-removals		-39,826.30				-39,826.30
Net Total	35,051.22	-39.826.3	4,451.79	4,028.76	12.98	3,718.45

SECTION 3: THE METHODOLOGY

3.1 Overall Approach

A participatory approach is used in the development of the Roadmap and Strategic Plan for Sri Lanka. This included a comprehensive literature survey, supplemented by a consultation process with relevant stakeholders and experts from the respective mitigation sectors who contributed to previous interventions, such as the updating of the NDCs and the development of the National Communications. Global trends and initiatives, the current status of GHG emissions, and the related policy environment in Sri Lanka provided the basis for the development of feasible strategies and actions to minimize emissions and increase carbon sequestration and capture from 2025 to 2050). The actions in the updated NDCs were revisited, and the feasible options have been developed further, while considering new and emerging interventions, actions and related strategies to achieve carbon net zero by 2050. The GHG emissions in terms of tonnes of CO_{2e} were estimated using the IPCC Guidelines (2006), and projections of emissions were carried out using long term forecasting techniques for population and economic growth. Towards a just transition to net zero pathways, social and gender inclusion aspects related to the proposed strategies and actions were analysed, and recommendations were provided. An economic analysis was also carried out to check the economic viability of the proposed actions for each sector with respect to the value of avoided carbon, and policy directions were recommended for the successful implementation of the Roadmap and Strategic Plan.

3.2 Sectors and the Coverage

The six sectors presented in Section 2.3.1 are covered in terms of potential carbon emission reduction, enhanced absorption, and sequestration, and contributions to the net zero processes. The sector-wise activity data, driver-related data and other specific data requirements depend on scope and mitigation activities are selected for the analysis. The historical time series data (as available) for the period 2000 – 2022 is used for developing history trends and identifying driving forces. The GHG emission in terms of CO_{2e} is estimate by the following expressions:

$$\text{GHG Emission} = \sum \text{Activity Data} \times \text{EF} \times \text{GWP},$$

where, EF represents the emission factor and GWP represents the Global Warming Potential of each gas. EF values are based on historical time series data, and driver/s are identified for each activity data for the sector using regression ((linear & multiple) models. Future activity data is forecasted using the following generic function derived by the regression model that establishes the relationships between the driver and activity data:

$$\text{Activity Data (unit)} = \sum_{i=1}^{n} m_i \times \text{Driver}_i + C,$$

3.3 Scenario Development and Prediction of Emissions 2025 – 2050

3.3.1 Introduction

Scenarios represent reasonable future circumstances with particular economic, social and environmental characteristics. Different scenarios can be used during the planning of net zero strategies and technologies to identify existing capacities and quantify required resources. At least two scenarios are used as the Baseline Scenario and the Carbon Net Zero (Mitigation) scenario:

Baseline Scenario: a hypothetical reference case of what would have most likely occurred in the absence of a proposed GHG project, using an estimate of GHG emissions, removals, or storage associated with a Baseline Scenario. The BAU scenario is a crucial point of comparison when it comes to investing, planning, and policymaking. It serves as a reference point against which to assess other scenarios or as a position to begin a systems analysis.

Mitigation Scenario: a hypothetical reference case of what would most likely occur in the presence of proposed GHG project/s. Mitigation scenario is defined as a description and a quantified projection of how GHG emissions can be reduced with respect to the Baseline Scenario, using an estimate of associated GHG emissions, removals, or storage in mitigation.

3.3.2 Baseline (Business as Usual – BAU) Scenario Development:

In the Roadmap and Strategic Plan, the 'most likely case', is where markets and institutions are NOT assumed to behave perfectly. This may imply the existence of "no regrets" mitigation options. The NDC Scenario is selected as the Baseline Scenario. A study of NDC implementation reveals that the emissions during 2021 and 2022 follow a path close to the implementation of the unconditional NDC actions in all the sectors (2023). Therefore, the predicted emissions in the NDC report for the unconditional actions, extended to the year 2050, continuing current trends in population, economy, technology, and human behavior, are taken as the Baseline Scenario. The population predictions are based on the population data from the UN World Population Prospect 2022 (2022), where the population is expected to increase up to 24 million. A real GDP average growth rate of 3.1% is used for the Baseline Scenario, which is taken from the average values for the GDP growth rate given in the CPP.

3.3.3 Mitigation Scenario Development:

A preliminary study revealed that it would be possible to achieve net zero emission status by 2050 (even before 2050), if all mitigation actions proposed for each sector, which went beyond the NDC actions, were to be implemented as proposed, in a timely manner. Therefore, the Mitigation Scenario was taken as the Carbon Net Zero Scenario. For each sector, drivers for growth of the sector were identified using available history data using regression analysis, and econometric models were used to predict the future demand and emissions in the sector activities, with the implementation of mitigation actions proposed for reduction of emissions and the increase in carbon stocks (sequestration and carbon storing in biochar & etc.). Several options/pathways of mitigation actions for each sector are considered under this scenario. According to the CPP preliminary report, the CPP scenario is defined as "additional ambition for climate change mitigation simulated on top of the NDC ambitions, ensuring that net zero emissions are reached in the year 2050". This is the 'Best Case' scenario, where carbon net zero is achieved and the vulnerability to climate change is minimized. In this case, the average growth rate of 4.2% is used, which is taken from the average values for the GDP growth rate given in the CPP preliminary report for the CPP scenario. The emissions in this scenario were calculated for each sector, so that the net emissions across the sectors will trend towards zero in the shortest possible timeframe, no later than 2050, while the most economically, socially, and environmentally acceptable pathways are identified for implementation.

SECTION 4: CARBON NET ZERO 2050 ROADMAP

4.1 The Overall Framework

4.1.1 The Notion

According to the UN Climate Science Panel, man-made GHG emissions need to reach "net zero" by mid-century to give the world a good chance of limiting warming to 1.5 °C and avoiding the worst impacts of climate change. Transitioning to a carbon net zero world is one of the greatest challenges humankind has faced. Sri Lanka, being a developing country, cannot compromise economic and social development to achieve carbon net zero status. Envisioning "A Carbon Neutral, Prosperous Sri Lanka", this Roadmap and Strategic Plan outlines strategies to avoid contributing to GHG emissions, promoting sustainable, green economic growth.

4.1.2 Sectoral Baselines and Targets

As discussed in Section 3.4 under the methodology, the GHG emissions for each sector under the Baseline Scenario is taken as the situation where the current trends would continue up to the year 2025, and the unconditional actions identified in the updated NDCs, i.e., those that do not need external support, are implemented up to 2030 and beyond.

The targets for achieving carbon net zero were set for each sector, in consultation with the sector stakeholders, and consideration of the technically and administratively feasible actions to mitigate emissions and to increase sequestration, provided that the funds, infrastructure and technological resources are not a constraint for implementation, over the period 2025 to 2050. The emissions and sequestration values for the sectors are calculated using the models described in Section 3, and the cumulative emission and sequestration scenarios of the Baseline.

The sector-wise baseline and target setting are described in this section.

4.1.3 Sectoral Baselines and Targets for GHG Mitigation

- *Energy Sector*

For the energy sector, CEB has developed the Long-Term Generation Expansion Plan (LTGEP) 2023-2042 which complies with the NDC commitment, with more than a 25% reduction in GHG emissions for the period from 2023 to 2030, compared to the BAU scenario of LTGEP 2013-2032. It is forecasted that the electricity peak demand increases on average at 5.3%. As per the LTGEP 2023-2042, the following three scenarios were identified to achieve the general policy guidelines declared by the government. This plan considers additions and retirements only up to year 2042.

> Scenario 1: Achieving 70 % RE by 2030, maintaining 70% RE beyond 2030 and no coal fired plant additions throughout the horizon;

Scenario 2: Achieving 70 % RE by 2030, maintaining 70% RE beyond 2030, no coal fired plant additions throughout the horizon and considering cross border interconnection with India; and,

Scenario 3: Achieving 70 % RE by 2030, maintaining 70% RE beyond 2030, no coal fired plant additions throughout the horizon and considering nuclear power development beyond 2040.

The CO_2 emissions in the domestic, commercial and other sectors (excluding transport and industrial sectors) were forecasted by considering the forecasted demand of LPG, kerosene, diesel, fuel oil and charcoal. The net emission from firewood and biomass are conceded as net zero.

The target set for the energy sector is based on the declaration in the updated NDCs to achieve carbon neutrality in the energy sector itself through a complete transition of all the energy value chains to net zero by 2050. Therefore, to reduce the predicted quantity of GHG emissions of 13.246 million tonnes/year of CO_{2e} to zero, by the year 2050, each energy source will have set targets as given in Table 4.1.

Table 4.1: Targets for emission reduction in the energy sector to achieve Carbon Net Zero by 2050

Energy sub-sector	Target for Emission Reduction by 2050 (million tonnes CO_{2e} per year)	Percentage Emission Reduction
Electricity	7.752	100%
Domestic and Commercial Energy	5.494	100%
Total Energy Sector (Excluding fuel used in Transport and Industry IPPU)	13.246	100%

- *Transport Sector*

Sri Lanka's GHG emissions from the transport sector in 2021 is 11 million tonnes CO_{2e}, as estimated in the updated NDCs. With the proposed mitigation measures, it is expected that the implementation of the updated NDCs will result in a GHG emission reduction against the BAU scenario by 4.0% in the transport sector (1.0% unconditionally and 3.0% conditionally), equivalent to an estimated mitigation level of 1,337,000 tonnes unconditionally, and 4,011,000 tonnes conditionally (a total of 5,348,000 tonnes) of carbon dioxide equivalent during the period of 2021-2030.

The GHG emission level from the transport sector is related to population as well as the GDP of the country since the latter determines the economic activity level of the country. How the transport needs are met to fulfil those economic activities under the existing transport infrastructure, level of motorization and transport policies will determine the level of CO_2 emissions relevant to the transport sector. The BAU scenario is considered the baseline where the unconditional NDC actions are extended to the year 2050, while the population and the economy would grow, while there are no additional mitigatory interventions taken in the future.

Using historical data to develop the emissions per capita and GDP per capita model, the future emission rates per capita can be estimated for the forecasted GDP and population values under the forecasting scenario for the Baseline. For example, in the year 2050, when the GDP increases up to US $ 168 billion, the per capita income for a 24 million population would be US $ 7,399. At existing emission rates this would give a per capita CO_2 emission rate of 0.79 tonnes.

Thus, the forecasted GHG emissions for 2050 is 19 million tonnes CO_{2e}. If the linear regression analysis-based forecast based on the historical data in the Climate Analysis Indicators Tool is used, the forecasted value is 24 million tonnes.

The transport sector mitigation strategies aim to reduce the emission level by 50% by 2050. This is the prudent estimate considering the projects that can be implemented during the period. As the prediction of emissions for the Baseline Scenario is 19 million tonnes/year in 2050, the target for emission reduction in the transport sector is 8.4 million tonnes/year in 2050.

- *Industry Sector*

The industry sector emissions are attributed from two sources: the industry energy use (both electrical energy and thermal energy) emissions and IPPUs. Considering the national economic development and population growth indices, the total emissions for the Baseline Scenario is calculated. Achieving a zero-emission national electricity grid with renewable energy sources (wind, solar, sustainable biomass) and climate friendly sources (such as nuclear energy) will automatically make the industry sector energy use related emissions zero. Strategies to make the national electricity generation net zero is addressed under energy sector. For the industry sector, use of green hydrogen is recommended, which will provide the following opportunities for the mitigation of GHGs:

- Buffering the grid qualities at renewable energy intermittencies.
- Use of green hydrogen as an energy storage to produce electrical energy during power deficiencies in the national grid with fuel cell technologies, and gas turbine-based power gyration.
- Use of green hydrogen as a source of thermal energy in industrial thermal energy applications.
- Use of green hydrogen as a fuel in the transport industry.
- Use of green hydrogen to produce green ammonia, for use as a marine fuel and to develop a national green nitrogen fertilizer industry.

The sector target is to reduce 2.568 million tonnes CO_{2e} by 2050, and the estimated reduction is 99.5%. The mitigation levels of each of the IPPU sub-sectors represent the targets that realize the goal of achieving net zero status. A more comprehensive assessment is required to identify and prioritize specific programmes and projects that could contribute to the target effectively.

- *Waste Sector*

Data gathered from the report of TNC of Climate Change in Sri Lanka were used for the prediction. GHG emissions from 2000 to 2010 of solid waste disposal, composting, incineration and open burning, wastewater treatment, and discharge were used to predict emissions from 2021 to 2050 with the past data and the econometric factors. The NDC unconditional actions up to 2030 are considered as the Baseline Scenario and the NDC unconditional actions were modeled for the prediction up to 2050.

Here, the population predictions from the UN was considered with three different scenarios as high, medium, and low variations in population in the country with a 3.1% GDP growth rate as given in the CPP preliminary report. The medium variant population shows a more realistic variation in GHG emissions since the population growth during the latter years during the study period decreased, which indicates there could be a natural tendency in the reduction of GHG in the future.

The waste sector envisages the reduction of GHG emissions through SynGas recovery from open dumps, MSW growth reduction to 50% and mandating 3R practice, converting the collection and transporting vehicle fleet to electrical vehicles, waste to energy plants, and introduction of sanitary landfills to replace waste dumps. Table 4.2 shows the targets for reduction in GHG Emissions from these actions. Note that, in the case of the waste sector, the total GHG reduction of 0.61 million tonnes CO_{2e} by 2050 is from the proposed mitigatory actions, whereas the rest (1.72 million tonnes CO_{2e} by 2050) is reduced from the modified actions proposed in the NDCs, extending these to 2050.

Table 4.2: Targets for reduction in GHG Emissions in Waste Sector

Strategy	Baseline CO_2e Emissions 2050 (thousand tonnes CO_{2e} per year)	Target for Emission Reduction by 2050 (thousand tonnes CO_{2e} per year)	Percentage Emission Reduction
Daily cover for open dumps	164.11	164.11	100%
Syngas recovery from open dumps	1.48	0.74	50%
Vertical subsurface flow constructed wetlands (VSSFCW)	90.78	90.78	100%
MSW growth reduction to 50%,	22.04	22.04	100%
Mandating 3R practice			
Circular economy for redesign, reuse & rethink			
Electric vehicles for waste collection	0.06	0.06	100%
Waste to energy plants	271.49	271.49	100%
Sanitary landfill	62.89	62.89	100%
Total in Waste Sector	2,332.66	2330.94*	99.9%

*Note: the total includes the target emission reduction from modified actions proposed in the NDCs extending these to 2050.

- *Agriculture Sector*

Emission prediction models for the agriculture sector are limited as many prediction models are focused on predicting yield and production of various crops. However, in general, data required for the model inputs are not available sufficiently to run these models. Prediction of emissions based on the NDC approach has been found to be the most suitable for model scenario development. For the Baseline Scenario, the reference curve has been fixed considering GDP and population change. The GHG reduction curve established on the assumption that the mitigation strategies mentioned in the updated NDCs are adopted continuously up to 2050. However, it was observed that the updated NDCs on the agriculture sector needs further improvements prior to being used for the prediction and forecasting of selected mitigatory options. Hence, another scenario was developed with some added detailed parameters to the livestock sector, namely, emissions from neat cattle, local as well as imported breeds, these were categorized into milking, not milking, and bulls and calves were analyzed in detail. Further to that populations like goats, sheep, swine, chicken, and ducks were also analyzed in detail to calculate the GHG emissions to refine the Baseline Scenario. In addition, it is proposed to remove paddy strow from paddy fields for various purposes to minimize GHG emissions as mentioned under mitigation activities. In this exercise crop diversification in paddy fields (as recommended in the NDCs) is not encouraged due to the fact that paddy production should be kept stable and all paddy soils are not suitable for crops like soybean, onion, groundnut et cetera.

This approach helped to increase the mitigation capability of the incremental planning proposed for five-year intervals up to the year 2050, and a percentage reduction obtained from the best-case scenario was used to formulate the mitigation planning.

Considering the feasible actions for reduction of GHG emissions, the targets for reduction of emissions from the agriculture sector have been set as given in Table 4.3.

Table 4.3: Targets for reduction of emissions from the agriculture

Strategy	Baseline emissions by 2050 ('000 tonnes CO_{2e}/year)	Target for Emission Reduction by 2050 ('000 tonnes CO_{2e}/year)	Percentage Emission Reduction
Paddy fields (due to methane emissions)	1,830	1,145	62 %
Reduce N2O by reducing urea imports	244	150	61 %
Direct/indirect N2O reduction	2,788	1,664	60 %
Methane – livestock management (neat cattle local, imported, goats and sheep)	1,251	758	61 %
Total	6,113	3,717	61 %

- *Forestry Sector*

The Baseline Scenario in the mitigation sectors refer to the scenario with the assumption that no mitigation policies or measures will be implemented beyond those that are already in force and/or are legislated or planned to be adopted. In the case of the forestry sector, this scenario was developed using the following assumptions for GHG mitigation:

A. Forest cover includes natural forests, forest plantations and rubber plantations according to the definition of forests by FAO.

B. Deforestation rate of 5,000 ha/yr from 2021-2030 as per the updated NDCs. This will continue up to 2050.

C. New plantings of 18,050 ha from 2021-2030 as per the updated NDCs and this will not continue afterwards due to limitations of land.

D. There will be 25,000 ha of reforestation/restoration/afforestation from 2025 and will continue up to 2030. This will also be discontinued afterwards.

E. Home gardens: annual increase of 1%, and the annual loss of 0.3%.

F. Coconut plantations: annual loss of 616 ha and the annual increase of 10,000 ha.

G. Tea plantations: annual increase of 1,800 ha; 40 trees/ha is the density of shade trees.

H. The total urban tree cover of the country is taken as 75,000 ha and the annual loss in general is 300 ha. There is an annual increase of 1% of the extent. It is expected that 100,000 trees will be added to the urban tree repository.

I. The loss of mangrove extent is 0.5% /year, while 100 ha is added annually.

The emissions due to deforestation, removal of mangroves and loss of trees outside forests including coconut plantations and home gardens were taken into consideration.

For the target in the Roadmap and Strategic Plan, it is expected that the rate of deforestation will be further reduced from 5,000 to 0 from 2031 to 2050. Accordingly, the overall target is to reduce 750,000 tonnes CO_{2e} per year during the period 2025 to 2050 from deforestation in the Baseline Scenario.

4.1.4 Overall Net Emissions in the Baseline Scenario

The variation of the net GHG emission levels (total emissions - total sequestration) is presented in Table 4.4 and Figure 4.1. As shown in the white line graph in Figure 4.1, the net GHG emissions has an increasing trend throughout the period 2025 to 2050. The Baseline Scenario would result in a net annual emission quantity of 23,621,843 MT CO_{2e} (23.62 MMt CO_{2e}) by the year 2050. To achieve carbon net zero by 2050, the net emissions value must be reduced by mitigation actions in all sectors, so that the emissions are reduced, and sequestration is increased to balance each other out.

4.1.5 Sectoral Baselines and Targets for Carbon Sequestration

In addition to the GHG emissions, another important aspect is the carbon sequestration potentials, particularly in the agricultural and forestry sectors. The following reference values/factors are taken in the estimation of the carbon sequestration potentials:

a. Carbon sequestration in natural forests @ 4.6 tonnes/ha.

b. Carbon sequestration in new forests: plantations up to 6 years is 3 tons/ha/year while beyond that is a maximum of 9 tonnes/ha/year.

c. Carbon sequestration rate of mature coconut plantations and forest plantations is 9 tonnes/ha/ year; appropriate rates of carbon sequestration (2-9 tons/ha/year) was used according to tree age and the young plants up to 6 years of age is 3 tonnes/ha/year.

d. Carbon sequestration rate of home gardens – 4.8 tonnes/ha/year; carbon sequestration rate of tea plantations, including the shade trees @40 trees/ha – 1.4 tonnes/ha/year; carbon sequestration rate of mixed trees and other perennials – 4 tonnes/ha/year; and carbon sequestration rate of mangroves – 24.76 tonnes/ha/year.

e. With regards to the urban trees, avenue plants and plants in urban spaces, the number of trees in a hectare was taken as 200 and the carbon sequestration rate was taken as 4 tonnes/ha/year considering the carbon sequestration of a mature tree as 0.02 tonnes/year.

Table 4.4: Total Emissions in Mt CO_{2e}

Sector	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Energy	9.99	9.80	9.43	9.53	9.77	9.68	9.73	9.80	9.82	10.01	10.44	11.09	11.24	11.63	12.15	12.36	11.77	12.19	12.22	12.37	12.51	12.65	12.80	12.95	13.10	13.25
Transport	10.32	10.51	10.71	10.91	11.13	11.35	11.58	11.83	12.08	12.35	12.63	12.92	13.23	13.55	13.88	14.24	14.61	15.00	15.41	15.85	16.31	16.79	17.30	17.84	18.41	19.01
Industry	1.73	1.80	1.87	1.94	2.01	2.08	2.11	2.15	2.20	2.24	2.27	2.31	2.34	2.37	2.40	2.43	2.46	2.48	2.50	2.52	2.53	2.55	2.56	2.57	2.57	2.58
Waste	1.92	1.96	2.00	2.03	2.07	2.10	2.13	2.16	2.18	2.21	2.23	2.25	2.26	2.28	2.29	2.30	2.32	2.33	2.34	2.35	2.35	2.36	2.35	2.35	2.34	2.33
Agriculture	6.45	6.52	6.52	6.60	6.67	6.62	6.61	6.61	6.63	6.68	6.69	6.70	6.70	6.70	6.69	6.69	6.68	6.68	6.66	6.63	6.60	6.57	6.53	6.49	6.45	6.40
Forestry emission	5.11	5.11	5.12	5.12	5.13	5.13	2.46	2.46	2.47	2.48	2.48	2.49	2.49	2.49	2.49	2.50	2.50	2.51	2.51	2.52	2.52	2.53	2.53	2.53	2.54	2.54
Forestry - Sequestration	19.73	19.87	20.00	20.14	20.43	20.72	20.20	20.31	20.42	20.54	20.65	20.76	20.88	20.99	21.11	21.21	21.32	21.44	21.57	21.68	21.80	21.92	22.04	22.16	22.28	22.14
Calculated Net Emissions	15.72	15.76	15.57	15.92	16.26	16.16	14.33	14.59	14.85	15.30	15.99	16.87	17.27	17.91	18.69	19.20	18.80	19.64	19.98	20.44	20.99	21.42	21.94	22.47	23.03	23.62

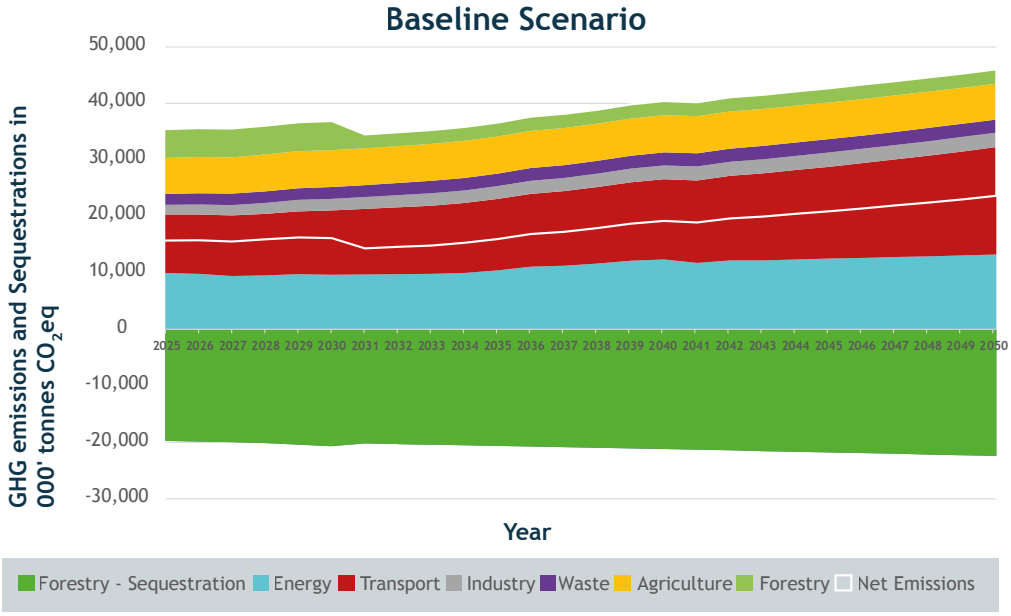

Figure 4.1: The Predicted Emissions and Sequestration in All Sectors for the Baseline Scenario

Tables 4.5 and 4.6 show the targets in land cover increase and the corresponding net carbon sequestration for the forestry sector under the Carbon Net Zero Scenario, respectively. There is no increase in land cover for shade trees in tea plantations and mixed trees with other perennials.

Table 4.5: Targets for land cover increasement in forestry sector in 2050

Description	Estimated Baseline Area in 2050 (ha/yr)	Target for Increased Area by 2050 (ha/yr)	% Area Increase against Baseline in 2050
Total forest cover including existing and new plantings	1,921,292	85,357	4.4%
Total trees outside forest including home gardens, coconut planation, and urban green cover with areas of avenue plants	2,451,006	135,811	5.5%
Blue Carbon Ecosystems	13,899	6,568	47.3%

Table 4.6: Targets for increased sequestration in forestry sector in 2050

Description	Baseline Sequestrations in 2050 (tonnes CO_{2e}/yr)	Target for Increased Sequestrations by 2050 (tonnes CO_{2e}/yr)	% Sequestration Increment against Baseline in 2050
Total forest cover including existing and new plantings	8,088,665	1,145,605	14.2%
Total trees outside forest including home gardens, coconut planation, tea plantations and urban green cover with areas of avenue plants	9,683,942	1,624,408	16.8%
Blue Carbon Ecosystems	323,292	183,470	50.75%
Total Sequestration	18,095,899	2,953,483	16.3%

There is no increase in sequestration for mixed trees with other perennials, while there is a reduction of sequestration in shade trees in tea plantations.

- *Waste Sector*

<u>Biochar:</u>

In addition to the carbon sequestration in agriculture and forestry sectors, a daily cover combined with biochar produced from the MSW in dumpsites or landfills can be used to trap GHG emissions (CH_4) by a considerable amount. According to a study carried out by Abraham and Xiao in 2019, 10% of GHGs can be absorbed by the daily cover laid on the waste at the dumpsite. Further, the soil mixed with biochar and the MSW will lay a natural platform to improve the composting process within the dump. This technique showed an absorption of 164,116 tonnes of CO_{2e} by 2050. This measure can be implemented as early as 2026.

<u>Vertical Subsurface Flow Constructed Wetland (VSSFCW):</u>

According to a study conducted in China in 2011 by Pan et.al, 50% of GHGs can be reduced using the VSSFCW rather than the conventional methods. The VSSFCW with an area of 1000m^2 can reduce GHG emission by 50% compared to the conventional wastewater treatment. The action plan is to implement a centralized system in the western area by 2031, which leads to a GHG reduction of 90,781 tonnes of CO_{2e} by 2050.

4.2 Sectoral Pathways and Strategies of the Carbon Net Zero Roadmap

4.2.1 Requisites

The Roadmap and Strategic Plan should essentially be supported by a sound policy and governance framework to provide strategic directions for the operationalization of the programmes and activities. In particular, the government should ensure alignment between policies and actions, including public policy and advocacy. The national leadership should ensure this commitment is not undermined by conflicting targets. The national leadership should demonstrate commitment to net zero and the principles by:

- Providing strategic direction, oversight, support, and sufficient resources to set and achieve targets.
- Incorporating net zero targets into core governance related documents (e.g., national policies, action plans, regulations etc.,).
- Disclosing stakeholder needs related to climate change as appropriate to the country and net zero emission targets.
- Publicly committing to achieving targets as soon as possible through communication by the highest level of national leadership.
- Clearly defining national leadership and sub level responsibilities.
- Appointing competent members of the national leadership to take responsibility for net zero actions.
- Ensuring competent persons are appointed to relevant roles and determining the frequency of updates to national leadership on climate-related issues and progress towards targets.
- Designing and implementing incentives for delivering net zero targets with national sustainability benefits.
- Ensuring consideration of actions needed to transition to net zero is prioritized at national level.
- Publicly and regularly communicating transition plans, progress and the necessary further action.

Once the above principles of good governance are in place, the sector-wise strategies and mitigation actions become more effectively implementable.

4.2.2 Energy Sector

- Energy Sector Mitigation Pathways and Emission Estimates

Rapid decarbonization of the power sector is a crucial step toward achieving net zero. Therefore, actions need to be taken so that by 2050, all the electricity will come from low carbon sources, subject to security, stability and reliability of supply, bringing forward the government's commitment to a fully decarbonized power system. The following key mitigation actions are considered as the strategies to reduce GHG emissions in the energy sector.

<u>Pathway 1:</u>

- Decommissioning of all coal power plants by 2044.
- No NG plant additions after 2033.
- Nuclear power plants to be introduced starting from 2035. The first addition will be 2×300 MW in capacity which will be introduced in 2035. The next addition will be in 2040 with a capacity of 1000 MW.

- HVDC inter connection to be introduced by 2034.
- Renewable energy such as biomass, wind and solar to be added throughout the planning time window.
- Coal, NG, Nuclear and energy from HVDC interconnection was considered to support the base load and throughout the planning period the base load is in between 27% to 50% of the total annual generation of electricity.

Pathway 2:

Considering the government's current uncertainty surrounding the construction of nuclear power plants, it is imperative to explore alternative strategies. A highly promising approach is to strive for 100% indigenous renewable energy generation, bolstered by efficient energy storage solutions. As per the LTGEP, following facts are considered in developing net zero strategies:

- No expected addition of major hydro power plants after 2024.
- No expected Mini hydro power plant additions after 2039.
- No expected pumped storage to be introduced after 2032.

- Energy Sector Strategies

Aligned with the National Energy Policy, it is required to have multipronged approaches in the energy sector to progress along the mitigation pathways presented above in achieving carbon net zero by 2050. Accordingly, the following broader strategies are proposed:

- Strategy 1: Gradual decommissioning of the existing thermal power plants which depends on imported fossil fuel.
- Strategy 2: Development of nuclear energy resources to the optimum level with sufficient environmental safeguards, by encouraging market demand for such resources.
- Strategy 3: Promote regional power grid connectivity and cross-border electricity trade.
- Strategy 4: Improving energy efficiency and conversion.
- Strategy 5: Energy transition by enabling the continued use of flexible and secure thermal energy while reducing negative impact to the environment.

Based on the above strategies, a series of mitigation actions are proposed in the energy sector to reduce GHG emissions. It is expected that there will be around 2,833 tonnes of CO_{2e} emissions in the energy sector by 2050, which can be brought to net zero by implementing the following additional actions.

- Dedicated energy plantations for biomass and counter balancing plantations in existing hydropower catchments and land earmarked for future energy infrastructure,
- Encourage the use of commercial biomass and biomass-based fuel products for industrial thermal applications and household use and eliminate petroleum usage in industrial thermal applications and households.
- Green hydrogen generation to support the decarbonization by flexible power generation.
- By implementing carbon capture and storage to reduce the rate of increase of CO_2 concentrations due to the combustion of fossil fuels for energy in the domestic, commercial, and other sectors.

If the above strategies and actions are implemented successfully, it is expected to achieve net zero in the energy sector, as illustrated in Figure 4.2.

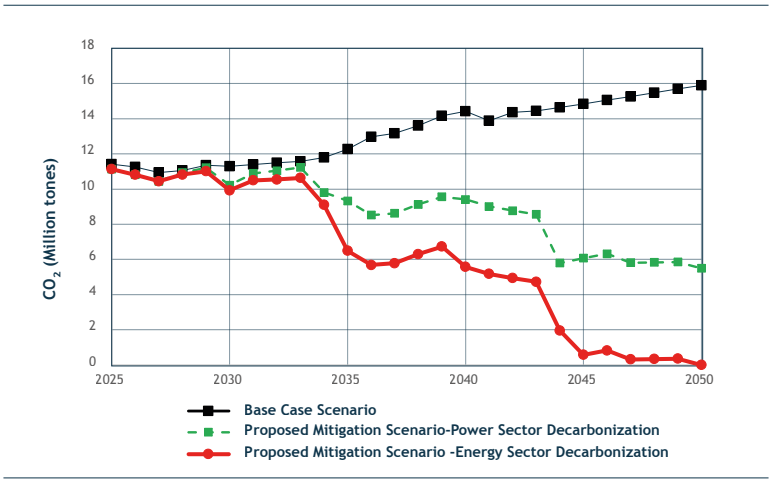

Figure 4.2: Net Zero Scenario in the Energy Sector

4.2.3 Transport Sector

- Transport Sector Mitigation Pathways and Emission Estimates

The proposed interventions in the transport sector focuses on identifying short and long-term interventions, as well as those that are high and low capital intensive. Depending on the government's implementation plan and financing availability, the most feasible actions from these may be chosen.

An overall categorization of the emission reduction pathways in the transport sector is given below:

f. Promote non-motorized transport: increase modal share of walking and cycling for short distance trips.

g. Facilitate remote working and e-commerce, e-learning to reduce the travel demand.

h. Bus fleet expansion and modernization.

i. Pricing strategies for fuel.

j. transport demand management in cities.

k. Develop the LRT network.

l. E-mobility: electrification of railway, buses, and private vehicle fleet.

The above mitigation pathways are expected to contribute to the 50% emission reduction targets set in the transport sector, as illustrated in Figure 4.3.

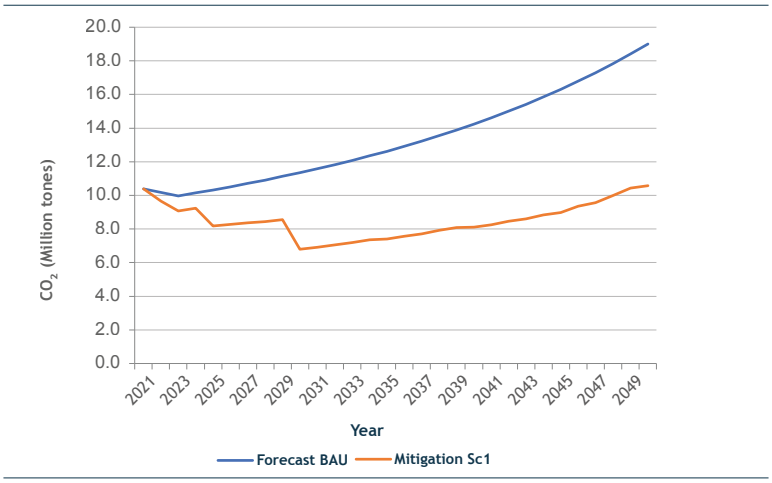

Figure 4.3: The emissions predicted for the transport sector under the baseline and net zero scenarios

- Transport Sector Strategies

The heavy fossil fuel dependance of the transport sector and the limitations in the readiness of the low carbon technology options signify the need of comprehensive GHG mitigation strategies. Aligned with the national/sectoral priorities, as reflected in updated NDCs, a set of broader strategies could be implemented to achieve the targets in the transport sector, as detailed below:

- Strategy 1: Improve pedestrian infrastructure on collector type roads in the country.
- Strategy 2: Promoting cycling.
- Strategy 3: Promoting remote working.
- Strategy 4: Promoting e-commerce and e-learning.
- Strategy 5: Modernizing the bus fleet, introducing low floor buses, and introducing new bus routes/frequency in cities to attract private vehicle users to buses.
- Strategy 7: Transport demand management strategies in key cities.
- Strategy 8: Implementation of LRT network in Colombo.
- Strategy 9: E-Mobility.
  - Intervention 1: Public transport – rail.
  - Intervention 2: Decarbonisation of long-distance and freight rail.
  - Intervention 3: Public transport – buses.
  - Intervention 4: Private and freight vehicles.
  - Intervention 5: Maritime and aviation sectors.

4.2.4 Industry Sector

- Industry Sector Mitigation Pathways and Emission Estimates

As IPPU emissions are highly process specific, and as such, very limited opportunities are available in reducing emissions (mitigations). There are several sub-sectors with specific opportunities for GHG mitigation. These industries include cement, lime, glass, ceramic, solvent use, and bakery. Following are among the potential GHG mitigation and other interventions towards carbon net zero:

- ✓ Cleaner production (CP) strategies for both process and energy use emissions.
- ✓ Circular economy concepts.
- ✓ Uses of green hydrogen as a thermal energy source, as an emerging option.
- ✓ Carbon offset with national forestry development plan or "Carbon Capture and Storage" strategy or "Carbon Capture, Utilization and Storage".

The estimated GHG emissions under the mitigation scenario, when all proposed mitigation actions are implemented over the period 2025 to 2050 are depicted in Figure 4.4.

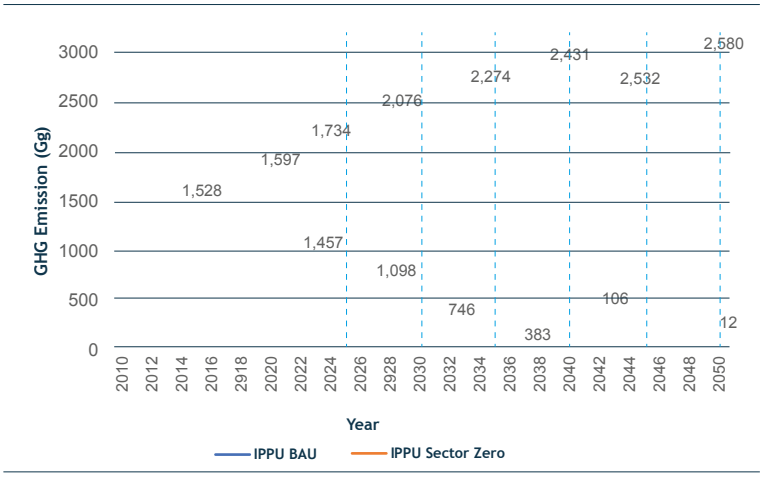

Figure 4.4: Estimated GHG Emissions from the Industry (IPPU) Sector in the baseline and Mitigation scenarios

- Industry Sector Strategies

The strategies for the decarbonization of the industry sector are identified through the actions proposed in the updated NDCs, as listed below:

- ➢ Strategy 1: Cleaner production
- ➢ Strategy 2: Eco-industrial parks and villages
- ➢ Strategy 3: Circular economy concept
- ➢ Strategy 4: Tri-generation
- ➢ Strategy 5: Industry specific process improvements – cement industry
- ➢ Strategy 6: Generic enabling activities
- ➢ Strategy 7: Legislations and enforcements

Based on power sector net zero emission reductions industry sector energy use will be totally a zero-carbon source hence industry energy use related emissions will become zero.

4.2.5 Waste Sector

- Waste Sector Mitigation Pathways and Emission Estimates

The timeline for the net zero carbon 2050 was decided in consideration of development, socio-economic, and demographic factors. The mitigation actions are phased across five years, for chronological execution, to minimize the GHG emission. There are eight mitigatory measures suggested, including two from the NDCs, which are to be continued until 2050 and beyond.

The mitigatory measures proposed are:

1. Daily cover for open dumps
2. Syngas recovery from open dumps
3. Vertical subsurface flow constructed wetlands (VSSFCW)
4. MSW Growth reduction to 50%.
5. Mandating 3R practice.
6. Electric vehicles for waste collection.
7. Waste to energy plants for non-biodegradable waste that remains after all other options.
8. Sanitary landfill
9. Circular Economy for Redesign, Reuse and Rethink.

The contributions of the above mitigatory intervention for the net zero targets are illustrated in Figure 4.5.

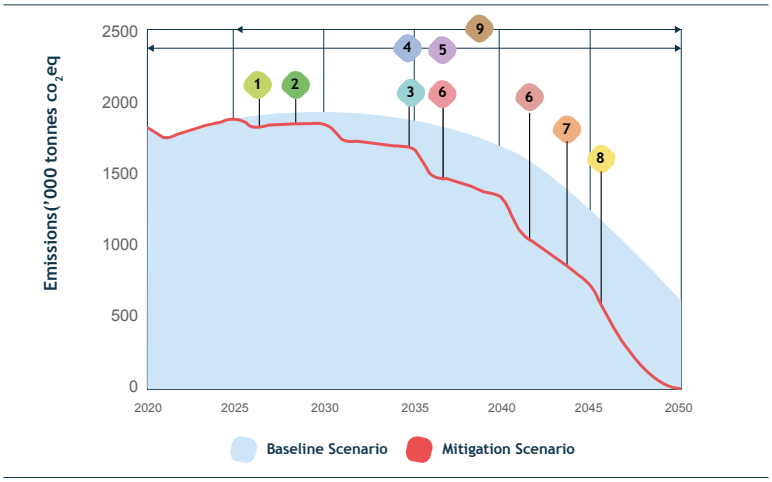

Figure 4.5: Net zero scenarios with mitigation measures

- Waste Sector Strategies

The following strategies are proposed for the waste sector to achieve net zero carbon emission in 2050:

- Strategy 1: Using biochar for daily cover in landfills and open dumps.
- Strategy 2: MSW growth reduction 3R practice, promote recycling, and the use of recycled materials.
- Strategy 3: Methane recovery for SynGas production from open dumps and sanitary landfills.
- Strategy 4: Constructed wetland for wastewater treatment and reuse of treated wastewater for greening.
- Strategy 6: Transforming the waste collection garbage trucks into electric trucks.
- Strategy 7: Introducing waste to energy plants for other provinces.
- Strategy 8: Establishing sanitary landfills for residual waste.

Further, community level biogas production from fecal material at the community level is a highly effective way to reduce GHG emissions. Overall, biogas production from fecal material at the community level has the potential to significantly reduce greenhouse gas emissions while promoting sustainable development.

4.2.6 Agriculture Sector

- Agriculture Sector Mitigation Pathways and Emission Estimates

The mitigation actions proposed to reduce GHG emissions from the agriculture sector activities include:

a. Reduction of methane and nitrous oxide generation in paddy fields by the removal of straw and using them for manufacturing paper and boards used in construction industry, production of biofuels, and in the packaging industry.

b. Reduction of methane generation from cattle by feed quality improvements, night feeding and supply of water and improvement in animal comfort.

c. Manure management and soil tillage reduction.

d. Reduction of nitrous oxide emissions from agricultural lands by reduction of artificial fertilizer applications.

Mitigation measures were formulated to achieve emission reductions beyond the unconditional target projection up to 2050. Finally, considering the resource availability in relation to the availability of extension services and other human, physical, financial resources, and in reference to the World Bank and CIAT report (2015), the "most likely case" was developed for mitigation purposes.

For the livestock sector, only the local and imported neat cattle populations were considered where other local breeds were not accounted, due to the difficulties in applying improved management practices. Calculated values of the mitigated amounts were then fed back into the Baseline Scenario to obtain the reduced emission values in CO_2 equivalent in '000 MT.

It is observed that, when the NDC unconditional targets are extrapolated to 2050 using the model, the actions were capable to reduce GHG emissions by 30 % from the year 2025 (5958 CO_{2e} in '000 tonnes to 4200 CO_{2e} in '000 tonnes) to the year 2050.

As shown in Figure 4.6, mitigation scenario can reduce GHG emissions by 61% compared to the Baseline Scenario.

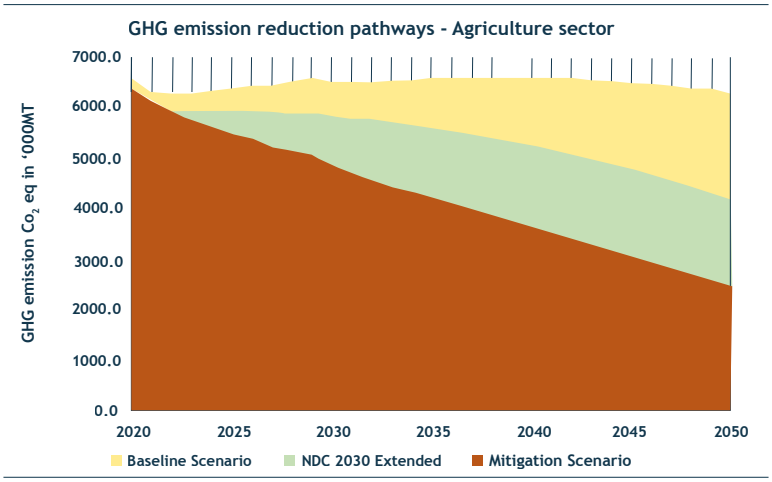

Figure 4.6: Best case scenario for the agriculture sector

- Agriculture Sector Strategies

In the agricultural sector, several strategies and activities are proposed to achieve the GHG mitigation targets set above towards carbon net zero by 2050. The main strategies proposed are:

- Strategy 1: Reduce methane emission from paddy fields by removing rice straw and through good management practices.
- Strategy 2: Use alternatives to chemical fertilizer for reducing N2O emission.
- Strategy 3: Reduce methane emission from livestock by improving feed quality and animal comfort.
- Strategy 4: Reduce N2O emission in soils due to microbial activities.
- Strategy 5: Adopt the 'evergreen agro-ecosystem concept' to improve carbon sequestration from paddy fields and rain-fed uplands.
- Strategy 6: Improve land management practices in agricultural lands to enhance the carbon stock in the soil.
- Strategy 7: Improve crop management practices in tea plantations.

Under each of these strategies, a set of GHG mitigation and carbon sequestration actions is identified, which will contribute to the targets established in the agricultural sector.

4.2.7 Forestry Sector

- Forestry Sector Mitigation Pathways and Emission Estimates

The Mitigation Scenario operates under the assumption that all feasible mitigation policies and measures will be implemented, in addition to those that are already in force and/or are legislated or are planned to be adopted. In the case of the forestry sector, this scenario was developed using the following assumptions:

J. Forest cover includes natural forests, forest plantations and rubber plantations according to the definition of forests by FAO.

K. The deforestation rate will be 5000 ha/yr from 2021-2030 as per the updated NDCs and will be reduced to 1000 ha from 2031-2035; and 500 ha from 2036-2040; 100 ha from 2041-2045 and then 0 ha from 2046-2050.

L. The new plantings will be 18,050 ha from 2021-2030 according to the Ministry of Environment, (updated NDCs) and this will not continue afterwards due to limitations of land.

M. There will be 25,000 ha of reforestation/restoration/afforestation from 2025 and will continue up to 2030. This will also be discontinued afterwards.

N. In home gardens, the annual loss of 0.3% will be stopped while the annual increase of 1% will remain.

O. In the coconut plantations, the annual loss of 616 ha will be stopped, while the annual increase will be 20,000 ha.

P. In the tea plantations, annual increase was taken as 1800 ha; and 40 trees/ha is the density of shade trees.

Q. The total urban tree cover of the country of 75,000 ha with the annual increase of 1% will remain and annual loss of 300 ha will be stopped. 100,000 trees will be added to the urban tree repository annually.

R. The loss of mangrove extent is 0.5% /yr will be stopped and there will be 200 ha added annually.

At the same time, the GHG emissions will be caused by the loss of forest cover, trees outside the forests, and mangroves. Figure 4.7 presents the total GHG emissions from the forestry sector including loss of forests and trees outside forests in the net zero scenario from 2025-2050. Note that it is assumed that there would be no loss in mangroves and urban trees and avenue plants in the net zero scenario.

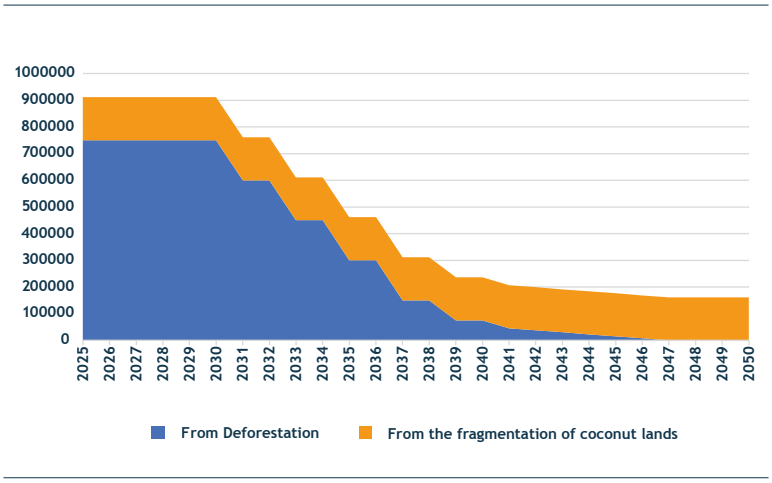

Figure 4.7: The total GHG emissions from the forestry sector including forests and trees outside forests in the Net Zero Scenario from 2025-2050

- Forestry Sector Strategies

According to the updated NDC (2021-2030), 18,000 hectares of new forests will be established by 2030 to achieve 30.8% of forest cover by 2030. In addition to this, the existing natural forests and forest plantations will be better protected. In the Roadmap and Strategic Plan, the Forest Department is hoping to reforest/afforest 200,000 hectares of land by 2050. This land is included under the category 'Other State Forests' which was vested under the management of Forest Department through the 5/2001 Circular. The circular was revoked subsequently, and the custody was transferred to the Divisional Administrations. However, out of the 500,000 ha, 200,000 hectares had been released to the Forest Department for reforestation/ afforestation. It is also expected to increase the contribution of trees outside forests to the GHG mitigation scenario. These include home gardens, coconut plantations, shade trees in tea plantations, urban trees and avenue trees, and trees in settlements and mixed plantations. The rubber plantations had been included in the category of forests according to the classification of FAO. Blue carbon ecosystems such as mangroves, seagrass beds and salt marshes had also been considered as important carbon sinks as they are reported to sequester carbon at rates 4-5 times higher than terrestrial ecosystems.

4.2.8 Overall Net Emissions in the Mitigation Scenario

Considering the GHG emissions and sequestration projections as modelled for the period from 2025 to 2050 for the six sectors, the best-case emission scenario that can be expected in the Mitigation Scenario is shown in Figure 4.8, and the emission quantities are given in Table 4.7. The net emission levels (total emissions - total sequestrations) are shown as a white line graph in Figure 4.8, and this shows a decreasing trend throughout the period from 2025 to 2050. The Mitigation Scenario would result in a net annual emission that would become zero by about year 2037, and will remain negative, the overall situation being carbon positive, or net sequestration, if all the proposed activities are implemented in a timely manner.

The mitigation actions expected to be carried out over the period up to 2050 are described in this section in the report. It is however imperative that the policy background is in place, the institutional capacity, financial provisions, infrastructure, technologies and research and development are strengthened as required, in a timely manner, if this prediction is to be made a reality.

4.2.9 Overall effects considering cross-sector impacts

There are many linkages among the sectors, therefore strategies and actions that are proposed for one sector can have an impact on another sector. To manage this, control measures may need to be established where such linkages may present an additional burden to carbon emissions that need to be mitigated while also accounting for any positive co-benefits. For instance, an increase in land allocated towards new forest plantations would reduce the land available for agriculture, transport, and other infrastructure, which in turn may lead to deforestation in other areas, if proper control mechanisms are not in place.

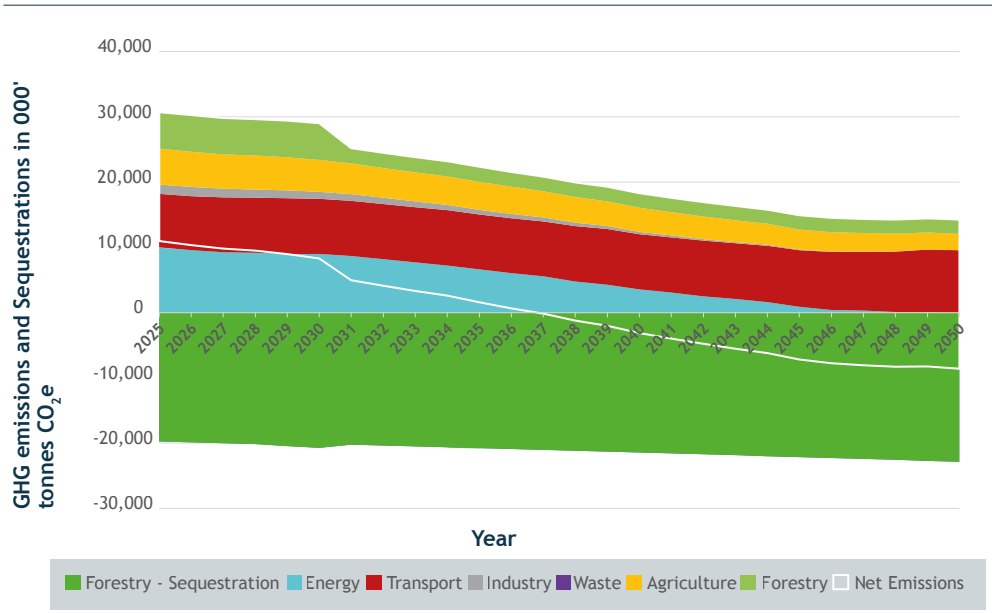

Figure 4.8: Overall Net Emissions in the Mitigation (Net Zero) Scenario

Table 4.7: Total Emissions in million tonnes CO_{2eq} in Mitigation Scenario

Sector	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Energy	9.99	9.56	9.27	9.18	8.98	8.99	8.70	8.21	7.72	7.22	6.63	6.04	5.55	4.76	4.26	3.57	3.08	2.49	2.10	1.60	0.91	0.42	0.33	0.09	0.09	0.00
Transport	8.19	8.28	8.38	8.44	8.55	8.44	8.43	8.44	8.45	8.47	8.39	8.44	8.45	8.53	8.56	8.43	8.45	8.53	8.52	8.65	8.65	8.88	8.98	9.26	9.57	9.58
Industry	1.46	1.41	1.35	1.28	1.19	1.10	1.03	0.96	0.89	0.82	0.75	0.67	0.60	0.52	0.45	0.38	0.32	0.26	0.20	0.15	0.11	0.07	0.04	0.02	0.01	0.01
Waste	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Agriculture	5.49	5.40	5.24	5.17	5.08	4.88	4.72	4.57	4.45	4.37	4.26	4.14	4.02	3.89	3.78	3.66	3.54	3.44	3.33	3.20	3.07	2.96	2.84	2.72	2.60	2.48
Forestry emission	5.61	5.61	5.61	5.61	5.61	5.61	2.33	2.33	2.33	2.33	2.33	2.26	2.26	2.26	2.26	2.26	2.19	2.19	2.19	2.19	2.19	2.18	2.18	2.18	2.18	2.18
Forestry – Sequestration	19.76	19.86	19.96	20.07	20.33	20.58	20.05	20.15	20.25	20.35	20.44	20.55	20.65	20.75	20.85	20.93	21.03	21.14	21.35	21.45	21.45	21.56	21.66	21.76	21.87	21.97
Net Emissions	10.99	10.40	9.88	9.60	9.09	8.44	5.16	4.36	3.60	2.87	1.92	1.00	0.22	(0.79)	(1.5)	(2.63)	(3.44)	(4.22)	(4.90)	(5.55)	(6.51)	(7.05)	(7.23)	(7.50)	(7.41)	(7.72)

*Note 1 – In the waste sector, the emission in 2025 as of the base line scenario is 1.92 million tonnes CO_{2e} per year and reduced by 0.01 million tonnes CO_{2e} per year due to the mitigatory strategy "MSW Growth reduction to 50% and Mandating 3R practice is currently under practice".

**Note 2 – In the waste sector, the GHG reduction of 0.61 million tonnes CO_{2e} by 2050 is from the proposed mitigatory actions, whereas the rest (1.72 million tonnes CO_{2e} by 2050) is reduced from the modified actions proposed in the NDCs, extended to 2050.

4.3 Gender and Social Inclusion Analysis of Proposed Actions

Gender and social concerns of the proposed mitigation actions were identified based on a literature review and an analysis of the views expressed by stakeholders during informal interviews. The views of the public, their knowledge and their everyday experiences regarding carbon emissions were highly relevant in understanding the pertinence of these measures in the current socio-economic context of the country. The data also pointed to the fact that knowledge and awareness on climate change and other environmental factors was significantly low among the population. Apart from a segment of the educated population, it was evident that many of the population are engaged in environmentally positive activities due to cultural and social influences, rather than a result of conscious efforts to protect the environment.

It is vital to note that, even though all the proposed actions under each sector are necessary to achieve carbon net zero goals, if these actions in any way contribute to discriminatory treatment of any social groups, the proposed action will have a negative impact overall on sustainable development.

4.4 Economic Analysis to Achieve Net Zero Status in Sri Lanka

To achieve net zero status in Sri Lanka, a variety of options have been proposed for each sector. Emission Reduction (ER) and Sequestration Enhancement (SE) options have been proposed under the proposed strategy towards achieving net zero status. The economic viability for each option was assessed based on the projected costs for future (up to 2050) and carbon emissions savings. A guidance note on the shadow price of carbon in an economic analysis published by World Bank suggests that the shadow price of carbon in US$, per 1 metric ton of CO_2 is equivalent to USD 42.00 (lower estimate) and USD 84.00 (upper estimate) for the year 2022. The net present value was calculated for each option using a discounted rate of 10%. Tables 4.8 and 4.9 provide a summary of the present values of all costs and benefits for each sector.

Table 4.8: Present values of all costs and benefits for each sector

Sector	Present Values (LKR) @ 10% Discount Rate		
	Costs	Benefit - Value of Avoided Carbon (lower estimate)	Benefit - Value of Avoided Carbon (lower estimate)
Energy	5,796,452,247,493	691,009,241,938	1,383,529,655,419
Transport	37,052,200,770,104	503,705,234,686	1,008,968,070,861
Waste	17,071,078,646	21,418,007,457	42,876,767,179
Forest	641,839,730,410	3,474,503,691,998	6,944,503,252,245
Agriculture	198,979,539,449	241,047,907	482,123,188

Table 4.9: Net present values of proposed mitigation actions for all actions combined for all sectors

Scenario	Net Present Value (LKR) @ 10% discount rate	
	Value of Avoided Carbon (lower estimate)	Value of Avoided Carbon (upper estimate)
All sectors combined	-15,696,635,726,157	-12,895,537,785,921
All sectors except transport sector	-1,605,608,533,731.52	1,000,688,710,618.99

The combined analysis resulted in negative net present values. When the transport sector is excluded from the analysis, it resulted in a positive net present value of LKR 1,000 billion indicating the viability of the remaining sectors under the upper estimate of the value of carbon.

It is important to estimate a proper price for the carbon savings to see how the options that are currently economically not viable could be made viable through some type of a resource transfer or through carbon credits. This analysis provides an initial framework for setting up proper financial mechanisms that need to be realized to finance the proposed mitigation measures from international sources. It is acknowledged that the proposed action plan does not include a roadmap to finance the proposed strategic actions.

Table 4.10 provides details related to investments required for all sectors (except IPPU).

Table 4.10: Investments required for all sectors

Period	Total investment cost (LKR million)
2023 - 2027	69,776
2028 - 2032	2,524,649
2033 - 2037	19,827,476
2038 - 2042	25,731,711
2043 - 2047	33,237,990
2048 - 2050	49,192,499
Present value @ 10%	44,136,870

SECTION 5: RECOMMENDATIONS

- Attention needs to be given to alternative financing options rather than depending solely on domestic budgetary allocations. It is recommended that green financing options available locally and internationally should be explored to fund investments needed to achieve the desired outcomes.
- The Central Bank of Sri Lanka has already prepared the Green Finance Taxonomy for the banking sector as part of the actions defined under the Roadmap for Sustainable Finance in Sri Lanka. The taxonomy was developed with the aim of enabling financial market actors to raise capital for green activities in local and international markets. Therefore, seeking concessional or priority-based funding for zero carbon projects from the banking sector could be considered as a potential financing option going forward.
- Implementation of the actions proposed to achieve carbon net zero involves a whole-of-government and whole-of-society approach.
- Further comprehensive investigation of each of the actions proposed in the Roadmap and Strategic Plan should be carried out to identify the viability and priority levels for implementation. This prioritization needs to consider the technology readiness level in the local context, the enabling environment including policy, regulatory and institutional setup, data, human resources and cost factors. This should also be supported by a sound evaluation and prioritization methodology with localized criteria and an indicator framework.
- To ensure sustainable growth, investing in research and development is vital. This will advance adoption of new technologies in all sectors, such as green hydrogen technologies, in the energy, transport and industrial sectors, leading to increased efficiency, cost-effectiveness, and safety, while minimizing carbon emissions, this will in turn further attract innovation and drive industry expansion.
- During the development process of the Roadmap and Strategic Plan while much effort was taken to include the opinions of the officials with decision-making power as this is a long-term plan, it needs to be regularly updated with reliable data as available in the future. The government should encourage an open dialogue with all stakeholders and monitor the achievement of the KPIs on a regular basis, at least biennially, and review the Roadmap and Strategic Plan accordingly.
- Appropriate mechanisms to ensure transparency and enhance effectiveness should be established by the government for collecting and analysing data and acting based on stakeholder feedback, and these should also be communicated to the public.
- It is suggested to launch a Spatial Finance Initiative in Sri Lanka with the support of Sri Lanka Banks' Association's Sustainable Banking Initiative and the Ceylon Chamber of Commerce's (CCC) Environmental, Social and Governance (ESG) Financing Subgroup with the Government providing access to the spatial data in an easy-to-use form to the financial sector to constructively engage with private sector clients to manage their risks.

- The strategies and actions proposed in the Roadmap and Strategic Plan will need to be internalized into the sectoral development plans of the relevant institutions, to achieve the vision of "A CARBON NEUTRAL PROSPEROUS SRI LANKA". To ensure that this Roadmap and Strategic Plan is integrated into the strategies of the private sector, the CCC is recommending that it is important for the Governance and Disclosures of Private Sector to be aligned, and as a first step, the government (Climate Change Secretariat) could work with the CCC to support private sector adoption of Climate and Nature Related Financial Disclosures (TCFD and TNFD), starting with corporates with revenues of over LKR 15bn, encouraging them to take an account not only of their own operations but of their value chain/business ecosystem towards a just transition.

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